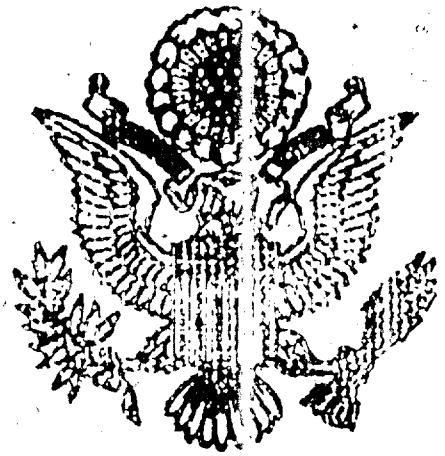
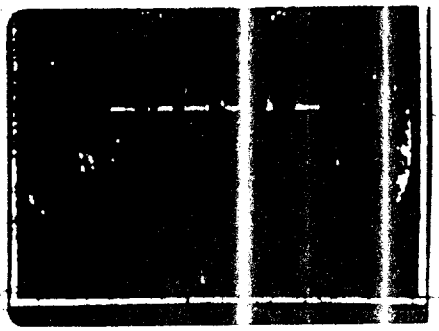
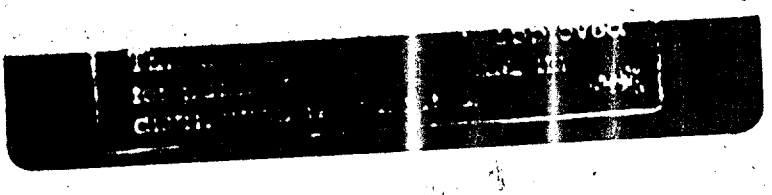
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MEDICAL DEPARTMENT, UNITED STATES ARMY

PREVENTIVE MEDICINE IN WORLD WAR II

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Volume II
ENVIRONMENTAL HYGIENE

Editor in Chief
COLONEL JOHN BOYD COATES, JR., MC
Editor for Preventive Medicine
EBBE CURTIS HOFF, Ph. D., M. D.

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OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., 1955

The volumes comprising the history of the Medical Department of the United States Army in World War II are divided into two series: (1) The Administrative and Operational series which constitutes a part of the general series of the history of the *United States Army in World War II*, published under the direction of the Office of the Chief of Military History, and (2) the Professional, or clinical and technical, series published as *The Medical Department of the United States Army* under the direction of the Office of The Surgeon General. Both series are being prepared by the Historical Unit, Army Medical Service. This is the first of a group of volumes to be published concerning preventive medicine as part of the latter series.

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THE MEDICAL DEPARTMENT OF THE UNITED STATES ARMY

PREVENTIVE MEDICINE IN WORLD WAR II

Volume II
ENVIRONMENTAL HYGIENE

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Foreword

After every war or major experience, it is only natural and to be expected that accomplishments, large and small, and, indeed the lack of them, should be recorded.

This volume is one of the Preventive Medicine series of the history of the Medical Department of the United States Army in World War II. It is a straightforward account of the role which the Medical Department played in the field of environmental hygiene. The planning, implementation, and monitoring of the major health measures required and undertaken in conjunction with an unprecedented mobilization and global employment of our Army are emphasized, particularly from the sanitary engineering viewpoint.

It is not intended to present a text on sanitary engineering, but rather to record the problems and military aspects of hygiene and sanitation as they arose. It was not a one-man or even a one-Department problem. Responsibilities for the overall program were not limited entirely to the Medical Department. Other branches of the Armed Forces, as well as various Federal agencies, were also involved.

No one author or number of authors could possibly cover in one volume all of the details and ramifications, worldwide, which the sanitary health problems of the Army entailed during World War II. Accordingly, this volume emphasizes in large part the major issues which confronted "top level" personnel and the specific measures taken. Credit and gratitude are due the authors not only for contributing these chapters but also, in many instances, for establishing the sound framework upon which future management of environmental hygiene within the Army may be based.

GEORGE E. ARMSTRONG
Major General, United States Army
The Surgeon General

Preface

This history is an evaluation of past events. Evaluation requires careful study of the chronology of these events, but more importantly it implies an analysis of the conditions, forces, circumstances, knowledge, motivations, and plans and operations that culminated in actual happenings. Such analyses should teach many lessons of both accomplishment and failure and serve as valuable and critical references to the solution in principle of future problems.

This volume is concerned with environmental hygiene and its impact upon the health, well-being, and morale of United States Army personnel during World War II. Its purpose is to record those plans, operations, and activities which utilized, modified, or controlled environment for health purposes. Accomplishment and failures have been of equal concern. The necessity for careful analysis and evaluation has been paramount in the minds of the authors and reviewers. No attempt has been made to chronicle the minutiae of the practice of environmental hygiene by theater. The scope of the problem was global. Therefore, emphasis has been placed upon principles and practices peculiar to areas of the world and the impact of the circumstances under which we operated.

Environmental hygiene in World War II is the story of the efforts of many people. The individual participation of the numerous medical officers, allied scientists, and sanitary engineers, both military and civilian in the United States and overseas, could not be recorded. Their work as individuals and as members of integrated health teams in many parts of the world is a credit to the nation.

The Advisory Editorial Board was created by The Surgeon General in 1948 to direct publication of the history of Preventive Medicine in World War II. The members appointed were eminent authorities in the fields of preventive medicine. All of them had held positions of great responsibility in the Medical Department during the war. General James Stevens Simmons served as Chairman of the Board since its inception. His leadership and enthusiasm provided inspiration and stimulus to all those concerned in this undertaking. He shared with authors and the editorial staff his rich experience as Chief of the Preventive Medicine Service, Office of The Surgeon General, during World War II and until his retirement from the Army in October 1946. His death in July 1954 deprived us of a distinguished leader and friend.

The Board prepared an outline which determined the scope of subjects to be covered and selected appropriate authors and reviewers. This volume represents one portion of that outline. The authors, chosen because of their special competence and wartime experience, were well qualified to sift the voluminous information obtained from official documents and personal interviews and to piece together concise, accurate, and authorative stories.

A contract was drawn up between the Armed Forces Medical Library (then Army Medical Library) and the Medical College of Virginia to establish an editorial office. From that office Dr. Ebbe Curtis Hoff maintained contact with the authors, received manuscripts and circulated them to reviewers, and performed professional editing. The manuscripts were then submitted to the Editor in Chief of the History of the Medical Department in World War II for final editing and processing for publication.

It is desired to acknowledge with gratitude the cooperation of Dr. William T. Sanger, President of the Medical College of Virginia, and Maj. Gen. William F. Tompkins, Comptroller of the College, for providing the facilities and staff necessary for carrying out the project and for their personal help and encouragement. Sincere thanks are expressed to Mrs. Jacqueline Pate, Mrs. Geraldine Glick, Mrs. Jeannette Martin, and Mrs. Virginia Wilson for secretarial work in the Editorial Office in the Medical College.

We offer grateful appreciation to the following for reviewing various chapters: Brig. Gen. Stanhope Bayne-Jones, USA (Ret.); Col. William S. Stone, MC, USA (Ret.); Dr. Fred C. Bishopp; Col. Emory C. Cushing, MSC (Ret.); Dr. John E. Gordon; Col. Karl R. Lundeberg, MC, USA; and Dr. Paul F. Russell.

We desire to acknowledge assistance in the preparation of several chapters. Dr. Lloyd Berry acted as consultant on the management of troops at ports and in transit. Mr. Jean Vincenz supplied information for the chapter on Waste Disposal. Mr. Lloyd K. Clark and Mr. W. Doyle Reed contributed to the preparation of the chapter on Insect Control. Mrs. Scioto M. Herndon assembled much of the source material and Mrs. Gertrude G. Johnson assisted in the writing of the chapter on Food Management.

The Medical Statistics Division, Office of The Surgeon General, under direction of Mr. E. L. Hamilton Chief, Mr. A. J. McDowell, Assistant Chief, and Mr. M. C. Rossoff, has provided or reviewed all of the statistical data contained in this volume except as otherwise indicated in the text. The Armed Forces Institute of Pathology, under direction of Mr. Herman Van Cott, prepared the illustrations for publication. The members of the Preventive Medicine Division, Office of The Surgeon General, acted as professional consultants throughout the editing of the volume. The Archives Branch, Historical Unit, Army Medical Service, gave willing and continuous help in searching historical files and providing source material to authors and supplying references. The Administrative Branch of the Historical Unit, under direction of Mrs. Catherine F. Marshall, gave general administrative support to the project and performed the final typing of these chapters. Mrs. Lillian V. Russell served as editorial clerk for this volume.

TOM F. WHAYNE
Colonel, MC, USA
Chief, Preventive Medicine Division
Office of The Surgeon General

9 February 1955

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INTRODUCTION

Environmental Hygiene in the Preventive Medicine Service

*James Stevens Simmons, Ph. D., M. D., Dr. P. H.**

This volume deals with that portion of the Army's preventive medicine program in World War II which is included under the broad term "Environmental Hygiene." Since the earliest period of recorded history, wise military leaders have recognized the importance of maintaining a high standard of cleanliness among their troops. Even before the microbiologic causes of disease were discovered late in the 19th century, it was suspected that filth was often associated with certain military diseases. However, it was not until early in the present century that the sciences of microbiology and epidemiology had advanced to the point where the new knowledge which they provided could be applied on a specific basis for the prevention of disease through sanitation of the environment.

During the four decades from 1900 to 1940 rapid advances were made in environmental hygiene and many of these resulted from the researches and field application of new sanitary knowledge by military scientists, including both physicians and sanitary engineers. The experience of the United States Army with environmental hygiene during World War II stands out as a milepost of achievement in the long history of military preventive medicine.

Two divisions of the Preventive Medicine Service of the Surgeon General's Office cooperated in the planning and development of the major portion of this program, which operated with unusual effectiveness both in the Zone of Interior and in the various theaters of war. One of these was the Division of Sanitary Engineering, which operated throughout the war under the direction of Col. William A. Hardenbergh, Sanitary Corps. The other was the Division of Sanitation, directed during the early part of the war by Col. William S. Stone, Medical Corps, who later became Chief of Preventive Medicine in North Africa and Italy. The able and distinguished leadership provided by these two officers and their associates brought about a high degree of efficiency in the Army's program of environmental sanitation.

There has been recorded in this volume the history of health aspects of food management, housing, and foreign quarantine. The results of research projects on various factors in disease transmission were valuable in formulating policies and planning in these fields. Civilian scientists, particularly through agencies such as the Office of Scientific Research and Development and

*This section was written in 1953 while General Simmons was Dean of the Harvard School of Public Health.

the National Research Council, cooperated with the military in conducting the studies requested. While it is impossible to measure accurately the health effects of these activities, they represent the untiring efforts of many devoted people and undoubtedly resulted in significant saving of time and military non-effectiveness.

An outstanding feature of the total preventive medicine program in World War II was the initiation of research which led to the discovery, development, and application of many new agents with which to control the numerous insect- and rodent-borne diseases which have always harried troops operating in the field. The Division of Sanitation initiated and stimulated much of the research and the Division of Sanitary Engineering was actively concerned with the development of new engineering methods for their application in the field.

In this volume the major activities in the field of environmental hygiene are reviewed, but I should like to emphasize here the fact that the joint contributions of these two major divisions of the Preventive Medicine Service to the control of insect-borne diseases constitutes one of the major scientific advances of the war. The development of more effective methods for the application of just one of the new insecticides, namely DDT, provided a powerful weapon which can now be used to free mankind from a host of former plagues, including malaria. This experience emphasizes the importance of both research and application to the future improvement of military environmental hygiene. It also indicates quite definitely that the services of the sanitary engineer should be a vital part of any future program of military preventive medicine.

Sanitary Engineering

William A. Hardenbergh

The Medical Department is responsible for the health of the troops and in performing this function it must use the skills not only of physicians, but also of many categories of nonmedical professional men. Military preventive medicine is based on the broad application of the principles of disease prevention to military conditions. In such a program, one of the prime factors is environmental hygiene. The term, and the work program it embraces, should not be applied solely to the routine day-by-day problems of sanitary housekeeping at posts, camps, and stations, for the handling of which nonprofessional technical skills are normally sufficient.

Environmental hygiene refers to those health problems which are so important and of such a nature as to demand long range planning and the use of special skills for their solution. Many of these problems relate to sanitary engineering, especially those involving water supply and purification, sewerage and sewage treatment, refuse collection and disposal, and insect and rodent control. Depending on local conditions, all of these may be important in rela-

tion to the health of the troops. To be most effective, sanitary engineers, specifically, should be utilized in the early stages of planning, including selection of campsites, approval of designs, planning of landing operations, and movement of large bodies of troops.

Because sanitary engineers are always in short supply during periods of emergency, such personnel should be utilized only in that particular work that requires this specialized knowledge and experience for its performance. For instance, such knowledge is needed to discharge the Medical Department's responsibility to cooperate with the Corps of Engineers in selecting designs for water treatment and sewage treatment plants which will insure efficient operation. Inspection of these plants by sanitary engineers results in the early detection of defects and assures continuous effective operation. Much saving of time, effort, and money is effected from the advice and help given during such inspections both in improving methods of operation and in on-the-spot correcting of minor defects. The services of the sanitary engineer can be used to advantage in many phases of insect and rodent control. He can survey the area in question and determine what type of engineering work must be done and how best to contribute to the overall problem of control. Since rodent control often involves refuse, or other waste, collection and disposal, it is most efficiently accomplished by sanitary engineering personnel.

Thus, the sanitary engineer is essential to a preventive medicine program because he is the means by which many medical objectives are accomplished. The epidemiologist points out the areas in which environmental control can contribute to health, and the sanitary engineer finds ways and means to accomplish these objectives. The reason for treating water is medical, but the method by which it is accomplished is engineering. The reason for disposing of human waste is to prevent illness; the design and operation of sewage disposal systems are engineering. The same is true of practically all aspects of environmental hygiene. Therefore it is essential that people with engineering background and fields closely allied to medicine be a part of the medical service to accomplish these objectives. The role of the sanitary engineer in the Medical Department team during World War II was a vital one, and the profession can well be proud of the manner in which its members discharged their varied duties and responsibilities.

CHAPTER I

Food Management

Colonel Tom F. Whayne, MC, USA

The company mess is an important agent in the spread of the gastrointestinal diseases and, to a lesser extent, in that of respiratory diseases. Since food may be contaminated at any stage in its preparation, the Medical Department placed great emphasis upon food management as one of the preventive measures to control disease. The diarrheas and dysenteries were an ever-present problem to the military command and, while not serious medically, were a major cause of time lost from duty.

The character of the company mess also has a decided influence on the physical effectiveness and morale of the individual soldier. The "amazing recuperative power" of American soldiers was remarked upon at a general hospital in the European theater and was attributed to the fact that the troops were "well-fed and well-trained" and thus "prepared to withstand severe injury." [1]

The basic consideration throughout all stages of food management is cleanliness. Sanitary measures include inspection of food and the sources of its supply, protection of food from dirt and flies during storage and preparation, inspection and supervision of food handlers, maintenance of high standards of cleanliness in kitchens and messhalls, and exclusion from the vicinity of the mess of any factors which might result in the contamination of food.

Many features of the general environmental hygiene program, although not part of food management itself, influence the effectiveness of food management. For example, the sanitary measures taken by mess personnel cannot have fully satisfactory results unless the facilities for waste and garbage disposal are adequate, a potable water supply has been provided, and measures have been instituted for the control of rodents and insects. In those areas where native sanitation was negligible and intestinal diseases endemic, individual compliance with hygienic measures and rules concerning the use of none but approved water and food supplies was particularly important.

The fundamental principles of field sanitation, and the attendant sanitary features of food management, had been well established by the time mobilization occurred in 1940. The execution of those measures was a function of command. The role of the Medical Department was to inspect, to recommend, and to keep the responsible officers aware of the necessity for strict compliance with standards.

[1] Annual Rpt, 1st Gen Hosp, 1944. HD.

Experience in World War I

The rapid mobilization of World War I and the unprecedented movement of two million men to an overseas theater presented overwhelming problems of transportation, housing, and messing. Although monthly sanitary reports had previously been made a requirement, and members of the Office of The Surgeon General conducted regular surveys, the exigencies of the war prevented many of the recommendations from being carried out in full. Often inexperienced line officers and men did not understand the necessity for complying with regulations until a local outbreak of intestinal disease illustrated the hazards involved.

The Medical Department history of World War I reports that from a sanitary standpoint the kitchen facilities in the United States were generally unsatisfactory.[2] Many of the difficulties came from faults in construction; usually the kitchen and storeroom space was too small. The arrangements for washing kitchen utensils were also considered inadequate. Messkits were usually washed individually in tubs or cans placed outdoors. Surveys reported that the washing was nearly always unsatisfactory, particularly in regard to the use of hot water, sufficiency of soap, and adequacy of rinsing. War Department circulars issued in October and November of 1918 outlined strict rules to follow, but enforcement varied from unit to unit.

Serious overcrowding of trains and transports, vigorously protested by the Medical Department, continued throughout the First World War because of the urgency of the military situation. The inevitable breakdown of sanitary control and the poor messing conditions resulted in a high incidence of intestinal and respiratory diseases among troops in transit.[3]

Several types of rolling kitchens, field ranges, and garrison ranges were provided for troops in Europe, but each had drawbacks. Attempts were made to send hot food forward to troops in the trenches, but were discontinued because food spoiled in the marmite cans.

Field sanitation in the American Expeditionary Forces improved from month to month as the troops gained experience. Many practical advances in field procedures for serving food and cleaning messgear were developed. The armistice was signed, however, before compliance with the rules had become general and before visible proof of their effectiveness was evident.

Responsibility for Subsistence in World War II

The Quartermaster General was responsible for the procurement, storage, and distribution of all food for the Armed Forces.[4] The Surgeon General, through the Veterinary Corps, was responsible for the sanitary inspection of foods of animal origin; he also supervised the sanitary aspects of all food

[2] The Medical Department of the United States Army in the World War. Washington, Government Printing Office, 1926, vol. VI, p. 696.

[3] Ibid.

[4] AR 30-2210, 15 Mar 40.

handling.[5] The Quartermaster Corps maintained inspection offices at all market centers and purchasing offices. Veterinary Corps officers of the Medical Department, specially trained in food inspection, were assigned or detailed to the various Quartermaster headquarters. The objectives of veterinary inspection were: (1) to protect the health of personnel from food-borne diseases and intoxications, and animal diseases transmissible through food to man; and (2) to insure that foods purchased by military establishments complied with all terms of the purchase contracts. In addition to inspecting all foods of animal origin, Veterinary Corps officers inspected other foods when so requested by the Quartermaster Corps.[6]

Officers of the Veterinary Corps inspected abattoirs, milk plants, and cold storage facilities for type, construction, state of repair, condition of equipment, water supply, and methods of operation. They also inspected subsistence at various points en route from producer to point of issue: at ports, unloading stations, and distribution points.

Subsistence was shipped by the Army Transportation Corps from Quartermaster depots and civilian warehouses to all parts of the world where American troops were stationed. The Corps of Engineers cooperated with the Quartermaster in the construction of warehouses and other storage facilities. The responsibility of the Quartermaster Corps was discharged when stores were issued to units.

TRANSPORTATION OF FOOD

The great bulk of the food used by American troops in all theaters was transported from the United States. The Quartermaster Corps carried on continuous research, with the cooperation of the Nutrition Branch of the Office of The Surgeon General, to devise rations that would meet the nutritional needs of the troops, require the minimum shipping space, and be sufficiently attractive so that they would actually be consumed by the troops.[7]

At the beginning of the war, shipping space was at a premium and other military needs had to be considered. In all theaters some food was procured for American troops by direct purchase or through reverse lend-lease. As the general shipping shortage eased, more food supplies were sent from the Zone of Interior and a larger proportion of fresh and canned foods was substituted for packaged rations and dehydrated foods.

The aim was to provide troops with hot meals, including fresh meats and vegetables, wherever the circumstances of their employment made this possible.[8] To this end, the Transportation Corps used not only ships, trains,

[5] AR 40-205, 31 Dec 42.

[6] AR 40-2005, 15 Sep 42.

[7] Risch, Erna: The Quartermaster Corps: Organization, Supply, and Services. *In* United States Army in World War II. Washington, Government Printing Office, 1953, vol. I, pp. 174-206.

[8] Wardlow, Chester: The Transportation Corps: Responsibilities, Organization, and Operations. *In* United States Army in World War II. Washington, Government Printing Office, 1951, p. 16.

trucks, and sometimes planes, but at times resorted to the use of mules, dogsleds, and native porters. Incredibly long distances were involved, particularly in the Middle East and Far East, and the supply lines had to be maintained against enemy action. Behind the Thanksgiving turkey dinner eaten in Burma, Anchorage, or Liége were complicated problems of efficient use of limited dock and storage space, packing to protect food from tropical heat or Arctic cold, and judicious employment of untrained natives as freight handlers.

Handling Food in Transit

Field trials during the Carolina maneuvers in 1941 and 1942 showed the necessity for establishing requirements for vehicles transporting bread, fresh meat, and other exposed food. Methods of loading, protective covering, care en route, and unloading were explained and prescribed.

Food was inspected by veterinary or medical personnel at various points in transit. A study covering the years 1942 through 1945 showed that the results of surveillance inspections, exclusive of rejections at time of procurement, never exceeded a rejection rate of 0.77 percent of the total food of animal origin inspected.[9]

Employment of untrained civilians as freight handlers in many parts of the world resulted in food spoilage and rejection by inspectors. For example, early in 1943 in Newfoundland frozen meat from plants in Canada often began to thaw out before it could be loaded for delivery to posts and had to be rejected for purchase.[10] In the Southwest Pacific area some food shipments arrived in an unsatisfactory condition due principally to improper stacking and stowage in the ships' holds.[11] Damaged poultry and canned goods were cited as causing much loss. Frozen perishables were sometimes contaminated by the entrance of water into the holds of the ships, but a large percentage of meat so contaminated could be salvaged by trimming.

Refrigeration During Transportation. Perishable food presented few problems in the United States. Although food could be satisfactorily shipped to the theaters, storage facilities and theater transportation were not adequate for their further handling. American refrigerator cars and trucks were sent to the European theater, but even as late as October 1944 perishables were still causing concern and additional refrigerator cars were requested for use between Cherbourg and Paris.[12] In tropical areas proper refrigeration remained a problem and it was not until 1945 that the Asiatic theaters received such equipment.[13]

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[9] Office of The Surgeon General, Health of the Army, 4: 2-10, Aug 49. HD.

[10] Manning, F. G.: Preventive medicine in the Northwest Service Command. HD: 314.7-2.

[11] Memo, Surg Hq Philippine Base Sec for CG Philippine Base Sec, 30 Aug 45, sub: Food spoilage in Philippine bases. HD: 728 EBM 102-C.

[12] Weekly Rpt, Vet Div Hq ComZ, 21 Oct 44. HD.

[13] Quarterly Rpt, Base E USASOS, 1944-4. HD.

STORAGE AT SITE OF MESS

Methods for storing food varied from routine handling in specially constructed warehouses to stacking cases in the open. Procedures were governed by temperatures and availability of sites. Lack of construction, in the early days of the war, necessitated stacking in the open, often without dunnage or covering tarpaulins. In the tropics, open sheds with thatched roofs (later tarpaulins) were erected under trees for protection from the sun. As time passed improvements were made; portable warehouses were erected and proved acceptable. Pallets, logs and timber, blocks of cement, and—in the South Pacific—blocks of coral were used as dunnage. Thorough cleaning of floors was necessary each time they were cleared to avoid the nuisance of disintegrating food and to discourage rat harborage. Staggered stacking and aisles between stacks allowed for proper ventilation. While protection from heat was one objective in the tropics, proper heating to avoid freezing of commodities had to be furnished in cold climates.

Suitable storage space often was difficult to find. Beaches, groves, and marshy ground were used when, for tactical and logistic reasons, better areas could not be provided. Security from enemy bombing was another consideration. In the Pacific, bases which were being abandoned shipped their supplies to operating bases which were already receiving routine shipments. It was physically impossible to store this excess properly. Extremely high temperatures and heavy rains caused rusting and disintegration of cans. As circumstances permitted and materials became available, warehouses were built and proper protection furnished for outdoor storage.[14]

In the European theater packages and boxes were stacked at least a foot off the ground. Vegetables were stored in bins, properly ventilated, and sorted daily to remove spoiled items.[15] As the war progressed, other theaters were able to improve storage procedures. Spoilage of food occasionally occurred in storage but was usually discovered during inspection. Refrigeration for storage of perishables was being supplied to theaters at the end of the war.

PREPARATION OF FOOD

Responsibility

Responsibility for actual food preparation was a function of command. To insure that the right foods were being purchased, and were then used properly, the Quartermaster Corps developed food laboratories and extended their interest to mess management. The Office of The Surgeon General was concerned with analysis and scientific appraisal of the ration, with its palatability, and with sanitary mess management. Cooperation between the two agencies at all levels did much to raise mess standards.

[14] Annual Rpt, Vet Sec Base D USASOS, 1943. HD.

[15] Gordon, J. E.: History of preventive medicine in the European Theater of Operations, United States Army 1941–1945. HD: 314.7–2.

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Programs to prevent waste of food and to develop a sense of individual responsibility for food conservation were encouraged. Nutrition branches of preventive medicine divisions paid particular attention to the manner in which specific components of the ration were selected, combined, issued, cooked, served, and eaten. Cooperation between nutrition officers of the Medical Department and food service supervisors of the Quartermaster Corps in Europe contributed greatly to the high level of nutrition attained in that theater. Medical laboratories and cooperative programs were also set up in other theaters and the ration and mess management were given particular attention.

Cooks and Mess Personnel

Cooks and bakers were trained in special schools in the Zone of Interior, in hospitals, and in special schools overseas. On-the-job training was instituted in camps and hospitals. Mess personnel were given training in bivouac cooking, and some cooks received special training in bakeries and meat cutting plants. While some unit reports state that cooks needed more training, most frequently cooks were rated as excellent, even under the most trying conditions.

When troops were first sent to England, units moved into unorganized camps, old quarters of the British Army, or nonmilitary housing. Cooks and mess personnel were handicapped by the inadequacies of cooking, storage, and cleaning facilities. To assist in solving these problems a team of experienced experts in sanitation visited each camp and installation in the theater to give definite advice and information on sanitary procedures and to aid units in their own immediate and particular problems.[16] This procedure gave headquarters an appreciation of problems in the field not otherwise possible. For individual units, help was furnished of a kind that could not be given through directives or formal recommendations. Similar teams were organized in the Pacific; and nutrition and sanitary officers made frequent visits to units to assist with difficulties as well as to make inspections.[17]

Quality of Preparation

The quality of food preparation varied with each unit according to its mess personnel and the equipment and facilities available. Feeding large groups of men within a given time was not easily accomplished. Hours were spent in preparation; lack of refrigeration or carelessness in storing sometimes resulted in food standing for long periods of time at room temperature, often not protected from flies or other sources of contamination. Reheating of food before serving was usually not sufficient to destroy bacteria. Keeping food warm on the back of stoves served as an incubator for the development of pathogens. The Medical Department repeatedly stressed that food should not be prepared

[16] See footnote 15, p. 9.

[17] Off of Surg USAF MidPac: A history of preventive medicine, U. S. Army Forces, Middle Pacific. HD: 314.7-2.

longer in advance than necessary, and also provided guides to show which foods could safely be prepared first.

Holiday meals were provided even when they greatly overtaxed the kitchens and equipment. The elaborate menus meant that much food must of necessity be prepared a long time in advance of the meal. Leftovers were inevitable and, in many instances, properly refrigerated storage space was not available. Several outbreaks of food poisoning, as well as diarrhea and dysentery, were traceable to improper management of holiday meals.

Instructions were issued to defrost meats before cooking. Possibility of contamination occurred when meat was improperly defrosted in water or placed uncovered on tables. Some mess personnel found that it was easier to cook meats without defrosting. Fried chicken and chops cut from pork loin while still in frozen condition were served successfully. One veterinary inspector noted: [18]

> It was particularly observed that the fibre containers in which the loins were issued were absolutely dry with no evidence of leaking material or drip. In my opinion, a very fine example of perfect handling, storage, issue and preparation, where no nutrients were lost, product absolutely sanitary and none of the attending defects which would have obtained if handled under advocated S. O. P.

Hospitals in general prepared food well, especially with reference to saving juices containing vitamins and using them in soups, stocks, and gravies.[19] Special recipes developed by kitchen personnel gave variety to the menu and added to the palatability of the food. Particular care was taken to prepare food in accordance with prescribed Army procedure and to serve all food, hot or cold, as indicated and within the shortest time possible after preparation.

An example of good food service under difficult tropical conditions was in Liberia, where refrigeration was a problem. The mess at Roberts Field was rated excellent. Local meat, fruit, eggs, and vegetables supplemented the regular menu and particular care was taken in the preparation of food.

METHODS OF SERVING

In general throughout the Army, the cafeteria type of service was adhered to, with mess personnel serving long lines of men, both in the field and in stationary messes. The method was satisfactory, economical, rapid, and offered the best results in the sanitary handling of food.

Self service was encouraged and practiced in certain units in the European theater and in some hospitals for ambulatory patients as a means of preventing food waste. Because of the possibility of contamination from many men handling ladles over food containers, and the subsequent danger from leftover food, this method required careful supervision.

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[18] Weekly Rpt, Vet Div ETOUSA, 3 Jun 44. HD.
[19] Quarterly Rpts, 3d Field Hosp SWPA, 1943–45. HD.

In hospitals, bed patients were fed from trays of several types. In the Zone of Interior, china and silverware were used with plain plastic trays. In the theaters plastic or metal compartmental trays were used. Some hospitals attempted to improvise trays which frequently proved unsatisfactory, while in other hospitals a shortage of trays necessitated staggered meal hours and the washing of trays two or three times during one meal. Some types of food carts, used to carry hot food to wards, were too small and were therefore overloaded. Insulated food containers were not satisfactory. After American Drinkwater-type carts were obtained, service in wards improved. In spite of many difficulties patients were, in general, properly fed, special diet requirements were met and food was well cooked and palatable.[20]

In the Mediterranean theater efforts were made to get hot food forward in thermos containers but this practice was discontinued when outbreaks of food-borne dysentery occurred.[21] In most areas of fighting, however, arrangements for heating the ration were supplied (or improvised) fairly close to frontlines. (See Fig. 1.) It was usually possible to serve hot coffee even if it was not practicable to serve a hot meal.

MESS SANITATION

Cleanliness in mess management was stressed through education and intelligent inspection. This was not accomplished without difficulty. Often inexperienced officers were, of necessity, made responsible for mess management. Although Veterinary Corps officers were utilized for mess inspection, there was a shortage of competent mess inspectors, and inspectors were too few. Circular letters issued by the Office of The Surgeon General, War Department bulletins, and medical bulletins from the offices of theater surgeons, as well as individual training in mess management in schools and on-the-job training helped to solve these problems.

A circular issued by one of the base sections of the communications zone of the European theater was typical of directives and guidance for mess management. It called attention to the protection of food, the inspection of messes, precautions to be observed in the preparation of food and in the washing of messkits and utensils. Directions in regard to general cleanliness and order of kitchens included the prohibition of common drinking cups, the observance of orderliness in placing and hanging of utensils, and the direction that tables, benches, and blocks be scrubbed with hot soapy water after each meal. Soiled rags were not to be left on work surfaces, ovens and stoves were to be cleaned thoroughly inside and out, and flies and other insects eliminated by all means available.

Accomplishment of the type of cleanliness prescribed, as well as of proper mess management, required training of cooks, mess personnel, and responsible

[20] See footnote 15, p. 9.
[21] Final Rpt. Prev Med Off MTOUSA, 1945. HD.



Figure 1. Hot food for combat engineers, France, 1944.

officers. Mess inspectors, nutrition officers, and noncommissioned officers in charge of messes were active in observing deficiencies and in correcting them; they also acted as instructors in schools and in on-the-job training. However, shortage of personnel and the employment of civilians who had not been trained

presented difficulties which to some extent compromised the full effects of sanitary training. Optimum operation often could not be achieved in the tropics because of the unsanitary habits of natives who, of necessity, had to be used as food handlers. Lack of screening and shortage of equipment—especially refrigeration—terrain and weather conditions which made the disposal of wastes and the maintenance of sanitation difficult, and the prevalence of communicable intestinal diseases in the native populations were other factors limiting the degree of success of mess sanitation.

Equipment in Messhalls and Kitchens

Most messes were well-equipped, conveniently situated, and competently operated. (See Fig. 2A.) In permanent or semipermanent installations, stoves replaced field ranges, adequate sinks and washing facilities were installed, and sufficient cooking and serving utensils were provided. In the early years of the war makeshift arrangements were at times resorted to because of shortage of equipment. The shortage of screening mesh made the control of insects difficult for several months. Tables ranged in type from those which were specially constructed with openings in the top to facilitate easy and quick cleaning, to hastily improvised ones.

Overseas, kitchens and messhalls were housed in tents (see Fig. 2B), prefabricated buildings, barns, native huts, or the best available shelter. Control of dust, care of spillage, and prevention of fly breeding required constant at-



Figure 2A. The kitchen of the 298th General Hospital, England, 1944.

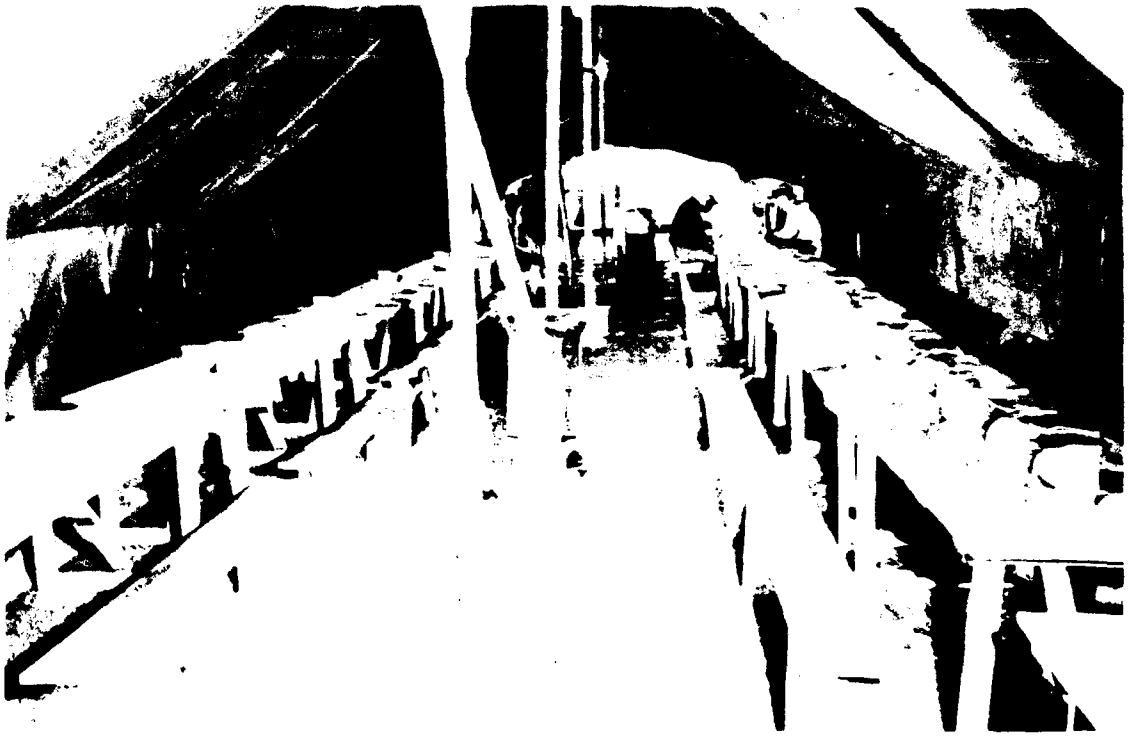


Figure 2B. An Army mess under canvas, France, 1944.

tention. Dirt floors were the rule in the field, but even when under tentage some units had concrete floors for the mess. For example, the mess and kitchen of a veterinary evacuation hospital in the Pacific theater were in a building roofed with fibrolite, lined with plywood, completely screened, and with a concrete floor.[22] In a general hospital in that theater also, the kitchen and mess were in a screened prefabricated building with concrete floors.[23]

Regardless of the type of housing and equipment, meals had to be prepared and served at stated hours, in the most expeditious manner, and with particular attention to quality, palatability, and nutritive value. Many improvisations, characteristic of the American soldier, were devised and, in spite of some shortages and adverse field conditions, palatable meals were produced by most units. Among the improvisations were steamtables, sinks, stoves for heating water, equipment for washing messgear, and in one case a grill large enough for 360 hamburgers at a time. Full advantage was always taken to supplement the standard Army equipment with any facilities available. In the European theater units were occasionally moved into buildings which had many types of electrical equipment. At times, when individual unit equipment was inadequate, several units pooled their equipment into one large kitchen and assigned the most experienced personnel to operate it.

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[22] Annual Rpts, 16th Vet Evac Hosp, New Guinea, 1943, 1944. HD.

[23] Semiannual Rpt, 9th Gen Hosp, 1945 I. HD.



Figure 5A. Improvised messkit laundry unit at the Medical Field Service School, England, 1943.

Dishwashing

Early in the war it became apparent that providing adequate hot water for dishwashing would become a problem in both field and established installations. Other problems were the development of detergents and disinfecting rinses, acceptable dishwashing machines, and the maintenance of proper dishwashing in overcrowded camps and stations.

Proper disinfection of dishes and messkits was a major factor in the prevention of the spread of respiratory and gastrointestinal diseases. In planning the construction of cantonment-type camps, no estimate was made of the amount of hot water required for kitchens. In early 1942, after the camps were in operation, the Medical Department made several surveys and found that the average temperatures of water provided for dishwashing ranged between 108° F. and 120° Fahrenheit. This was far short of the 180° F. which bacteriologic tests had shown was necessary for proper disinfection. The Corps of Engineers conducted tests to determine the most efficient heating system with the materials then available. It was found that prior to the war a considerable number of cast iron heaters were in the hands of wholesalers and dealers because of the lack of civilian demand. These heaters would be immediately available and were considered adequate for the needs of the Army. A program to procure and install the heaters for cantonment-type camps was started.[23]

[23] Committee to Study the MD, 1942, Testimony, pp. 278–280.



Figure 3B. Messkit laundry in a unit of the XXII Corps, Germany, 1945.

On 22 September 1942 an order from the Commanding General, Services of Supply, directed that new installation of hot water heaters was to be discontinued, in order to conserve critical metals.[25] The Medical Department immediately protested the order, pointing out that this equipment was manufactured and about half of the needs already purchased, and stressing the need for the proper disinfection of dishes. They also pointed out the danger of epidemics of respiratory and gastrointestinal diseases if such disinfection was not accomplished.[26]

Services of Supply recognized the importance of sufficient hot water for proper dishwashing and disinfection but held the view that this could be accomplished in permanent stations by improvised methods such as were used in the field. The Chief of Engineers disagreed and pointed out that cancellation of orders already placed would "break down the confidence and good will of the vendors. . . . This in turn would hinder procurement of items of heating equipment . . . for new construction." He noted that the War Production Board had approved the hot water program and stated that materials were available for steam boilers, water heaters, and other equipment needed to heat water. The Chief of Engineers concluded that since all messhalls were used for a greater number of troops than they had been originally designed to serve, proper disinfection of dishes could not be accomplished by improvised methods

[25] Ltr, CG SOS to CofEngrs, 22 Sep 42, sub: Messhall hot water program. AG: 674.3.
[26] Ltr, SG to CG SOS, 5 Oct 42, sub: Messhall hot water program. AG: 674.3.

because of lack of time, labor, and facilities for such work. In November permission was granted for the installation of 4,900 hot water heaters in already existing messes but the continuance of the hot water program was not approved.[27]

The Medical Department also investigated the problem of adequate dishwashing machines. Immersion-type machines were considered inferior to the spray cabinet type particularly when the machines were overloaded. Inexperience of personnel in the operation and maintenance of the machines was also a factor in the failure to wash and disinfect dishes properly. By January 1943 permission to install spray rinse units in operating messes was secured; these items were already in stock in adequate supply.[28]

Scarcity of fuel made it difficult to maintain water at the proper temperature in the field. Various improvisations were used to raise and hold water at the boiling point. In addition to specially constructed fire pits under G. I. cans (see Fig. 3), Immersion heaters, Sawyer and improvised stoves were used. The Medical Department recommended to the Quartermaster Corps that a germicidal rinse be used when boiling water could not be provided for rinsing dishes. Investigation and experimentation produced several disinfecting rinses and compound germicidal rinses were issued to the field. They proved unsatisfactory for disinfection in the concentration and immersion time practicable in the field. Other chlorine rinses and detergents for both garrison and field use were also developed.

The Army laid down definite procedures for the washing of messkits as well as dishes. Messkits were dipped into one container of hot, soapy water and rinsed in two containers of hot, clear water which was kept boiling. (See Fig. 3.) They were to be air dried. In the field it was frequently the practice to place a can of hot, soapy water at the head of the messkit line for the purpose of removing remnants of food from the kits before washing them in the usual first can of soapy water. The same objective was accomplished in stationary posts by scraping and prewashing dishes by hand. In the European theater for groups of 125 men, three 12-gallon cans were used and for 250 men, three 24-gallon ones. When this ratio was maintained, dishwashing was considered satisfactory, but when the messline was overcrowded, the wash cans contained little soap and the rinse water was polluted with soap and scum. In such a situation messgear could not be properly disinfected.

Personal Hygiene of Mess Personnel

Army regulations prescribed physical examinations once a month for all permanent food handlers.[29] Medical inspectors and surgeons of posts had authority to require additional and more detailed examinations when neces-

[27] 1st ind, CG SOS to CofEngrs, 11 Oct 42; 2d ind, CofEngrs to CG SOS, 27 Oct 42; 3d ind, CG SOS to CofEngrs, 6 Nov 42, on basic ltr cited in footnote 26, p. 17.

[28] Ltr, Capt R. E. Engel, CE, to Sanitation Div SGO, 15 Jan 43. HD: 720 (Dishwashing).

[29] AR 40-275, 15 Nov 32.

sary.[30] Examinations were required prior to detail to messes or before food handlers moved into maneuver areas. Inspections of civilian food handlers in overseas bases were particularly important, and helped to prevent spread of intestinal diseases. In one instance in the South Atlantic theater, approximately 700 individuals were examined and only 18 were found fit to be employed as food handlers.[31]

Examinations such as these did not prove altogether satisfactory. A man could contract disease between examinations. Food handlers with negative stools initially could be positive for intestinal pathogens on subsequent examination, especially carriers or those who had recovered from disease. Temporary mess personnel were not given examinations and although they were not to assist in cooking, the possibility of contamination of food or serving utensils was present. For these practical reasons routine examinations were eventually discontinued.

In addition to examinations, daily inspections by the mess officer or mess sergeant for personal cleanliness of food handlers were also required. Food handlers were trained in hygienic habits of person and dress. Hair and nails were to be kept short; hair was to be combed and the head covered (women were required to wear hairnets). Hair, hands, nails, face, and teeth were to be kept clean; washing of hands after a visit to the latrine was mandatory; clean, white clothing that covered the armpits was required. Any food handler showing evidence of illness, skin disease, infected cuts, or boils was not permitted to work in messes or commissaries.

In well-established hospitals and posts, where it was possible to procure an adequate water supply, proper standards of personal hygiene were easily maintained. Through education, training, supervision, and inspection, standards of personal hygiene at all installations improved as the war progressed.

Bathing facilities for food handlers were often below American standards in overseas areas. For example, in the United Kingdom water often was scarce and central showers in camps were at times some distance from the kitchen. This necessitated long walks to and from barracks and kitchens and consequently reduced the frequency of baths. On some islands in the Pacific, water was not only scarce but was also brackish. A salt water soap was developed to overcome the latter difficulty. Handwashing facilities were often lacking or inadequate. It was found that in some units a common towel was provided in the kitchen for all mess personnel; in others no soap or towels were available in toilets. Medical inspection helped to correct local deficiencies in hygienic practice.

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[30] FM 21-10, 1940.

[31] Medical History World War II, USAF South Atlantic, p. 314. HD: 314.7-2.

Overcrowding of Messes

The rapid mobilization in the early years of the war which caused an influx of men into camps and posts in the United States resulted in overcrowding of messes. Later the shipping of large numbers of troops resulted in the overcrowding of staging areas both in the Zone of Interior and overseas.

A mess designed to accommodate 117 men could not be expected to accommodate 300 to 400 at a meal. Two or three seatings at a meal made it necessary for food to be prepared too long in advance since stoves and other equipment had been provided only for the prescribed number of men. Food, therefore, had to be stored before serving, affording opportunity for contamination since storage space was also limited. Another problem was that of properly washing and disinfecting dishes or messgear. When these had to be washed two or three times during a meal it was not always possible to insure enough time, nor hot water, for the proper washing and rinsing of the messgear. In addition, after long hours mess personnel sometimes became careless and untidy and did not always maintain prescribed sanitary standards.

MESS INSPECTION

Inspection of messes was the responsibility of the Medical Department which set up requirements and procedures for proper storage, preparation, and serving of food and for mess sanitation.

Usually messes were inspected formally once a week and informally several times, with the mess officer or mess sergeant making daily checks on equipment and personnel. Storage space and refrigerators were included in these inspections. Inspectors conferred with mess personnel explaining proper procedures, pointing out errors, and indicating methods for improvement in mess operation.

The most effective inspectors tried to make inspections instructive and educational. Their return inspections were welcomed for they had taught and consulted instead of criticizing for imperfect performance and management. Col. Clell B. Perkins, the Chief Veterinarian of the Third United States Army, and other inspectors under his guidance so improved mess standards and management within that army that he received commendatory letters from division and other higher commanders, including the army commander, for his services. All those who handled food were cooperative and willing to improve conditions because of his careful, thorough, and courteous "consultation" with mess staffs on their problems.[32]

In addition to regular inspection of messes, frequent spot checks in Red Cross canteens and in post exchanges were also of value in assisting these units to maintain proper sanitation in the preparation and serving of food. Nutrition officers inspected for preparation, adequacy, and nutritional value of the diet.

[32] Ltr, CG 65th Inf Div to CG 3d Army, 16 Dec 43. HD: 720 EBM 104-D (Vet).

Training in Special Inspection Techniques Overseas

In addition to training in routine inspection techniques, both in the Zone of Interior and overseas, training was given in specialized phases of inspection applicable to the particular theater.

Lectures on food inspections and the care and handling of subsistence were given to mess personnel of 19 organizations on Base D in the Pacific.[33] This was done primarily to prevent unnecessary condemnation and destruction of edible foodstuffs by inexperienced medical and mess personnel. In addition, 20 enlisted men from a veterinary evacuation hospital were given a 1-week course in canned food inspection.

During February and March 1944, enlisted personnel of the Veterinary Section at Milne Bay were taught how to inspect canned products and how to inspect containers to determine if they would withstand climatic conditions of the advanced areas.[34] At another base in the Pacific a school was initiated to instruct the veterinary personnel in food, dairy, and egg inspection.[35]

In New South Wales the Veterinary Section of the Procurement Division conducted a school of instruction on the inspection of foodstuffs.[36] Subjects included inspection procedures to determine wholesomeness and soundness or spoilage of subsistence stores, and the technical aspects of food analysis. In addition, the methods of cutting, boning, curing, processing, manufacturing, grading, classifying, packaging, and storing of foodstuffs were demonstrated. Since the majority of personnel coming on duty with the veterinary section in 1944 were inexperienced in procurement inspection duties the courses mentioned were continued and made mandatory.

In the European theater the Ninth Air Force had a hygiene and sanitation team consisting of a medical officer experienced in epidemiology, hygiene, and preventive medicine; a veterinary officer responsible for food inspection; and a sanitary engineer. Its duties were concerned with food in respect to supply, handling, storage, and preparation; disease control; transportation and storage of water; messes and all mess equipment; and waste disposal. Similar teams were set up in each of the six commands of the Air Force.[37]

In the Eighth Air Force each veterinary officer was assigned 15 to 20 stations. It was impossible for an officer to be present for the inspection of every shipment of food upon its arrival at each station. To insure, as nearly as possible, that only sound food was finally issued to messes, these officers advised and trained personnel handling subsistence at each base on the procedure and important points to be observed in detecting and reporting food products which might be unsafe for use. Each station was assigned an at-

[33] Hist, Vet Sec Base D SWPA, 30 Sep 44. HD.
[34] Quarterly Rpt, Vet Sec Base A SWPA, 1944-1. HD.
[35] Annual Rpt, Vet Sec Base Sec 1 USASOS, 1943. HD.
[36] Quarterly Rpts, Vet Br Procmt Div, Base Sec USASOS, 1944-1, 1944-2. HD.
[37] See footnote 15, p. 9.

tending veterinarian who not only made periodic visits to inspect, assist, and advise personnel in the inspection, storage, and handling of food, but also made himself available for any emergency inspection which was necessary. Lectures were delivered on various subjects of inspection procedures to each class of medical officers attending the course of instruction at the Central Medical Establishment of the Eighth Air Force.[38]

SPECIAL ENVIRONMENTAL FACTORS

Many problems of mess sanitation were common to all overseas theaters; some, however, had problems which were peculiarly their own. In the China-Burma-India theater the Army had to contend with the age-old bucket system of waste disposal; only a few urban areas had flush toilets. Pit latrines were foreign to native custom and, because of habit and superstition, natives employed as food handlers refused to use them. Heavy rains often caused latrines to overflow, which produced not only a health menace, but also a disagreeable nuisance. Screens were secured but a constant watch was necessary to keep them from being stolen or having holes cut in them by curious natives. Garbage was burned or buried and liquid wastes were run into soakage pits or, in areas such as Karachi, into the desert where they were allowed to evaporate.[39]

Throughout the Orient and the tropics, water was almost universally heavily contaminated since natives defecated wherever and whenever it was convenient. Fresh fruits and vegetables grown from such soil, which additionally was fertilized with human feces, were potential causes of the intestinal diseases and required careful handling in messes. They were to be considered entirely safe only when cooked. Additionally, in some areas high humidity or high dry temperatures hastened food spoilage. In moist areas mold and fungi grew readily and rapidly on some types of food. In general the price of health was constant vigilance in relation to food and more especially in mess sanitation.

In the Mediterranean theater civilian mess attendants were widely used. They were good cooks but were often lax in sanitation. It was common to see them wiping their faces and kitchen utensils on their aprons, rearranging food on plates with their fingers, wiping drops of water from plates with the apron or a much-used cloth, reusing tumblers without washing them, swatting flies with a butcher knife or spatula. The practice of mess sanitation, nevertheless, came to be reasonably well observed in this theater.[40]

The Persian Gulf Command presented sanitary problems to the American forces because of the lack of sanitary sewage systems and inadequate public

[38] Annual Rpt, 8th AF, 1944. TAS.

[39] Van Auken, H. A.: A history of preventive medicine in the United States Army Forces of the India-Burma theater, 1943 to 1945. HD: 314.7-2.

[40] See footnote 21, p. 12.

health supervision of eating establishments. Although local restaurants were declared off limits, soldiers were curious about native customs and did patronize them. Water for cooking, dishwashing, and drinking came from the Karun River which also served as a public bathing place, laundry, latrine, and sewage system for all the villages along its course. In order to maintain even minimal sanitary standards it was necessary to provide potable water from highly contaminated sources, dispose of wastes under difficult circumstances, and train natives in the rudiments of sanitation.[41]

TROOP MOVEMENT—MESS SANITATION

While the serving of troops in transit differed somewhat from that of more static troops in methods and details, fundamentally the same policies and procedures were followed. The maintenance of proper sanitation and waste disposal was more difficult. Potable water supplies, toilet facilities, ventilation, and sleeping accommodations were not always satisfactory nor adequate even in the Zone of Interior and in overseas theaters were far less so. Overcrowding of ships and trains increased all of the problems and proper mess management required concentrated effort.

In the United States troop trains carried regulation kitchen cars equipped with coal stoves, sinks, and showers. Meals were served in passenger and dining cars and usually paper plates and cups were used.

With the shipment of large numbers of troops to overseas theaters it was inevitable that transports should be overcrowded. This put a heavy burden on messing facilities and required mess personnel to be on duty for long periods of time. Latrine and bathing facilities were inadequate to serve the increased numbers. Hot water could not be furnished in sufficient quantities for dishwashing and bathing. Storage and refrigeration space were overburdened and consequent breakdown in prescribed sanitation occurred.

This overcrowding, censured by the Medical Department, resulted in several outbreaks of diarrheal diseases aboard transports en route to the European theater in the fall of 1943. These epidemics led to corrections at ports of embarkation and out of 378 troop movements from 1 January to 10 June 1944 there were only eight outbreaks of diarrheal diseases.[42]

The surgeon of a ship carrying troops to the Pacific stated that ventilation was good everywhere except on the lower decks during hot weather, and as far as possible troops were allowed to sleep on open decks while in the tropics. Food supplies were adequate, of good quality, and palatable, although served under difficulties and lacking variety. There was plenty of fresh water for drinking but only salt water for washing and bathing. Dishwashing facilities were not adequate but were improved before the voyage ended. Meat was

[41] McNaughton, L. M.: Persian Gulf Command: Preventive Medicine. HD: 314.7-2.
[42] See footnote 15, p. 9.

properly handled and of good quality, dehydrated milk was mixed only when needed and served with little delay, vegetables were well processed and of good quality, food storerooms were maintained in excellent condition, and chill- and freeze-rooms were kept at the correct temperatures. It was noted that almost seven times as many persons were served as facilities had been intended for. Health was generally good but even under the conditions just described and the precautions taken, there was one explosive outbreak of diarrhea.[43]

Food for ships was consistently of good quality due to planned supply by the Quartermaster Corps and careful inspections of food by port veterinarians when ships were being loaded. The causes of outbreaks on ships seem to have been, for the most part, unsanitary conditions resulting largely from gross overburdening of mess facilities and personnel and the necessity for almost continuous feeding without ample opportunity for cleaning mess utensils and equipment, or often for the proper preparation of food.

Travel within the India-Burma theater presented great difficulties to the Medical Department. The theater had hardly opened before reports [44] were received from units making rail trips in India that a large percentage of the troops were being infected with malaria and dysentery en route. Third-class coaches, which were the type usually provided, consisted of only a single large compartment with benches along the walls or down the center of the car. The trains had no air-cooling systems. Kitchens—when available—were dirty, full of flies, and unscreened. Latrines were bucket type and furnished breeding places for flies. There was little hot water and messgear could not be properly washed. Water furnished by the railways in these coaches could not be safely used because of almost universal contamination.

There was no opportunity to control drinking water or food sold by local vendors at train stops. In spite of orders to the contrary, troops bought this food because messing facilities were not always provided and rations were sometimes insufficient.

At first, at least 25 percent of the men were infected with malaria or dysentery during a journey. Specific measures were taken from time to time, particularly for the prevention of malaria, but it was over a year before planned supervision of all health factors was accomplished and the incidence of food-borne diseases materially reduced. The situation had improved before the first large group of troops arrived. When these 4,000 troops traveled across the country with only 27 cases of minor disorders it was apparent that measures taken had been successful.

SPREAD OF DISEASE

The Army considered that the prevalence of gastrointestinal diseases in a command reflected its sanitation. Maneuvers provided an excellent test

[43] Ltr, Trans Surg USAT A F1650 to CG Base Sec 7, sub: Surgeon's report of voyage. HD: 721 (Transports) SWPA.
[44] See footnote 39, p. 22.

of the effectiveness of previous training in sanitation. Serious outbreaks of bacillary dysentery did occur in units on maneuvers in this country. These outbreaks usually subsided as soon as proper attention was given ordinary measures of mess and latrine sanitation.[45]

Continuing efforts by the Medical Department to prescribe proper mess management methods, and by the command to enforce them, resulted in a very satisfactory rate of control of the diarrheas and dysenteries in the Zone of Interior during the last years of the war. Hospital admission rates for these diseases in 1944 and 1945 compared favorably with those of the peacetime Army.

There is no way to estimate the number of mild outbreaks of food poisoning and diarrhea which certainly did occur, but which were not severe enough to warrant hospitalization. These outbreaks were sporadic, usually confined to small groups, and due to local deficiencies in environmental or food management measures. It is not known whether they were sufficiently widespread to affect the efficiency and morale of our troops.

The diarrheal diseases presented a serious and continuing problem to Army Forces overseas. The best control in a combat area was effected in the European theater where hospital admission rates were held nearly at the level of those of the Zone of Interior. The importance of the unreported outbreaks due to local mess deficiencies cannot be estimated. The chief of preventive medicine for the theater concluded that control had been satisfactorily maintained, and that intestinal diseases had played a relatively inconsequential part in relation to the general disease rates for the theater.[46] Data based on sample tabulations of individual medical records show that in the European theater, diarrhea and dysenteries comprised 5 percent of all admissions due to disease.

The potentially explosive character of diarrheal diseases was illustrated by the 1943 epidemic in North Africa, when the annual admission rate reported from the theater rose sharply from 66 per 1,000 men in April to a high of 410 per 1,000 in June. Such sharp epidemics were usually confined to smaller areas, but certain theaters had very marked seasonal variations. Fortunately the diarrheal diseases required relatively short periods of treatment; 1944 figures show an average of 9 days per admission for diarrhea and dysentery and 19 days per admission for all disease.

SUMMARY

Although many problems confronted the Medical Department in connection with the feeding of millions of men stationed in all parts of the world, nevertheless, for the most part, the problems were met and solved. The objective of well-balanced, palatable meals properly served was successfuly accomplished.

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[45] ASF Monthly Progress Rpt, Sec 7, Health of the Army, 31 Aug 43. HD: 720.
[46] See footnote 15, p. 9.

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The Medical Department was responsible for seeing that food was protected from contamination, after issuance by the Quartermaster Corps. This involved inspection for proper maintenance of environmental sanitation around messhalls and kitchens, for proper storage of food both before and after preparation, and investigation of any outbreaks of gastrointestinal disease or food poisoning. The Medical Department was also responsible for preparation and service of food in hospitals. To accomplish this, principles and policies of preventive medicine were published and personnel were trained in carrying them out.

A comparison of mess operation in World War II with that of World War I shows that great improvement had been achieved in most phases of mess sanitation and food service. Facilities for all operations were usually adequate except in isolated instances, housing for messes was better, kitchens were more adequately equipped, training of mess personnel received greater and more detailed attention, more and better laboratories were established, the ration was given careful study and development, and mess management, sanitation, and inspection were stressed.

The accomplishment of these improvements reflects not only the implementing of the policies of the Medical Department and its Preventive Medicine Service, but also the cooperation of the Medical Department with the Quartermaster Corps, the Army Transportation Corps, and the Corps of Engineers in the procurement and transport of food and proper housing for messhalls and kitchens, as well as adequate storage space in depots, dumps, and at the site of messes.

CHAPTER II

Housing

Colonel Tom F. Whayne, MC, USA

Housing for troops—whether permanent post barracks, temporary cantonment buildings, or tents—must provide shelter, comfort, and the facilities necessary for the maintenance of health. The features of housing which influence health most importantly are ventilation, space, heating, lighting, screening, plumbing, and the means available for the destruction of the arthropod vectors of disease.

Diseases transmitted by contact, through the air, and by insects are those most likely to be influenced in their spread by housing or housing facilities. Screening, the use of DDT as a residual spray on the walls and ceilings of buildings or tents, and the individual use of insect repellents have greatly reduced the hazard of the insect-borne diseases. Contact diseases, especially scabies, are intimately related to the degree of crowding, and can be relatively easily controlled if crowding is prohibited, laundering and dry cleaning of bedclothes are frequently and efficiently done, and if cases are identified and treated as early as possible. A more difficult problem arises in the influence of housing on the spread of respiratory diseases. Ventilation, crowding, and heating are all important factors, of which crowding, that is, the opportunity for close contact between persons, probably is the most important.

In the World War I mobilization period when measles, mumps, pneumonia, and later influenza were highly prevalent, great emphasis was placed upon the importance of adequate floor space and cubic footage of air per occupant as a fundamental control measure.[1] General population experience and herd immunity to some of the diseases of the respiratory group, together with improved diagnostic methods and therapeutic agents, have greatly reduced group susceptibility and loss of time which was heretofore expected from these diseases. The streptococcal diseases, influenza, pneumonia (both of virus and bacterial origin), and the ill-defined group of upper respiratory diseases probably of undetermined virus origin have continued as important sources of temporary disability and loss of time, especially in unseasoned troops. Close contact in overcrowded housing facilities is undoubtedly a factor in their spread.

The strict space requirements which became part of Army regulations following World War I, while desirable, required some reevaluation under such circumstances of rapid mobilization as existed in World War II. It is necessary for the Armed Forces to make the most economical, efficient, and healthful use of the limited housing facilities available during mobilization and training

[1] The Medical Department of the United States Army in the World War. Washington, Government Printing Office, 1926, vol. VI, pp. 129-172.

periods. At best, this is a compromise between the urgent need to furnish housing accommodations for the rapid influx of personnel and the provision of the most healthful living surroundings possible. Rapid turnover, movement, and shipment of organizations to active theaters make it uneconomical to provide optimum housing for the total mobilized military population in the Zone of Interior. The bringing together of unseasoned recruits, a great number of whom have not built up sufficient immunity to many of the communicable diseases, especially the respiratory and streptococcal diseases, makes this the most important phase for the application of all protective health measures. A balance between these objectives must be found so that the maximum number of troops may be temporarily housed in facilities which will not require an exorbitant outlay, but which will not result in a cost in health that would interfere with the military effort.

Military cantonments house military communities surrounded by civilian communities. For the protection of health, they must be planned with the view to dislocating or overtaxing civilian facilities as little as possible. It is particularly important that water supplies, sewage disposal, and malaria control be planned and executed with full knowledge and cooperation of civil authorities in order that water demands do not create unnecessary shortages, safe sewage disposal is accomplished, preventable nuisances are abated, and extra-cantonment disease control is effected without uneconomical duplication of effort.

Additional problems arise when civilian buildings such as hotels or schools are converted to emergency housing for military use. Maximum use of space for soldiers in such buildings often results in a number of residents in excess of the normal civilian occupancy. This places great demands and often overloads on water supplies and sewerage as well as messing facilities, and greatly increases the probability of gastrointestinal disease. Cross connections between water supplies and sewerage, which may not have been a hazard under normal occupancy, immediately become potential dangers to health. Further study and research are required on methods for air sterilization and the disinfection of airborne dust, droplets, and droplet nuclei.

HOUSING IN WORLD WAR I [2]

Housing for United States military personnel on permanent posts and stations prior to and at the beginning of World War I was satisfactory for the small Army then in being. Mobilization for the war brought with it the urgent demand for temporary housing facilities at a time when even the size of the company and regiment for the American Expeditionary Forces had not been determined. Provision of temporary buildings for cantonments and tentage for camps was a Quartermaster responsibility. Significantly, there was no medical member on the Council of National Defense Subcommittee on

[2] See footnote 1, p. 27.

Construction or in any of the divisions within the Office of The Quartermaster General which had to do with this responsibility. Type of construction was based on the barracks plans of The Quartermaster General for 1911 which had been developed for "temporary buildings for mobilization camps." Specifications were revised in 1916. These plans provided for rough, one-story buildings, 20 feet wide, differing in length, and with capacities for between 37 and 97 men. Sliding windows, 34 inches by 37 inches, spaced 7 feet apart provided the only ventilation. The plans called for cots to be arranged along the longitudinal axis of the building in such a way as to provide 27 square feet and 291 cubic feet of space per man. These plans were approved by the Secretary of War in March 1917 without Medical Department consultation concerning the sanitation and health features involved.

Pilot barracks, however, were constructed at Fort Myer, Virginia, and The Surgeon General was invited to inspect them and to make recommendations concerning their acceptability. On 3 May 1917 The Surgeon General officially advised the Chief of Staff against the construction of large buildings for many men because of the hazard of the respiratory diseases. For the type of buildings on exhibit at Fort Myer, he recommended full-length ridge ventilation, air inlets at windows with deflecting panels, higher side walls, and screening of ventilators and windows. Recommended space requirements per individual were 60 square feet and 600 cubic feet.

The immediate need for housing motivated The Quartermaster General to construct two-story barracks with roof ventilation on the second floor, and three shafts for ventilation of the lower floor. Space in these buildings provided 360 to 374 cubic feet of air space per man, and the type of construction was temporarily approved by The Surgeon General after considering the limitations on appropriations and the urgency of the situation.

Because of crowding in all types of housing accommodations, however, The Surgeon General recommended to the Secretary of War that a board of highly qualified medical experts be appointed to examine plans and to submit recommendations. The board was activated on 14 June 1917 and consisted of Surgeon General William C. Gorgas, Dr. William H. Welch, Dr. Franklin Martin, and Dr. Victor C. Vaughan. The consensus of the board's findings was that overcrowding existed to the danger point, that is, men were too close together, there were too many men per dormitory, and the floor space and cubic footage of air per man (338) were inadequate. They cited previous experiences in the Panama Canal Zone and in South Africa with "septic pneumonia," which had resulted from overcrowding and noted that the space for the American soldier was lower than that provided in any prison in the United States, lower than that permitted by law for the barest of lodging houses, and was below tenement house standards enforced 20 to 50 years before. It was further noted that British and French Army standards required 500 cubic

feet of air space per man, and that the British limited barracks occupancy to 30 men. Danger from meningitis was particularly pointed out and the report condemned double bunking, the use of lockers for clothing, and the inadequate bathing facilities.

As a result of the board's report, The Quartermaster General was instructed by the Secretary of War in June 1917 to carry into effect, where possible, the specifications recommended by the board in construction not already begun. The Quartermaster complied in principle, but construction was far advanced on many of the old types of building, with the result that there was little tangible improvement in the situation. In addition, the rapid filling of the draft in September 1917 overloaded camps, and was cause for many adverse housing reports by camp sanitary inspectors. On the basis of these reports, The Surgeon General drew up minimum space requirements and officially recommended to The Adjutant General that the War Department adopt them. War Department directives to subordinate echelons followed, but despite this action there was severe overcrowding throughout the winter 1917–18. In fact, the history of housing for World War I notes that overcrowding continued to exist until the armistice, and even after it.

Housing at flying fields was somewhat better in design but the space allotted to individuals nevertheless was only 42 square feet and 404 cubic feet per man.

Thus it is to be noted that at no time during World War I was housing in the temporary cantonment-type buildings entirely satisfactory from the health point of view.

In tented camps the pyramidal tent was the principal shelter facility. This tent measured 16 feet by 16 feet, had 2,775 cubic feet of air space, and with 8 men provided 32 square feet and 348 cubic feet per man. With 12 men, there were only 231 cubic feet per man. Because of the emergency and the shortage of shelter, the maximum capacity of 12 men was used in many commands. The undesirability of this practice was first protested by the commanding officer of the Southeastern Department, and again in August 1917 by The Surgeon General. As a result, in September 1917, War Department orders directed not more than 8 men be assigned to each tent.

In the winter of 1917–18, there was a severe epidemic of measles complicated by pneumonia. In December The Surgeon General inspected camps to determine factors influencing the extent of the outbreak, and cited overcrowding as one of the major factors. A great many camps were inspected and numerous reports on the conditions found were submitted to the Chief of Staff by The Surgeon General. As a result, and as an emergency measure, tent occupation was restricted to 5 men by order. Later, in June 1918, the Secretary of War directed that the capacity of the pyramidal tent would be 6 men in the summer when there was no sickness, but that in temporary emergency situations 8 men might be housed per tent. Occupancy was limited to 5

men in the winter or when sickness prevailed in the camps. It was, however, many months before these scales of accommodation could be met in the tented camps.

Ventilation. Many methods of ventilation in the temporary cantonment-type of buildings were developed. They included several styles of ridge vents, hinged windows, and sliding windows with and without deflectors. Because of the unevenness and inadequacies of heating and shortage of bedclothes, it was difficult to enforce proper ventilation practices.

Heating. Heating of temporary buildings in World War I mobilization camps was crude. It was largely developed independently of ventilation and sanitary requirements, and was, on the whole, wasteful of fuel. Stoves, small furnaces, and—in some of the northern cantonments—steam were used. There was no effort to humidify the air. In tents, small stoves were the means of heat and up to the fall of 1917 these were not always available.

Beds and Bedding. Left to their own devices, soldiers in the temporary cantonment buildings were likely to crowd their beds together in groups in one end of the building to allow space for recreation in the other. The Surgeon General condemned this practice and insisted upon spacing of beds to provide the least possible opportunity for close contact, especially while the occupants were sleeping. The practice of double decking to conserve space was common and early in the war was consistently advised against by The Surgeon General. However, his views on the dangers of this practice were ultimately relaxed. Administratively, there were many advanatges in double bunking and while The Surgeon General held to the hazard of overcrowding, he withdrew his objections on condition that each tier of double bunks was limited to two beds, and that a space allowance of 50 square feet and 500 cubic feet per man was available. This change in view apparently resulted from the increasing recognition of the importance of contact as a means of spreading respiratory disease. Wide separation of sleepers was the fundamental point involved and double bunking under these new restrictions accomplished this.

The World War I soldier had no sheets, pillows, or pillowslips, and pajamas were not issued. Bedclothes consisted of white cotton bed sacks filled with straw, and blankets and comforters. During the winter of 1917–18, the supply of blankets and woolen underwear was inadequate in many camps, and facilities for laundering blankets and comforters did not meet the need. Great emphasis was placed upon sunning and airing of bedclothes as a means of partial sterilization.

Barracks Floors. Dressed lumber of inferior grade made up the barracks floors of the cantonment buildings. Wearing to roughness occurred early, and dirt and mud tracked in by the soldiers gave rise to great quantities of dust. Studies at Camp Travis, San Antonio, Texas, by the sanitary inspectors showed the desirability of treating floors with a mixture of crude oil and kerosene. This procedure was indorsed by The Surgeon General, and on 8 January 1918 he officially recommended the use of oil preparations on all barracks floors.

On 22 January 1918 the Secretary of War directed The Quartermaster General to provide the necessary materials for oiling of floors except in hospitals. On hospital floors a mixture of wax and turpentine was tried and found to be too expensive. Satisfactory results, however, came from coating the floors lightly and at infrequent intervals with a light paraffin oil.

The use of oil on barracks floors was well received and toward the end of the war, a special oil was developed by The Quartermaster General and was recommended for adoption by The Surgeon General on 16 December 1919.

Bath and Toilet Facilities. Bath and toilet facilities in the temporary cantonment buildings, while not elaborate, were in general satisfactory and were cause for little adverse comment or criticism on the part of The Surgeon General.

Messing Facilities. In the buildings constructed early in the war, messing facilities were installed on the lower floor of each building. Later, detached buildings for messing were provided. The history of the period records that in general there was too little kitchen and storage space, poor facilities for cleansing messkits and utensils, an inadequate number of grease traps, and that poor sanitary conditions prevailed.

Shelter in the American Expeditionary Forces in Europe

Tents, temporary barracks, and billets made up the shelter available to the American soldier in Europe in World War I. Construction of temporary barracks for one-third of the strength of the American Expeditionary Forces was planned. The types of barracks selected were demountable, 20 feet by 100 feet buildings, known during the period as "Adrian" and "Bryant" types. Contracts for 23,000 units were let to French, British, and Swiss contractors. Fifteen thousand of these, including 4,500 hospital barracks, were delivered during the war. Delivery was slow, however, until August 1918. Before that time, there had been much temporary construction from lumber supplied by forestry troops. Sizes of buildings varied between 20 feet by 100 feet and 20 feet by 120 feet. Some were entirely of wood; others were of wood with corrugated iron roofs, while still others were covered with tar paper. Construction was mostly for rest camps, replacement and supply depots, divisional areas, training schools, and prisoner of war camps. As used for a large part of the war only 20 square feet of space per man were provided. The surgeon of the American Expeditionary Forces made repeated efforts to have this flagrant overcrowding reduced but it was only on 21 November 1918 that the space per man was raised to 40 square feet. It was the opinion of the surgeon's office that this action resulted in a definite improvement in the disease rates for the Expeditionary forces so housed.

By agreement with the French authorities, Americans were permitted to billet in civilian homes and buildings in accord with French law. However, few

soldiers were billeted with families but instead used empty buildings, stables, and barns. For the most part, sanitation in and around these buildings was poor and improvement was difficult because of dual military and civilian control, and differences in concepts of sanitation.

Because of inadequate heating and protection from the cold, ventilation in the crowded buildings was difficult and could be accomplished only by regular nightly inspections by officers with authority to direct proper procedures.

Heating. There were too few stoves for adequate distribution. The stoves were of different types, many being the very small European variety, others large and bulky. In general, it was eventually found that the American-developed Sibley stove gave the best results. Limits on the issue of coal were necessary for both heating and cooking.

Drying Rooms. Facilities for drying wet clothing of soldiers came to be a recognized requirement. A general order in January 1918 directed that special drying rooms would be provided. This became the responsibility of local commanders and resulted in a great variety of expedients to accomplish the purpose. Drying rooms were especially related to the prevention of trenchfoot by drying of socks and other garments.

Beds and Bedding. Wooden bunks and cots were most in evidence. Double decking was commonly practiced. The standard device was a wooden bedstead, double-decked, to accommodate 2 men on the lower tier and 2 on the upper. Mattresses were of straw and hay, the used hay eventually being fed to draft animals. The blanket supply was often inadequate.

Shelter During Active Operations. Trench shelter was influenced by the type of small arms and artillery missiles in use. With the development of high trajectory missiles, trench mortars, hand bombs, and grenades, as well as the constantly increasing use of heavy artillery barrages, shelters had to be dug deeper and deeper into the ground. Caves and deep dugouts, sealed for gas protection, were most commonly used along the trenches. Water drainage and waste disposal were a problem. In most, ventilation was through the entrance alone, although in some of the more elaborate, vents or air shafts were provided. Stoves within the dugouts aided in the circulation of air.

In the type of warfare largely engaged in by the American forces, existing trenches and dugouts were used when available. Otherwise, shelter was completely improvised and often was no more than the shallow foxhole.

American troops operating in Siberia were housed in barracks. These buildings were found to be grossly contaminated by human excreta and infested with vermin. There was no sewerage, no running water, no light, and, in fact, there was no evidence of any environmental sanitation. Much energy had to be expended in improving the condition of these barracks to make them at all habitable according to American standards.

In North Russia, railway cars were provided and there was some construction of barracks. Some men were billeted in native houses, which, while universally vermin-infested, were well built of logs and well heated.

HOUSING IN THE UNITED STATES ARMY BETWEEN WORLD WARS I AND II

Rapid demobilization and the predominant public sentiment that a long era of peace and prosperity was in prospect gave little stimulus to the study and development of housing following World War I. Later, in the economic depression, economy was the watchword of the Congress, the Army was small and was largely installed in permanent posts and stations except during small-scale, small-unit summer maneuvers.

Many of the old World War I type of temporary buildings were continued in use at these posts and stations for a variety of purposes. Some were used for storage, others converted to temporary noncommissioned officers' quarters, while the majority were used for housing and classrooms for Citizens' Military Training Camps, Reserve Officers' Training Corps, and Officers' Reserve Corps during summer training periods. Others became training facilities for National Guard units, and at a later period still others were used for storage of equipment and housing of personnel for the Civilian Conservation Corps. Since these buildings were in use only during the summer, their deficiencies in relation to health were not sufficiently important to stimulate development of new and improved types of buildings for temporary housing of troops. Permanent buildings for the small number of soldiers of the Regular Army on the other hand were constructed where needed and in many cases were excellent in design, utility, and health-protective features.

Medical Department evaluation of housing in relation to respiratory disease incidence in World War I resulted in the establishment of liberal housing standards. Space requirements per man as written into Army Regulations (AR 40–205) after the war provided a minimum of 60 square feet and 720 cubic feet of space per man, exclusive of space utilized for wall lockers, foot lockers, furniture, and fixtures. A reduction to 50 square feet per individual was permitted during emergencies. The principle was established that squad rooms should be small and should not contain more than 30 beds.

HOUSING IN WORLD WAR II

Policy in the Zone of Interior

Responsibility for Housing

Mobilization for World War II found the United States Army without coordinated plans and blueprints for efficient and healthful housing to accommodate the great influx of personnel necessary for rapid war mobilization.

A vast construction program had to be planned and put into action to provide housing accommodations.

During World War I and between the World Wars, the Quartermaster General's Office was responsible for the provision of shelter and housing. Division of construction responsibility did not make for efficiency, and accordingly Public Law 326 of the 77th Congress, approved 1 December 1941, made provision for the construction activities of the Army to come under the guidance of the Corps of Engineers. In consequence the Secretary of War directed the transfer of construction, real estate, and repair and utilities activities from the Quartermaster Corps to the Corps of Engineers effective 16 December 1941.[3] For practical construction considerations and efficiency in the development of the housing program, this undoubtedly was well-advised. Medically speaking, however, it did have an influence in that Medical Department-Quartermaster Corps staff relations, while not always harmonious, had resulted in consideration of housing in relation to health and to some of the practical limitations associated therewith. The Corps of Engineers, on the other hand, cognizant of its new responsibilities and without the background of close Medical Department association at first failed to appreciate housing as an important factor in the maintenance of the health of troops.

The Under Secretary of War on 9 December 1941 directed the Chief of Engineers that all War Department construction projects then under way or authorized, except those specifically excluded from the urgent category, would be completed with the utmost dispatch. The Chief of Engineers was further directed to expedite completion of such projects or the critical portions of them by every feasible means including multiple shifts and overtime operations. The additional funds to accomplish these objectives were to be made available when necessary.[4]

Emphasis, from highest authority downward, was upon immediate action to meet immediate needs. As was the case in World War I, recommendations of the Medical Department were not sought as to the features of housing related to health protection.

Wartime Construction

The need for rapid economical expansion of housing for the accommodation of troops was urgent. In May 1942 the Commanding General, Services of Supply, advised the commanding generals of all corps areas that a rapid buildup of troops with the formation of a large number of units at many posts was necessary between June and September, and directed that every effort must be made to utilize all available housing to its fullest capacity.[5]

As an outgrowth of an agreement between the War and Navy Departments and the War Production Board in May 1942, the Secretary of War published

[3] Ltr, QMG to all QMs, 4 Dec 41, sub: Transfer of construction activities from the Quartermaster Corps to the Corps of Engineers. SG: 600.12-1.

[4] Memo, Robert P. Patterson, Under SecWar, for CofEngrs, 9 Dec 41, sub: Expediting construction projects. SG:600.12-1.

[5] Ltr, CG SOS to CGs all CAs, 28 May 42, sub: Troop housing. HD: 621 Housing.

a "Directive for War-Time Construction" [6] for general distribution to commands and chiefs of services. The agreement outlined the principles governing wartime construction and directed that consumption of materials and equipment by construction activities not be allowed to impede the production of combat supplies and equipment. All construction had to be reduced to the absolute minimum necessary for the war effort. Each project had to be passed upon by an agency of the Federal Government and could not be approved for construction unless it met the following criteria:

1. It is essential for the war effort.
2. Postponement of construction would be detrimental to the war effort.
3. It is not practicable to rent or convert existing facilities for the purpose.
4. The construction will not result in duplication or unnecessary expansion of existing plants or facilities now under construction or about to be constructed.
5. All possible economies have been made in the project, resulting in deletion of all nonessential items and parts.
6. The structure of the project has been designed of the simplest type, just sufficient to meet the minimum requirements.

Before a project could be authorized, it had to be ascertained that sufficient labor and materials were available for building and that public utilities and transportation were adequate to serve the project. All construction was to be of the cheapest temporary character, with structural stability only sufficient to meet the needs for which intended during the period of war use. (See Fig. 4.)

The guiding principles were to utilize those materials which were most plentiful, to reduce mechanical and electrical features to bare essentials, and to install electrical systems of the simplest design. Certain critical items were prohibited for use in construction, whether in war plants or for housing.

Space and the Problems of Overcrowding

In consequence of the emphasis on conservation of materials and economy in construction, it was only to be expected that the space requirements per man in temporary buildings should have been reexamined and reduction in allowances considered. Despite the firm policy on overcrowding as directed by AR 40–205, failure to comply with its requirements was apparent as early as 1939. Plans for a hospital barracks building for an Air Corps station at Fairbanks, Alaska, provided a building of such design that many beds would have been placed on interior rows far away from light and ventilation. The Surgeon General called attention to the danger of spreading respiratory diseases and disapproved construction of buildings which would accommodate more than two rows of bunks per squad room.[7] Schematic drawings for dispensaries and barracks in the Panama Canal Zone showed the same defects. This was protested by The Surgeon General in a letter to The Adjutant General on 6 No-

[6] Ltr, TAG to CG AAF, CGs all Depts and CAs, CofEngrs, CofOrd, QMG, Chief Signal Off, Chief of CWS, SG, and COs Exempted Stas, 1 Jun 42, sub: Directive for war-time construction. SG: 600.12-1.

[7] Ltr, SG to QMG, 6 Nov 39. HD: 621 Housing.

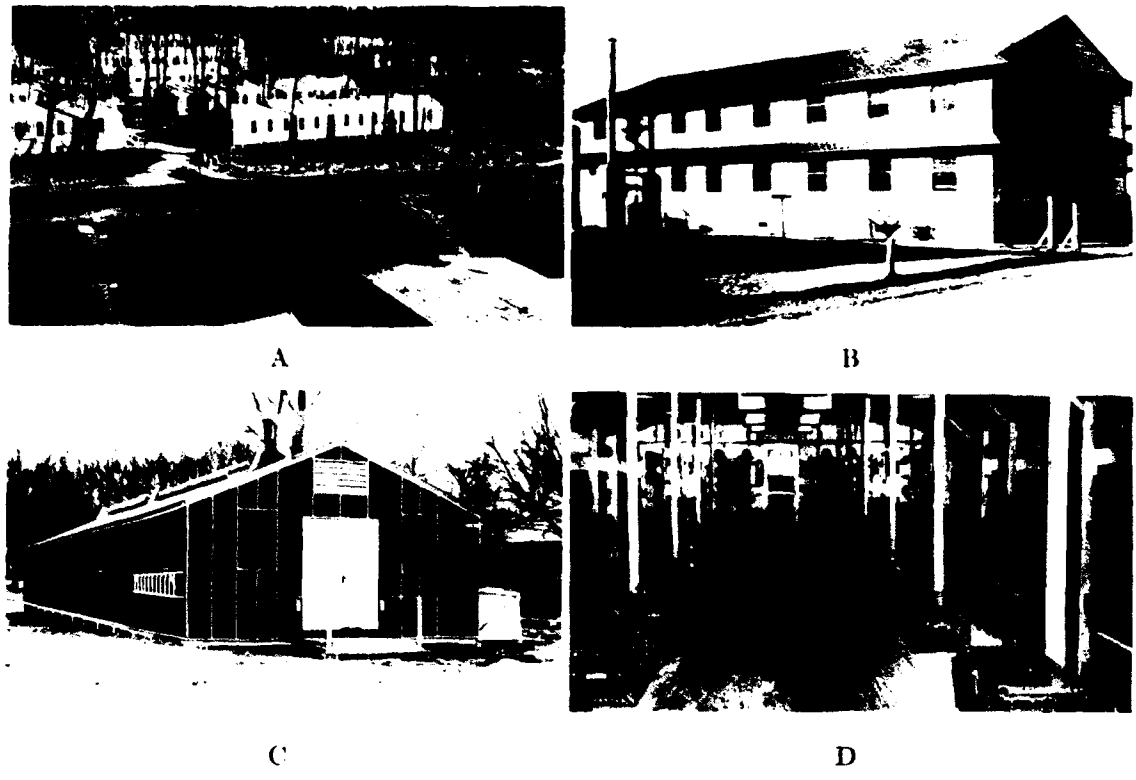


Figure 4. A. Cantonment area, Camp Shanks, N. Y. B. Two-story barracks, Fort Sam Houston, Tex. C. Exterior of typical barracks, Fort Benjamin Harrison, Ind. D. Interior of cantonment barracks, Camp Barkeley, Tex.

vember 1939, in which he insisted upon desirable health features and pointed out that, "the health, welfare, and morale of enlisted men is of greater importance than the small economies that may be effected by unsatisfactory or inadequate housing." [8]

The Surgeon General's recommendations were disapproved on 9 December 1939,[9] and in February 1940 he summarized regulations, policies, and accepted procedures in relation to housing as concerned both The Quartermaster General and The Surgeon General. He cited the World War I experience, and previous experience in the Panama Canal Zone, and recommended that all preliminary floor plans for barracks buildings be submitted to his Office for comment in regard to sanitary features. Further, a change in AR 40–205 was recommended which would establish the latter action as a requirement. The Quartermaster General protested that change in design of barracks and study of preliminary plans by The Surgeon General would be impractical. On 22 May 1940 the Secretary of War ruled against the recommendations of The

[8] Ltr, SG to TAG, 6 Nov 39, sub: Adequate ventilation for barrack buildings in Panama. HD: 621 Housing.

[9] Ltr, TAG to SG, 19 Dec 39, sub: Squad rooms in barracks, with 1st ind, SG to TAG, 26 Feb 40; 3d ind, QMG to TAG, 10 Apr 40; 4th ind, TAG to SG, 22 May 40. HD: 621 Housing.

Surgeon General but encouraged the submission of recommendations concerning the maximum number of men to be housed in the squad room, factors of sanitation, adequate ventilation, and the prevention and control of communicable diseases.

During this period the greatest medical interest continued to center around spacing and the prevention of overcrowding. Comments and sanitary reports received from the field indicated that the housing provisions of AR 40–205 were not being complied with in many cases. One report established that the floor space per bed had been reduced to 32 square feet. In a letter to The Adjutant General dated 25 November 1940, The Surgeon General pointed out the crowding of troops in barracks and recommended the publication of a circular letter to corps area and department commanders directing adherence to AR 40–205 and urging that increased efforts be made to expedite the completion of housing facilities.[10]

The Surgeon General was asked to specify the number of men that could be housed in the prefabricated Nissen hut for winter training. Eight men or a squad were recommended for occupancy of one hut, which gave 72 square feet and 529 cubic feet of space per man.[11]

As an illustration of the type of floor space reduction effected, despite The Surgeon General's objections,[12] barracks space for medical detachments was reduced to emergency space allowances in November 1941.[13]

By January 1942 housing requirements for inductees in training were considerably in excess of available housing as judged by acceptable space allotment per man. War Department Assistant Chief of Staff, G–3, requested the opinion of The Surgeon General as to increasing the capacity of the 63-man barracks to 75 men. To this The Surgeon General reluctantly agreed because of the emergency and because the rates for respiratory diseases were favorable at that time. He pointed out that the increase allowed only 52 square feet per man and should be considered as only a temporary emergency measure.[14] Crowding beyond the emergency limitations was cause of complaint on the part of The Surgeon General when it was reported that 84 men were being housed in 63-man barracks at Scott Field, Illinois. In this case the risk of epidemic disease outbreaks was interpreted as being beyond reasonable limits. Tentage or other housing facilities was recommended in order that the 75-man limitation per barracks should not be exceeded.[15]

Again in April, The Surgeon General supported the housing of troops on the basis of 60 square feet per man with a minimum emergency reduction to 50

[10] Ltr, SG to TAG, 25 Nov 40, sub: Overcrowding of barracks. HD: 621 Housing.

[11] Memo, Col J. R. Hall, MC, for Gen McAfee, 15 Jul 41, sub: Nissen hut. HD: 621 Housing.

[12] 1st ind, SG to TAG, 31 Oct 41, on Ltr, TAG to SG, 25 Oct 41, sub: Capacity of barracks—cantonment type. SG: 621.-1.

[13] Ltr, TAG to QMG, 13 Nov 41, sub: Capacity of barracks—cantonment type. HD: 621 Housing.

[14] Memo, Brig Gen L. B. McAfee, Asst to SG, for Col W. B. Leech, G–3, 7 Jan 42. SG: 621.1-1.

[15] Monthly Sanitary Rpt, Surg Scott Fld, Ill., 1 Apr 42, with 10th ind, SG to CG SOS, 13 May 42. SG: 721.5–1 (Scott Fld) B.

square feet per man and recommended that these standards be adhered to in planning for theater of operations housing. The Chief of Engineers replied that construction of housing in the theater of operations would depend on shipping facilities and local conditions. It was pointed out that Engineer manuals were then under revision and incorporated acceptable space and plumbing facilities for barracks, hospitals, latrines, bathhouses, and lavatories for construction of theater of operations facilities.[16]

Rapid mobilization continued to create emergency housing demands. On 4 July 1942 the Chief of Engineers addressed a memorandum to the Commanding General, Services of Supply, in which he called attention to the constantly increasing critical situation in the construction industry. He stated that the contemplated rapid increase in the military establishment made it advisable to increase the housing capacity of the Army by changes in the space allowances per man, as well as by additional construction. The Chief of Engineers pointed out that current space requirements had been established in peacetime, and were not the minimum which had been employed in past wars. He quoted from an American Expeditionary Forces order of World War I which allotted 20 feet of floor space per man. Reduction of space requirements, he argued, would eliminate the need of much construction for the expanding Army and make that portion of the national effort available for more essential work. He recommended that new construction be authorized on a basis of 50 square feet of floor space and 450 cubic feet of air space per man. Emergency allowance of 40 square feet of floor space and 375 cubic feet of air space was recommended for temporarily increasing capacity.[17]

The Surgeon General vigorously opposed the recommendations of the Chief of Engineers:[18]

> The reduction of the space allowance per man in barracks proposed by the Chief of Engineers violates two important principles: First—that if less than 60 sq. ft. of floor space and 720 cubic ft. of air space are allotted to each man for any period of time, the incidence of infectious disease will greatly increase. Second—that if more than 30 men are housed in one room the rate of spread of infectious disease if introduced into the room will be greatly increased.

The housing requirements as laid down in AR 40–205 for the Zone of Interior and TM 5–280 for theaters of operations, stated The Surgeon General, had been carefully arrived at by scientific observation and experience. He believed that those requirements were essential if high rates for infectious diseases were to be prevented. The quoted World War I emergency allowance had proved inadequate, he reminded them. One of the first orders issued following the armistice had been to double the housing space allotted to troops in France in order that the rates for infectious disease might be decreased. The Surgeon

[16] 1st ind, SG to CG SOS, 4 Apr 42; 2d ind, CofEngrs to Dir Tng SOS, 8 May 42, on Ltr, Surg 2d CA to SG, 24 Mar 42, sub: Inconsistencies in official publications re barrack space and latrine facilities. HD: 621 Housing.

[17] Memo, CofEngrs for CG SOS, 4 Jul 42, sub: Capacity barracks. SG: 621.–1.

[18] 1st ind, SG to CG SOS, 11 Jul 42, on Memo, Dir Reqmts Div SOS for SG, 8 Jul 42. SG: 621.–1.

General continued that if military necessity required theater of operations commanders to reduce the space allotment per man in barracks, they should do so with full knowledge of probable cost in noneffectives due to infectious diseases. He pointed out that the incidence of such diseases during the current mobilization has been practically that of the peacetime Army, and that this had been due in part to proper housing of troops. He urgently recommended that no change be made in housing requirements except where this expedient had to be taken by a field commander to meet a temporary situation.

Again, on 25 August 1942, The Surgeon General called to the attention of the Commanding General, Services of Supply, the dangers of reducing space requirements. He cited optimum, minimum, and emergency floor space and cubic space standards, and warned against the use of double bunking.[19] Nevertheless, on 10 September 1942 the Commanding General, Services of Supply, addressed the several staff agencies as follows:[20]

> The floor space to be provided at all staging areas is announced as 40 square feet for each occupant. Double bunking is authorized to accomplish this allotment of floor space.

On 21 October 1942 the commanding generals of all service commands, all ports of embarkation, the Military District of Washington, all posts, camps, and stations, and the chiefs of the supply services were issued the following instructions:[21]

> 1. In order to conserve critical materials, and to utilize all existing construction to the fullest extent, space allowances for troop housing are reduced to forty (40) square feet per man wherever such action will eliminate or reduce the necessity for additional construction.
>
> 2. The provisions of Army Regulations 40–205, paragraph 19, *a* (1) and other instructions conflicting with this policy of space allowance are temporarily suspended.
>
> 3. It is desired that Service Commanders and/or exempted station commanders initiate a survey without delay to determine to what extent this increased housing capacity can be provided at each post, camp or station under his control. The following criteria are announced in accomplishing this survey:
>
> *a. General*
>
> (1) In assigning facilities, preference should be given to retaining integrity of unit messing, administration and supply of combat tactical units so as not to seriously interrupt their training schedules. It is anticipated that very few additional messes will be required and that most messes will operate at more than one sitting.
>
> (2) The entire capacity of each housing area will be utilized even if this involves the assignment of more than one unit to the area, except that a single barracks will normally not be used to house the men of more than two units.
>
> (3) Careful consideration will be given to the capacity of training aids as affecting the number of troops which can be effectively trained at a station. Joint use of existing training aids and staggered activation of units should be considered. Construction of only a limited amount of additional training aids is anticipated.

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[19] Memo, SG for CG SOS, 25 Aug. 42, sub: Double bunking. SG: 621.-1.

[20] Memo, CG SOS for CofEngrs, Chief of TC, SG, CGs 1st, 2d, 3d, 4th, and 9th SvCs, and QMG, 10 Sep 42, sub: Authorized floor space for staging areas. SG: 621.-1.

[21] Memo, TAG for COs all SvCs, PEs, MDW, COs all Posts, Camps, and Stas, Chiefs of Supply Svs SOS, 21 Oct 42, sub: Reduced space allowances at posts, camps and/or Air Force stations. HD: 621 Housing.

(4) The capacities of the utilities systems at each station will be carefully considered. It is contemplated that strict water and power discipline will be enforced and that little additional water, sewage and power will be required. The Chief of Engineers will render advice to Commanding Generals concerned in this matter.

(5) It is anticipated that no additional hospital facilities will be required in addition to that provided by memorandum for the Chief of Engineers, dated September 19, 1942 file SPRMC 632 (9–9–42), Subject: "Additional Hospitalization," (Copy inclosed). In those few exceptional cases where it is considered essential, commanders concerned will submit requests for additional hospitalization.

(6) No construction of additional recreational and camp administrative and supply facilities is contemplated.

b. Divisional Housing

Plans contemplate that basics will be assigned to all divisions and that each division will have a 5% to 15% overstrength. In view of this overstrength, little excess divisional housing is anticipated to become available for further assignment as a result of this survey. Each divisional area will be thoroughly studied.

c. Non-Divisional Housing

Thorough application of this policy to non-divisional housing at each station is contemplated.

d. Replacement Training Centers and Schools

Due to the peculiar training problems involved reduction in living space for those in training at these installations should be regarded as the exception and should be given careful consideration in each case. Reduction to forty (40) square feet for *trainees, students* and *enlisted instructors* is not contemplated except in emergencies.

e. Reception Centers

Reduction below fifty (50) square feet per man should be considered in these installations only in emergencies.

f. Overseas and Staging Areas

Reduction of space to forty (40) feet will be effected at each such installation.

4. The following table is issued as a guide, indicating number of men that are presently accommodated in the various types of barracks and capacities available by application of this policy:

Type	*Lavatory*	*Heat*	*Present 60 S. F.*	*50 S. F.*	*40 S. F.*	*Plan*
TROOP BARRACKS						
Barrack	Yes	Furnace	63 Men	77 Men	94 Men	700–1165
Barrack	Yes	Space Heaters	63 Men	76 Men	93 Men	700–1165 M
Barrack	Yes	Space Heaters	74 Men	88 Men	109 Men	700–1165 M
Barrack	Yes	Furnace	45 Men	54 Men	65 Men	700–1175
Barrack	Yes	Furnace	45 Men	60 Men	75 Men	700–1175 M
Barrack	No	Furnace	63 Men	78 Men	95 Men	700–1185
Barrack	No	Space Heaters	63 Men	80 Men	97 Men	700–1185 M
BKS–63	Yes	Furnace	63 Men	72 Men	91 Men	800–443
BKS–74	Yes	Furnace	74 Men	84 Men	105 Men	800–443
B–A–T	No	Space Heaters	34 Men	40 Men	50 Men	T. O. 700-5500
HOSPITAL BARRACKS						
HB–63	Yes	Central Heat	63 Men	76 Men	93 Men	700–1204
HB–18	Yes	Central Heat	18 Men	20 Men	26 Men	700–1203
HB–36	Yes	Central Heat	36 Men	43 Men	55 Men	700–1203
HMDB–65	Yes	Central Heat	65 Men	87 Men	114 Men	800–2270
HMDB–133	Yes	Central Heat	133 Men	180 Men	236 Men	800–1917
B–A–T	No	Space Heaters	34 Men	40 Men	50 Men	T. O. 700–5500

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HUTMENTS AND TENTS

Normal	*New Capacity*	*Temporary Emergency Capacity*
5 Men	6 Men	8 Men
15 Men	18 Men	22 Men

By reference to the probably greater susceptibility of recruits to the infectious diseases, the directive recognized the peculiar training problems at replacement training centers and schools and at reception centers where reduction of space per man below 50 square feet was to be considered only in emergencies. This was later interpreted also to include induction centers.[22]

Reduction of temporary cantonment barracks space to 40 square feet per man was an arbitrary command decision made as a result of urgent necessity against the best advice of military medical authorities. There is nothing in the correspondence contained in Medical Department files to indicate that the position of The Surgeon General was taken into full account in evaluating the risk involved. Certainly The Surgeon General on numerous occasions made clear the possibilities of disease transmission. That The Surgeon General's position may have been overconservative is evidenced by the lack of any major outbreaks of infectious diseases or unduly high rates for the respiratory group of diseases in general in American forces in the Zone of Interior for World War II. Only speculation can be brought to bear upon what might have happened in the face of a pandemic of influenza or other respiratory or infectious diseases, despite group immunity and vastly improved methods of therapeusis.

Dissatisfied with the decision and greatly concerned about the risk involved, The Surgeon General initiated a thoroughgoing field study of housing conditions which was carried out by the Army Epidemiological Board. (See pp. 50–54.)

Space standards for Women's Army Auxiliary Corps personnel were established on the basis of 50 square feet per enrolled woman and 120 square feet per officer. Reduction to 42 square feet per enrolled woman in converted buildings and 45 square feet in new construction was authorized where conditions of well-being permitted and substantial economy resulted.[23] In October 1943 Army Service Forces requested the opinion of The Surgeon General as to increasing space allowance from 50 to 60 or 70 feet per enlisted woman. The Surgeon General replied that there was no medical reason to permit such an action when male soldiers were housed in 50 square feet per man with the minimum of 40 square feet in emergencies.

When the hurried period of construction was over and large forces were deployed into the combat theaters, housing for Zone of Interior forces and training elements more nearly met requirements, and by the latter part of 1944, available space per individual more nearly complied with acceptable standards.

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[22] AR 40-205, C 2, 26 Mar 43.
[23] WD AG Memo W100-9-43, C 1, 3 Jul 43, sub: Housing for WAAC personnel. SG: 620.-1.

By February 1945, consideration was being given to expanding space standards for postwar housing of the Army. A series of correspondence and conferences document the efforts.[24] The Office of the Chief of Engineers proposed a statement of policy which would allow each enlisted man or woman 80 square feet per individual, computed on net squad room space exclusive of stairwells, lavatories, connecting corridors, and utility space, but including open aisles. For planning purposes, the Special Planning Division of the Army Service Forces had recommended that capacity of housing should be determined on the basis of 60 square feet per enlisted man. The Preventive Medicine Division, Office of The Surgeon General, concurred in the recommended statement of policy of the Chief of Engineers, provided the requirement was, "for that portion of the buildings specifically designed for sleeping quarters and no ceiling will be under eight and three-quarters feet high." [25] In April 1946 the Secretary of War directed that a study of existing housing regulations be made and stated that appropriate changes to Army regulations and other publications would be drafted to reflect the proposed administrative policy with respect to the allocation of housing space for troops and members of the Women's Army Corps.[26] Changes in requirements were not made at that time, however.

In March 1946 higher rates for the respiratory diseases motivated The Surgeon General to advise the Chief of Staff that the constant introduction of susceptibles through the high ratio of new recruits to the number of seasoned troops in the Army, together with continued overcrowding of these troops in barracks and other places of assembly constituted a significant health hazard. He recommended that introduction of new recruits in large basic training organizations should be curtailed, especially during the winter and spring seasons, that assignment of new recruits to posts then experiencing high respiratory disease incidence should be discontinued, and that not less than 60 square feet per man in barracks should be provided for basic trainees.[27]

Movement of troops through West Coast ports in the preparation for the assault on Japan was another cause for concern because of the temporary gross overcrowding of housing facilities.[28] Several outbreaks of type B influenza in the spring of 1945 added to the fear that overcrowding might set the stage for an epidemic of great consequence.

Tents

The preventive medicine problems associated with tentage during World War II were not of great significance. There was an interest in special types

[24] SG: 724.9 1945–46.

[25] Memo, Brig Gen S. Bayne-Jones, SGO, for Chief Opns Serv ASF, 19 Feb 45, sub: Space requirements for troop housing. SG: 724.9.

[26] Memo, Actg ACofS G–4 for CG ASF, 30 Apr 46, sub: Space allowances, WAC housing facilities. SG:620.

[27] Ltr, SG to CofS thru CG ASF, 13 Mar 46, sub: Troop training and housing in relation to respiratory diseases. SG: 724.9.

[28] Ltr, SG to CofS thru CG ASF, 25 Jun 45, sub: Avoidance of overcrowding. SG: 724.9.

of tents for protection against the Arctic cold and for the use of mountain troops. Field use of the pup tent was universal and the pyramidal tent with or without frames supplied shelter in the temporary tent camps.

The question of space in the pyramidal tent for the housing of troops during winter months arose in January 1942 when G–3 (Operations and Training Division) of the War Department General Staff requested medical advice. The Surgeon General replied that since the pyramidal tent when placed on the standard wooden frame contains 2,335 cubic feet of air space, if 5 men were housed in the tent, each would have 471 cubic feet of air space; if there were 6 men, the air space would be reduced to 392 cubic feet. Considering the current respiratory rates, the number of men in each housing unit, and the need for housing space for additional troops, it was believed that 6 men could be housed in each framed pyramidal tent until adequate housing space could be provided. The Surgeon General considered that this arrangement should not unduly jeopardize the health of the individuals concerned provided that:

1. Adequate housing space is made available at the earliest possible time.
2. The allotment of 6 men per tent will not be made where the climate is unduly severe or prolonged rainy periods are experienced.
3. Epidemics of virulent respiratory diseases do not occur.

He recommended that plans be made for making additional housing space immediately available in the event that severe respiratory epidemics were encountered.[29]

Space on Ships

The urgency for shipping large numbers of troops overseas in limited transport accommodations made consideration of the danger of disease from overcrowding subordinate. Unusual and unnecessary outbreaks of gastrointestinal and respiratory diseases resulted from overcrowding on transports and are discussed in another volume of this history.

The Preventive Medicine Service recommended on 16 September 1942 that the minimum allowance per man on hospital ships should be 25 square feet of floor space, and not less than 250 cubic feet of air space, exclusive of space occupied by authorized personal baggage or hospital equipment. It was further recommended that not more than two tiers of hammocks, beds, or bunks be permitted:[30]

> Where bunks are used, the lower tier should be raised at least 18″ above the deck, and there should be not less than 3 feet between the two tiers, or the upper tier and the deck above, so as to enable the occupants to sit upright. The bunks should be arranged so as to leave a passageway of at least 30 inches between each other and the sides of the ship in order that handling of patients, cleansing of quarters, ready communication and ventilation may be facilitated. Bunks, if used, should be not less than 6′3″ by 2′ wide.

[29] Memo, SG for Col W. B. Leech, G–3, 14 Jan 42, sub: Housing of troops in tents during winter months. SG: 620.–1.
[30] Memo, Lt Col W. S. Stone, MC, SGO, for Col Cook, Prof Serv SGO, 16 Sep 42, sub: Plans for hospital ships. HD: 621 Housing.

Double-Decked Bunks

While use of double-decked bunks had become a necessity during World War I and, with reservations, had been accepted by medical authorities, the sanitary practice, training doctrine, and policy between the wars specifically prohibited their use. (See paragraph 19, AR 40–205, 15 December 1924.) In the preparation for World War II, the question of double decking first arose in 1940 when a representative of G–4 (the Supply Division) of the War Department General Staff requested the point of view of The Surgeon General on the use of double-decked bunks as a temporary measure to increase the capacity of barracks. The Surgeon General emphatically protested the practice, cited the recommendations of the Medical Board appointed by the Secretary of War in 1917, called attention to the special dangers related to the crowding of recruits by the use of double-decked bunks, and specifically recommended not only that double-decked bunks should not be considered but that in future construction of barracks squad rooms should accommodate not more than approximately 30 men.[31]

In November 1940 The Surgeon General again condemned, somewhat emotionally, the use of double-decked bunks:[32]

> A recent Sanitary Report mentions crowding of barracks until the floor space per bed was reduced to 32 square feet per man. To reach this excessive degree of crowding it was necessary to employ that most dangerous sleeping arrangement—the double deck bunk. This office desires to again record its unequivocable condemnation of this vicious practice. . . . *The double-deck bunk should have no place in our plans for housing men in camps and barracks.* Their use on transports represents a necessary compromise and years of experience have shown that we must pay dearly for even this brief violation of sanitary principles. In the World War we accepted as necessary the high respiratory admission rates that resulted from crowding men on transports for the ocean passage but we cannot condone the exposure of men to such frightful hazards for prolonged training periods.

More dispassionately in an indorsement from The Surgeon General to The Quartermaster General on 13 January 1942:[33]

> This office considers that the use of double deck beds is a violation of modern principles of sanitation and disease prevention. The crowding that usually results from the use of this type of bed greatly increases the possibilities of transmission of respiratory infections and makes it impossible to prevent the rapid dissemination in a barrack of parasitic insects such as lice and bedbugs. This is due not only to the relationship of the beds but also to the fact that lounging is generally practiced by all personnel on the beds of the lower deck.

By the latter part of February 1942 it was recognized that double bunking might have to be accepted in the interest of emergency troop housing. In an indorsement to The Quartermaster General, while maintaining previous objec-

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[31] Ltr, Col J. E. Baylis, Exec Off SGO, to TAG, 6 Aug 40, sub: Comment on the use of double-decker bunks to increase the capacity of barracks. HD: 621 Housing.

[32] See footnote 10, p. 38.

[33] 2d ind, SG to QMG, 13 Jan 42, on Ltr, Louis Hanson Co., Chicago, to WD Standardization Branch, 29 Dec 41. SG: 427.–4.

tions, The Surgeon General noted that the Medical Department's principal objection to the use of double bunks was due to the common practice of utilizing them to reduce the available floor space per man to less than the 50 square feet allowed under emergency conditions only. In the event that the needs for troop housing were such that it was necessary to reduce temporarily the space allotted per man to 50 square feet of floor space and 500 cubic feet of air space, The Surgeon General admitted that it might be advisable under certain conditions to use double-decked beds if they were properly handled. When the distance between side rails of adjacent beds became less than 2 feet, double-decked bunks should be used, but in no instance should the amount of floor space be reduced below 50 square feet per man, or the distance between side rails of adjacent double-decked beds to less than 5 feet.[34] (See Fig. 4.)

On direction of the Commanding General, Services of Supply, The Surgeon General in August of 1942 made a thorough study of space requirements for barracks in the Zone of Interior, summarized the epidemiologic and sanitary evidence against overcrowding (including the use of double bunks), pointed out the possibility of an influenza epidemic, and recommended strict adherence to the space requirements then provided by AR 40–205.[35] Reduction of space to 40 square feet per occupant and authority for double bunking was announced on 10 September 1942 by Services of Supply.[36] This decision was further interpreted to apply in staging areas, at camps, posts, and stations of both the Ground and the Air Forces, and in the prisoner of war and internment camps.[37]

Plumbing Facilities

The preventive medicine aspects of plumbing facilities including water supply, sewage disposal, and bathing facilities are related in detail in Chapters III and IV. The plans formulated by the Corps of Engineers in conjunction with the Office of The Surgeon General provided for facilities that were adequate for all normal demands and which included the necessary health-protective features. It was only when unusual loads were placed upon these facilities as a result of crowding that much concern was felt. The following sanitary facilities had been required by AR 40–205 prior to the war and were maintained as the normal requirements in the same regulations as republished in December 1942. They remained in effect throughout the war period.

	Minimal (percent)	*Normal (percent)*
Toilets	5	7–8
Lavatories	8	10–12
Showers	4	5–6
Urinals	4	5

[34] 7th Ind, SG to QMG, 28 Feb 42, on Ltr, QMG to QM 3d CA, 20 Jan 42, sub: Double-decking steel cots. SG: 427.–4 (Cp Lee) C.

[35] See footnote 19, p. 40.

[36] See footnote 20, p. 40.

[37] Memo, CG SOS for CofEngrs, 28 Sep 42, sub: Double bunking of camps and Air Force stations. HD: 621 Housing.

Engineer field manuals prior to May 1942 had recommended 1 latrine seat for 20 to 40 men, but in the manual published shortly thereafter latrine capacities of 1 seat for 10 to 20 men, 1 bathhouse per battalion area, and 1 lavatory per company were established. These unit requirements were planned for theater of operations facilities and did not apply to Zone of Interior housing for which Army regulation requirements were the guide. Recommended fixtures for hospitals were: [38]

Fixture	*Patients*	*Nurses*	*Employees*
Water closet	1 per 8–10	1 per 6	1 per 25
Lavatory	1 per 5–7	1 per 6	1 per 25
Urinal	1 per 18–20	------	1 per 40
Shower	1 per 18–20	1 per 6	(*)
Bathtub	1 per 25	(**)	-------

* Shower for each toilet room, hospital messes only.
** Minimum of 1 tub and 1 shower in each toilet room.

In addition a dental lavatory was authorized for each nurses' bathroom, and a drinking fountain for each nurses' quarters building.

In housing constructed for Women's Army Corps, The Surgeon General recommended that 2 of the shower baths originally planned be eliminated and that 2 tubs be substituted therefor and that for all such construction 2 tubs per barracks be provided except under temporary emergency conditions.[39] Toilet facilities were to be furnished on the basis of 1 toilet per 8 to 10 individuals.[40]

Recommended sanitary facilities for hospital ships included lavatories at the rate of 1 for each 20 men; toilets, 1 for each 30 men; showers, 1 for each 50 men; and trough urinal, 1 for each 30 men. Facilities also were to be provided for the proper washing of bedpans in each ward or compartment housing more than 50 men.[41]

Hotels used for housing troops created new sanitary engineering problems. Because of the large number of soldiers quartered in the hotels, sewerage discharge facilities were overloaded and at times water supply lines were drawn upon so heavily as to create danger. Old, and often improperly designed, plumbing fixtures had cross connections between water and sewerage lines, and thus became greatly intensified sources of risk. These defects could be corrected only by detailed surveys, hotel by hotel, by competent sanitary engineers. Such a corrective program was carried out and is discussed in Chapter III.[42]

Heating

A variety of sources of heat were used in barracks of various types for the temporary housing of men during World War II. These included hot-air

[38] Memo, SG for CofEngrs, 5 Jun 42. SG: 632.-1.

[39] Ltr, Dir WAAC to Chief Admin Serv SOS, 21 Nov 42, sub: Conversion of mobilization type barracks for use of units of WAAC, with 1st ind, SG to CG SOS, 25 Nov 42. SG: 620.-1.

[40] See footnote 23, p. 42.

[41] See footnote 30, p. 44.

[42] Semimonthly Rpt, Sanitary Engr Div SGO, 1-15 Sep 42. HD: 024.

furnaces, space heaters (stoves, oil heaters), and central heating plants using either hot water or steam, usually the latter. Types of barracks with various capacities at 60, 50, and 40 square feet per man, and the type of heat furnished are presented in the table on page 41.

Space heaters or stoves, by furnishing principally radiant heat, gave rise to an unevenness of temperature in large barracks that resulted in overheating near the stove and too low temperatures in other parts of the barracks. Furnaces which recirculated and reheated the air of the barracks were cause for considerable difference of opinion. Some observers contended that air passing over the dome of the furnace was pasteurized and thus destroyed the bacteria and viruses in the air, while others felt that no pasteurization effect resulted and that circulation served to disseminate the viral and bacterial agents of respiratory diseases. It was proved that large amounts of dust and lint were circulated through the hot-air systems, a circumstance which later gave impetus to the study of the use of bactericidal and viricidal aerosols for the control of the respiratory diseases in barracks and wards.

There is no proof that heat or lack of heat in the temporary types of cantonment buildings largely used to house American troops in the Zone of Interior influenced the spread of disease. In general, the heat supply was sufficient for reasonable comfort. Undoubtedly, there were morale problems associated with under heating and overheating of buildings. In the absence of sufficient heat, ventilation often was impaired because barracks occupants closed air vents, windows, and doors to conserve all possible heat. From the point of view of preventive medicine, heating of buildings as carried out in World War II was not a basic problem.

Ventilation

The concept that actual ventilation was less important than the avoidance of overcrowding and that the distance between occupants of a building was more important than a change of air grew out of the experiences of World War I and came to be more firmly entrenched as a result of research in World War II. Hence the great interest in overcrowding and space and cubic footage per man already discussed. The urgency to construct housing to keep pace with the expansion of the Army and the economies imposed by the shortage of critical materials gave little opportunity to develop heating and ventilation practices and equipment beyond those already in being at the beginning of the war.

It was soon recognized that ventilation in messhalls and kitchens, particularly those serving fewer than 500 men was not adequate. On 28 July 1941, Construction Division Letter 368, subject: "Ventilation in messhall kitchens of less than 500 men," was published. It outlined the methods by which improvement of kitchen ventilation and messhall ventilation could be obtained. Special emphasis was placed upon the construction of hoods, vent ducts, and

exhaust fans. Specifications for these fixtures were detailed in the directive.[43]

With the shipment of large forces overseas, and consequently some diminution of pressure upon housing facilities in the Zone of Interior by late 1943, studies were planned by the Subcommittee on Ventilation of Barracks of the Committee on Sanitary Engineering, National Research Council, to determine better methods of ventilation and heating in barracks. The subcommittee on 6 December 1943 recommended that a survey be made of air conditions in representative barracks during the months of January, February, and March 1944 for the purpose of answering the following questions: [44]

1. What air conditions prevail in the better and in the poorer barracks?
2. Are unsatisfactory air conditions due largely to improper equipment, improper operation, or both?
3. Is there any demonstrable effect of such unfavorable barrack conditions on the health of men, as indicated by sickness records?
4. What practical improvements can be safely and economically applied?

Studies on heating and ventilation of tents and barracks eventually were formalized by a research contract with the Harvard School of Public Health under the guidance of Professor Constantin P. Yaglou. Professor Yaglou's investigations could not be initiated early enough to influence housing during the war, but since the war have been continued under the Medical Department Research and Development Board.

By January 1945 the shortage of fuels for heat, light, and power dictated a review of heating and ventilation practices in Army housing. On 6 January the Secretary of War warned that the shortage of liquid and gaseous fuels was critical and that production of coal during the balance of the current heating season would be insufficient to meet requirements. In order to alleviate this emergency condition, he directed that immediate action be taken by all commanders to restrict use of all fuels, heat, light, and power to the minimum consistent with health and military necessity. On 8 January this directive was amended so that the orders would not be permitted to affect service clubs, day rooms, and movie theaters.[45]

In February 1945 the Chief of Engineers sought advice from The Surgeon General on ventilation as related to the fuel conservation program and suggested that letters delineating policy and procedure for conservation of fuel and the best protection of health be sent to all commands for general distribution either jointly by the Chief of Engineers and The Surgeon General or separately from each service. Because winter was nearing an end it was the feeling of The Surgeon General that little could be accomplished by this means. He suggested a conference to study the subject and to outline appropriate action

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[43] OQMG Construction Div Ltr 368, 28 Jul 41, sub: Ventilation in messhall kitchens of less than 500 men. HD: 621 Housing.

[44] Rpt, Heating and ventilating conditions in barracks, 6 Dec 43. Filed as Appendix A to Minutes of 12th Meeting, NRC Committee on Sanitary Engineering, 22 Jan 44. HD: 040.

[45] Memo, CofEngrs for SG, 9 May 45, sub: Restriction on use of fuels, heat, light, and power. HD: 621 Housing.

for the winter 1945-46. The conference on 4 May 1945 brought out that the exact value of ventilation in the prevention and spread of disease was very difficult to determine by experimentation. Overventilation produced chilling and might in some instances do more harm than good. The need for more definite experimental work to obtain accurate data on various factors such as ventilation, drafts, and heating in buildings for use in future design and construction was recognized. As applied to the then current type of construction for theater of operations and mobilization barracks, it was noted that the type of construction was open, that climatic conditions varied greatly and that each post and station would have to work out the problem on the merits of existing local situations. Hard and fast rules and definite policy and procedure could not be outlined. It was agreed that an article on the medical aspects of ventilation and heating would be prepared for early publication in the Army Medical Bulletin, following which letters would be sent to each service command surgeon and engineer by The Surgeon General and the Chief of Engineers, respectively, advising coordinated efforts in solving the problems.[46]

The article, published in August 1945, stressed the influence of heating and ventilation on health and comfort of the troops, noted the open type construction of Army cantonment buildings, and stressed that the spread of airborne infections depended more upon proper spacing of individuals than upon ventilation except under circumstances of totally inadequate ventilation. ". . . . No amount of overventilation can compensate for overcrowding." Complete coordination with the responsible engineer was urged. ". . . . It should be possible for the post surgeon and post engineer to develop a program suited to the location, the type of buildings, and heating facilities. The maximum conservation of fuel with full protection of the health of troops will result from such a co-ordinated program of heating and ventilation." [47]

Housing Investigations by the Army Epidemiological Board

Following the arbitrary decision of the Commanding General, Services of Supply, to reduce space allowance for troop housing to 40 square feet per man in October 1942,[48] the Preventive Medicine Service, Office of The Surgeon General, arranged for the Army Epidemiological Board to survey conditions in Army camps. Since the investigation was to consider space, overcrowding, heating, and ventilation in relation to the health of the American soldier, the findings have been brought together under one heading rather than diluted as a part of the appropriate sections previously discussed.

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[46] Rpt of Conference on Ventilation, 4 May 45. HD: 621 Housing.
[47] Heating and ventilation program for the conservation of fuel. Bull. U. S. Army M. Dept. 4: 174-175, Aug 1945.
[48] See footnote 21, p. 40.

The Board was requested to consider especially the current and expected incidences of acute respiratory diseases and meningococcal meningitis in troops. Between 16 December 1942 and 1 January 1943, members of the Board and its commissions inspected 19 posts and camps in different sections of the country as follows: [49]

Place	*Date*	*Investigator*
1. Fort Devens, Mass	16 Dec 42	Dr. F. G. Blake
2. Camp Edwards, Mass	17 Dec 42	Dr. F. G. Blake
3. Fort Monmouth, N. J	17–22 Dec 42	Dr. Colin MacLeod
4. Camp Edison, N. J	17–22 Dec 42	Dr. Colin MacLeod
5. Camp Wood, N. J	17–22 Dec 42	Dr. Colin MacLeod
6. Camp Upton, N. Y	17–22 Dec 42	Dr. Colin MacLeod
7. Camp Kilmer, N. J	17–22 Dec 42	Dr. Colin MacLeod
8. Mitchel Field, Long Island	17–22 Dec 42	Dr. Colin MacLeod
9. Fort Meade, Md	23–28 Dec 42	Dr. K. F. Maxcy
10. Fort Bragg, N. C	22 Dec 42	Dr. J. H. Dingle
11. Fort Knox, Ky	22 Dec 42	Dr. E. W. Goodpasture
12. Camp Campbell, Ky	28 Dec 42	Dr. E. W. Goodpasture
13. Fort Custer, Mich	18–19 Dec 42	Dr. T. Francis, Jr.
14. Camp Grant, Ill	17 Dec 42	Dr. O. H. Robertson
15. Chanute Field, Ill	17 Dec 42	Dr. M. Hamburger
16. Jefferson Barracks, Mo	3 Dec 42	Dr. J. J. Phair
17. Fort Ord, Calif	22 Dec 42	Dr. K. F. Meyer
18. Fort Lewis, Wash	29–30 Dec 42	Dr. K. F. Meyer
19. Camp Adair, Oreg	31 Dec 42	Dr. K. F. Meyer

Reports of the investigators were submitted to The Surgeon General early in January 1943. The data obtained was used almost immediately in an indorsement to the Chief of Engineers in which the extent of the survey was pointed out and particular attention called to the inadequate provisions for proper ventilation, especially in the theater of operations type of building and in buildings in eastern areas where the blackout was required. It was recommended that immediate steps be taken to insure that ventilation of approximately 1,800 cubic feet per man per hour be provided in all barracks during the sleeping period and that windows be fitted with deflectors so as to prevent undue exposure to draft and chilling of occupants of beds near the windows.[50]

On 15 January 1943 a special conference was held in the Preventive Medicine Service, Office of The Surgeon General, to discuss problems of acute respiratory diseases, meningococcal meningitis, and the relation of housing conditions to current and expected incidences of these diseases in troops. There was a thorough discussion of all matters brought out in the several reports submitted by members of the Board and its commissions. Spacing and sleeping arrangements in barracks; ventilation; washing and sterilizing of mess utensils; overcrowding of facilities of various types such as lavatories, post

[49] Minutes of Special Meeting, Board for the Investigation and Control of Influenza and Other Epidemic Diseases in the Army, 29 Jan 43. HD: 621 Housing.

[50] 4th Ind, SG to Cof Engrs, 17 Jan 43 on Ltr, CG 1st SvC to CG 1st AF, 9 Dec 42, sub: Ventilation of barracks. SG: 673 Westover Fld.

exchanges, and theaters; exposure to wet and cold; and sanitary conditions in general were considered.[51]

The members of the Board were unanimous in their opinion that a complex of factors entered into producing respiratory disease under the housing conditions then existing and that no one factor was responsible. All were critical of the crowding that existed and expressed concern that should influenza, meningitis, or other respiratory or infectious disease become epidemic, conditions were highly favorable for their rapid spread. Reduction of space to 40 square feet per man, while not considered desirable, was not necessarily considered an important factor. Most were in accord that double bunking not only was not undesirable but, under conditions of military necessity, created more floor space and air space and less actual contact of the men during sleeping. While the increase in respiratory diseases as a whole appeared to be largely seasonal, it was obvious that in some camps both respiratory diseases and meningitis had been influenced by housing conditions. The crude type of ventilation and its application by the occupants of the buildings was universally condemned.

Dr. Kenneth F. Maxcy in his report on Fort George G. Meade, Maryland, noted that:

> Attention is particularly directed to defects in design and operation of the heating systems installed in standard two-story barracks (Plans 700–1165 and 800–443). From the point of view of comfort and spread of infection improvement could and should be made. This is a very practical and important problem which might receive more extended attention from Dr. O. H. Robertson and his Commission on Cross Infections in Hospitals.

Dr. Ernest Goodpasture noted that at Camp Campbell, Kentucky:

> It was stated that there is considerable difficulty in maintaining a proper temperature in the barracks although spot inspection takes place regularly.

Dr. Francis G. Blake, President of the Board, noted the following for Fort Devens, Massachusetts:

> Theatre of operations barracks were less satisfactory. Those inspected were equipped with 40 single bunks adequately spaced, alternated head and foot, approximately 50 sq. ft. per man, but the ventilation seemed unsatisfactory, the air being hot and dry even though cans of water, simmering or boiling, were present on the stoves in an effort to correct this. When the windows are opened at night cold drafts blow on the heads of men with head toward the wall. The necessity of going outdoors to the latrines and showers, particularly for unseasoned recruits in winter, might contribute to respiratory disease.

Particular concern was expressed for recruits who were considered highly susceptible. It appeared in some of the reports that the flow of men through

[51] Memo, Col. S. Bayne-Jones, MC, for Gen Magee, 20 Jan 43, sub: 1. Conference on acute respiratory diseases. 2. Special meeting of Epidemiological Board to be held on January 29, 1943. HD: 621 Housing.

the induction and reception centers, by the introduction of "unseasoned" recruits, contributed to high incidences of respiratory diseases.

The minutes of the special meeting of the Board held on 29 January 1943 record the following resolutions which were transmitted to The Surgeon General:[52]

> In view of the increasing incidence of acute respiratory diseases and meningococcal meningitis during December 1942 and January 1943 and based upon an inspection of camps by members of the Board and its Commissions, the Board desires to go on record as emphasizing the influence of crowding in barracks, mess halls, and recreation halls on the spread of meningitis, acute respiratory and other epidemic diseases. Crowding is only one factor in this situation but a highly important one. In general terms it can be positively stated that the greater the crowding the greater is the risk of an epidemic of serious proportions. The order reducing the minimum floor space per man in barracks from sixty (60) square feet to forty (40) square feet, while a military necessity, is in an undesirable direction from the standpoint of maintenance of health. The effect of this provision not only results in overcrowding in barracks but also an equally undesirable overcrowding in mess halls, wash rooms, latrines, post exchanges, etc., and overloads all existing facilities.
>
> * * * * * * *
>
> The Board especially emphasizes the greater susceptibility of recruits to acute respiratory and other epidemic diseases and the greater risks of epidemics during the winter months (December through March), particularly under conditions of crowding.
>
> * * * * * * *

On 1 February 1943 the Chief of Preventive Medicine Division, Office of The Surgeon General, transmitted the resolution of the Board to The Surgeon General, and a letter was sent to the Secretary of War which summarized the investigation and in part is quoted as follows:[53]

> The point of these reports is that a potentially dangerous situation now exists, that the risks of a serious epidemic are foreseen, and that consideration should be given to possible measures to prevent the development of epidemics or to cope with them if they occur.
>
> It is realized the problems are both military and medical. The following recommendations are offered for consideration:
>
> *a.* The return to space allowance of 60 square feet as soon as possible.
>
> *b.* The decrease of induction of men into the Army during February, March, and at least the first half of April 1943.

The Commanding General, Services of Supply, ruled that, "This headquarters considers it inadvisable at this time to change the existing policy covering space allowed in barracks. . . ." He noted that the reduced space allowance principle was actually in effect in only a relatively few installations

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[52] See footnote 49, p. 51.

[53] Ltr, Maj Gen J. C. Magee, SG; Col J. S. Simmons, MC; Col S. Bayne-Jones, MC, to SecWar thru CG SOS, 4 Feb 43, sub: Relation of reduced space allowance in posts and camps to the increasing incidence of acute respiratory diseases and meningococcal meningitis in the Army. HD: 621 Housing.

and that a general reduction in space allowance need not be made until about July 1943, the extent then being dependent upon the rate of overseas movement of trained troops. Temporary emergency expansion of housing would be provided if serious epidemics developed and additional assignment of troops to stations experiencing epidemics would be discontinued during the critical period.[54]

While The Surgeon General had exhibited foresight in having the situation studied by medical authorities, and had carefully presented the multiple factors involved in the hazard, higher authority appeared to have little understanding of the dangerous potentialities of the situation or that epidemics result from multiple causation. The Commanding General, Services of Supply, stated in his memorandum of 4 February 1943:[55]

> It is desired that you make a further study of the effect which reduced floor space in barracks has actually had upon the incidence of communicable disease among the troops. If, in your opinion, such study shows that the single factor of reduced floor space for troops has actually resulted in a marked increase in the incidence of communicable diseases, further consideration will be given to correcting the situation. Request for reconsideration should be accompanied by the study referred to above.

In his reply on 22 March 1943 The Surgeon General noted that the incidence of acute respiratory disease reached a peak about the middle of January, following which the rate diminished slowly but progressively. He remarked a decreased intake of new troops at certain crowded camps and that no troops were assigned to such posts during critical periods. He reviewed the findings of the Epidemiological Board, stressed the importance of multiple factors in the possible causation of an epidemic outbreak of respiratory diseases, and expressed the opinion that it would be futile to undertake an investigation in an effort to determine the weight of the single factor of reduced floor space for troops.[56]

Fortunately, outbreaks of respiratory disease and meningitis were limited to point epidemics at a few posts and stations where locally applied control measures prevented their spread. The Army Epidemiological Board was called upon as necessary during the remainder of the war to investigate special problems as indicated with reference to housing. Discussions at the 15 April 1946 meeting of the Board strongly reaffirmed the position of being opposed to the use of double bunking as a means of crowding:[57]

> It is recommended that double bunking is justified in barracks, but should not be used to accommodate more than one man per sixty square feet of floor space (i. e. per one hundred and twenty square feet of floor space for each double bunk).

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[54] Memo, CG SOS for SG, 4 Feb 43, sub: Relation of reduced space allowance in posts and camps to the increasing incidence of acute respiratory diseases and meningococcal meningitis in the Army. HD: 621 Housing.

[55] Ibid.

[56] 1st memo ind, Maj Gen J. C. Magee, SG; Col S. Bayne-Jones, MC; Col J. S. Simmons, MC, to CG ASF, 22 Mar 43, on memo cited in footnote 54. HD: 621 Housing.

[57] Memo, Dr. F. G. Blake, Pres., Board for the Investigation of Epidemic Diseases, for Chief Prev Med Serv SGO, 17 Apr 46, sub: Double bunking in barracks. SG: 724.9.

Miscellaneous Factors of Housing Related to Health

Civilian Housing for Employees of Army Industrial Plants

Housing as an important factor in the protection of the health of civilians employed in Army-owned and Army-operated industrial plants was recognized early in the war by The Surgeon General. On 28 July 1942 he addressed the following to the Legislative and Liaison Division of the Office of the Chief of Staff: [58]

> 1. The dislocation of populations due to the development of essential war industries in areas where adequate housing and sanitary facilities are not available presents a serious health problem for the employees of these industrial plants. If the war effort is to be successfully carried on without epidemic diseases interfering with the labor required for wartime production, it is essential that adequate housing and sanitary installations be provided for workers in the vicinity of industrial plants producing war equipment and munitions.

Housing for dependents of military personnel, while not a military medical responsibility, likewise was recognized as a potential health problem. Quartering of dependents in hotels leased by the War Department was not permitted but military agencies were encouraged to make informal arrangements with local hotels to furnish accommodations at fixed rates without liability to the Government.[59] Health and morale problems of civilian employees of Government-owned and operated industrial plants became a concern of the Industrial Hygiene Division of the Preventive Medicine Service, Office of The Surgeon General, and have been recorded in another volume in this series.

Screening of Housing and Tentage

Screening of temporary and permanent housing for protection against arthropod pests and vectors of disease was an accepted principle and was provided for throughout the war with few exceptions. Tight construction of buildings in tropical areas to prevent the ingress of mosquitoes and other insects was at times cause for concern. Likewise, screening of doors and windows was not always efficiently done nor maintenance of screened openings properly carried out.

Methods of hanging screen doors were cause for considerable controversy. For best protection against flies, mosquitoes, and other insects, screen doors should swing outward and this method was recommended by The Surgeon General. Fire and safety regulations, however, required exterior doors to open out; the screen door necessarily had to open inward if hung on the same

[58] 1st ind, SG to Lt Col G. Parker, Legislative and Liaison Div, Off of CofS, 28 Jul 42, on Ltr, Lt Col G. Parker, Legislative and Liaison Div, Off of CofS, 25 Jul 42, sub: FWA Docket No. West Virginia 46-135 for emergency sanitation facilities, Point Pleasant, West Virginia. SG: 600.12-1 (Pt Pleasant)F.

[59] WD AG Memo W600-30-42, 13 Dec 42, sub: Housing of military personnel in hotels and similar establishments. SG: 600.12-1.

frame. A number of expedients were tried, such as dividing doors so that the upper half of the solid door opened and left a secondary screened upper half attached to the lower half for insect protection. Plans were drawn for the construction of vestibules with a screen door on one end and the solid door on the other, both opening to the outside, but this added so much to the cost of construction that it could not be adopted as an overall procedure. The simplest and most practical solution was that since in warm climates it was rarely necessary to close solid exterior doors during the warm period when insects were a problem, those doors, opening outward, could then be removed and replaced by screen doors.[60]

On 22 June 1944 the Chief of Engineers published a circular letter which directed that, "In new construction, all exterior doors, both solid and screen, will be hung to swing out." [61] A subsequent circular letter, 4 April 1945, stated that: [62]

> It is not intended that a repairs and utilities program of replacement of existing exterior doors be initiated. However, screen doors damaged beyond economical repair which require replacement will be replaced in accordance with instructions contained in the above referenced Circular Letter No. 3116.

This controversy continued into 1945. It provides further evidence of lack of staff coordination which resulted in conflicting War Department directives. These small matters may have far-reaching effects upon the protection of health on the one hand and unnecessary cost of construction on the other, and, in addition, expend the valuable time of staff, command, and technical officers who have to spend many hours in resolving them.

Before the war, bed nets in buildings and large tents, and mosquito nets to fit the pup tent, had been in common use. Early in the war, there was developed a jungle hammock with a water-repellent top and netting sides for protection of the jungle soldier while sleeping. Because of the nature of combat and the development of effective insect repellents and suppressive antimalarial drugs, it was unnecessary and impracticable to furnish the individual soldier with protective mosquito netting in personnel tents. Some effort had been made to provide such protection in the malarious theaters by local purchase of netting, but it was not until August 1944 that the requirement for insect-proofing of tents came under review by The Quartermaster General. In an indorsement to the Commanding General, Army Service Forces, dated 4 September 1944, The Surgeon General stated that his Office had long felt the need for mosquito-proofing liners for tents and recommended that they be made available to malarious theaters at the earliest practical moment. He recommended that 18-mesh screening material be used and asked that several types be tried out. For planning purposes The Surgeon General was asked to

[60] Ltr, SG to CofEngrs, 18 Jun 42, sub: Hanging of screen doors on cantonment buildings; 1st ind, CofEngrs to SG, 10 Jul 42; 2d ind, SG to TAG, 26 Aug 42; 3d ind, TAG to SG, 3 Sep 42. HD: 621 Housing.

[61] OCE Cir Ltr 3116, 22 Jun 44, sub: Screen doors. HD: 621 Housing.

[62] OCE Cir Ltr 3663, 4 Apr 45, sub: Buildings—replacement of screen doors. HD: 621 Housing.

delineate the world areas in which insect-proofing of personnel tents should be supplied.[63] Supply of these items had not become a reality by the end of the war.

Bedding

Bedding, aside from the fact that it is not always provided in sufficient quantities for comfort, has at least two other health implications of importance. Bedclothes and especially blankets on which dust and bacteria in the air have settled are sources for recontamination of air when the bedclothes are handled as in bedmaking, and may be a factor in the spread of respiratory diseases. The development of oiling through a laundry process to trap bacteria and dust particles on bedclothes is discussed later in this chapter.

In reception and induction centers and in housing facilities for temporary occupancy overseas, men must be passed through rapidly. It was impractical to launder bedclothes, especially blankets, daily, so that it was a necessity for blankets to be used by several occupants between launderings. Under these circumstances, it was found that blankets became infested with the larval mites of scabies and contributed materially to the spread of this disease in American troops. Adequate prevention of scabies requires the frequent laundering of bedclothes and preferably the dry cleaning of blankets to prevent shrinkage and destruction of the napping effect of the wool.

Housing in Overseas Theaters

Shelter in overseas theaters varied from the open foxhole through unlimited improvisations made from the wood of crates and boxes (see Fig. 5), winterized and tropicalized tents, bombed-out buildings, prefabricated hutments, armories, barracks, and private dwellings to the elaborate resort hotels of Western Europe and Italy. Necessity was the deciding factor and the American soldier was both ingenious and versatile in adapting the means at hand for shelter. Conditioned troops overseas adapted themselves well to the limited housing facilities available and while overcrowding according to normal standards was universal, there is little evidence to support the assumption that the type of housing available materially influenced the incidence of the respiratory and infectious diseases.

Housing for troops in the forward combat areas was primarily a matter of the individual or small unit taking advantage of such shelter as the terrain provided, together with such improvised temporary measures as could be taken for comfort and protection. World War II was largely a war of movement, and units as large as a division in combat areas were rarely stationary for long enough periods of time to justify more than the most temporary of improvisations even under winter combat conditions. Local houses, barns, casernes,

[63] Ltr, QMG to CG ASF, 15 Aug 44, sub: Insect-proofing of personnel tents; 2d ind, SG to CG ASF, 4 Sep 44; 6th ind, QMG to SG, 12 Dec 44. SG: 424.1.

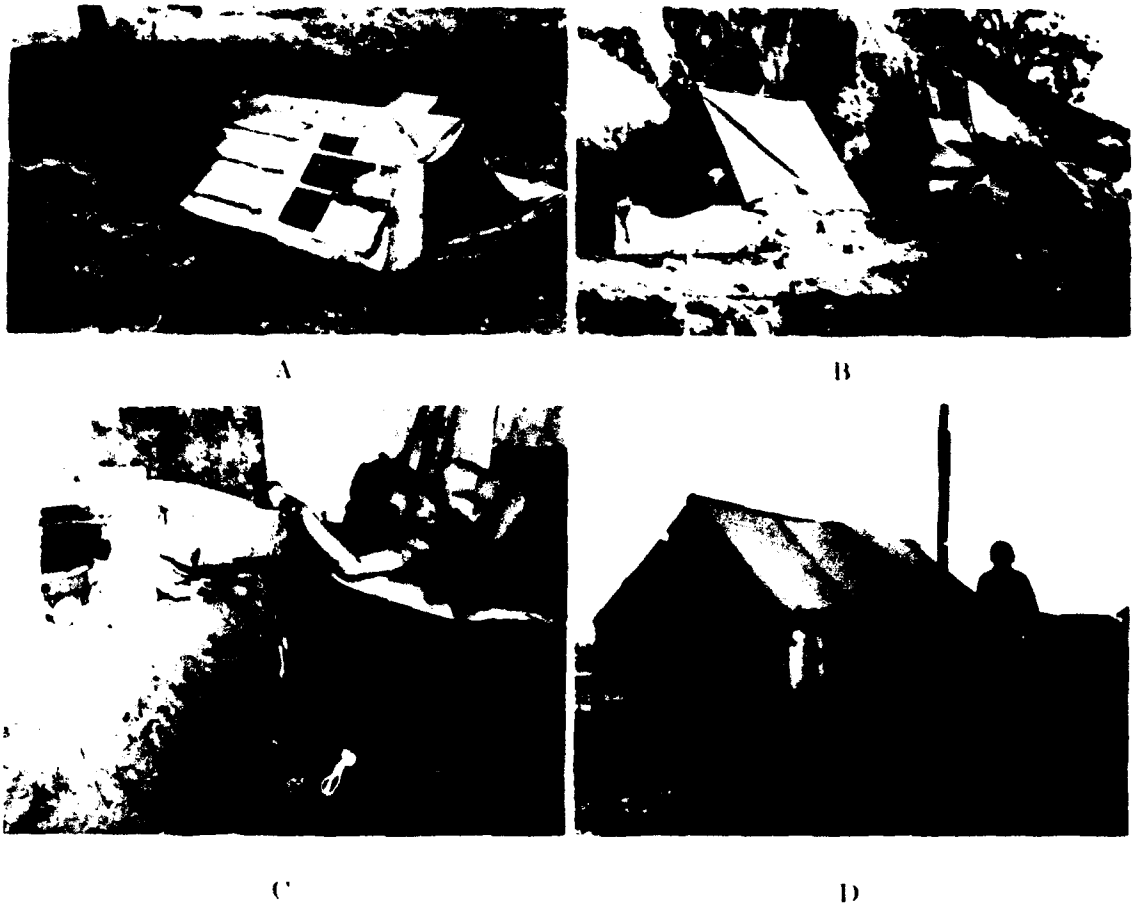


Figure 5. A. A foxhole in France, 1944, made with a door, shelter half, German canvas, and an old leather coat. B. A shelter, improvised from ammunition cases, shelter halves, and dirt, dug into the base of a cliff, Italy, 1944. C. Interior of cave-home, North Africa, 1943. D. Tent made from packing boxes, North Africa, 1943.

sheds, churches, and other buildings in villages and towns were utilized if they were available. Even in division headquarters areas, shelter was often crude and varied tremendously from location to location. Rearward of division areas the opportunity to seek more permanent shelter was greater, and army and corps headquarters usually provided reasonable housing facilities by temporary use of available buildings in villages and towns and in tentage and trailers. As beachheads were expanded to include sufficient territory to justify communications zones, service troops and headquarters of groups and theaters were provided with adequate housing in buildings, although crowding prevailed as a general rule.

In theaters such as the Mediterranean, where protection from the arthropod-borne diseases, especially malaria, was necessary, repellents, DDT residual spraying, and bed nets were relied upon. Screening was used largely on latrines, mess buildings, and for the protection of patients on hospital wards.

In the Mediterranean and European theaters, where operations took place during the winter months, heating for such buildings as were used was often inadequate. In Italy great dependence was placed upon the diesel oil space heater provided from Army sources. The supply was not enough to meet the demand, and forward of army areas many improvised methods of heating were devised. Most of these were some form of gasoline-fueled contrivance and varied all the way from buckets of sand saturated with gasoline to elaborate devices using gasoline or waste motor oil. Wood and coal were scarce and were severely rationed.

In England the long period of preparation for the invasion presented housing problems similar to those existing in the Zone of Interior except that the housing shortage was more acute and American troops had to be billeted in what was available or could be constructed rapidly from British and, later, American resources.

Examples of living conditions in England are found in the historical reports of the units. The annual report for 1942 of one of the American divisions in England reports that the troops were quartered in two-story brick buildings which were subdivided into barracks rooms with central halls and latrine urinals off these halls. The rooms were originally intended for 12 men but were made to accommodate 24 by use of double-decked beds. Head to foot sleeping was imposed and frequent checks on ventilation were instituted. Ventilation presented a rather large problem as blackout curtains covered all windows after dark. Every available means was used to keep the sick rate due to upper respiratory conditions at a minimum. Despite precautions, the sick rate jumped from 8 per 1,000 per day to 30 per 1,000 per day. The increase in respiratory diseases was believed to be due to a number of factors: "1. Overcrowding; 2. Fatigue from long hikes and vigorous training; 3. Cold, damp climate condition to which the men were not accustomed; 4. Lack of sunshine; 5. Season of the year." [64]

The surgeon of the Eighth Air Force reported for 1942 [65] that many units were stationed on Royal Air Force airdromes, the majority of which were built in accordance with the British dispersal policy. The typical setup was a communal center composed of messhalls and ablution huts (bathing and toilet facilities) for officers and enlisted men. The living quarters consisted of fabricated or wooden huts grouped in living sites dispersed around the communal center, some as far as 1½ miles away. The living quarters were crowded, especially on the satellite airdromes which were originally constructed to accommodate approximately 400 troops and actually housed about 1,000. Forty-one square feet of floor space per man was ruled to be adequate. Upon arrival some of the men were quartered in tents, but this was gradually corrected.

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[64] Annual Rpt, Surg 29th Inf Div ETO, 1942. HD.
[65] Annual Rpt, Surg 8th AF, 1942. HD.

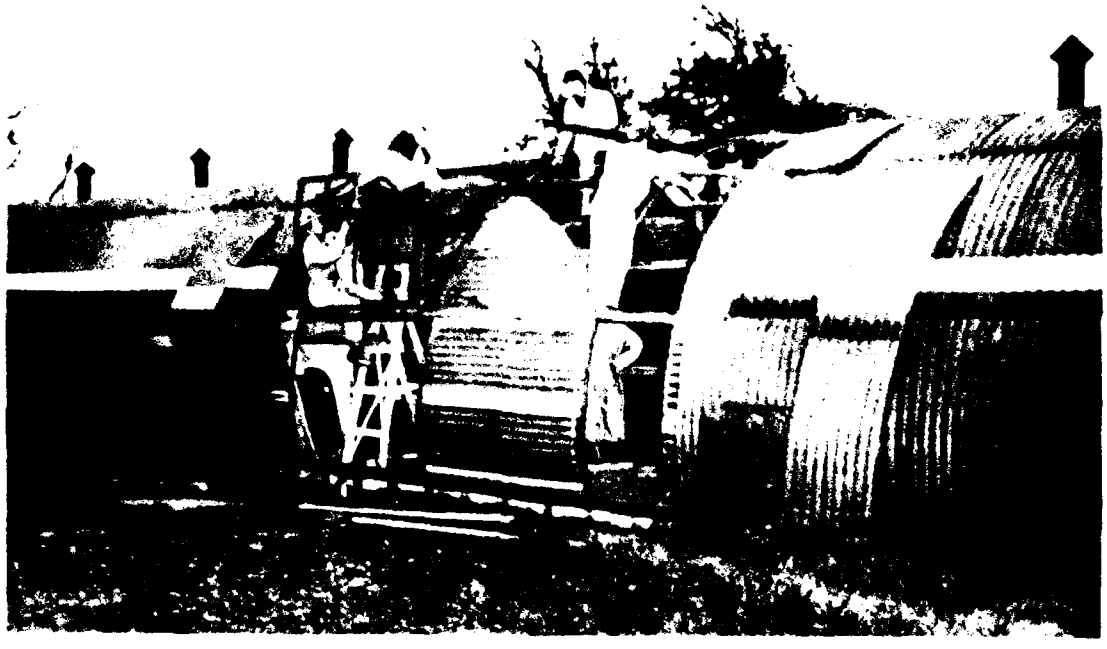


Figure 6A — Engineers building connections between two Nissen huts, England, 1942

Heating the huts was a problem. The very limited coal supply prevented a fire from being kept going all day and only at night was one allowed in living quarters. Consequently bedding and clothing were constantly damp during cold weather and many men preferred to go to bed to keep warm rather than rely upon the meager warmth rendered by the small stoves. Bathhouses were without heat and the water was frequently cold. Many of the men preferred the municipal bathing facilities available in the nearby communities. In general, bathing facilities were not considered adequate, especially for a stationary theater.

Water was supplied from nearby municipal water companies or from deep wells near the airdromes. Chlorination at the source was the practice in municipal water works. Routine monthly bacteriologic analysis by the Army proved the water to be potable at all times. Laundry was done each week by British firms and the service given was considered satisfactory. Cleaning and pressing were also done by British plants but often 2 to 3 weeks elapsed before clothes were returned because of the shortage of cleaning fluid and labor.

The Eighth Air Force surgeon considered that messing facilities in most instances were adequate, but recorded that there were stations where overcrowding existed and messhalls built to accommodate 500 people were feeding 1,400 to 1,600 per meal. Sanitation of messhalls and kitchens was a problem because of inability to obtain cleaning equipment and material, lack of modern



Figure 6B. Typical interior of a Nissen hut, Iceland, 1942.

equipment and plumbing, and in many cases *poor* management and apparent lack of interest on the part of responsible officers. On stations where the messes were under British supervision the problem was more acute because United States authorities were handicapped in taking any corrective action. Storage space in most cases was adequate but was often poorly arranged and unorderly.

The wide dispersal plan in a rolling hilly country made it impossible in some camps to construct running water toilets at all living sites. Here it was necessary to depend on the bucket-type latrine which is not all that is to be desired from the sanitary standpoint. Buckets were collected and emptied daily by civilian contractors and it was quite difficult to force them to cleanse the buckets properly before returning them to the site. This arrangement was also used at stations under construction, pending the building of running water toilets. Each newly constructed station had a modern sewage disposal plant to care for all sewage. Pit or trench latrines were not used in the United Kingdom because of the high water table.

Because of the speed of the buildup in the summer and fall of 1942, accepted standards of accommodation had to be waived. Hutments, barracks, tents, and prefabricated British and American buildings were utilized. (See Fig. 6.) Gordon, in discussing housing in England during this period, described the billet as any building with a roof and walls and noted that they

included castles, manor houses, theaters, stores, armories, schools, churches, private homes, and other types of buildings.[66]

A field hospital reported varied housing conditions as they moved from one location to another in France. At Nancy enlisted billets were made more comfortable by the acquisition of wooden double-decked beds. A large kitchen in the building made it possible to prepare all meals without the use of most of the mess equipment issued the organization. Empty oil drums were utilized for trash containers around the hospital area. When quartered in tents, the hospital used roofing paper or lumber for flooring in order to keep tents dry and comfortable and to maintain a higher degree of cleanliness. Boardwalks were laid to combat mud during wet and rainy weather. The units converted German bomb crates into handy and light latrine boxes. These boxes were easy to move and set up again, saving the time and labor involved in finding suitable lumber and building new boxes at each new location. At one location, several knockdown huts were found and used for offices, property shacks, and maintenance shops. Shellholes were discovered to be very useful for soakage pits.[67]

Scales of accommodation were set jointly by the chief surgeon and the chief of engineers for the theater. Sixty square feet per double bunk and 400 cubic feet of air per man comprised the average accommodation. Women's Army Corps personnel were allowed 48 square feet per person. Seven or eight men were assigned per pyramidal tent.

Shortages of fuel existed throughout the period in England and on the Continent. European stoves in general were unsatisfactory. In England, 8 pounds of coal and 1 pound of kindling per man per day was the allowance and on the Continent, the coal allowance was cut in half. The necessity for blackout, both in England and on the Continent, did influence ventilation and with the lack of heat during the winter, soldiers closed windows and stuffed vents in an effort to keep comfortable. Later, blackout baffles and establishment of the rule that there should be a 1½ square foot inlet and outlet per each 10 men improved the situation. In the more permanent installations, cook stoves were not hooded during the early months and gave rise to some danger. This, however, was remedied and no casualties were reported from carbon monoxide poisoning except for an isolated case or two where kerosene or oil burners were used to heat tightly closed trailers in which personnel slept.

Bathing facilities were limited both in England and on the Continent. While showers were provided, it was found that unless shower rooms were heated in the winter months, limited use only was made of them. On the Continent, bathing facilities for units in general often were improvised or were

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[66] Gordon, J. E.: History of preventive medicine in the European Theater of Operations, United States Army, 1941–1945. HD. 314.7-2.

[67] Semiannual Rpt, Hq 58th Field Hosp ETO, 1945–1. HD.

of the field type. Quartermaster bathing and sterilization units, while serving a very useful purpose, were not in sufficient number nor mobile enough to provide good bathing conditions for the average unit at the front.

In the Pacific theaters, where there were fewer buildings suitable for housing troops, much greater dependence had to be placed upon temporary construction, the use of tents, and improvised shelter constructed by the soldier or the small unit. Tents for personnel in the forward areas were impractical because of the necessity for camouflage and the difficulty with which they could be transported. Because of the equable climate in many parts of the Pacific area, ventilation and heating were not significant problems. Many of these areas, however, were highly malarious, and meticulous attention to the protection afforded by housing from mosquitoes was required. Bed nets were largely used in housing facilities for personnel, although later in the war, some of these buildings could be provided with screening. In the hot climates, American tents were found to offer good protection against the rain and to last well, but because of their color and the single layer of canvas, were extremely hot. No means for insect-proofing tents were provided. In the China-Burma-India theater, for example, the preventive medicine history records that pyramidal tents were placed over wooden frames, the walls of which were covered with mosquito netting, the sides of the tents being raised and extended to form an awning effect. British tents were much used in this theater and were found to be cool and comfortable. They were readily available and were constructed with a double layer of light-colored canvas. They had been designed for desert use and therefore were not found to be efficient in shedding rain for long periods. These tents had the additional feature of netting sewed to the edge of the inner tent, which made protection against insects much easier.

Native-type construction in the Pacific theaters was often utilized. (See Fig. 7.) For example, in the China-Burma-India theater, the basha hut was often used as a semipermanent shelter for personnel. These huts were made of grass mat walls on a bamboo frame and had thatched roofs. A method for insect-proofing them was developed by the use of Hessian cloth (burlap) tacked on the walls and painted white. Windows were covered with mosquito netting and netting screen doors improvised. The basha huts were not satisfactory in the rainy season and the thatched roofs provided harborage for rats.[68]

An example of the types of building used in the Southwest Pacific is shown by the 153d Station Hospital at Port Moresby. The hospital was completed in a few months by the personnel of the unit and men attached from other units in the area without interruption of care of casualties. In the beginning of January 1943 the hospital area was cleaned, grass cut, and

[68] Van Auken, H. A.: A History of preventive medicine in the United States Army forces of the India-Burma theater, 1942 to 1945. HD: 314.7-2.

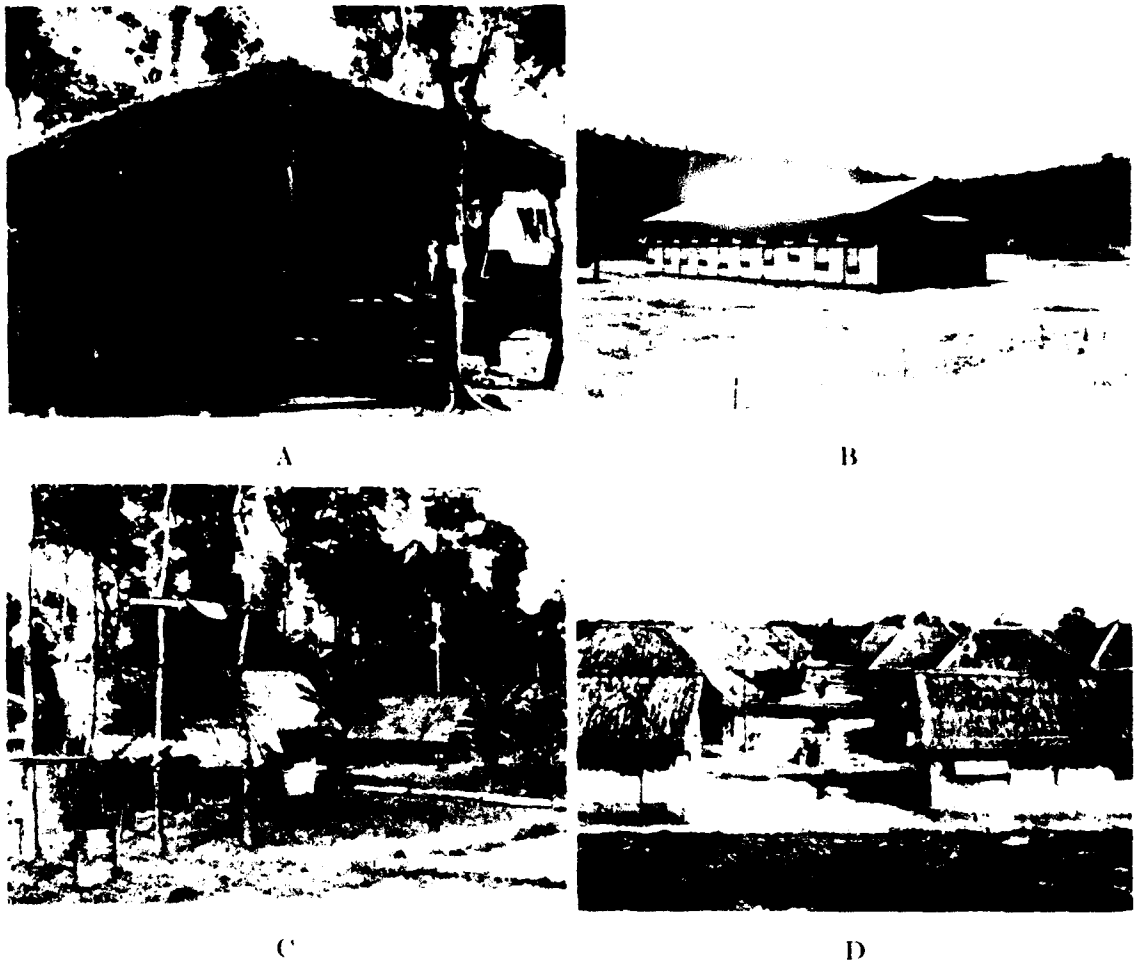


Figure 7. A. Front of native-type hut, occupied by soldiers in New Caledonia, 1942. B. Exterior of completed tropical hut, closed type, New Caledonia, 1942. C. Officers' quarters of 14th Evacuation Hospital, India-Burma theater, 1945. D. Raffia houses in northern part of India, 1945.

floors and frames for the ward tents constructed. Sidewalks were built and construction of floored, framed, and screened pyramidal tents for quarters for the nurses started. By the end of January, a total of 24 of the wards and 11 of the pyramidal tents had been completed. In addition, the mess kitchen had been enlarged to twice its original size, a storage room had been built for rations, ramps had been run from a large surgery ward to the two operating rooms, and drains and culverts had been constructed throughout the area.

A group of natives under the leadership of personnel of the Australian Army constructed a number of grass huts. These served as offices, a nurse ward, a messhall for patients, and recreation rooms. Maintenance work consisting of repairs and additions to the plumbing, water supply, and drainage system; building of additional showers and wash basins; and the digging of latrines and soakage pits was done by the hospital detachment. This work,

in addition to the heavy load of patients which the hospital cared for, made it necessary for the personnel to work 14 to 18 hours daily.[69]

Housing in Alaska and along the Alcan Highway was provided under circumstances where semipermanent installations could be constructed. In the early period (1942–43) pyramidal tents winterized by the construction of floored wooden frames were used. Subsequently, a variety of hutments, some prefabricated and some constructed locally, came into use. These included Stout huts, Butler huts, Quonset huts, National huts, Cemesto units, and Cowin huts. In addition, there were table of organization frame buildings, Civilian Conservation Corps buildings, Loxtave buildings, Gloekler units, and Repeater stations. Heating was accomplished almost universally with the oil burner space heaters except in station hospitals where steam heat was supplied. In general, 60 square feet per man was available for most of the period. Toilet facilities consisted largely of pit latrines equipped with heating units and homemade showers until 1943. By 1944 flush toilets and showers were installed.[70]

Housing and shelter in the theaters of operations were far from satisfactory and overcrowding in the permanent and semipermanent accommodations was universal. Except where the nonavailability of screening or the improper use of screening provided inadequate protection and thus contributed to malaria infections, however, there is no evidence that housing per se materially influenced the incidence of disease. Even in England during the preinvasion period where scales of accommodation were cut to the minimum, and in face of the influenza epidemic of 1943, the chief of preventive medicine for the theater stated that there was no reason to believe that overcrowding influenced the course of the epidemic, except perhaps in isolated local situations.

Research on the Spread of Disease and The Control of Airborne Infections in Housing

The studies of housing in relation to disease, and measures for the control of infections spread through the air in housing, made up the greatest part of the research program related to housing during the war. At the beginning of the war it was understood that the causative organisms of certain of the infectious and respiratory diseases were airborne, and could be transmitted from one person to another, especially under crowded conditions in housing. Actual modes of transmission, however, were not fully determined and methods of prevention and control, except for avoiding crowding to minimize close contact, especially during sleeping, had not been developed. Researches on these problems during the war, while they added much to medical knowledge, nevertheless did not provide entirely satisfactory or conclusive answers.

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[69] Quarterly Rpt, 153d Sta Hosp SWPA, 1943-1. HD.

[70] Manning, F. G.: History of preventive medicine in World War II, Northwest Service Command, 6 Jul 45. HD: 314.7-2.

Ventilation and heating in temporary barracks were given relatively early consideration in 1943, a circumstance largely motivated by the arbitrary War Department decision to crowd men into temporary housing facilities on the basis of 40 square feet per man and the institution of double bunking. The Sanitary Engineering Committee of the National Research Council established a temporary Subcommittee on Atmospheric Control following its meeting on 3 March 1943.[71] The terms of reference for the subcommittee were largely limited to the sanitary engineering aspects of the problem which were interpreted to include the application of ultraviolet irradiation and aerosols for air sterilization.[72] On 14 June 1943 the subcommittee considered the question of future developments and concluded that there was not sufficient basic information on the use of ultraviolet irradiation and aerosols to proceed with any definite recommendations as to their use in military establishments.[73]

Progress was slow for the remainder of 1943 and at the 6 December meeting of the Sanitary Engineering Committee a special report by Professor Constantin Yaglou noted that,

> Heating and ventilating conditions in barracks are not entirely satisfactory. Complaints from drafts and "colds" appear to have been aggravated by the introduction of double decked beds, presumably because barrack heating and ventilating systems are not well suited to high beds and crowded spaces.

The report further noted that in the barracks of temporary construction which were heated by force draft warm-air systems, the main air duct running centrally along the length of the room near the ceiling discharged air from side outlets with a velocity of between three and four hundred feet per minute, whereas the maximum allowable air movement was 40 square feet per minute according to standard engineering practice. Because of the resulting chilling effect, temperatures in the buildings had to be maintained at 70° or 80° F. for comfort. In the table of organization barracks, heated by stoves, the situation often was the opposite. Men on the upper bunks near the stoves became overheated, while men at a distance from the stoves were uncomfortably cool. Provision for ventilation of the table of organization barracks was inadequate and the heating systems in all types of barracks were fired by soldiers who were inexperienced and had had insufficient training.[74]

Professor Yaglou stated that there was no systematic study of representative winter air conditions in barracks and of the effect of these conditions on the health of men, and recommended that a survey be made of air conditions in representative barracks during the months of January, February, and March. An outline for the proposed study which detailed the questions to be explored in analyzing air conditions in barracks and possible corrective measures which

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[71] Minutes of 4th Meeting, NRC Committee on Sanitary Engineering, 3 Mar 43. HD: 040.
[72] Minutes of 5th Meeting, NRC Committee on Sanitary Engineering, 6 Apr 43. HD: 040.
[73] Minutes of 7th Meeting, NRC Committee on Sanitary Engineering, 14 Jun 43. HD: 040.
[74] See footnote 44, p. 49.

could be taken was presented. The proposed observations common to both the mobilization and table of organization barracks were:[75]

1. *Observation Areas.* Sleeping quarters of barracks to be divided into four or six equal zones and observations to be made in the center of each zone.

2. *Temperature Gradients.* To be measured at 2-foot intervals from floor to ceiling (a) in the center of each zone and (b) a foot from each wall along a vertical line near the middle of the wall.

3. *Air movement* in the center of each zone at bunk levels, by means of thermocouple anemometers, thermo-anemometers, or kata thermometers.

4. *Total outside air supply* in the center of each zone using the Wheatstone bridge conductivity method. In this method, a small quantity of a foreign gas having a high thermal conductivity, such as hydrogen or coal gas, is liberated into the space, and the rate of its disappearance as measured by the Wheatstone bridge gives a direct measure of the rate of air change.

5. *Weather conditions* including outside dry and wet bulb temperatures, wind velocity and direction, cloudiness, precipitation, etc.

Repeated efforts were made by the Preventive Medicine Service and by the Subcommittee on Atmospheric Control to initiate the studies recommended by Professor Yaglou. These met with no success, and on 3 March 1945 the deputy director of the Preventive Medicine Service addressed Dr. Lewis H. Weed, Chairman, Division of Medical Sciences, National Research Council, regretting that the investigation recommended by the subcommittee could not be accomplished that year. Since the problem was a long-range one, he suggested that by planning in advance, a well-organized study might be put into effect the succeeding winter by some Army group.[76]

Investigations on the effectiveness of glycol vapors under the auspices of the Committee on Sanitary Engineering were begun at Northwestern University, Chicago, Illinois, in July 1942. Small-scale field trial tests in a hospital corpsman school at the United States Naval Training Center, Great Lakes, Illinois, reported in March 1944, showed encouraging results as to the effects of glycol in reducing transmission of airborne infections and a reduction in the carrier rate for hemolytic streptococci among men sleeping in the glycolized barracks.[77]

Similarly, investigations on ultraviolet irradiation for air sterilization were begun under the auspices of the Committee on Sanitary Engineering on 15 December 1943 at the Naval Training Center at Sampson, New York.[78] By August 1944 the glycol studies of the committee had been discontinued. Ultraviolet irradiation, according to reports at that time, had been found to provide a decrease of between 15 to 35 percent in respiratory diseases in the barracks in which it was used.[79]

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[75] Minutes of Meeting, NRC Temporary Subcommittee on Atmospheric Control of the Committee on Sanitary Engineering, 16 Dec 44. HD: 040.

[76] Ltr, Actg Chief Prev Med Serv SGO to Dr. Lewis H. Weed, Div of Med Sciences NRC, 3 Mar 45. Filed as Appendix A to Minutes of 23d Meeting of NRC Committee on Sanitary Engineering, 5 Mar 45. HD: 040.

[77] Minutes of 14th Meeting, NRC Committee on Sanitary Engineering, 22 Mar 44. HD: 040.

[78] Minutes of 13th Meeting, NRC Committee on Sanitary Engineering, 28 Feb 44. HD: 040.

[79] Minutes of 18th Meeting, NRC Committee on Sanitary Engineering, 21 Aug 44. HD: 040.

The Army Epidemiological Board, through the Commission on Air-Borne Infections, carried out most of the research sponsored by the Army. The principal studies centered around the glycol vapors for air sterilization and the use of oils for the treatment of floors and bedding for the purpose of trapping pathogenic organisms.

Oiling of floors had been used in World War I, toward the end of which a standardized light oil had been adopted by the Quartermaster General's Office. This measure had been adopted, however, more to abate the nuisance of dust than for the specific control of disease through reducing the bacterial content of air. The sterilization of air by the use of germicidal mists and vapors originated in Lister's attempts to use phenol sprays in operating rooms as an effort to control wound infections.[80] Beginning in 1928, a number of investigators published results of their experiments using a variety of chemical agents. Germicidal aerosols were first reported in 1938 by Trillat [81] and by Masterman.[82] Among the agents used were resorcinol, sodium hydrochloride, hexylresorcinol, and alkyl sulfate. Alkaline propylene glycol was first used as a vehicle for hexylresorcinol and alkyl sulfate. English investigators in 1940 continued studies on the bactericidal mists and found that the influenza virus was susceptible to such aerosols.

Robertson at the University of Chicago in 1941 published the results of work on propylene glycol vapor and its effectiveness as an aerosol against a number of organisms including influenza A virus.[83] With the organization of the Commission on Air-Borne Infections, Doctor Robertson was selected to guide the researches of this group and, together with a number of collaborators and assistants, carried out extensive researches on air sterilization by propylene and triethylene glycols and on the effects of oils in reducing bacteria content of air when used on floors and bed clothing. The results of these researches have been published and appear in reprint form in the several volumes of the Army Epidemiological Board Collected Reprints (1943–1948) under the section on the Commission on Air-Borne Infections.

Field studies of this commission began at Chanute Field, Illinois, and later were transferred to Camp Carson, Colorado, to Peterson Field, Colorado, and to Fort Lewis, Washington. At Camp Carson it was established that the air bacterial count was reduced 70 percent in barracks with oiled floors when compared with similar barracks with unoiled floors. Oiling of both the floors and bedding gave a reduction of 90 percent in the bacterial count. Studies of the streptococcal content of air and blankets gave a similar reduction. In a

[80] Robertson, O. H.; Bigg, E.; Puck, T. T.; Miller, B. F., and Baker, Z.: Sterilization of air by means of germicidal aerosol mists and vapors. *In* American Association for the Advancement of Science. Aerobiology Publication No. 17, Washington, D. C., 1942, pp. 271-280.

[81] Trillat, A.: Les aérosols microbiens: applications. Bull. Acad. de méd., Paris 119: 64-74, 11 Jan 38. Also, Propriétés des aérosols microbiens: applications. Ann. d'hyg. 16: 49-62, Feb 1938.

[82] Masterman, A. T.: Air purification in inhabited rooms by spraying or atomizing hypochlorites. J. Indust. Hyg. & Toxicol. 20: 278-288, Apr 1938.

[83] See footnote 80.

group of 5,750 men living in barracks with oiled floors, there were 31 percent fewer hospital admissions for respiratory infections than in a comparable group living in untreated barracks. The reduction in hospital admissions was 50 percent when the additional measure of oiling of bedding was combined with oiled floors, together with a 42-percent reduction in positive streptococcal throat cultures in cases admitted to the hospital.[84]

A number of studies by investigators working under the auspices of the Commission on Air-Borne Infections gave similar results and it appeared that the oiling of bedclothes and floors gave a means by which airborne infections might be materially controlled through the reduction of the number of pathogenic organisms suspended in air inside buildings.

Similarly, investigations of Robertson and his group demonstrated that propylene glycol and ethylene glycol applied in small concentrations as an aerosol also resulted in drastic reductions in the bacterial content of air in buildings. The methods for producing aerosols, and devices for metering the aerosol into the air, were developed. Subsequently, it was shown that ethylene glycol was preferable to propylene glycol in that concentrations could be less. It was eventually selected as the preferred disinfecting aerosol. Toxicologic tests failed to reveal any untoward effects from breathing the glycols. Animals maintained in atmospheres of the glycols several times the concentration required for air sterilization for periods up to 18 months showed no ill effects. Fertility was not impaired; the animals gained weight; there were no respiratory signs or symptoms; and subsequent meticulous pathologic studies on sacrificed animals demonstrated no ill effects in any of the tissues.

Glycolization together with the oiling of floors and bedclothes gave maximum reduction in bacterial content of the air, up to 95-percent reduction being reported under some circumstances. Glycolization alone studied in a convalescent home for children showed a drastic reduction in cross infections caused by the streptococci when compared with control wards under similar conditions.

There was some evidence that the glycols were effective against the undetermined pathogenic organisms of the common upper respiratory diseases and influenza A, but the most drastic effects were observed in the streptococcal diseases caused by the beta hemolytic streptococcal groups.

Studies up to this point had been made under endemic conditions and had engendered much enthusiasm for these methods as effective means for the control of the airborne diseases.

More mature consideration, however, led the Army Epidemiological Board to the conclusion expressed by Dr. Kenneth Maxcy before the National Research Council meeting of the Committee on Sanitary Engineering on 4 June 1945 that the effectiveness of the glycol method in reducing the bacterial content of air under controlled conditions is unquestioned, but the limitations of

[84] Sanitary Engineering Rpt No. 10, NRC Div of Med Sciences, 17 Sep 45. HD: 040.

its application to barracks, hospital wards, and other places of assembly have not been fully explored. Furthermore, there had not been a critical trial of the method to determine whether it would reduce the transmission of respiratory infections.[85] Additionally, efforts to control an outbreak of respiratory diseases at Fort Bragg, North Carolina, in battalions of men under the observation of the Commission on Respiratory Diseases of the Army Epidemiological Board failed to show significant results between barracks in which floors and bedclothes had been oiled and untreated barracks. In the barracks under study, however, there had continued to be a 75-percent mean reduction in the bacterial air count during the period of maximum air contamination in the early morning, and cultures of treated and untreated blankets showed a 90-percent mean retention of bacteria by the oiled textiles. These results were in complete agreement with studies by Robertson and his group and others, but failed to explain why, under epidemic conditions, there had been little difference in the spread of upper respiratory diseases between the oil-treated and untreated barracks.[86] These studies showed that during the endemic period there had been an approximate reduction of between 30 and 40 percent in the cases of acute respiratory diseases from the oiled group as compared with the control group. In contrast, during the epidemic period, the reduction was between 6 to 12 percent. Thus it was concluded that as a practical measure, oiling of floors and bedclothes had a moderate influence in reducing the transmission of acute respiratory diseases during the period of low endemic incidence, but the method was not effective in the control of acute respiratory disease in new recruits during an epidemic phase.

It was therefore necessary to reexamine modes of transmission of airborne diseases and to consider that while airborne bacteria in association with dust from floors and bedclothes in living quarters did form a "secondary reservoir," it was an important source of infection during endemic periods, that a more primary reservoir probably inherent in the host himself came into play during epidemic periods, and that at these times transmission probably was still from person to person by actual contact.[87] (See Appendix A for full report of Fort Bragg study.)

Further study was made of bacteria in relation to dust, droplets, and droplet nuclei in the air as means of transmission.

The Navy studied the control of respiratory infections by ultraviolet irradiation of barracks at the United States Naval Training Center, Sampson, New York. A unit of 22 barracks with 4,400 men was divided into 4 groups—1 treated to high intensity ultraviolet irradiation, 1 to low intensity ultraviolet irradiation, and the other 2 serving as controls. The training period of only 5 weeks allowed only short observation of any group of men and in all some 30,000

[85] Minutes of Meeting, NRC Committee on Sanitary Engineering, 4 Jun 45. HD: 040.

[86] Supplement to Monthly Rpt of 1 Dec 44 [Commission on Acute Respiratory Diseases], sub: Control of respiratory diseases by oiling floors and bedding. HD: 621 Housing.

[87] See footnote 84, p. 69.

men passed through the unit between 15 December 1943 and 1 June 1944. The low intensity ultraviolet irradiation showed little effect but hospital admissions for respiratory infections in the high ultraviolet irradiation group were 25 percent lower than in the control group. For the first 2½ months of study, the illness rates were relatively high and the difference in the admissions between high intensity ultraviolet irradiated barracks and the controls was between 35 and 40 percent. Bacterial counts showed a reduction of about 50 percent in airborne organisms in the irradiated barracks when compared with control barracks. The study was continued into the winter of 1944–45. It was concluded that there was an average reduction of cross infection of about 18 percent. Further conclusions were invalidated because prophylactic sulfadiazine was administered to both the irradiated and control groups as a control measure against scarlet fever in January of 1945.

The studies at Camp Sampson also included the combination of ultraviolet irradiation with the oiling of floors and bedclothes. It was reported that dust counts during sweeping and activity showed a 34-percent reduction in the oiled as compared with the control barracks, and that the daily mean dust count was lowered by 41 percent. Bacterial counts were 75 percent lower in the oiled than in the unoiled barracks, most of the organisms being found near the floor and in decreased numbers towards the ceiling. Oiling materially reduced the numbers of alpha and beta hemolytic streptococci. These organisms were entirely eliminated from the air by combining oiling with ultraviolet irradiation.

For a 3-month period beginning in the latter part of February 1945, oiling reduced hospital admissions for respiratory infections by 13 percent when compared with untreated barracks. Oiling of floors and bedclothes combined with ultraviolet irradiation of air reduced hospital admissions by 29 percent. Caution was necessary in interpreting these results because of the short duration of the period of the study and the fact that some of the control barracks were supplied with oiled blankets and some of the test barracks were issued unoiled blankets. It was concluded, however, that the combination of oiling of floors and bedclothes with ultraviolet irradiation influenced the reduction of airborne infection.[88]

Conclusions drawn at this time were that both ultraviolet irradiation and ethylene glycol vapor in association with oiling of floors and blankets gave promise as substantial methods in the control of airborne infections under certain conditions in military housing and that further study was required to evaluate completely their effectiveness and best methods of use. There was considerable question as to whether treatment of sleeping quarters alone was

[88] (1) Hamburger, M. Jr.; Robertson, O. H., and Puck, T. T.: The present status of glycol vapors in air sterilization. Am. J. M. Sc. 209: 162-166, Feb 1945. (2) Wheeler, S. M.; Ingraham, H. S.; Hollaender, A.; Lill, N. D.; Gershon-Cohen, J., and Brown, E. W.: Ultraviolet light control of air-borne infections in a Naval training center. Am. J. Pub. Health 35: 457-468, May 1945. (3) Minutes of Meeting, NRC Temporary Subcommittee on Atmospheric Control of the Committee on Sanitary Engineering, 20 Aug 44. HD: 040.

sufficient or whether these measures should be applied to all housing where congregation of personnel occurred for any appreciable periods of time, such as messhalls, movies, post exchanges, and lecture rooms.

Oiling of floors and bedclothes received better acceptance since it was a simple, inexpensive procedure which had proved its usefulness in reducing dust, lint, and bacterial content of the air and could be easily applied without added special equipment or specially trained personnel.

The floor oil which came to be accepted by the Army Epidemiological Board was a pale paraffin oil which met the following Government specifications: Flash point in degrees Fahrenheit, 300 or more; viscosity at 100° F., 70 to 110; pour point degrees Fahrenheit, 30; color, pale lemon. The general requirements were that the oil should be clear, well-refined petroleum oil, free from foreign matter, and have no objectionable odor.[89]

Oil for the treatment of blankets was prepared as an oil-in-water emulsion designated as the "T-13 formula," the contents of which were mineral oil (Fractol A), 87 percent and Triton NE (emulsifying agent), 13 percent by weight. The emulsion was diluted for the final laundry rinse water and required no deviation from routine laundry procedures in the handling of woolen or cotton textiles. The process added an additional cost of 1½ cents per pound for woolen and ⅜ cents per pound for cotton fabrics for the initial treatment, and only $\frac{1}{10}$ cent and ⅛ cent for woolens and cottons respectively for subsequent launderings. Woolens required little or no aftertreatment, while cottons had to be re-treated after each use. The treatment caused no distinguishable change in appearance of the materials, added only 2- to 5-percent weight in oil to the blankets, and no evidence was produced that skin irritation resulted in the user.[90]

At the meeting of the Committee on Sanitary Engineering on 17 September 1945, Professor Yaglou briefly summarized the position of research on control of airborne infections in buildings by stating:

> Glycolization of air in combination with oiling of floors and bed clothes appeared to be but little more effective than oiling alone. Such oiling measures reduced respiratory diseases of bacterial origin but not of virus origin in Army camps and Station Hospitals.
>
> Ultraviolet radiation is effective against virus-containing droplet nuclei, and its efficacy is likely to be increased by combining radiation with dust control measures. Results of tests by the Navy and National Institute of Health are not as yet conclusive on this point, and continuation of these studies is therefore well justified.

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[89] (1) Memo, Brig Gen S. Bayne-Jones, Prev Med Serv SGO, for Dir Sanitation and Hygiene Div SGO, 19 Oct 44, sub: Standardization of oil for treatment of floors, with incl rpt, 18 Sep 44, sub: Treatment of floors with oil, materials and methods recommended by the Commission on Air-Borne Infections, AEB. HD: 621 Housing. (2) Loosli, C. G., and Robertson, O. H.: Recent studies on the control of dust-borne bacteria by treatment of floors and bedclothes with oil. Am. J. M. Sc. 209: 166–172, Feb 1945.

[90] (1) Loosli, C. G.: Dust and its control as a means of disinfection of air. Am. J. Pub. Health 37: 353–359, Apr 1947. (2) Puck, T. T.; Robertson, O. H.; Wise, H.; Loosli, C. G., and Lemon, H. M.: The oil treatment of bedclothes for the control of dust-borne infection. I. Principles underlying the development and use of a satisfactory oil-in-water emulsion. Am. J. Hyg. 43: 91 104, Mar 1946. And Loosli, C. G.; Wise, H.; Lemon, H. M.; Puck, T. T., and Robertson, O. H. The oil treatment of bedclothes for the control of dust-borne infection. II. The use of triton oil emulsion (T-13) as a routine laundry procedure. Idem. 43: 105 119, Mar 1946.

A resolution adopted by the Subcommittee on Atmospheric Control urgently recommended continuation of comprehensive studies on the control of airborne infections.[91] At the 9 November 1945 meeting of the committee, it was reported that The Surgeon General of the Navy had authorized two studies to be conducted at the United States Naval Training Center, Great Lakes, Illinois: one, a study of dust control by the oiling of floors and blankets; the other, a study of ultraviolet light, using the equipment originally employed at Sampson Naval Training Station, New York. It was further noted that the Army Epidemiological Board was guiding a control study on the use of triethylene glycol vapor at the Harriet Lane Home in Baltimore, Maryland.[92] By January 1946, the Army had discontinued all field studies on the control of airborne infections.[93]

At the end of the war period, the position of research on atmospheric control was summarized at a meeting of the Committee on Sanitary Engineering.[94] Although the current methods of sterilization of air were capable of reducing the bacterial count by as much as 95 percent, much additional work was needed before their value could be assessed in terms of reducing the attack rate from various respiratory diseases.

The indirect transmission of infection by airborne droplet nuclei and dust was not the only mechanism involved, and its relative importance in comparison with direct transmission by contaminated objects from hands to mouths was as yet unknown and probably varied with different bacterial and virus diseases. Even to control indirect airborne transmission would require treatment not only of sleeping quarters in barracks but of other confined spaces in which men congregate, such as messhalls and drillhalls, ship's service buildings, post exchanges, dispensaries, and washrooms.

Although oiling of floors and bedclothes had been shown to be effective in reducing the bacterial content of the air, its value in preventing transmission of infection was still undetermined. While it appeared to be useful in reducing incidence of bacterial infections such as those caused by the hemolytic streptococcus, recent experience at Fort Bragg had indicated that this method was ineffective in reducing the spread of acute respiratory disease, which commonly occurs among recruits when they are assembled in barracks during the winter months.

Two primary conditions were considered necessary for effective application of ultraviolet radiation in the disinfection of air: (1) Radiation must be supplemented with dust suppression measures, since ultraviolet is not efficient against bacteria in virus protected by dust; and (2) radiation intensity must be high but not so high as to affect the eye or skin.

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[91] Minutes of Meeting, NRC Committee on Sanitary Engineering, 17 Sep 45. HD: 040.
[92] Minutes of Meeting, NRC Committee on Sanitary Engineering, 9 Nov 45. HD: 040.
[93] Minutes of Meeting, NRC Committee on Sanitary Engineering, 14 Jan 46. HD: 040.
[94] Minutes of Meeting, NRC Committee on Sanitary Engineering, 25 Feb 46. HD: 040.

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It was recommended that the possibilities of reducing the spread of respiratory diseases by high intensity ultraviolet radiation be further evaluated in combination with dust control and by treating not only the sleeping quarters but other places where men congregate. It was considered also highly desirable that the value of germicidal vapors be tested in a similar manner since the evidence then available did not clearly indicate whether this method was or was not more effective for this purpose than ultraviolet radiation.

The Committee on Sanitary Engineering closed out its wartime activities with a report on the heating and ventilation of a new barracks developed at Fort Belvoir, Virginia. The barracks allowed 80 square feet of gross floor area and 600 cubic feet of gross cubic space per man with a single bunking arrangement but included plans for emergency double bunking. Partitioning panels between bed spaces, 10 feet long and 5 feet high, spaced 10 feet apart, characterized the interior arrangement of the lower dormitory. The committee felt that the partitions should be extended to the ceiling in an additional trial barracks, and studies made as to ventilation, heating characteristics, and the spread of disease. Facilities for ventilation were considered adequate and provision had been made for a large circulation rate for air, being on the order of 20 cubic feet per man of outside air plus recirculation of inside air. Heating was by mechanically stoked coal heater which automatically retained desired temperatures, under the control of a thermostat. It was the general consensus of the committee that the equipment and general interior appointments of the barracks were excellent and that a great improvement had been made over the old mobilization and temporary officers' barracks, but at a considerable increase in cost.[95]

[95] Appendix A to Minutes of Meeting, NRC Committee on Sanitary Engineering, 8 Apr 46. HD: 040.

CHAPTER III

Water Purification

*William A. Hardenbergh**

WATER SUPPLY IN THE UNITED STATES ARMY BEFORE WORLD WAR II

A review of the background of field water supply in the United States Army is helpful in evaluating the methods in use in the early part of World War II and in indicating the necessity for progressive changes to meet the conditions encountered during the war. In the Civil War, as in the preceding wars in which this country was engaged, each soldier was responsible for his own supply of water in the field. There is some evidence that in one case at least—Jackson's march from Frederick Hall to Mechanicsville on his way to the Seven Day's Battle—scarcity of water influenced the result of the battle. Jackson's troops, marching through an exceedingly dry country, frequently broke ranks to drink from the roadside wells. This delay and the general lack of water caused Jackson to arrive nearly a day late at his rendezvous.[1]

In the Spanish-American War, the same general policy of individual water supply was maintained. In World War I, with the heavy concentration of troops in limited areas—as many as 400,000 men in an army area of 20 or 25 square miles—local supplies were no longer sufficient. Engineer water supply regiments were formed to meet this situation. Their duty was to procure water from the rear area and haul it forward to the troops. Generally one water point was established in the rear of each brigade and the water hauled to the frontline troops in 110-gallon mule-drawn carts.[2]

During the period between World Wars I and II no marked changes were made in these field water supply procedures. But with the development of highly mobile units, such as tank and armored divisions, it became apparent that the relatively fixed method of supply from a water point would be unsuitable. Following the use of lightweight filters by the Sanitary Corps at Carlisle Barracks, Pennsylvania, from 1935 to 1938, the Fort Belvoir (Va.) laboratory of the Corps of Engineers developed the portable sand filter to supplement the mobile purification unit.[3] This smaller unit was advantageous in that one could be allotted to each combat team so that each major portion of a division

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[1] Freeman, Douglas Southall: Lee's Lieutenants. New York, Charles Scribner's Sons, 1942, vol. 1, pp. 506, 509.

[2] The Medical Department of the United States Army in the World War. Washington, Government Printing Office, 1926, vol. VI, pp. 772–820.

[3] The reports on this work were filed at the Medical Field Service School, Carlisle Barracks, Pennsylvania, in 1935, 1936, 1937, and 1938, but have since been destroyed.

could be made self-sustaining so far as water supply was concerned. These portable and mobile units, both of which showed certain deficiencies, will be considered later in this chapter.

The problems of supplying water for an army engaged in warfare in the remote and uncivilized portions of the world are serious. Psychologically neither the Army nor the water supply profession was ready in 1940 to meet them. The Army had given small consideration to the possibility of fighting in the Pacific islands, China, Burma, and elsewhere, or to maintaining installations in such areas as South America and Africa. Sanitary engineers in the United States had had little experience in overseas water supplies, and almost none in the provision of rapidly constructed supplies such as are necessary to meet the needs of service units and other overhead installations in the field.

The result of this inexperience was a tendency to exaggerate and overestimate the problems that would be encountered. In considering the fact that all water sources in such areas as New Guinea, India, or China are contaminated, it is not always realized that the same conditions exist in this country and that it is not safe to drink untreated water from any stream in the United States. Furthermore it was not realized that water treatment problems are even more difficult in this country because sewer systems discharge concentrated loads of organic pollution into rivers which are later used for water supply. Because sewers are lacking in practically all areas in the Pacific islands, Africa, South America, India, and China, surface waters, though contaminated, do not present as difficult a treatment problem as do those in the United States. The Ohio River, for instance, which is used successively by a number of large cities as a means of sewage disposal and then of water supply, has no counterpart in the overseas areas in which the United States Army fought.

The situation then was to view the problems likely to be encountered overseas in their proper light and to appreciate that the application of standard methods of water purification was required wherever American troops were located, and that the application of these methods would result in a water as safe and satisfactory as that to which troops are accustomed in this country. This is true of both field supplies and fixed installations. Some additional problems had to be solved in individual water purification, particularly canteen sterilization, because of the prevalence overseas of amebic cysts and other chlorine resistant organisms, and of the conditions imposed in combat areas by military needs.

MEDICAL DEPARTMENT RESPONSIBILITIES IN THE PROCUREMENT OF WATER

The procurement of water in wholesale quantities is the basic responsibility of the Corps of Engineers.[4] In the past it had been considered the

[4] AR 100-80, 9 Jun 42, and subsequent revisions.

responsibility of the Medical Department to make occasional tests of water delivered by the Corps of Engineers and, in addition, to supervise the treatment of retail water supplies—that is, the Lyster bag and canteen. Obviously, such a limited application of Medical Department responsibility ignored the many factors which might affect health in the provision of wholesale water supplies. Since it was necessary to establish major operating bases and service troops constituted a large part of our overseas forces, a broader interpretation of Medical Department responsibility was necessary.

The Medical Department organization at the beginning of the emergency was inadequate to assume responsibility for the provision of safe water to our troops, either in the field or at fixed installations. The surgeons or other medical officers at posts, camps, or stations, or attached to units, made inspections of water procurement and treatment facilities and in most cases took routine samples of the water and forwarded them to the laboratories for testing. In accordance with Army Regulations (AR) 40–205, 31 December 1942, when Lyster bags were used, the water was frequently tested to determine the residual chlorine. However, the general difficulty of handling liquid orthotolidine and the lack of suitable reagents prevented a satisfactory degree of control. In the field, samples were not normally taken for bacteriologic analyses but at fixed installations this was done fairly frequently.

Since little attention was given to recording regularly the results of water analyses and minimal consideration was given to the quality of operation at fixed plants, a treatment policy based on the record of water quality at any post or station was impossible. The provisions of War Department Technical Manual (TM) 8–227, 17 October 1941, which stated the manner of reporting water analyses, in effect fixed the standards of potability of Army water supplies. This fixing of standards was unjustified not only because a technical manual should not determine such important policies, but because the insistence upon bacterial count as a standard of quality resulted in a great deal of inconvenience and confusion. The report of a nonpotable sample not infrequently resulted in the entire personnel of a post being ordered to use Lyster bags, irrespective of the past good record of the water supply or the efficiency of the treatment plant.

The production of safe water is basically dependent upon the purification plant and its operation. The plant must be designed to render the water safe under conditions of heavy water demand and most severe contamination. Design must also contribute to operation by making good operation easy, and incorrect and unsafe operation difficult. The plant must contain no sanitary defects; it must be operated by skilled personnel; and the purified water must be protected against recontamination until it is consumed. Without these essentials as a basis, mere routine inspection and sampling are useless. For this reason, in order to accomplish Medical Department control of water

quality, the responsibility of the Medical Department had to be extended to cover the factors enumerated above.

A cooperative relationship was therefore established with the Corps of Engineers covering these factors, and also the development of better field water supply and purification equipment and the operation of this equipment. The functions of the two organizations were delineated in 1941 and published by the Corps of Engineers in the editions of its "Repairs and Utility Manual" issued in 1942 and 1944. In the application of this program, the responsibilities of the Medical Department were extended to include the following:

1. Sanitary surveys and approval of the sources of water supply.

2. Design factors for water purification plants and equipment to insure that construction, whether for field service or for fixed installations, was based on recognized sanitary engineering principles, assuring the production of safe water.

3. The sanitary safety of the plants producing such water. (This involved a continuing sanitary survey of fixed installations and the detection and immediate correction, in cooperation with the Corps of Engineers, of sanitary hazards and defects.)

4. The adoption of policies having an influence on the safety of the water, such as pretreatment to insure the production of a water that could be effectively chlorinated, the application of chlorine or other sterilizing agents, and the detection of toxic and poisonous agents.

5. Skilled operation of both field and fixed water supply installations, including cooperation in training operating personnel and frequent surveys and checks to maintain a record of operation on which to base further action.

FIXED WATER SUPPLIES

Policies Regarding Plant Design and Selection of Water Sources

A primary factor in design is determination of the amount of water to be supplied. It was believed that fixed water supply installations should normally be capable of supplying, for the estimated maximum strength, the amounts indicated below: [5]

	Gallons per capita per diem
Airfields, camps, and cantonments (mobilization type)	100
Airfields, camps, and cantonments (table of organization type)	70
Permanent and other fixed posts	150
Armored division posts	150
Hospitals (beds plus personnel)	150
Animals	25
Plants, ports, and storage:	
for each 8-hour shift	35 to 50
for resident population	100

[5] Engineering Manual, OCE, 19 Jul 44.

Further requirements in regard to supply included the following:

1. The source of supply was to be approved by The Surgeon General.

2. When wells were used, well capacity was to be sufficient to supply the total daily water requirement in 16 hours; there were to be at least two wells, and standby power was to be provided for at least one-half the wells.

3. When surface water supplies were proposed, the watershed yield was to be sufficient to provide 150 gallons per capita per day.

4. Actual or potential sewage contamination was to be avoided, particularly sewers so located that overflow or structural failure would discharge sewage to the stream or the storage reservoir.

5. Reservoirs and their immediate tributaries were not to be subject to direct surface wash from inhabited portions of the camp or from adjacent communities, stables, or hog farms.

A distribution system, in order to meet heavy demands without creating negative pressures, was to be designed so that its lines would have a capacity 2½ times the expected average daily requirement, with a residual pressure of not less than 30 pounds, basing design on $C=100$ in the Hazen-Williams formula. Cross connections with a sewer system or with any unapproved water supply were always prohibited. Waterlines and sewerlines were not to be placed in the same trench, and preferably not nearer than 10 feet horizontally and 6 feet vertically to each other, unless the sewerline was of cast iron with leaded joints. All newly laid pipes and newly constructed storage tanks were to be disinfected before use, employing standard methods and a concentration of at least 50 parts per million of chlorine. When jute was used for making joints, it was to be disinfected, preferably by live steam under 15 pounds pressure.

Dual systems had to be specifically approved for each installation by The Surgeon General and the Chief of Engineers. These were not constructed except for the most cogent reasons; after approval as indicated above, and after construction, all hydrants and exposed piping of systems carrying unsafe water were painted a distinctive color and appropriately labeled in accordance with a standard procedure, indicated in the safety code of the American Society of Mechanical Engineers.

Storage is desirable to minimize the effects of power or pump failure or a major break, and good practice dictates the following requirements: With adequate standby power and pumping facilities, or with a gravity supply available, elevated storage should not be less than one-half the average daily consumption. Where standby facilities or a gravity reserve supply are not available, storage should be available for 3 days of average consumption. Adequate pumping and power facilities were deemed to be a minimum of three pumps, of such capacity as to permit full operation with the largest unit out of service; and standby power, preferably gasoline or diesel of sufficient capacity to drive pumps having a capacity of at least one-half the average daily consump-



Figure 8A. Salinas River Dam. Water supply for Camp San Luis Obispo, California.

tion. Pumping stations should be designed to prevent the entrance of contaminated water under all reasonable conditions.

Adequate and thorough pretreatment before filtration was required, including coagulation, mixing or flocculation, and settling — normally for 4 hours, but with shorter periods permissible under special conditions. The design of rapid sand filters was required to follow standard practice, with a sand bed

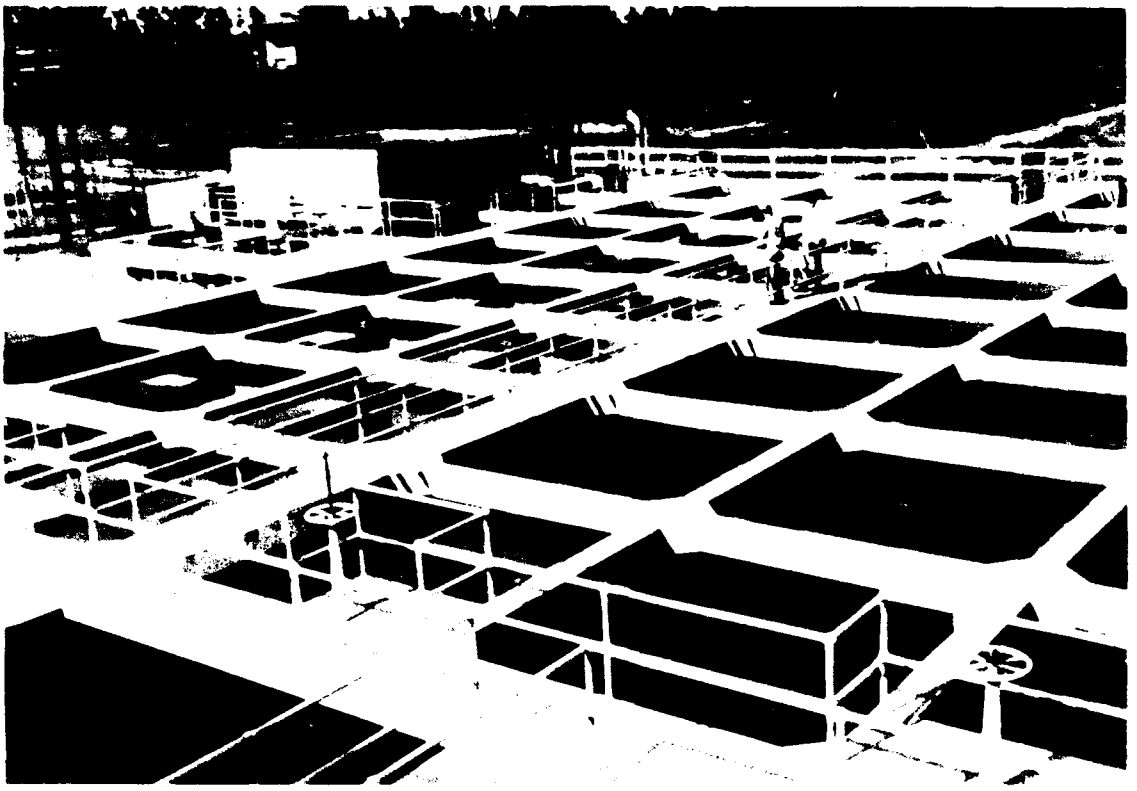


Figure 8B. Aerator and section of settling basins, water treatment plant, Camp Livingston, Louisiana.

24 inches thick, and with the effective size of the sand 0.40 and 0.50 mm. and the uniformity coefficient 1.6 to 2.0. The standard wash-water rate was established at not less than 15 gallons per minute per square foot; rate controllers were required; normal operating rates for rapid filters were 2 gallons per minute per square foot of filter surface and were not to exceed 3 gallons. So far as possible pretreatment for and design of pressure filters was made to conform to the standards established for gravity filters, with a maximum rate of operation of 6 gallons per minute per square foot. Slow sand filters were limited to 6 million gallons per acre per day with sand of effective size 0.25 to 0.35 mm., uniformity coefficient 2.5 to 3.5, and a minimum depth of 20 inches.[5]

The formulation of these policies and their practical application to the construction program of the Army required some time. Meanwhile new camps, and water treatment plants to serve them, were being built and other pressing problems, having to do largely with water sources, arose. As already stated, a water plant must be designed to purify a specific water. Therefore, studies had to be made of the probable quality of the raw water, as regards organic contamination, after the camp was built in order to assure that the treatment plant would always provide safe water.

[5] Engineering Manual, OCE, July 1941

A principal difficulty at this stage involved the selection of water sources for the proposed cantonments. Consideration had to be given not only to the population already contributing contamination to the watershed in the case of surface supplies, but also to the situation that could reasonably be expected after the construction of the camp. Experience had shown that a large subsidiary population (approximately 30 percent of the camp population) accumulated around an Army camp and that this population was not normally provided with adequate sewerage facilities. Consequently, it was to be expected that surface waters in the vicinity of the camp would become heavily contaminated.

Another factor of importance was the amount of water available. It was realized that the initially planned size of a camp was often exceeded—sometimes it would be 2 or 3 times as great as was expected. For that reason, and also because the construction of large storage reservoirs as a wartime project for camp water supplies is not normally possible, careful studies had to be made of the amount of water available. These studies involved runoff, rainfall, and evaporation and other losses. In a number of cases provision also had to be made for an adjacent civilian population. This was especially the case when the camp was located near a small community. The sudden and tremendous growth resulting from establishment of the camp practically precluded the construction of a community water supply system and necessitated provision of water by the Army in order to prevent disease epidemics.

Ground waters were given preference as a source of supply wherever they were available. Not only did this lower the initial investment in money and in critical materials, but it also reduced the difficulties of contamination incident to the increase of population around the camp. Moreover, treatment procedures were simplified or their necessity avoided altogether. Where the mineral content of the water was such as to interfere with effective chlorination, or to corrode or clog water piping, treatment for the removal of these minerals was necessary.

In a number of cases, it was possible to purchase water from nearby municipalities, and whenever feasible this was done to conserve construction material, reduce initial costs, and save time. Experience indicated that municipal water supplies, while accomplishing these objectives, were subject to some shortcomings. For example, the quantity of water available for Army use often fell below the initial estimate, either because the actual capacity of the plant was overestimated, or because the increased water usage caused by growth in city population as a result of the construction of the camp was not considered. The quality of the water was often below Army standards due to defects in the plant or the system, lack of adequate chlorination, faulty operation, or the inability of the plant to produce consistently satisfactory water when operating

at maximum capacity.[7] When estimating the capacity of a plant, consideration had to be given not only to filter area and capacity, on the basis of 24-hour production, but to peak loads according to Army needs, clear well or other storage, and pipeline capacity to meet these needs.

Surveys of Plants by the Sanitary Engineering Division

With the matters of plant design and selection of water sources handled adequately by cooperation of the Medical Department with the Quartermaster Corps and the Corps of Engineers, the Sanitary Engineering Division, Office of The Surgeon General, undertook the second step in the program by initiating sanitary surveys of all existing plants. This was in accordance with the requirements of AR 40–205. A letter was sent to all service commands on 8 August 1941 directing that "essential information regarding water supply . . . plants be obtained and transmitted to the office." [8] An outline sheet was attached indicating the information that was desired and it was suggested that, since to be of value the data must be prepared by trained sanitary engineers, the Sanitary Corps engineers then on duty be utilized for this work. The initial survey covered about 128 plants but this program was later expanded to include practically all installations serving the Army. Resurveys were generally made annually as a routine matter.

Numerous defects were located by these surveys, including cross connections, improper features of design, lack of protection for wells and storage reservoirs, and defects in the plants themselves. At first the reports, with recommendations for corrective action, were forwarded through the service command surgeons to the Sanitary Engineering Division. These were then examined and forwarded to The Quartermaster General for correction. So much time was consumed by this procedure and such a burden of work placed on higher echelons that, at a conference with The Quartermaster General, it was determined that a policy should be adopted to insure that the maximum number of defects be corrected at the station level.

Accordingly, directions were issued that the Sanitary Corps engineers making the surveys would present their findings and recommendations to the post engineer and that a memorandum by the post engineer would accompany the report to the service command surgeon.[9] By this means all but a small proportion of the corrections were accomplished locally. Only those defects requiring major changes reached service command level, and only a very few had to be forwarded to the Office of The Surgeon General.

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[7] Rosecrans Field, Army Air Base, Air Transport Command, for example, experienced difficulty in maintaining adequate chlorination of its water supply as described in monthly sanitary reports from that field in 1943.

[8] Ltr, SG to Surg 1st CA, 8 Aug 41, sub: Sewage and water supply installations at camps, posts, and stations, with 2 incls. HD: 720 Water.

[9] Memo, SG for Surg 1st CA, 1 Jul 42, sub: Sewage and water supply installations at camps, posts, and stations. SG: 720.2-1 (1st CA) AA.

The reports received were usually very complete and included a description and map of the area, information on the population served, the daily consumption of water, a complete description of the source of supply, and a detailed technical description of the treatment methods. Pictures frequently accompanied the report.[10] At the same time that the water survey was made a similar survey was made of the sewerage and sewage disposal facilities.

Chlorination of Fixed Supplies

The value of adequate chlorination to safeguard the quality of water has long been known. Civilian use of chlorine for this purpose has normally been on a marginal basis; and in some cases on little more than a token basis. At the opening of the war, Army regulations did not specifically require chlorination of all fixed water supplies, such as at posts, camps, and stations, although it was accepted procedure. Chlorination of water obtained under field conditions was prescribed in detail. The work done by the Sanitary Corps at the Carlisle summer camps between 1935 and 1938 had indicated the value of chlorine as an agent in the detection of most warfare gases and of many poisons. If such warfare agents or poisons were injected into a water supply, inability to maintain a chlorine residual would indicate their presence. Similarly the introduction, intentional or otherwise, of organic matter containing pathogenic organisms, in the presence of a chlorine residual would result either in the destruction of the organisms or in loss of the residual due to its reaction with the organic matter. It was thus felt that two important results would be obtained by the universal use of chlorine in Army water supplies. First, the quick detection of added contaminants through sabotage; and secondly, the destruction to some extent of pathogenic bacteria introduced by design or reaching the water through cross connections or some accidental source. For this and other reasons a policy was established requiring that all water in fixed Army water supply systems be chlorinated to produce a residual of not less than 0.4 part per million in commonly used parts of the water system.[11] The residual requirement was based upon results of a poll made of all service command sanitary engineers.

An additional element of great importance was the fact that practically every municipal plant supplying water to the Army, as well as a large proportion of Army plants, was operating close to, at, or even over its design capacity. Under such conditions of loading, defects in design, construction, and operation are most apt to show up. It is believed that this factor alone was sufficient reason and justification for the chlorination requirement.

While this blanket requirement for chlorination proved to be one of the most important factors in producing a high quality of water for Army installa-

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[10] For example see: Rpt, Camp Joseph T. Robinson, Ark., 26 Sep 41, sub: Water supply, with 1st ind, Surg 7th CA to SG, 10 Oct 41. HD: 720 Water.

[11] Ltr, CofEngrs to CG 1st SvC, 21 Oct 42, sub: Chlorination of water supplies. CE: W&S, R&U.

tions, it was the cause of much contention. Many cities, proud of the quality of their water, objected to the requirement for chlorination or rechlorination. The waterworks industry generally opposed the procedure contending that such heavy use of chlorine would cause a revulsion against it. Many service commands and stations objected because of cost and predicted that chlorinous tastes would make some waters nonpotable.

Fortunately none of these objections proved to have a sound basis. The cost was extremely small as compared to the benefits derived in the prevention of disease, and very few stations reported serious taste difficulties.

The requirement for chlorination as issued, provided that all water supplied to posts, camps, stations, and other Army installations be chlorinated as follows: [12]

1. Except as specified below, the following chlorine residuals, as determined by standard test methods, were to be maintained in those parts of the distribution system in active or continuous service. Where chlorine alone was used the residual would be 0.4 part per million. An initial contact period of not less than 30 minutes between the chlorine and water were to be provided prior to use. If ammonia was used to remedy chlorinous tastes, it would be added following the 30-minute contact period. Where chlorine and ammonia were added approximately simultaneously to form chloramines, or where ammonia was present in the raw water to the extent that a substantial portion of the chlorine residual was in the form of chloramine, the residual would be 0.6 part per million and an initial contact period of not less than 1 hour provided prior to use of the water.

2. Parts of the system in active or continuous use were considered to be laterals, submains, or mains serving kitchens, barracks, messhalls, and similar installations. When testing to determine compliance with these requirements for residual chlorine, water was allowed to run from fixtures until the local connection was cleared. The amount of residual chlorine was not to be judged by samples taken from dead ends, unused mains, fire hydrants, or similar places.

3. Upon approval of the commanding general of the theater, base command, department, or service command, based upon bacteriologic examination of the water to determine uniform compliance with Army standards of potability, and on a sanitary survey and report when deemed necessary, the above requirements could be modified as follows:

a. When water had been initially chlorinated by the Army to a minimum residual of 0.4 part per million after 30 minutes contact, the maintenance of a chlorine residual of 0.4 part per million throughout the active parts of the distribution system were not required where: Mains were excessively large for usual needs and the water was consequently retained in the distribution

[12] Ltr, CofEngrs to CG 4th SvC, 21 Jun 43, sub: Chlorination of drinking water supplies at fixed Army installations', HD: 720 Water.

system for such periods that maintenance of the required residual had been shown to be not reasonably possible; where properly protected storage reservoirs float on the distribution system and maintenance of the required chlorine residual in them, or in that portion of the distribution system supplied by them, had been shown to be not reasonably possible; or where iron, sulfur, or other mineral chlorine-consuming compounds present in the water prevent maintenance of the required residual, provided that such compounds were not of such character or in such amount as to prevent effective initial chlorination. Under these conditions a chlorine residual would be maintained so far as practicable.

b. The rechlorination by the Army of water supplied from municipal or privately owned systems to posts, camps, and stations located within the network of such systems, would not be required, provided: The water furnished by the municipal or private supply uniformly met Army standards of potability; all water so furnished had been chlorinated; and no serious physical or operational sanitary defects existed in the municipal or private water supply, treatment, or distribution system, or in the distribution system of the Army installation, as determined by a sanitary survey and report.

4. The specified chlorine contact period requirements could be modified to provide only the maximum practical contact period prior to use without the construction of contact reservoirs, for: Supplies from wells that were Army-owned and -operated, located on Army reservations, and were properly constructed and protected against contamination; and for chlorinated water obtained from municipal or privately owned systems for which rechlorination was necessary to insure Army standards of quality.

When these residuals were difficult to maintain without the creation of chlorinous or other tastes and odors, consideration was given to breakpoint chlorination. Residuals resulting from breakpoint chlorination were generally maintained at about 0.3 part per million free chlorine, and tests for free chlorine were later made by the orthotolidine-arsenite method.

In general, solution feed chlorinators, using gaseous chlorine, were recommended but in the case of small water supplies, hypochlorinators were used. Where continuous chlorination was required, standby chlorinating apparatus was provided, and also essential spare parts. Chlorinators were generally installed, preferably near interior walls, in separate rooms with a door opening outside as a safety measure. Heating apparatus was provided when needed in order to maintain a temperature not less than 50° F. in the chlorinator room. First aid equipment and a gas mask were available in an accessible place close to, but not in, the chlorinator room. The standard World War II Army gas mask canister protected against chlorine, but not against ammonia, therefore, where ammonia gas was used as an adjunct to chlorination, a special canister was necessary.

Operation of Plants

Good design and the absence of defects alone are inadequate to produce a safe water; skilled operation also is necessary, even with chlorination. Appreciating the need for such trained personnel, the Corps of Engineers established standards for operators.[13] So far as possible, the Sanitary Engineering Division, Office of The Surgeon General, cooperated in the procurement and training of operating personnel. Applicants for commissions in the Sanitary Corps who did not meet physical or educational requirements but had suitable experience in water plant operation were referred to the Corps of Engineers for employment as civilians.[14] The facilities of the Sanitary Engineering Division for contacting technical personnel were utilized. As a result, needs for skilled operators were reasonably well met.

Training programs and schools were developed by the Corps of Engineers to establish standards of operation and to increase the skills of the operators. In many of these schools, especially the earlier ones, the Sanitary Engineering Division cooperated by assigning personnel as instructors. There was also some in-service training, utilizing the post Sanitary Corps engineer to assist the operator. In a few cases, where operators lacked experience or serious operating problems existed, the Sanitary Corps engineer was specially selected and assigned to the post because of his knowledge of water treatment. In a few cases personnel was loaned. Thus, the fullest degree of cooperation existed between the Sanitary Engineering Division, Office of The Surgeon General, and the Repairs and Utilities Division, Office of the Chief of Engineers, and this same cooperation extended to and throughout the service commands

Laboratory Facilities

Adequate space, personnel, and equipment were recommended, and generally provided, for necessary laboratory determinations to control the quality of the water. In general, provision was made for determination of pH, turbidity, alkalinity, acidity, odor, and color. Bacteriologic testing facilities were usually available at the larger plants and always available within reasonable shipping distance in a Medical Department laboratory.

Testing Program

The Medical Department being responsible for tests to determine the safety and potability of water used by military personnel, the surgeons of theaters and other commands were required to arrange for an adequate sampling and testing program. Corps of Engineers personnel performed operational tests necessary in the procurement of water and the operation of treatment

[13] OCE Cir Ltr 1946, 15 Aug 42, sub: Regulations governing personnel for post engineer offices.

[14] Operators wanted for Army sewage and water plants. Pub. Works 72: 54-55, Jun 1941.

plants. Medical Department laboratory facilities were made available to the Corps of Engineers. Actually, in most service commands, arrangements were made whereby a joint sampling and testing program was carried on.[15]

Frequency of Testing. In general, samples for bacteriologic examinations were required to be taken from the distribution system at fixed installations on the basis of 1 sample per month per thousand strength, with a minimum of 10 samples per month for each installation. The number was modified in relation to the skilled supervision immediately available, character of the source of the water, adequacy of treatment facilities, and type of protection in the distribution facilities. Under field conditions, samples for bacteriologic analyses were taken as directed by the surgeon of the unit involved.

Standards of Quality. The Army standards of water quality were contained in TM 8–227, "Methods for Laboratory Technicians," 17 October 1941, which based potability on bacterial count as well as presence of organisms of the coliform group, a procedure not recognized by public health agencies. Since revision of the entire manual was under consideration, it was deemed expedient to take immediate corrective action by War Department circular. Consideration of bacterial counts was restricted to waters examined within 6 hours, if impure, and 12 hours if relatively pure, after collection.[16] More workable and modern standards of bacteriologic quality were prepared, the standards were eliminated from TM 8–227, and as soon as the revised edition of this manual was issued[17] the following standards were adopted:[18]

At fixed installations water may be considered satisfactory from the bacteriologic standpoint when not more than 10 percent of the total number of portions of samples examined during the preceding 30 days show the presence of organisms of the coliform group. However, if 3 or more of the portions constituting a single sample show organisms of the coliform group, the water should be considered nonpotable if this occurs in consecutive samples or in more than 5 percent of the samples when 20 or more have been examined in the preceding 30 days, or if it occurs at all when less than 20 samples have been examined in the preceding 30 days. When 3 or more of the portions of a single sample show the presence of organisms of the coliform group, another sample should be collected promptly from the same sampling point and the collection repeated daily until the results of at least 2 consecutive samples show the water to be of satisfactory quality, which, in this instance, is defined as 1 sample showing no coliform organisms and the other showing coliform organisms in not more than 1 portion. On new supplies where experiences do not extend

[15] Ltr, CG 4th CA to COs listed Posts, Camps, and Stations, 7 Feb 42, sub: Bacteriological examination of water supplies. HD: 720 Water Supply (SnC).

[16] WD Cir 119, 11 May 43.

[17] TM 8-227, Oct 1946.

[18] Medical Department Standards of Quality and Special Control Measures for Drinking Water Supplies at Fixed Installations, 12 Jun 46. HD: 720 Water.

for as long a period as 30 days, samples should be taken daily if possible and the water considered potable if it meets the standards prescribed above when consideration is given either to the last 2 samples or to all of the samples and portions thereof. The intensity of pollution in the case of check samples and new supplies may be gaged by the results for 1 ml. and 0.1 ml. portions.

Procedure. Upon receipt of information that a water sample is nonpotable, the surgeon should immediately take check samples, including one or more from the point where the nonpotable sample was taken, and forward these for testing. He should personally or through a qualified sanitary engineer, if possible in cooperation with the post utility officer, inspect the water facilities to determine the cause of the nonpotable sample and to locate and detect sanitary defects. If no defects are found or if immediate corrections of defects are made, use of the water may be continued pending a report on the quality of the check sample or samples, provided a chlorine residual, as indicated elsewhere, is maintained at all times. When two consecutive unsatisfactory samples have been reported, water for drinking should be treated in Lyster bags pending permission by service command, theater, base command, or comparable headquarters to resume full use of the water; adequate sampling procedures should be initiated to provide a true index of the quality of the water, both raw and treated; and a sanitary survey of the entire water system should be made by a qualified sanitary engineer.

Results of the Water Quality Control Program

As a result of this broad and comprehensive program, the quality of Army water was uniformly excellent from a health point of view. In general, it surpassed by a considerable margin the quality of water supplied by the average American municipality, as measured by percentage of nonpotable samples. Army water supplies, by utilizing all modern methods of treatment, were palatable. Activated carbon, aeration, and chemical treatment were used freely in order to provide the best and safest water available.

Results in the Zone of Interior

Water supply quality is usually judged by the percentage of nonpotable samples examined in accordance with standard methods. In the Army, records are available from two sources: from the reports of post engineers, and from reports of Medical Department laboratories. Experience has shown that the former are likely to include raw water, swimming pools, and similar samples; but they form a more comprehensive record and will be used here. These records were available beginning 1 July 1943, and the following tabu-

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lation summarizes water quality for all stations in the Zone of Interior, by quarters:[19]

Year and quarter	Number of samples taken	Percent of nonpotable samples
1943		
July–September	63, 919	3. 5
October–December	60, 144	2. 2
1944		
January–March	63, 021	1. 4
April–June	56, 792	1. 5
July–September	51, 150	1. 9
October–December	40, 597	0. 9
1945		
January–March	41, 787	0. 3
April–June	44, 652	1. 1

Fourth Service Command Water Data.[20] In 1944 there were 306 water supplies utilized by military installations in the Fourth Service Command. Of these, 164 were well supplies, 133 were purchased from municipalities, and 9 were surface supplies with military treatment plants. Air Force stations utilized 207 of these supplies and Ground and Service Force stations 99. The control program for water supplies in the Fourth Service Command was inaugurated in 1942, as a cooperative project of the service command surgeon and the service command engineer. Since it was not felt that adequate bacteriologic control could be accomplished by using all station hospital laboratories, 13 treatment plants and hospital laboratories were designated and equipped for water analysis. Weekly samples were submitted by each post to the specific laboratory selected to serve it, and a monthly duplicate set was sent to the service command laboratory in order to check upon and coordinate laboratory technique and produce results that were comparable.

In 1942 approximately 13 percent of all samples submitted were nonpotable; in 1943, of 63,526 samples, 4.5 percent were nonpotable; in 1944, of 61,524 samples, 2.4 percent were nonpotable. The nonpotable samples at Army Air Force stations were usually higher in percentage than at Army Ground Force and Army Service Force stations. In 1944, Army Air Force stations showed 2.8 percent nonpotable, while 1.7 percent of the samples from other installations were nonpotable. In this connection, few of the purchased municipal supplies had a nonpotable percentage of less than 2 percent, even after rechlorination. However, from health reports, it appears that a nonpotable percentage in a civilian community somewhat in excess of 2 percent creates little hazard.

[19] Tabulated by author from reports from service command headquarters on OCE forms. HD: 720 (Water Quality, SvC).

[20] Memo, Maj J. H. Morgan, SnC, for Col Blew, SnC, 4th SvC, 5 Apr 45, sub: Quality of military water supplies, 4th Service Command. HD: 720 (Water Quality Rpts, SvC).

Eighth Service Command Water Data.[21] Water quality control was not as thoroughly organized in the Eighth Service Command as in the Fourth, but exceedingly good results were obtained. Practically all stations sent monthly samples to the service command laboratory; in addition, 14 area laboratories carried on water analyses for other stations. It is believed that the district system of using Sanitary Corps engineers, whereby every station in the service command was visited every month by a qualified sanitary engineer, had much to do with attaining this excellent record. Engineers were located at the largest posts and visited from 3 to 6 adjacent posts or airfields monthly under service command orders.

Water Data from Other Service Commands.[22] The Third Service Command maintained a superior degree of control over water quality. For 1943 the average nonpotable samples for all stations (excluding Army Specialized Training Program colleges) was 3.4 percent. By the first half of 1945, this average was reduced to approximately 0.6 percent for the period January to June, inclusive. The Seventh Service Command for the same period (January to June, inclusive, 1945) maintained a nonpotable rate of 0.7 percent. The averages for the Ninth Service Command were as follows: for 1942, 13.2 percent nonpotable; for 1943, 2.8 percent; and for 1944, 0.9 percent. In the Sixth Service Command, the percentage of nonpotable samples for the period December 1944 to May 1945, inclusive, was approximately 0.5 percent. These results are typical of most service commands.

These data indicate clearly the results of the water quality control program. At the beginning of the program, samples from Army installations in continental United States averaged between 10 and 20 percent nonpotable, a dangerous level. This was so reduced that the target objective of 2 percent, set by part 2, Army Service Forces Circular 239, 25 June 1945, was generally attained and in most cases was bettered. It is, of course, impossible to measure what this improvement meant in terms of reduction in incidence of disease, just as it is difficult to measure the results of most preventive medicine activities.

FIELD WATER SUPPLIES

The term "field water supplies" is applied to the use of canteens, Lyster bags, portable or mobile water purification units (either sand or diatomite), and usually to distilling equipment. (See Fig. 9.) There were, however, a number of installations using evaporating or distilling equipment, such as was used on Ascension Island, which could more properly be classified as fixed rather than as field supplies.

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[21] Data found in HD: 720 (Water Quality Rpts, SvC).
[22] Ibid.



Figure 9. A. *3,000-gallon storage water tank in field maneuvers, Zone of Interior.* B. *Water is being pumped to vehicles, Zone of Interior.* C. *Water being pumped into water containers, South Pacific Area, 1943.* D. *Soldiers getting water from Lyster bag, Third Army maneuvers in Louisiana, 1942.*

For a number of years prior to 1940, little attention had been given to field water purification. There was no other policy than Lyster-bag treatment. No satisfactory canteen sterilizing compound was available, but the standard hypochlorite ampule appeared to meet well the needs for Lyster-bag treatment.[23] There was unwarranted confidence in the ability of the portable and mobile water purification units to purify any water without pretreatment. A chlorine residual of 0.5 part per million was required in field water supplies.

In October 1940 the requirement for field chlorination was changed to 1 part per million chlorine residual.[24] The testing for chlorine residual in the field using orthotolidine solution was difficult because of the necessity for using a special comparator and for processing the orthotolidine solution at the time tests were to be made. In 1942 and 1943 Capt. (later Lt. Col.) L. K. Clark of the Sanitary Engineering Division, with others, developed a light kit

[23] FM 8-40, 15 Aug 40.

[24] Memo, AG for Chiefs of Arms and Services and CGs of Armies and CAs, 21 Oct 40, sub: Water purification. HD 720 Water.

using an orthotolidine testing [illegible] and comparator which will be discussed later. This made quick testing possible under nearly all field conditions.

Canteen Sterilization

It appeared necessary, early in the course of the war (December 1941), to adopt a tablet suitable for sterilizing a single canteen full of water. Halazone tablets, which are discussed more fully hereafter in connection with other sterilizing agents, were selected but were not adopted as a standard item by the Medical Department Technical Committee until 1944.[25] Two tablets in one canteen of water give a chlorine dosage of about 4.5 parts per million when measured by the acid starch iodine method. This dosage gives a slight chlorinous taste. Halazone, when two tablets are used per canteen, is an effective bactericide and also an effective cysticide provided the water is not too turbid, does not contain excessive organic matter, and has a pH not above about 7.5. Considerable controversy arose during the course of the war as to the effectiveness of chlorine compounds as cysticidal agents. The preponderance of evidence was that halazone was satisfactorily effective. The tablets required several minutes to dissolve but retained their strength well under most storage conditions. Tests made by Colonel Clark in the Philippines in 1944 and 1945 demonstrated that halazone tablets 1 to 2 years old as delivered in the field retained approximately their full strength.

Practically every promising compound was investigated in an effort to find an ideal sterilizing agent for military use. The qualities desired in the tablet or other material were summarized as follows:

1. It should be nontoxic to human beings, yet accomplish quick and complete kill of human pathogenic bacteria in heavily contaminated water, preferably within 10 minutes and not over 20 minutes.
2. It should dissolve, or release its bactericidal elements, in a short period of time (5 minutes or less).
3. When packaged in a suitable container, it should be stable and nondeteriorating (not over 20-percent deterioration) under a wide variety of temperatures (−40° to 160° F.) and humidity (0 percent to 100 percent) over a period of not less than 1 year.
4. It should be capable of being applied by the ordinary enlisted man.
5. It should be compact enough to allow packaging, in a small container, sufficient sterilizing material for 50 canteens of water.
6. It should not impart objectionable taste or color to the water nor react with the material of which the canteen is made.

These specifications were prepared and distributed to commercial concerns and other interested government agencies in order to enlist as much technical and production assistance as possible.

[25] Minutes of Meeting, Medical Department Technical Committee, 17 Jan 44. HD: 334.

In connection with this program the following compounds and devices, among others, were investigated:[36]

Chloramine T. This product, in tablet form, did not meet the above specifications in that it was very slow to dissolve, especially after being stored at elevated temperatures for a few weeks, and had slow bactericidal action.

Halazone. This product (p-sulfonedichloramidobenzoic acid) did not meet the specifications in that it was slow in its bactericidal effects, and upon storage the tablets did not dissolve quickly. It was approved early in 1942 as an expedient in order that individual purification tablets could be issued to the soldiers immediately. Halazone was considered superior to the other products available at that time because it was found to be very stable, it possessed fairly good solubility, and it appeared to be faster in its bactericidal action than other available chloramine tablets.

Diversol. Diversol, a sodium hypochlorite which possesses great stability because it is combined with a phosphate, was objectionable in that the presence of phosphate raised the pH of the water to such an extent that it materially reduced bactericidal action, and as a tablet it was not sufficiently soluble. Diversol was available in powdered form or packaged as a capsule. Capsules were considered objectionable because it was felt that the soldier might throw the capsule in his canteen of water without opening it. Water soluble capsules were not considered satisfactory because they did not meet the rigid storage requirements that were deemed necessary.

Chloramine B. Chloramine B appeared to accomplish satisfactory bactericidal action, but it was necessary to add an acid salt in a separate tablet. It was not possible to combine the Chloramine B and the acid salt and get good solubility. The concentrations used resulted in a decidedly objectionable taste.

Succinchlorimide. While this agent appeared to be an effective bactericide, tests showed it to lack cysticidal value, being far less effective than a hypochlorite containing about 70 percent available chlorine, or halazone. Also, it appeared to lack quick solubility and its good bacterial killing power was not sufficient to overcome these other defects.

Azochloramide. This product was available in liquid form and in combination with chloramine with hypochlorite. It was not sufficiently stable and it did not lend itself well to packaging.

Hypochlorite. Hypochlorite was tried out in several forms of tablets such as: a coating for an inside tablet made of some dechlorinating agent such as sodium sulphite, as an effervescent tablet, and as a plain tablet. None of these worked out satisfactorily in that they were too slow to dissolve, they deteriorated (in available chlorine) on storage, and they reacted with the filler or the effervescent salt.

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[36] Memo, Maj L. K. Clark, SnC, for Chairman, NRC Committee on Sanitary Engineering, 22 Feb 43, sub: Water purification compounds for use by the individual soldier. HD: 720 Water.

Electric Current. An electrolytic device was also tested in the shape of a pocket outfit which obtained electric current from small dry cells. This device was much too large for field purposes and it was also unsuitable on the basis of its ineffective bactericidal action.

Silver. This was tested in the form of carbon silver pellets and carbon silver powder in capsules. The powder form was objectionable because when the canteen was inverted for drinking, the carbon flowed out with the water. The use of ionic silver for water purification has never been generally accepted as being effective under severe conditions of turbidity and bacteria content. Some authoritative tests indicate it is bactericidal only for certain organisms. Also it is slow in its action.

A silver-coated nylon was tried. The nylon used was a very fine fiber, which after coating was well combed and fluffed so as to give the appearance of a handful of dark colored raw wool. This was objectionable because it was difficult to get complete contact between the nylon and the water due to the minute bubbles of air entrained in the nylon when water is added. Once the water had come in satisfactory contact with the nylon, it was impossible to pour out a full canteen of water, in fact the quantity of silvered nylon required restricted the capacity to about two-thirds of a quart. Also, the germicidal efficiency of silver primarily depends upon intimate and prolonged contact with the water; this necessitated continuous shaking.

Activated Carbon Aspirator. This consisted of a tube just small enough in diameter to be inserted into the canteen. When a soldier wanted a drink of water he had to insert this tube into the canteen and suck on the exposed end. The tube was surrounded by activated carbon in granular form, and was intended to be used in conjunction with a heavy dose of chlorine. It was objectionable in that there was no practical means by which it could be adapted to the several million canteens already in use, and because the suction necessary to draw water out of the canteen was too great.

Ceepryn and Other Quaternary-Ammonium Compounds. Ceepryn appeared to give good bacterial kill in doses of 100 parts per million, but this resulted in an objectionable taste in the water. The quaternary-ammonium compounds in general were objectionable because they were more bacteriostatic than bactericidal. Ceepryn also caused foaming in the concentrations required to insure bactericidal action.

Water Sterilizer and Neutralizer Tablets. These water sterilizer tablets were made from calcium hypochlorite. The neutralizer was merely sodium thiosulphate in tablet form, colored pink to differentiate it from the sterilizer tablet. The sterlizer tablet provided a dose of 16 parts per million of chlorine in a canteen of water. An objection to this method was that the sterilizing tablets and the neutralizer tablets were placed in separate bottles, making it possible for the soldier to add the tablets in reverse order, thereby nullifying the effect of the chlorine.

Sodium Chlorite. This product was found to be somewhat dangerous and even though it possessed good bactericidal qualities, it was not considered safe to use because of the fire hazard involved.

Calcium Hypochlorite and Sodium Sulphite. These products were packaged in a small vial container, the hypochlorite being in the form of a powder and the sodium sulphite in the form of a tablet which was coated with collodion. The hypochlorite furnished a dose of not less than 15 parts per million of chlorine in a canteen of water and the collodion coating on the sulphite tablet was designed to allow disintegration of the tablet in not less than 15 minutes in warm water. The powder and the dechlor tablet were packaged in a small glass vial with a rubber stopper, 12 to a box. Halazone was later used instead of calcium hypochlorite. Extensive tests indicated that, irrespective of the type of chlorine compound used, cysticidal action was not assured in all cases. It appeared that in a small percentage of cases, the coating on the sulphite tablet dissolved too quickly to permit the necessary contact, or dialysis created a dechlorinated zone around the tablet.

Iodine Compounds. Iodine compounds of much promise were developed. Bursoline, or diglycine hydriodide, gave good cysticidal action, was a good bactericide, dissolved readily, and gave no unpleasant taste. It contained a large amount of iodine—about 16 mg.—but did not retain its strength under conditions of high heat and humidity. At 140° F. and 100 percent humidity, 80 percent of the iodine was lost in 1 month (tests, U. S. Bureau of Standards). Various packaging devices were used without materially changing these results.

Globaline. This compound was a triglycine hydroperiodide. The reactions in water were the same as Bursoline, but Globaline contained only one-half as much elemental iodine. Bactericidal and cysticidal qualities were good, as was its ability to act effectively in the presence of turbidity and organic matter. Ability to stand up and retain its strength under conditions of high heat and humidity were approximately the same as Bursoline.

In connection with the research work done on the many compounds tested, the most valuable single report was Interim Report No. 4, Disinfection of Water, Contract No. OEMcmr-251, dated 12 July 1945.[27] The three preceding reports on the subject are also of much value. In interpreting the results of certain minor portions of the reports relating to pH increases due to the addition of hypochlorite or similar compounds, it should be borne in mind that the work was done at Cambridge, Massachusetts, where the tap water is unbuffered, and that small additions of alkali may result in marked increases in pH.

Field Water Purification Equipment

At the beginning of the war, portable and mobile sand filters were the only field water purification equipment available, aside from the Lyster bag. Other

[27] Filed as Appendix A to Minutes of Meeting, Conference on Water Sterilization, NRC Div of Med Sciences, 12 Jul 45. HD: 720 Water.

equipment was developed during the war, and methods of operating the sand filter units were considerably modified, special attention being given to pretreatment before filtration. This pretreatment was made possible by providing additional canvas storage tanks (usually 3,000-gallon capacity) to allow a period of coagulation and sedimentation. Some devices were developed to permit continuous coagulation and settling while utilizing the standard storage tank. Most of these provided a baffle or other device to allow withdrawal of settled water.

Difficulty was experienced in obtaining satisfactory operation of field purification units. Provision of water in the field is a function of the combat engineers. Many engineer officers considered that pretreatment was unnecessary and simple passage of the water through a sand filter, no matter how high the rate, was sufficient, and in fact, was the only feasible field procedure. While a coagulant was added a few seconds before the water reached the filter, it was not effective in performing the function for which it was intended. Some of the coagulant passed through the filter in solution to form a floc in the storage tanks. The principles of water filtration require that as much as possible of the suspended and colloidal matter in the water be removed before it is applied to the filters. This is normally accomplished by sedimentation, usually aided by a coagulant, and a settling period of an hour or more is desirable.

The Sanitary Engineering Division, Office of The Surgeon General, as well as Corps of Engineers officers experienced in water purification, recommended the development of pretreatment methods, believing these were entirely feasible in the field and would result in the production of more and better water. In fact, such pretreatment had been found essential in removal of warfare gases. Pretreatment was found to be essential also in the removal of amebic cysts when sand filters were used. The water equipment laboratory of the Engineer Board at Fort Belvoir worked out a standardized method of pretreatment. All theaters were notified of this method. However it was not until sanitary engineers were placed with troops in the field that extensive and effective use was made of this procedure.

Field water purification methods in the European Theater of Operations were discussed in a letter which stated:[28]

> Operation of field water purification equipment during the early combat days was such that a potable water was not assured at the time it left the water point. Records of bacteriological analysis indicated that an excessive amount of nonpotable water was being distributed. The sources became more contaminated as the front line moved east with the result that the quality of water dropped still lower. Along with the highly contaminated sources that were used, the treatment methods employed were not capable of reducing the bacterial load and turbidity sufficiently. The usual treatment procedure was to feed the coagulant and chlorine just prior to filtration, and allowed particles [suspended materials] to be collected in the filter. Filter rates were in excess of 15 gallons per minute. This high rate permitted [organic] particles readily to pass through the filter.

[28] Ltr, Maj E. J. Marzec, SnC, to Engr Theater Bd, 15th Army, 28 Sep 45, sub: Field water purification. SG: 720.2 (European Command) AA.

Following the policies developed by the Third United States Army, adequate pretreatment of the water was finally required.[29] Addition of coagulant, mixing, and sedimentation permitted removal of the major portion of the turbidity before the water was applied to the filter. Raw water turbidities in excess of 100 parts per million were reduced to less than 10 parts per million, and a marked reduction in bacteria occurred. Chlorination prior to or during sedimentation permitted a long contact period, marked diminution of bacteria, and stable chlorine residuals. Filter rates were reduced to 10 gallons per minute for the portable and 60 gallons per minute for the mobile unit. When these rates were exceeded, the quality of the finished water depreciated. The result of applying pretreated and conditioned water to the filters was to extend filter runs from as short a period as 20 minutes to a minimum of 2 hours and frequently as long as 4 hours. The increased filter runs resulted in more treated water being processed than with previous short runs, even though the rate of filtration was reduced.

With short filter runs, raw water was used for backwashing. Wash rates were often too high, causing loss of sand, often so extensive as to leave no sand in the filter at all. Since suitable filter sand was practically impossible to obtain in combat areas in the European Theater of Operations, the filters were then useless.

Pretreatment in the field was finally standardized with the addition of 6 to 10 grains per gallon of a coagulant, normally ammonia alum, and about half as much sodium carbonate; mixing was accomplished by the inflowing water. One hour was normally allowed for sedimentation, though a better rule was to permit settlement until the side walls of the tank were visible for a depth of 3 feet. Prechlorination at the rate of 1.8 to 3.6 parts per million was frequently used. Activated carbon was routinely supplied and frequently used, normally at the rate of 1 pound per 8,000 gallons of water.

The use of ammonia alum as a coagulant had some disadvantages. Ammonia is released to the extent of about 4 percent by weight of the alum used, and this combines with the chlorine, forming chloramines. While chloramines persist better than chlorine residuals, they are slow-acting bactericides. As a result, as high as 45 percent of the samples taken in the filtered water tank, after an hour's contact period, may be positive for *Escherichia coli*. Prechlorination, with the chlorine applied at the same time as the coagulant, permitted a much longer contact period; and clarification of the water through adequate pretreatment, permitting more effective postchlorination, solved the problem.

Brief descriptions of field water purification equipment are given hereafter. In general, when properly operated, this equipment was capable of satisfactory performance. Experience in the field indicated that all manuals on water purification issued with equipment or used for reference should include specific

[29] (1) ETO Cir 106, sec III, Water Supply for Continental Forces, 24 Oct 44. (2) Tec Tng Bull 30, Off of Chief Engr ETO, 1 Jan 45, sub: Water purification. HD: 720 Water.

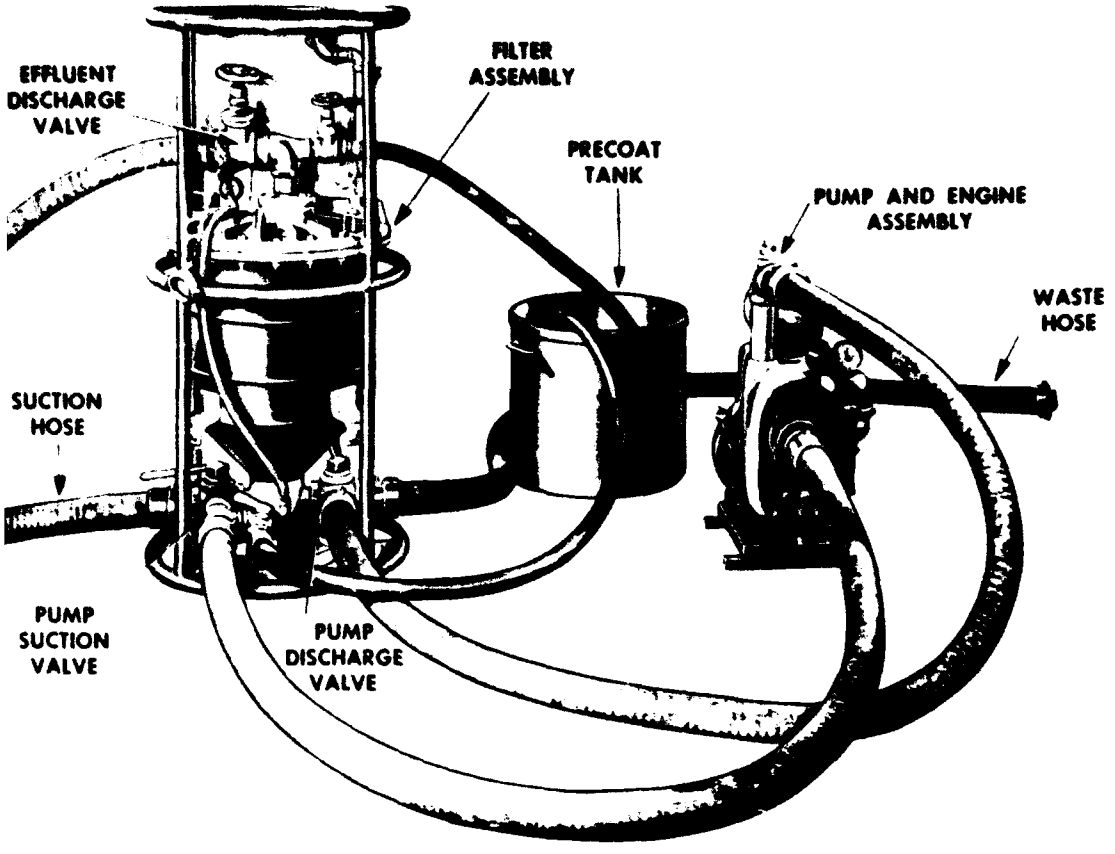


Figure 10A. Portable purification unit.

steps in proper treatment. A letter from the European Theater of Operations, where water purification was probably much less of a problem than in India, China, and the Pacific, stated that "Coagulation with sedimentation prior to filtration should be a must for all waters requiring filtration. Adequate chlorine contact times should be specified." [30] Technical Manual 5–295, August 1945, prepared by the Corps of Engineers included methods of pretreatment, and provided complete descriptions and operating procedures for all field water purification equipment.

Training of engineer enlisted personnel at Fort Belvoir for water purification unit operation appeared adequate, but untrained personnel were sometimes used as replacements. Use of such untrained personnel was responsible for much of the unsatisfactory water obtained from field purification units. Officers must be trained adequately in water purification theory and procedures, and their duties must be so limited that they will have sufficient time for proper supervision of operating personnel. "Establishment of organized units such as a water treatment company whose sole function is to treat water in the field is considered necessary in order that suitably trained officer personnel

[30] See footnote 28, p. 97.

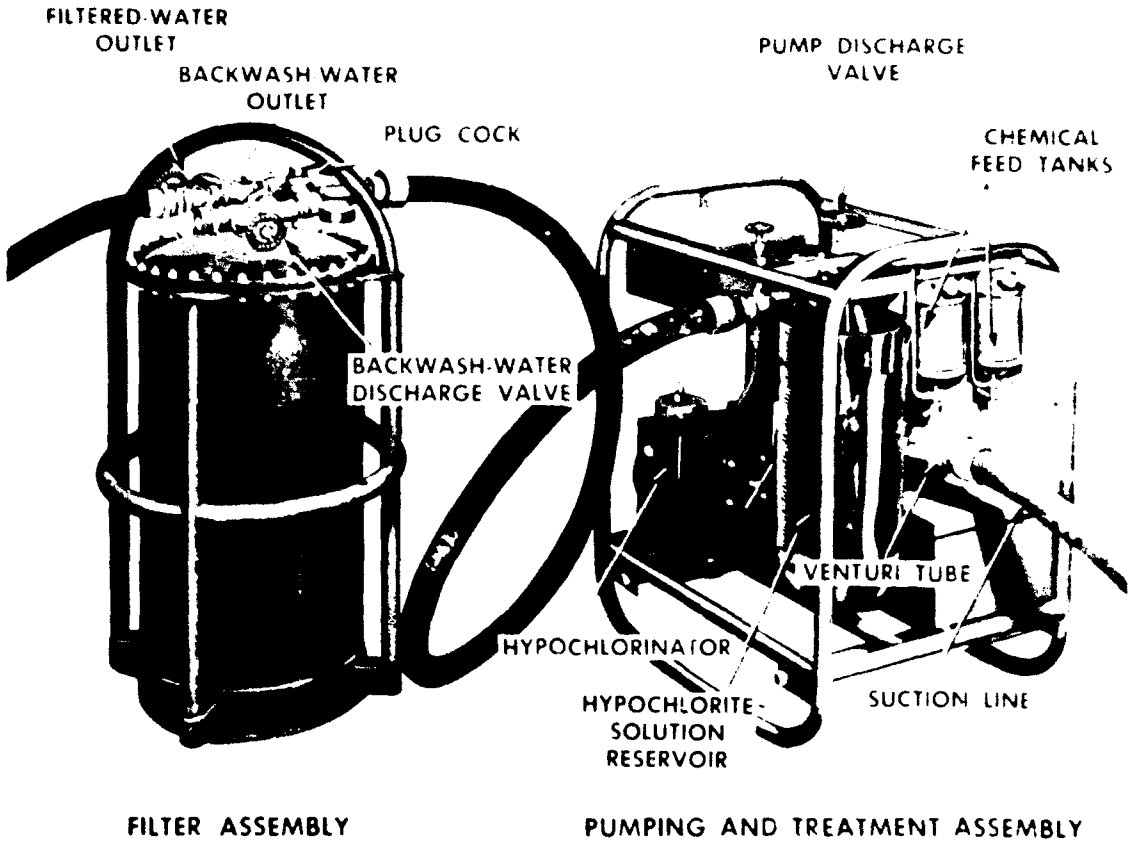


Figure 10B. Fifty gallons per minute diatomite water purification unit

will be commanding the unit and enlisted personnel will not be subjected to rapid change." [31]

Portable Water Purification Unit. This consisted of a pressure-type sand filter, having a filter area of about 1.5 square feet, and a pumping and chemical feed section. (See Fig. 10A.) In addition two or more canvas tanks were supplied. With proper pretreatment of the water and operation of the filter at rates not in excess of 10 gallons per minute, this unit gave good results. The weight was about 700 pounds; the heaviest single piece weighed about 400 pounds. The operation of the portable unit was as follows: When the filter became dirty, it was backwashed by reversing the flow of water. Proper pretreatment of the water, by removing nearly all of the suspended matter, increased the length of filter runs, decreased the frequency of washing, and permitted effective postchlorination.

Mobile Water Purification Unit. This was a 42-inch diameter pressure-type sand filter mounted complete with pump, chlorinator, and other accessories, on a trailer or on a 2½-ton 6-wheel truck. The filter surface area was about 9 square feet. The output of this filter should be restricted to 60 gallons per

See footnote 28, p. 97

nute. Operation was generally the same as for the portable unit. Because e capacity of the chlorinator supplied with the unit was restricted, prechlorition by the batch method was always considered desirable; in areas where ıebic dysentery was a hazard, such prechlorination was necessary.

Diatomaceous Earth (Diatomite) Filters. The diatomite filter consisted ıentially of a shell similar to that of a sand filter, with several septa or suprts for the filtering layer of diatomaceous earth, and with necessary valves, ›ing, and controls. Various types of septa were used, including fine wire d porous refractory materials. A suspension of diatomaceous earth was culated through the filter to form a thin layer on the surface of the septa. ıis layer, which was usually one-tenth to one-sixteenth of an inch thick, repıenting 0.10 to 0.15 pound per square foot of surface, formed the filtering ›dium. In addition to the original thin layer of diatomaceous earth, more uld be added at any time during the filtering process. This process was med "slurry feed" and was advantageous with some waters in decreasing e frequency of backwashing. Diatomite filters removed amebic cysts and ›duced clear and sparkling water; they would not remove all bacteria and e usual postchlorination procedures were necessary. Pretreatment of the ıter was necessary and conserved diatomaceous earth (filter aid). Washing the filter was accomplished by simple reversal of the flow through the filter. om 1,250 to 3,000 gallons of properly pretreated water were filtered with pound of filter aid, depending on operating skill and quality of water, and me of the used filter aid could be recovered.

Two sizes of diatomite filters were available. The 15-gallons per minute it was designed to serve small field units of troops. The 50-gallons per mine unit was designed to replace the portable and mobile purification units scribed previously. The 50-gallons per minute diatomite filters could be mbined into multiple groups of units for serving fixed installations, such as spitals, airbases, and posts, requiring not more than 250,000 gallons per day.

The complete 15-gallons per minute set consisted of a filter and feeder ›tion, two gasoline-engine driven pumps, four 500-gallon tanks, hose, supes for the production of 40,000 gallons of water, and accessory equipment. ıe effective surface area of the filter was 3.6 square feet. The total weight all of the above components was 580 pounds. The heaviest single piece ›ighed about 65 pounds. The set was adaptable for pack carrying by men animals.

The complete 50-gallons per minute diatomite unit consisted of a filter unit, uipment chest, chemicals (alum, soda ash, and activated carbon), filter aid, e pumping units, four 3,000-gallon tanks, and accessory equipment. (See g. 10.) Total filter area was about 10 square feet. The heaviest single unit ›ighed about 300 pounds. Total weight, including sufficient chemicals to ›duce 1,200,000 gallons of water, was 5,700 pounds. Volume was 270 cubic ›t. This filter unit, which produced 3,000 gallons per hour, was well adapted

to supplying water to small fixed and semipermanent installations. If 2 units were used, operated in parallel, about 120,000 gallons of water could be produced daily. For larger installations, 4 units were furnished, complete with manifold piping and suitable large pumps. Tanks for pretreatment and storage were furnished prefabricated with the filters, or constructed locally. These multiple units supplied up to 240,000 gallons per day for the 4-unit set. Under average conditions, 100,000 gallons of water required for pretreatment about 55 pounds of alum, 15 pounds of soda ash, and 5 pounds of hypochlorite; and for filtering, about 50 pounds of filter aid. With good pretreatment, less was required. The 50-gallons per minute filter unit was also available in a smaller set rated at 35-gallons per minute, containing three 3,000-gallon tanks, four pumps, lighter hose, and smaller quantities of chemicals and filter aid. The total weight, including sufficient chemicals to produce 300,000 gallons of water, was 3,600 pounds. Volume was approximately 160 cubic feet.

Residual Chlorine Testing in the Field. Residual chlorine testing in the field is important in checking the quality of the water. The orthotolidine test for residual chlorine was intended to be used to verify all chlorination procedures. The test could be made 10 minutes after the chlorinating agent had been applied. Temperature of the water tested was above 20° centigrade. If the water was cold, the comparator tube was held in the hand until water was sufficiently warm enough to add the orthotolidine reagent. Following addition of the reagent the maximum color that developed in 5 minutes represented the residual chlorine and was matched with the standard disc of the comparator. If free chlorine alone was present the color flashed to a maximum in less than a minute. If chloramines were present the color was slow in forming and reached a maximum after 5 minutes. The increase in color after 5 minutes was not large, however, and was generally disregarded.

Development of Orthotolidine Tablets. The shipment, handling, and distribution in the field of orthotolidine solution was very difficult. In order to simplify chlorine residual testing procedures, tests were made with a number of paper, cloth, and woven glass strips, impregnated with an acidified orthotolidine. These were promising, but were not deemed completely satisfactory. Work was continued and an effective tablet developed, so small that 50 could be placed in a tube less than 1 inch in diameter and 3 inches long. The tube fitted into another container of clear plastic, carrying a color band representing 1 part per million of chlorine. The water to be tested was placed in this container and an orthotolidine test tablet added. By comparison with the color band a sufficiently accurate reading was obtained.[32] Two kits were packaged in the same carton with 100 ampules of calcium hypochlorite, thus insuring the presence of a comparator and orthotolidine whenever hypochlorite was used and a residual test was desired. This development made it possible to check

[32] TM 5-295, Aug 1945.

chlorine residuals quickly and easily anywhere, and added tremendously to the efficiency of the water quality control program.

Detection and Removal of Poisons in Water. As a precautionary measure to protect troops in the field, procedures were developed in cooperation with the Corps of Engineers and the Chemical Warfare Service to detect poisons in water and to devise simple measures for their removal when possible. Four steps were necessary: (1) detection, (2) determination if treatment is possible, (3) treatment, and (4) verification of the success of treatment. Since removal of poisons is difficult every effort was to be made to find an uncontaminated water source. Water from contaminated sources was never to be treated by individuals but always by engineer units.

Poisons in water may be organic or inorganic. Organic substances include chemical warfare agents, alkaloids (including nicotine and strychnine), and arsenicals. Inorganic poisons include arsenites, arsenates, the compounds of cyanides, and the heavy metals. Suspensions of bacteria also may be used as a contaminant. Fish oil and bone oil have been employed to make water undrinkable. The presence of these contaminants may sometimes be indicated by color, odor, or appearance of the water; by the presence of dead fish or other aquatic life; or by other visible signs. More often, chemical tests must be used for detection.

For this purpose, a simple screening kit was devised to determine the presence of poisons in dangerous concentrations.[33] These kits were issued to the medical officer of each battalion or similar unit. Among the general tests of value in detecting many poisons are those for pH and chlorine demand. Other tests that could be made with the kit indicated the presence in water of unsafe amounts of mustard (H), nitrogen mustards (HN), lewisite (L), ethyldichlorarsine (ED), and other chemical warfare agents or substances containing arsenic. The kit would not detect the presence in water of cyanides or heavy-metal salts. The presence of large quantities of alkaloids and other organic poisons might be indicated by high chlorine demands. Tests with this kit were rough qualitative tests, sufficient only to determine the presence or absence of certain poisons in water. If any single test gave a positive result, it was recommended that the water point be shut down, and an attempt made to locate an uncontaminated source. The proper intelligence officer, Medical Department officer, and water control officer were to be notified at once. It was recommended that no attempt be made to treat the water until procedures had been outlined by the water control officer or other qualified officer.

A more comprehensive and elaborate testing apparatus (kit, water testing, poisons, treatment control, for chemical warfare and other toxic agents) was issued to engineer water supply companies and to field-type hospitals for use by water control or other qualified officers.[34] It was capable of quantitative

[33] See footnote 32, p. 102.
[34] See footnote 32, p. 102.

measurements of mustard (H), nitrogen mustard (HN), lewisite (L), ethyldichlorarsine (ED), and other chemical warfare agents or substances containing arsenic, present in water. It detected also the presence in water of poisonous cyanides and heavy-metal salts; however, the tests for these substances were qualitative only.

Activated carbon is the essential material in the removal of poisons from water. Special brands of activated carbon are necessary. Since some carbons will not remove poisons, a series of experiments at Fort Belvoir resulted in the selection of Norit C–18, Nuchar C–115, and Nuchar AL as the most efficient for the removal of poisons.[35] Tests indicated that up to 30 parts per million of some poisons can be removed by the application of activated carbon at the rate of 5 pounds per 1,000 gallons of water. Tests of the carbons involved comparisons with activated carbon made from coconuts, which is generally the most effective agent for poison removal. The coconut carbon was not available in sufficient amount to meet Army needs. By examining and comparing about 40 activated carbons, with the cooperation and advice of the industry, varieties were found which were as effective in poison removal as the coconut carbons, were plentiful, and were much cheaper.

The activated carbon treatment of poisoned water must be applied before chlorination or filtration through the water purification units. Chlorine applied to the contaminated raw water before the carbon treatment was found to increase the difficulty of removing organic poisons with carbon. The carbon treatment recommended consisted of four steps:[36] (1) Adding enough carbon to reduce the amount of poison in the water to harmless proportions; (2) proper agitation of the water and carbon during the treating process; (3) settling of the carbon from the water; and (4) testing the treated water to be sure it was safe. The treatment was generally the same for nonpoisonous contaminations with bone oil and fish oil. However, these latter were found often to require heavier doses of carbon, or stage treatment, using two or even more applications of carbon.

Samples of the settled water were tested with the treatment-control kit, if available; otherwise the screening kit was used. The treated water had to be free of any taste or odor characteristic of the poison it contained, and it had to meet one of the following appropriate tests: For nitrogen mustards (HN), a negative or borderline test with the DB–3 reagent (absence of blue color); for lewisite (L), ethlydichlorarsine (HD), or other arsenicals, less than 10 parts per million arsenic residual measured as arsenic trioxide (stain on the Gutzeit test strip one-half inch or less in length).

For mustard (H), and other organic poisons, the chlorine demand had to be less than 4 parts per million. If the tests showed that the treated water

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[35] The Engr Bd Rpt No. 789, Treatment of water contaminated with toxic substances, 15 Dec 43. Filed in Engr Research and Dev Lab, Ft Belvoir, Va.

[36] See footnote 32, p. 102.

was still unsafe because the residual poison content was above permissible levels, the carbon treatment was repeated using fresh carbon. Where coagulants were used, the clear water above the sludge and settled coagulants was pumped into a second treatment tank fitted with a bottom valve. This was done to avoid interference between the settled coagulants and the action of the fresh carbon. If no coagulants were used, fresh carbon was added directly to the original treatment tank. The re-treated water was tested again as described above. If safe, it was then filtered and chlorinated.

In order to give effect to this study, a school was established at Edgewood Arsenal, Maryland, in cooperation with the Chemical Warfare Service, at which sanitary engineers were trained in the detection of poisons in water and in the methods for their removal.[37] About 150 sanitary engineers took the training. These men were dispersed to the various overseas theaters, a record being kept by name, serial number, and theater location for each man so that if need arose in any theater for such skills the theater commander could be notified of the men immediately available to him. Fortunately, need for their services due to use of poisons did not arise.

Training Film

At the request of the Sanitary Engineering Division, the Training Division of the Surgeon General's Office prepared Training Film 8–1174, entitled "Purification of Water." Lt. Col. L. K. Clark, SnC, was assigned as technical adviser to assist in the preparation of the script, facilitate the procurement of property and equipment, and furnish technical advice on the production of the film. The film covered briefly the operation of mobile and portable purification units but principally it was designed to teach the soldier how to procure and safeguard his own drinking water under field conditions.

Results of Field Water Purification Policies

Many factors influence compliance in the field with prescribed policies and operating instructions. This is especially true in combat areas. Frequent moving over rough terrain results in damage to the purification units; replacement parts are often not readily available; and properly trained operators may not always be in charge. Inaccessibility of purification units makes supervision difficult at times and sampling for bacteriologic examination and chlorine testing is often impossible. Moreover, the comparatively insanitary conditions which usually exist in combat and other field areas largely prevent a good assay of the health protection resulting from compliance with prescribed water purification policies.

However, to the end of the war, there had been reported no major outbreaks of intestinal disease among troops that were traceable to water obtained

[37] Ltr, Dir Tng Div SGO to Dir Mil Tng ASF, 20 May 43, sub: Training program, with 1st ind, Asst Exec, Tng Div ASF to SG, 28 May 43. HD: 353 (PI-CW Sch).

from authorized Army water supply points. In a few minor outbreaks, water had been under suspicion but these suspicions were not confirmed by epidemiologic investigation except in extremely few cases. While it is likely that minor outbreaks occurred which were not reported it is believed that practically all American troops in the field received safe water, especially during the later years of the war.

WATER SUPPLY OVERSEAS

Information on World Water Supply Conditions

Twice in 1942 questions arose as to the kind of water supplies, the quality and quantity of water available, and the treatment required for overseas supplies. The first time was in connection with the proposed diversion into France to relieve the pressure on Russia. It was found that a tremendous mass of detailed information regarding the water supplies of northwestern France was available in reports of the Royal Engineers, British Expeditionary Forces, for the period 1914 to 1918. The second problem arose in connection with the North African landing. Fortunately an engineer who had represented an American firm manufacturing water purification equipment and had visited and supplied equipment for all or most of the North African water supplies offered information necessary for planning for water supply.

These instances made it seem possible that adequate information was available on all of the water supplies of the world if the proper sources of data could be located. Accordingly the Corps of Engineers of the Army and Geological Survey of the Department of the Interior established a joint organization to procure the necessary information in advance of landings, so that proper equipment and personnel could be supplied for efficient water procurement. A sanitary engineer, assigned to the Medical Intelligence Division of the Office of The Surgeon General, acted as intermediary for the Sanitary Engineering Division.

The work of the joint Engineer-Interior group was outstanding and the information furnished by it was remarkable for its completeness and accuracy, making it possible to plan in advance precisely what the equipment, materiel, and personnel needs for water supply and purification would be for any operation.

The same general program of water quality control that was followed in the Zone of Interior was applied to fixed installations overseas and the end results were generally the same—provision of safe water to the troops. Application of the program was more difficult in overseas areas, and results were obtained more slowly. This was due to several causes. Line commanders often could not quickly be convinced of the needs for special attention to water supplies when such needs required valuable shipping space and the use of equally valuable engineer equipment. Some theater surgeons were slow in



Figure 11A. Pumping station for hospital installation on spring-fed stream, Finschhafen, New Guinea.

building up adequate sanitary engineering staffs. The long distances; scarcity of transportation; press of other work requiring the use of Engineer troops, such as airfields, ports, and roads; and the general lack of appreciation of the need for skilled men for water quality control, all combined to slow progress.

It was not the policy of the Sanitary Engineering Division, Office of The Surgeon General, to attempt to provide supervision of details of work in the various overseas theaters, as it was believed that better results would be obtained by leaving such supervision to the theater staffs. Only those problems that involved policy determination or that indicated the need to devise better procedures to meet overseas conditions will be discussed in this chapter.

European Theater of Operations. A study of water supplied by Engineer water points was made in 1944. This indicated that many water points were not producing potable water. According to reports of bacteriologic analyses, 49 percent of the samples collected in August 1944 were nonpotable. Treatment was modified to provide chlorination and coagulation of the water, sedimentation, and filtration of the settled water at rates not exceeding 10 gallons per minute for the portable unit and 60 gallons per minute for the mobile units. This represents a rate of approximately 6 gallons per minute per square foot of filter surface. By November 1944, nonpotable samples represented only



Figure 11B. 500,000 gallon water storage reservoir under construction, Finschhafen, New Guinea

11 percent of the total and further reductions to 5 percent, 2 percent, and 1½ percent were recorded in the 3 following months. This method of treatment also markedly lengthened filter runs when the raw water was turbid and increased the output of the purification units.[38]

A field team of the Combined Intelligence Objective Subcommittee of the Combined Chiefs of Staff carried out a study of the civilian water supplies of Germany in 1945. A Sanitary Corps engineer from the Surgeon General's Office, Lt. Col. J. J. Gilbert, was assigned to the team for that purpose.[39]

The Southwest and South Pacific Areas. The canvas water tanks supplied as standard equipment for field water supply deteriorated very rapidly in these areas. As quickly as possible, canvas tanks were replaced with 700-gallon Navy pontoon tubes or with metal storage tanks. A considerable amount of research was carried on at the water equipment laboratory of the Engineer Board at Fort Belvoir to develop storage tanks which would be resistant to mildew and tropical deterioration. Mildew-proofing was of some benefit; various other materials for the tanks were tried, including glass fiber, but no wholly satisfactory solution was ever found.

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[38] Semiannual Rpt, Med Sec 3d Army, 1945 1. HD

[39] CIOS Rpt 19338, Water and Sewage Treatment Facilities in Germany, by Lt Col Gilbert, Dr. Fischer, Mr. Gorman, and Mr. Sheridan. AF Med Library.

Chlorination requirements in the Southwest Pacific area varied with local conditions. In field supplies, it was found that the residual of 1 part per million [40] was satisfactory; in large base distribution water supply systems, the general requirement for 0.4 part per million residual appeared to insure safe water; in Leyte, however, because of the presence of cercariae in some waters, a residual of 5.0 parts per million was required after 30 minutes contact.[41] Treatment results were generally good. In January 1945 at Base K (Leyte) of 247 samples examined in the laboratory, 17 percent were nonpotable; in February 6 percent of 775 samples were nonpotable; and in March only 2.5 percent of approximately 800 samples were found to be unpotable.[42]

In anticipation of the Philippine operations, data on the water resources of the islands had been obtained through the Medical Intelligence Division, Office of The Surgeon General. Since these indicated that good quality ground water was widely available at medium depths—usually less than 100 feet—it was recommended that the troops going into Leyte and nearby islands be supplied with shallow well-drilling and suitable pumping equipment. The theater surgeon was advised of this source of supply and its use recommended to reduce the hazard of amebic dysentery and schistosomiasis. However, the assault date was advanced and only a part of the recommended equipment was available for the Leyte operations. Lack of equipment was overcome, wells being sunk by jetting, and ground waters widely used.

It was planned to supply the troops assigned to the invasion of Japan with diatomite filters, but the end of the war precluded this necessity. The Tenth Army was partly supplied with diatomite filters for the Okinawa operations. It was likewise planned to equip the Philippine staging areas for the Japanese invasion with diatomite filters.

The India-Burma Theater of Operations. The presence of amebic dysentery and the factors of troop dispersion and scarcity of equipment presented problems in water supply to the theater staff. Water was generally plentiful in quantity, though much equipment provided through reverse lend-lease was deficient by American standards. Water was boiled to provide safety against amebic dysentery infection, but because of recontamination before the water was consumed, this proved unsatisfactory. Samples from a number of stations, taken over a period of several months, showed that 80 percent of the delivered water was nonpotable. The requirement that chlorination be the last step in purification resulted in a marked improvement in water quality. Filters were installed at many Air Force stations, and filtration and chlorination reduced nonpotable samples to approximately 2 percent of the total.[43]

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[40] Annual Rpt, Chief Surg, USAFWP, 1945, pt. 2. HD.
[41] Annual Rpt, Chief Surg, USAFWP, 1945, pt. 1. HD.
[42] Quarterly Rpt, Base K SWPA, 1945-1. HD.
[43] (1) Van Auken, H. A.: A history of preventive medicine in the United States Army Forces of the India-Burma theater, 1942 to 1945. HD: 314.7-2. (2) Firth, G. R.: Sanitary engineering in the China-Burma-India theater. HD: 721.

In this theater, it was found that preparation of the water for treatment and filtration at a rate of not more than 6 gallons per minute per square foot of filter area, were necessary for removal of amebic cysts. Details of the methods found most suitable will be presented in a later section of this chapter.

India-China Division of the Air Transport Command. Water was at first supplied to troops in these stations through the Chinese War Area Service hostel system. Surface water was carried to elevated tanks by Chinese water carriers. Water was muddy and grossly contaminated; boiling did not remove sediment, taste, or odor; and recontamination was frequent. Several diatomite filters were flown to China and installed; at other posts "homemade" sand filters were constructed. By means of prechlorination, coagulation, sedimentation, and filtration, satisfactory water was produced. By the beginning of 1945, fairly satisfactory water supplies were furnished to all of the 31 bases in this area. All of these installations were capable of meeting or exceeding the War Department requirement or target of not more than 2 percent nonpotable samples.[44]

Persian Gulf Service Command. Water was supplied in July 1944 to 38,700 personnel in this command, of which 27,464 were United States Army personnel. The average consumption per capita per day was 85 gallons. The highest per capita use was at Camp Amirabad, where it was 117 gallons per capita per day; the lowest was at Sharjah, a British controlled station, where it was 10 gallons per capita per day; the lowest average for a United States installation was at Gor-Gor, 25 gallons per capita per day. Nine of the 40 posts and camps were served by rivers and creeks, 21 by wells, and the remainder by springs and "kanats." Portable purification units were used at 18 installations, distillation at 1, and slow sand filters at 2.[45] Results of treatment were indicated by the following disease incidence: In 1943, there were reported 509 cases of protozoal dysentery and 601 cases of bacillary dysentery among 23,000 troops; while in 1945 there were 7 protozoal and 110 bacillary dysentery cases among 13,000 troops.

South Atlantic Theater. There were no serious problems in the theater, except that of water supply at Ascension Island. Reliance had to be placed on distillation units and only 7 to 10 gallons per capita per day could be made available, more than half of which had to be allocated to purposes other than washing and bathing. A well was drilled to a depth of 700 feet in an attempt to produce more water, but the water obtained from it was hot and so highly mineralized as to be unfit for use. By means of chlorination and continued control over operation of water plants in the theater, the proportion of nonpotable samples was maintained at or under 2 percent on a theater-wide basis most of the time.[46]

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[44] Ltr, Div Sanitary Engr to CG India-China Div ATC, 25 Nov 44, sub: Improvement of water supplies at China ICD-ATC bases. HD: 710 Dysentery.

[45] McNaughton, L. M.: Preventive medicine, Persian Gulf Command. HD: 314.7-2.

[46] Medical History World War II, USAF, South Atlantic, 31 Oct 45. HD: 314.7-2.

SPECIAL PROBLEMS

Many entirely new problems arose during the course of the war—new, so far as previous specific experience was concerned. Generally, a decision had to be made before exhaustive research and tests could be carried out, in which case past experience in allied problems had to be drawn on as a basis for policy. Whenever possible the tentative conclusions were checked by such tests as time permitted.

Amebiasis. There was probably no single factor in connection with water supply that caused more annoyance or interfered more seriously with treatment procedures than the threat of amebiasis. Some sound information was available in regard to the removal of cysts by filtration as a result of Baylis' work in Chicago.[47] The data in regard to the amount of chlorine required to destroy cysts were confusing and conflicting. It appeared that the work of Chang and Fair at Harvard,[48] and of Stone [49] at the Army Medical Center had established that chlorine in concentrations of 3 to 5 parts per million, or even less, would kill cysts. This conclusion was supported by additional work done at Harvard and at the National Institutes of Health at the request of the Sanitary Engineering Division and by corroborative work at the Naval Medical Institute.

However, some of the older medical text books supplied to the Army overseas stated that no concentration of chlorine,[50] or only an exceedingly high application, would destroy cysts. With this as a basis, some overseas officers insisted on boiling all water in order to destroy the cysts. Boiling does not protect water from recontamination, and under the practice followed in some theaters of using natives for handling food and water in order to reduce the need for Army personnel, recontamination was inevitable. Many officers when ordered to chlorinate the water, would follow chlorination with boiling, which resulted in driving off the chlorine, thus destroying any possibility of residual protective effect.

In addition, some of the Army laboratories located in endemic amebic areas began tests of their own on the resistance of cysts of *E. histolytica* to chlorine. One of these reported on subculturing of cysts, and seemed to indicate that chlorine was not effective.[51] The importance of this test was that cysts used were obtained from patients in local hospitals, whereas most or all previous tests had been made on cultured cysts. However, the work in regard to chlorination procedures was not sufficiently thorough to form a basis to

[47] Baylis, J. R.; Gullans, O., and Spector, B. K.: The efficiency of rapid sand filters in removing the cysts of the amoebic dysentery organisms from water. Pub. Health Rep. 51: 1567–1575, 13 Nov 36.

[48] Chang, S. L., and Fair, G. M.: Viability and destruction of the cysts of *Endamoeba histolytica*. J. Am. Water Works A. 33: 1705–1715, Oct 1941.

[49] Stone, W. S.: The resistance of *Endamoeba histolytica* cysts to chlorine in aqueous solutions. Am. J. Trop. Med. 17: 539–551, Jul 1937.

[50] Craig, Charles F.: Amebiasis and Amebic Dysentery. Springfield, Ill., Charles C Thomas, 1934, pp. 51–52.

[51] See footnote 43 (1), p. 109.

judge the soundness of this work. The report as issued further complicated matters in China, Burma, and India, without adding anything of value to the solution of the problem.

It was also demonstrated by the water equipment laboratory at Fort Belvoir and the National Institutes of Health, in work initiated at the request of the Sanitary Engineering Division, that the Army portable water filter when operating at maximum rates would pass amebic cysts through the sand bed.[52] Further tests demonstrated that a reduction in operating rate to 10 gallons per minute (6½ gallons per minute per square foot), when preceded by coagulation and settling would result in removal of the cysts. It was also demonstrated that the diatomite filter would remove the cysts.

Following further studies and tests, it appeared that, with a pH less than 7, a chlorine residual of 2 parts per million remaining after 30 minutes of contact would, in water that was moderately clear and free from excessive organic matter, destroy the cysts. However, a longer contact period and a heavier application of chlorine was deemed desirable to provide a margin of safety. Accordingly, general policies were adopted for use in regard to water treatment in areas where amebiasis was a hazard, and these were issued to the theaters.[53]

Experience emphasized the need for water discipline and training to insure that a sufficient amount of chlorine be added to the water and that an adequate contact period be provided thereafter; that field water purification units be operated precisely as directed; and that as good a source of water be used as it was possible to find. On the basis of reports from the field it was believed that relatively little amebiasis was due to water-borne transmission and that most of that due to water resulted from neglect of simple and commonsense rules of sanitation. Detailed directives regarding treatment to destroy or remove cysts were as follows:[54]

> It is essential that all water suspected of containing amebic cysts, whether clear or turbid, be coagulated and settled before filtration. Prechlorination, with the chlorine being added at the same time as the coagulating chemical, is desirable, as it provides a considerable added measure of safety; the application of 3 to 4 p. p. m. of available chlorine is recommended. The coagulant dosage should be sufficient to give a heavy, rapid settling floc; usually from 3 to 6 grains of coagulant per gallon of water should be added. Lime or soda ash may be required to accelerate floc formation. Three 3,000-gallon canvas tanks may be used in rotation to permit adequate settling before filtration. The water should be settled until the side of the tank is visible to a depth of 3 feet, which indicates a turbidity of 8 or 9. This may require from 30 minutes to an hour or more, depending on how well the water has been coagulated. Even with pretreatment, output of some filters must be restricted [to about 6½ gallons per minute per square foot] in order to assure removal of all cysts. . . .
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> * * * * * * *

[52] The Engr Bd Rpt 834, Efficiency of standard Army water purification equipment and of diatomite filters in removing cysts of *Endamoeba histolytica* from water, Project WSS 346, 3 Jul 44. HD: 720 Water.

[53] For example, Message CM-OUT-5640, Engr Div OCE to CG North African Theater, 14 Jun 43. HD: 710 (Dysentery, Amebic) NA.

[54] TB Med 190, 1 Aug 45.

In fixed rapid sand gravity filters, the sand bed should be not less than 24 inches thick and the sand particles should be properly graded (effective size 0.40 to 0.50 mm and uniformity coefficient 1.6 to 2.0). . . . Filters should be designed to provide for peak load flows at the normal operating rate of 2 gpm per square foot of filter surface; rate of filtration should not exceed 3 gpm. When properly operated, such filters will remove cysts of *E. histolytica*. The filtrate should be chlorinated and performance [of the filter] checked. . . .

In areas where construction materials are scarce, consideration may be given to the construction of slow sand filters. In these, the sand bed should be about 30 inches in depth initially and should be renewed whenever the depth falls to 20 inches. Sand with an effective size of 0.25 to 0.35 mm and a uniformity coefficient of 2.5 to 3.5 is desirable. The filter bed should be retained in a tight tank or basin. Rate of operation should be limited to 6 million gallons per acre per day. The filtrate should be chlorinated.

* * * * * * *

Halazone tablets (tablets, water purification, individual) contain 2.2 milligrams of available chlorine, only one-half of which is measurable by the orthotolidine test. Existing directives require the addition of 2 tablets to each canteen with clear water, and 4 tablets when the water is turbid or contains organic matter. It is important that there be 30 minutes contact between the chlorine and the water before the water is consumed. The addition of 2 tablets per canteen provides an initial concentration of 4.4 parts per million of chlorine, and of 4 tablets 8.8 p. p. m. Tests indicate that Halazone tablets when used as directed above will kill cysts under normal field conditions. Effective results cannot be expected with water heavily contaminated with organic matter; boiling . . . should then be used [followed by chlorination].

When using Lyster bags and calcium hypochlorite, grade A, the water should be treated in the bag by standard methods to provide 1 p. p. m. chlorine residual after 10 minutes contact. One additional ampule of grade A calcium hypochlorite must then be added and the water allowed to stand for 30 minutes more. One ampule of grade A calcium hypochlorite in a Lyster bag gives a chlorine dosage of 2.3 p. p. m. In moderately clear water with a pH of 7.0 or less, a concentration of 2 p. p. m. of chlorine remaining after 30 minutes contact will destroy amebic cysts. A chlorinous taste may result from the recommended treatment. Storage or standing for 2 or 3 hours will usually reduce or eliminate the chlorinous taste.

* * * * * * *

Boiling is effective in destroying the cysts, and should be employed where the water is too turbid or contains too much organic matter for chlorine to be effective. The water should boil at least 1 minute. Chlorination before boiling is useless, but the water should be chlorinated after it has cooled, following boiling. After boiling and cooling, enough hypochlorite should be added to produce a residual, after 10 minutes, of 1 p. p. m. This residual is necessary to protect against recontamination. In addition, special care should be taken in handling the boiled and chlorinated water to prevent it from again being infected with cysts. When water has been [properly] filtered . . . [and chlorinated], boiling is unnecessary.

The diatomite filters already described remove cysts.[55] Pretreatment is necessary with these filters in order to obtain satisfactory lengths of filter

[55] (1) The Engr Bd Rpt 863, 15-GPM light diatomite water purification equipment, 12 Sep 44. Engr Bd, Ft. Belvoir, Va. (2) The Engr Bd Rpt 864, Water purification equipment, diatomite, portable, 50-GPM, 13 Sep 44. Engr Bd, Ft. Belvoir, Va. (3) See also footnote 52, p. 112.

runs. The filtrate must be chlorinated in accordance with normal practice to destroy bacteria and reduce the danger from recontamination.

Schistosomiasis. This disease also presented a hazard which was brought forcibly to the attention of the Army with the invasion of Leyte. Fortunately, in anticipation of such a problem, studies had already been made of the procedures necessary in water treatment to remove or destroy the cercariae. The directive pertaining to schistosomiasis stated:[56]

> The areas in which schistosomiasis is a hazard include the Philippines, China, Japan, Formosa, North and West Africa, the West Indies, and South America, in all of which amebiasis is also present. Schistosomiasis can be contracted by direct contact with infested water, as by swimming, bathing, wading, or working in the water, and by drinking contaminated water. Therefore, water used for drinking, bathing, or laundry purposes must be treated. Personnel operating water supply or purification equipment should wear rubber boots when wading in water, and should use rubber gloves or other approved methods of protection when they are required to place their hands in untreated water.
>
> The methods of water treatment used to remove or destroy the cysts of *E. histolytica* are effective against the cercariae of *S. mansoni*, and present information indicates that the same methods are also effective for *S. japonicum* and *S. haematobium*. Since schistosomiasis exists only in areas where amebiasis is a hazard, the methods of water purification recommended for the prevention of amebiasis should be followed to insure protection against both diseases. Careful chlorination of the water to insure a residual of 1 p. p. m. of chlorine after 30 minutes contact is essential with all sand filters, since these cannot be relied on to remove the cercariae.
>
> Water for bathing, including showers, and laundry purposes, may be pretreated, filtered, and chlorinated as indicated [above] . . . .
>
> A residual chlorine of 1 p. p. m. remaining after 30 minutes contact destroys the cercariae. Therefore, water to be used for bathing may be effectively treated by chlorination to produce this residual after storage in a tank for 30 minutes.
>
> Since a temperature of about 125° F. is required to destroy cercariae, heating as provided by the usual [Army field] bathing unit is ineffective, and one of the methods described above must be employed.
>
> Because of the small size of the snails, it is usually not practicable to remove them by using a screen placed at the raw water intake.

Transmission of Hepatitis by Water. Studies and observations of the incidence of hepatitis in various theaters indicated that water might be a factor in the transmission of this militarily important disease. The Army Epidemiological Board, with the technical assistance of the Sanitary Engineering Division, conducted a series of experiments, which proved that epidemic jaundice can be transmitted by water contaminated by feces from patients suffering from the disease.[57] Since this disease can be transmitted only through man, it was necessary to use human volunteers for the experiments.

An initial test indicated that a chlorine residual of 1 part per million in unfiltered water of high organic content with 30 minutes contact would not inactivate or destroy the virus. Another test, using only coagulation and

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[56] See footnote 54, p. 112.

[57] Annual Rpt, Army Epidemiological Bd, Commission on Measles and Mumps, FY 1945. HD: 334 AEB.

ctivated carbon was also unsuccessful, though the onset of the disease was ıarkedly delayed. In a third test, the water was chlorinated to provide a sidual of 15 parts per million after 30 minutes contact and then dechlorinated. ı this test, none of 5 volunteers contracted the disease, but 4 out of 5 of the ontrol group became ill.[58] However, there was some laboratory or clinical vidence that the virus had not been entirely inactivated, though evident illness id not develop in the test group, nor did the subjects obtain immunity to the sease, since in later tests they developed hepatitis.

The test was later repeated with water that was coagulated, filtered through atomite filters, and chlorinated to produce resi ıals of 10 and 5 parts per illion, the water being dechlorinated after 30 minutes contact. In this series ' tests, the results were essentially the same as at the higher chlorine dosages. one of the volunteers who consumed treated water suffered from hepatitis. ı addition, an extra group of 5 were given contaminated water which had been retreated and filtered as above and chlorinated to produce 1.2 parts per million sidual after 30 minutes contact. None of these contracted hepatitis. It ppears that coagulation and filtration are essential, and that these processes nd to inactivate the virus and also, by clarifying the water, permit effective ılorination. The previous test using 1.1 parts per million of chlorine apparıtly failed because the water was so highly contaminated that chlorination ould not be fully effective.[59]

In view of these results, the possible use of superchlorination was reviewed. his procedure would have many advantages in overseas areas in insuring comlete sterilization of the water, even under adverse conditions, and would also sure destruction of the cysts of *E. histolytica*. By subsequent dechlorination, l objectionable chlorine tastes can be removed; and the creation of free ılorine residuals, capable of persisting for long periods, provide more effective rotection against recontamination. Accordingly, in cooperation with the ater equipment laboratory at Fort Belvoir, a series of procedures for superıd dechlorination of water were developed and forwarded to the theaters for mment.[60] The procedures suggested were:

1. At water points served by portable water purification units:

a. At operating rate of 10 gallons per minute, the chlorine feeding unit capable of dosing the water at any rate up to 72 parts per million of chlorine. ıfficient chlorine should be applied and the water tested to insure a residual of to 15 parts per million in the final tank. It is simplest to coagulate and settle ısing activated carbon if desired) in accordance with general practice and to ld the chlorine as the water is pumped to the final tank, ready for delivery.

[58] Neefe, J. R.; Stokes, J., Jr.; Baty, J. B., and Reinhold, J. G.: Disinfection of water containing causative agent of ectious (epidemic) hepatitis. J. A. M. A. 128: 1076-1080, Aug 1945.

[59] (1) Neefe, J. R.; Baty, J. B.; Reinhold, J. G., and Stokes, J., Jr.: Inactivation of the virus of infectious hepatitis in nking water. Am. J. Pub. Health 37: 365-372, Apr 1947. (2) Baty, J. B.: The treatment of water to inactivate the ısitive agent of infectious hepatitis. HD: 710 Hepatitis.

[60] Memo, Col W. A. Hardenbergh, SnC, Dir Sanitary Engr Div SGO, to Maj G. A. Hall, SnC, Off of Surg USASOS VPA, 25 Jul 45.

If no pretreatment is necessary, the chlorine is added by the pumping and chemical feed unit.

b. Dechlorination of the water is best accomplished at the latest possible time prior to use, thus minimizing opportunity for recontamination. When the water is dispensed in Lyster bags, the water in these should carry as near as possible to the maximum residual. If canteens are filled from the Lyster bags, a dechlorinating tablet should be added to the canteen; this will remove all taste and odor of chlorine in approximately 5 minutes. The water is then ready to drink. Water to be used for cooking may be chlorinated in the same manner. If the water is to be dispensed from the Lyster bag, as for drinking from cups, the entire contents of the Lyster bag may be dechlorinated. Sodium thiosulphate is the most generally desirable dechlorinating agent.

2. At water points served by the mobile purification unit:

a. At the operating rate of 60 gallons per minute, the chlorinator on the mobile purification unit will not supply a sufficient amount of chlorine to provide a residual in excess of about 8 parts per million. The best procedure is to batch-chlorinate in a storage tank to give the desired residual and then use the chlorinator on the unit to add the additional required amount. Procedure in dechlorination is the same as for the portable unit. Procedures for diatomite filters are the same as for the portable and mobile units.

b. When it is necessary to treat water in Lyster bags, three ampules of grade A calcium hypochlorite will be required to provide a residual of 5 parts per million. A special ampule or capsule can be provided to assure an adequate dosage and avoid the necessity for using a large number of standard ampules or the weighing of bulk hypochlorite, grade A. A dechlorinating tablet is necessary and can be provided.

3. Canteens: When water is drawn from Lyster bags already superchlorinated, only the addition of a dechlorinating tablet is necessary. When it is desired to superchlorinate in the canteens, the chlor-dechlor package may be preferable. This gives an initial dosage of 15 to 25 parts per million. A dechlorinating tablet is provided in the package; further treatment is unnecessary. The water can be consumed as soon as the chlorine taste disappears.

4. Fixed installations: In general, at fixed installations, either permanent or semipermanent, the water should be dechlorinated before it leaves the purification plant. This may be done by using activated carbon or by adding a dechlorinating agent. Powdered activated carbon, which is available in all overseas theaters, may be used. Sanitary Corps sanitary engineers should be utilized to study local problems and prepare procedures. The following procedure may be used: Calcium hypochlorite is added as the water enters the primary settling tank in an amount sufficient to produce a residual of 10 to 15 parts per million of chlorine. Coagulant may be added at the same time. Activated carbon should not be added until the chlorine has had a contact period of 30 minutes. The arrangement of the settling and mixing basins will

determine the details of the procedure. Approximately 1 pound of carbon will be required to remove 6 pounds of chlorine, provided good mixing of the carbon is obtained. Some chloramine residual may remain in the water after contact with the activated carbon. If this is not sufficient to maintain the desired residual in the water, additional chlorine may be added to the filter effluent by means of a chlorinator or hypochlorinator.

It was recognized that the procedures described would result in a considerable increase in the use of chlorine products. The application of 10 parts per million of chlorine requires about 120 pounds of grade A calcium hypochlorite per million gallons of water. Dechlorinating agents would also be needed. Most important and difficult of all would be the job of training water purification personnel in the new procedures. It was anticipated that a considerable number of sanitary engineers would be needed. In return, it was believed that practical elimination of water-borne disease would result. The end of the war so greatly reduced the need for these measures that they were never carried out.

Comments on these procedures were received from a number of theaters, and pertinent data are abstracted here briefly. Col. Marcus D. Kogel, MC, medical inspector of the China theater stated:[61]

> In spite of our insistence on the use for drinking purposes of water that has been boiled and chlorinated after cooling, and in spite of every safeguard in the conduct of the mess, the incidence of amebic dysentery is appallingly high. . . . There must be another source . . . in addition to water and food. In the Kunming area . . . and in other places in China . . . the natives live in squalor. . . . The ground is covered with human and animal excrement and the passing vehicles grind this material into a dust which at times is so thick as to obscure the landscape. . . . In this extraordinary country we not only eat fecal material, but we breath it. I consider this to be a significant source of amebic and helminthic infection. I regret that the super and de-chlorination technique was not adopted early in the war. I believe it would have prevented a good deal of amebiasis and virus hepatitis, and perhaps some poliomyelitis.

Lt. Col. Ralph R. Cleland, SnC, Chief Sanitary Engineer of the European Theater of Operations, stated:[62]

> It is my opinion and that of others in the ETO that the use of ammonia alum in the field constitutes a hazard to the health of the troops. Major C. C. Agar's (SnC) work in the Third Army area demonstrated that their non-potable samples, representing water chlorinated to give an orthotolidine residual of 1.0 parts per million after 30 minutes contact, were due to the formation of chloramines, the necessary ammonia being furnished by the ammonia alum. Major Harley Riley (SnC) of the Ninth Army found waters in Holland which required from 10 to 20 grams per gallon of alum to form a satisfactory floc, which in this instance would furnish the ammonia for up to 30 parts per million or more of chloramine. To offset this condition, it is necessary to give longer periods of contact, a practice which is difficult when a water point is pushed by consumers or the hours of daylight are short and the crew is anxious to finish. In other words: "Come on, are we going to be here all night; let's shoot the chlorine to this water and scram." Contact time is forgotten. I would suggest that the orthotolidine-arsenite test be made standard to eliminate false residuals.

[61] Personal communication to author, 19 Sep 45.
[62] Personal communication to author, 6 Aug 45.

Further comment on conditions in the European theater was embodied in a memorandum[63] by Lt. Morris Ribner, SnC, to the surgeon of the Third United States Army, which included the following points: Experience has indicated that portable water purification units can use breakpoint chlorination and maintain residuals of 1 to 2 parts per million in the clear well. All water, irrespective of initial turbidity should be prechlorinated and coagulated. Treatment of water in Lyster bags and canteens to 15 parts per million residual is not recommended. With portable purification units, use of the continuous floc method of coagulation and settling and prechlorination, filtration at a rate not to exceed 10 gallons per minute, and dechlorination with granular carbon or sodium thiosulphate solution is desirable. The modified methods of water treatment used in the European theater probably fulfilled some of the requisites for controlling hepatitis. These methods provided long contact periods with residuals around 2 parts per million. In any case, the hepatitis rates after adoption of the new methods of treatment were consistently very low as compared with those of the preceding year.

Comments from Mid-Pacific,[64] prepared by Lt. Col. C. H. Connell, SnC, included the following specific points: Super- and de-chlorination procedures have no technical nor mechanical aspects more complicated than other water treatment processes normally practiced in the field. Addition of chlorine at the beginning of the treatment process instead of at the end of the coagulation sedimentation period is recommended. A dechlorinating agent can be used in precisely controlled dosages to leave 1 to 3 parts per million residual. The task of procuring, treating, distributing, and protecting the water supply for 15,000 to 25,000 troops justifies the assignment of a qualified sanitary engineer with principal duty as supervisor of water supply.

Swimming Pools and Bathing Beaches. Because swimming pools and bathing beaches may contribute to the spread of disease, their general design and supervision of operation was a responsibility of the Medical Department.[65] In addition to recreational use, swimming pools were used to teach swimming to troops of amphibious units in order to reduce losses incident to landing operations. Standards for swimming pools were prepared by the Sanitary Engineering Division, Office of The Surgeon General, in close liaison with the Corps of Engineers, who prepared plans for construction.[66] These plans were approved by the Sanitary Engineering Division for the Medical Department and thereafter were followed in all authorized construction.

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[63] Memo, 1st Lt Morris Ribner, SnC, Asst Med Insp, Off of Surg, Hq XX Corps, to Surg 3d Army, 11 Sep 45, sub: Treatment of water by superchlorination with a portable purification unit. HD: 720 Water.

[64] Ltr, Lt Col Cecil H. Connell, SnC, 18th Med Gen Lab, to Surg Army Forces POA, 22 Aug 45, sub: Super and dechlorination of water to destroy hepatitis virus and cysts of *E. histolytica*. HD: 720 Water.

[65] (1) AR 40-205, par. 2, 31 Dec 42. (2) TB Med 163, Sanitary Control of Army Swimming Pools and Swimming Areas, May 1945.

[66] SG Cir Ltr 118, 12 Jul 43, sub: Army swimming pools and swimming areas.

The greatest difficulty in the application of these standards lay in the fact that many Army pools were built with nonappropriated funds, most of them from post exchange or similar funds. Such pools were usually constructed from designs made by the local engineer, or a local designer. Often no official information reached service command headquarters until the pool was wholly built. Few of these pools met sanitary engineering requirements, and satisfactory operation was difficult or impossible.[67]

Investigations were made to determine the need for and desirable elements of design of therapeutic or reconditioning pools, but in most cases, the standard Army pool appeared to be suitable for these uses. In general, for these purposes, about two-thirds of the pool area should have a depth of 3½ to 5 feet in order to permit exercises, including calisthenics, while standing chest deep in the water, or to permit patients to be seated at tables in the water. In some therapeutic pools, provision must be made to heat the water to 90° F. or thereabouts.

The standard plans for swimming pools prepared by the Corps of Engineers conformed in general to the "Recommended Practice for Design, Equipment, and Operation of Swimming Pools and Other Public Bathing Places" (an official report (1942) of the American Public Health Association). Army pools built after 1942 from appropriated funds were constructed in accordance with modern practices in swimming pool design. Since these pools were of more recent construction, and since there were a number of large pools, there was probably a higher percentage of Army pools with gravity sand filters in their recirculating systems than was the case in civilian pools. Some of the Army pools were built with a ledge or shelf around the deep end at about a 4-foot depth to aid instructors using the pool to teach lifesaving in connection with landing operations and disasters to vessels at sea. While many crude and inadequately equipped pools were built, in general, the Army with its extensive staff of sanitary engineers, succeeded in the sanitary supervision of the operation of swimming pools so that the danger of the spread of infection by this means was kept to a minimum.

To accommodate the heavy peak loads on showers, toilets, and lavatories, due to their use by training classes, the number of showers provided at Army pools was about four times the number installed at civilian pools. The number of toilets and urinals at Army pools was more than twice the number normally installed at civilian pools.

Ship Water Supply. The safeguarding of ship and port water supply was one of the most difficult problems encountered by the Sanitary Engineering Division. The wide variety of ships used; the crowding dictated by military

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[67] (1) Capt D. F. Smallhorst, SnC, to CG 9th SvC, 21 Oct 43, with inclosures, Investigation of Swimming Pools at (a) Marana AAF Base, Ariz., 4 Aug 43; (b) Fort Huachuca, Ariz., 27 Jul 43; (c) Marin County Golf Course, 76th MP Bn, Calif., 10 Aug 43; and (d) Camp Williams, Utah, 21 Aug 43. HD. (2) Ltr, Maj John J. Poutas, MC, and Capt John E. Kiker, SnC, to Chief, Med Br Hq 4th SvC, 4 Jun 43, sub: Medical inspection of 339th College Training Detachment (Air Crew), Furman University, Greenville, S. C. SG: 721.5 (2183d AAF Base Unit) CC.

necessity; the need for added water tank capacity to meet this increased loading; and the general lack of suitable purification equipment on ships, all combined to intensify the problem. In ports, the need for increased fire protection and the frequent lack of municipal regulations or policies regarding cross connections were added difficulties.

A directive issued by The Adjutant General, based upon recommendations of The Surgeon General, required 0.3 part per million chlorine residual in the water supply of ships transporting military personnel.[68] The directive called for the installation of chlorinating equipment on the ships, but relatively few installations were made. As more ships were employed and more troops were being transported outbreaks of enteric disease began to show up. These outbreaks were caused, among other things, by contaminated water resulting from: (1) the practice of taking on unsafe drinking water while in foreign ports; (2) placing drinking water in tanks which had been previously used for other liquid cargo such as oils; (3) the practice of flooding drinking water tanks with harbor water to act as ballast on return trips; (4) interconnection between the ship's piping for salt waterlines and drinking waterlines.

In April 1943 inquiries were sent to all ports of embarkation requesting information as to action taken on previous recommendations.[69] Replies indicated that, with some exceptions, little actual work had been accomplished. The notable exception was at the San Francisco Port of Embarkation where Capt. Daniel E. Bonnell, SnC, under the direction of Brig. Gen. Wallace DeWitt, MC, Port Surgeon, organized a crew whose responsibility was to inspect all troop-carrying ships coming into port, supervise the sterilization of all tanks and piping carrying drinking water, and then install a super- and de-chlorination unit if the ship did not have such a unit.[70] These units were developed largely by Captain Bonnell in cooperation with some commercial concerns.

Considerable time and effort was expended in an attempt to improve existing conditions. Repeated contacts were made with representatives of the Maritime Commission, War Shipping Administration, the Public Health Service, the Ship's Operations Division of the Transportation Corps, and the Navy. By the end of 1943 an increased number of ships were properly equipped for water sterilization but the number so equipped never approached a satisfactory total. This was due to: (1) The intricate chain of command and responsibility for new ships under construction and ships under charter;

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[68] (1) Ltr, SG to TAG, 16 Apr 41, sub: Protection of water and food supplies on Army transports, with inds. SG: 720.-1(BB). (2) Ltr, AG 720.2(5-28-41)MC-C, 25 Oct 41, sub: Defensive procedures in connection with biological warfare. AG: 720.2.

[69] For example see, Ltr, Chief of Trans to CG NYPE, 2 Apr 43, sub: Protection of water supply on Army transports, with ind. OCT: 671(NY).

[70] (1) Memo 6, Off of Port Surg, SFPE, 28 Dec 42, sub: Chlorination—transport drinking water supply. OCT: 671 (SF). (2) Memo for file, Maj Lloyd K. Clark, SnC, 24 Sep 43, sub: Water supplies in connection with ships transporting Army troops. HD: 720 Water (Ships and Docks). (3) Bonnell, D. E.: Water conditioning units designed for transports by Port Surgeon's Office, San Francisco Port of Embarkation. HD: 720 Water(SF).

(2) lack of time due to urgent military situations; (3) the difficulty some agencies had in enforcing their requirements; (4) indifference and lack of cooperation on the part of shipowners and skippers; and (5) the provision on some new transports of distilling apparatus sufficient to meet all the daily fresh water needs.

Although the installation of chlorinating equipment on ships left much to be desired, it must be recorded that all port surgeons placed in effect a program for testing and for hand chlorination of drinking water supplies. The program consisted of: (1) A sampling schedule for all ships arriving and departing from port, the samples being tested for residual chlorine and bacteriologic content; (2) actually chlorinating, manually, all water loaded for drinking purposes; (3) cleaning and coating potable water tanks when indicated; (4) instructing ship personnel in the methods of hand chlorination and the need therefor; and (5) providing transport surgeons with written instructions on the need for maintaining the safety of drinking water, and on methods for sterilization of water.

Another problem in ship water supply arose because salt water was used for showers, flushing toilets, and in some cases for dishwashing, vegetable peeling, and laundry. The congestion of ships in ports contributed greatly to harbor pollution. The presence of 50 or 60 ships, each carrying 2,000 troops, would result in the pollution of a harbor with the untreated wastes of 100,000 persons, while the ships were drawing salt water from the same source for their daily requirements. Once in convoy, there is a chance, though a much smaller one, that the ships at the rear, will pick up contamination in the salt water pumped into the service lines. One test indicated, however, that such contamination was not usual, since all the samples taken were negative.

Port Water Problems. The water supply problems at ports were mainly of two general classes: those incident to fire protection, and those resulting from the supply of water to ships.

The need for fire protection on piers, especially where munitions were stored or loaded, led to the proposal by the Office of the Chief of Engineers to install Siamese connections. These permit the use of city water in sprinkler systems, and also allow salt water to be pumped in by fireboats to supplement the city supply. The result is contamination of the city water supply by salt water which is forced in at a pressure greater than the static pressure of fresh water in the mains. The proposed use of Siamese connections was disapproved as a serious health hazard; and the use of a dual system was recommended as being cheaper, more effective, and safer. By this arrangement, the sprinkler system was fed by the city supply, while salt waterlines provided supplemental services for firefighting use.

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Ships take water at piers through extensions from city mains, usually one or more outlets being provided for each berthing place. At most piers these outlets are not provided with backflow preventers. Also, at most piers, ships without power (and sometimes those with power) connect to the pier waterlines for fire protection. If, when so connected for fire protection, the ship's fire pumps are started, sea water may be and frequently is forced back into the city waterline outlet, resulting in dangerous contamination of the supply, including that of other ships served by the same pier branch. A number of epidemics of intestinal disease resulting from this practice were reported by the Sanitary Engineering Committee of the National Research Council.[71]

Conferences were held with representatives of the United States Coast Guard, Navy, Public Health Service, the Maritime Commission, and War Shipping Administration. The Sanitary Engineering Committee of the National Research Council was asked to prepare a report and recommendations. With these at hand, Army Service Forces Circular 234, 1944, was prepared and issued.[72] As a result of this directive, a large number of pier outlets were equipped with backflow prevention devices. These ranged, in accordance with local requirements, from single check valves, to Underwriter's double check valves, and special devices. The problem arose as to who would bear the cost of installation. A policy was finally adopted which provided for payment by the Army on Army-owned piers; for installation by the Army on leased piers with final charge against the owner of the pier; and for municipal and other pier owners to pay for the type of installation they were required or desired to make.

Another serious problem was the supply of water to ships in overseas ports, especially in the Pacific, where potable water is often scarce. Since a soldier requires a minimum of 1 ton per month of supplies after initial equipment is landed, the supply of 100,000 men requires at least 100,000 tons per month. A Liberty ship unloads at the rate of 300 to 700 tons per day, depending on facilities and loading. At an average of 500 tons per day, about 7 ships must be unloading all of the time; 2 or 3 or even more times as many ships will be in the harbor or nearby. Water must be provided for all of these and for the troops unloading and handling the material. Therefore, in the larger Pacific operations, special provision for water supply for ships' use and for port personnel had to be made.

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[71] (1) Rpt, NRC Temporary Subcommittee to Committee on Sanitary Engineering, 20 Nov 43, sub: Cross connections and back-siphonage connections under war conditions. HD: 040. (2) Rpt, NRC Temporary Subcommittee on Cross Connections of the Committee on Sanitary Engineering, 21 Oct 44, sub: Supplementary report re cross connections and back-siphonage connections. SG: 720. (3) NRC Sanitary Engineering Rpt No. 8, "Report on Cross Connections and Back Siphonage Connections under War Conditions," 6 Dec 44. HD: 040.

[72] (1) Minutes of 16th Meeting, NRC Committee on Sanitary Engineering, 23 May 44. HD: 040. (2) ASF Cir 234, 26 Jul 44.

Hotel Water Supplies. The use by the Army of hotels for housing troops created a serious problem in regard to water.[73] Most of these hotels were old ones, with at least some cross connections in many of them, with plumbing susceptible to back-siphonage. The number of troops assigned to each hotel was generally 2 or 3 times as great as the number of guests at peak operations. In 1 hotel which had served a peak of 4,100 guests, 9,850 troops were quartered; in another in which guests had exceeded 1,500 but once or twice, 4,950 troops were housed.

The regularity of hours, coupled with this heavy personnel load, resulted in demands on the water supply and waste disposal systems greater than they were designed to carry. As a result, negative pressures up to 10 inches of mercury developed on the upper floors of some hotels at times of peak demand. In addition discharge sewers backed up to the second, or even third, floor level in some of the overloaded hotels. This was frequently the case in hotels where roof water from rains was carried away by the hotel sewer system. In such cases, arrangements were made to have the lower floors served by a separate system of drains, discharging to pumps in the basement, which delivered the sewage to the street sewer.

As soon as hotels were selected, sanitary engineers were dispatched by the service commands, on recommendation of the Sanitary Engineering Division, to make sanitary surveys of these structures.[74] These surveys included examination of the sufficiency of the water and waste disposal systems under peak load conditions, the type of toilet fixtures, and the possibility of leakage of overhead sewers in basements onto food under preparation. Specific recommendations for correction of defects were made. Close cooperation with the Repairs and Utilities Division, Office of the Chief of Engineers, was maintained to insure immediate correction of defects. In a few cases it was necessary to delay assignment of personnel to a hotel until corrections had been made.

The types of hazards found were those generally familiar to engineers—cross connections in air conditioning, laundry, and other equipment; defective plumbing fixtures; and defective or leaking sewers. At many hotels, as an added factor of safety, the water was rechlorinated to provide a definite residual. As a result of these precautions, no epidemics of disease traceable to the water supply occurred at any hotel taken over by the Army.

College Supplies. The inauguration of the Army Specialized Training Program placed many thousands of soldiers in colleges. It was known that in some colleges sanitary defects existed, and that at others the expected crowding of dormitories would overload water and sewage facilities. Therefore, the service commands were directed to make surveys at colleges similar to those

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[73] Memo, Col W. A. Hardenbergh, SGO, for Col J. S. Simmons, SGO, 11 Sep 42, sub: Health hazards from use of hotels for housing troops. HD: 720 Water.

[74] Ltr, Exec Off SGO to CG 8th SvC, 30 Mar 43, sub: Health hazards from use of hotels for housing troops, with incl. HD: 720 Water.

already made at hotels.[75] As was expected, numerous defects were located, but in nearly all cases these were corrected promptly by the college authorities or by the Repairs and Utilities Division. Where corrections were not made, the program was cancelled. This action was necessary in very few instances.

Protection Against Sabotage. In January 1942 the Surgeon General's Office was requested by the War Research Service under Mr. G. W. Merck to prepare for that agency a list of the defensive procedures necessary to safeguard water supplies against intentional contamination or damage. The request came as a result of the office's previous work on methods of detecting the presence of warfare agents in water. The War Research Service was desirous of initiating defense procedures against sabotage of water supplies at Army installations and at industrial plants engaged in war production.

A list of defensive procedures was prepared and later distributed by the Adjutant General's Office to Army installations.[76] These procedures included the following: Thorough surveys by competent engineers to determine all existing sanitary hazards and measures for their elimination; installation of measures and equipment to prevent access such as protective fencing, flood lighting, guards, et cetera; provision of laboratory facilities to make necessary chemical and bacteriologic tests; provision for adequate spare parts, repair and reserve machinery and treatment supplies; maintenance of records and maps; investigation of employees; provision for rapid replacement, repair, or substitution of key pipelines, pumps, and engines; preparation of adequate detailed maps of water systems; regular inspection of the water source; daily tests of oxygen consumed and frequent tests for chlorine residual; and chlorination of all Army water supplies to produce a residual of 0.4 part per million.

One of the programs of The Provost Marshal General was the security of essential industrial plants.[77] He requested advice in regard to measures for the protection of water supplies serving such plants. The Sanitary Engineering Division of the Surgeon General's Office replied that the greatest hazard was in cross connections, actual or potential, which might by accident or design permit dangerous contamination of the drinking water. The Sanitary Engineering Division was then asked to furnish personnel for and supervise a program of protection.

Visits were made to all service commands and the commanding generals, surgeons, and internal security division directors were informed of existing conditions and requested to authorize the additional personnel needed for the

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[75] Ltr, SG to CG 1st SvC, 6 Apr 43, sub: Water supply safety at colleges utilized in Army Specialized Training Program. SG: 720.2-1.

[76] (1) Ltr, TAG to CGs AGF, AAF, SOS, and others, 11 Sep 42, sub: Detection of contamination in water supplies. SG: 720.2. (2) Ltr, TAG to CGs all SvCs and others, 14 Jun 43, sub: Continued protection of water supply. AG: 671.1. (3) Ltr, TAG to CGs AGF, AAF, ASF, and others, 5 Jul 44, sub: Detection of contamination of water supplies. AG: 381.

[77] (1) Ltr, TAG to Under SecWar and Chiefs of Supply Arms and Services, 7 May 41, sub: Interior protection of plants and utilities. SG: 004.003-1. (2) Memo, Under SecWar to SG, 12 May 41, sub: Plant protection inspection service. SG: 004.003-1. (3) Plant Protection Inspection Bull. No. 1, US Army Med Dept, 12 Aug 41. SG: 004.003-1.

work. Lt. Col. William H. Weir, SnC, was placed in charge of the work with 23 assistants, most of whom were company grade Sanitary Corps engineers, especially selected because of experience in this field of work. Since the Internal Security Division, Office of The Provost Marshal General, already had a large staff of semitechnical inspectors, mostly men with experience in fire prevention, and since the initial program included over 15,000 installations, the program was based on instructing these inspectors and utilizing them for the major part of the actual work.

Close relations were established and maintained with the Public Health Service, and with the various State boards of health. The program included surveys of conditions within the manufacturing plants when considered necessary, and examination of the water supplies serving them to detect sanitary defects and locate conditions that would permit effective sabotage. These latter surveys were generally made by the sanitary engineers of the Sanitary Corps, since sound technical knowledge was required, and usually in cooperation with the sanitary engineers of the applicable State board of health.

Examinations of the manufacturing establishments were made on the basis of need. Plants that had been operating before the war and had not been greatly enlarged were generally found to be relatively free from hazards; in fact records of previous examinations by State or local health agencies were often available. Plants with dual water supplies, especially those built under conditions of wartime speed, were most likely to have defects. Thus by a process of screening, the number of installations requiring immediate attention was reduced greatly.

This program was initiated on 1 June 1943, and terminated 20 months later. So far as is known there was never any substantial interruption to essential war materiel production as a result of contamination of water supplies, either by accident or design. The quick, effective, and skillful use of sanitary engineers with special qualifications for the work must have been an important factor in attaining this result.

Water from Airfield Runways. In one of the Caribbean bases, the construction of a large catchment area was necessary in order to supplement local water supplies. The use of airfield runways, an area of about 40 acres, was proposed to obviate the need for constructing a special catchment area at a considerable cost. The possible presence of lead in the water was considered the greatest objection to the proposal. No data were available as to the lead deposited from the leaded gasoline spilled while filling and that used by planes while warming up, taking off, and landing.

Computations based on the amount of gasoline used and its lead content indicated that lead deposit would not be excessive. Tests were then made at two fields in the United States, runoff water being collected during rainy periods and tested. Samples were taken during the first flushoff, and after the rain had fallen for a definite period. These samples were taken from

the runways and from the warmup areas. In no case, though taken from heavily used fields,[78] did the samples show any excessive amount of lead. The use of runways as a catchment area was therefore approved, but special treatment of the water by coagulation, activated carbon, and filtration was specified, since these procedures are effective in reducing lead content.

Distillation. Due to the shortage of water at many of the islands occupied by our troops, distillation was used extensively, especially in the Pacific.[79] All the development of distilling apparatus was carried on by the Corps of Engineers. Since some of the equipment operated at relatively low temperatures—around 115° F.—the question arose as to the bacterial content of the distilled water. A series of tests made under the auspices of the Public Health Service indicated that such water was sterile.

Prisoner of War Base and Branch Camps. There is a tendency to neglect sanitation at prisoner of war camps. However, it is a shortsighted practice because disease among prisoners endangers the health of our own troops. In protecting water supplies at these camps, service command headquarters required that: All drinking water must be chlorinated in accordance with routine Army practice; common drinking cups must not be used, individual canteens to be furnished instead; routine bacteriologic examinations must be made on all drinking water supplies; and each camp must submit a sanitary report.[80]

Few chlorinators were installed at branch camps; Lyster bags were used in most places.[81] Most of these camps were temporary and under similar conditions piped water would not customarily have been furnished to United States troops. Therefore, unless piped water was already locally available, it was customary to dispense the water in Lyster bags.

Procedures at Inactive and Surplus Installations. In preparation for inactivation and subsequent disposal of camps in the Zone of Interior at the close of the war, it was necessary to prepare standard procedures for water supplies to be applied to installations in these categories. Since some inactive installations might be reactivated, consideration had to be given to maintenance of the water supply and treatment facilities in such condition of readiness for service as might later be required. A directive covered the following essentials:[82]

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[78] For example, Ltr, L. T. Fairhall, Natl Inst of Health, to Col W. A. Hardenbergh, SGO, 9 Mar 42, with incl, "Analysis of Water Collected at Bolling Field, Anacostia, Washington, D. C., March 2, 1942." SG: 720.21-1.

[79] (1) History of preventive medicine in the Western Pacific Base Command. HD: 314.7-2. (2) A history of preventive medicine, United States Army Forces, Middle Pacific. HD: 314.7-2.

[80] History of Sanitary Engineering Activities during World War II in Seventh Service Command. HD: 720 Water.

[81] (1) 6th ind, CO Sta Hosp, Florence Internment Camp, Ariz., to CO Florence Internment Camp, 6 Dec 43, on Monthly Sanitary Rpt for Oct 1943. SG: 721.1 (Florence PW)C. (2) Ltr, CO Sta Hosp, Florence Internment Camp, Ariz., to CO Florence Internment Camp, 7 Feb 44, sub: Consolidated sanitary report for year 1943. SG: 721.5 (Florence PW)C.

[82] (1) Sanitary Procedures to be Followed at Installations Declared Inactive or Surplus. HD: 720 Water and Sewage. (2) TB Eng 66, May 45.

At inactive installations, with water purification plants employing sedimentation and filtration, water consumption requirements were to be computed for maintenance personnel and equipment, together with that necessary for fire protection, flushing, and irrigation: based on this requirement, sedimentation tank capacity was to be reduced to approximately 2 hours detention, coagulant dosages being maintained as necessary. Filter capacity was not to be reduced, but all existing filters were to be operated in rotation, as required. Filter operating rates were to be reduced and each filter operated for short periods every 2 or 3 days. Where necessary, treatment was to be applied to prevent organic growths. Where there was more than one filter plant, one might be placed in inactive condition, provided the other could furnish fire protection service.

All water was to be chlorinated to provide a residual of 0.4 part per million as required by current directives. Since the range of water requirements might vary materially, adequate chlorinator capacity was to be available in case of fire or other heavy demand. Chlorine cylinders in excess of requirements were to be returned. Clear wells and tanks were to be kept filled. Auxiliary treatment, such as iron removal, softening, and the addition of inhibiting agents, might be discontinued as determined by the service command. Algae control was to be maintained in reservoirs and tanks.

Where water was obtained from deep wells, chlorination facilities were to be maintained in the same manner as those for filtration plants. Auxiliary treatment, softening, and algae control were to be governed as indicated above. It was recommended that wells which produced the least satisfactory water or were more expensive to pump be placed in standby condition. For purchased water, the same general conditions applied, covering quantity, chlorination or rechlorination, and auxiliary treatment.

In distribution systems, normal water pressures were to be maintained; dead endlines were to be flushed regularly; all storage tanks were to be kept filled, protection being provided against freezing when necessary. The distribution systems were to be fully maintained, with repeated inspections to locate leaks and damage to valves and hydrants. All mainline valves were to be operated at approximately 6-month intervals to insure proper functioning. Fire hydrants were to be tested after prolonged cold periods and the hydrant barrel pumped out after testing. Heating of water in the riser pipes of elevated reservoirs by auxiliary steam boilers or water heaters was recommended to prevent freezing.

The plant operator and the minimum number of skilled operators needed when the post was reactivated were to be maintained when the degree of readiness was prescribed. If inactivation should be for an indefinite period, with no degree of readiness prescribed, at least one skilled operator was to be re-

tained. The usual operating logs were to be maintained, and normal pH and chlorine residual tests made. Routine bacteriologic testing, consistent with safety, was to be continued.

At surplus installations in the course of completion of salvage all equipment—including pumps, motors, chemical feed machines, meters, chlorinators, and laboratory materials, supplies, and equipment—were to be cleaned, protected, and properly stored. All calcium hypochlorite, acids, strong alkalies, and poisons were to be removed from the plant, including the laboratory. Other procedures were to include the following:

Reservoirs were to be checked to determine their safety against floods and overflows after normal deterioration takes place. The pipeline from the reservoir or other active source of supply was to be cut or effectively blocked as near as possible to the source, adequate provision being made for overflow from reservoirs, and to prevent waste of water or damage because of pipeline discharge. Sedimentation basins, filters, storage tanks, clear wells, and distributing reservoirs were to be drained and the outlets so arranged that these would not hold water. Where hazard existed to nearby residents or other civilian personnel or to domestic animals, surface level tanks and reservoirs were to be covered or filled with sand or dirt. Elevated tanks were to be drained and ladders or steps removed. Wells were to be capped or otherwise securely covered.

The distribution system was to be dewatered and valves and hydrants left open. Hydrant caps were to be loosened, the threads well greased, and the caps left in place. Piping and other equipment that was not removed was to be drained to prevent damage by freezing.

When installations were reactivated they were first to be surveyed by a competent sanitary engineer in company with the responsible Corps of Engineers officer, and the following steps taken: If water was purchased, the contractor was to be notified of the probable increased demand; necessary personnel for operation were to be employed; equipment for operation was to be inspected, reset if necessary, and tested; adequate stocks of chlorine and other chemicals required for purification were to be obtained; tanks, reservoirs, and any parts of the distribution system that had been removed from service or that had been filled with untreated water were to be thoroughly flushed and disinfected and the water tested for potability.

Location and Removal of DDT from Water. The large-scale application of DDT in battle areas overseas and its probable eventual use in this country indicated that investigations should be initiated to determine methods of detecting and measuring appreciable DDT concentrations in water; determining toxic concentrations; and establishing techniques for the removal of DDT from water. The Sanitary Engineering Division requested the Fourth Service Command Medical Laboratory [83] to initiate these investigations and made

[83] Annual Rpts, 4th SvC Med Lab, 1944, 1945. HD.

available the services of Capt. (later Maj.) John A. Carollo to direct the work.

Various methods of measuring DDT in water were tested. Since mosquito larvae are highly susceptible to DDT, this method cannot be utilized except for very small concentrations. The xanthydrol-KOH-Pyridine test was found to be most useful in general work, and sufficiently accurate for all practical purposes. The toxicity of water containing DDT was tested by feeding to mice. It was indicated that concentrations as high as 50 parts per million did not affect the test animals.

In developing methods for removing DDT from water, it was desirable that, as in the case of warfare gases and other toxic contaminants, standard methods and materials of water purification should be utilized with as little variation as possible. Therefore, primary attention in determining methods of removal was placed on coagulation, the use of activated carbon, and filtration. It was found that chemical coagulation and settling, followed by filtration, was effective in reducing materially the concentration of DDT. In general, the iron salts appeared more effective than aluminum sulphate. In both cases, dosages of coagulants are slightly higher than those normally required for water purification. The addition of activated carbon materially improves removal of DDT. For normal DDT concentrations, 2 parts per million of activated carbon is effective, but heavier concentrations require a larger application of carbon.[84]

LIAISON WITH OTHER AGENCIES

Close relations in regard to water supply were maintained with the water equipment laboratory of the Engineer Board, Fort Belvoir, the National Institutes of Health, and the Sanitary Engineering Laboratory at Harvard University. Liaison was also maintained with the Stream Pollution Laboratory, United States Public Health Service, Cincinnati, Ohio; the Naval Medical Institute; and various commercial organizations which contributed materially to the solving of water purification problems, principally in the use of activated carbon, in chlorination, and in coagulation. The sanitary engineering sections of the various divisions of the Office of the Chief of Engineers cooperated very closely and effectively in many ways.

Water Equipment Laboratory of the Engineer Board. The water equipment laboratory of the Engineer Board developed the diatomite filter, working in close cooperation with the Sanitary Engineering Division, Office of The Surgeon General, and tested it under all conditions of expected field usage. Various models, ranging from 15 gallons per minute to 200 gallons per minute were standardized for use. Among other valuable contributions of this laboratory were the studies on removal of toxic contaminants from water, involving the testing of a large number of activated carbons; studies with the National Institutes of Health on the efficacy of filters in the removal of amebic

[84] Carollo, J. A.: The removal of DDT from water supplies. J. Am. Water Works A. 37: 1310-1317, Dec 1945.

cysts and cercariae of schistosomiasis; establishing effective methods of pretreating water to aid in cyst and cercaria removal and to provide effective chlorination; and development of other equipment such as tanks, pumps, distilling apparatus, and well-drilling sets.

A Sanitary Corps engineer was assigned to the Engineers' water equipment laboratory during much of the war. At all times, the closest relations were maintained by means of personal contacts and visits. A number of the civilian engineers employed at the laboratory were commissioned in the Sanitary Corps when the need for their services at Fort Belvoir became less urgent.

The National Institutes of Health. This agency was extremely helpful in determining the efficiency of various methods of destroying amebic cysts and cerceriae in water. All substances considered as having cysticidal value were tested at the National Institutes of Health, and usually in addition at Harvard and the Naval Medical Institute. The National Institutes of Health also tested the effectiveness of many sterilizing compounds.

The Sanitary Engineering Laboratory, Harvard University. This laboratory assisted mainly by doing research in water sterilizing and by testing water sterilizing compounds. It was principally instrumental in the development of the iodine compounds for individual water sterilization—Bursoline and Globaline, and also provided valuable information in regard to methods effective in the destruction of amebic cysts.

Stream Pollution Laboratory, United States Public Health Service. This laboratory carried out a very complete series of tests on the chlor-dechlor tablets, and also aided materially in checking much of the work done by others in the removal from water of toxic contaminants.

Naval Medical Institute. The laboratory facilities of the Naval Medical Institute were used mainly for checking the results of other laboratories. It was felt that results from at least three laboratories were desirable as a basis on which to establish important policies, especially on those problems where a paucity of information existed.

CHAPTER IV

Waste Disposal

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and

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Proper disposal of both liquid and solid wastes was necessary to protect the health of the Army and of the populations in areas adjacent to Army installations. The function and responsibility of the Sanitary Engineering Division, Office of The Surgeon General, was to work with the Quartermaster Construction Division and its successor in the Corps of Engineers in the establishment of bases of adequate design and to assist and advise in their subsequent operation.[1]

SEWERAGE AND SEWAGE TREATMENT

A sewer system may be said to transfer nuisance and health hazard to someone else's property as far distant as the sewer is long. It has been amply demonstrated that sewage contains the causative organisms of many diseases and that treatment, by either artificial or natural means, is essential to protect health and to prevent nuisance and damage to property. Every major Army camp in the United States was located near a center of population. Not only did troops visit these nearby communities, but in most cases a considerable civilian population developed as near as possible to the camp boundaries. Thus, each Army camp and the communities adjacent to it constituted, in effect, interdependent areas so far as health conditions were concerned.

Policies and Responsibilities

With these factors in mind, the Sanitary Engineering Division established as its policy in regard to sewage disposal that the Army ought to construct adequate facilities to protect the health of troops and civilians to prevent nuisance both within and without the camp, and, so far as possible, to avoid property damage outside the camp boundaries.[2] To accomplish these objectives, modern, well-designed and properly operated plants were necessary. Moreover, there had been established in all States, by the respective State boards of health, standards of design for sewers and sewage treatment plants.

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[1] (1) Public Law 326, 77th Congress, 1 Dec 41. (2) AR 40-205, 15 Dec 24, and 31 Dec 42.

[2] Memo, Col W. A. Hardenbergh, SnC, for Dir Prev Med Div SGO, 23 Sep 42, sub: Chronological record of activities, Sanitary Engineering Branch. HD: 024.

Since these standards were based on local conditions and local needs, as developed by years of experience, it was felt that they represented the best possible guide toward the desired objective. It was therefore a part of the Sanitary Engineering Division's policy that such State standards be followed except in clearly unusual cases.

In opposition was the policy that Army reservations were not subject to State regulations and that treatment of Army sewage, if any treatment were given, was for the Army itself to decide. This policy is sound only if the sewage is not discharged from, and does not affect people residing outside, Army reservations. The matter was further complicated by the fact that no modern standards for sewage treatment had been adopted by the Army.[3] Therefore, it was necessary to develop new designs to meet Army conditions and needs.

Army regulations imposed on the Quartermaster Corps the responsibility for design, construction, and operation of sewage treatment plants (since 1942 this has been a responsibility of the Corps of Engineers).[4] The Medical Department was specifically charged only with the performance of certain tests, most of which were outdated, and none of which could have any influence on the quality of the plant effluent. Since, to function properly, a sewage treatment plant must be adequately designed to meet local conditions, the broader responsibility of the Medical Department for health and sanitation was deemed to include responsibility for essential factors in design and participation in the selection of treatment processes.

In order to establish a basic policy satisfactory to the Medical Department in respect to the disposal of sewage, frequent conferences were held with personnel of the Construction Division, Office of The Quartermaster General, and with consulting engineers employed by them.[5] The Sanitary Engineering Division believed that only efficient types of plants, capable of producing satisfactory effluents, should be used; that these be designed on accepted bases of organic and population loadings; that, in design, consideration be given to the local situation so that advantage could be taken of favorable conditions, and danger to health and property damage be avoided; and that State boards of health should be consulted with reference to the type of plant, basis of design, and degree of treatment for installations within their respective States.

As a result of these conferences, the Engineering Manual (edition of March 1942; Chapter VII, revised January 1943), published by the Corps of Engineers which had meanwhile taken over the construction functions of The Quartermaster General, set up new and wholly satisfactory standards which

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[3] The Medical Department of the United States Army in the World War. Washington, Government Printing Office, vol. VI, pp. 241-62.

[4] (1) AR 100-70 and C 1, 5 Nov 42. (2) AR 100-80 and C 2-8, 10 Aug 42.

[5] (1) Memo, Col Larry B. McAfee, MC, SGO, to TAG, 19 Apr 41, sub: Operation of sewage treatment plants. SG: 672.-1. (2) Memo, Lt Col John A. Rogers, MC, SGO, to TAG, 19 Sep 41, sub: Design of sewage treatment plants for camps, posts and stations. SG: 672.

had previously been agreed upon and put into effect. It directed that sewage treatment plants should be designed to meet the requirements of local and State health departments, especially as to degree of treatment and disposal of effluent; and that the degree of treatment should depend upon the amount of diluting water available in the receiving stream during periods of minimum flow, the state of pollution of the stream, and the use of the stream below the point of discharge of sewage. Furthermore, factors of design were established, based on modern standards. The adoption of this policy marked an entirely new step by the Army in regard to sewage treatment and resulted in the virtual elimination thereafter of complaints and damage suits due to improper or inadequate sewage disposal.

Characteristics of Army Sewage. Before discussing the design factors established, it is desirable to consider the characteristics of Army sewage, and the ways in which it differs from municipal sewages. A relatively small amount of information was available from World War I;[6] this was supplemented by investigations during 1941. Army sewage is normally stronger, due to lesser use of water per person in most installations; it contains more suspended solids and more grease; and it has a greater biochemical oxygen demand. It is generally fresher than municipal sewage. Variations in hourly flow are greater, and when these are combined with marked increases in organic content, as from 0600 to 0800 hours, treatment by some types of processes is difficult. (See Charts 1 and 2.) During 1944, at the request of the Sanitary Engineering Division,[7] the Sanitary Engineering Committee of the National Research Council, through a subcommittee on sewage treatment at military installations, initiated a comprehensive study of Army and Navy sewages and treatment devices.[8] (See pp. 160–166.)

After consideration of all data available at that time, the following characteristics of Army sewage were adopted for design purposes:

	Pounds		
	Per soldier per 24 hours	*Per civilian 8-hour basis*	*Per resident personnel*
Suspended solids	0. 27	0. 13	0. 27
5-day biochemical oxygen demand	0. 20	0. 10	0. 20
Ether-soluble matter	0. 09	0. 05	0. 09

As an illustration of the greater strength of Army sewage, per capita biochemical oxygen demand, contributions to municipal sewage is estimated at 0.16 pound per day.

An analysis of sewage from 44 Army treatment plants, made in 1944, indicates that the weighted average for biochemical oxygen demand was 0.1921 pound per capita and for suspended solids 0.1545 pound per capita per day.

[6] See footnote 3, p. 132.

[7] Ltr, Brig Gen James S. Simmons, Chief Prev Med Serv SGO, to Dr. L. H. Weed, NRC, 3 Jun 44. HD: 720.6 Sewage (NRC Subcom).

[8] (1) Minutes of 13th Meeting, NRC Committee on Sanitary Engineering, 28 Feb 44; 15th Meeting, 18 Apr 44. HD: 040. (2) Minutes of 1st Meeting, Temporary Subcommittee on Sewage Treatment at Military Installations, NRC Committee on Sanitary Engineering, 22 May 44. HD: 040.

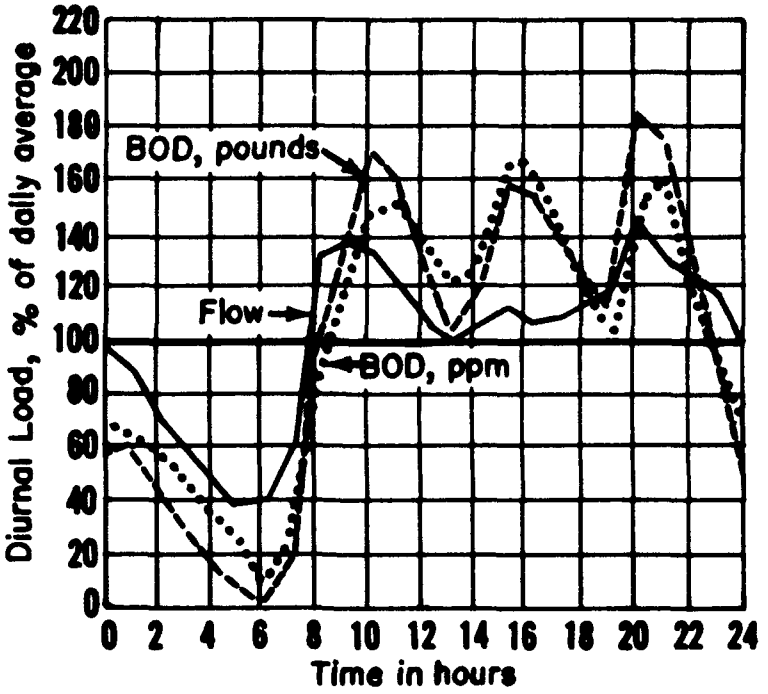


Chart 1. Typical hourly variation in flow and biochemical oxygen demand. Data represent average rate for each hour. Composite—Camp Joseph T. Robinson (Ark.), Camp Hood (South) (Tex.), and Fort Sill (Okla.).

Sewage Treatment. Where it was possible to do so, existing municipal sewage treatment plants were utilized to avoid constructing new facilities. Very few large Army camps could be served in this way; the distances involved, and the cost of constructing long outfall or force mains, and frequently of pumping the sewage, were decisive factors. Probably more important, in the case of large camps, was the fact that very few municipal plants had the excess capacity required to treat the sewage from a camp. On the other hand, discharge into a city sewer system on a service charge or other basis was relatively common in the case of airfields, general hospitals, and other small installations. In a few cases, the Army constructed for the municipality the additional units necessary to care for the increased load.

Sites for sewage treatment plants were selected carefully, giving consideration to the following factors: The topography and location of the receiving stream most desirable, from all viewpoints, for the discharge of the sewage effluent; a location as far distant as practicable from buildings, private homes, and centers of activity, with consideration given to the direction of prevailing winds; space for proper arrangement of plant structures and for possible future extensions to the plant; and a site that would not interfere with military operations. It was not always possible to find positions meeting all these requirements, but studies generally disclosed reasonably suitable locations.

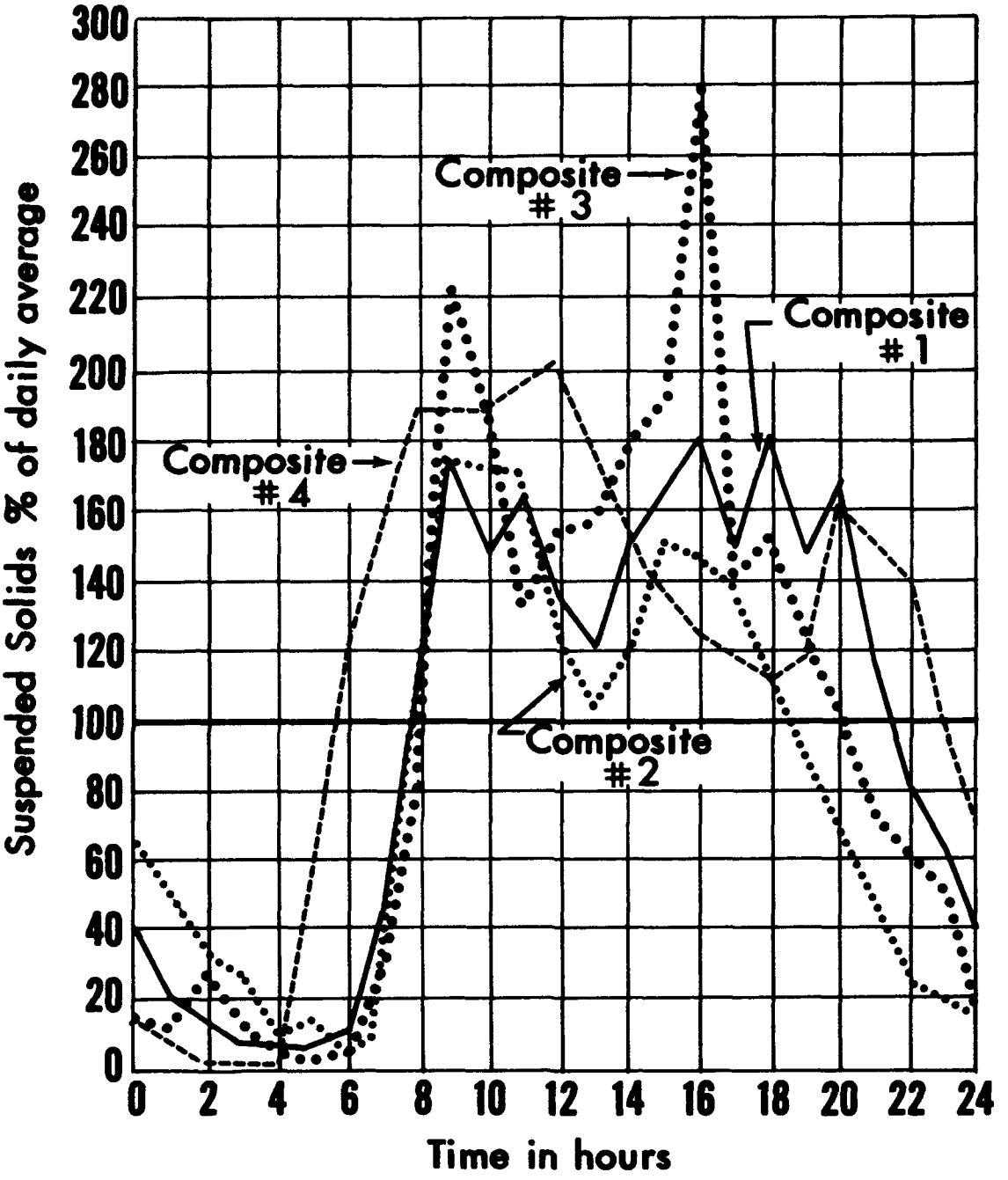


Chart 2. Typical hourly variation in suspended solids, pounds. Data represent average rate for each hour. Composite No. 1, Camp Joseph T. Robinson (Ark.), Camp Hood (South) (Tex.), and Fort Sill (Okla.). Composite No. 2, Fort Leonard Wood (Mo.), Camp Campbell (Ky.), Camp Roberts (Calif.), and Camp Swift (Tex.). Composite No. 3, Enid Army Air Field (Okla.), Lake Charles Army Air Field (La.), and Will Rogers Field (Okla.). Composite No. 4, Fitzsimons General Hospital (Colo.).

BIOCHEMICAL OXYGEN DEMAND AND SUSPENDED SOLIDS, POUNDS PER CAPITA PER DAY IN RAW SEWAGE

Post	Biochemical oxygen demand, pounds per capita			Suspended solids, pounds per capita		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Camp Campbell	0. 179	0. 226	0. 150	0. 157	0. 201	0. 123
Camp Crowder	0. 244	0. 292	0. 213	0. 241	0. 276	0. 210
Fitzsimons General Hospital	0. 217	0. 282	0. 163	0. 137	0. 185	0. 110
Camp Gordon	0. 218	0. 270	0. 168	0. 166	0. 203	0. 136
Great Lakes (Main)	0. 214	0. 279	0. 153	0	0	0
Fort Benjamin Harrison	0. 201	0. 301	0. 129	0. 188	0. 351	0. 122
Lockbourne AAB	0. 215	0. 276	0. 143	0. 157	0. 206	0. 121
Fort Sheridan	0. 190	0. 283	0. 092	0. 198	0. 311	0. 084
Camp Swift	0. 288	0. 276	0. 165	0. 201	0. 254	0. 160
Turner AAF	0. 211	0. 290	0. 128	0. 195	0. 335	0. 118
Fort Leonard Wood	0. 215	0. 270	0. 176	0. 210	0. 311	0. 159
Boca Raton AAF	0. 103	0. 119	0. 084	0. 099	0. 120	0. 078
Buckley Field	0. 213	0. 279	0. 154	0. 144	0. 189	0. 112
Camp Callan	0. 230	0. 280	0. 155	0. 250	0. 274	0. 182
Camp Carson	0. 180	0. 300	0. 146	0. 144	0. 220	0. 116
Camp Claiborne #1	0. 262	0. 398	0. 179	0. 197	0. 329	0. 121
Camp Claiborne #2	0. 172	0. 261	0. 151	0. 124	0. 163	0. 097
Drew Field	0. 186	0. 258	0. 108	0. 186	0. 280	0. 117
Camp Forrest	0. 195	0. 374	0. 128	0. 186	0. 412	0. 128
Fort Jackson	0. 183	0. 212	0. 128	0. 150	0. 198	0. 124
Fort Knox	0. 170	0. 212	0. 115	0. 159	0. 200	0. 109
Fort Bragg	0. 225	0. 310	0. 178	0. 157	0. 208	0. 124
Fort Dix	0. 167	0. 239	0. 113	0. 174	0. 250	0. 121
Kearns AAF	0. 198	0	0	0. 250	0	0
Keesler AAF	0. 148	0. 206	0. 099	0. 213	0. 338	0. 129
Camp Kilmer	0. 164	0	0	0. 185	0	0
Fort Sill	0. 179	0. 216	0. 135	0. 160	0. 194	0. 113
Camp Myles Standish	0. 281	0. 398	0. 159	0. 110	0. 162	0. 069
Fort Francis E. Warren	0. 264	0. 504	0. 241	0. 166	0	0
Fort Riley	0. 209	0. 318	0. 138	0. 292	0. 496	0. 191
Camp Roberts	0. 178	0	0	0. 141	0	0
Camp Joseph T. Robinson	0. 175	0. 241	0. 144	0. 097	0. 123	0. 071
Topeka AAB	0. 155	0	0	0. 183	0	0
Willow Grove	0. 137	0. 220	0. 093	0. 182	0. 312	0. 126
Camp Butner	0. 175	0. 251	0. 144	0. 155	0. 204	0. 108
Fort Monmouth	0. 107	0	0	0. 110	0	0
Camp Shelby #2	0. 171	0. 249	0. 086	0. 148	0. 222	0. 082
Great Lakes (Green Bay)	0. 209	0. 281	0. 142	0	0	0
Camp Blanding	0. 086	0. 104	0. 076	0. 139	0. 192	0. 114
Davisville	0. 153	0. 254	0. 107	0. 187	0. 241	0. 139
Camp Funston	0. 185	0. 391	0. 120	0. 216	0	0
Seymour Johnson Field	0. 189	0. 284	0. 144	0. 151	0. 226	0. 109
Camp Perry	0. 260	0. 354	0. 133	0. 209	0. 290	0. 137

BIOCHEMICAL OXYGEN DEMAND AND SUSPENDED SOLIDS, POUNDS PER CAPITA PER DAY IN RAW SEWAGE—Continued

Post	Biochemical oxygen demand, pounds per capita			Suspended solids, pounds per capita		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Camp Wheeler	0. 190	0. 252	0. 119	0. 131	0. 155	0. 084
Weighted Average	0. 1921			0. 1545		
Arithmetic Average		0. 277	0. 138		0. 245	0. 121

Design factors were generally based on standard sanitary engineering practice, with allowance for the greater strength of Army sewage.[9] In the use of certain new processes, as contact aeration, there was insufficient background of municipal experience upon which to base design, and difficulty was encountered in efficient operation of many of these plants. Scarcity of construction materials later in the war resulted in the use of some wooden settling tanks, as at Camp Shanks, and some unheated digesters.[10] These were not very satisfactory as compared with installations of standard design, but in most cases temporarily met needs reasonably well.

Sewage Flow. It was assumed that in camps and cantonments, average sewage flow would be 70 gallons per person per day. In many camps these rates initially were greatly exceeded, due in part to the use of automatic flush urinals, but water conservation measures eventually reduced flows in most camps to about 70 gallons or even less. Design basis for camp hospitals, permanent posts, and airfields was 100 gallons per resident person per day; and 30 gallons per person for those employed on 8-hour shifts in airfields, storage depots, ports, and similar places. Where ground water infiltration was likely, an allowance of 10,000 gallons per mile of sewer per day was added. The highly variable hourly flows found in Army installations were provided for in design, for the following rates of peak to average flows: for 1,000 population, 3.7 to 1; for 5,000, 3.55 to 1; for 10,000, 3.34 to 1; for 20,000, 3.05 to 1; for 35,000, 2.7 to 1; and for 50,000, 2.55 to 1. A typical hourly flow variation is shown in Chart 3.

Sewer Design. In accordance with good practice, sewers for building connections had a minimum size of 6 inches and other sewers of 8 inches. Sewers were laid on slopes to provide a minimum velocity of flow, when flowing half full, of 2 feet per second, exceptions being made only where excessive depths of trenching or employment of pumping could be avoided by using flatter grades. Design capacities of sewers were based on Kutter's formula using $n=.013$.

[9] Engineering Manual, OCE, Jan 1943.

[10] Rpt, Subcommittee on Sewage Treatment, NRC Committee on Sanitary Engineering, May 1946. HD: 040.

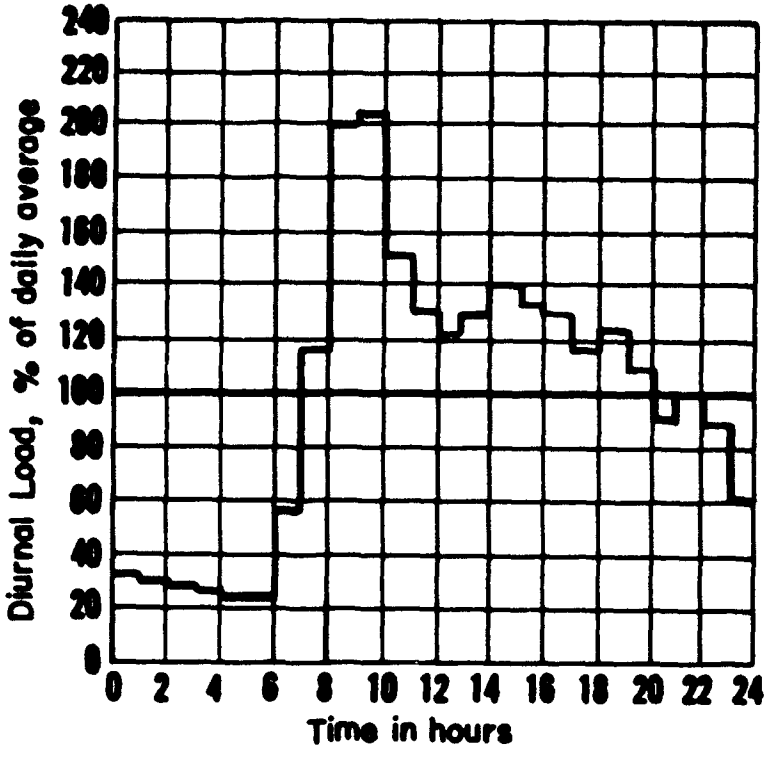


Chart 3. Typical hourly flow variation. Composite graph of Bushnell (Utah), Darnall (Ky.), and Fitzsimons (Colo.), General Hospitals.

Allowance was made for losses through manholes, special structures, and at changes in size. In the early construction, adequate inspection was lacking, and at some camps sewer grades were not uniform, lines were not straight, and joints were poorly made. These defects were not numerous and were corrected when found.

Generally accepted practice was followed in planning the sewer system; construction of sewers under paved roadways was avoided; laying of water- and sewer-lines in the same trench was prohibited, though this did occur in a few early camps. A cover of at least 2 feet over the pipe was provided, which was found to be insufficient if heavy Army vehicles were driven over the lines. Manholes were placed at the upper end of all laterals and at each change of slope or direction. Cross connections between sewers and the water supply system were prohibited.

Grease traps were necessary because of the large production of grease in Army messhalls and the consequent interference with sewage plant operation. The first commercial grease traps installed inside the kitchens were generally too small, and some of these were replaced by larger ones. Other traps were modified by the installation of an orifice which limited the rate of flow through the grease trap. One school of thought in the Army favored outside grease traps and some of these were installed. In general, it appeared that neither

inside nor outside traps were completely effective. Food and fat conservation practices adopted later, which called for regularly scheduled cleaning of the grease traps, helped to reduce the grease problem, but troubles resulting from grease occurred at a number of sewage plants. There was some evidence that these problems were more prevalent in soft water areas.

In general, good clay or concrete pipe was used for sewers. It was not considered necessary or desirable to use wood or other substitutes. Sewer joints were either of bituminous material, which was considered preferable, or cement mortar. Manholes were of brick, cement blocks, or poured concrete. Manhole covers were sometimes of wood. Standard sewer loading designs were observed, and sewer bedding employed where indicated. Cast iron, steel, or cement asbestos pipes were used for force mains.

Sewage Pumping. Sewage pumping stations were necessary at many camps. They were designed to handle the maximum rates of flow listed above, care being taken in design to avoid long intervals between times of operation of pumps during minimum flow periods. For stations serving populations of less than 5,000, two pumping units were usually installed, each capable of handling the probable maximum rate of flow. At larger stations, three or four pumping units were installed. Overflows were provided, in case of power outages or excess flows, where such short-time discharge of the sewage would not cause any danger to health or undue nuisance; elsewhere standby power, usually a gasoline engine-driven pump capable of handling the maximum flow, was installed. In general, storage capacity was provided in the sump for 10 minutes average flow for stations serving less than 2,500 population, and 3 to 5 minutes for larger stations. Provision was generally made against surge damage, for drainage of the force main, and for protection against floods.

Nonclogging types of pumps were used, protected by a screen, and installed in a dry well, with the power equipment above possible overflow levels. So far as could be done, pumping stations were located away from built-up areas in order to avoid possible nuisance. Special provision, as burial or incineration, usually had to be made for the screenings collected at pumping stations.

Design of Plants. So far as possible, an effort was made to design a sewage treatment plant to produce an effluent adapted to specific local conditions, based on the dilution available and on the downstream use of the receiving stream. Increases in camp populations, resulting from a reduction in barracks floor space from 50 square feet per man to 40 square feet, by adopting double bunking, or by the construction of additional housing, often required the addition of secondary treatment. Obviously, a stream that could handle the sewage from a camp of 15,000 men after primary treatment could not, without nuisance, handle similar waste from 35,000 troops; secondary treatment units would then be needed. By informal cooperation between the Corps of Engineers and the Sanitary Engineering Division, Office of The Surgeon General, timely studies were initiated in the field, and the needed facilities installed as soon as possible.



Figure 12A. Biofiltration sewage treatment plant filters with settling tank in background.

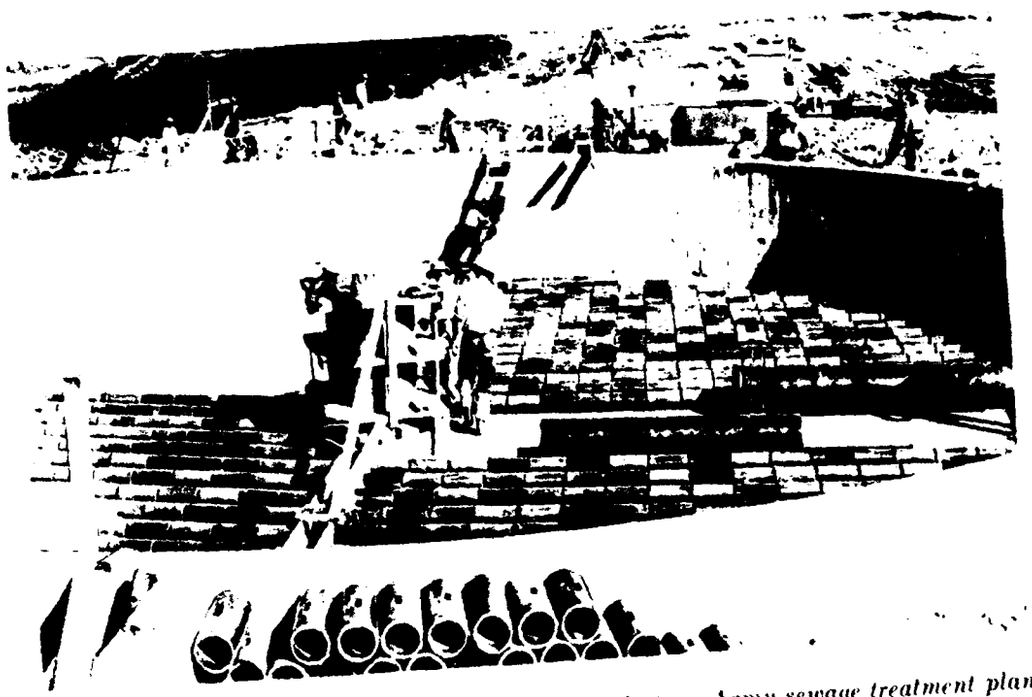


Figure 12B. The construction of a trickling filter bed at an Army sewage treatment plant.

Treatment plant units were designed to treat the average daily rates of flow. However, studies indicated that most of the flow occurred during a 16-hour period. Therefore, consideration was given in the hydraulic design to provide for the following rates of flow: a 16-hour average rate of flow at 125 percent of the average 24-hour flow; and a maximum 4-hour flow at 175 percent of the average 24-hour rate. The probable minimum 4-hour rate of flow was assumed to be 40 percent of the 24-hour average. The hydraulic design of conduits and other elements of the plant carrying sewage provided passage of peak flows of three times the average flow, as experience indicated that there would be occasional peak flows at this rate [11] (see Chart 4).

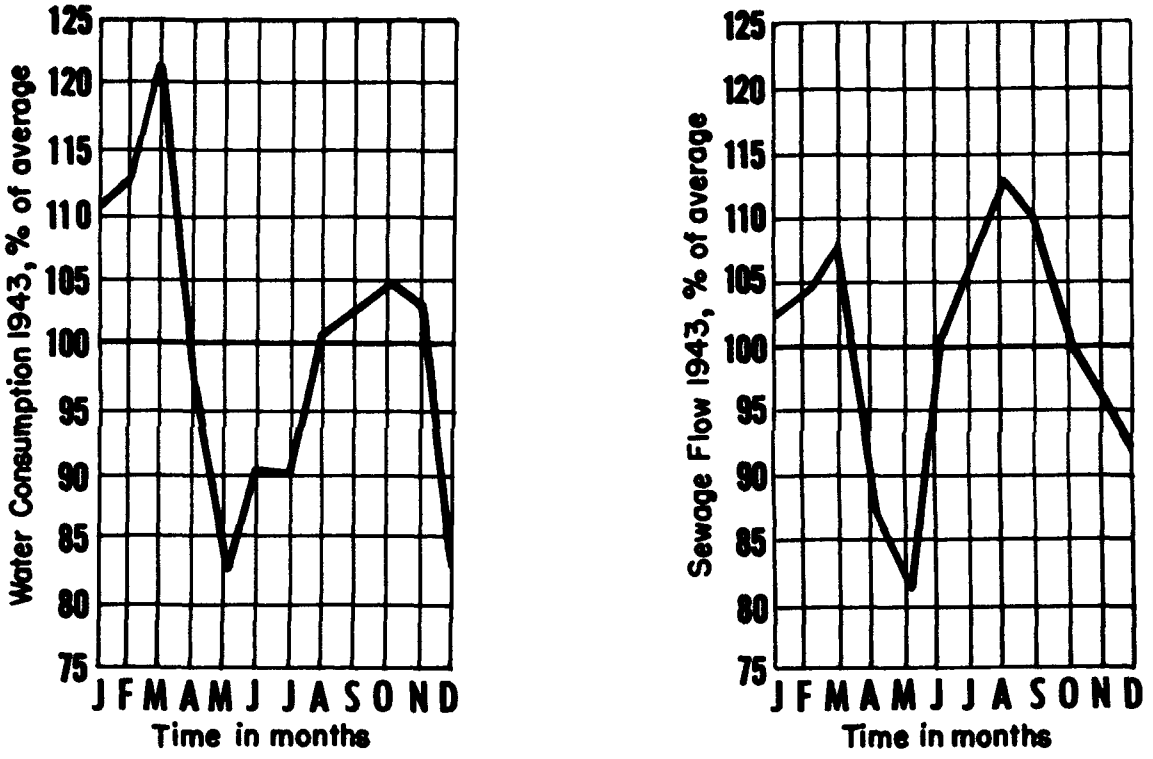


Chart 4. Variation in water and sewage flow during 1943 at Camp Edwards, Massachusetts Total sewage flow during year was 86 percent of total water consumption.

[11] See footnote 10, p. 137.

As the rate of mobilization was increased, camp populations soared far beyond original anticipation. In order to provide for reasonably anticipated increases in camp populations, such as might be obtained through double bunking or reduction in floor space, without substantial augmentation of housing facilities, and for other possible unforeseen developments, plants were designed with a capacity factor, depending on size, as follows:

Specified population	*Capacity factor*
10,000 or less	2.00
20,000	1.50
30,000	1.25
40,000	1.10
50,000 and over	1.00

By this plan, a plant designed to serve a camp determined as likely to have a population of 20,000 was built 50 percent oversize. Thus, the sewage flow for design purposes was 20,000 men x 70 gallons x 1.5=2,100,000 gallons per day. It does not cost nearly as much to build a plant 50 percent larger in the first place, as it does to enlarge a plant 50 percent after it has been built. In practice, it is believed that the use of the capacity factor was economical and a powerful factor in obtaining adequate plants.

Screens and Comminutors. Screens cleaned either manually or mechanically were used. The first larger plants were generally equipped with mechanically cleaned screens. Later, especially on small plants, many hand cleaned screens were used. Comminutors were widely used and were of special value because their use eliminated handling and disposal of screenings. A few mechanical grit removers were installed but many plants utilized the old type of manually cleaned grit chamber with velocities of 1 foot per second and detention periods of 30 to 45 seconds. The usual method of grit disposal from these manually cleaned chambers was by burial.

Measuring Flows. The policy of the Corps of Engineers resulted in the general installation of modern flow-measuring devices. Small plants, under 5,000 population, generally used V-notch weirs. Larger plants used Parshall or rectangular flumes or Venturi meters, with recording, indicating, and totalizing equipment. On plants serving over 10,000 population, it was general practice to install equipment to measure and record sewage and sludge recirculation. As a result of the universal installation of such equipment, operation was greatly facilitated and data became quickly available on which to design more economical and effective plants.

Sedimentation. Sedimentation is the primary process preceding any secondary treatment, and may also, where ample dilution is available, be the only required treatment. For plain sedimentation and for preliminary treatment preceding trickling filters or contact aeration, a displacement or retention period of 2 hours was required, based on the 16-hour average rate of flow, or

2.5 hours based on the 24-hour average flow. An additional allowance, on the same retention basis, was made for recirculated sewage or sludge. For treatment preceding activated sludge, a retention of 1.2 hours based on the 16-hour average rate of flow was required. Most settling tanks were equipped with mechanical sludge removal devices, the exceptions being Imhoff-type tanks and a few wooden tanks constructed during periods of critical material shortage and generally intended for rather limited periods of service. In general, these makeshift tanks were not satisfactory, though they did fulfill the temporary need for which they were designed. However, it was practically impossible to make them watertight or maintain them in a sanitary condition.

Filters. Trickling filters were the standard type of secondary treatment. (See Fig. 12.) Most of them were circular, with sewage application by rotary distributor. Both low capacity, or standard filters, and high capacity filters were used, and both gave excellent results. In computing the load applied to trickling filters for design purposes, the biochemical oxygen demand of the raw sewage was assumed to have been reduced 35 percent by passage through sedimentation tanks.

Standard or low capacity trickling was designed for loadings of not more than 600 pounds per day of applied biochemical oxygen demand per acre foot for filters not over 6 feet deep. It was assumed that low capacity filters, following primary sedimentation, would effect an overall biochemical oxygen demand reduction of 85 to 95 percent. This assumption was generally borne out by the investigations of the Sanitary Engineering Committee of the National Research Council, which are summarized hereafter.[12]

High capacity trickling filters had not undergone any protracted service under municipal conditions and relatively few performance data were available on them. An early error, in order to save small amounts of money, was the attempt to avoid the use of patented devices or processes. As a result several hybrid plants were constructed which later had to be rebuilt after periods of unsatisfactory service. Single-stage high capacity filters were assumed to produce an overall biochemical oxygen demand reduction of 60 to 80 percent, and two-stage plants, a reduction of 85 to 95 percent. Design loading was 3,000 pounds of biochemical oxygen demand per acre foot. Actually, many plants of the high capacity type operated quite satisfactorily with loadings 50 percent or more greater than design. Several types of high capacity filters were used, and all gave good service, with the plants employing recirculation proving especially adaptable to Army conditions.

An outstanding advantage of trickling filters of both standard and high capacity types was their ability to withstand sudden heavy loadings without deterioration of the quality of the effluent. This is an especially valuable characteristic for Army use, where the universal regularity of hours creates

[12] See footnote 10, p. 137.

sharp peaks of flow accompanied by a correspondingly sharp increase in organic content of the sewage. From midnight to 0700, flow may be small and sewage weak, but between 0700 and 0900 the volume may triple or quadruple and the strength increase in the same ratio. Thus, within 2 hours, the organic loading may increase by 10 or 12 times.

Activated Sludge. Only a few large activated sludge plants were built. These gave excellent results when loaded on the basis of municipal design, though laundry wastes had a tendency to interfere with operation when the plants became fully loaded. Both diffused air and mechanical aeration type plants were built. Based on the average daily rate of sewage flow, plus 25-percent allowance for return sludge, diffused air aeration tanks provided for 8.0 hours of retention, and mechanical aeration tanks for 12.0 hours. A number of activated sludge plants were installed at airfields and, like the larger plants, produced high-grade effluents when not overloaded. Due to unfavorable factors of high fluctuations in flow, large laundry flows, and need for highly skilled operators, activated sludge plants were not considered desirable for many installations.

Contact Aeration. Contact aeration (Hays) plants were installed at many airfields and at a few large camps. Their design was based on very limited municipal experience and in general they proved unfitted for Army use. Few contact aeration plants, when loaded over one-half their design basis, produced satisfactory effluents. Revised design bases required 175 square feet of contact media surface per pound of applied biochemical oxygen demand per day, with spacing between plates (if used) of 1½ inches, and application of 0.75 to 1.50 cubic feet of free air per gallon of sewage. In addition to unsatisfactory operating results, both initial and operating costs were higher than those for most standard methods. Most of the plants were built during 1941 after which the construction of new plants of this type was rarely approved.

Final Settling. Final settling tanks were designed on the basis of 2.0 hours of retention at the 16-hour maximum rate of flow or 2.5 hours of retention based on the average 24-hour flow rate. Since some treatment plants provided recirculation, the flow rate was defined to include recirculation, so as to provide the retention period indicated. The requirements were the same for all types of secondary treatment. Recommended side depths were 8 to 10 feet, and the recommended overflow rate, based on the average daily rate of flow, was 800 gallons per day per square foot of tank area.

Sludge Digestion. The digestion of sludge resulting from settling of Army sewage offered a problem in regard to digester capacity. Early experience indicated that standard municipal digester capacity was dangerously close to being inadequate under Army conditions. However, the requirements of the

Engineering Manual of March 1942, with the capacity factors previously indicated, appeared to be ample to provide good digestion. The standards were:

Type of plant	Digestion tank capacity: Cubic feet per person heated tanks	Digestion tank capacity: Cubic feet per person unheated tanks
Plain sedimentation	2. 0	3. 0
Chemical precipitation and settling	3. 0	4. 5
Sedimentation and trickling filters	3. 0	4. 5
Activated sludge	4. 0	6. 0
Contact aeration	3. 0	4. 5

These capacities were multiplied by the proper capacity factors. For instance, a plant designed to treat the wastes from 20,000 troops, by sedimentation and trickling filters, was required to have a digester capacity of $3.0 \times 1.5 = 4.5$ cubic feet per person if heated, or $4.5 \times 1.5 = 6.75$ cubic feet per person if unheated. Usually, designs provided for heated tanks. In order to conserve critical materials, the heating equipment was omitted, except in extremely cold climates, until the full capacity of the digester was required.

Supernatant liquor from digesters may interfere materially with treatment in some plants, depending on the type of treatment and the character of the supernatant. Therefore, piping arrangements were specified to permit discharge of the supernatant to various places in the plant, generally into the influent line ahead of the primary settling tanks, or to the sludge drying beds.

Sludge Drying. It was deemed unnecessary to provide equipment for mechanical dewatering of sludge, and open or uncovered sludge drying beds were used. These were constructed of sand and gravel, or cinder, and under drained, to provide 1 square foot of drying area per person. In a number of cases, where difficulty was encountered in digester operation or when sludge drying beds were inadequate, sludge was lagooned and allowed to digest. In general, sludge digestion and disposal was not a serious problem after 1941, largely due to generous digester design and to increasingly better operation of sewage treatment plants.

Chlorination of Sewage. Chlorination of sewage was provided at many installations, but was seldom used. In fact, many chlorinators were removed from sewage plants in 1942 when the water chlorination policy created a shortage of such equipment.[13] When used, a maximum capacity of 80 pounds of chlorine per million gallons of sewage for the daily average flow was generally provided. However, chlorination is relatively ineffective in sewage treatment and can never be a substitute for an adequate plant. Its use tends to create a false sense of security and delays the application of realistic measures. Chlo-

[13] (1) Ltr, Col G. F. Lewis, CE, Chief Repairs and Utilities Br, OCE, to CG 1st SvC, 21 Oct 42, sub: Chlorination of water supplies. CE: 671 (1st SvC) SPEUM. (2) Ltr, Col R. C. Kuldell, CE, Chief Repairs and Utilities Br, OCE, to CG 7th SvC, 19 Mar 43, sub: Chlorination of sewage. CE: 671.2 (7th SvC) SPEUM.

rine will not penetrate the organic particles in partly treated sewage but may delay decomposition. Chlorine may be effective in odor control and was used occasionally for this purpose. The final chlorination policy adopted was to chlorinate only secondary treatment effluents and then only when they might pollute a drinking water supply. A 15-minute contact period based on 4-hour peak rate of flow was provided.[14]

Imhoff Tanks. Imhoff tanks were used during 1941 for a few large plants, throughout the war for small installations, and in 1943 and thereafter when their use would permit the saving of critical materials. The sedimentation compartments of Imhoff tanks were required to provide the same detention period as was required for primary sedimentation, with velocities through the sedimentation chamber not to exceed 1 foot per minute at peak flows. Sludge compartments for southern camps were designed on the same basis as unheated digesters, and in northern areas this capacity was increased 25 percent. General operating results from Imhoff tanks were good.[15]

A few wooden Imhoff and plain settling tanks were built in order to save materials and money. In general, these temporary-type tanks did not operate acceptably. They should be considered only under the most urgent conditions of scarcity of critical materials and need for haste.

Equipment. Mechanical equipment was used freely in all but the temporary-type tanks. Such equipment proved its worth. Installations for primary treatment were built for circular and rectangular sludge removal devices, and for mechanically cleaned bar screens and comminutors. Most filters were equipped with rotary distributors of the reaction type and of the design required for the particular filter used. Both floating cover and fixed cover digesters were used. Activated sludge plants embodied the latest mechanical equipment. Almost without exception, all of this equipment was incorporated in well-designed and well-operated plants.[16]

Results of Army Program

As a result of the policy of applying established sanitary engineering principles to Army conditions, there was never a serious problem in respect to Army sewage disposal in the United States. It is not intended to indicate that some plants did not occasionally fail to function properly, that other plants were not overloaded, or that good operation was not sometimes lacking. Sanitary engineering skill was, for the first time in American war experience, applied early in the emergency, with the result that sewage disposal was eliminated as a serious problem. It was demonstrated that, despite the need for haste, sound engineering principles can be followed and that important details of design need not be overlooked. The cost of doing the work properly in the

[14] See footnote 9, p. 137.
[15] See footnote 10, p. 137.
[16] See footnote 10, p. 137.

first place was undoubtedly much less than the cost of hasty construction plus the cost of continual alteration, addition, and rebuilding; and the results were far more effective in protecting health and preventing nuisance.

In its cooperative work with the Quartermaster Corps and the Corps of Engineers, the Sanitary Engineering Division, Office of The Surgeon General, went far beyond the requirements expressed in Army Regulations (AR) 40–205. Such procedure was necessary to accomplish results. The best operation cannot produce a satisfactory effluent from a plant that is improperly designed; rebuilding is costly, time consuming, and rarely fully satisfactory. The only solution is to insure that the plant is originally adequately designed and equipped to fulfill its function.

The results of this program are well described in a letter from Dr. Thomas Parran, Surgeon General, United States Public Health Service, to The Surgeon General of the Army:[17]

> . . . . It has been most gratifying to note the almost complete lack of complaint from State and local health authorities with regard to sewage disposal from Army establishments. Despite the urgency of expediting construction and the justification that might have been offered for bypassing normal procedures in development and subsequent operation of these establishments, the Army has made every effort to conform to the standards of stream pollution control established by State and local authority.
>
> The good will engendered by this policy has been of direct benefit to the Public Health Service in this as well as other fields of public health interest. I am glad to have this opportunity to express to you the appreciation of the Service, and particularly that of the Sanitary Engineering Division, for the far-sighted policy the Army has followed in this matter.

Laboratories and Operators

For proper control of plant operation, an adequate laboratory is essential. Most Army sewage treatment plants were provided with necessary laboratory space and equipment to perform the tests needed for plant control.[18] Standards for operators were established by the Corps of Engineers, the qualifications depending upon the size and complexity of the plant. To supplement the limited number of trained operators available, schools and short courses were established. Where necessary, the Sanitary Engineering Division, Office of The Surgeon General, cooperated by temporary loan of skilled engineers to aid in operation and by the assignment of instructors.[19]

Other Methods

In an attempt to save critical materials, a "minimum water-borne" system was developed.[20] A single waterline and a single sewer ran through

[17] Ltr, Dr. Thomas Parran, Surg Gen USPHS, to Maj Gen Norman T. Kirk, SG, USA, 17 Jul 44. HD: 720.6.
[18] Handbook on Repairs and Utilities. OCE, Construction Div, 1942.
[19] Annual Rpt, Sanitary Engineering Br, Prev Med Serv SGO, 1943. HD.
[20] Ltr, Col James H. Stratton, Chief Engr Br OCE, to SG, 28 Aug 42, sub: Sewage disposal, field training camps. CE: 672.

each area. Kitchens and latrines were placed at the same end of the company street in order to save piping. The latrines consisted of a V-shaped concrete trough over which latrine boxes were placed. A flush tank periodically flushed out deposits. In some installations a small dam maintained a pool of water a few inches deep under the seats. Shower and lavatory waste water was sometimes used for flushing. These installations were moderately satisfactory for wartime conditions.

Small installations presented some of the greatest difficulties in actual application.[21] Men without experience in the design and construction of this kind of waste disposal plant frequently spent thousands of dollars in futile attempts to construct facilities for isolated buildings. The most striking examples were in connection with so-called table of organization type dispersed construction. The spacing of buildings accentuated the difficulties and cost of building sewers. Construction engineers or local utility officers often installed cesspools or septic tanks and subsurface disposal areas. Since scant attention, if any, was paid to porosity of soil, presence of ground water, and other limiting factors, many of these installations were total failures.

The principal difficulty lay in the fact that such construction was usually carried on without reference to higher headquarters and the first knowledge of the installation was a mention of unsatisfactory operation or of nuisance in the monthly sanitary report. In cooperation with the Corps of Engineers, criteria for design were established and these were published in a later edition of the Engineering Manual. These criteria established the capacities of settling tanks and cesspools and provided a basis for determining if subsurface irrigation would be feasible. This was accomplished by the standard method of constructing a pit, 6 inches or 1 foot square, to the depth at which it was intended to install the subsurface lines. After wetting, the pit was filled with water and the time and rate of absorption noted as a basis for design. Establishment of these criteria and requirements that projects involving certain sums of money be forwarded to the War Department for approval finally eliminated most of the difficulty in respect to these small installations.

Latrine Installations

At some camps, sewers were not installed, latrines being used instead.[22] For the most part, these camps were temporary or were originally intended for use only for a limited time. From the point of view of health, there was no objection to the use of latrines. However, since there were no sewers, shower and kitchen wastes were often discharged into roadside ditches, or allowed to flow over the ground, frequently creating a serious nuisance.

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[21] Semimonthly Rpt, Sanitary Engineering Br, Prev Med Div SGO, 1-15 Jun 43. HD: 024.

[22] (1) Pail latrine. Bull. U. S. Army M. Dept. (77):11-14. 1 Jun 1944. (2) Memo, Col W. A. Hardenbergh, SnC to CG SOS, 6 Jul 42, sub: Sanitary survey of Camp Sutton, Monroe, North Carolina, and the extra-cantonment area. HD: 720 Water and Sewage. (3) Sanitary Rpt, 45th Div, Camp Barkeley, Tex., Jun 1941. SG: 721.5-1.

Generally favorable ground conditions are necessary for satisfactory and economical use of pit latrines. In this respect Army conditions differ from those encountered in health work involving rural sanitation. In the Army, the loading on latrines is so heavy that conditions must be favorable for their satisfactory use. The presence of ground water within 10 feet of the surface is unfavorable. In tight clay soils, pits fill rapidly. Where rock is encountered, the same difficulty of rapid filling of the pit is encountered and the necessary excavation into rock requires much labor and is very costly. In moderately open soils, the standard Army pit latrine is highly satisfactory.

In some places where pit excavation was difficult, as at Camp Sutton, North Carolina,[23] where solid rock predominated, attempts were made to develop incinerator or other special types of latrines. None of these proved satisfactory. Incineration required excessive amounts of fuel and much of the time of two men for operation of a company installation, and results were unsatisfactory. One general difficulty with all pit latrines was to keep flies out of them and to prevent hatching of fly eggs deposited in them. Oil proved ineffective and was a fire or explosion hazard; it was not recommended. DDT dusting and the spraying of DDT solution inside the latrine box and pit and within the latrine enclosure were not uniformly effective.[24] Paradichlorobenzene (PDB) following favorable reports on its use in the Pacific area [25] was tested at various stations in the Fourth Service Command. A variety of reports on its usefulness was received. It appeared that in areas of high temperatures (probably over 80° F.), moderately tight soils, and perhaps relatively high humidities, it was effective in killing fly larvae and preventing emergence of adult flies.

The standard United States Army pit latrine [26] (see Fig. 13) was invariably used in all semipermanent and permanent installations where sewers were not provided. The general rule was to provide seats for 5 to 8 percent of the personnel. Latrine enclosures were generally screened and made weatherproof. Seats were usually arranged in 2 blocks of 4, back to back, but other arrangements were used. Pits were usually dug 10 feet deep, if soil conditions were favorable, and new pits were constructed when those in use were filled to within 2½ to 3 feet of the surface. Since water from local shallow wells was never used as a source of water supply, no experiences were recorded in regard to ground water contamination.

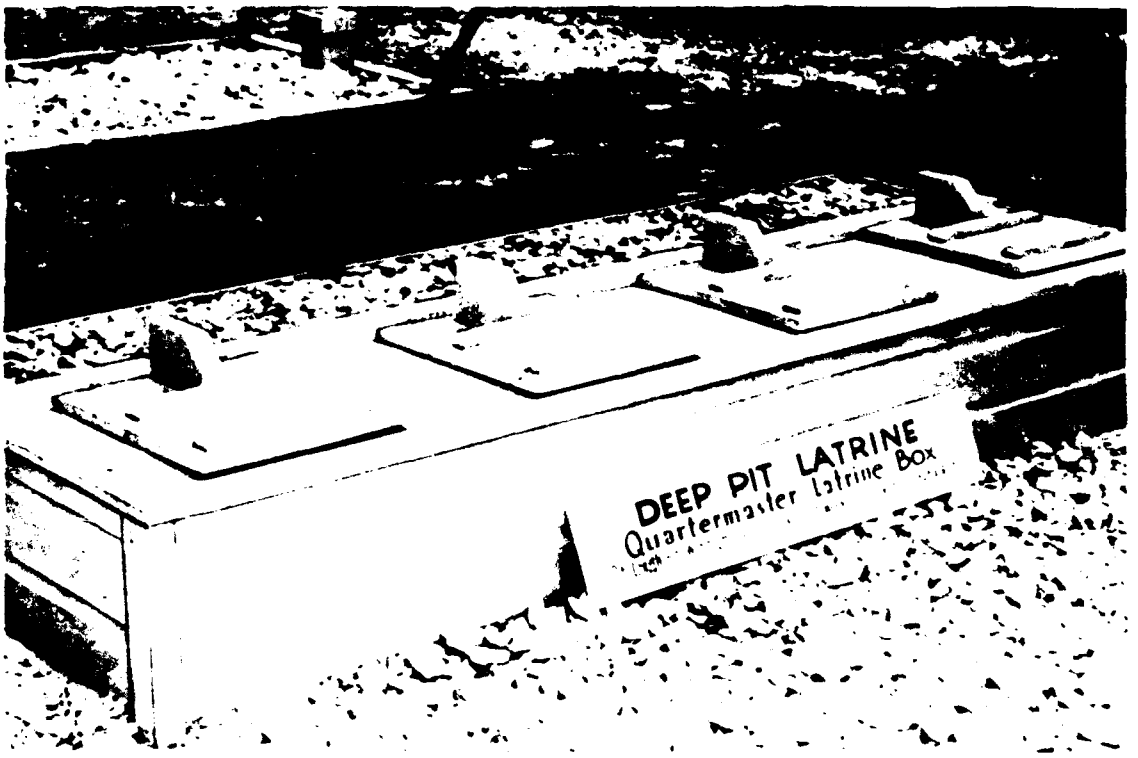
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[23] Blew, M. J.: Sanitary Survey of Camp Sutton, Monroe, North Carolina, and the Extra-Cantonment Area. 9 Jun 42. HD: 720.

[24] (1) TB Med 194, 17 Aug 45. (2) Ltr, Lt L. E. Taylor, SnC, to Surg Central Pac Base Comd, 19 Oct 44, sub: Test with DDT for fly control in pit latrines. HD: 350.05.

[25] (1) Ltr, Capt F. Sherman, SnC, to Surg Central Pac Base Comd, 12 Sep 44, sub: Report of additional tests with paradichlorobenzene (PDB) to control flies and maggots in pit latrines. HD: 350.05. (2) Toffaleti, J. P.: Fly control studies in the S. W. P. A. HD: 725 (Fly Control, 19th Gen Lab).

[26] (1) Dunham, George C.: Military Preventive Medicine. 3d ed. Harrisburg, Military Service Publishing Co., 1940. (2) FM 21-10, 31 Jul 40.



A



B

Figure 13. A. *Deep pit latrine.* B. *Trough urinal.*

In only one large camp, Gordon Johnston, Florida, was it necessary to use pail latrines. At this camp, situated on the Gulf Coast of western Florida, ground water was only a foot or two below the surface. Consequently, a pail system was adopted. Latrines provided 10 seats for 200 men. Floors were of wood. Pails were removed from the rear. As was expected, removal doors could not be kept flyproof. Scavenging was performed daily, cans being removed and replaced with clean cans. Trucks carried 50 to 60 cans. A washing station was constructed outside the camp. A shallow well furnished water and a small steam automobile cleaner provided hot water and steam. The cans were dumped in burial pits, then washed with hot water, steamed, and swabbed with a phenol solution. This scavenging process, which was performed by sanitary companies, was costly but exceedingly well done.[27]

In camps where pit latrines were installed, water from lavatories and showers and the liquid wastes from kitchens presented a considerable problem. At first these wastes were discharged to roadside ditches, gullies, or small streams, resulting in nuisance, and fly and mosquito breeding. No standard method was ever devised to overcome this difficulty, various palliative measures being employed. At Camp Shelby, Mississippi, small settling or detention tanks were employed. At Camp Barkeley, Texas, a pipe system was finally constructed, solving the problem. In some camps, either pipe or open drains, generally the former, were constructed when conditions became nearly intolerable. It is believed that in those areas where soil conditions will not permit disposal into the soil, a system of pipe drains should always be constructed initially as part of the camp equipment.

Overseas Installations. Methods used overseas varied with localities and conditions. In Great Britain, sewage treatment plants for United States troops were constructed and operated by the British.[28] Generally they were inadequate by American standards. No sludge digestion tanks were provided. Where sewers were not available, pail latrines were used. On the Continent, after the invasion of France, troops billeted in towns or cities utilized available sewerage facilities. Elsewhere pit latrines were used, even for the more permanent camps. Straddle trenches and catholes were used by combat troops.

Sewerage facilities at assembly and staging area camps in the European Theater of Operations varied according to the local requirements. Camp Carlisle of the Assembly Area Command (near Rheims, France) was located at a former French garrison post and was provided with a water carriage sewerage system and septic tanks which had been constructed by the French. Other camps in the Assembly Area Command were provided with standard pit latrines. These latrines were satisfactory, due to the short period of use, even though the ground was of chalk formation and not very porous. Soakage pits

[27] See footnote 22 (1), p. 148.

[28] Gordon, J. E.: History of preventive medicine in the European Theater of Operations, United States Army, 1941-1945, vol. 2, pt. IX. HD: 314.7-2.

were used for liquid kitchen wastes and shower drainage. They were satisfactory for the kitchen wastes, but would not absorb shower drainage, which resulted in an overflow into street drainage ditches and necessitated the construction of numerous pits.

At Camp Phillip Morris (near Le Havre, France) a modified minimum water-borne system was used for the latrines. A 50-gallon drum provided automatic water flushing of the trough beneath the latrine box. The shower and kitchen waste waters were not used for this purpose. All liquid wastes were carried by sewers to covered settling tanks after which the wastes were oxidized in a series of large holding ponds. This treatment was effective as the receiving stream supported fish life even though the dilution factor was low. This type of treatment should be used only where the ponds can be located in an area where they will not create a nuisance and where sufficient area is available to provide a holding period ample for the complete oxidation of the wastes.

The Calas Staging Area was constructed for a maximum strength of 70,000 troops, and was located on the Marseilles, France, watershed. A water-borne sewerage system was constructed for all kitchens and showers and for some latrines. Other latrines consisted of concrete lined pits, the contents of which were hauled away in wagons and buried with the garbage from the camp or discharged into the sewer system. The sewage from the sewerage system was first settled in 2 septic tanks. From these 2 tanks it was discharged into 4 septic tanks. The effluent from the second tank discharged into a small stream which carried the wastes away from the Marseilles watershed. This principle of double primary settling is widely practiced in Great Britain but has not been adopted in America. The sludge from the septic tanks was dried on open sand beds.

Sewage Disposal in the Southwest Pacific. By far the most used method of fecal matter disposal was by pit latrines, constructed and operated in accordance with prescribed Army standards. However, a large number of water-carried sewage systems were installed for station and general hospitals and in a few cases for higher headquarters areas. Sewage from these systems was usually passed through the prefabricated wood septic tanks provided for hospital construction. These tanks came in units, 8 x 20 x 8 feet deep, with standard inlets and outlets and baffles at each end. They were so made that they could be combined to make larger tanks.

Usually, a 1,000-bed hospital would use 2 septic tank installations, the tank in each installation being 16 or 24 feet wide by 40 feet long. Effluent from the tanks was usually directed to a drainage course running to the sea. Raw sewage was dumped directly into the sea where deep water was available, and where no shore installation would be affected. At Finschhafen, raw sewage from a 1,000-bed hospital was emptied into a 35-foot limestone sinkhole which had 22 feet of water at the bottom. The top of the hole was sealed with a reinforced concrete slab leaving an opening for the dumping of garbage.

No secondary sewage treatment was employed in the theater except for some hospital installations in Australia where Imhoff tanks and trickling filters were used, and at Finschhafen where soil absorption trenches were employed for one 500-bed hospital. Overflow from this bed was also chlorinated by a drip-feed apparatus.

In Manila many of the camp areas were underlain with hard limestone, and latrine pits had to be dynamited or dug with air drills. Seepage from these pits was very poor and it was difficult to dig the pits as fast as they filled up. To overcome this problem, flush troughs were designed and used quite extensively. There were many types of flushing devices installed but one of the best types was a single tip-bucket which dumped when full of water and then came back into filling position. Most of the troughs were so designed that about 2 inches of water remained in the trough invert after flushing. Water was usually obtained from a pressure system and the wastes were carried to a septic tank of wood or concrete, the effluent from which was directed to a stream or, where possible, to the city sewage system. The flush trough latrine proved to be a big improvement over pit latrines, especially in maintaining fly control and general cleanliness.

Manila Sewage System. There was very little intentional enemy damage to the sewerage system in Manila. The three lift stations on the north side of the Pasig River were unharmed and were restored to service by the end of February when power was brought in. Two of the four lift stations on the south side were burned, but the burning did not damage the pumps which were placed at the bottom of dry wells. Fortunately, the entire system, although surcharged, would operate by gravity without the lift pumps operating, and at no time did sewage overflow above street or ground level. Some sewage lines in streets were damaged by shellfire but generally they were laid too deep to be affected. Some manholes were stopped up with debris. The outfall line to the sea which passes through shallow water in the harbor was broken in several places soon after Allied ships entered. Repair of this damage was postponed because of lack of materials and equipment and because the sewage appeared to be carried out to sea without causing nuisances to shore installations

Sewage Treatment in the South Atlantic.[29] At Ascension Island each company area or outpost had its own pit latrine or slit trench. The bases on the mainland had water carriage systems of sewage disposal and generally utilized a septic tank followed by some type of secondary treating device.

At Natal, extensive sand filters were followed by effluent chlorination, since the water of the stream into which this waste was discharged was used by natives for many domestic purposes. The same practice prevailed at Fortaleza, while Sao Luiz and Amapa utilized the conventional subsurface tile drain fields. The septic tank effluent at Belem was discharged into a stream which ultimately

[29] Information supplied by Gus R. Herzik, Jr., formerly Lt. Colonel, SnC, USAR.

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reached the Amazon River. Although some discussion was undertaken regarding the need for secondary sewage treatment, it was concluded that the dilution in this case was so tremendous that the establishment of secondary treatment could have been justified only on the basis of it being a concession to good public health practice.

With the exception of the island installations, garbage was disposed of through the employment of conventional sanitary fills. On the island bases, garbage was disposed of by dumping at sea.

Other Areas. In Newfoundland, water flush sewerage and moderately adequate treatment, consisting of an Imhoff tank and trickling filter, were installed at the United States bases at St. John.[30] The same general standards were observed in the Caribbean bases.[31] In South America, sewer systems were installed with rather primitive treatment facilities. In West Africa, excluding Liberia where pit latrines were used except at headquarters, sewerage was provided but generally no treatment. Throughout the Far East, the same general standards were followed.

In the low coral islands of the Pacific, the ground water is normally quite close to the ground surface. Under such conditions standard pit latrines are not very satisfactory. In some cases, after occupation, latrines were built over the ocean, but in most cases mound latrines were used. Earth (usually this was mainly sand) was heaped to a height of 4 or 5 feet so that a pit 6 or 8 feet deep could be constructed without reaching into ground water.

In addition to obtaining much longer use by this method, some of the risk of contaminating the ground water was averted. This was particularly important because water supplies on most of these coral islands were extremely scarce. A mound latrine will usually have side slopes of 1 to 3 feet, and the top should be level, 2 to 3 feet out from the edges of the pit. For an 8-seat pit, 8 feet long and 4 feet wide, the mound must have a level top surface 12 or 14 feet by 8 or 10 feet, and the movement of around 40 cubic yards of dirt is necessary if the mound is to be 4 feet high. Bulldozers or other power equipment are desirable to handle this large volume.

Amphibious Operation. Experience indicated strongly the need for well-designed knockdown-type latrine boxes to be carried ashore early in the operations. The use of such boxes would greatly improve sanitary conditions during the first week or 10 days after landing. The Navy made excellent use of knockdown boxes.[32] To be of greatest value, these should be of good material, simply and strongly constructed so as to retain flyproofness and other sanitary qualities for a reasonable length of time under severe weather and handling conditions.

During 1945 several manufacturers submitted knockdown latrines for testing at the equipment laboratory at Carlisle Barracks, Pennsylvania. At

[30] Sanitary Survey of Newfoundland, 2-17 Nov 40, Lt Col W. A. Hardenbergh, SnC. HD: 721.

[31] See reports filed in HD: 721 San Surv.

[32] Drums used for field latrines. Construction Battalion Activities (NAVDOCKS P-114) 2: 3. Library Navy Bureau Yards and Docks.

the end of the war a folding portable plywood latrine had been standardized by the Medical Department for use in medical units as far back as station hospitals. None was purchased due to cessation of hostilities.

Cold Areas. Standard pit latrines were preferred to pail latrines in cold areas. Pits were dug in the summer, and areas for winter pit construction were protected from freezing by straw or other covering. Pit construction in frozen ground is difficult but may be accomplished with the use of air hammers or explosives.

In some cold areas, when pit latrine construction was not practical pail latrines were used. Boxes were constructed for easy removal of the cans and facilities for collection, replacement, emptying, and cleaning of the cans provided. In planning cold weather operations, 80 cans were provided for each 1,000 men for initial issue; monthly allowance thereafter depended upon the local conditions and length of stay.

Paradichlorobenzene. In the Pacific Ocean area, paradichlorobenzene (PDB) proved a satisfactory method of controlling fly breeding in pit latrines.[33] The rice-size crystals were used, being added at the rate of about 5 pounds twice weekly in a 12-hole latrine. The fumes from PDB gave the latrines a pleasant odor and killed the fly larva by penetrating into the surface of the pit contents. Indifferent success with its use was obtained in continental United States and therefore it was never adopted as a standard method of fly control.

Special Problems

Schistosomiasis. The special problems arising in the United States were technical in nature and covered a very broad range. The presence of many soldiers suffering from schistosomiasis in Moore General Hospital, near Asheville, North Carolina, and in Harmon General Hospital, Texas, presented a problem due to the possibility of spread of infection to local snails.[34] In both cases, the hospital sewage was discharged into the municipal sewer systems, but neither city treated its sewage. Despite the fact that species of snails capable of acting as intermediate hosts are not found in the United States in the vicinity of these cities, if at all, the effect of treatment of sewage was investigated.

A patient suffering from schistosomiasis discharges ova with his feces. These hatch into miracidia, which enter the snail host. After transformation in the snail, cercariae are shed by the snail, and these are the transmitting agents of the disease. In moderately clear water, cercariae are susceptible to chlorination and can be killed by 0.5 part per million residual after 30 minutes of contact. Sedimentation will not remove the ova; trickling filters will not retain

[33] See Chapter VII, p. 267.

[34] (1) Ltr, Surg Gen USPHS to SG USA, 11 Aug 45. SG: 710 Schistosomiasis. (2) Ltr, Dep SG to Surg Gen USPHS, 23 Aug 45. SG: 710 Schistosomiasis. (3) Memo, Maj J. B. Batz, SnC, to CofEngrs, 28 Aug 45, sub: Chlorination of sewage effluent. SG: 720.6 (Moore GH).

or destroy the miracidia, the ova, or the cercariae. Chlorination of raw sewage is clearly ineffective. Thus a high degree of treatment, which will remove all lumps of organic matter large enough to protect any of the previously mentioned forms, must be provided and be followed by chlorination. Since snails that could act as hosts were not present in the areas adjacent to Moore General Hospital and Harmon General Hospital, no such special treatment was deemed necessary.

Inadequacy of Plants Due to Sudden Increase of Load. The rapid growth of some cantonments outpaced the capacity of the sewage treatment plants, since additions could not be constructed rapidly enough. In the Eighth Service Command, aeration or holding ponds were utilized to provide immediate needed added capacity. These gave good service. It was found that storage for 30 to 45 days in ponds not more than 4 or 5 feet deep resulted in marked purification. In some cases the effluent was as good, on the basis of remaining biochemical oxygen demand, as from secondary treatment devices. Generally the ponds were arranged in series of 3 to 5, with the effluent from one emptying into a second, and thence into a third. Such ponds were not tried in other areas but it is believed they would have given fair results. They should be located away from built-up areas so as to avoid the odor nuisance.

Waste From Chemical Warfare Plants. Some of the wastes were exceedingly difficult to treat. Heat treatment was necessary in some places. In others, the waste had a high biochemical oxygen demand value and was so quickly putrescible that decomposition was well started within an hour. Thus, treatment in standard plants was exceedingly difficult. Every known method of pretreatment to reduce the strength and to stabilize the waste was tested. At one plant, aeration ponds were tried and gave remarkably good results on a laboratory scale. However, the war ended and the plant closed just as construction of the ponds was about to begin. In the laboratory tests, the biochemical oxygen demand of this waste, diluted with sewage, was reduced from about 450 to 10 in 30 days.

Control of Filter Flies. The effectiveness of DDT in the control of insects led to investigation of its possible use for controlling filter flies (*psychoda*) in trickling filters.[35] The Fourth Service Command was requested to initiate, through its laboratory, investigations on the subject. Capt. (later Maj.) John A. Carollo, SnC, was given the responsibility for the work. Working in cooperation with the city of Atlanta at its plants, Captain Carollo demonstrated that a dosage of about 1 part per million of DDT applied to the filters with the sewage for a 24-hour period would give complete control of filter flies, under conditions existing at these plants, for a week or 10 days, without interference with the purification processes of the filter. Later work indicated that the *psychoda* may develop a considerable tolerance to DDT.

[35] (1) Brochers, W. C.: Experiments with DDT in filter fly control. Sewage Works J. 18: 181–207, Mar 1946. (2) Carollo, J. A.: Control of trickling filter flies with DDT. Sewage Works J. 18: 208–211, Mar 1946.

Use of Sewage for Irrigation and Sludge for Fertilizer. Many of the southwestern camps were in a semiarid area where water has great value and the use of sewage for irrigation is common. In many others, the needs for soil improvement or for fertilizing grass cover on airfields prompted the use of sewage sludge as a fertilizer or soil conditioner. On the other hand, the work of the National Institutes of Health demonstrated that digested and air-dried sludge contains viable ova of intestinal parasites or even the worms themselves. In order to establish a policy, a directive covering the use of sewage for irrigation and of sludge for fertilizer was prepared and submitted to the Sanitary Engineering Committee of the National Research Council, various interested State boards of health, and to the Corps of Engineers.

The use of undigested or raw sludge for fertilizer was prohibited.[36] Digested sludge was approved for fertilizing purposes for grasses, grain crops, and shrubbery, except in the Fourth and Eighth Service Commands and that portion of the Ninth Service Command south of the 37th parallel due to the danger of hookworm infection. In these areas the use of liquid digested sludge was restricted to areas not routinely used by troops or civilians. Air-dried sludge was restricted to similar areas unless it had been composted for 4 months prior to use. No restriction was placed on the use of heat-dried sludge.

Sewage effluents to be used for irrigation were required to have been treated by settling and oxidation or by other processes yielding effluents of equal quality. For effluents to be used for irrigation of cantonment grounds, parade grounds, and similar grass areas, chlorination of such effluents to produce a chlorine residual of 0.5 part per million after 10 minutes contact was required. The use of sewage effluents to irrigate crops eaten raw was prohibited. Especial stress was laid on the necessity for preventing cross connections with or contamination of water supplies, and minimizing opportunity for use of the effluent for drinking, other domestic purposes, or bathing. It was recommended that grass areas irrigated with sewage should be closed to personnel for 24 hours after application of the sewage. Transportation of sewage effluents in pipes under pressure was restricted to installations approved by service command headquarters and it was required that such pipes be clearly marked and located safely away from pipes carrying potable water.

Inactivation and Closure of Camps. Special problems arose in connection with the decrease in population in many camps in the Zone of Interior during the later stages of the war and with the inactivation of camps. Marked reduction in camp population results in a nearly proportionate decrease in the flow of sewage, with the result that the period of retention in settling tanks increases. In warm weather, with excessive retention, sewage begins to decompose anaerobically, placing an excessive burden on oxidation devices and on diluting streams. The procedures for surplus and inactive installations and reactivation were prepared by the Sanitary Engineering Division, Office of the Surgeon

[36] TM 5-665, Nov 1945.

General, coordinated with the Corps of Engineers, forwarded to service commands for their guidance, and published as a technical manual by the Corps of Engineers. Pertinent provisions of these procedures follow:

Sewerage and water service at inactive installations—that is, those that were in charge of caretaking personnel—were required to be maintained ready for reuse, the procedures being generally governed by the degree of readiness required, as 30-day or 60-day, and the type of sewage treatment. An extremely low flow of sewage under inactive conditions often required that flows be concentrated to specific parts of the plant, or that other procedures be taken to insure prevention of nuisance. It was deemed essential that, in inactive installations, both sewers and sewage treatment processes be kept in operation.

Where civilians were served by the post sewerage system, they were notified as soon as possible of the inactive status of the camp. Immediate arrangements were undertaken to relieve the Government of the responsibility for this service, such arrangements having the approval of the State board of health. This implied that boards of health of the State and of interested cities should be kept reasonably informed of plans for inactivation or declaring the camp surplus.

The operation of the sewage plant was normally continued if early reactivation was indicated by the degree of readiness prescribed. Treatment was provided so that sewage effluents would be consistent with requirements for protection of health and prevention of nuisance. When operation of sewage plants was discontinued, camp personnel was served by pit latrines or small septic tank installations with subsurface tile disposal. To facilitate this, it was recommended that all caretaking and other personnel should be housed in one area. Pit latrines and soakage pits could then be provided as recommended in Field Manual (FM) 21–10. So far as possible, when pits or small septic tanks were used, personnel were housed in the area best suited for these installations.

When the sewage flow was greatly reduced, some types of sewage plants were so reduced in efficiency that some time was required after activation before adequate treatment was again attained. When this condition existed, flow was concentrated into the least number of units consistent with design, but the greatest number consistent with the volume of flow. In some cases, recirculation was employed to eliminate excessive detention periods and resultant septic action, using excess pumps and temporary lines where design did not provide for recirculation. Treatment devices in excess of those required to prevent nuisance or hazard to health were inactivated. Chlorination of sewage effluents was generally discontinued. Screens, comminutors, and grit removal devices were operated normally as needed, and also sludge digestion and drying facilities.

Trickling filters were normally retained in service. Filter dosing tanks were protected against freezing by reduction in tank capacity or by using only one tank. Siphons and exposed lines were drained or otherwise protected

against freezing. To insure good operation during inactivation and upon reactivation, the plant supervisor and the lowest possible number of operators were retained on the job. Routine tests to show strength of sewage and of effluent, and the condition of the receiving stream above and below the point of discharge were continued on a reduced scale.

Maintenance personnel, so far as possible, were grouped in housing close to a main sewer in order to minimize deposits of solids in sewers. A program of flushing sewers was initiated at some installations. So far as feasible, sewage flow was so maintained that lift station discharge pipe contents were discharged at least once every 6 hours. When necessary, fresh water was used to accomplish this; special attention was given to avoidance of cross connections. Float controls in wet wells were set at low levels to insure frequent operation of the pumps. All pumping equipment, and generally all other equipment, was operated at least once each week.

When sewage plant operation was discontinued, it was recommended that the sewage treatment plant should be bypassed if this were possible without extensive alterations or damage. In case the plant was bypassed, screens, grit chambers, and comminutors were cleaned and, where applicable, drained. Screenings were buried or incinerated. It was recommended that sedimentation tanks should be drained, cleaned, and unless drainable by gravity, filled with clean water and oiled to prevent mosquito breeding. Protection had to be provided against uplift when tanks were drained, and against freezing when they were filled. Except for drainage of lines to prevent freezing, no special procedures were necessary for trickling filters. Activated sludge plants were treated the same as sedimentation tanks, except that special precautions were required to protect porous tubes and plates.

Sludge digestion tanks were required to be drained slowly, at the rate of 10 to 15 percent of the contents per week. Care had to be taken to avoid formation of explosive mixtures in digesters during drainage. When the digestion tank had been emptied, it was thoroughly ventilated and then cleaned, and the gas collection lines were disconnected. Sludge beds were cleaned and kept clean, consistent with drainage of the digester. Vegetation on unused beds was kept cut or salt applied. Pumps and lines carrying sewage or sludge were drained and washed out. Sewage pumping stations inlet lines were drained and cleaned. The pumps were left in operation to remove infiltration into the sewers, where possible by a bypass to the nearest waterway.

At surplus installations, sewerage facilities and sewage treatment were maintained pending transfer of the post to another service, or completion of salvage operations. During the completion of salvage, the connection between the sewer system and the treatment plant was broken to prevent ground water from overflowing the plant. When desirable and possible, a connection was made between the sewer system and a waterway for the discharge of infiltration water. All tanks were drained and cleaned. Where construction permitted,

the tanks were so arranged that they would not fill with water. Where this was not possible, the tanks were filled with earth, sand, or gravel so they would not be a hazard from either accident or mosquito production.

All sumps and hoppers were drained or filled. It was recommended that sludge digestion tanks should be drained and cleaned, care being taken to prevent explosions or gas poisoning. Undigested sludge and screenings were buried. Sludge beds were cleaned. Salvageable equipment was ordered removed, cleaned, properly protected, and stored. Chlorine, chlorine containers, acids, alkalies, poisons, and chemicals were removed from the plant. Latrines were oiled, filled, and marked; seats of latrines left in place were firmly nailed down. Urinal sumps and soakage pits were filled. Septic tanks not provided with a concrete cover were filled. It was directed that pumps should be removed from pump pits, cleaned, and stored. It was also directed that a record be kept of all procedures in inactivation or closure and copies maintained in service command headquarters.

Reactivation. At installations, which were to be reactivated, it was directed that qualified operating personnel be obtained as soon as it was decided to reactivate, and that all equipment and connections should be reset and remade. If sewage disposal or water service were purchased, the contractor was notified at once when service would be needed. Sewers were inspected and flushed or cleaned. Bypasses were closed. Tanks, lift stations, and wet wells were cleaned of all foreign materials. Secondary treatment units were placed in operation at the earliest possible moment in order to develop necessary biologic growth. Chlorination was used when necessary to supplement secondary treatment during the development of biologic activities.

National Research Council Subcommittee on Sewage Treatment at Military Installations

At the suggestion of Lt. Col. (later Col.) R. E. Lawrence, CE, Office of the Chief of Engineers, and the author, the Committee on Sanitary Engineering of the National Research Council appointed a temporary Subcommittee on Sewage Treatment at Military Installations in April 1944.[37]

The subcommittee consisted of the following members:

F. W. Mohlman, Chairman, Director of Laboratories, Sanitary District of Chicago

Lt. Col. J. J. Gilbert, SnC, Assistant Director, Sanitary Engineering Division, Office of The Surgeon General

C. C. Ruchhoft, Stream Pollution Laboratory, United States Public Health Service

Comdr. V. C. Tipton,, Director, Preventive Medicine, Bureau of Medicine and Surgery, United States Navy

[37] See footnote 8 (1), p. 133.

Lt. Comdr. C. L. Pool, Sanitary Engineering Division, Bureau of Yards & Docks, United States Navy
J. T. Norgaard, Water & Sewage Section, R & U Branch, Office of the Chief of Engineers, United States Army
Prof. G. M. Fair, Sanitary Engineering, Harvard University
H. Stevens, Engineering Division, Office of the Chief of Engineers, United States Army

Objective and Procedures. At its first meeting on 22 May 1944,[38] the subcommittee established its objective as: "A critical study and review of design and operation of sewage treatment plants in military installations." The functions of the subcommittee were established as:

1. To record experience, countrywide in scope under varied climatic conditions, with many different processes of sewage treatment.
2. To establish useful norms to guide in the solution of future problems of a similar nature, such as
   a. Flow and character of sewage
   b. Methods of analysis and control
   c. Performance of treatment processes
   d. Design of treatment units
   e. Training and performance of operators
   f. Roughing filters
   g. Oxidation ponds
   h. Sand filters
3. Special topics were to be investigated as follows:
   a. Grease removal and disposal
   b. Effect of reduction of water consumption
   c. Operation and maintenance costs
   d. Sludge digestion
   e. Disposal and drying of sludge
   f. Chlorination
   g. Laundry wastes
   h. Effluent disposal

The services of Harold A. Thomas, Jr.,[39] Assistant Professor of Sanitary Engineering at Harvard University, were secured to assist the subcommittee in the collection of information and the preparation of the report. Capt. R. E. Heacox, SnC, together with a number of other highly qualified Sanitary Corps sanitary engineers, was assigned to temporary duty at Harvard University to assist Professor Thomas in analyzing the data and preparing the report. The work of these men contributed greatly to the success of this subcommittee.[40]

[38] See footnote 8 (2), p. 133.

[39] (1) Ltr, Dr. L. H. Weed, NRC, to Brig Gen J. S. Simmons, Prev Med Serv SGO, 6 Jun 44. HD: 720.6 Sewage (NRC Subcom). (2) See also footnote 7, p. 133.

[40] Minutes of 5th Meeting, Temporary Subcommittee on Sewage Treatment at Military Installations, NRC Committee on Sanitary Engineering.

Procedure in Surveys. Through the Sanitary Engineering Division, Office of The Surgeon General, questionnaires prepared by the subcommittee were distributed to the Sanitary Corps engineer in each service command surgeon's office.[41] These engineers, in cooperation with the service command engineer's office, assisted the subcommittee in the selection of the plants to be surveyed and then either made the surveys or authorized Sanitary Corps engineers under their command to make the surveys and complete the questionnaires. The completed questionnaires were returned to the Sanitary Engineering Division for forwarding to the subcommittee.

Types of Plants Surveyed. Complete surveys were made of a total of 89 sewage treatment plants. These plants were divided into the following types and numbers: [42]

Type of treatment	*Number*
Imhoff	2
Primary	10
Activated sludge	8
Standard filter	29
Biofilter	16
Aerofilter	4
High capacity filter	7
Roughing filter	8
Chemical precipitation	2
Oxidation ponds	3
Total	89

Surveys were not made of plants utilizing the Hays process, as surveys previously made by consulting engineers were available to the subcommittee.

Plants in Use. The number of each type of plant surveyed does not indicate any ratio to the total number of plants installed. While records in the Office of the Chief of Engineers were not entirely complete, they indicated that the Army constructed and operated approximately 400 sewage treatment plants during the war. This number can be divided into approximately the following percentages of the various types of treatment:

Type	*Percent of total*
Imhoff	18.0
Primary	6.0
Activated sludge	3.0
Aerofilters	1.0
All other filters	60.5
Chemical precipitation	0.5
Hays	11.0
Total	100.0

[41] Ltr, SG to CG 8th SvC, 26 Aug 44, sub: Sewage treatment at military installations. HD: 720.6 (Sewage, NRC Subcom).

[42] See footnote 10, p. 137.

In the southwest part of the country some 40 oxidation plants were constructed. As these plants provided additional treatment to one of the above processes, they are not listed separately. About 20 oxidation plants followed primary treatment and 20 followed secondary treatment. Small septic tanks and subsurface drainage installations were not included in the above analysis.

Report of the Subcommittee

The completed report [43] of the subcommittee was issued in the summer of 1946. Following are brief summaries of various sections of the report:

Characteristics of Military Sewage. Most of the flow distributions studied exhibited a greater range in volume of flow than is normal in municipal sewage. In about one-quarter of the plants studied, the ratio of range of flow to the daily average flow exceeded 200 percent. In many cases, the morning peak flow was greater than 160 percent of the daily average, and the morning peak rise was very abrupt. Moreover, the strength of the sewage increased markedly along with the increase in volume. This combination of rapid and considerable increase in both volume and strength placed a heavy burden on the treatment plant; and, in fact, could not be handled successfully by some methods of treatment.

The volume of laundry waste amounted to about 5 gallons per person per day or about 7 percent of the average sewage flow.

The weighted average of biochemical oxygen demand, based on studies at 44 typical plants, was 0.192 pound per capita per day; and for suspended solids, 0.154 pound. In 48 plants where longtime measurements were available, average sewage flow was 74.7 gallons per person per day. At most camps, sewage arrived at the plant in a fresh and uncomminuted condition.

Screens, Racks, and Comminutors. Most screens were of the bar type, with openings ranging from ¾ to 1¾ inches, and averaging 1 inch. Average screenings removed amounted to 3.2 cubic feet per million gallons of sewage. A high proportion of the plants were equipped with comminutors, which gave excellent service. Grit was usually a problem for about 18 months following camp construction, and installation of grit removal equipment was a virtual necessity. Average grit removal per million gallons of sewage was 2.1 cubic feet.

The bases of design for these plant units were as established in the Engineering Manual in cooperation with the Sanitary Engineering Division, Office of The Surgeon General.

Sedimentation. Standard good practice was normally employed in the design of sedimentation tanks, with 2.5 hours retention except for activated sludge plants, which were designed on the basis of 1.5 hours. Secondary tank overflow rates were held to 800 gallons per day per square foot of tank area

[43] Sewage treatment at military installations. Report of the Subcommittee on Sewage Treatment in Military Installations of the Committee on Sanitary Engineering, National Research Council. Sewage Works Journal 18: 789-1028, Sep 1946; Summary and conclusions, Idem. 20: 52-95, Jan 1948.

or less. A number of Imhoff tanks were installed, but most plants utilized the separate sedimentation units with mechanical sludge removal equipment.

In practice, actual sedimentation periods were somewhat above design figures, according to this study. However, efforts previous to the date of the study had markedly reduced water wastage and water use in nearly all military posts, thus the flow of 74.7 gallons per capita per day of sewage was less than the figure actually used in design, resulting in excess capacity in some places.

Studies by the subcommittee indicated that primary settling tanks without recirculation removed 39.1 percent of the biochemical oxygen demand and 52.9 percent of the suspended solids; with recirculation, removals averaged 29.4 percent and 36.4 percent. Secondary settling tanks without recirculation removed 42.7 percent of the biochemical oxygen demand and 61.8 percent of the suspended solids; and with recirculation 25.6 percent and 47.4 percent respectively.

Trickling Filters. More than half of the sewage treatment plants installed at military posts included trickling filters. These were high rate and standard rate, shallow and deep. All shallow filters utilized recirculation; some deep filters did and some did not. Deep filters, without recirculation—normally the standard rate filters—gave an average effluent biochemical oxygen demand of 35 parts per million, with an overall plant removal of 90.6 percent or about 336 pounds per acre foot of biochemical oxygen demand. Deep filters with recirculation were primarily of the aerofilter type. These accomplished an overall average biochemical oxygen demand removal of 86.2 percent and an overall suspended solid removal of 86.6 percent; and the average removal of biochemical oxygen demand was 1,340 pounds per acre foot.

Single-stage shallow filters with recirculation gave excellent results, the overall average biochemical oxygen demand removal in the plants studied being 81.3 percent. In the heavily loaded plants—those with loadings of 2,000 to 4,500 pounds per acre foot—removal was 87.7 percent. Overall suspended solid removal averaged 82.3 percent. In this type of plant, volumetric dosage rates were high, ranging from 11.1 to 31.9 million gallons per acre per day.

A wide variation in design was presented by the two-stage filters, and loadings also varied greatly. First-stage filter loadings were as high as 8,680 pounds per acre foot; second-stage filter loadings were usually under 1,000 pounds per acre foot, but at Camp Roberts exceeded 5,000 pounds. In the two-stage plants, overall plant removal of biochemical oxygen demand averaged nearly 90 percent, with suspended solid removal the same. These two-stage plants produced a high quality effluent, even under very heavy loadings.

Trickling filters were well adapted to Army use, withstanding both overloading and the shock loading typically obtained at military installations. Design bases were as follows: deep filters, without recirculation, 4,620 persons

per acre foot; filters with recirculation, 23,100 persons per acre foot. No standard design bases were established for two-stage filters.

An analysis of the operating data obtained from this study has permitted development of a formula for determining plant efficiency which has been invaluable in design and is widely used by engineers.

Contact Aeration. About 50 plants of this type were constructed at Army installations, and many others for the Navy and other military purposes. In general, operation was not satisfactory. There was not sufficient background of experience in the use of these plants, and the knowledge that was available was based on municipal experience, with installations having entirely different sewage flow and strength characteristics from those encountered in military posts. As a result, nearly all plants were underdesigned and required one or more reconstructions. Even then experience appeared to indicate that this type of plant was basically unfitted to handle the widely varying flows and strengths encountered in military posts. Operation costs were generally high.

Activated Sludge. Plants of the activated sludge type were constructed at about 20 Army posts, both large and small. These plants included both diffused air and mechanical aeration types. Under the conditions that existed in military installations, these activated sludge treatment plants did not give the fine results normally obtained in the municipal sewage treatment field. Air requirements were high. The study indicated that, on the basis of present design, activated sludge plants are not sufficiently flexible to handle the large variations in sewage volume and sewage strength that are normal at military posts.

Sludge Digestion and Disposal. In general, in neither design nor operation did sludge digestion facilities vary materially from the normal of municipal operation. Design bases for digesters were adopted early in the war at the following: for heated tanks, 3.0 cubic feet per capita for trickling filter plants; 4.0 cubic feet per capita for activated sludge plants; and 2.0 cubic feet per capita for primary treatment plants. For unheated tanks, 50 percent more capacity was provided. Naturally, the actual loadings determined by the study differed from these, being 4.2 cubic feet per capita for trickling filter plants; 11.2 cubic feet per capita for activated sludge plants; and 1.5 cubic feet per capita for primary treatment plants. Many plants employed two-stage digestion. Mean production of sludge gas was 1.25 cubic feet per capita at the 6 complete treatment plants studied. The gas yield per volatile solids added was 13.9 cubic feet per pound, and 20.5 cubic feet per pound of volatile matter destroyed. Digested sludges averaged 7.2 pH, 5.0 percent total solids, and 54.1 percent volatile matter. In practically all plants, sludge was dried on open beds.

Oxidation Ponds. Oxidation ponds were utilized at a number of installations, practically all in the Southwest. Design capacities were in the range of 400 to 700 persons per acre of surface, with detention periods of 25 to 30 days.

Pond depths were about 3 feet. These ponds generally gave good results, with effluents ranging from 20 to 40 parts per million of biochemical oxygen demand at well-designed installations.

Waste Treatment in Germany

In June 1945, Lt. Col. J. J. Gilbert, SnC, Assistant Director, Sanitary Engineering Division, was assigned to temporary duty with the Office of the Chief Surgeon, European Theater of Operations. Colonel Gilbert was in turn attached to a field team of Combined Intelligence Objectives Subcommittee of the Combined Chiefs of Staff. The functions of this team were to investigate and report on the water supply, sewage, and industrial waste treatment in Germany.[44]

The following paragraphs summarize the findings of the team as regards waste disposal practices in Germany:

Screening. Rotary screens for storm water overflow were found to be used to a limited extent. Bar screens were generally cleaned by mechanical means. There appeared to be an increased trend toward screenings grinding.

Grit Chambers. Except in a few very large plants, grit was removed by settling the sewage in plain longitudinal channels, the grit being removed by hand or by means of bucket elevators or grab buckets.

Settling Tanks. Clarification tanks of both round and rectangular types were found. All designs were characterized, to a great extent, by complicated inlet and outlet designs, and by the use of very large and deep sludge hoppers. Mieder-type mechanisms were generally used for cleaning the rectangular tanks. In the round units, both pitched blade and spiral scrapers were used. For secondary settling, deep Dortmund tanks were preferred.

Aeration Tanks. Aeration units were generally of the spiral flow diffused air type. Imhoff-type paddles, formerly used to a considerable extent, appeared to be in disfavor. Straight mechanical aerators were practically nonexistent. During the war, in order to save power, most aeration units were taken out of service.

Filters. Filter media beds were generally very deep by American standard—4 meters—and the media were graded in size. Precast concrete underdrains were used in preference to ceramic tiles. High rate filters appeared to be coming into favor. Enclosed filters seemed to be preferred in the Emscher and Ruhr districts due to the influence of Pruss.

Contact Aerators. This secondary treatment device had completely disappeared in Germany, being superseded by the activated sludge process or by trickling filters.

Digesters. Practically all digesters were heated and provided with gas collection facilities. Rotating heating coils for better heat transmission were

[44] CIOS Rpt 19338, Water and Sewage Treatment Facilities in Germany, by Lt Col Gilbert, Dr. Fischer, Mr. Gorman, and Mr. Sheridan. AF Med Library.

common. External sludge preheaters were also used to some extent. The preferred internal heating coils were of a type that can be removed for cleaning without interfering with tank operation. Stirring or sludge distribution devices were widely used, care being taken in their design not to disturb bottom digested sludge. Stage digestion was used to a considerable extent. Digestion tanks were generally built with conical tops as well as conical bottoms in order to reduce the surface area of possible scum layers and to make it easier to break down scum mechanically. Earth banking of digesters was rare, cork or air cell insulation being used to conserve heat.

Gas Utilization. The compression and utilization of methane gas for driving automobiles was almost universally used in Germany and had been developed to a high degree. The impression was that the principal reason for operating German sewage treatment plants throughout the war was expressly for gas collection and utilization. Rather than use the digester gas for sludge heating or for power generation at the sewage plant, coal and electrical energy were used for these purposes in order to make a maximum amount of gas available as automobile fuel.

Sludge Drying. Open sand beds were generally used for sludge drying. In a few projected large plants, mechanized dewatering of sludge on vacuum filters was contemplated.

Chlorination. During the war chlorination was not practiced at any plant because of the lack of chlorine gas. Even in normal times, the use of chlorine in connection with sewage treatment in Germany was unusual.

Fish Ponds. Fish ponds, although still used at the time of the survey to a considerable extent for effluent treatment, were falling into disuse. It seemed questionable that their use would be contemplated in future designs.

Sewage Farms. This method of sewage treatment was favored during the war years, but following the war was regarded as a temporary makeshift and appeared likely to be discarded in favor of more orthodox sewage treatment methods.

Chemical Treatment. The use of chemicals for sewage treatment was rare in Germany due to high chemical costs. The Niersverband process may have some promise for very strong sewage.

General. In general, concrete work at German sewage plants is very complicated. Mechanical equipment is likewise complex and cumbersome. Development of plants and processes after the early 1930's when the Nazis came into power practically ceased.

Training of Troops in Waste Disposal

In cooperation with the Training Division, Office of The Surgeon General, and the Signal Corps, Training Film 8–1179, "Human Waste Disposal," was written and filmed. It illustrated the various methods of disposing of human

wastes in the field so that water supplies would not be contaminated and fly breeding would be controlled.

SOLID WASTES

While refuse, such as garbage and rubbish, does not directly affect health, its careless disposal may cause excessive prevalence of flies, other undesirable insects, and rodents. Moreover, because proper disposal begins in the kitchen and because such wastes are handled openly—that is, placed in cans and hauled away by trucks—and not like sewage which is transferred by underground pipes to a remote area, the Army had placed much emphasis on its proper handling in kitchens and collection vehicles.[45] Unfortunately this emphasis did not, during peacetime, carry through to final disposal.

Amount of Waste

Experience within the continental United States has shown that, during the war period, the nonedible garbage and the nonsalvageable rubbish amounted to 1.25 to 1.50 pounds per man per day. During peacetime, the amount will approach 2.0 pounds per man per day as salvage operations on rubbish are reduced. During the war, edible garbage that was salvaged averaged approximately 0.5 pound per man per day. In peacetime, this figure will increase and may reach 1 pound, or even 2 pounds, per man per day.

Policy

The overall Army policy during peacetime was based on utilization of the edible portions of the garbage.[46] In many cases, this was fed to hogs on the post, the profits, if any, accruing to the benefit of some post organization. In general, such activities were fairly well controlled from the sanitary viewpoint; however, if cost records had been maintained, it is probable that the cost for soldier or other labor would have been excessive and there would have been a deficit, instead of profits. At other posts, the garbage was sold to private individuals, or they were allowed to collect it without charge or at a small charge. Except for the necessity for use of a dump on which to dispose of nonedible material, this policy was moderately satisfactory during peacetime.

Prior to the beginning of the emergency, a few incinerators had been constructed at the larger fixed posts. These were mainly based on the so-called United States Standard Incinerator, which was developed near the close of World War I. Except for a relatively few items, this incinerator was a good one. The 1940 policy of the Quartermaster Corps appeared to be to provide incinerators of this type for important large new camps. Furthermore, in

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[45] FM 8-40, 1940.

[46] See footnotes 1 (2), p. 131, and 18, p. 147.

1940, this incinerator was redesigned in accordance with modern municipal practice, but it was found later that it possessed certain defects as regards Army needs.

The policy of the Sanitary Engineering Division, Office of The Surgeon General, was in general agreement with that of the Quartermaster Corps in regard to the provision of incinerators and with their basic design. It was thought, however, that consideration ought to be given to setting up a sound policy for collection and to the training of incinerator operators. It was realized that the separate collection of edible garbage would create very difficult, if not unsolvable, problems in incinerator operation due to overheating of the furnaces. Even the separation for salvage of tin cans,[47] by making the mass of garbage placed in the furnace more solidly packed and homogenous, reduces the efficiency of the furnace. The policy of making each organization collect its waste and haul it to the incinerator resulted in overcrowding at, and overloading of, the plant during certain hours, and the storage of the excessive amount of waste delivered often created nuisance conditions at the incinerator.

The general policy of salvage of refuse was desirable. Tin cans were saved for their tin or metal content. There was a general shortage of food and fats. Under such conditions it seemed essential to utilize edible garbage for feeding to hogs, and some income was derived by the Government through the sale of such waste, though this was relatively insignificant. During normal peacetime, salvage of grease and garbage is not worthwhile; in wartime it is necessary. Most of the difficulty in solving the refuse problem adequately was due to this fact. During the years of peace a system of disposal is used that is relatively satisfactory, but which is not suited to war conditions. Much time and money may be wasted before Army practice and procedure can be adapted to new conditions and new solutions are employed. Further study of war conditions and war needs should be made, not only to determine methods but also availability of equipment, supplies, and personnel.

Collection

The prewar methods of collection also operated with a reasonable degree of satisfaction during peacetime. This policy was prescribed in AR 40–205. It required that filled refuse cans be collected daily in an appropriate covered and watertight vehicle and a clean can be left in place of each can removed. The amount of labor and equipment required by this procedure was, viewed by municipal engineering standards, excessive; but the costs were indirect and not subject to or discoverable by auditing, nor revealed by reports. It required the shortages of labor and equipment resulting from the war to emphasize these factors.

Private collectors were generally permitted or encouraged by the Army to collect garbage, being governed more or less closely by regulation and inspec-

[47] OCE Cir Ltr 3486, 1 Dec 45, sub: Tin can salvage.

tion. Since they were intimately and quite properly interested in profit, time-honored Army methods and procedures in collection soon began to be questioned because of their cost. It was natural that the shortage of cans, trucks, and tires would be used as an argument for changing the rules in regard to collection. It was also natural that collections by private contractors did not measure up to the standards to which the Army was accustomed. Spillage, because of careless handling and inadequate equipment, occurred. Probably the basic difficulty lies in the fact that the man who collects garbage and feeds it to hogs becomes so inured to insanitary conditions that he cannot understand why anyone should object to spilling just a little of the refuse.

Furthermore, a truck can carry a relatively limited amount of garbage in cans. The cans must be lifted onto the truck at the loading point and lifted off at the unloading point. The same size and weight truck can carry two or three or even more times as much garbage, if it is possible to empty cans directly into it. Fewer men are required, or the same number of men can handle more garbage. When a clean can is left for each filled can hauled away, somewhat more than twice as many cans must be available as are actually used. There is considerable wear and damage in loading and unloading. Also it is hard work to lift a garbage-filled can onto a truck, and this directly affected the availability of labor to the contractor.

It was thus clear that conservation of trucks, cans, and labor would be possible by a change in AR 40–205. Consequently, on 14 April 1944, paragraph 16 of this regulation was changed, by War Department Circular 146, Section II, to permit the transfer of garbage from cans to watertight tanks or truck bodies at the messhalls. Provisions had to be made for thoroughly cleansing the cans immediately after the garbage was transferred.

When the filled can is removed and replaced by a clean can, facilities for washing cans must be provided at a central point away from the mess. Initially, incinerators were equipped with hot water for washing, but space was generally lacking in which to handle all the cans of a large camp. In some places, extensions or additions were constructed to provide the needed space. However, the most economical arrangement is a platform, with unloading space on one side, washing facilities in the center, and storage and loading space for clean cans on the other side. There should be ample hot water; but no reliable data are available on how much is required. It is probable that with proper nozzles and quick-opening valves, about 2 gallons per can should be provided, based on the rate of washing. Steam is of great advantage in the removal of grease, but is not necessary to sterilize the cans.

When regulations were changed to permit emptying of cans at messhalls, provision had to be made for can washing at each kitchen by kitchen personnel. The Corps of Engineers, after consultation with the Sanitary Engineering Division, Office of The Surgeon General, designed several can washing platforms. In general, these combined the garbage can stand, a paved area on

which the truck stood during loading in order to facilitate cleaning up any spilled garbage, and the washing device equipped with hot water from the kitchen. The paved area sloped to a drain near the washing rack. Where sewers were available, the disposal of wash water was easy. Otherwise, it offered a problem which could be but partly solved by seepage pits, subsurface drains, or discharge into a watercourse.

When cans are washed at central can washing stations, the work is a function of the post engineer. When cans are washed at messhalls, mess personnel as a rule do the work, in addition to their other duties. Thus when emptying of cans into trucks at the messhall is permitted, there is a marked reduction in collection costs, due not only to eliminating can washing costs but to the decreased cost of collection. In a later paragraph, some of the peacetime possibilities for better service at reduced cost will be presented.

Disposal at Fixed Installations

The choice of methods for disposal of garbage and refuse is limited. While some consideration has been given by municipalities to grinding and discharge into sewers, this method was unproved during the war, and was considered costly since additional sewage treatment facilities have to be provided. Incineration, sanitary fill, feeding to hogs, and dumping are the means of disposal usually employed. In the United States, sorting and salvage (termed "tipping" by the British) is not economically feasible. The best method of disposal is the one that meets the needs of sanitation and decency and is cheapest. Incineration and sanitary fill are satisfactory from the viewpoint of sanitation and decency, when properly carried out.

Incineration. Incinerator design was on a sound basis as regards municipalities, but as already noted there were insufficient data on Army conditions and, moreover, conditions changed during the war. Most municipal incinerators are designed to burn mixed refuse, which includes garbage and other wastes as well. In fact, a principal advantage of the use of incinerators is the reduction of the cost of collection through permitting all refuse to be collected at one time and in one container, whereas hog feeding requires that two or more collections be made and two or more containers used. Municipal mixed refuse has an average moisture content around 50 to 60 percent and the incinerators are designed to operate at temperatures of about 1400° F. with mixed refuse, without addition of other fuel. It was on these bases that the Army incinerators were designed in, and previous to, 1941.

The Army policy of segregation of edible garbage changed very materially the composition of the material delivered to the incinerators. Moisture content was reduced, in some cases to 30 percent or 40 percent. As a result, the waste burned at temperatures much higher than the incinerator was designed to withstand. It is believed that in many cases, temperatures rose as high as 2000° to 2500° Fahrenheit. Incinerators quickly burned out and costly repairs

were necessary. Even where all waste was burned, some commanders insisted on separate collection of edible and inedible wastes as directed by regulations. Inexperienced operators frequently overheated the furnace with highly combustible material and then poured in the wet edible garbage, cracking and warping the grates. As a result of these factors, garbage incineration was costly and generally unsatisfactory during 1941 and 1942.[48]

Another difficulty with incinerators resulted from poor scheduling of collections. It was common practice for collection teams to start at the same fixed hour. All the teams would arrive at the incinerator at approximately the same time. There was insufficient space on the standard incinerator floor to store all of this waste, with the result that collection teams were delayed for considerable periods. An element of danger arose in that the floors were sometimes so crowded as to leave insufficient working space around the charging openings for the attendants. As a result of these difficulties, the trend for disposal turned toward the use of sanitary fills.

Hog Feeding Farms. Initially no requirements in regard to operation of hog farms were imposed. As a consequence some of these were located close to Army installations and even on the watersheds of streams furnishing water to the post. Excessive fly prevalence in the military areas naturally resulted from the proximity of the hogs, and there were complaints of odors. While the disposal of garbage by feeding to hogs is practically certain to create nuisance, this can be minimized by installation of proper facilities and by careful operation. Recommendations in this regard were prepared by the Sanitary Engineering Division, Office of The Surgeon General.[49]

The standards for hog feeding farms should include: (1) concrete feeding platforms; (2) water under pressure; (3) means for prompt collection and proper disposal of the uneaten waste, which amounts to about 40 percent of the garbage placed on the platforms; and (4) a density of not over 50 hogs per acre. Because there is normally a very narrow margin of profit in this industry, it is usually impossible to enforce these standards. For instance, in municipal operations, it requires 50 pounds of garbage to produce 1 pound of pork and therefore 40 pounds of pork are produced by feeding 1 ton of garbage. If hogs sell for 15 cents a pound, a ton of garbage is worth $6.00 less the costs of collecting, hauling, and farm operation. Complete data were never available on Army garbage, but it is believed that the food values were higher than for municipal garbage.

As a result of the difficulties from fly production and odors, contracts for the sale of Army garbage were modified to require that the feeding area be at least 5 miles from the reservation boundary and that operation of the farm comply with the State and local laws and regulations. Since very few States

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[48] 17th ind on Sanitary Rpt, Col W. A. Hardenbergh, SnC, to Surg Fort Leonard Wood, Mo., 29 Apr 42. SG: 721.5-1 (Ft Leonard Wood) N.

[49] Ltr, Lt Col J. A. Rogers, MC, SGO, to TAG, 30 Sep 41. HD: 720.7.

have regulations that apply in rural areas to such operations, except the nuisance laws, this latter requirement was productive of little improvement in farms or in their operation. However, so far as Army installations were concerned, the removal of the hog farms from the immediate vicinity of the camp generally eliminated odor problems and at least greatly reduced fly prevalence resulting from hog farm operation.

It is recognized that in times of food shortage, utilization of edible food wastes from Army camps is necessary. It is doubtful if public opinion would sustain any other policy. Feeding of this waste to hogs is the best method of utilization. Local and State laws and ordinances are inadequate to insure proper operation of these farms. Any improvement therefore can come only by incorporating into the sales contract certain minimum sanitary requirements, and these would have to be enforced by the post sanitary inspector. The problem is thus a difficult one, and can be solved only by close cooperation between the Medical Department, the Quartermaster Corps, and the Corps of Engineers.

Dumps. The difficulties encountered in operating incinerators have been described. As the incinerators became inoperative, dumps were used for the disposal of inedible wastes. Such inedible wastes contain much organic matter. In addition, it is practically impossible to prevent unauthorized dumping of much organic matter, such as spoiled foods, bones, and, when the amount of leftover food is checked routinely, wasted or surplus food that is disposed of secretly. As a result, the dumps became heavily rat-infested; and in most of them there was considerably fly and pest mosquito production. The latter usually occurs under the dump, rather than in water containers on it. The abundance of rats is always surprising. It was estimated that 4,000 were killed in one Army dump in New England, and that nearly 25,000 were destroyed by one application of poison on a municipal dump near an Army post in the West.

Sanitary Fills. The refuse disposal difficulties encountered by the Army were similar to those that have plagued municipalities for many years. Armies, too, have had this problem always with them, even back to the siege of Troy, which is probably the first recorded instance of trouble with refuse disposal. During the decade preceding the start of the war, a method of disposing of garbage by burial, termed sanitary fill, had been developed and was used by a number of municipalities. Properly operated, this method had produced satisfactory results in prevention of nuisance, including odors, flies, and rats. (See Fig. 14.) The Corps of Engineers proposed in 1942 that this method of refuse disposal be approved for use by the Army.[50]

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[50] OCE Cir Ltr 1768, 30 Jun 42, sub: Disposal of garbage and waste material.



A

B

Figure 17. A. Dump at Bradley Field, Connecticut. B. Same, after being converted into a sanitary fill.

Consideration was given to the use of the sanitary fill for the following reasons: (1) municipal practice had shown it to be satisfactory; (2) critical shortages of material hampered the incinerator repair and modification program; (3) there was a shortage of personnel qualified to operate incinerators; (4) sanitary fills could often be so located as to reduce the length of haul, thus conserving trucks and personnel; and (5) preliminary estimates indicated that under many conditions both initial and operating costs would be less.

In the sanitary fill, all the waste materials are compacted and thoroughly sealed under about 2 feet of dirt, and divided into a continuing series of sealed cells. The method is suitable for disposal of mixed refuse, nonedible garbage, rubbish or ashes, but not for edible garbage alone, as this is ordinarily too liquid to handle. About 1 acre per year per 10,000 troops is required, if a 6-foot depth of fill is used. Because there is no nuisance and the fill is not unsightly, a remote location is not necessary. It is difficult to use this method in cold weather areas, and a high water table is undesirable, though satisfactory operation is possible in both cases.

In the discussion with the Corps of Engineers, it was recommended that detailed operating instructions be prepared and that arrangements be made to insure that the first installation be satisfactory. This procedure was deemed advisable because of the necessity to demonstrate the practicability of the sanitary fill to all concerned. The Sanitary Engineering Division made specific arrangements with the service command surgeon for the first installation and the Corps of Engineers provided trained supervisory personnel to insure its proper construction.

The first installation was at Fort Benning, Georgia, early in 1943. Results were satisfactory. Essentially the same procedure of preliminary correspondence with the service command surgeon and assignment of trained personnel to supervise installation was followed in each service command. Special attention was given to instructing the service command surgeon and the service command sanitary engineer in the essential details of this method; and personnel of the service command repairs and utilities branches were trained in the proper methods of operation.

As a result of this careful preliminary program there were no failures in the initial installations; in fact there were remarkably few unsatisfactory sanitary fills. As the values of the method were appreciated, a great many installations were made; and in most cases each installation meant the elimination of a dump. Standard procedure was to cover abandoned dumps with compacted earth. In the Eighth Service Command alone, more than 75 dumps were eliminated in the fiscal year ending 30 June 1945.

Peacetime Army Waste Problems. The problem of refuse disposal at fixed posts in the Zone of Interior is complicated by the fact that conditions in peacetime vary materially from those that will occur in war. Normal peacetime waste disposal problems are about the same for Army posts as for municipali-

ties, but the same methods cannot be used in wartime. The changes in composition of the waste and the peacetime experiences and views of surgeons and of line commanders, which are often exceedingly difficult to modify, make the problem a difficult one. It is believed that both incineration and sanitary fill are well adapted to Army needs, provided operators are properly trained in sound procedures.

One of the complicating factors, of course, is the wartime large-scale sale of edible garbage. Removing this unbalances the remaining waste so as to interfere materially with incinerator operation. Existing regulations, which provide for peacetime segregation of edible garbage, should be changed. Edible garbage should not be separated unless a sound reason exists therefor. There is seldom or never a sound reason in peacetime; it is believed that it invariably costs more to utilize the food values in garbage than they are worth. Collection of grease is desirable to prevent interference with operation of sewage treatment plants. When fats are needed, as during the war, collection is doubly desirable. In peacetime, such fats are usually unsalable.

In view of these facts, collection of mixed garbage is desirable in peacetime; that is, there should be no separation. Except for large boxes and crates, all waste should be mixed. This would permit satisfactory disposal by either incineration or sanitary fill and would markedly reduce the real cost of refuse collection.

Consideration should also be given to the use of modern collection equipment, such as closed, watertight, low-loading bodies. These eliminate high lifting of heavy cans, reduce spillage while loading, greatly reduce the number of collection personnel, and generally eliminate nuisance because of odor, leakage, and the blowing about of paper and ashes. Because such equipment has capacity to handle 8 to 15 yards of refuse, it is too heavy to operate on unimproved roads. Therefore, approaches to messhalls and kitchens must be surfaced.

The collection of mixed refuse with one collection vehicle handling all waste material would considerably reduce both vehicle and labor requirement. Collection of refuse is a costly operation, and has been the subject of much study on the part of municipalities. In general, it is believed that adoption of a single collection system, handling mixed refuse, would reduce costs at least 50 percent as compared with the costs of collecting several categories of waste.

Disposal of waste is also a costly procedure. It costs the average municipality about $2.00 per ton to incinerate waste. A part of this cost is canceled by the reduced cost incident to single, or mixed, refuse collection. Available cost data on sanitary fills indicate that the overall cost of purchase, depreciation, maintenance, and operation of equipment is not appreciably less than the cost of incineration for camps up to about 10,000 population. In larger camps, because of needs for more incinerator units and operators, the cost comparison is more favorable to sanitary fills. From the viewpoint of the Medical Depart-

ment, both methods are satisfactory when properly operated and the choice between them depends primarily on local conditions.

Field Refuse Disposal

Field refuse disposal [51] did not present any serious problem. Burial was generally adopted, pits being dug by troop units and covered over when filled or at departure. These were sometimes uncovered by animals, generally dogs or hogs. An effective preventive was to spread broken glass liberally over the contents before covering. The various field incinerators were used in many areas, the inclined plane type in its many variations being the most widely used.

Amphibious Operations. The preinvasion shelling destroyed many enemy food dumps, breaking and scattering food containers. In addition, during the first few days after landing, proper refuse disposal was almost impossible of accomplishment. As a result, flies and rats often were so numerous as to become a high-priority morale and health problem. Cleaning up was difficult and took time; in some cases special units were designated for this task. Generous use of sodium arsenite reduced fly breeding, and poisoning operations were employed to control rodents. In the use of sodium arsenite, care was taken to protect water supplies from contamination.

Overseas Disposal. Refuse disposal overseas was generally solved locally. In most areas, food was so scarce that Army garbage was in great demand. In some places, natives would leap into the garbage to seize choice pieces. Dumping, sale to local farmers, and burial were the methods normally used. In general, large disposal areas were not needed. Generous use was made of cross-trench and inclined plane incinerators; both types gave good service. In some overseas areas burial in large trenches was employed, even where it would have been more practical to utilize sanitary fill.

Garbage Disposal in the Southwest Pacific. Disposal of garbage was the bane of the medical inspector's life. Regardless of instructions or methods of their enforcement, there were always units promiscuously dumping garbage in road ditches, slightly remote sites, or on designated trash dumps. At some bases the base engineer assumed the responsibility of disposing of all garbage. This was best accomplished by converting large 80-foot steel barges into scows by erecting sidewalls preferably of steel plate, and installing a large capacity engine-operated centrifugal pump with fire hose and nozzle. Quick-opening sluice gates would release most of the garbage, the remainder being washed out and the scow cleaned with water pumped from the sea.

Sanitary fill was attempted and was successfully employed at a few bases during the dry season but as soon as the rainy season came, trucks and equipment bogged down and this method would have to be abandoned. No central incineration was attempted but many unit incinerators were constructed and

[51] See footnote 26, p. 149.

satisfactorily operated. In fact, unit incineration was specified in most of the newer bases. In this way each unit could be held responsible for the proper disposal of its garbage. The inclined plane type of incinerator was employed using fuel oil as auxiliary heat. Many embellishments were added such as charging hoppers, preliminary drying pans, and messkit wash water heaters.

Disposal of Garbage From Ships. This was usually the responsibility of the port commander, and "ducks" were used to gather the garbage daily and carry it out of the harbor for dumping. However, much garbage was dumped overboard in the harbors especially when there were hundreds of ships at anchor and all available craft were required for lightering cargo to shore. On White Beach at Hollandia (New Guinea) it was necessary to have a sanitary crew patrol the beach daily to pick up spoiled meat, vegetables, shipping crates, and empty boxes.

The stopover harbors for ships bound to the Pacific presented the same problems as existed in harbors in the Southwest Pacific. At Honolulu Harbor a fleet of scows was organized to collect garbage from ships in the harbor. This was necessary because most ships laid over for 3 or 4 days and storage of garbage on the ships for this period of time caused odors and attracted flies.

Refuse Disposal. Burnable trash was required to be burned in unit areas. Unburnable trash was required to be dumped at specified sites. One of the notable omissions in base development was the tardiness in selecting central sites for trash and refuse disposal. In the absence of well-marked accessible sites, refuse soon litters an entire base and complicates the general sanitation program.

Inactive and Surplus Stations

With the reduction in size of the Army, and the inactivation pending further need, or the surplusage and ultimate disposal of many camps, procedures were prepared for the guidance of post engineers and surgeons in regard to waste disposal facilities and operations.

These standardized procedures directed that at inactive installations sanitary fills would be operated without change; incinerators would also continue operation, but all waste would be concentrated in one unit if possible; dumps should be cleaned, covered with 12 inches of earth, and dumping restricted to the minimum area actually required by maintenance personnel; and all garbage and refuse should be collected together as mixed refuse, with disposal by sanitary fill or incineration.

At surplus installations, before disposal, all rubbish and garbage should be collected and disposed of, and all cans cleaned; all boilers and hot waterlines at can washing stations and incinerators should be cleaned, including the inside of the furnace, and dumps and sanitary fills should be completely covered with at least 12 inches of earth.

CHAPTER V

Control of Insects

William A. Hardenbergh

With Introduction by

James S. Simmons, M. D.

INTRODUCTION

The United States Army has a distinguished record for achievement in the control of the dangerous insect-borne diseases. This record runs back to the pioneer work on the etiology and transmission of yellow fever by Maj. Walter Reed and his associates in Cuba at the end of the Spanish-American War. It includes the historical demonstrations of the practical control of the vectors of both yellow fever and malaria by Gen. William C. Gorgas in Havana and during the construction of the Panama Canal. This pioneer record of leadership also includes the important researches of Col. Charles F. Craig, his associates and his followers, who contributed so much to our knowledge of the control of malaria and its vectors among American troops in the Philippines, in Panama, and in the United States.

Thanks to the scientific discoveries of these early workers and their associates, the control of insect-borne diseases in the permanent posts of our peacetime Army became progressively more effective throughout the period from 900 to 1940. However, it was recognized clearly that the control of certain of these diseases, especially malaria, was much more difficult under field conditions—particularly in the tropics. The urgent need for further research to develop more effective methods with which to protect troops operating in the field was emphasized by the author in 1935, following field maneuvers in Panama, when—in spite of the vigorous application of the best control methods then available—these maneuvers had to be terminated because of the high incidence of malaria. The comment on this episode was as follows:

> Such occurrences show the importance of malaria as a military problem, and indicate the need for the development of more effective methods for the prevention of this disease in the field. The difficulties encountered by troops living under the relatively favorable peacetime conditions which exist in the Canal Zone afford a serious warning of the dangerous situation that would undoubtedly arise should it become necessary for our Army to operate for a long period in the American tropics.

This was the situation in 1939, when our Army began to plan for entry into World War II, should this become necessary. At that time, the peacetime incidence of malaria among our troops was at the lowest point since the Revolu-

tionary War; but the problem of protecting troops in the field was still of major concern. For this reason, one of the first recommendations made by the chief of the wartime Preventive Medicine Service was that an extensive program of research be developed in the hope of discovering a true prophylactic for malaria and of developing better methods for the field control of the insects responsible for disease. Through the cooperation of the National Research Council and its Committee on Medical Research, these recommendations were put into action during the early years of the war. The millions of dollars spent for the researches, conducted with the assistance of all the scientific agencies of the country, paid rich dividends in new agents which were of enormous importance to the winning of the war. Much of this research was stimulated and coordinated from the Preventive Medicine Service by Col. William S. Stone and his staff of the Division of Sanitation. As new control agents and methods became available, they were immediately applied in the field; the planning and coordination of the field control of insect-borne diseases was under the direction of Col. William A. Hardenbergh, Chief of the Division of Sanitary Engineering. Later in the war, a third unit of the Preventive Medicine Service, Tropical Disease Division, became actively concerned with this enormous insect control program, first, under the leadership of Col. Paul F. Russell and, later, that of Col. Oliver R. McCoy. This unit helped in developing the malaria control and survey units which were useful in the theaters of war.

Thus, the joint efforts of these three major units of the Preventive Medicine Service planned and guided one of the most spectacular programs for the control of insect-borne diseases ever carried out in the history of the world.

Early in the war, before the new insecticides had been developed, the Division of Sanitary Engineering began its program for the control of disease-bearing mosquitoes in all the military posts and stations of the Zone of Interior. Through cooperative arrangements requested through the Secretary of War, the Federal Security Administrator arranged for the United States Public Health Service to supplement this military program by organizing an extra-military, civilian-operated program in all the areas surrounding Army installations. Taken together, these two programs operated throughout the war at a joint cost of more than 30 million dollars. As a consequence of this gigantic attack on mosquitoes, malaria was not a serious hazard to American troops stationed in the continental United States and, as is shown elsewhere in the history, most of the infections contracted by soldiers occurred in the tropical combat zones overseas. This joint Army-civilian mosquito control program in the United States was so successful that it pointed the way to the eventual eradication of malaria in our country. Backed by the Armed Forces, at the end of the war, the Public Health Service was able to obtain from Congress funds to continue this civilian program; and, as a consequence, malaria is no longer an important disease in this country.

Thus those who took part in the Army's great insect control program during World War II have added another bright page to the history of the military fight against these scourges of humanity.

INSECT CONTROL PROBLEMS IN 1940

In the fall of 1940 consideration was given to the problems of insect control, and primary interest centered on malaria and the control in the United States of anopheline mosquitoes, the vectors of that disease. It was not known at that time that the armies of the United States would soon be fighting in some of the most malarious areas of the world, but it could be seen that the mobilization program then under way would involve the training of large numbers of troops in States in the South where malaria was prevalent. It was also appreciated that malaria would present a serious problem in the Caribbean bases, acquired a short time previously (2 September 1940) from Great Britain, and that in Central and South America the problem would be even more acute.

In World War I the armies of the United States had not been engaged in combat in any areas where malaria was a serious hazard. There was, therefore, no need in that war to devise measures for protecting troops in the field from malaria. Consideration was given, however, to mosquito control in and around camps in States in the South to protect troops from malaria, and about 3 million dollars was spent in that work during 1918 and 1919. Despite this effort, 10,510 cases of malaria were reported among troops in the United States, with a total of 130,673 days lost from training.[1]

The need for malaria control in training camps in the South during World War II was fully appreciated, as indicated by the following excerpt from a memorandum to the Chief, Planning and Training Division, Office of The Surgeon General: [2]

> Malaria, a disabling disease of great economic importance, is endemic in many areas of the South, where most of the training camps are located and where a majority of the troops will be stationed. Even in areas where this disease is not now a serious problem, the presence of anopheline mosquitoes and the introduction of soldiers with chronic infections from malarial sections may combine to make it so. Although the mortality rate from malaria is low, its disabling character makes it highly important from the military viewpoint.

That malaria might interfere with campaigns conducted in highly malarious areas was also appreciated, but the extent to which it would hamper military operations in general had not been foreseen. Historical records were available to indicate how seriously this disease might affect the course of a campaign. A classic example in World War I was the experience of the British and French

[1] Medical Department of the United States Army in the World War. Washington, Government Printing Office, 1928, vol. XV, pt. 2, p. 515.

[2] Memo, Lt Col W. A. Hardenbergh, SnC, SGO, for Chief Planning and Training Div, SGO, 3 Feb 41, sub: Provision for malaria and mosquito control during the 1941 season. HD: 725 (Gen).

troops in Macedonia. Some 80 percent of 120,000 French troops were hospitalized, over 25,000 British soldiers were sent home with chronic malaria, and more than 2 million man-days were lost in the British Macedonian Army during 1918 because of malaria.[3]

The proposed Caribbean and South American bases were therefore studied to determine the extent of malaria hazards. Little information was readily available regarding the important mosquito vectors, the factors influencing the spread of malaria, and the prevalence of the disease. These data had to be developed by study of all available material; by field surveys; and by information obtained from physicians, engineers, and entomologists who had resided in or visited these areas. It was shown that in many of these bases malaria would present a serious problem and that control measures would be necessary.

In the course of these studies the possible need for malaria control in more remote areas was considered. Additional bases in Central America, Brazil, West Africa, and the Far East seemed possible or probable in early 1941, and by December of that year it appeared certain that the United States would have to maintain armies in many of the highly endemic regions of the world—Africa, the East Indies, India, Burma, and the Middle East, as well as in a great many minor localities where malaria was almost universal. The paucity of concrete information from many areas as to the important malaria vectors, and the local conditions under which they would be encountered, made it difficult to plan for malaria control problems that might be met when the United States entered the war. Therefore increased stress was placed on gathering and evaluating all of the information possible. It was also clear that the available resources in personnel, equipment, and materials would have to be ascertained.

Procurement of personnel was a serious problem. The number of medical officers familiar with the epidemiology and control of malaria was extremely limited, as was the number of sanitary engineers who had had previous experience in mosquito control. The northern States, where malaria was not a problem, had the great majority of sanitary engineers, both because the rates of pay were higher and, with a greater population and more numerous water and sewage plants, the services of more of them were required. Medical entomologists were also extremely scarce since there was only a limited field for them under ordinary conditions. To meet these needs, records of scientific personnel were consulted to build up a list of trained and experienced men. In addition, as the mosquito control program in the Zone of Interior got underway in 1941, all the entomologists of the Sanitary Corps and as many as possible of the engineers from the North were sent to camps in the South to gain firsthand experience in mosquito control.

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[3] Wenyon, C. M., et al.: Malaria in Macedonia, 1915–1919. J. Royal Army Med. Corps 37: 81–108, Aug 1921.

The well-known methods of drainage, filling, and applying larvicides were available for control around fixed installations. These were considered adequate. Equipment for drainage was available; improvements since World War I in construction and dirt-moving equipment permitted a reduction in cost and an increase in the speed of the work. The problem of protecting troops in temporary camps and in the field remained to be solved. The procedures required for reducing effectively the malaria hazard under field and combat conditions had to be developed at firsthand, with no large-scale previous experience as a guide.

Perhaps the greatest handicap, and the one most difficult to overcome, was the lack of understanding and appreciation of the malaria hazard by nearly all line officers and by many medical officers. With no previous experience in handling troops in areas of endemic malaria, the almost universal tendency was to ignore all recommendations for protection of troops on the basis of interference with military operations. The lessons gained from experience, together with a continuous program of education, steadily reduced this handicap as the war progressed.

In addition to the control of malaria-carrying mosquitoes, it was realized that extensive control measures would have to be carried out against other insects, not only to prevent disease but also to promote the comfort, efficiency, and morale of troops. Flies are well-known transmitters of disease; bedbugs are destructive of morale; cockroaches, while perhaps not a health menace, are undesirable; and many other insects might have to be controlled.

MOSQUITO CONTROL

The actual work of malarial mosquito control may be broadly divided into that done in the Zone of Interior and that carried on overseas. Although mosquito control around fixed installations overseas had many of the characteristics of that in the Zone of Interior, the methods used were frequently quite different; mosquito control for troops in the field was a wholly different type of problem. These two phases of the work are therefore discussed separately.

Mosquito Control in the Zone of Interior

As previously noted, the records of World War I indicated that malaria would present a considerable health problem during any mobilization involving large concentrations of troops in States in the South. Reports of malaria incidence among civilians showed that malarious areas in the United States had been expanding since 1935, especially along the Mississippi and Missouri Valleys.[4] For these reasons it was considered necessary to initiate mosquito

[4] Bierring, W.: Malaria in the upper Mississippi Valley. J. Iowa Med. Soc. 30: 294–295, Jul 1940.

control measures on a larger scale in the United States in the summer of 1941, and plans for the work were made in the fall of 1940.[5]

Control Operations in 1941

Consideration of the necessary organization, personnel, and finances was recommended to Col. (later Brig. Gen.) James S. Simmons, Chief, Preventive Medicine Subdivision, Surgeon General's Office, on 2 November 1940.[6] During December 1940, the author, with Dr. L. L. Williams, United States Public Health Service, visited most of the camps then existing or under construction and many of the proposed campsites.[7] State and local health organizations were contacted and the problems of malaria prevention discussed with them, with the surgeons of the Fourth and Eighth Service Commands, and with port surgeons. Based on the information obtained and on a general knowledge of the area, an estimate of the work to be done and of the approximate cost of a mosquito control campaign was prepared.[8] In making the estimates, the use of standard oiling and ditching gangs to maintain control in each area was contemplated. It was assumed that oiling gangs would consist of 3 oilers, a foreman-inspector, and a truck driver; and that ditching gangs would consist of 15 laborers and a foreman. The costs of initial equipment for each gang, of labor, and of operation were estimated. To each of the 21 camps included in the original estimate were assigned such numbers of oiling and ditching gangs as appeared necessary for control. The estimated total cost for the season of 1941 was about $1,500,000. This did not include allowance for the pay or expenses of Army officers and enlisted men engaged in the work.

Special consideration was also given to an organization for carrying out the work. It was deemed impracticable to direct the entire program from the Office of The Surgeon General. Therefore a policy of decentralization was adopted whereby the campaign was placed under the general direction of the corps area surgeons. With the concurrence of the surgeons, sanitary engineers were assigned to corps area headquarters and to posts for direct supervision of the projects. To standardize, so far as possible, the methods of carrying on the work, general directives were prepared in the Office of The Surgeon General and forwarded to the corps area surgeons.[9] These directives outlined the type of work to be done, the general methods to be employed, the records to be maintained, and the amount and type of information regarding mosquito prevalence and malaria incidence required to determine the character of the control program. To facilitate this phase of the work, all available entomolo-

[5] Memo, Lt Col W. A. Hardenbergh, SnC, SGO, for Col. J. S. Simmons, SGO, 20 Nov 40, sub: Mosquito control for camps and posts. HD: 710 Malaria.

[6] Annual Rpt, Sanitary Engr Subdiv, Prev Med Div SGO, FY 1941. HD.

[7] Hardenbergh, W. A.: Report of trip with Dr. L. L. Williams to State and local health departments and camps in Fourth and Eighth Corps Areas. HD: 721 Sanitary Survey (1940-41).

[8] See footnote 2, p. 181.

[9] For example see, Ltr, SG to Surg 9th CA, 21 Feb 41, sub: Plans for mosquito control, with incls. SG: 725.11-1 (for each CA) AA.

gists in the Sanitary Corps (14) were placed on duty in camps in southern States. In many areas in the South mosquitoes appear in late March and early April. It was therefore considered necessary that work should begin in those areas not later than 1 April, and the entire program was based on starting promptly at that time.

The estimate of costs prepared by the sanitary engineer on duty in the Office of The Surgeon General was based on a general consideration of overall needs. It was not specific for each post; therefore final allotments could not be made for the summer's work. For this purpose, detailed local surveys were necessary. The directive outlining procedures [10] for making such surveys and for planning the necessary control measures was intended to standardize the methods of estimating local costs and to insure that adequate consideration be given to all local factors. It was realized that few Medical Department officers had the necessary background to determine the need for a mosquito control program, or to plan a sound program. The directive, therefore, also included detailed instructions for determining and evaluating needs.

Specific information was sought concerning mosquito-borne diseases, especially malaria, among the civilian population near the post as well as among personnel on the reservation. Since most of the posts were newly established, there were few instances of such diseases among the troops and reliance on civilian records was necessary. In addition, information regarding the seasonal prevalence of disease-bearing and of pest mosquitoes in areas adjacent to the reservation was required. The need for a mosquito control program was determined on the basis of the information obtained.

In those areas where control measures were needed, a survey of the reservation by trained personnel to determine potential mosquito breeding places was required, and it was recommended that Sanitary Corps engineers do this work. All potential breeding places were to be marked on a large-scale map of the area. It was recommended that when possible the survey should be made in company with the Quartermaster or Engineer Corps officer likely to be responsible for the work.

Estimates were required of the work necessary on water courses, collections of water, seepage and overflow areas, and salt marshes. The work included brush clearance, removal of marginal aquatic vegetation, stream channel clearance, major and minor drainage, filling, and the use of larvicides. For each potential breeding place, the types of control work were listed, with an estimate of the cost of each. It was requested that, wherever possible, estimates of costs by months for labor and materials for drainage and ditch maintenance, and for oil and its application, be given.

It was realized that these estimates would not be completed in time to use them as a basis for initial allocation of funds for the work. Instead, estimates

[10] "A Suggested Outline for Reporting Record of Surveys and Plans Recommended for Mosquito Control Programs on Military Reservations," sent as inclosure to letter cited in footnote 9, p. 184. HD: 725 (Forms).

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which had been prepared in the Office of The Surgeon General were used, and to insure that the work be started promptly, it was considered advisable to administer the funds through the Medical Department, using such supplies and equipment as might be available from the Quartermaster Corps and the Corps of Engineers. Both of these agencies, however, were then engaged in camp construction projects which required all of their resources. Therefore, on 10 February 1941 the Chief, Finance and Supply Division, Office of The Surgeon General, addressed a letter to the Budget Officer of the War Department,[11] calling attention to the requirements of Army Regulations (AR) 40–205, 15 December 1924, specifically paragraph 20*e*, which imposed upon the Medical Department responsibility for certain measures in regard to mosquito control; he also stated that informal contact with The Quartermaster General indicated that sufficient Quartermaster funds were not available for control. It was requested that, in view of the immediate need to institute control measures, action be expedited to allot, from savings due to a lag in hospital construction, the sum of $1,500,000 for mosquito control. Authorization for the use of these funds was granted on 20 March.[12] In anticipation of this authorization, arrangements for instituting a control program had been made. The money released on 20 March was immediately allocated to the corps areas on the basis of the estimates made by the sanitary engineer on duty in the Office of The Surgeon General as follows: [13]

Corps areas	*Sum allocated*
First	$38, 550
Second	58, 300
Third	100, 000
Fourth	474, 175
Fifth	23, 975
Sixth	82, 275
Seventh	81, 325
Eighth	290, 825
Ninth	153, 250
	$1, 302, 675
Available for emergencies	197, 325
Total	$1, 500, 000

The Office of The Surgeon General outlined the procedure to be followed in allotment of funds for mosquito control in a letter to corps area surgeons, 27 March, as follows: [14]

1. Funds were expendable for certain kinds of equipment, materials, labor, and trained personnel for mosquito control at camps, posts, and stations.

[11] Memo, Col F. C. Tyng, SGO, for WD Budget Off, 10 Feb 41, sub: Mosquito control. SG: 725.11-1.

[12] Ltr, WD Budget Off to SG, 20 Mar 41, sub: Mosquito control. SG: 725.11-1.

[13] Memo, Lt Col W. A. Hardenbergh, SnC, SGO, for Chief Finance and Supply Div SGO, 24 Mar 41, sub: Allocation of funds for malaria and mosquito control, FY 1940–41. HD: 725 (Estimates).

[14] Ltr, SG to Surg each CA, 27 Mar 41, sub: Procedure in mosquito control. SG: 725.11-1 (for each CA).

2. Corps area surgeons, subject to approval of the corps area commanders, would apportion the funds to the various posts according to need, generally upon recommendation of the Sanitary Corps engineer assigned to that office.

3. Accurate records of expenditures were to be maintained and submitted to The Surgeon General on the first of each month, showing the amount and cost of work done and the effectiveness of the control program.

4. An estimate of the funds required by months for the fiscal year 1942 was to be submitted on 1 June 1941.

Post surgeons, under the general direction of the corps area surgeons, with the advice and assistance of the sanitary engineers and entomologists who had planned the program, carried out the work. Crews were organized, materials purchased, and drainage and larvicidal operations begun so that an effective campaign of control was under way by 1 April 1941.[15] Because of restrictions on the expenditures of medical and hospital funds, there was some difficulty in purchasing equipment, but this was soon overcome by arrangement with The Quartermaster General and the Corps of Engineers.[16]

In planning the program it had been thought that Works Progress Administration and Civilian Conservation Corps labor might be used in this work. While corps area and post surgeons were urged to make use of these sources whenever possible, it was pointed out that most of these workers were already engaged in high priority defense projects. Besides, in mosquito control, time is an essential factor; drainage work and oiling must be begun as early in the season as possible. For these reasons, while every practical effort was made to utilize Civilian Conservation Corps and Works Progress Administration resources, principal reliance was placed on the efforts of the Medical Department, the outright hire of civilian foremen and labor, and the direct purchase of supplies and materials.

Methods of Control. The methods employed for control [17] were those that had proved effective in the past; they included filling, oiling, applying larvicides, and ditching, clearing, and cleaning to remove standing water. It was soon found that with modern dirt-moving equipment, filling was more widely applicable than in the past. Bulldozers, power graders, power shovels, and similar equipment permitted the quick filling and permanent elimination of areas which otherwise would have required costly initial ditching and continuous maintenance. Ditch linings were placed where economically applicable. Oils used were principally No. 2 diesel or No. 2 fuel oil, but some crankcase drainage oil was used after dilution with kerosene. In addition to oils, considerable use was made of the New Jersey or pyrethrum larvicide, and the phenol larvicides. These were diluted with water before spraying, and were

[15] For example see, Annual Rpt, Surg 4th CA, 1941. HD.

[16] Ltr, SG to AG, 28 Jun 41, sub: Mosquito control, with incls. SG: 725.11-1.

[17] Ltr, Col W. A. Hardenbergh, SnC, SGO, to Chief Prev Med Div SGO, 24 Feb 42, sub: Report on mosquito control activities, calendar year 1941. HD: 725 (Gen).

thus simpler to distribute in the field than oil. Effectiveness and cost appeared to be about the same whether one type of larvicide or the other was used. Some camps preferred oil while others used mostly pyrethrum and phenol larvicides.

Funds for Fiscal Year Ending in 1942. Medical Department funds were utilized from the beginning of the program until 30 June 1941. Up to that time $1,058,000 had been expended for all purposes, including oil and other larvicides, labor, tools, hire of equipment, and the establishment of mosquito identification laboratories. As of 1 July, the remaining $442,000 of Medical Department funds was allocated for the hire of personnel only; in addition, there was made available $750,000 of Quartermaster funds under the appropriation "Regular Supplies." It was thought that this amount, a total of $1,192,000, would be insufficient for the entire 1942 fiscal year, but because of uncertainty as to the extent of the expansion program of the Army a close estimate of needs could not be made.[18] At the end of the calendar year 1941, there was left from this appropriation approximately $464,000, of which $274,000 remained unallocated in the corps area headquarters, and $190,000 was unexpended in the individual stations.[19] This money was made available during the third and fourth quarters of fiscal year 1942. It was not sufficient to meet the estimated needs and an additional appropriation of approximately $485,000 was requested.[20] This included money necessary for control measures in new camps scheduled for construction early in 1942.

Achievements in 1941. Control work was carried on during 1941 in approximately 150 camps, posts, stations, and airfields. This number was larger than had been anticipated during planning and the costs of control were therefore greater. As of 1 January 1942, reports from the corps areas showed that the following amount of work had been done: [21]

Work	*Amount*
Ditches dug	1, 474, 272 feet
Fill placed	932, 617 cubic yards
Channeling completed	1, 285, 539 lineal feet
Cleared	4, 090 acres
Cleaning done	100, 000 lineal feet
Lining made	139, 191 lineal feet
Oil applied	528, 995 gallons
Pyrethrum and phenol larvicides applied	468, 195 gallons
Paris green mixture spread	52, 500 pounds

In the execution of this first year's mosquito control program, many difficulties were encountered and lessons learned. Among the problems were those caused by improper or careless construction of new camps. As a result

[18] See footnote 16, p. 187.

[19] See footnote 17, p. 187.

[20] Supplemental Budget, Last Quarter FY 1942, "Control of Malaria, Plague, and Other Insect-Borne Diseases." HD: 725 (Estimates).

[21] See footnote 17, p. 187.

of reports from numerous posts, a letter was addressed to The Adjutant General calling attention to various defects.[22] Among them were undrained or unfilled borrow pits, which were generally prolific mosquito producers. Depressions around piers supporting buildings, resulting from careless backfilling, also required extensive corrective work. In one camp alone there were more than 1,500 such defects. Perhaps most serious was the tendency to leave depressions, which later filled with water, under buildings when grading operations were carried on only to the edges of buildings. In some cases, these defects were difficult to discover and costly to correct.

Poor drainage was another common defect. Some tent camps were so located as to be partially flooded during heavy rains. Water standing under tent floors resulted in a serious mosquito nuisance. Improperly placed culverts either impounded water above the culvert, or caused the formation of a pothole at the exit. Erosion, caused by removal of vegetation during grading operations, filled culverts and ditches and materially hampered control work. Scrap lumber left over from the construction program was often dumped or piled in low areas, affording favorable facilities for the growth of large mosquito populations which were difficult or impossible to control, and also constituting rat harborages. These manmade mosquito-producing areas, most of which could have been avoided, caused a great deal of needless and costly work.

The construction of large areas of impervious surfaces within the camps, such as roadways, parking places, and roofs, with quick and heavy water runoff, added many serious drainage problems such as erosion of beds of small streams, ponding behind undersized culverts, and washing out of roads and bridges. In few instances was any consideration given to this factor in planning and constructing the early camps. As a result, mosquito control operations had to be extended to remedy the damages from such sources and to prevent increased mosquito breeding in overflowed areas and potholes in stream beds.

In order to maintain close touch with conditions at proposed new camps, and to advise The Surgeon General of conditions at such installations, reports and surveys of all proposed camps were reviewed to determine the probable mosquito producing areas, the prevalence of *Anopheles quadrimaculatus*, and the incidence of malaria. Problems in mosquito control were analyzed. Consideration was given to the desirability of changing the location of barracks to avoid areas of heavy anopheline breeding.[23]

Cooperation with United States Public Health Service. The Public Health Service cooperated in malaria control during 1941, in accordance with an agreement made in February 1940 between the Secretary of War and the

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[22] Ltr, SG to TAG, 25 Aug 41, sub: Mosquito breeding resulting from construction operations. SG: 725.11-1.
[23] See footnote 6, p. 184.

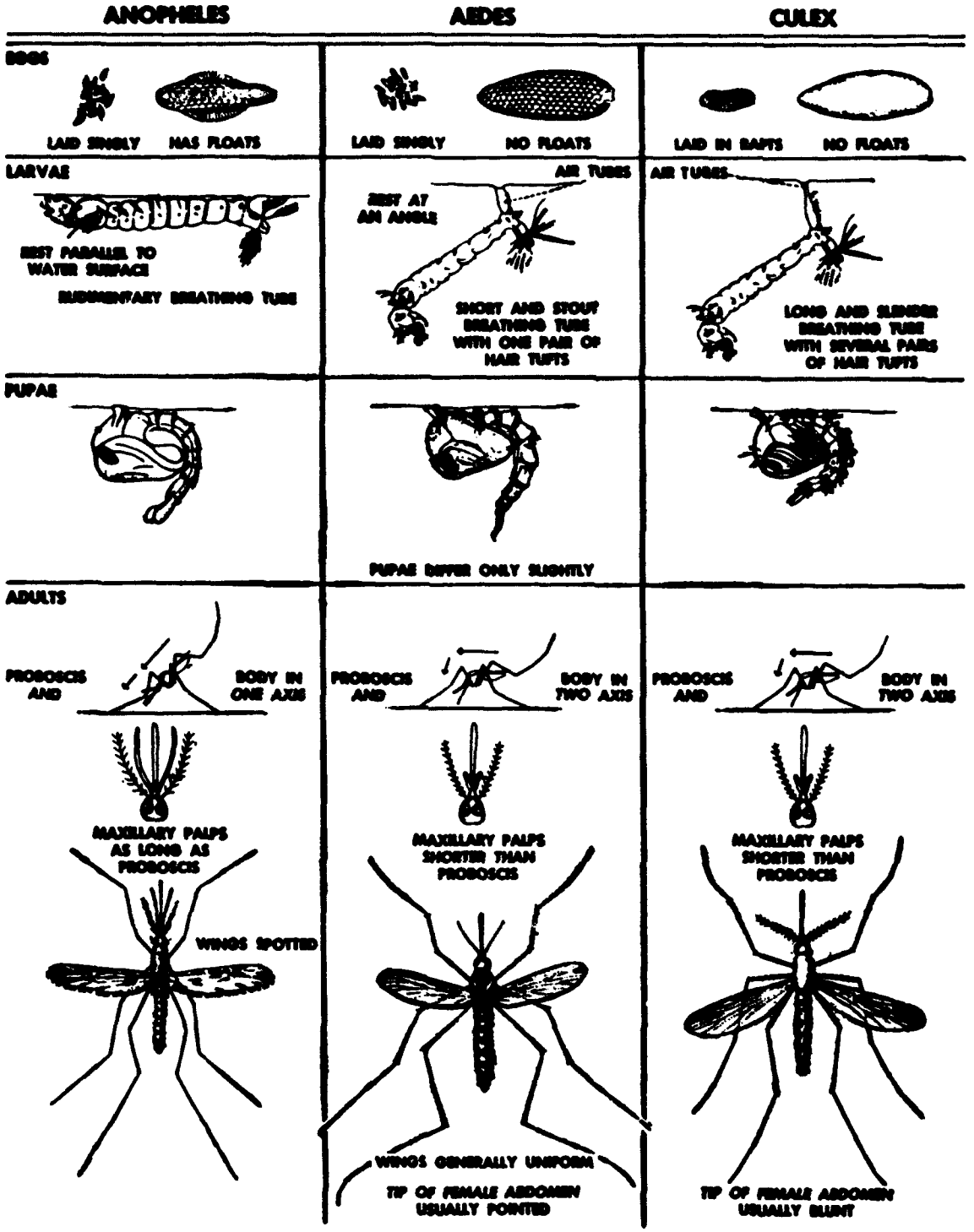


Figure 15. Principal characteristics for identifying the three mosquito genera of medical importance.

Administrator, Federal Security Agency,[24] under which the Public Health Service undertook the responsibility for sanitation in the extramilitary areas. This program was slow in getting under way, and was complicated by the insistence of the Works Progress Administration on doing much of the work, despite the fact that in the critical areas where mosquito control was most needed, Works Progress Administration labor was generally not available in sufficient numbers or at the required time. As a result of these and other factors, the 1941 extracantonment program was relatively ineffective,[25] though in succeeding seasons a highly efficient and extremely effective program was developed.

Malaria Rates in 1941. As a result of the work carried on by the Army during 1941, the malaria rate among troops in the continental United States was held to a satisfactorily low level. The 1941 rate of 1.92 per thousand per year compared favorably with the 1917 rate of 7.46, the 1918 rate of 3.88, and the 1919 rate of 3.28. The average rate during the 10 peacetime years, 1931 through 1940, was approximately 2.30. During 1941 approximately 43 percent of the Army was stationed in the Fourth and Eighth Corps Areas, as compared with an average of about 36.5 percent during the peacetime years of 1938, 1939, and 1940.

Maneuvers were held in Louisiana and Arkansas by the Second and Third Armies and in the Carolinas by the First Army during the late summer and fall months of 1941. Following these maneuvers, the number of malaria admissions sharply increased. Troops returning to their home stations [26] brought a large number of cases of malaria to Camp Custer, Michigan; Fort Sheridan, Illinois; and Fort Leonard Wood, Missouri, as well as to other posts. The malaria rates from the Seventh Corps Area were so influenced by malaria patients returning to Fort Robinson, Arkansas, for hospitalization that they reached a high of 15.6 in September and 15.4 in October.

The incidence of malaria traceable to these maneuvers was so great—approximately 500 cases, or 25 percent of all malaria reported in the Zone of Interior during 1941—that a letter was addressed to The Commanding General, Services of Supply, outlining protective procedures.[27] These included: (1) Location of campsites and bivouacs away from areas of known heavy malaria incidence; (2) the greatest possible use of mosquito nets; (3) issuance and use of mosquito repellents; (4) issuance and use of pyrethrum sprays to kill resting mosquitoes in buildings and other harborages within one-quarter mile of bivouac areas; and (5) use of protective clothing, such as leggings, long-sleeved shirts, and the like.

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[24] Basic agreement is discussed in Ltr, SecWar to Fed Sec Admin, 30 Jan 40 and reply of 12 Feb 40. Additional letters authorizing utilization of Public Health Service which extend and implement this agreement are also in SG: 042.2-7.

[25] Memo, SG for TAG, 15 Jan 42, sub: Extra-military mosquito control program. HD: 725 (Extra-Cantonment).

[26] Annual Rpts, Surgs 6th and 7th CAs, 1941. HD.

[27] Ltr, SG to CG SOS, 13 Jul 42, sub: Protecting troops against malaria during maneuvers. HD: 710 Malaria (Maneuvers).

Reduction in Pest Mosquitoes. One of the incidental advantages of malarial mosquito control was freedom from pest mosquitoes, resulting in noticeably increased efficiency, comfort, and morale of troops. Trap catches were made regularly at nearly all important stations and these demonstrated, with few exceptions, that the prevalence of all types of mosquitoes was far below the commonly established nuisance point. While the control of pest mosquitoes cannot be justified when it requires time and effort that might better be expended for other military purposes, the normal malarial mosquito control campaign effects a reduction in many other species usually with little additional work or expense.

Experience Gained by Sanitary Corps Officers. One byproduct of the malaria control program was training sanitary engineers and entomologists of the Sanitary Corps in mosquito control work. Approximately 100 officers gained such experience, and these men formed the nucleus through whom it was possible during 1942 to train additional officers to meet overseas needs for this work. It was the practice to order all newly commissioned Sanitary Corps officers to duty at camps in the South in order that they might gain experience in mosquito control work.

Fiscal Estimates for July 1942 to June 1943. Before the 1941 work was well under way, it was necessary to prepare a fiscal estimate for the period July 1942 to June 1943. On 3 June 1941, such an estimate was prepared,[28] on the basis of the plans as then known for the expanded housing for the Army, requesting $3,500,000 for mosquito control and additional sums for typhus and plague control. As the Army later expanded, this estimate had to be supplemented and the costs for the 1943 fiscal year totaled between 4 and 5 million dollars. Estimates also had to be made of personnel needs. The expansion of the Army in the Zone of Interior and increasing needs for sanitary engineers and entomologists overseas made procurement of qualified Sanitary Corps personnel a vital necessity.

Procurement and Requirements of Personnel

In connection with the needs for personnel, a study was made of the sources from which sanitary engineers were available and were being drawn.[29] In part this was done in order to determine the extent to which State and local health departments were suffering. The study indicated that the number of sanitary engineers with State boards of health was not great enough to meet potential needs by a wide margin and that other sources must be drawn on. Furthermore, it was shown that sufficient men to meet then existing requirements would not be available. It was primarily on the basis of this and similar subsequent studies that experience re-

[28] Memo, Lt Col Simmons for Chief Finance and Supply Div, 3 Jun 41, sub: Estimate for fiscal year 1943, malaria, plague and typhus control. HD: 725 (Estimate of Costs).

[29] Rpt, Subcommittee on Qualifications of Personnel Commissioned by the SnC, NRC Committee on Sanitary Engr, 18 Nov 42. SG: 322.0541-1.

quirements for commission in the Sanitary Corps were later reduced to 2 years from the 4 years originally established. However, in all cases a suitable college degree was required.

A long distance estimate of actual needs made early in 1943, which, including an annual allowance of 5 percent for attrition, indicated a total ultimate need of about 1,075 sanitary engineers. Attrition was substantially less than that estimated, approximating 3 percent, and the maximum number of sanitary engineers on duty at any one time was approximately 979 in early 1945, though a somewhat larger number was actually commissioned. In general, an allowance of about 3 percent or somewhat more for "working capital," that is, for officers in pools, in hospitals on temporary duty, or in other special assignments was necessary, over and above other requirements.

War Department policies changed from time to time. In late 1941, commissions to civilians under 30 were banned,[30] but the War Department Personnel Board was authorized to decide the merits of each case presented for exemption and most Sanitary Corps applicants recommended by the Surgeon General's Office were commissioned. Later in 1942, the age was raised to 35 although scarce categories were still exempted from that requirement.[31] This undesirable raising of the age level could have resulted in a serious loss of qualified men. Information relating to the limited number of qualified sanitary engineers available was gathered and presented to the War Department with a tabulation of needs by the Army, Navy, Public Health Service, and essential civilian agencies.[32] As a result, sanitary engineers were declared a "scarce" category by the War Manpower Commission and the War Department, and commissioning of qualified men in the under-35 age group was permitted.[33]

By the middle of 1943, most of the sanitary engineers were in the Army or the Public Health Service, or engaged in essential civilian health work. Those who were of military age and physically fit were mainly in the Army, 600 being on duty with the Sanitary Corps by August 1943.[34] Because of the continuing need for sanitary engineers, the experience requirement was lowered to 2 years, and the type of civilian experience was viewed less rigorously. For a time these measures were sufficient to meet the Army's needs, but it was soon evident that further measures would have to be taken to provide needed personnel.

Army Specialized Training Program. To meet the need for sanitary engineers, it was determined to make use of the Army Specialized Training Program, and to make provision for the training of enlisted personnel to serve with the Sanitary Engineering Division, Office of The Surgeon General.[35] Professors

[30] AR 605-10, 10 Dec 41, and WD Cir 27, 29 Jan 42.

[31] WD Cir 367, 7 Nov 42, and AR 605-10, 30 Dec 42.

[32] Memo, Col Gilbert for Gen Lull, SGO, 24 Nov 42, sub: Appointment in SnC, AUS, of applicants below age of 35. SG: 322.054-1.

[33] Semimonthly Rpt, Sanitary Engr Div, Prev Med Serv SGO, 1-15 Dec 42. HD: 024.

[34] Annual Rpt, Sanitary Engr Br, Prev Med Div SGO, FY 1943. HD.

[35] Annual Rpt, Sanitary Engr Br, Prev Med Serv SGO, 1943. HD.

Earle L. Waterman of the University of Iowa and J. J. Doland of the University of Illinois were requested to prepare a training program based on the standard 6-term basic course of the Army Specialized Training Program, but providing 2 additional terms of 13 weeks each, the 7th and 8th terms.[36] In these terms, sanitary and public health engineering subjects were stressed.

In all, 261 men were graduated from Term 7 courses, and 243 were graduated from Term 8 courses. Of these, the last 53 to graduate were assigned to the Corps of Engineers for duty, since it appeared that the Sanitary Corps would not require them. Of the 190 entering Medical Administrative Corps Officer Candidate School, 151 or 80 percent graduated.[37] This high percentage reflected the care which was used in the selection of these men through the Army Specialized Training Program. Rutgers University, New York University, the University of Illinois, the University of Michigan, and Harvard University were utilized to train the men enrolled in Term 7. Those used for Term 8 were Harvard University, the University of Michigan, and the University of Illinois.

Procurement of Entomologists. In all, approximately 250 entomologists were commissioned in the Sanitary Corps, and many more hundreds served as noncommissioned officers and enlisted men in the malaria control and survey units. After 1942, commissions were granted only to qualified entomologists already in the Army, almost universally to enlisted men.

Procedures in Procurement of Personnel. In the early stages of procuring and commissioning sanitary engineers and entomologists, the Sanitary Engineering Division, Office of The Surgeon General, located the potential officer, persuaded him to apply, arranged for the necessary processing, including a physical examination, and forwarded the papers to The Adjutant General for action. With the formation of the Officer Procurement Service, this procedure was greatly simplified, so far as the Sanitary Engineering Division was concerned. It was necessary only to notify the Officer Procurement Service of the name of the prospective officer and, when the preliminary information had been forwarded, to review his application to determine if he met the requirements. In addition, the Officer Procurement Service located a substantial number of qualified men and thus aided materially in recruitment. Until it was dissolved the Officer Procurement Service contributed very materially to the sound and necessarily rapid growth of the Sanitary Corps.[38]

Sources of Personnel. The study of 249 sanitary engineers in the Army, Navy, and Public Health Service as of 1 October 1942[39] showed that 94 had been obtained from State departments of public health and 32 from other health agencies; 71 were from other governmental agencies; 28 from commercial

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[36] Ltr, Col W. A. Hardenbergh, SnC, SGO, to Prof. Earle L. Waterman, U. of Iowa, 4 Mar 43. SG: 000.8 (U of Iowa) W.

[37] Semimonthly Rpt, Sanitary Engr Div, Prev Med Serv SGO, 16-30 Apr 45. HD: 024.

[38] OPS was established by WD Cir 367, 7 Nov 42; it was dissolved by WD Cir 161, 2 Jun 45.

[39] See footnote 29, p. 192.

organizations; 12 from consulting and designing offices; and 12 from miscellaneous sources. It thus indicated that somewhat over half of the sanitary engineers had been supplied by the health agencies. No later complete study was made due to lack of time and pressure of work. However, a rough check of the roster of sanitary engineers as of 4 January 1945, totaling over 970 names, indicated that about 22 percent were from State health departments, 20 percent from other governmental agencies, 17 percent from cities and counties, 20 percent were consulting engineers, and the remaining from the various training programs.

Control Operations, 1942–44

The number of stations at which mosquito control operations were carried on, as well as the total amount of work done, increased materially in 1942. This necessitated the provision not only of more funds, but also of more sanitary engineering and entomologic personnel. There were no marked changes or decided improvements in the methods employed for control work. However there was a decided and important change in policy and supervision. As the sanitary engineers and entomologists in service command headquarters and at posts became more experienced, a greater degree of responsibility was placed on them. This decentralization reduced the burden on the Sanitary Engineering Division of the Surgeon General's Office and, in general, resulted in more effective work.

Reports of all mosquito control operations by the Army in the Zone of Interior during 1942 indicated the following amount of work was done: [40]

Work	*Amount*
New ditching, hand	412 miles
New ditching, machine	44 miles
Ditches cleaned	1, 245 miles
Ditches lined	127 miles
Clearing and brushing	23, 237 acres
Ditch slopes sodded or seeded	1, 640 acres
Fill placed	1, 550, 550 cubic yards
Oil applied	1, 238, 048 gallons
Other larvicides applied	77, 693 gallons
Paris green mixture applied	57, 150 pounds

The Corps of Engineers succeeded in 1942 [41] to the responsibility for mosquito control work formerly the function of the Quartermaster Corps. Funds for mosquito control were lumped with other funds for post utilities and it became impossible to determine the exact cost of the work. In 1942 the volume of work increased with the expansion of the Army. It was estimated that approximately $3,250,000 was spent directly for mosquito control work, or a little more than $1 per soldier in the continental United States.

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[40] Annual Rpt, Sanitary Engr Br, Prev Med Div SGO, 1942. HD.
[41] Public Law 326, 77th Cong., 1 Dec 41, and AR 100-80, 9 Jun 42.

In large camps in the South, average costs for mosquito control were approximately $1 per man. In northern areas where the mosquito season was short, control was possible at somewhat less than that. Air Force stations required a considerably higher per capita outlay because of the small populations in relation to areas to be controlled.

The results of the 1942 mosquito control work were surprisingly good in accomplishing a reduction of malaria incidence in the Zone of Interior. The total malaria rate for troops in the continental United States (not only malaria acquired in United States) fell to 0.64 per thousand per annum, the lowest rate the Army had ever reported up to that time. The effective work of the Office of Malaria Control in War Areas, the agency through which the Public Health Service was carrying out its extracantonment control program, was an important factor in obtaining this low rate. By reducing mosquito incidence in areas adjacent to Army posts, it reduced the hazard of exposure of men on leave or pass. The most important factor was the efficient performance of control work, under Sanitary Corps supervision, by the Corps of Engineers. An effective basis of cooperation and teamwork was established through which it was possible to schedule work as needed for routine control and also to meet emergencies as they arose.

During 1942 all stations were required to furnish man-hour reports on each kind of work involved in mosquito control. Overall figures showed the following average requirements:[42]

1. For clearing and brushing, 63 man-hours per acre.
2. For channel or ditch cleaning, 0.12 man-hours per lineal foot.
3. For new ditching by hand, 0.63 man-hours per lineal foot.
4. For machine ditching, 0.17 man-hours per lineal foot.
5. For ditch lining, 0.236 man-hours for preparation of lining and 0.213 man-hours for placing, both on the basis of square feet.
6. For oiling, 0.56 man-hours per gallon of oil spread, and 14.7 gallons of oil per acre of surface treated.

By 1943 mosquito control was a major routine activity at 350 posts, camps, and stations, thus increasing the volume of work. Major items of mosquito control operations were:[43]

Work	*Amount*
Brushing and clearing	86, 973 acres
Channel and ditch cleaning	2, 200 miles
New ditching	600 miles
Ditch lining	112 miles
Filling	2, 999, 500 cubic yards
Oil applied	1, 714, 000 gallons
Larvicide applied	131, 562 gallons
Paris green mixture applied	45, 700 pounds
Water surface eliminated	22, 100 acres

[42] Hardenbergh, W. A.: Mosquito control by the United States Army, 14 Mar 44. HD: 700.7.
[43] Semimonthly Rpt, Sanitary Engr Div, Prev Med Serv SGO, 15-29 Feb 44. HD: 024.

The labor required to perform this work amounted to 6,836,000 man-hours. Nearly 5 million dollars was expended on mosquito and malaria control during 1943.

An analysis of the work done in comparison with preceding years indicates that, in accordance with the general policy of the Sanitary Engineering Division, Office of The Surgeon General, the proportion of permanent work had been markedly reduced and that ditch maintenance and oiling were the principal weapons of control. It was believed that heavy drainage, lining of ditches, and placing of pipe drains should be justified by a reduction in immediate control costs, and instructions to this effect were sent to all service commands. A considerable decrease occurred in the use of paris green and of special larvicides, indicating that oil was the best larvicide for routine large-scale control under Army conditions. DDT was not yet generally available for mosquito control, its use being restricted to control of other insects and to airplane application on a limited scale.

The Army's mosquito control program during 1943 resulted in a further considerable reduction in malaria contracted from exposure in the United States. The rate of less than 0.3 per thousand men per year represented another new low mark for the Army. Admissions from overseas were not included in this figure. This reduction was accomplished through increased efficiency in organization, better cooperation with the Corps of Engineers, and the increasingly effective work of Malaria Control in War Areas of the Public Health Service, combined of course, with the cumulative effect of the work done in the 2 preceding years. In the key service commands, such as the Fourth, where malaria had always been a problem, an entomologic reporting system had been established.[44] By this means early information on mosquito breeding conditions and prevalence was available to service command headquarters to aid in timely planning of the work.

The 1944 mosquito control program was practically a continuation, as regards scope and policies, of that of the preceding year. The results were about as expected, in that there was a further reduction in malaria resulting from exposure in the Zone of Interior, the rate falling to about 0.16 per thousand per year. DDT became available for use in small amounts and was used principally for experimental airplane application.[45] Increasing numbers of soldiers with malaria were being returned from overseas (nearly 5,000 per month during the latter part of the year), increasing the hazard of transmission. To meet this problem, control measures were intensified outside the reservations, both in the Zone of Interior and overseas, by agreement with Malaria Control in War Areas,[46] wherever it appeared that a hazard existed due to the preva-

[44] Ltr, Col C. G. Souder, MC, Hq 4th SnC, to Col W. A. Hardenbergh, SnC, SGO, 26 Aug 42, with incl. HD: 710 Malaria (ZI).

[45] Memo, SG for CofS ASF, 3 May 44, sub: Requirements versus production of DDT. SG: 441 DDT.

[46] Minutes of Meeting, USPHS Interservice Committee for Control of Exotic Diseases, 13 Mar 44. HD: 725 (Extra-Cantonment).

lence of anophelines. As a result, no malaria outbreaks of importance were attributed to this source, either among troops or civilian populations.

Preparation of Estimates. Estimates for the cost of mosquito control, including fiscal year 1944, were made by the Sanitary Engineering Division, Office of The Surgeon General.[47] These were based on estimates prepared initially by Sanitary Corps engineers and entomologists located at the various posts, and reviewed by the Sanitary Corps engineer (and entomologist when one was available) in service command headquarters. The estimates were then consolidated and supplemented by allowances for projected stations. These requests for funds, which covered all types of installations—Army Air Forces, Class IV, and service command—were defended before the Budget Officer of the War Department and the Bureau of the Budget by the Sanitary Engineering Division. The appropriated money was made available to the Corps of Engineers for use, under Medical Department supervision, in mosquito control. Beginning in 1942, however, this money was lumped with other "Repairs and Utilities" funds and its identity thus lost. There were few instances in which lack of funds hindered needed mosquito control work.

Beginning with the fiscal year 1945, estimates for the cost of mosquito control work were based on cost experience and cost projections made by the Corps of Engineers. The Medical Department thus was relieved of the last of its financial responsibility for mosquito control. It is believed that a much more economical procedure would have been to have the Sanitary Engineering Division, on the basis of its engineering and entomologic knowledge, prepare and check such estimates, and the Corps of Engineers maintain a separate, accurate record of expenditures for mosquito and other insect control work.

Use of DDT. Use of DDT in mosquito control in the Zone of Interior was generally restricted to test airplane application. These were intended to determine effective amounts to be used, types of airplanes best suited for the work of spraying, length of residual effect, and crop damage. In addition to tests carried on by the Department of Agriculture, the Army did extensive work at the Stuttgart Army Air Base, Arkansas, located in a ricefield area which produced mosquitoes prolifically. Tests were also made of other methods of application. Mixing DDT with irrigation water was unsuccessful. Application as an emulsion to dry fields had little effect when the fields were later flooded. Airplane spraying of the field did not satisfactorily control adult mosquitoes. A Cub-type airplane was used and application was relatively light. In general, the methods employed were not very effective in broad-scale mosquito reduction.[48]

Inactive and surplus installations. In anticipation of the end of the war in Europe, and the consequent inactivation or disposal of posts, camps, or stations

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[47] Ltr, SG to CG each SvC, 3 Nov 42, sub: Insect, rodent, and other vermin control program, estimate of costs for F/Y 1944. HD: 725 (Est of Costs).

[48] Reports of airplane application of DDT at Stuttgart, Arkansas, are found in HD: 725 (DDT, Field Uses).

in this country, a program was prepared late in 1944 to meet mosquito control needs during inactivation or salvage. Because the time factor is important in mosquito control, and control once lost cannot be reestablished after midsummer, provision had to be made for continuing oiling and maintenance work at posts likely to be reactivated. The instructions prepared in regard to malaria control are summarized in the following paragraphs.[49]

If a mosquito population has become entrenched, a minimum of about 6 weeks is required to effect control, so that the decision to continue or discontinue mosquito control work at a camp placed on a "standby" basis had to be based on seasonal and climatic factors. For example, in Virginia cessation of control work on 15 August would probably have been safe, whereas a similar procedure in Louisiana might have resulted in a considerable incidence of malaria if the post were reoccupied in late September. Usually it costs no more to maintain control than to reestablish it later in the same season.

At inactive installations, it was recommended that all drainage operations be discontinued and that reliance for control be placed on larviciding. It was advised that the prevalence of disease vectors and the efficiency of the control measures be checked by frequent routine entomologic surveys and that when a station was inactivated, the Public Health Service should be notified, giving as much information as possible in regard to future plans, so that extramilitary mosquito control measures might be modified if necessary. It was requested that a list of special mosquito control equipment available at the post, not including general engineering construction equipment, be forwarded to service command headquarters.

The same procedure was recommended at stations declared surplus. During completion of salvage, paris green, oils, and larvicides were to be removed; sprayers and dusters cleaned; oil drums emptied and stacked, or removed; and caps, fuses, and dynamite or other explosives removed or safely stored.

Control Operations in 1945

General policies for mosquito control operations, as well as the details of carrying them out, remained essentially unchanged in 1945. However, the possibility of importation of Japanese B encephalitis from the Orient was considered to be an additional hazard. Several species of nonanopheline mosquitoes found in California and Oregon had been shown by laboratory experimentation to be able to transmit the disease.[50] Therefore, late in 1944, plans were made to intensify mosquito control work within Ninth Service Command Army reservations during 1945. However, airfields, cantonments, and general hospitals usually comprised relatively small land areas, and Army control measures therefore had to be supplemented by extended work

[49] "Sanitary Procedures to be Followed at Installations Declared Inactive or Surplus." HD: 720 Water and Sewage.

[50] Reeves, W. C., and Hammon, W. M.: Laboratory transmission of Japanese B encephalitis virus by seven species (three genera) of North American mosquitoes. J. Exper. Med. 83: 185–194, Mar 1946.

by the Public Health Service. This organization was requested to intensify and expand its work around all posts, hospitals, or ports of debarkation in California, Oregon, and Washington that would be used by personnel returning from the Pacific. Late in the year steps were taken to establish a branch office of Malaria Control in War Areas in the headquarters of the Ninth Service Command to insure vigorous prosecution of the work if this became necessary during the 1946 season.[51]

Despite the return from overseas during 1944 and 1945 of nearly 5,000 troops per month suffering from malaria, the control measures enforced jointly by the Army and by Malaria Control in War Areas were so effective that the malaria rate for disease resulting from exposure in the United States was still further reduced. The rate per thousand per year for 1945 was approximately 0.11.

Prisoners of War

Prisoners of war also presented a malaria problem. Many of the Italian and German prisoners captured in North Africa, Sicily, and Italy were infected with malaria. When these prisoners were established in branch camps, the dual problem arose of protecting both the local populations and the prisoners against malaria. Because branch camps were often established on short notice, perhaps in the middle of the mosquito season, and sometimes in highly malarious areas, it was not considered feasible or possible to conduct mosquito control measures. Based on surveys of several prisoner of war camps, it was estimated that it would cost from $5,000 to $15,000 per camp to establish adequate malaria control. This would fall entirely on Malaria Control in War Areas since the camp area was usually isolated from other military cantonments. Malaria Control in War Areas did not have either the skilled personnel or the equipment for such extensive work. Therefore special emphasis was placed on surveys of proposed campsites to avoid the most unfavorable locations, and on strict enforcement of malaria discipline among prisoners.

In accordance with this general policy, instructions prepared in collaboration with the Tropical Disease Control Division, Office of The Surgeon General, included the following: [52] Prisoners known by blood examination to have malaria, with or without symptoms, would be effectively screened from mosquitoes; those with symptoms of the disease would be treated in a hospital until two thick-film examinations made at 2-day intervals after conclusion of treatment did not show any malaria parasites.

In permanent camps, located in districts where anopheline mosquitoes might be present, barracks were to be screened so as to exclude mosquitoes. Appropriate mosquito control measures were to be enforced within the camp area, and instituted, when deemed necessary by the service command, in a

[51] Annual Rpt, Surg 9th SvC, 1945. HD.
[52] ASF Memo 840-10-43, 19 Jun 43, sub: Malaria among prisoners of war. HD: 710 Malaria (Directives).

1-mile zone surrounding the camp; the latter was to be done by arrangement with the Public Health Service.[53]

In branch camps which would be occupied during the mosquito season for 3 months or more, the same type of control was advised as for permanent camps, depending upon the season and the hazard to local residents, troops, and prisoners of war. In branch camps scheduled for short-period occupancy, it was recommended that principal emphasis be placed on screening as several weeks would elapse before the hazard of malaria transmission could be reduced. In temporary camps of this type, properly screened quarters, recreation buildings, and latrines were required. When tents were used for housing, sleeping nets had to be provided if it was not practical to mosquito-proof the tents. Screening of recreation buildings was considered especially necessary in tent camps. In all areas where there appeared to be a significant risk from anopheline mosquitoes, prisoners were required to remain in screened buildings or under bed nets from sundown to sunrise.

Cooperation of Sanitary Engineering Division, Office of The Surgeon General, with Other Agencies

Malaria Control in War Areas. The Office of Malaria Control in War Areas was organized by the Public Health Service to discharge its functions and duties in regard to mosquito control around Army establishments, Navy installations, and in important war industrial areas.[54] Its activities were restricted to anopheline mosquito control unless the Army requested it to carry on other types of mosquito or insect control.[55] In a number of cases, advantage was taken of the resources of Malaria Control in War Areas for such special tasks. In order to facilitate certain types of work, arrangements were made whereby Army mosquito funds could be made available to Malaria Control in War Areas for special work off the post, as for pest mosquito control.[56] One example of this work was the salt marsh mosquito control project around the convalescent center near Virginia Beach, Virginia, in the vicinity of Fort Story.[57]

While the military reservation boundary was usually meticulously observed as the dividing line between Army mosquito control work and Public Health Service operations, there were numerous local adjustments whereby the areas in which work was necessary were allotted, irrespective of location, to the organization best fitted to accomplish control. The aim was to insure

[53] TM 19-500, C 8, 4 Sep 45.

[54] Emergency health and sanitation activities of the Public Health Service during World War II. Pub. Health Bull. 302: 21, 1949.

[55] Ltr, SG to Surg 9th CA, 9 May 42, sub: Mosquito control outside of reservations. SG: 725.11-1 (9th CA) AA.

[56] Ltr, SG to all SvComdrs, 13 Aug 43, sub: Pest control on property contiguous or adjacent to military reservations. HD: 725 (Extra-Cantonment).

[57] Ltr, Surg 3d SvC to CO Fort Story, Va., 19 Jan 45, sub: Pest control on property contiguous or adjacent to military reservations. SG: 725.11 (Ft Story) N.

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effective mosquito control at the lowest cost. In a few instances, the services of Army sanitary engineers and entomologists were made available to Malaria Control in War Areas, and the converse was equally true.[58] The close cooperation and the excellent personal relationships that existed between both organizations were of great value in insuring effective work.

The procurement of construction equipment, including trucks, illustrates the cooperation that existed. Since civilian supplies of trucks, both light and heavy, were almost exhausted before 1943, equipment needs of Malaria Control in War Areas were presented to the Sanitary Engineering Division, Office of The Surgeon General, for forwarding to the Ordnance Department.[59] The expansion of work by Malaria Control in War Areas, because of the construction of some 80 general hospitals and many airfields, in addition to the necessary checking and surveillance program incurred by the establishment of prisoner of war camps, required much additional equipment not available through civilian sources. Furthermore, in order to aid in overcoming a critical shortage of personnel, applicants for commissions in the Sanitary Corps who could not be appointed were, if suitably trained, referred to Malaria Control in War Areas.[60] In this manner, a number of well-trained men who could not meet Army physical standards were utilized as civilian employees.

Corps of Engineers. Relations with the Corps of Engineers were equally satisfactory and effective in carrying on the mosquito control program. The interest of post and service command engineers in the drainage program made the use of heavy construction equipment possible. This permitted rapid building of large drainage ditches and quick and economical filling in of many breeding areas, which was especially helpful in the early years of the program. Another advantage accruing from the cordial relations with the Corps of Engineers was the ability of the post engineer to concentrate labor and equipment for rush work.[61]

In order to carry out more effectively its responsibilities in insect and rodent control, the Repairs and Utilities Branch, Office, Chief of Engineers, requested the assignment of a qualified entomologist from the Office of The Surgeon General. Lt. (later Capt.) W. D. Reed, Sanitary Corps, was detailed to duty with the Corps of Engineers and assumed advisory charge of the work. Capt. George D. Jones, Sanitary Corps, was later detailed as his assistant.[62] The understanding of Medical Department problems and functions by these men contributed greatly to the success of the mosquito control program. They cooperated in the development and testing of new equipment and materials, and in analysis of cost and effectiveness of various methods of performing the work.

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[58] Ltr, Dir Sanitary Engr Div to Off of Malaria Control in War Areas USPHS, 14 Dec 44. HD: 725 (Extra-Cantonment).

[59] Ltr, Off of Malaria Control in War Areas USPHS to CG ASF, 28 Apr 44, with 2d ind, CG ASF to CofOrd, 8 May 44. HD: 725 (Extra-Cantonment).

[60] Ltr, Col W. A. Hardenbergh to Mr. H. N. Old, USPHS, 19 Aug 41. HD: 322.054.

[61] Reed, W. D.: Insect and rodent control in the Corps of Engineers. J. Economic Entomology 37: 333-335, Jun 1944.

[62] Ibid.

Special Problems

Distribution of DDT. To handle the problems incident to the manufacture, allocation, testing, and use of DDT, The Surgeon General's DDT Committee was formed, with representatives from interested arms and services.[63] This committee was later supplanted by the Army Committee for Insect and Rodent Control, which coordinated Army and Navy interests and needs.[64] The Army Committee also coordinated the Army test program and analyzed a great deal of the resulting data. When DDT became plentiful in 1945, a great many stations planned broad-scale airplane application. Entomologic experience had indicated that such broad dissemination of DDT in this country might destroy valuable insect life. In order to prevent such damage by restricting projects to those in which favorable conditions existed, and to insure that maximum knowledge be obtained from the experience relating to each project, the Army Committee issued a series of regulations on airplane application in the Zone of Interior.[65] This was feasible, not only because control was generally possible through Army channels, but also because the Army Committee controlled the distribution of DDT. Extra allotments were almost always necessary for airplane work, over and above the allowance permitted by War Department Circular 151, 17 April 1944.

Many applications were received for airplane dispersal of DDT in the United States. This material is so deadly to most insects that it was considered necessary to restrict its use pending further information. However, since the only way to obtain such information is through carefully controlled field projects, an operation procedure was drafted which later was issued as War Department Circular 207, 10 July 1945. Prior to the issuance of this circular, an effective degree of supervision was maintained through restriction of allotments of DDT by the War Production Board and through the Army Air Forces, which controlled the airplanes available for application. The provisions of the circular required adequate biologic and entomologic surveys of the area to be sprayed, both before and after spraying; an estimate of the cost of the work as compared with ground control methods; an estimate of the amount of DDT needed and a statement as to its source; and information regarding the plane or planes to be used. The Army Air Forces determined whether or not flying conditions permitted safe use of airplanes for dispersal; the Army Committee passed on other factors.

Control of Salt Marsh and Pest Mosquitoes. Special problems arose, not all of which were solved. Control of ricefield mosquitoes in Arkansas and Louisiana was practically impossible. In the Fort DuPont area of Delaware there were thousands of acres of marsh areas which could not be drained. Since

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[63] Memo, CofS ASF for SG, 22 Feb 44. HD: 725 (DDT Cmtee).
[64] WD Memo 40-44, 8 Nov 44.
[65] TB Med 182, Jul 1945; WD Cir 207, 10 Jul 45; TB Med 194, 17 Aug 45; TB Med 200, Feb 1946.

these marshes were important muskrat-producing areas, intense opposition to the airplane application of DDT lest it destroy the fur-producing life in the marsh obviated institution of effective control. Salt marsh mosquitoes were a nuisance at practically every coastal installation between Portland, Maine, and Brownsville, Texas, but little could be done toward their control. Governors Island, New York, was sprayed with DDT, and some local control measures were applied along the Atlantic and Gulf Coasts. In general, these followed routine control practice.

There were many reasons for not attempting control of mosquitoes in salt marshes except infrequently on the most casual and local basis:

1. Local control alone is ineffective, since adult *Aëdes sollicitans* travel 30 miles or more with favorable winds, and protection would therefore require very extensive work.

2. Immediate results cannot be expected from a control program, since about two seasons of work are required before a measurable reduction in number of mosquitoes is accomplished.

3. The amount of manpower, equipment, and materials needed for the work could not be justified on the basis of its contribution to the war effort.

4. Pest mosquito control is a highly political and promotional subject, and every resort which may be visited by troops seeks governmental aid.

Selection of Campsites. Some consideration was given in the selection of campsites to the problem of control of malaria vectors and other mosquitoes. However, the cost of a comprehensive mosquito control campaign was so small, in contrast with the cost of constructing and maintaining an Army post, camp, or station, that this problem had relatively little weight in choosing a location. Aside from salt marsh areas, it was possible to control relatively speedily and economically almost any mosquito breeding areas found in the United States.

Achievements of Mosquito Control Program in the Zone of Interior

As previously mentioned, during 1942 each post was required to submit,[66] through its service command, to the Office of The Surgeon General, detailed monthly reports on the work done, together with the results as measured by mosquito catches. These reports were tabulated and filed in the Sanitary Engineering Division.[67] These data, especially those on man-hour costs, should be useful in estimating requirements for similar work in the future. Entomologists made large collections of mounted mosquitoes and other insects, which were used for display and for classes studying insects.

General results of the mosquito control program in the Zone of Interior included a reduction in malaria to a point previously thought unattainable,

[66] Ltr, SG to Surg each CA, 4 Mar 42, sub: Mosquito control, monthly activity reports. SG: 725.11-1 (each CA) AA.
[67] "Consolidated Report of Mosquito Control Activities." SG: 725.11-1 (for each SvC).

and a remarkable freedom within camps from pest mosquitoes. This was accomplished by a carefully organized, comprehensive plan for control, using the skill and previous experience in civil life of Sanitary Corps engineers and entomologists. The work during 1941 and 1942 served also as valuable training for men who later had to spearhead the overseas control program.

OVERSEAS MOSQUITO CONTROL

Evaluation of Problems

The problem of malaria control in the United States was relatively simple as compared with the protection of our troops in overseas areas, especially during field operations. In South and Central America, Africa, India, Burma, portions of China, Italy, and the South and Southwest Pacific, malaria was the most important military disease. Unless the troops were adequately protected against mosquito carriers of disease, military campaigns could not be successfully carried out; or the losses from disease would have been so great as to require excessively large forces to perform a mission.

In the Sicilian campaign, malaria cases exceeded battle casualties.[68] In the initial stages of the New Guinea campaign, 6 or 8 patients with malaria were evacuated for each battle casualty.[69] The airbases in West Africa suffered excessively from malaria, the rate at times exceeding 2,000 per thousand troops per year. Malaria was especially important here, since many planes en route to England passed through West Africa, and a considerable number of cases, which had clearly been contracted in West Africa, developed in nonmalarious England.[70] The malaria rate was also very high in the early South Pacific operations, especially the Solomons campaigns,[71] and in India and Burma.[72]

These experiences were not unexpected. The prevalence of malaria in the tropics and its importance as a military problem were appreciated, even though the seriousness was perhaps not fully realized. The Medical Intelligence Division, Office of The Surgeon General, gathered information from all available sources regarding the incidence of malaria and the mosquito carriers of the disease, including the characteristics, habits, and identification of mosquitoes. This was necessary since data concerning many of these mosquitoes and their importance as malaria vectors were not generally available.

The data thus collected were reviewed and evaluated in connection with Army experiences with malaria during the 1941 maneuvers. It is doubtful if the high command of the Army prior to 1941 had ever seriously considered

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[68] ASF Monthly Progress Rpt, Sec. 7, Health, 31 Oct 43. HD.
[69] Estimate prepared by author based upon malaria rates and hospital admission figures.
[70] Annual Rpt, Chief Surg USAFIME, 1943, p. 18. HD.
[71] ASF Monthly Progress Rpt, Sec. 7, Health, 31 Jul 43. HD.
[72] ASF Monthly Progress Rpt, Sec. 7, Health, 30 Sep 43. HD.

that our troops might fight in such malarious areas as the Southwest Pacific, India, and Burma. Consequently our Army leaders were unprepared for the restrictions imposed by malaria on their plans, and our Army was lacking in the organization and skilled personnel necessary to combat successfully this very important enemy. Even many of the senior officers in the Medical Corps did not understand the importance of malaria control in connection with military operations.

Plans for Control. Analyzing the problem of malaria control and planning for it was a function of all interested divisions of the Preventive Medicine Service, with the Sanitary Engineering Division contributing in regard to personnel, equipment, and methods of mosquito control. From these studies, four principal needs became apparent: (1) a special adviser, skilled in malaria, to aid the surgeon; (2) specially equipped and trained units to carry on survey and control work; (3) the indoctrination and training of all troops in malaria prevention since in many instances in combat, protection against malaria is entirely up to the individual; and (4) the development among officers of all grades, from the lowest to the highest, of effective malaria discipline to insure carrying out of the directives necessary for malaria control.

Malariologists. The special adviser to the surgeon on malaria was termed a malariologist. His qualifications were an intimate knowledge of malaria, its diagnosis and transmission, and at least a general knowledge of methods of mosquito control. In the beginning, it was deemed essential that he be a Medical Corps officer, but later many Sanitary Corps officers were utilized as malariologists. Since very few medical officers with the requisite knowledge of malaria were available in 1942, a special training program in malariology was established. The number of skilled malariologists was always limited; even at the peak of operations there were less than 100 in the field.

Malaria Control and Survey Units

The special units for malaria control were intended to provide in one small detachment, the skills, personnel, and equipment needed to determine the vectors of malaria and the seriousness of the hazard, and to plan and supervise a control program. There was no past experience upon which to base the size of these detachments, or to indicate their duties. The British forces in the Middle East had set up organizations of the same general nature, but sufficient information had not yet become available upon which to base any judgment as to the specific mission of the units, their most desirable size, or the type of equipment needed. In fact, the British units varied considerably in the several areas in size and scope of duties.[73]

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[73] Ltr, CG USAFIME to SG, 25 Aug 42, sub: Antimalarial organizations. SG: 725.11-1.

It seemed desirable to the Tropical Disease Control and Sanitary Engineering Divisions, Office of The Surgeon General, which were studying this problem, that these units should be of two types. One should be equipped to study the malaria problem from the field laboratory, reporting on the incidence of infection, identifying the mosquito vectors of the disease, determining foci of infection, and advising on the most effective methods of controlling the local disease vectors. The other should be equipped to supervise engineer troops or civilian labor in carrying on the control work, or if necessary to perform the control m[illegible]es themselves. In order to avoid the use of the term "laboratory," [illegible]eemed to be objectionable to many field commanders, the unit design[illegible] analyze conditions was called a malaria survey unit, and the one set up [illegible]ry out or supervise control measures was appropriately called a malaria [illegible]rol unit.

Malaria Control Units

Personnel. The malaria control units were organized to consist of 1 officer and 11 enlisted men. The officer was specified as a malaria control officer, sanitary engineer, Military Occupational Specialty 7960. Since the enlisted men would have technical work to do, they had to possess special qualifications. The following was the table of organization for the unit:[74]

Rank	*Military Occupational Specialty*	*Number*
Capt	san. engr., 7960	1
Tech. Sgt	medical, 673	1
Staff Sgt	-----do	1
Sgt	sanitary, 196	1
Cpl	clerk, general, 055	1
T/5	san. tech., 196	3
Pfc	truck driver, 345	3
Pvt	utility repairman, 121	1

The size of the unit was a compromise. It was thought that a large unit, because of rigid personnel allotments to theaters, would be difficult to assign, and unless so organized as to be easily divisible into effective sections of subunits, would be unwieldy in many situations.

Equipment. Preparation of a table of equipment and selection of equipment for the control unit presented another problem. Heavy equipment, such as tractors, bulldozers, and light draglines, was not included in the table because of the critical shortages. In many areas a medium size bulldozer would have been most valuable, while in others it would have been useless; but if such an item of equipment were specified, it had to be provided for all units. In addition, it was believed that Corps of Engineer equipment would generally be available and that Corps of Engineer personnel would be used for large drainage jobs. In fact, the small size of the malaria control unit precluded its use on large projects and such duties were not intended.

[74] TOE 8-500. 23 Apr 44.

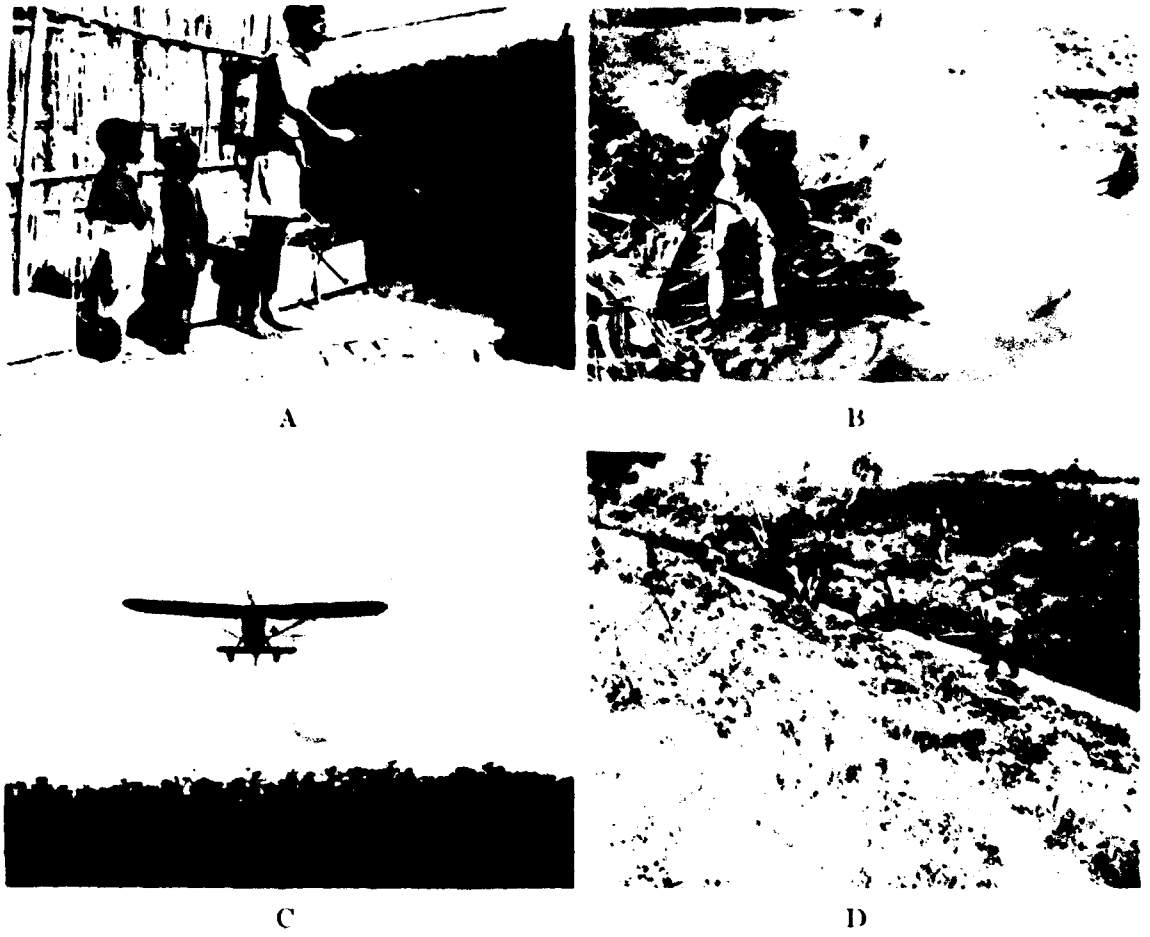


Figure 16. Mosquito control. A. Spraying of a native basha in village in India, near an Army barracks, 1945. Village is sprayed once a week. B. Applying larvicide dust to mosquito breeding area. C. Spraying with Army L–5 airplane equipped with breaker-bar equipment. (U. S. D. A. photo). D. Italian laborers, working for 134th Malaria Control Unit, clearing Derevante Canal to remove mosquito breeding places.

For these and other reasons, including the problems of maintenance of heavy machines, the equipment and materials furnished to malaria control units included only the minimum needed for the operations expected actually to be carried on by it. If large numbers of natives were employed, the necessary handtools had to be provided from other sources as it was obviously unsound to burden a unit with three or four hundred picks and shovels, which could be provided through regular supply channels if needed. In general, an initial supply of equipment and suitable spare or repair parts to meet immediate needs was provided. The details of equipment and materials furnished are indicated in Table of Organization and Equipment 8–500, column FA, 23 April 1944. Usual tools included: axes, mattocks, shovels, brush hooks, machetes, picks, rakes, saws, sledges, scythes, forks, dusters, and sprayers.

Qualifications for Officers of Control and Survey Units. It was thought that the commanding officers of these units should not only be well trained in mosquito control but should be qualified sanitary engineers, since it was likely that in many areas they would be the only officers with this training. For that reason a group of about one hundred such officers was carefully selected for assignment as commanders of the early units. Unfortunately conditions overseas were such that few of these men ever received promotions above the grade of captain. Most of them were frozen in their table of organization positions and remained as unit commanders. It had been hoped that some of them would be selected as area or base sanitary engineers or malariologists. Later units were commanded by engineers with construction experience. In general these officers were adequate and well trained, but not of the average caliber of the first group.

Training of Control and Survey Units. Personnel for malaria control and survey units were assembled and activated at Camp Barkeley, Texas, and Camp Ellis, Illinois. After activation they were given unit training at Camp Plauche, Louisiana, prior to shipment overseas. This unit training was in accordance with Mobilization Training Program 8–21, 4 May 1943, "Medical Department Training Programs for Malaria Survey and Malaria Control Units."[75] The program included a total of 192 hours, 4 weeks at 48 hours each. If shipping space was not available upon completion of the unit training and there was sufficient time, the officers and some or all of the enlisted men of the units received additional malaria control training at the United States Department of Agriculture Research Laboratory at Orlando, Florida; at the special course in malaria control conducted by the United States Public Health Service and the Florida State Department of Health; or later at the Panama School of Malariology.

Malaria Schools for Officers. In order to provide practical field training for Sanitary Corps and Medical Corps officers in malaria control, an informal training course was organized by the Tennessee Valley Authority in the summer of 1942. In 1943 the training area was moved to Florida and the training was placed under the jurisdiction of the United States Public Health Service and the Florida State Board of Health.

The Rockefeller Foundation International Division provided facilities for teaching in the Department of Malariology at the State Board of Health, Jacksonville; at the Escambia County Malaria Department, Pensacola, Florida; and at the Station for Malaria Research at Tallahassee, Florida, all under their immediate direction. They also provided, together with the United States Public Health Service personnel, for direction and teaching of the course. In order to provide a more extensive training program in malariology and one better integrated with Army procedures and administration, the

[75] WD MTP 8–21, 4 May 43. HD 710 Malaria (TO).

Army School of Malariology was opened in the Canal Zone in January 1944.[76] This school was organized with a staff of 3 Medical Corps officers (a commandant, assistant commandant, and a parasitologist) and 3 Sanitary Corps officers (2 engineers and 1 entomologist). The course at the school was an intensive one of 4 weeks duration and repeated every 6 weeks. The aim of the school was to afford basic instruction in facts of malariology in general, particularly all procedures of survey and control. The course was a practical one with approximately all theory integrated with and demonstrated through actual field experience and practice.[77] Basic subjects were taught to all attending the school, both officers and enlisted men. Instruction was given, with varying degrees of intensity, in the following:

Parasitology
Entomology
Clinical diagnosis including parasitologic examination and detection of palpable spleen
Mapmaking
Drainage procedures and manufacture of concrete products
Larviciding by hand machine, power machine, and airplane, and entomologic control of this measure
Use of dynamite in drainage
Mosquito collections
Personal protection against infection in bivouacs, and
Participation in procedures of complete surveys and, through their interpretation, the choice of control methods.

In addition to the teaching program the school conducted essential research investigations applicable to general field control procedures.

Among these studies were:

1. Special studies of longevity of killing effect on mosquitoes of DDT in various types of application and under varying climatic conditions.

2. Comparison of various methods of control procedures in selected and comparable towns including utilization of chloroquine, oxychloroquine, painting interior of house with DDT in kerosene, and spraying of a town with DDT at weekly intervals by airplane.

The results of these experiments were most conclusive and useful.[78]

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[76] Memo, Dir Trng Div SGO for Chief Pers Serv SGO, 8 Jan 44, sub: Students for Army School of Malariology. HD: 710 Malaria (Army School).

[77] Memo, SG for Dir Mil Trng ASF, 25 Jan 44, sub: Program of instruction for courses at Army School of Malariology (Canal Zone), with incl. HD: 710 Malaria (Army School).

[78] (1) Elmendorf, J. E., Jr.: Preliminary report on field experiments to demonstrate effectiveness of various methods of malaria control. Plan of investigation and original studies. Am. J. Trop. Med. 27: 135–145, Mar 1947. (2) Elmendorf, J. E., Jr.: Second and supplementary report on field experiments to demonstrate effectiveness of various methods of malaria control. Am. J. Trop. Med. 28: 425–436, May 1948. (3) Elmendorf, J. E., Jr., and others: Longevity of killing effect of DDT for mosquitoes contacting screen wire painted with DDT solutions. Am. J. Trop. Med. 26: 663–685, Sep 1946.

The desirable enrollment for the course was established at 25 students, with 50 as a maximum, although at times over 70 officers and enlisted men were enrolled. Many of the Sanitary Corps officers who were commanders of malaria survey or malaria control units attended this school before shipment overseas.

The school performed another function, namely admission to enrollment of medical personnel of the Allied forces. In this capacity a number of British and Canadian officers were trained and a few from other countries. As a gesture of good will toward Latin America, a few civilian doctors were also accepted for training.

Training Film. The Tropical Disease Control and Training Divisions, Office of The Surgeon General, collaborated in preparing Training Film 8–953, "Malaria, Its Cause and Control." Lt. Col. Willard V. King, Sanitary Corps entomologist and Lt. Col. Lloyd K. Clark, Sanitary Corps engineer, were assigned as technical adviser and assistant technical adviser, respectively, to assist in the preparation of the script, selection of locations for shooting the film, procurement of necessary properties, and to furnish technical advice during the filming. The film was released for distribution in early 1943.

Distribution of Control Units. In all, 161 malaria control units were organized and sent overseas, or were activated in the theaters. In addition, 16 units were activated, officered, and trained but were still in the Zone of Interior when Japan surrendered.[79] As of the beginning of 1945, malaria control units were distributed approximately as follows: [80]

Southwest Pacific	67
Central and South Pacific	33
India-Burma	34
China	1
South America and Antilles	4
Middle East	7
Mediterranean	12
Persian Gulf	2

Malaria Survey Units

The purpose of these units was to conduct general and specific surveys, as required in the field, of the incidence of malaria and malaria parasites and to check the effectiveness of suppressive treatment and control measures. (See Fig. 17.) To carry out these responsibilities, it appeared, after careful study, that 2 officers and 11 enlisted men would be required. The officer per-

[79] "Activation of Malaria Units, January 1943 to September 1945." HD: 710 Malaria (Orgn).

[80] Memo, Dir Trop Disease Control Div to Chief Prev Med Serv, 2 Apr 45, sub: Present status of malaria control organization. HD: 710 Malaria (Orgn).

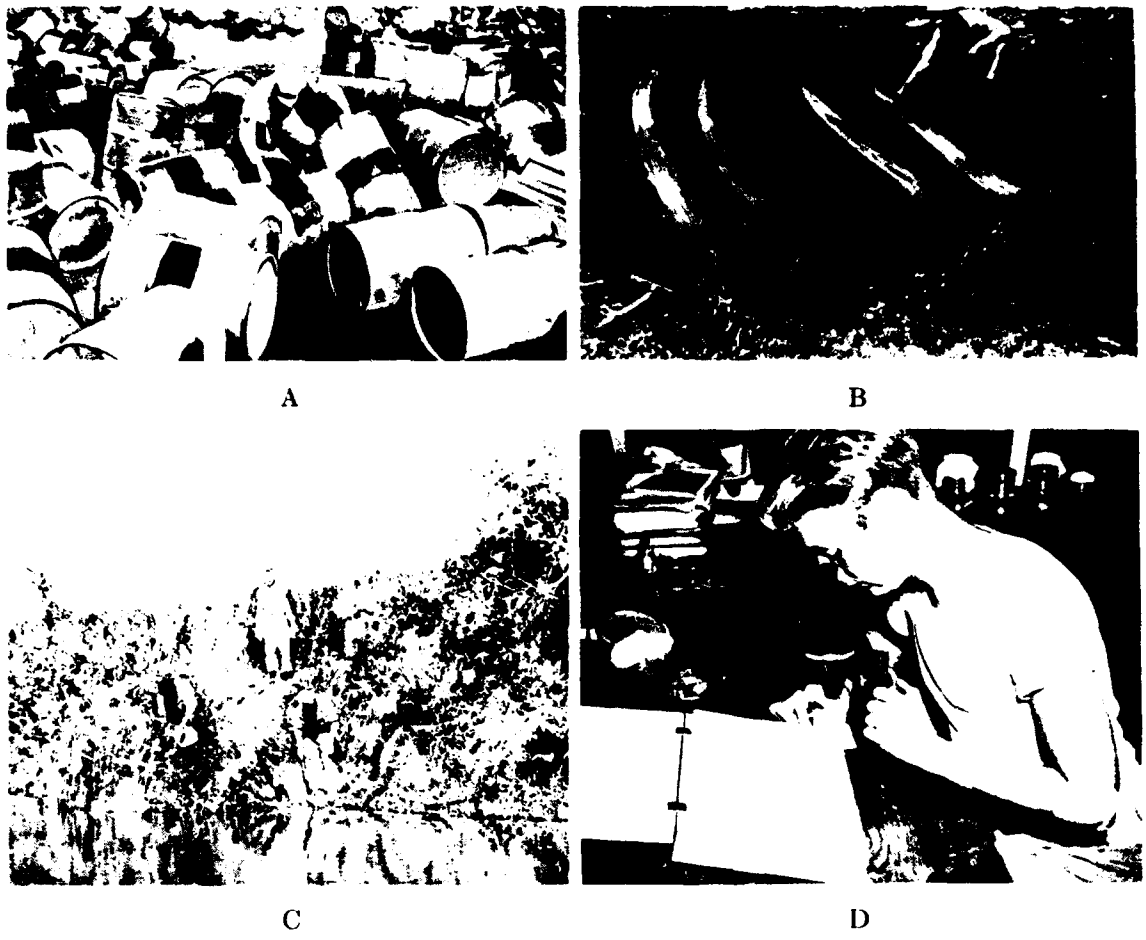


Figure 17. Mosquito survey. A. Inspecting pools of water in empty barrels in dump which form good breeding places for Aedes scutellaris, New Guinea, 1944. B. Examining water-filled vehicle ruts for mosquito larvae in New Georgia, 1943. C. Dipping for mosquito larvae in marginal vegetation. D. Identifying adult mosquitoes to provide guidance for control program.

sonnel included an entomologist and a parasitologist. The table of organization allowed the following personnel: [81]

Rank	*Title*	*Military Occupational Specialty*	*Number*
Capt	Entomologist	3315	1
	Parasitologist	3310	1
Tech. Sgt	Medical	673	1
Staff Sgt	Med. Lab	858	1
Sgt	Sanitary	196	1
T/4	Clerk, general	055	1
T/5	Med. Lab. Tech	858	4
Pfc	San. Tech	196	2
Pvt	Truck Driver	345	1

[81] See footnote 75, p. 209.

Equipment. As with every Army unit, the equipment provided represented a compromise between what was desirable and what was practicable. Since the primary functions of these units were investigative; i. e., to collect basic data on malaria incidence and malaria vectors upon which the surgeon and malariologist could act, equipment was limited to that necessary for performance of these functions. Important items in the table of equipment included drafting equipment, tools, rubber boots, tentage, chemicals, specimen boxes and vials, dissecting microscope, and laboratory equipment.[82] Actually, in the field, malaria survey units conformed less closely to the initial plans for their use than did the malaria control units. This was probably due to the broad wording of the original directive[83] and perhaps even more so to the research background of many of the officers of these units.

Training. The officer personnel of the malaria survey units were exceptionally well trained and capable. Entomologists were assigned by the Sanitary Engineering Division, Office of The Surgeon General, and parasitologists by the Laboratory Division. The training given these units after activation and organization oriented and equipped them in respect to malaria. In addition, after the establishment of the Army School of Malariology at Panama, a number of the officers were sent there for instruction.

Distribution of Survey Units. In all, 76 malaria survey units were organized and 72 were sent overseas or were activated in overseas theaters.[84] Early in 1945 the overseas distribution of these units was essentially as follows:[85]

Southwest Pacific	34
Central and South Pacific	27
Mediterranean	1
India-Burma	4
China	2
South America	1
Middle East	3

Some of these units were demobilized incident to closure or consolidation of theaters. At the end of the war, 68 malaria survey units were overseas.[86]

Assignment of Control and Survey Units to Theaters

The basis for estimating requirements for control and survey units, was finally fixed for malarious areas at 1 control unit per 7,500 troops and 1 survey unit per 20,000 troops.[87] This general allowance was on a theater basis and

[82] See footnote 75, p. 209.

[83] Ltr, SG to CGs Theaters of Opns, SvCs, and each Off of Malaria Orgn, 24 Mar 43, sub: Special organization for malaria control. HD: 710 Malaria (Orgn).

[84] See footnote 79, p. 211.

[85] See footnote 80, p. 211.

[86] Malaria control overseas. Bull. U. S. Army M. Dept. 4: 501–503, Nov 1945.

[87] 1st Memo Ind, SG to CG ASF attn Mobilization Div, 21 Feb 45, on Memo, SG to CG ASF, 20 Dec 44, sub: Projected requirements for malaria control units and malaria survey units for overseas theaters for 1945. HD: 710 Malaria (Orgn).

was not applicable to small areas, or to fixed posts, as Air Transport Command bases. In the South and Southwest Pacific it was the general practice to attach 1 control and 1 survey unit to each combat division.[88] These units accompanied the divisions, usually going ashore 2 to 5 days after the initial landings to initiate malaria control work.

The Office of The Surgeon General could not assign survey and control units to overseas theaters. Such units had to be specifically requested, and the shipping space for them specifically provided, by the theater. By the middle of 1943 when the value of these units began to be appreciated, requests for them were numerous. At this time there was usually a delay in shipment because the Office of The Surgeon General was not permitted to activate such units in advance of the overseas call. Activation of a reasonable number of units in advance of actual calls would have permitted shipment of more fully trained units when the calls were received.

With increasing emphasis on the war in the Pacific, an estimate of needs for the fourth quarter of 1945 was made early in that year. This estimate was based on the factors already discussed and provided for 278 malaria control and 130 malaria survey units, distributed as follows: [89] Southwest Pacific, 18 control and 18 survey units with division, and 120 control and 50 survey units with service troops; Pacific Ocean Areas, 11 control and 11 survey units with division, and 70 control and 26 survey units with service troops; China-Burma-India, 40 control and 15 survey units; Pacific Force, 5 control and 5 survey units with division, 14 control and 5 survey units with service troops.

In the Mediterranean theater control and survey units were utilized under the general direction of the 2655th Malaria Control Detachment. In the Middle East they were generally employed at fixed installations, as at Dakar, Roberts Field, and Accra. In the China-Burma-India theater they were assigned to bases or to sections of the Ledo Road. In South America, they were used in detachments, around the airbases at Amapa, Belem, Fortaleza, Natal, and Recife. In the Antilles they were employed at and around the principal fixed bases.

It is not feasible to summarize in detail the accomplishments of these units in this volume. The records of malaria incidence in the various theaters illustrate the gains. It is evident that our Pacific and Asiatic campaigns would have been impossible without the control of malaria. The malaria control and survey units were an essential part of this accomplishment, not only because of the work they actually did, but also because of their contribution to malaria discipline and malaria control organization.

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[88] See footnote 87, p. 213.

[89] Memo, SG for CG ASF, 20 Dec 44, sub: Projected requirements for malaria control units and malaria survey units for overseas theaters for 1945. AG: SPAOE 322.

The following quotation from a message from Brig. Gen. Guy B. Denit, Surgeon, Southwest Pacific Area, published at his headquarters, 25 December 1944, indicates the nature of the work done by these units: [90]

> The reduction of the malaria attack rate in this theater to a point at which it no longer contributes a dangerous handicap to our military effort is an achievement of historical importance in preventive medicine. It has been the result of a joint effort which is to the great credit of all who have participated. In this accomplishment the malariologists and the malaria survey and control units have played the major role. Despite hardships and often danger, their achievements have been notable. The Medical Department is proud of your initiative and perseverance, of your professional contributions, and of the striking success of your efforts.

An important lesson, learned from hard experience in malaria control, is that where malaria is a serious and special problem, it requires for control specially trained personnel working on a full-time basis. However, experience also demonstrated that control is always possible, and that military operations can be carried out in highly malarious areas, without serious handicap, provided a suitable malaria control organization is established.

Other Activities of the Units

In addition to malaria control, both the survey and the control units were widely used on other work. For example, they contributed to general sanitation measures in the Southwest Pacific, all the way north from New Guinea.[91] When Manila was captured, the need for general sanitation was so great that about a dozen malaria control and survey units were assigned to the work of cleaning up insanitary conditions in the city, including the application of DDT (residual).[92]

Schistosomiasis. Survey units were utilized for investigation of the prevalence of danger areas in connection with the outbreak of schistosomiasis following the landing on Leyte, Philippine Islands, in October 1944.[93] Previously, Sanitary Corps entomologists and malaria survey units had been used to determine foci, vectors, and methods of prevention of scrub typhus in New Guinea and adjacent islands.[94] Sanitary Corps entomologists were principal participants in the development of methods of impregnating clothing for the prevention of this disease.[95]

Rodent Control. To meet the need for rodent control teams in the Pacific, personnel of malaria survey and control units were given brief instruction in this subject pending the activation of rodent control units.[96] The Southwest

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[90] Message from the Chief Surgeon in the Far East. Bull. U. S. Army M. Dept. 3(86):53, Mar 1945.
[91] For example see, Monthly Malaria Control Rpt, 93d Malaria Control Unit, 31 Jan 45. HD.
[92] Annual Rpt, Chief Surg U. S. Army Forces Western Pacific, 1945, pt. I. HD.
[93] Quarterly Rpt, 5th Malaria Survey Unit SWPA, 1944-4. HD.
[94] Quarterly Rpt, 26th Malaria Survey Unit SWPA, 1944-3. HD.
[95] See Chapter VII, pp. 256-57.
[96] For full story of rodent control overseas, see Chapter VI.

Pacific Area established a training program in rodent control in the Philippines. Experienced Navy and Sanitary Corps men were used as instructors. The need for extensive rodent control as a health protective measure did not arise, though control operations were conducted on many South and Southwest Pacific islands, including the Philippines, as a precautionary measure and to prevent damage to supplies.

Water Quality Control. Sanitary engineers in command of control units were utilized for water quality control and supervision in the South Pacific and in the China-Burma-India theater, and the uniformly good quality of the water in those areas was largely due to their efforts.[97] In the Philippines, the sanitary engineering skills of control unit commanders were utilized in many ways in addition to those mentioned above, including water supply to Medical Department installations, and assistance in establishing these installations. Normally such work was a function of the Corps of Engineers, but in combat areas, Engineer troops were so involved in building airfields, roads, landing facilities, and the like, that they often were not able to provide for Medical Department needs at the time required.

Personnel Problems

Training for Sanitary Engineers. At the beginning of the war there were few sanitary engineers in the United States experienced in mosquito control, consequently it was necessary to institute training. An adequate supply of officers trained in mosquito control was gradually built up.

Sanitary engineers, to be of all-around value to the Army, had to be familiar with water supply, waste disposal, and mosquito control. If a man was qualified in the first two of these specialties, he could readily become satisfactorily proficient in mosquito control, because it is relatively simple in application, and engineering principles of organization and management apply to it. On the other hand, the engineer who had been engaged in malaria control work was not always well trained in water supply and sewerage, which were far more difficult to master and required greater training and experience. Thus, because of the scarcity of malaria control engineers, because they required further broad training, and because assignments had to be picked carefully for them, relatively few of such specialized personnel could be commissioned. Malaria control needs had to be met by sanitary engineers whose principal experience had been in other lines of work.

Entomologists. Entomologists specially trained in medical entomology and malaria control were also scarce. The opportunities for employment in entomology are greatest in agriculture, pest control, teaching, and research. It was therefore necessary, just as with sanitary engineers, to take men otherwise qualified and to train them in mosquito and malaria control. In both

[97] For full story of water control in the theaters, see Chapter III.

cases, it was found that men with adequate education and experience developed into excellent mosquito control personnel after a comparatively short period of training and practical experience.

In the Southwest Pacific, and in other theaters, where there were many well-trained sanitary engineers assigned to malaria control units, a frequent criticism was that their talents were not being fully utilized and that most mosquito control programs could have been carried on by engineers of lesser talent and experience. This was often true. In order to remedy the situation, the Sanitary Engineering Division, Office of The Surgeon General, continuously urged and recommended that such highly qualified officers be utilized for the more important positions arising in the theater and that they be replaced as unit commanders by younger and less experienced men.

The malaria survey units were sometimes inclined to regard themselves as purely research organizations. Actually their function was to aid in protecting the health of the Army. In addition to determining the malaria incidence in an area, the malaria vector, and the best methods of control, it was intended that survey unit personnel assist control personnel by making routine checks and inspections and by giving entomologic advice.

Parasitologists. The parasitologist of the survey unit usually had relatively little to do. On the basis of field reports and experience, it is believed that a properly trained entomologist would have been able to do all the parasitologic work required. Furthermore, it is possible that a merging of the control and survey units might have been advantageous. Evidence available at the end of 1945 appeared to indicate that a single detachment of 3 sections—headquarters, survey, and control, with a strength of 2 or 3 officers and 20 to 25 enlisted men—could perform the functions of both units. However, experiences in the different theaters indicated that no one organization was most efficient for all theaters, and that improvements could be suggested for any type of unit. The units, as organized, worked efficiently and effectively under many conditions.

Malaria Discipline Among Troops

The inculcation of malaria discipline among troops was provided for by War Department Circular 223, 21 September 1943, which established an antimalaria detail of 1 noncommissioned officer and 1 enlisted man in each company, battery, or similar organization, and also required that all troops be given 4 hours of instruction in methods of protection against malaria. To implement the circular, War Department Training Circular (TC) 108, 21 September 1943, was issued, outlining a 4-hour course of instruction covering: (1) the cause and control of malaria; (2) the necessity for control and for malaria discipline, and the responsibility of unit commanders and of individuals; (3) environmental control methods, including screening; and (4) individual

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control methods, including repellents, bed nets, insecticides, protective clothing, and suppressive drugs. The Sanitary Engineering Division, Office of The Surgeon General, cooperated with and assisted the Tropical Disease Control Division in the preparation of these directives.

The role of malaria control and survey units in this program was in general to give the required instruction and to supervise the activities of antimalaria details among the troops to which they were assigned. The latter included a continuous program of training special personnel, inspection of local control measures, and coordination of activities. There were nearly 300 officers of the Sanitary Corps and 2,550 enlisted men engaged in overseas malaria control, in addition to the antimalaria details and the thousands of native laborers employed in drainage and larviciding operations.[98]

Summary of Overseas Data

Malaria rates overseas reached a peak in August 1943, but dropped dramatically thereafter in spite of the fact that military operations continued in highly malarious areas and involved constantly increasing numbers of troops. In most or all theaters, the drop in malaria rates coincided with the building up of the malaria control organization and resulted from both the control work done and the growing realization by the high commanders of the absolute necessity for malaria control.

Southwest Pacific. The 1943 rate for malaria in this theater as indicated by hospital and quarters admissions was 245 per thousand per year. The rate for the first half of 1944 was 75; for the second half, 41. For the first half of 1945, the rate rose to 58. Early in 1943, when malaria control and survey units first became available, the theater requested 12 control and 3 survey units,[99] and later in the year, 3 more survey units.[100] At the end of May 1944, there were 28 control and 21 survey units in the Southwest Pacific,[101] and by the end of 1944 this had increased to 67 control and 33 survey units,[102] some of which had been transferred from the South Pacific as operations in that theater closed down. In addition, there were 44 Sanitary Corps engineers and 2 entomologists in the theater, but not attached to these units.[103]

South Pacific. In this theater the rates for midsummer 1943 were very high, approximating 600 per thousand per year. When this theater decreased in importance as the war moved north and west in 1944, it was made a part of United States Army Forces, Pacific Ocean Area, later Middle Pacific, and the

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[98] See footnote 86, p. 213.

[99] Radio C 1303, MacArthur to TAG, 24 Dec 42. HD: 710 Malaria (Units, SWPA).

[100] Memo, Asst Theater Malariologist for Surg GHQ SWPA, 1 Nov 43. HD: 710 Malaria (Units, SWPA).

[101] Memo, Capt N. W. Bolduan, SGO for Maj O. R. McCoy, SGO, 8 May 44, sub: Status of units. HD: 710 Malaria (Units).

[102] Annual Rpt, San Engr Div Prev Med Serv SGO, 1944. HD.

[103] Ibid.

many troops in nonmalarious areas obscured the true picture. The 1943 average rate was 208, which fell to 43 in 1944, and to 5 in the first half of 1945. Initial requests from this theater in early 1943 were for 3 control and 3 survey units.[104] By the end of that year there were 14 control and 9 survey units in the theater or en route to it,[105] and by May 1944, 22 control and 16 survey units.[106] At the close of the war there were in United States Army Forces, Middle Pacific, 26 control and 26 survey units.[107] There were also 36 other Sanitary Corps engineers and 9 entomologists in the theater.[108]

China-Burma-India. Rates in the Asiatic theater declined from 181 per thousand in 1943 to 174 in 1944 and to 37 for the first half of 1945. Much of this reduction was because of the use of atabrine, but the excellent work of the malaria control organization contributed greatly toward the reduction. In November 1944, there were in the theater 35 malaria control units, 6 malaria survey units, 16 other Sanitary Corps engineers, and 10 entomologists, in addition to sanitary engineers with the Air Transport Command.[109] The initial request in early 1943 was for 3 control and 3 survey units;[110] by December 1943, there were 15 control and 4 survey units in the theater or en route to it.[111]

Mosquito-borne disease control presented mainly a problem of discipline since mosquito control measures were adequate for service personnel in camps, and individual protective devices such as mechanical and chemical repellents were also adequate and effective except for the extremely small ground combat force of Americans in the theater. However, mosquito discipline was so poor that it eventually became necessary to direct daily use of atabrine for most of the theater area in order to control malaria. Continuous use of atabrine was easier to enforce than other protective measures. Of course, a tremendous amount of draining, oiling, dusting, and spraying (both hand and airplane) was accomplished. However, except for airplane spraying of combat areas which was not highly developed in time to be of maximum value, these measures principally added comfort to the troops.

West Africa. In the West African areas, from Dakar on to the south through Liberia and Accra to the stations in Nigeria on the Central African route, malaria was a tremendous problem. Malaria is endemic throughout all of West Africa, and the *Anopheles gambiae*, an efficient carrier, was prevalent. At Dakar an attempt at control was made in 1943, but effective control was not

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[104] Memo, Trop Disease Control Div SGO for Col J. S. Simmons, SGO, 13 Feb 43, sub: Army antimalaria organization. HD: 710 Malaria (Orgn).

[105] Memo, Capt N. W. Bolduan, SGO for Maj O. R. McCoy, SGO, 1 Dec 43, sub: Present status of malaria control personnel in the Army. HD: 710 Malaria (Orgn).

[106] See footnote 101, p. 218.

[107] Memo for file, Lt Col O. R. McCoy, Trop Disease Control Div SGO, 5 Nov 45, sub: Deployment of malaria units. HD: 710 Malaria (Orgn).

[108] See footnote 102, p. 218.

[109] See footnote 102, p. 218.

[110] See footnote 104.

[111] See footnote 105.

attained until 1944. The airfield at Rufisque was in an area where control was difficult. At one time the malaria rate exceeded 2,000 per thousand per year.[113] With the arrival of the 33d Malaria Control Unit, a broad program of drainage was initiated but complete control was not accomplished until Yof Field was completed and the Rufisque area abandoned.[113]

Control at Roberts Field in Liberia was exceedingly difficult due to the many favorable *A. gambiae* breeding areas adjacent to the post and the heavy local incidence of malaria. Control work was begun in 1942 by the 2655th Malaria Control Detachment.[114] After withdrawal of this detachment, the 27th Malaria Control Unit and the 16th Malaria Survey Unit, both Negro units, did excellent work in draining swamps and extending control operations. Rates in this area were never brought to a satisfactory level.[115] This was due, at least in part, to lack of malaria discipline among troops in Liberia, nearly all of whom were Negroes.

In Accra, a joint campaign was carried on by British and American troops. The former urged and installed, under reverse lend-lease, a very large drainage system which had little effect on malaria incidence. Until 1944, conditions were unsatisfactory, from a malaria and mosquito control viewpoint, at the Accra Airbase. With the use of atabrine and further intensive control measures, especially larviciding, by the 33d and 27th Malaria Control Units, the rate declined.[116] Accra, Roberts Field, and Dakar were areas from which *A. gambiae* were, during 1943, transported to Brazil by airplane, resulting in a strong protest by the Brazilian Government. The measures taken to prevent airplane carriage of mosquitoes are discussed later.

South Atlantic. Prompt action by the theater and the South Atlantic Wing, Air Transport Command, in instituting malaria control measures in and around South American bases prevented any serious incidence of malaria. Control work utilized Brazilian resources as well as those of the Office of Inter-American Affairs.[117] Early in 1944, the 57th Malaria Control Unit took over the work;[118] still later the 202d Malaria Survey Unit was sent to the theater.[119] Due to the prompt and energetic measures taken, rates as low as 15 to 20 per thousand per year were attained in 1943, and these were substantially lowered in succeeding years.

North Africa and Mediterranean. Following the capture of Sicily, during which malaria casualties exceeded battle losses, the theater undertook a broad-scale program of malaria control. The 2655th Malaria Control Detach-

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[113] See footnote 70, p. 205.

[113] Annual Rpt, 33d Med Composite Unit (Malaria Control), 1944. HD.

[114] Ltr, Maj J. M. Andrews, SnC to Chief Health Off Roberts Field, Liberia, 5 Aug 42, sub: Malaria investigations and control activities in the Roberts Field area. HD:725.

[115] Annual Rpts, Sta Surg Roberts Field, Liberia, 1943, 1944. HD.

[116] Annual Rpt, Surg West African Service Comd USAFIME, 1944. HD.

[117] Annual Rpt, Surg USAF South Atlantic, 1942. HD.

[118] Annual Rpt, 57th Malaria Control Unit, 1944. HD.

[119] Annual Rpt, 202d Malaria Survey Unit, 1944. HD.

ment was brought to Italy from Africa to coordinate and supervise the work.[120] The initial request in early 1943 was for 4 control and 4 survey units.[121] By the end of 1943, there were 7 control and 5 survey units in or en route to the theater.[122] In the middle of 1944, the control units had been increased to 14.[123] At the end of 1944, 12 control units and 1 survey unit remained in the theater.[124]

Caribbean. Malaria control work was initiated in 1941 in most of the bases of the Caribbean Defense Command. In Puerto Rico, the United States Public Health Service had an effective program. Several of the bases on that island presented very serious problems, requiring extensive drainage and larviciding.[125] In Trinidad, unusual difficulties in control were encountered in connection with mosquito breeding in bromeliad vines in immortelle trees. This was solved by cutting some vines, by applying $CuSO_4$, and by airplane spraying.[126] At Panama there was an early problem due to the establishment of searchlight and antiaircraft batteries and of listening posts outside the controlled area.[127] All of these problems were overcome so that malaria was not a serious cause of illness in the Antilles after 1942.

Persian Gulf Command. In the Persian Gulf area malaria was a serious problem along the rivers. An entomologist was assigned to this area in 1942 to determine the malaria hazard and recommend measures for its control.[128] Due to these early investigations and the vigorous control program initiated, malaria did not become an important cause of noneffectiveness in the Persian Gulf Command. Three malaria control units were activated locally in 1943.[129]

Importation of Mosquitoes by Airplanes. In 1943 the Brazilian Government protested vigorously against the importation by United States aircraft of *A. gambiae* from West Africa.[130] A few years before, Brazil had suffered very seriously from a malaria epidemic which had been controlled only by the eradication, with the help of the International Health Division, Rockefeller Foundation, of *A. gambiae* from Brazil. This campaign cost 2 million dollars.[131] Naturally that nation was averse to the reintroduction of this highly efficient malaria carrier, with the probability of another serious epidemic of the disease.

A commission composed of the author and Lt. Col. (later Col.) K. R. Lundeberg, MC, both from the Office of The Surgeon General; and Maj.

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[120] Annual Rpt, Surg MTO, 1944, App 28. HD.

[121] See footnote 104, p. 119.

[122] See footnote 105, p. 219.

[123] Annual Rpt, Surg MTO, 1944. HD.

[124] See footnote 102, p. 218.

[125] Ltr, Surg Puerto Rican Dept to SG, 3 Apr 41, sub: Plans for mosquito control. SG: 725.11-1 (PR) AA.

[126] Ltr, Capt L. B. Dworsky, SnC, Trinidad Sector and Base Comd to Col W. A. Hardenbergh, SnC, SGO, 11 May 43. SG: 725.11 (Trinidad) F.

[127] Ltr, Lt Col P. Russell to SG, 5 Nov 42, sub: Malaria tour in the Panama Canal Department. SG: 720.-1 (PCD) AA.

[128] Annual Rpt, Surg Persian Gulf SvC USAFIME, 1942. HD.

[129] Monthly Malaria Rpt, Hq Persian Gulf SvC USAFIME, Sep 1943. HD: 710 Malaria (PG).

[130] Protests of Brazilian Government and replies are filed in HD: 725 (*A. gambiae*) (Brazil-Africa).

[131] Soper, F. L., and Wilson, D. B.: *Anopheles gambiae* in Brazil 1930-1940. New York, The Rockefeller Foundation, 1943.

Elliston Farrell, MC, representing the Air Surgeon, proceeded to South America and thence to Africa. In Accra they were met by Col. Paul F. Russell, MC, representing the North African Theater of Operations, and Lt. Col. T. G. Ward, MC, of the Middle East theater. It was recommended that a program of intensified mosquito control at West African bases and more effective disinsectization of aircraft before departure from Africa be initiated, and that the airfields of entry in South America and the Caribbean be mosquito-proofed to prevent breeding of any mosquitoes that might be transported across the Atlantic.[132]

To carry out these recommendations, Major Farrell was assigned as malariologist for the West African area and charged with supervision of disinsectization of aircraft and of mosquito eradication measures.[133] Additional malariologists and malaria control and malaria survey units were assigned to the airbases in West Africa, and broader and more intensive control measures were initiated.[134] These recommendations were made in the late fall of 1943, and substantial accomplishment of the desired objectives had been attained by the middle of 1944.[135]

Airplane Application of DDT. Since the control of malaria was one of the greatest problems of the Southwest Pacific area, it was natural that the development of methods of use of DDT were followed with much interest by the high command of that area. Also, because of the conditions that existed in the theater, airplane application appeared to offer great promise. The first airplane application of DDT in the Southwest Pacific was at Nadzab in July 1944,[136] using Fifth Air Force planes. This work was largely experimental in nature, and was intended to verify the procedures suggested by the Office of The Surgeon General and the laboratory of the United States Department of Agriculture at Orlando, Florida. (See Fig. 16.) The trials at Nadzab were followed by work at Owi [137] 2 weeks later; but this spraying was, in part at least, intended to determine the efficacy of such application in the control of mites transmitting scrub typhus. Results of this work were not promising; and a check on the effect of the spraying on flies and mosquitoes, both larvae and adults, indicated that results were inconclusive. A part of Biak was sprayed 2 days later;[138] Sansapor on 4 August [139] and Amsterdam Island on

[132] Ltr, Col W. A. Hardenbergh, SnC, SGO, and others to SG, 4 Dec 43, sub: Mosquito and malaria control at West African airfields. HD: 725 (*A. gambiae*) (Brazil-Africa).

[133] Memo, Dir Epidemiology Div SGO for Mil Pers Div SGO, 30 Jan 44, sub: Malariologist, West Africa. HD: 725 (*A. gambiae*) (Brazil-Africa).

[134] Ltr, TAG to CG USAFIME, 1 Feb 44, sub: Malaria control personnel, USAFIME. HD: 725 (*A. gambiae*) (Brazil-Africa).

[135] Farrell, E.: The *Anopheles gambiae* problem in Brazil and West Africa, 1941–44. Bull. U. S. Army M. Dept. 8: 110–124, Feb 1948.

[136] Memo, Col Maurice C. Pincoffs, SWPA to Lt Col G. Orth, SWPA, 11 Aug 44, incl 1. HD: 725 (DDT) (SWPA).

[137] Ltr, Maj F. J. Dy, SWPA to Chief Surg USAFFE, 21 Aug 44, sub: Lt. Colonel Cornelius B. Philip's report on scrub typhus at Owi and Biak Islands. HD: 725 (DDT Airplane Spraying) SWPA.

[138] Ltr, Maj F. J. Dy, SWPA to Col H. F. Smith, SWPA, 24 Jul 44. HD: 725 (DDT Airplane Spraying) SWPA.

[139] See footnote 136.

5 August.[140] Both B–25 and A–20 planes were tried out in these various applications. The former was able to carry a greater load of DDT and oil and was generally preferred for such work.

In the DDT spraying of Amsterdam Island, and later in spraying of Sixth Army Headquarters at Hollandia, it appeared that good results were obtained against adult mosquitoes but that larvae, especially the smaller ones, were not seriously affected.

The first large-scale spraying of a combat area was at Morotai,[141] where the beachhead was sprayed on D-day, 15 September 1944, and again on D+1. In the initial spraying, 4,754 acres were covered with 0.13 pound of DDT per acre; the next day 2,600 acres were sprayed at the rate of 0.46 pound. A final application of 0.30 pound of DDT per acre was made on 29 September. Following the initial spraying, living larvae were found in the sprayed area. Inability to evaluate conditions in the beachhead area before spraying on D-day contributed to the lack of reliable data.

Extended tests were conducted on the methods of airplane application of DDT during November 1944 in the vicinity of Hollandia,[142] using the Husman-Longcoy spray unit and light planes of the Cub-type. This work was under the general direction of Capt. W. C. McDuffie. In the majority of the tests, results were erratic and mostly unsatisfactory, but where conditions were favorable, reduction of 90 to 98 percent of adults was obtained and also good control of larvae. This work established a basis for the use of airplanes in DDT application and helped to lay the groundwork for later successful airplane application in areas further north.

In the Middle Pacific,[143] DDT spraying by aircraft was employed early in the assault period—September and October 1944—in the Western Carolines campaign in which Ulithi and the Southern Palau islands were captured. The air application of DDT was coordinated with a well organized insect control and general sanitation program, which was instituted as early as possible after landing. The dividends of this sound approach—combining air application with good ground control methods and enforcement of sanitation—were far less dysentery than in any previous landing and the relative absence of other diseases.

A severe dengue epidemic occurred following capture of the island of Saipan. About two-thirds of the island was sprayed with DDT by C–47 planes in September 1944.[144] Entomologic evaluations indicated a high degree of mosquito

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[140] Memo, Capt P. J. Darlington, SnC to Surg 6th Army, 16 Aug 44, sub: Results of airplane spraying of Amsterdam Island with DDT. HD: 725 (DDT Airplane Spraying) SWPA.

[141] Rpt, Capt P. J. Darlington, SnC, Hq XI Corps, 27 Sep 44, sub: Airplane spraying of DDT of Morotai Island. HD: 725 (DDT Airplane Spraying) SWPA.

[142] McDuffie, W. C., and others: Studies on the application of DDT-oil sprays by light airplanes for control of mosquitoes. HD: 725 (DDT Airplane Spraying) SWPA.

[143] Whitehill, B.: Administrative history of medical activities in the Middle Pacific. HD: 314.7-2.

[144] Memo, Sanitation and Hygiene Div SGO to Chief Prev Med Serv SGO, 10 Nov 44, sub: Report of spraying DDT from C-47 airplane on Saipan, with incl. HD: 710 Dengue (POA).

and fly control and the dengue epidemic abated rapidly. Spraying was repeated a short time later and a good degree of mosquito and fly control was maintained. Capt. D. G. Hall, SnC, who participated in this project later carried on very extensive spraying on other islands in the Southwest Pacific. He was largely responsible for the equipping of C–47 planes to carry fourteen 55-gallon drums, or about 770 gallons of DDT solution. In an effort to reduce fly and mosquito incidence in Manila after its capture, that city was sprayed several times from the air, under supervision of Col. M. C. Pincoffs, Acting City Health Officer, and air application was supplemented by intensive groundwork, which is always a necessary accompaniment of air spraying.[145]

Essentials of a Program for Protection Against Malarial Mosquitoes

Experience in World War II demonstrated that the first essential in malaria control is that line commanders understand the influence malaria can have on their operations, so that they will appreciate the need for skilled antimalaria personnel, the timely provision of antimalaria supplies, and the unhampered prosecution of the work. This might have been brought about had data on the influence of malaria and other tropical diseases on military operations been included in the curricula of all command and staff schools of the Army.

A second essential is the provision of skilled personnel to direct and carry on the work. Experience indicated that ideally this includes malaria control officers or malariologists, an intermediate supervisory and command organization where the scope of the work is sufficient to require it, and malaria control and survey units. During the war, the intermediate organization was generally lacking.

Experience disclosed a third essential—the provision that all basic troop training include instruction in personal measures for protection against disease. So far as malaria is concerned, this may be termed malaria discipline, but the necessity existed equally for other diseases. All soldiers should be taught the procedures which they must apply in order to do their share toward protecting their health. Such instruction includes the use of repellents, bed nets, atabrine, and other means of personal protection.

There might well have been a closer degree of cooperation in overseas theaters between the Corps of Engineers and the malaria control organization. As previously stated, no heavy equipment, such as bulldozers, draglines, or tractors, were included in the table of equipment for malaria control units. Work of a nature requiring such equipment should have been performed by the Corps of Engineers, but this was rarely done during the war. The need for road, airport, and port facility construction was so great as to require all

[145] Rpt, Capt J. T. Griffiths, SnC, 2 Aug 45, sub: DDT airplane spraying in Manila. HD: 725 DDT (Manila).

the resources of Engineer troops, with the result that malaria control was left to the Medical Department personnel and the latter did not have adequate equipment or enough personnel to do the job.

CONTROL OF FLIES AND OTHER INSECTS

Cooperation With Corps of Engineers[146]

In 1942 the War Department defined responsibility for the various phases of insect and rodent control essentially as follows: Corps of Engineers, supervision and execution of control measures; Medical Department, recommendations, advice, and necessary technical supervision; Quartermaster Corps, procurement, storage and supply of general issue insecticides, rodenticides, and equipment.

Entomologic service at the outbreak of war was provided entirely by entomologists and sanitary engineers of the Medical Department. In the spring of 1943, the Chief of Engineers transferred responsibility for insect and rodent control measures from the Repairs and Utilities Division to a special Insect and Rodent Control Section. An entomologist from the Medical Department, 2d Lt. (later Capt.) W. D. Reed, was selected to head the new organization.

Professional entomologists, both civilian and military, were obtained to direct the work in all service commands. Post engineers were authorized to hire personnel as necessary to discharge their responsibilities for insect and rodent control. Sanitary Corps personnel continued to make investigations and recommendations, provide technical supervision where required, furnish laboratory service, and conduct research and developmental work. In overseas theaters responsibility for insect and rodent control operations remained with the Medical Department for the duration of the war.

The cooperative efforts of the Medical-Engineer team produced effective control measures in the Zone of Interior for pests that affect the health, morale, and efficiency of personnel. The program included control of such pests as mosquitoes, flies, cockroaches, bedbugs, ticks, mites, fleas, and ants. The Corps of Engineers was also interested in the protection of Army property, and carried on control activities against pests that damage and destroy supplies and equipment. The work included control of termites, Lyctus beetles and other wood-destroying insects, pests of trees and shrubs, insects attacking flour and other items of subsistence, rats, mice, and field rodents.

Research and developmental work was conducted at the Engineer Research and Development Laboratories at Fort Belvoir, Virginia, which resulted in better equipment for insecticide dispersal. A new and more effective knapsack

[146] (1) Reed, W. D.; Bunn, R. W., and Blanton, F. S.: Entomology in the Army. J. Economic Entomology 40: 289–293, Jun 1947. (2) Bunn, R. W.: Entomological service in the Army. Mil. Surgeon 101: 40–44, Jul 1947.

sprayer (3-gallon capacity) replaced the old 5-gallon sprayer. Improvements were made in high pressure sprayers and rotary hand dusters.

The joint responsibility of the Medical Department and the Corps of Engineers required close cooperation, a mutual understanding of the problems involved, and a harmonious working relationship. These essentials were maintained throughout the war.

Fly Control

Flies, such as the common housefly and related varieties, are an important factor in the spread of the organisms which cause enteric diseases. Dissemination of dysentery organisms by flies depends primarily on insanitary disposal of feces. Proper disposal of human wastes is a paramount consideration not only to lessen chances of food contamination by flies but also to prevent feces from serving as a breeding place for flies. Other general measures of sanitation essential for fly control include proper disposal of kitchen wastes, treatment of breeding places with DDT, careful attention to screening, and use of DDT residual spray on screens in messhalls, latrines, and other places where flies gather.

In some instances in order to achieve continuous fly control, it was necessary to go beyond the military reservation to discover the fly-breeding places. In the First Service Command, garbage dumps and hog farms in the vicinity of Cushing General Hospital and Grenier Field, Massachusetts, produced many flies. In cooperation with the Massachusetts State Board of Health and the United States Public Health Service, DDT residual spray was applied to resting places in the vicinity of fly-producing areas. DDT was also used at horse barns near Second Army Headquarters in Tennessee and at dairy barns in various places in the Fourth Service Command where fly nuisances were produced.

Dogfly Control. The dogfly or stablefly, *Stomoxys calcitrans*, is a blood-sucking fly which was a serious nuisance and threatened to interfere with training, especially at Eglin and Tyndall Fields and Camp Gordon Johnston in Florida. The dogfly occurs in all parts of the United States, usually in association with barnyards, where it breeds in manure. However, its occurrence in epidemic numbers is limited to the Northwest Florida Gulf Coast from St. Marks westward to Pensacola, where the principal breeding is in marine vegetation deposited by late summer high tides.

Dogfly control was a cooperative function of the Department of Agriculture and the Public Health Service.[147] The Bureau of Entomology carried on field operations from its experiment station at Panama City, Florida, with funds in part supplied by the Army Air Forces. The program was successful in reducing the dogfly population to the extent that there were no interruptions of training programs because of dogfly attacks.

[147] Annual Report of Dogfly Control, U. S. D. A., 1944. HD: 725.

Control in Florida for most of the airfields was accomplished by spraying the beach deposits of marine grasses with a mixture of creosote and salt water. (See Fig. 18.) Barges were used for transporting the creosote and for housing the pumps; hose lines were then carried to the shore where a team of three men sprayed the grasses. In 1944 extensive field experiments indicated that light surface applications of either DDT or DDT byproduct oil sprays would give effective control. Records indicate that 84-percent control was obtained with DDT on heavily tide-washed grass deposits and over 99-percent control on grass which was not covered by the tides.



Figure 18. Accumulations of dead marine grasses which furnish breeding grounds for the dogfly on the northwestern Florida coast are sprayed with creosote oil from a power sprayer mounted on a light barge.

Because of the different type of beach encountered at Camp Gordon Johnston and its distance from the Bureau of Entomology's experiment station, it was believed to be more economical for the camp to operate its own control program.[148] Sodium arsenite was used as the killing agent, rather than creosote. Extensive raking and hauling of the marine grasses into compost piles was also carried out. The DDT program, initiated in 1944, required only a small portion of the manpower used by the other measures and was apparently more effective in results.

[148] Hogden, D. B.: Summary sanitary report for Camp Gordon Johnston, Florida, period of Sep 1942 through Mar 1946. HD.

Procedure for general dogfly control as adopted by the Army [149] was to scatter, bury, or compost the rotting vegetation where the flies were breeding and to dust with 10-percent DDT or spray with 5-percent DDT solution in oil.

Fly Breeding in Latrines. In the Pacific, experience indicated that paradichlorobenzene (PDB) was effective in preventing fly breeding in pit latrines. Tests were immediately instituted in this country. Much appeared to depend on type of soil, humidity, and temperature. In warm and humid areas, where the soil was dense, good results were obtained, but it was not so effective where the pits contained standing water, where they were less than 6 feet deep, or where a draft was created through faulty covering of the latrine house. All available PDB was sent to the Pacific.

Fly Breeding on Battlefields. Spread of bacillary dysentery as well as acute discomfort and irritation was caused by fly breeding during and after the campaign on the Gilbert Islands.[150] Flies bred in the dead, in destroyed enemy ration dumps, in enemy or our own unsanitated latrines, and in garbage accumulations. In early 1944 plans were made to avoid this situation in the imminent campaign on the Marshall Islands. It was found that sodium arsenite was effective in destroying flies and maggots,[151] and techniques were at once developed for its use in battlefield sanitation. Chemical warfare decontaminating trucks were used to spray the dilute sodium arsenite, and teams were trained in the preparation of the solution, spraying from knapsack sprayers, and necessary precautions to be taken when using this violent poison.[152] Results of these methods were satisfactory in the Marshalls campaign and were adopted in all subsequent fighting in the Pacific.[153]

Control of Other Insects

Control of Cockroaches. Cockroach control was an ever-present problem both in the Zone of Interior and overseas. In warm damp climates such as the Panama Canal Department [154] and South Atlantic theater [155] where large numbers of these pests existed, constant and meticulous attention to sanitary measures was required to maintain any semblance of control.

Sodium fluoride was issued as the roach control poison at the beginning of the war. Aerosol pyrethrum spraying, which was developed and used for mosquito control, served incidentally to control roaches. The efficacy of DDT against roaches was tested at Camp Blanding, Florida, by the Orlando laboratory of the Department of Agriculture and the Fourth Service Command.

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[149] TM 5-632, Oct 1945.

[150] A history of preventive medicine in World War II, United States Army Forces, Middle Pacific. HD: 314.7-2.

[151] Rpt, Capt F. Sherman, SnC, to Surg CPA, 1 Jan 44, sub: Destruction of maggots in decomposing meat. SG: 725.

[152] Ltr, Comdr in Chief POA to Island Comdrs, 7 Jan 44, sub: Fly control, with sodium arsenite as a means of, and training personnel for. SG: 725.

[153] (1) Hq USAF POA Cir 33, 16 Sep 44, sub: Use of sodium arsenite for fly control. SG: 725. (2) Sherman, F.: Special sanitary problems following battle, 7 Aug 44. HD: 720. (3) Ltr, A. G. Downing, Officer in Charge Burial Development to CG USAF, Central Pacific Area, 16 Feb 44, sub: Report of burial. SG: 293.

[154] History of preventive medicine in World War II, Panama Canal Department. HD: 314.7-2.

[155] Medical history, South Atlantic theater, 31 Oct 45. HD: 314.7-2.

Both DDT dust and a 5-percent solution in kerosene were tried. Although only partial control was achieved, DDT was considered the best poison against roaches discovered to that time.[156] In 1943 and 1944, spraying of messhalls, latrines, and barracks with DDT during antimosquito and antifly campaigns, served at the same time as a roach control measure. Later when the supply of DDT increased, both the dust and spray were recommended for cockroach elimination. In cases of extreme infestation, fumigation was advised, but since that did not have any residual effect, followup spraying with DDT was considered necessary.[157]

The Medical Department stressed the necessity for cleanliness of kitchens and latrines as the principal control measure. Regular inspections by unit commanders, as well as Medical Corps and Veterinary Corps officers, helped to keep kitchens and messhalls at high sanitary standards and protected food from contamination.[158]

Control of Bedbugs. Bedbugs, although of little or no importance in the transmission of disease, were a source of much annoyance and had an adverse effect upon morale. These pests could be introduced into camps so easily and multiplied so rapidly that they not infrequently became a troublesome problem.[159]

Before the discovery of DDT, methods of control were somewhat crude, painstaking, and at times discouraging. In the Zone of Interior principal reliance was placed upon fumigation with hydrocyanic gas.[160] At the beginning of the emergency, fumigation was done by local contract, but it was soon decided that Army personnel could accomplish the work at one-third to one-fourth the cost of civilian contracts.

The Panama Canal Department[161] reported using several of the then prescribed methods: flaming beds with a blow torch, painting beds with 10-percent cresol and kerosene, and treating walls and woodwork with the same solution. All infested mattresses and pillows were treated by steam, exposed for 30 minutes to dry heat at 140° F., or sprayed with the cresol solution.

Bedbug infestation was a particularly serious problem in the Hawaiian Department[162] where almost all military posts became infested in late 1942. The temporary light wooden barracks were difficult to fumigate and served as a source of reinfestation after cots and bedding had been treated. The bedbugs invaded laundries, were returned to supply rooms and Quartermaster warehouses in cots and blankets, and invaded new units to which these items were reissued. An extensive coordinated effort by all units under the supervision of

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[156] Annual Rpt, 4th SvC, 1944. HD.
[157] See footnote 149, p. 228.
[158] FM 21-10, 31 Jul 40.
[159] Bishopp, F. C.: Some insect problems in World War II. HD: 700.7.
[160] See footnote 158.
[161] See footnote 154, p. 228.
[162] See footnote 150, p. 228.

a permanent detail of insect control specialists was successfully undertaken in the latter part of 1944, before DDT was available.

Since the advent of DDT, bedbugs have ceased to be a problem on Army posts.[163] Thorough treatment of barracks not only gives complete kills, but barracks remain free of infestation for a period of a year or more. Frequent thorough inspection of barracks and prompt treatment of minor infestations are the recommended practices.[164]

Control of Ticks. These arachnid parasites are widely distributed geographically, and in addition to being annoying pests they transmit several diseases, notably Rocky Mountain spotted fever, Bullis fever, Sao Paulo fever, relapsing fever, and tularemia. Tick-borne diseases did not constitute an appreciable military problem in World War II, but ticks were sometimes a serious nuisance to troops on maneuvers.[165]

Control of ticks [166] included control of tick-infested animals—rats, chipmunks, ground squirrels, meadow mice, and other rodents. A completely satisfactory method of insecticidal treatment of outdoor areas was not developed, although spraying with DDT dust at the rate of 4 pounds to the acre (40 pounds of 10-percent dust) gave promising results in experimental tests. Spraying with nicotine sulfate and sodium arsenite was sometimes effective. Clearing vegetation from infested areas reduced tick prevalence and was often recommended for training grounds.

Control of indoor infestation was maintained by spraying walls and furniture with 5-percent DDT solution in kerosene, which destroys immature ticks after 24 hours.

Individual measures were considered necessary precautions against tick bite. Repellents were rubbed or sprayed at the trouser and sleeve cuffs to prevent tick entrance. Protective clothing, with trouser legs secured by boots or leggings, was prescribed for wear in infested areas.

Control of Mites. Mites, some of which are also known as chiggers or redbugs, caused considerable discomfort to the troops both in the Zone of Interior and overseas. The most important from the Army point of view was the mite which transmits scrub typhus and was encountered in great numbers in certain parts of the Pacific theater, notably New Guinea and adjacent islands, and the India-Burma theater. Because of the large loss of man-hours from scrub typhus, the Preventive Medicine Service used every possible control measure.[167] Area control of mites was never achieved although some reduction

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[163] For example see: Annual Rpts. Surg 4th SvC. HD.

[164] See footnote 149, p. 228.

[165] McCoy, O. R.: Relation of insects to the health of military personnel. J. Economic Entomology 73: 459–464, 18 Nov 44.

[166] See footnote 148, p. 228.

[167] A full description of mite-control work done in connection with scrub typhus will be found in the volume relating to arthropod-borne diseases in this series.

in mite population resulted from clearing or burning underbrush and grasses. Insecticides were not effective in destroying the mite, DDT proving disappointing in this instance.

Individual measures proved to be the only adequate protection against scrub typhus. One of the repellents developed for the anopheline mosquito, dimethylphthalate, was found to be effective also in repelling the scrub typhus mite. Experimentation [168] showed that impregnation of the clothing was the most successful method of use. Further research disclosed that benzyl benzoate, another mite repellent, persisted in clothing after several washings. Thereafter benzyl benzoate alone, or in combination with dibutylphthalate, was made standard treatment for clothing to prevent attack by mites.

In the Zone of Interior, although not known to carry any disease, chiggers produced extreme annoyance from bites, especially throughout the States in the South. Area control of mites was usually not recommended [169] although in some instances treatment with sulfur dust following removal of brush and weeds was advised. Chief reliance was placed on individual use of mite repellents.

Another species of mite which was of some military importance was the itch mite which produces scabies. Scabies became increasingly prevalent among the civilian populations in Europe as the war progressed. Proper personal hygiene measures and cleanliness of bedding, combined with periodic inspections and prompt diagnosis and treatment of cases, kept scabies within control.

Control of Lice. Since lice transmit epidemic typhus fever—historically a disease of armies—relapsing fever, and trench fever, it was considered essential to keep louse infestation under rigid control. Control methods included delousing of individual soldiers and disinfestation of clothing, equipment, and vehicles.

Because of the threat from typhus fever in Europe and the Middle East, one of the early research objectives sought by the Medical Department was an effective lousicide. In 1942 the Bureau of Entomology developed a preparation known as the MYL formula which was an effective killing agent. A portable field chamber for disinfesting clothing and bedding using methyl bromide ampules was devised to replace the bulky steam sterilizer formerly necessary.[170]

When DDT was turned over to the United States Government in the fall of 1942, it was immediately tested against the louse. The 10-percent dust was found to be a potent killing and disinfesting agent and all available DDT was earmarked for use in typhus-infested areas. It was found that effective control of lousiness could be achieved by dusting the individual fully clothed. In this manner it was possible to treat many infested civilians, refugees, and prisoners

[168] (1) Bushland, R. C.: Tests against chiggers in New Guinea to develop a practical field method for impregnating uniforms with dimethylphthalate for scrub typhus prevention. Am. J. Hyg. 43: 219-229, May 1946. (2) Also see Chapter VII.

[169] See footnote 149, p. 228.

[170] See Chapter VII, p. 253.

of war. Louse infestation among American troops was kept to a minimum, and the danger from typhus fever among our troops never materialized.[171]

Control of Fleas. Flea-borne diseases include bubonic plague and endemic typhus fever.[172] Both are primarily diseases of rodents, particularly rats, and are transmitted from rat to rat by fleas. Transmission to human beings occurs incidentally by the bite of the infected flea.

Great emphasis was placed upon rodent control as the primary means of destroying the fleas.[173] When it was found that DDT dust was highly effective against fleas, it was used in conjunction with rat poisoning campaigns. Burrows, runways, and rat harborages were dusted to reduce the flea population. In addition, houses in infected areas, and infested individuals were dusted with 10-percent DDT dust. Insect repellents, issued to American troops, were also found to be effective in repelling fleas.

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[171] For complete discussion of preventive action taken against lice in relation to epidemic typhus see chapter in volume concerning arthropod-borne diseases in this series.

[172] See chapters on these diseases in the arthropod-borne disease volume of this series.

[173] See Chapter VI, pp. 237-241.

CHAPTER VI

Rodent Control

William A. Hardenbergh
and
Joseph J. Gilbert

Rodent-borne diseases have been intimately connected with wars as far back as the Siege of Troy. Some of the great plague epidemics of the past resulted from migrations and troop movements incident to war. Because of this fact, in the partial mobilization of 1940, early consideration was given to the possibility of rodent-borne diseases, particularly plague and murine typhus, occurring among troops. While the latter disease had never seriously interfered with military operations, it was deemed to be of potential military importance.

Sylvatic plague has been prevalent for more than 40 years among ground squirrels and other wild rodents in our Western States. It gradually spread eastward and by 1940 had been reported in a number of localities east of the Continental Divide. Sylvatic plague is seldom transmitted to man; however, it presents a hazard to persons who come in close contact with wild rodents, and constitutes a possible source of plague epidemics. There is some evidence that the great plague epidemics of China of some 50 years ago had their origin in the sylvatic plague reservoir in the wild animals, especially marmots, of Manchuria.

Though it is generally accepted that the plague pandemic of the 14th century known as the "Black Death" originated in Central Asia, whence it spread to Europe as well as into India and China, only recently has proof for this assumption been established. Such proof appears in a book by John Stewart,[1] who describes the discovery by the Russian archeologist, D. A. Chwolson, of two Nestorian graveyards near the Iszyk-Kul Lake, an area well known to form part of the Central Asiatic plague focus. Inscriptions stating that the persons referred to had died of plague were found on three graves belonging to the years 1338 and 1339, and Chwolson also noted that the number of graves dating back to those years was exceptionally high. This evidence leaves no doubt that plague was rampant in Central Asia before Europe, India, and China were ravaged by the "Black Death."

Murine typhus, which is incidentally transmitted to man by rat parasites, has long existed in the South Atlantic and Gulf States. However, records regarding its incidence were so incomplete in 1940 as to prevent a reliable assay

[1] Stewart, John A.: The Nestorian Missionary Enterprise, the Story of a Church on Fire. Edinburgh, T. & T. Clarke Co., 1928.

of its general prevalence and importance. Further, it had been postulated that murine typhus might be passed from man to man by the louse, as is epidemic typhus,[2] and from the military viewpoint the latter disease was one of the most important ever known. For these reasons, murine typhus was considered to be a potential threat.

The necessity for a rodent control program in the United States was therefore indicated when limited mobilization began in 1940. The seriousness of the problem could not be determined, nor could its scope be established. However, in view of the potential danger that existed, it was thought necessary to initiate preparatory surveys and make tentative plans for effective action if such action were needed.

A similar question arose in connection with the Caribbean bases acquired in 1940. While it was not known that there were any infected rats or infective fleas in this area, disease records were neither complete nor current. Moreover, infection was always possible through air or water transport.

Potential problems in overseas theaters were tremendous. Human plague was prevalent in South America, Africa, the Middle East, India, Burma, China, and the East Indies. Sylvatic plague was also present in many of these areas. Murine typhus was reported in southern Europe, Central and South America, Africa, western Asia, and India. There was also the possibility that heavy rat infestations in combat areas would affect troop morale, as it did during the trench warfare of World War I.

These facts clearly indicated that it was necessary to give consideration to the establishment of rodent control programs both in the Zone of Interior and overseas. Although vaccination could confer a certain amount of immunity to bubonic plague, control of rats and of rat fleas remained necessary, especially in view of the hazard of murine typhus. Therefore, assembling of statistics on the incidence of plague and murine typhus was initiated, and steps were taken to establish policies and procedures and to train men for rodent control work. The first problem was that of sylvatic plague in our Western States. It was decided to initiate a partial control program directed against field rodents, and to utilize this program also to train personnel.

SYLVATIC PLAGUE CONTROL IN THE ZONE OF INTERIOR

The known prevalence of sylvatic plague in the Western States necessitated rodent control work at camps in that area, particularly in the Ninth Service Command. Funds were authorized for use in that work.[3] Early in the summer of 1941 work was begun at Fort Ord, which had an area of 31,319 acres; Hunter Liggett Military Reservation, 350,000 acres; Camp Roberts, 43,481 acres; and

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[2] Zinsser, H.: The Rickettsia diseases. Varieties, epidemiology and geographical distribution. Am. J. Hyg. 25: 430–463, May 1937.

[3] Telegram, SG to Surg 9th CA, 24 May 41. SG: 121.2-1 (9th CA)AA.

San Luis Obispo, 18,116 acres.[4] In September, following an investigation and recommendation by the Los Angeles Health Department, a control program was initiated at Fort MacArthur.[5] Eventually control operations were extended to include the airbase at Boise, Idaho; Camp Adair, Oregon; Camps Cooke and Beale in California; and most of the posts around the San Francisco Bay area, including those in Marin County.[6]

Methods of Control. The control of sylvatic plague is normally based on destruction of the rodents which harbor the parasites, the vectors of the disease. Poisoning is the principle method of control, supplemented to a minor degree by trapping, gassing, and shooting. In poisoning, various kinds of grain, previously treated with poison, are spread in or near the rodent burrows or feeding places. The established policies of the Fish and Wildlife Service of the United States Department of the Interior were followed in all ground rodent control work, as these had been proven by many years of field work to be effective and economical.

For the control of field rodents, reliance was placed mainly on the use of poisoned grain and carbon disulfide; both trapping and poisoning were utilized for mice and rats.[7] Early in 1941 Civilian Conservation Corps personnel were utilized for field rodent control, but later in the summer objection was made to their use on projects involving handling and application of poisons.[8] Thereafter civilian employees and soldiers were used for that work.

There is no record of the total amount of funds expended on ground squirrel control in the Ninth Service Command. During the fiscal year 1942, $15,700 was provided initially.[9] On 20 July 1942, $50,000 was made available for rodent control,[10] following a report by Dr. Karl F. Meyer of the Hooper Foundation, University of California, indicating that a high percentage of fleas from Fort Ord were infected with sylvatic plague.[11]

Cooperation with Other Agencies. In addition to the work done by the Army inside the camps, the United States Public Health Service, under its agreement regarding extramilitary sanitation,[12] carried on control measures in areas adjacent to the camps.[13] This work was done by the Plague Suppressive

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[4] (1) Ltr, Surg 9th CA to SG, 24 Jul 41, sub: Sylvatic plague control program, 9th CA. SG: 729.5-1 (9th SvC)AA. (2) Chart, "Rodent Control Program, Ninth Corps Area," undated. HD: 729.5 (9th CA).

[5] Memo, Lt R. S. Moore, Off of Surg 9th CA, for Col Beery, Surg 9th CA, 27 Sep 41, sub: Rodent control. HD: 729.5 (9th CA).

[6] (1) Ltr, N. E. Wayson, USPHS Plague Suppressive Measures, San Francisco, to P. D. Mossman, USPHS Liason Off 9th CA, 19 May 43. HD: 729.5 (9th CA). (2) Ltr, Lt Col F. H. Stover, SnC, Off of Surg 9th CA, to Col W. A. Hardenbergh, SnC, SGO, 5 Dec 42. HD: 729.5 (9th CA).

[7] See footnote 4 (1).

[8] Ltr, SG to Dir CCC, 29 Jan 42. SG: 729.5-1 (9th SvC)AA.

[9] Ltr, SG to Surg 9th CA, 28 Aug 41, sub: Sylvatic plague control. SG: 729.5-1 (9th SvC)AA.

[10] Ltr, SG to Surg 9th CA, 20 Jul 42, sub: Sylvatic plague on the Fort Ord military reservation. HD: 729.5 (9th CA).

[11] Ltr, Dr. K. F. Meyer, Dir Hooper Foundation, to Col J. S. Simmons, SGO, 14 Jul 42. HD: 729.5 (9th CA).

[12] Basic agreement is discussed in Ltr, Sec War to Fed Sec Admin, 30 Jan 40 and reply of 12 Feb 40. Additional letters authorizing utilization of Public Health Service which extend and implement this agreement are also in SG: 042.2-7.

[13] Ltr, Surg 9th CA to SG, 20 Aug 41, sub: Sylvatic plague control program, 9th CA. SG: 729.5-1 (9th SvC)AA.

Measures Office of that agency.[14] In California, surveys and studies were made by the State Department of Public Health. In general, the same methods of control were used, and the work inside and outside the reservation areas was closely coordinated.

The Fish and Wildlife Service of the Department of the Interior is responsible for the control of harmful and predatory animals.[15] One of the important duties of this organization is the control of ground squirrels and rodents, for which it maintains an organization of technically trained men. In addition to making available basic data on rodent control, the Fish and Wildlife Service provided laboratory services, prepared poisoned grain at the Denver Research Laboratory, and recommended personnel technically trained in rodent control for commissions in the Sanitary Corps.[16]

Close liaison was also maintained with the Hooper Foundation [17] and with the Western States, most of which had rodent control organizations. Thus by establishing working relationships with the Public Health Service, the Fish and Wildlife Service, and various State agencies, it was possible to provide an effective organization for rodent control while utilizing only a very small number of Army personnel. It was considered that this organization was adequate for the known needs and that it would furnish a nucleus around which a larger force could be built if necessary.

Program in the Ninth Service Command. In 1942 the sylvatic plague control program was intensified in the Ninth Service Command.[18] Six rodent control specialists, commissioned in the Sanitary Corps, were assigned to that service command. These officers usually had to be stationed at fixed posts, but through temporary duty details could be moved about to provide the necessary technical supervision for the work at the times and places it was most needed. Since poisoning is the most effective means of control, and as seasonal factors govern the effectiveness of poisoning, the rodent control officers supervised the work at several camps in rotation, moving south as the season advanced. Small groups of enlisted men and civilian employees were trained for duty at the various camps where ground squirrel control was desirable.

In order to avoid selection of additional campsites in areas heavily infested with sylvatic plague, campsite survey reports of all proposed camps in the Western States were reviewed carefully. The study of these reports also provided data on which to base plans for control or protective measures where these were needed.

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[14] For example, see Ltr, N. E. Wayson, USPHS Plague Suppressive Measures, San Francisco, to Dr. J. W. Mountin, USPHS, 15 Dec 42. HD: 729.5 (9th CA).

[15] Ltr, Act Sec of Interior to SecWar, 3 Jan 41, and reply, 25 Jan 41. SG: 720.5-1.

[16] (1) Ltr, W. E. Riter, Div of Predator and Rodent Control, Fish and Wildlife Serv, Dept of Interior, to Dr. J. W. Mountin, USPHS, 24 Sep 41, with incl. HD: 729.5 (9th CA). (2) Ltr, Dr. J. W. Mountin, USPHS, to Maj W. S. Stone, SGO, 26 Sep 41. SG: 729.5-1. (3) Ltr, SG to Surg 9th CA, 6 Jun 41, sub: Purchase of poison grain for sylvatic plague control. SG: 725.11-1 (9th SvC)AA.

[17] See footnote 11, p. 235.

[18] Annual Rpt, Med Br Hq 9th SvC, 1942. HD.

No cases of plague occurred among soldiers in the Zone of Interior. While it was not anticipated that plague would constitute a major problem in the Zone of Interior, the control activities undertaken were considered justified by the potential dangers. Moreover, this program provided excellent training for personnel who were later needed for rodent control overseas.

MURINE TYPHUS CONTROL IN THE ZONE OF INTERIOR

Murine typhus was known to be endemic in the Southeastern and Gulf States, particularly Alabama, Georgia, and Texas. It was believed that reporting of cases was inadequate; this precluded a sound evaluation of the incidence and importance of the disease. Conditions within Army camps were not generally conducive to the spread of typhus, consequently it was expected that there would be few cases reported among soldiers.

However, from the data at hand, the initiation of a rodent control program seemed justified to protect the health of the troops. It was therefore decided to establish rodent control measures at all posts, camps, and stations where rats were prevalent, and to cooperate, in so far as this could be done, with the Public Health Service and with State and city typhus control programs in communities frequented by soldiers.

Execution of the program was decentralized to the service commands in accordance with a general outline of the scope of the work to be done. The Eighth Service Command requested the assignment of a Sanitary Corps rodent control specialist to direct the work. The other service commands operated under the direction of the service command sanitary engineer and entomologist. In nearly all service commands Sanitary Corps personnel with experience in rodent control were discovered and utilized.

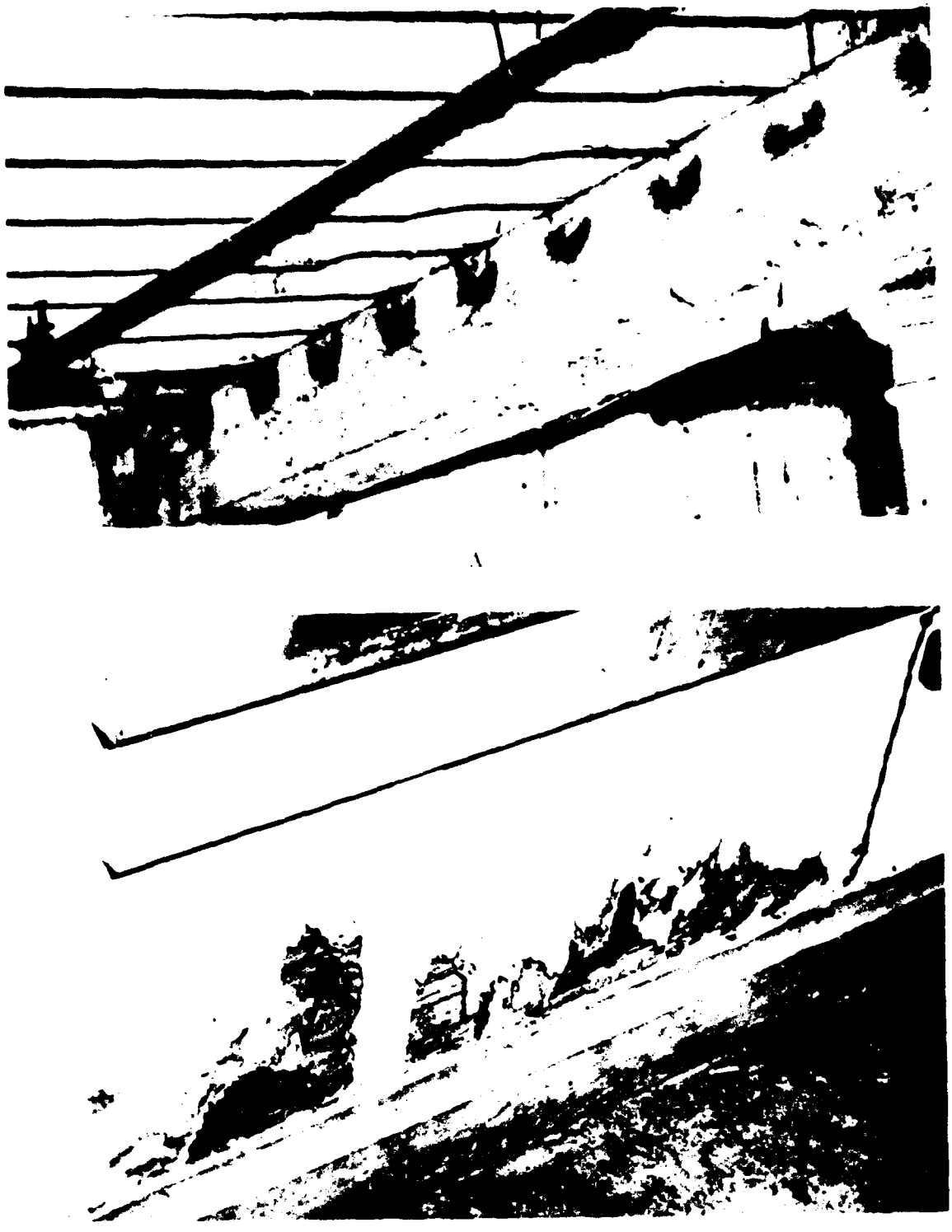
In the Eighth Service Command the program made use of the service command rodent control officer as an adviser and consultant to the various posts.[19] He worked with post surgeons and the sanitary engineers on surveys, and on trapping, poisoning, and rat-harborage eradication. (See Fig. 19.) Prior to the appointment of a special adviser to the repairs and utilities office of the service command engineer, this rodent control specialist also advised the various post engineers on damage prevention and rodent control.

In conjunction with the rat control work carried out in Texas by both the Public Health Service and the Texas State Board of Health, a DDT-dusting program to control rat fleas was begun in late 1944.[20] Rat runways, burrows, and harborages were liberally sprinkled with DDT dust. Good results were reported in reduction of the number of fleas and other parasites, and in 1945 the program was amplified and expanded to include several large cities.[21] The

[19] Annual Rpt, Med Br Hq 8th SvC, 1942. HD.

[20] Minutes of Meeting, NRC Committee on Sanitary Engineering, 27 Nov 44. HD: 040.

[21] "Lavaca County Typhus Control Program, as reported by Dr. Irons," Appendix A to Minutes of Meeting, NRC Committee on Sanitary Engineering, 4 Jun 45. HD: 040.



A

B

Figure 19. Evidence of rat infestation. A. Rat runway along beam. B. Typical rat damage to wall.

Army cooperated by making DDT available and by the loan of an entomoligist of the Sanitary Corps.[22]

In the Fourth Service Command the typhus and rodent control programs of the various State boards of health were strongly supported. Epidemiologic studies [23] were made of all cases of typhus among military personnel to determine, if possible, where the disease had been contracted. It was found, as a result of these studies, that much of the infection was occurring in communities far distant from military reservations, and consequently beyond the reach of control measures carried out in extramilitary areas by the Office of Malaria Control in War Areas of the Public Health Service. Accordingly letters were written by the service command sanitary engineer, for the signature of the commanding general, to the mayors of many municipalities where typhus was known to be prevalent. These letters called attention to the presence of the disease in the community, pointed out the measures available for control, and requested the mayor to establish a rodent control program in cooperation with the State and the Public Health Service.[24] As a result of this program, a great deal of corrective work was accomplished, but it is not known what, if any, reduction in the incidence of murine typhus was accomplished.

Methods of Control. The methods available for typhus control are those which reduce the number of rodents and include ratproofing of buildings, and poisoning and trapping of rats (Fig. 20). Ratproofing is costly and has never proved to be fully effective; poisoning and trapping require constant effort, since one campaign accomplishes only a temporary reduction in the number of rats. Thus typhus control imposes a heavy financial burden on any municipality, large or small. Another method for typhus control, designed to reduce the number of fleas on rats, was tried in the 1944–45 DDT-dusting program carried out in Texas. Reports indicated a marked reduction in parasites; there was no reduction in the number of rats and the effect on the incidence of typhus remains to be proved. DDT-dusting of rat runways and harborages was later carried out in connection with poisoning campaigns to minimize the danger of infected fleas escaping from the dead rats to domestic animals or man.[25]

Incidence. The incidence of murine typhus in troops in the Zone of Interior was low, and there were no deaths due to the disease. The typical case history indicated that exposure occurred in a drugstore, restaurant, or cafe in a civilian community, usually adjacent to the camps but sometimes many miles away. It is believed that no cases actually were contracted on a military post.

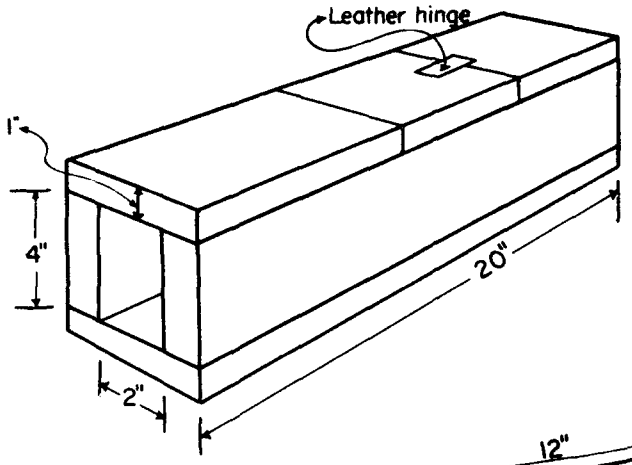
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[22] Minutes of 4th Meeting, Army Committee for Insect and Rodent Control, 28 Mar 45. HD: 334.

[23] See case histories and SG form 494, revised 2 Nov 44. HD: 710 (Typhus, Army, Investigations).

[24] Ltr, Col M. J. Blew, SnC, Hq 4th SvC, to Col W. A. Hardenbergh, SnC, SGO, 17 Jan 44, with 12 incls. HD: 729.5 (Typhus Control).

[25] TM 5-632, Insect and Rodent Control, Oct 1945.



Construction of bait box or feeding station.

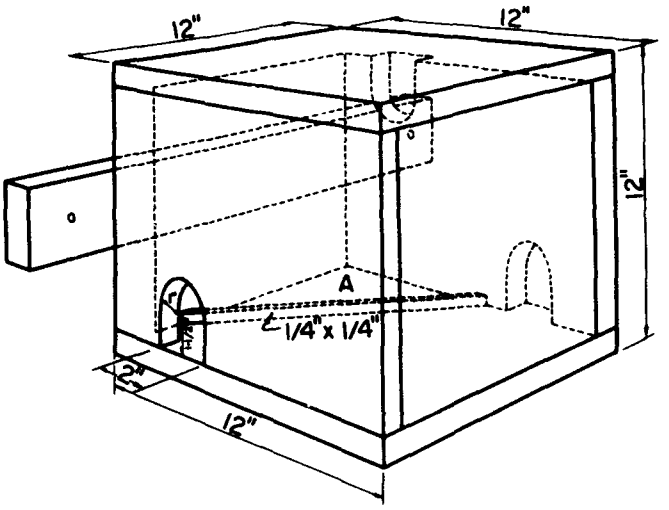
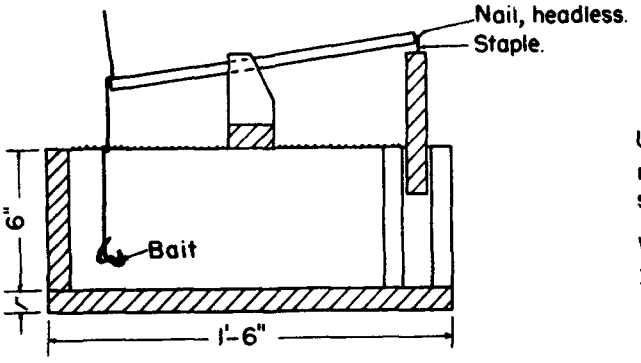


Diagram of a bait box showing 2-inch openings (Courtesy of Fish and Wildlife Service, U.S. Department of the Interior).



Longitudinal Section of Box Trap

Use old scrap lumber free from new wood odor, well dried and seasoned.

Wire cover not less than 16 guage, 3/8-inch mesh.

Figure 20. Examples of recommended bait boxes and box traps for poisoning rats.

RODENT CONTROL IN THE ZONE OF INTERIOR

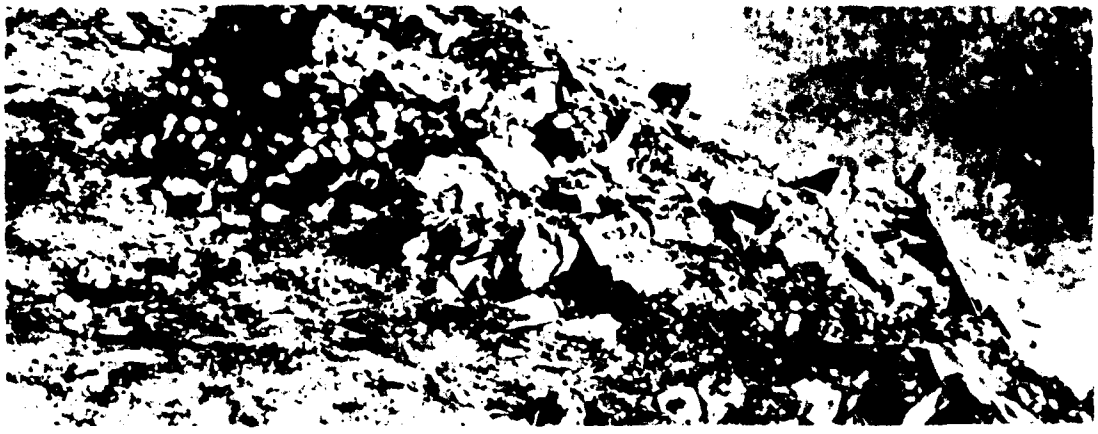
Administrative Responsibility and Policy. The responsibility for the actual work of rodent control in the Zone of Interior rested with the Repairs and Utilities Division of the Office of the Chief of Engineers.[26] Moreover, many of the conditions within a camp which promote or retard rodent population were under control of the post engineer. Within that category were the post dump, which was perhaps the most important rat harborage, waste lumber piles, and other salvage areas. The responsibility of the Medical Department was limited to inspections and recommendations.[27] In practice, Medical Department personnel had to supervise the work and often actually had to perform some technical portions of it. The necessity for close working relations with Corps of Engineer personnel was apparent.

As an early step in rodent control at Army posts, personnel of the Medical Department held conferences with members of the Repairs and Utilities Division to acquaint the latter with the problem and recommend plans for control work. The repairs and utilities officers in the various service command headquarters were informed of the general plans through Corps of Engineer channels and also by the Sanitary Corps engineers in each service command surgeon's office. The same general procedure was followed at post level. As a result of this coordination and understanding, the program operated smoothly and with a minimum of supervision.

In the spring of 1943 the Chief of Engineers established an Insect and Rodent Control Section in the Repairs and Utilities Division.[28] Capt. W. D. Reed, a Sanitary Corps entomologist, was assigned to direct the work and close liaison was maintained with Sanitary Corps officers of the Medical Department. The program of the Engineers was also broadened to include prevention of rodent damage to stored products. The Medical Department was in no way concerned with this phase of the work, but its rodent control program was strengthened because of it. Greater attention was paid by post engineers to ratproofing, elimination of rat harborages, and to poisoning and trapping. Another important program of the Corps of Engineers from the viewpoint of rat control was the stress laid on the use of sanitary fills (Fig. 21), with the consequent elimination of hundreds of dumps. Where the dumps gave evidence of heavy rat infestation, poisoning or gassing was utilized to reduce the rat population before the dump was covered and abandoned, thus preventing migration of the rats, when food became scarce, to nearby buildings.

Rodenticides. The lack of good rat poisons in the early stages of the war handicapped control work. Red squill was a war casualty since the better grades of squill came from the Mediterranean area and imports of these ceased

[26] AR 100-80, 10 Aug 42.
[27] AR 40-205, 31 Dec 42.
[28] Reed, W. D.: Entomological engineering. The Military Engineer 37: 1, Jan 1945.



A



B

Figure 21. A. Example of unsanitary dump which had large rat population. B. One night's catch of rats from this dump. This area was later made into a sanitary fill.

early in the war.[29] After the occupation of North Africa, squill again became available, but the quality was poor. Even when reinforced, it rarely attained prewar standards. A disadvantage of squill was its deterioration in storage, so that stocks for overseas use could not be accumulated. Thallium sulfate was one of the most effective rodenticides. The United States production never exceeded 3,500 pounds per year, and this decreased materially during the war. Total world production before the war amounted to about 12,000 pounds annually, the Low Countries being the principal overseas producers, followed by France and Germany. The failure of the import supply made necessary strict control of the use of thallium sulfate. It was reserved generally for overseas plague control work. A stock pile of 800 pounds was maintained by the Office of The Quartermaster General as a reserve and was issued only on approval of The Surgeon General.[30]

Barium carbonate therefore had to be used for rat control during the early months of the war.[31] This is a weak poison, not highly effective. Later zinc phosphide became available. This was a reasonably satisfactory poison and was used for general rodent control in both the Zone of Interior and overseas.[32]

Active steps were taken to develop more effective poisons. The National Research Council, by contracts with various organizations, and the Fish and Wildlife Service sponsored the necessary research.[33] Alpha naphthylthiourea (ANTU), one of the poisons extensively tested, was found to have apparently a selective action, being specific for wild Norway rats.[34] Sodium monofluoroacetate, also called "1080," was perhaps the most effective poison developed, and in the closing months of the war was fully tested in the field.

Samples of sodium monofluoracetate were widely distributed for testing both in the Zone of Interior and overseas; [35] the Ninth Service Command was to test it for use against field rodents and the Fourth and Eighth Service Commands for use against rats. An instruction sheet accompanying the sample described sodium monofluoroacetate briefly and outlined the purpose of the test and the suggested test procedures. It also gave directions for poison concentrations to be used for the various rodents, methods of distribution, precautions, and data to be covered in the reports.

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[29] Memo, Chief Sanitation Br SGO for Chief Supply Serv SGO, 11 Feb 43, sub: Rat poisons. HD: 729.5 (Supplies).

[30] Memo, QMG for CG ASF (Reqmts Div), 27 Oct 44, sub: Rodenticides and rodenticide control equipment, with inds. HD: 729.5 (Supplies).

[31] See footnote 29.

[32] See footnote 30.

[33] Minutes of 2d Meeting, Rodent Control Subcommittee of NRC Insect Control Committee, 30 Nov 44. NRC files, Chemical-Biological Co-ordination Center.

[34] NRC Insect Control Committee, OSRD Co-ordination Center Review No. 1, A review of the physiolcgical and toxicological action of alpha naphthylthiourea. HD.

[35] Ltrs, CG ASF to CGs 1st, 4th, 5th, 8th, and 9th SvCs, and CG SWPA, 20 Apr 45 and Chief Health Off Panama Canal Dept, 9 Jun 45, sub: Field test of rodenticide sodium fluoroacetate. SG: 438 (for each command).

Results of the field tests were surprisingly good.[36] A test of "1080" on rats was made at a garbage dump close to large Army warehouses near Ogden, Utah. It was estimated that more than 10,000 rats were killed in one evening and night. At the Gulfport Army Air Field, Mississippi, tests were made with meat baits and with water baits. The reported degree of control was "absolute." At Harlingen Army Air Field, Texas, a series of 13 experiments led to the conclusion that sodium monofluoroacetate was far superior to all other rodenticides that had been used. The Rodent Control School in the Southwest Pacific, after a number of field tests, concluded that this poison was more acceptable to rats than zinc phosphide or thallium sulfate, was as readily accepted as unpoisoned baits, that only a small amount was required for kill, and that high concentration might be used. All the reports received were wholly favorable regarding the efficacy of this poison. It was found to be effective when used with bait or dissolved in water. Most of the reports rated sodium monofluoroacetate on a par with or above thallium sulfate.

OVERSEAS RODENT CONTROL

A study of data on the world incidence of plague and murine typhus indicated that rodent control might become necessary in almost any place in the world. It was known that plague existed in 1943 in Dakar, French West Africa, and in 1944 a serious epidemic occurred there. The disease also broke out near Suez during the closing months of 1943 and the spring of 1944. Plague was considered a serious threat all along the China Coast. It was reported to exist in some Japanese cities, though the last cases reported from Yokohama occurred in 1926. For these reasons it seemed necessary to formulate a positive program to train and equip personnel for rodent control in time to meet the needs of our forces in the Chinese and Japanese areas.

Preliminary Plans for Control Units. Tentative plans were therefore drawn during 1944 for a rodent control unit organization.[37] Plans were based largely on the experience gained with the highly successful malaria control and survey units, some of which were already being employed on rodent control work in the Pacific.[38] Inasmuch as most of the personnel of these units were well-trained technically, two men were selected from each of a number of units and given a short training in rodent control. These men then served as a nucleus for further training of other personnel. A disadvantage of utilizing malaria control and survey units was that their equipment was not adapted to effective control of rodents.

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[36] NRC Insect Control Committee, Rpt No. 163 [OSRD Co-ordination Center Review No. 7], A summary of field reports on 1080 (sodium fluoroacetate). HD.

[37] Memo, Capt M. W. Kelly, SnC, for Dir Sanitary Engr Div SGO, 3 Aug 44, sub: Rodent control unit. HD: 729.5 (Unit Orgn).

[38] For example see Quarterly Rpt, 12th Malaria Control Unit SWPA, 1944-1. HD.

A list of equipment for rodent control in the Pacific areas [39] was prepared for the Civil Affairs Division of the War Department Special Staff. A unit of equipment was based on that required for an intensive 10-day campaign in an urban area of 100,000 population. It consisted of 2,000 rattraps, 200 pounds of calcium cyanide, 12 calcium cyanide foot pumps, and 60 pounds of zinc phosphide. Eleven units of these supplies were to be purchased and stored in the various Pacific areas for distribution as needed in case of a plague outbreak.

Survey of Needs by Theater. Early in 1945, in order to obtain information on which to base an estimate of the needs for rodent control, a letter was addressed to "Commanders of all theaters, defense commands, departments, and base commands" requesting a general factual report "as to the rodent problems in your command, and the control measures now in effect. Since the measures for control depend to a considerable extent upon habits and characteristics of the local rodent population, information from your command will be helpful in developing more effective rodenticides, equipment, and control methods."[40]

Replies [41] from the Mediterranean theater indicated that rodents were, at most, a minor problem, causing some damage to supplies but no disease; however, in the Peninsular Base Section, damage to supplies and equipment, chiefly by mice, amounted to $2,500 per month. The European theater reported slight infestation, and no important damage to supplies. The Canadian, Alaskan, Newfoundland, and Northwest Service Command areas also reported the problem to be small and under satisfactory control. The South Atlantic theater and Caribbean Defense Command reported minor infestation and no problems of disease. The Bermuda Base Command reported heavy infestation of rodents but no disease.

The 113th General Hospital in the Persian Gulf Service Command reported no problem of rodent-borne disease. The India-Burma theater reported no rodent-borne disease in United States troops, but a heavy infestation of rodents outside United States Army bases, indicating the need for a rodent control specialist. The Africa-Middle East theater reported a potential health problem in Palestine, Egypt, and Libya; some bubonic plague among civilians in Tunis, Oran, Casablanca, Marrakech, and Algeria, but none in Army installations; and plague among civilians in West Africa.

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[39] Memo, Lt Col J. J. Gilbert, SnC, for Dir Civil Public Health Div SGO, 24 Oct 44, sub: Rodent control in Far East. HD: 729.5 (Gen).

[40] Ltr, TAG to Comdrs all Theaters, Def Comds, Depts, and Base Comds, 14 Mar 45, sub: Rodent survey and control. HD: 729.5.

[41] (1) Reports of rodent survey from Peninsular Base Section (Mediterranean Theater of Operations), Western Hemisphere commands, and Persian Gulf Command are filed in HD: 729.5. (2) Reports from the Mediterranean, European, India-Burma, Africa-Middle East, China, Southwest Pacific (USAFFE), and South Pacific (POA) theaters are filed in SG: 729.5 (1945) (for each theater).

The China theater reported that rodent infestation was and always would be a serious problem in all areas of that theater:

> Constant control programs must be maintained to reduce the dangers of rodent-borne diseases. Bubonic plague is endemic in many areas . . . and it is believed advisable that trained personnel should be available to conduct plague surveys and maintain extensive control programs in and around all military installations.

In the Southwest Pacific rats were prevalent, but it was not considered that rodents offered a health problem except in the instance of an epidemic of scrub typhus which was attributed to rats. To some extent rats affected morale. In the South Pacific constant control was necessitated by migration of rats from the jungle and there were reports of rats biting sleeping soldiers.

Organization and Equipment of Units. In view of the fact that special rodent control personnel were requested by several important theaters, including India-Burma, China, and the Pacific areas, the formation of rodent control units with an organization similar to that of malaria control units was deemed necessary. Accordingly, a tentative table of organization and equipment for such a unit was prepared early in 1945.[42] The table provided for 3 officers and 12 enlisted men. The officers were a rodent control specialist, a sanitary engineer, and an entomologist. The personnel and equipment were considered adequate for an effective program in an urban area of 100,000 population, or a rural area of 200 square miles, utilizing 100 to 200 civilian employees. The functions of the unit were to be: to conduct rodent-borne disease and rodent surveys; to organize and conduct rodent control programs; to act as consultant on rodent control problems; to supervise natives or prisoners of war in the control program; and to train Army or other personnel for the work.

A copy of the proposed table of organization and equipment was sent to several overseas theaters with the request that it be reviewed and the Office of The Surgeon General advised in regard to its adequacy, the probable requirements for such units in 1945 and 1946, and other comments and recommendations. As a result of these letters, the following information was obtained:[43]

Theater	*Adequacy of proposed T/O&E*	*No. of units required 1945–1946*
China	Slight revisions	20
European	Slight revisions	1
India-Burma	Adequate	1
Mediterranean	No comment	0
Middle East	Adequate	1
Pacific Ocean Areas	Adequate	3
Southwest Pacific	More laboratory equipment	10
Total		36

[42] T/O&E 8-500, C2, Medical Service Organization (proposed). HD: 729.5 (Unit Orgn).

[43] Ltrs, SG to CG each Theater, attn Surg, 21 Mar 45, sub: Rodent control, with incl, "A Proposed Infectious Rodent Survey and Control Team"; and all replies are filed in HD: 729.5 (Unit Orgn).

Of the units required by the China theater, 5 were for 1945 and 15 for 1946. The Southwest Pacific did not contemplate using any units during 1945, but estimated that 10 such units would be required for 1946. Only 2 of the 3 units requested by the Pacific Ocean Areas were desired for 1945.

As a result of these replies from the theaters and the recommendations contained in them, the proposed organization was revised.[44] In order to give greater flexibility, the number of enlisted personnel was increased to 13 instead of 12 men and the unit was divided into a headquarters section, a survey section, and a control section. A rodent control officer with the rank of major was to head the unit, the survey section commander was to be a captain with qualifications of an entomologist, and the control section commander a captain, sanitary engineer.

The headquarters unit was intended to provide command and administrative personnel for 2 to 10 survey and control sections, as needed. It consisted of 1 major and 1 enlisted man. The survey section of 1 officer and 4 enlisted men was designed to conduct rodent and rodent-borne disease surveys. The control section of 1 officer and 8 enlisted men was intended to perform or supervise the work of control and to provide training facilities for additional personnel. Specific qualifications as well as unit training were required of the enlisted personnel.

Suitable equipment was planned so that the survey and control sections would be able to operate independently. Among the special technical equipment proposed were 2 special Medical Department chests, rifles, shotguns, 5 vehicles, bait buckets, traps, specimen bags, and fumigant foot pumps. The Medical Department chests had sufficient equipment for an officer to make a special survey or to conduct a small control project.

The end of the war in the Pacific eliminated much of the need for these units. In most instances, malaria control and survey units already in the area were utilized for immediate problems. Therefore the proposed table of organization and equipment was not officially approved and none of the units was ever actually organized.

SPECIAL PROBLEMS

Captured Areas in the Pacific. When Pacific operations were planned, the need for rodent control was considered. All available data were gathered for each area on local conditions favoring rodent-borne diseases, such as records of plague incidence, general sanitation, and prevalence and types of rodents.[45] With these data at hand, recommendations were made for appropriate rodent and plague control measures and personnel needed to carry them out.[46] It

[44] TOE, Infectious Rodent Survey and Control Detachment (proposed). HD: 729.5 (Unit Orgn).

[45] An example of the data utilized is OSRD (NRC) Insect Control Committee Rpt No. 54, "Rats and Mice (Family Muridae) of Burma, Siam, . . ., and all Pacific Islands, including Australia and Japan." HD.

[46] See footnote 40, p. 245.

was believed that rodent control might become a problem in certain of the captured enemy seaports. Provision for rodent control supplies were included in the equipment designated for each Civil Affairs Division unit in the Far East.[47] A rodent control officer of the Sanitary Corps was assigned to military government in the Southwest Pacific.[48] He conducted surveys and acted as adviser on rodent control problems. He also assisted in training sanitary engineers and members of malaria control and survey units for this work.[49]

Rodent Control Bulletin. There was need for an Army publication which outlined the policy of The Surgeon General in respect to rodent control, together with suggested methods to be employed for this purpose. War Department Technical Bulletin, TB Med 144 "Rodent Control," dated April 1945, was prepared by the Sanitary Engineering Division. This bulletin served as a guide to Army personnel for effective rodent control. Included in the bulletin were paragraphs on the need, responsibility, and methods of control; recommended construction of bait boxes and traps (Fig. 20); poison formulas; and a suggested table of organization and equipment for infectious rodent survey and control teams which could be organized in the field as needed.

Inactive Installations. A directive [50] prepared on the sanitary procedures to be followed at installations declared inactive—a problem that arose after the defeat of Germany and the consequent reduction in the size of the Army—recommended that dumps be covered with earth and the dumping area be restricted to the absolute minimum. The directive advised that a thorough poisoning program be carried out prior to covering dumps, in order to prevent migration of rats to nearby areas when their food supply was exhausted. It recommended that when a station was to be closed, all poisoned baits and grains, stores of rodent poisons, and dangerous traps should be removed.

Plague Outbreak in Dakar. In April 1944, a plague outbreak among civilians in Dakar, French West Africa,[51] necessitated the sending of a Sanitary Corps officer [52] to this area to aid in the control of rats and bring the outbreak under control. Five hundred and sixty-seven cases of plague were reported, with 514 deaths—a case fatality rate of 91 percent. All cases were in Negroes except 1 in a Syrian and 3 in French Europeans. None developed in American personnel. The mode of transmission of the epidemic remained in question, but it was believed that the disease was transmitted from person to person by the house or body flea (*Pulex irritans*) or the body louse, as in-

[47] TB Med 149, 17 Mar 45.

[48] Ltr, Brig Gen J. S. Simmons, SGO, to Brig Gen G. B. Denit, USASOS SWPA, 1 Dec 44. HD: 710 Plague.

[49] Quarterly Rpt, 93d Malaria Control Det SWPA, 1945-3. HD.

[50] "Sanitary Procedures to be followed at Installations Declared Inactive or Surplus," undated. HD: 720 Water and Sewage.

[51] Lewis, P. A.; Buehler, M. H., and Young, T. R.: A report on plague in Dakar, Senegal, French West Africa, 1944. HD: 710 Plague (Dakar).

[52] Officer did not arrive in theater until September 1944. Annual Rpt, 93d Sta Hosp and Surg Base Comd WASC USAFIME, 1944. HD.

fected rats were found only at the beginning of the outbreak, and it was questionable if any cases of primary pneumonic plague occurred. The epidemic was brought under control in November 1944.

The control measures used by the Americans to combat this plague outbreak consisted of immunization of American personnel and of natives working in American installations; elimination from Army camps of the majority of the native workers and strict supervision of the hygiene of those retained; restriction of American personnel to plague-free areas except when on essential official business; systematic treatment of natives and dwellings throughout the native section with DDT as an anti-flea measure; and a continuous rat control program in American installations.

SUMMARY ON RODENT CONTROL OPERATIONS

The Army's rodent control program included two phases: protection of foods and supplies, which was a function of the Corps of Engineers; and disease prevention, which was a responsibility of the Medical Department. Rodent control in warehouses, posts, and supply depots greatly reduced the losses to goods in storage and probably paid exceptional dividends. However, the actual costs remain unknown because accounting methods did not differentiate sufficiently to permit even an approximate estimate of the money spent in this work.

The preventive work done by the Medical Department must be considered entirely in the light of an insurance program. Aside from the money spent on sylvatic plague control measures and on equipment for control units, neither of which was considerable, all other costs were negligible. No rodent disease problem of a serious nature ever developed; whether the measures that were adopted and carried out were responsible will never be known. The fact remains that, for an exceptionally small outlay, the Army was ready with trained personnel, sound policies, and necessary equipment to meet any emergency.

The rodent control program brought trained men into the Army and resulted in the development of policies which, in peacetime, should greatly reduce losses due to insect and rodent damage to supplies, foods, and equipment. Moreover, it provided a background which should be valuable in any future war or emergency. It is almost certain that any future war will be fought in areas where rodent control will be a requisite, both for health protection and to prevent excessive damage to stores and to the morale of personnel.

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CHAPTER VII

The Research Background of Insect and Rodent Control

William A. Hardenbergh

When the first formal preventive medicine organization was created in the Office of The Surgeon General early in 1940, it was appreciated that, if the United States should become involved in the war, the control of insect vectors of disease would present a staggering problem. Many areas already affected by the war had long suffered from malaria, typhus, and other diseases transmitted by insects; and it seemed likely that other areas, some of them presenting even greater disease hazards, would become battlegrounds.

Judged in the light of conditions in the areas where our armies might operate, the methods then available for the control of insect-borne diseases were totally inadequate. Aside from quinine, atabrine, and a few other drugs, there were available for the control of malaria the time-honored methods of mosquito eradication—oiling and draining, spraying with hand-operated dust guns, and screening. Pyrethrum (which was soon to be in seriously short supply) was the only effective insecticide, and citronella the only available repellent. Powdered sulfur was used to control louse infestation. As in World War I, steam sterilizers were employed for the disinfestation of bedding and clothing.

Few of these methods were well adapted to the protection of armies in the field, especially under the conditions of rapid movement; nor were they effective enough to justify the belief that they would provide any adequate degree of protection in those areas where the incidence of insect-borne disease was high. The need for developing more effective materials, methods, and equipment was clear.

The Surgeon General's Office centralized the planning for developing better products and better methods for insect control in the sanitation section of the preventive medicine organization. Maj. (later Col.) William S. Stone, MC, reported early in 1941 and was placed in charge of this work.

EARLY STEPS IN RESEARCH ORGANIZATION

Initial steps were taken in 1940 to institute study and research. At the suggestion of Lt. Col. (later Brig. Gen.) James S. Simmons, in charge of preventive medicine, The Surgeon General requested the National Research Council to cooperate in the necessary studies. The National Research Council formed a Committee on Chemotherapeutic and Other Agents in May;[1] and on 19 June 1940 one of the subordinate groups of this committee, the Subcommittee

[1] Ltr, Dr. L. H. Weed, Div of Med Sciences NRC, to Col C. C. Hillman, SGO, 22 May 40. HD:040 NRC (Chemotherapeutic and Other Agents).

on Tropical Diseases,[2] held its first meeting. An organization was thus created and working relationships were established which were potent factors in solving the many problems of tropical disease control that arose during the war. Furthermore, this arrangement brought to the Medical Department the knowledge and skills of many of the nation's leading authorities in the field of tropical medicine.

In the meantime, utilizing the resources of the Medical Department, a search was initiated to find better agents for insect control. The potential needs of the Army were outlined. Contacts were made with industry and with existing organizations engaged in insect control to determine what agents and what methods might be available for or adapted to Army use.

As a result of this work and in consideration of the probable needs of the Army as viewed in the light of world conditions, The Surgeon General [3] requested the National Research Council to consider the advisability of using cutaneous application of insect repellents and, if advisable, to evaluate existing preparations and initiate development of new ones. He also requested that the Council recommend insecticides to be used in the treatment of human infestations with lice and scabies.

The Subcommittee on Tropical Diseases, on 13 October 1941, recommended that a formal research program on insect repellents and insecticides be carried out jointly by the Committee on Medical Research, Office of Scientific Research and Development, and the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. On 26 February 1942 the Bureau of Entomology [4] contracted for a program of research, including the development and testing of a satisfactory insecticide.

A research laboratory had been established by the Bureau of Entomology at Orlando, Florida, in 1931. The primary purpose of this laboratory was to study the various phases of mosquito control. However, the facilities available were such that the research program on lousicides, insecticides, and repellents was centered there. The Bureau of Entomology also had a large laboratory at Beltsville, Maryland, and the activities of this laboratory were channeled into research allied to military needs as quickly as possible.

RESEARCH AT ORLANDO, FLORIDA

The first objective of the Orlando laboratory was to appraise quickly and in a simple way the potential values of existing materials and methods for insect

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[2] Minutes of 1st Meeting, NRC Advisory Committee on Tropical Diseases, 19 Jun 40. SG: 040.9-10.

[3] Ltr, SG to Dr. L. H. Weed, Div of Med Sciences NRC, 28 Aug 41, sub: Insect repellents and insecticides to be used for the treatment of skin infestation. SG: 438.-1.

[4] Memo, Dir Sanitation and Hygiene Div SGO for Chief Prev Med Serv SGO, 4 Apr 45, sub: Chronology of agencies involved in the investigation of insecticides and insect repellents. HD: 725 (DDT Committee).

control. During the course of the research program [5] some 10,000 chemicals, chemical formulations, or items of equipment were studied. Of these, perhaps a dozen or more reached a state of practical use; but in this small number were a few of epochal importance.

The project given highest priority during the early stages of investigation was the development of a killing agent against human lice. Of the three species of lice affecting man, the body louse (*Pediculus humanus corporis*) was considered most important since it is the vector of typhus fever. Even though louse-borne typhus had always been one of the major diseases of wartime, no satisfactory method of control had been developed. Measures previously employed for controlling louse infestation in troops—mainly steam sterilizing of clothing and bedding, and bathing—were ineffective under, and unsuited for, mobile field and combat conditions; and were most difficult to apply effectively to civilian populations.

In carrying out the louse-control studies, about 7,500 chemicals were tested, of which about 400 were of sufficient promise to justify work beyond the primary sifting procedure. The methods used involved the necessity for maintaining a large colony of lice—25,000 to 75,000—and the employment of human subjects for feeding and testing (Fig. 22). Many of the chemicals were highly effective at the time of application, but had no lasting effect; some had the ability to kill louse eggs also. Finally, as a result of the studies, a louse powder was formulated which contained the following ingredients:

	Percent
Pyrethrins (20% pyrethrum extract)	0.2
N-isobutylundecylenamide (synergist)	2.0
2,4-dinitroanisole (ovicide)	2.0
Isopropyl and diisopropyl cresoles (antioxidants)	0.25
Pyrophyllite (diluent) to make	100.00

This preparation, called the MYL formula, was recommended for adoption in August 1942.[6] It was the most effective agent available for control of body lice, head lice, crab lice, and fleas until the advent of DDT. It had rapid killing action and, when applied at the rate of 1 ounce per garment, provided residual protection for about a week.

During the same period, the use of fumigants as delousing agents to replace the cumbersome steam sterilizer was investigated.[7] Methyl bromide was found to be highly effective and methods for using it in mass delousing operations were developed, utilizing the rapid vaporizing action of the chemical. Both insects and ova were destroyed. A light and readily portable field chamber was devised for disinfesting clothing and bedding. Using this, a fumigation

[5] Knipling, E. F.: Insect control investigation of the Orlando, Fla., laboratory during World War II. *In* Annual Report of the Smithsonian Institute, Washington, 1948, pp. 331–348.

[6] Memo, SG for CofEngrs, 19 Aug 42, sub: Repellents for flying insects. HD: 725 Insecticides and Repellents.

[7] Latta, R., and Yeomans, A. H.: Methods and equipment for fumigation of clothing infested with body lice. J. Economic Entomology 36: 402–404, Jun 1943.



Figure 22. The body lice, clinging to small pieces of cloth, receive a human blood meal sufficient to satisfy them for 12 hours. U. S. D. A. photograph by Knott.

and bath company of 88 men could delouse the clothing of an entire division in 48 hours. Later a gas-proof bag was developed for use by small groups, or even individuals. A 30-cc. ampule of methyl bromide was employed for the bag. Methyl bromide was used extensively to the end of the war, especially for disinfesting clothing and bedding of troops and prisoners of war entering the United States from overseas.

At the Orlando laboratory, more attention was given to research on mosquito and malaria control than to any other project.[5] This was justifiable, because mosquitoes were the most important of all insects in their potential influence on the war. Research was concentrated in three major sections: (1) larvicides, (2) insecticides for adult mosquitoes, and (3) repellents. The research work involved rearing enormous numbers of mosquitoes as many as 50,000 mature larvae or adult *Anopheles* were needed each day at the peak of the research program.

The larvicide program aimed at the development of new agents and the increased efficiency of known agents. Relatively little progress was made in this field of research between the starting of the program in October 1942 and the first trials of DDT as a larvicide in February 1943. The same was generally true of the program for the control of adult mosquitoes, though one val-

[5] See footnote 5, p. 253

uable development was perfected. The liquefied-gas method of dispersion, generally described by the term "aerosol," which had been discovered previously by Goodhue and Sullivan,[9] was utilized in the development of the aerosol bomb. This had progressed sufficiently by August 1942 to permit tentative specifications for manufacture to be prepared.[10] First deliveries to the Army were made in November 1942; and by January 1943 the bombs were being issued to troops in highly malarious areas at the rate of 150 per 1,000 men per month;[11] in March, the allowance was increased to 225; and in July to 300 per 1,000 men per month.

Extensive experimentation was directed toward more effective application of larvicides and of adult killing agents by means of airplanes. When DDT became available, it gave an added impetus to this work. Methods and equipment for dispersing DDT compounds by both observation and combat planes were developed.

The need for an effective insect repellent was urgent, because soldiers in many conditions of field service could not be protected adequately against mosquitoes. Before the war little had been done in the development of repellents, though in New Jersey a compound, 2-ethyl-1,3-hexanediol, designated Rutgers 612, had been developed by workers at the Rutgers Experiment Station. In the Orlando research program, several thousand repellent materials were tested. The first objective was to evaluate those available and to determine the efficiency and safety of use of the promising ones.

Within 6 months after research was initiated, 3 materials were recommended to the Army for use.[12] These were dimethylphthalate, 2-ethyl-1,3-hexanediol (Rutgers 612), and n-butylmesityloxide oxalate (Indalone). The latter was the least satisfactory, from an overall viewpoint, but it had to be used initially because production of Rutgers 612 could not be stepped up at once to produce a quantity sufficient to meet the Army's needs. By December 1942 tests were completed on dimethylphthalate, including tests for repellency, lasting ability, and harmlessness to users. It was found to be equal to Rutgers 612 in repellent value and it was readily produced in quantity. Later it was found to have additional values, being effective against both sandflies and mites. The use of dimethylphthalate in the control of scrub typhus in the Southwest Pacific and the China-Burma-India theaters was an outstanding contribution to the health and morale of the troops.

Since each of these repellents—dimethylphthalate, Rutgers 612, and Indalone—appeared to be superior to the others under certain conditions of use or against certain insects, it was recommended that they be combined in the proportions of 6 parts of dimethylphthalate, 2 parts of Rutgers 612, and

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[9] Goodhue, L. D.: Insecticidal aerosol production; spraying solutions in liquefied gases. Indust. Engin. Chem. (Indust. Ed.) 34: 1456–1459, Dec 1942.

[10] Ltr, SG to CofEngrs, 26 Aug 42, sub: Pyrethrum aerosol insecticidal spray. SG: 438.-1.

[11] Memo, SG for QMG, 25 Jan 43, sub: Suggested basis of issue for pest control supplies. SG: 438.-1.

[12] Minutes of Conference on Insect Repellents, 12 Nov 42. HD: 040 Insect Control OSRD.

2 parts of Indalone. This so-called 6–2–2 repellent was adopted for standard issue.[13] Procurement was initiated and the repellent issued to troops on a strength basis, varying from 335 2-ounce bottles per 1,000 men per month in areas where insects were prevalent for only a short period during the year to 3,000 per 1,000 men per month in certain tropical areas.[14]

Work was continued on repellents with the aim of developing a cosmetically acceptable compound that would protect the user from attack for 10 hours, or overnight. This aim was not attained. Though promising chemicals were found, none appeared to be superior to the three repellents already developed, nor to the 6–2–2 mixture of them.

Another major phase of investigation was centered on the control of mites and chiggers. In the 1941 and 1942 maneuvers in the Southern States, there were a considerable number of hospital admissions of military personnel due to dermatitis and cellulitis resulting from chigger bites. Later, in the Southwest Pacific and the China-Burma-India theaters, scrub typhus occurred in sufficient numbers to present a hazard to both health and morale. Fortunately, the earlier work at Orlando had developed an agent which could be used against



Figure 23. Mosquitoes pass over arm treated with a repellent (left) to untreated arm. Straps make it easier for the subject to keep his arms in position for 4 or more hours and the mirror enables him to make the count of mosquitoes on each arm. U. S. D. A. photograph.

[13] Ltr, SG to QMG, 1 Nov 43, sub: Repellent, insect, 2-oz bottle. SG: 438.-1.
[14] WD Cir 151, 17 Apr 44.

the vector of this disease. This agent was dimethylphthalate, one of the three repellents developed against mosquitoes. When applied to socks, cuffs, and other openings in clothing as a barrier, it provided a high degree of protection against chiggers. (See Fig. 23.) Later, in the Pacific, Sanitary Corps officers working with the United States of America Typhus Commission developed methods whereby dimethylphthalate emulsions could be used for impregnating clothing for more positive protection from the mite vectors of scrub typhus. For use in the treatment of clothing, an allowance of 40 gallons of dimethylphthalate per 1,000 men per month was made in areas where scrub typhus was a hazard.[15]

The goal in subsequent research was to develop a miticide which would not be removed from clothing by washing. Benzyl benzoate was found to persist after two or three launderings. This agent, alone or in combination with dibutylphthalate, was made the standard treatment for clothing to prevent attack by mites and protect against scrub typhus.[16]

OTHER EARLY RESEARCH AND INVESTIGATION

These research projects were not the only ones initiated at the Orlando laboratory under the contract of February 1942, and before the advent of DDT in the fall of 1942; but they are sufficient to show the scope and character of the work that was undertaken and to indicate the solid values that were achieved in developing materials to meet the Army's needs. The fact that answers were found to many of the questions unanswered in 1940 reveals the foresight and wisdom of the preventive medicine organization in its early initiation of a broad research program.

Coincident with the study of repellents and insecticides, their toxicology had to be determined. It was manifestly useless to develop materials which, no matter how efficient they might be, would create sickness and cause hospital admissions when used. The program of toxicologic study was conducted by Dr. Paul A. Neal and his associates at the National Institutes of Health of the United States Public Health Service, by Dr. Herbert O. Calvery of the Food and Drug Administration of the Federal Security Agency, and by others.

To provide more effective coordination of the increasingly wide activities of the many groups undertaking research, and to locate and utilize additional skills to supplement the existing program, a Conference on Insecticides and Repellents was formed by the Division of Medical Sciences of the National Research Council. The first meeting of this group was held 18 August 1942.[17]

In October 1942 representatives of the Geigy Co. of Switzerland delivered to the Orlando laboratory the first supply of the then relatively unknown chemical DDT. Though the Swiss chemists were thinking in terms of agri-

[15] See footnote 14, p. 256.
[16] Memo, SG for QMG, 1 Mar 45, sub: Benzyl benzoate as miticide. SG: 438.
[17] Minutes of Conference on Insect Repellents, 18 Aug 42. HD: 040 Insect Control OSRD.

cultural and not military uses, under the skillful handling of the Orlando scientists, the amazing ability of DDT to destroy nearly all of the insects important as disease vectors quickly became apparent. Most remarkable of all was its characteristic retention of ability to kill insects by mere contact over a hitherto unattainable length of time. Its adaptation to field work was not, however, a simple or an easy matter. It was necessary to prepare and test thousands of formulations, involving a consideration of numerous solvents, diluents, and emulsifiers to meet the various uses to which DDT could be put.

PROBLEMS IN THE DEVELOPMENT OF DDT

As the great values of DDT became known, the necessity for expanding manufacturing facilities and for standardizing the product were recognized. Production was small in 1943 since the Cincinnati Chemical Co., a Geigy subsidiary, was practically the only producer. However, sufficient DDT was available for extensive testing at Orlando. On the basis of the investigational work carried on from October 1942 to May 1943, its effectiveness was determined to be exceedingly high. It was, thus, valuable in its own right because of its unsurpassed qualities, and it was valuable also because it would release pyrethrum, then in very short supply, for needed aerosol bomb dispenser production.

In May 1943 the Orlando laboratory presented to the Insecticide and Insect Repellent Conference of the National Research Council a detailed report covering the results obtained with DDT. Progress had been so great in developing methods of utilizing this chemical that on 20 May 1943 the National Research Council was able to recommend to the Army the adoption of a louse powder containing 10-percent DDT in pyrophyllite to replace the MYL formula, which used pyrethrum, thus releasing more of that scarce material for other uses.[18] At about the same time, as a result of a comprehensive series of toxicologic studies, the safety of DDT under the conditions of Army use was established.

The first field studies on DDT were carried out in North Africa in the fall of 1943 by Army medical officers and representatives of the Rockefeller Foundation.[19] It was shown that mass delousing of troops could be effected by blowing or dusting DDT powder in pyrophyllite under the clothing, using a hand-operated dust gun.

By November 1943, the demands for DDT were so greatly in excess of production that it was realized that additional measures would have to be taken to expedite its manufacture. Meanwhile, in order to conserve the available supply, The Surgeon General recommended to The Quartermaster General a reduction in the DDT content of louse powder from 10 percent to 6

[18] Ltr, Dr. L. H. Weed, Div of Med Sciences NRC, to SG, 20 May 43. SG: 438.-1.
[19] Annual Rpt, Prev Med Div NATOUSA, 1943. HD.

percent.[20] It was found later that the 6-percent powder was relatively ineffective, as compared with that containing 10 percent of DDT, and that no real savings were accomplished by the reduction. The DDT content was, therefore, increased to the former 10 percent.

At about this time a relatively serious and very threatening outbreak of louse-borne typhus occurred in Italy. It began in December 1943 and was halted abruptly in January 1944 by the widespread use of DDT louse powder in conjunction with an extensive immunization program.[21] Theater Medical Corps officers, Allied Military Government officers, and a control team of the Rockefeller Foundation, assisted by the Typhus Commission, accomplished prompt control and established the high values of DDT in this field of preventive medicine. The DDT was applied by dusting the powder under the garments.

The production of DDT continued to lag and there were many technical problems of manufacture and standardization to be solved. Late in November 1943 The Surgeon General [22] sent an urgent letter to The Quartermaster General requesting that he do everything in his power to expedite the production and procurement of DDT. Again, on 29 December 1943 The Surgeon General [23] pointed out to the Chief of Staff, Army Service Forces, the desperate need for DDT, enumerated some of the problems in production, and requested that the highest priorities be given for the provision of the critical items needed in its manufacture. One difficulty was the lack of facilities for the production of chloral hydrate, an essential in DDT production. In the early part of 1943 there had been only two old plants equipped to produce this material and plant expansion thereafter had been slow.

THE DDT COMMITTEE

The need for a central coordinating group to develop the necessary production of DDT and to work out procedures for the standardization of the products of the various plants was now apparent. These facts were outlined in a letter by Dr. Vannevar Bush,[24] Director of the Office of Scientific Research and Development, to the Commanding General, Army Service Forces. As a result, the Army Service Forces [25] directed the formation of The Surgeon General's DDT Committee. The responsibility of the DDT Committee was to study and make recommendations concerning the production and use of

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[20] Memo, SG for QMG, 16 Nov 43, sub: Insecticide powder, body insect; insecticide, powder, delousing. SG: 438.-1.
[21] Cushing, E. C.: Report of mission on typhus, 2 Mar 44. HD: 710 Typhus.
[22] Ltr, SG to QMG, 30 Nov 43, sub: Manufacture and procurement of the chemical, DDT. SG: 441 (DDT).
[23] Ltr, SG to CG ASF, 29 Dec 43, sub: Report on acceleration of DDT production. SG: 441 (DDT).
[24] Ltr, Dr. V. Bush, OSRD to Gen Somervell, ASF, 17 Feb 44. HD: 725 (DDT Cmtee).
[25] Memo, CG ASF to SG, 22 Feb 44. HD: 725 (DDT Cmtee).

DDT. The first meeting was held on 3 March 1944, with the following agencies represented:[26]

Office of Scientific Research and Development
United States Public Health Service
United States of America Typhus Commission
United States Department of Agriculture
United States Army
United States Navy

The following technical services of the Army were represented: Medical Department, Quartermaster Corps, Corps of Engineers, Ordnance Department, and Chemical Warfare Service. In addition, officers from the Production Division and the Plans Division, Army Service Forces, and from the Office of the Air Surgeon, Army Air Forces, were present.

Representing the Office of The Surgeon General were officers from the Sanitary Engineering Division, the Sanitation and Hygiene Division, and the Tropical Disease Control Division of the Preventive Medicine Service.

The most immediate problems to be solved were outlined in Dr. Bush's letter, as follows: Production and supply, particularly with regard to the chemical problems in the manufacturing field; methods of field use, including chemical smokes, bursting charges, and airplane distribution of sprays; toxicity studies (since not all of the possible toxic effects of DDT and the chemicals used with it were known); and production of a technical bulletin or manual describing the uses of DDT.[27]

At the first meeting of the DDT Committee the production of DDT for the next 3 months was estimated as follows: March, 100,000 pounds; April, 163,000 pounds; and May, 293,000 pounds. Three companies (Geigy, Merck, and DuPont) were then in production and another (Hercules) was preparing for large-scale manufacture. Plans for production contemplated 800,000 pounds a month by July, while estimated Army needs were set at 377,000 pounds a month—a figure soon to be greatly increased. Technical personnel for the plants presented somewhat of a problem since many of the men engaged in research and production were under 26 years of age. Priorities for the DDT production program were issued by the War Production Board on the same basis as for penicillin, that is AA1.

The DDT Committee felt that the relative potency of the end products from the several processes of manufacture then being used required further study. In order to accomplish standardization, the National Research Council was asked to initiate a study of the DDT being produced by the four manufacturers; and it was arranged for a Chemical Warfare Service officer to study

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[26] First Interim Rpt (DDT Committee), 3 Mar-15 May 44. HD: 725.

[27] TB MED 14, "Use of DDT as a Mosquito Larvicide," had already been prepared by the Preventive Medicine Service and published 3 Mar 1944.

the various plants and processes. General specifications for a desirable end product and rapid methods of testing had already been developed by the Department of Agriculture.

In order to clarify these and other problems, four subcommittees were appointed: (1) Production, supply, and chemical problems; (2) field applications; (3) toxicity; and (4) preparation of technical handbooks and manuals.

By the end of May 1944 additional training literature had been prepared; the hazards associated with the manufacture and use of DDT had been defined and protective measures, where necessary, had been devised; and a tremendous amount of work had been done in the matter of field applications, especially on the methods of airplane distribution. An early test covering methods of distribution, amounts of application, and results was made at Stuttgart, Arkansas, in 1944. Field trials were under way, as part of a continuing program, in Panama; and in Africa, China-Burma-India, the South Pacific, and the Southwest Pacific, additional work was being undertaken, mainly on the problems of airplane distribution. Studies of chemical smokes and bursting charges had not shown any promise, but were being continued. The Ordnance Department took over most of the field tests on bursting charges, while the Department of Agriculture continued the development of DDT toxic smokes.

During the succeeding few months the probable requirements for DDT had been greatly increased. The actual production for the same period approximated the estimates made at the first meeting of the DDT Committee, totaling 551,000 pounds for March, April, and May as compared with the estimated 556,000 pounds. In May it was estimated that June production would be 450,000 pounds and that production would increase thereafter about 100,000 pounds a month to 955,000 pounds in November, with a total production for 1944 of about 5,730,000 pounds. The actual production in 1944 amounted to 10,000,000 pounds, so rapidly was the manufacturing program pushed.

Estimated requirements, as of the same date, for 1944 and 1945 were as follows: For the Army for 1944, 3,793,730 pounds, of which 510,000 pounds were for louse powder; 343,000 pounds for louseproofing underwear; and more than 900,000 pounds for airplane distribution and for residual treatment of buildings. In addition, 255,000 pounds were to be set aside for Civil Affairs. The 1945 Army requirements were estimated at 7,882,000 pounds, with less being used for louse powder, but with more than 4,000,000 pounds being estimated as needed for airplane distribution. For Civil Affairs and the Red Cross, the 1945 needs were estimated at more than 850,000 pounds. In addition, requests were anticipated from the British, Australians, Chinese, and Russians totaling from 10 to 15,000,000 pounds.

Up to this time, in order to expedite production, 43 persons under 26 years of age had been deferred under the draft act; 9 others engaged in development work were also deferred; and requests for deferment of 17 others were being processed.

To expedite the studies on the chemical problems of DDT, contracts had been drawn with three universities, Harvard, Ohio State, and Maryland, under the general direction of the National Defense Research Committee, Office of Scientific Research and Development. Two chemists at each of these universities were assigned to study the problems of the purity of DDT, the methods of synthesis, and the byproducts. Results of these investigations [28] determined the content of commercial DDT to be 65 to 73 percent pure para para derivative, identifying the composition of an additional 19 to 21 percent of the content as 1-trichloro-2-0-chlorophenyl-2-p-chlorophenylethane, and determining the character and toxicity of the remaining 10 percent of residue.

Specifications to obtain the most desirable end products were developed still further. The National Defense Research Committee also contracted with the DuPont Company to study the wettable powder forms of DDT. Pennsylvania State College and Rhode Island State University did much to clarify and solve the chemical problems of manufacture, furnishing information which greatly increased commercial output. Massachusetts Institute of Technology made noteworthy contributions to the control of insects destructive to materiel.

Three important reports [29] were made in the spring of 1944, bringing up to date the available knowledge of three important phases of DDT use. One of these was "Tropical Diseases Report No. 7, Directions for Use and a Discussion of Insecticides and Repellents Investigated at the Orlando Laboratory for the Armed Forces." This report, dated 7 March 1944, summarized the developments of the preceding 18 months' work with DDT and established a basis for its effective use in the control of many insect vectors of disease. Of its 27 pages, 21 were devoted to the uses and methods of use of DDT. Another report was that of the Subcommittee on Field Uses of the DDT Committee which summarized methods and procedures developed in the airplane application of DDT sprays. The third report covered the results of the exhaustive toxicologic studies of DDT and its solvents by the Food and Drug Administration. This report established that DDT and its solvents could be used with safety provided reasonable precautions were observed.

As the production of DDT mounted, the fields of interest and of use extended far beyond those in which the Army itself was concerned. There was need for a broader base for the necessary development and testing work. For instance, the necessity for investigating its effect on beneficial insect life, if used in civilian insect control, was wholly appreciated, but was not a problem with which the Army was directly concerned, nor with which it had time to deal. The Public Health Service was desirous of using DDT for the control of pest insects in extramilitary areas. Cities were seeking allotments for fly-control work and farmers for crop protection. Before DDT could be used

[28] Haller, H. L., and others: The chemical composition of technical DDT. J. A. Chem. Soc. 67: 1591-1602, Sep 1945.
[29] Filed as appendixes to First Interim Rpt (DDT Committee), 3 Mar-15 May 44. HD: 725.

for such purposes, and under relatively unskilled supervision, much broader bases of information and more detailed instructions for use had to be available. Accordingly, in September 1944 the Office of Scientific Research and Development formed its Insect Control Committee to supplement the work being done by the DDT Committee; and, in October organized a Subcommittee on Rodent Control which began a study of rodenticides and of the methods of rodent control.

Rodent control was also becoming a problem for the Army, though steps had been taken by the Sanitary Engineering Division as far back as 1941 to train a small group of its officers in that field of work. In Africa, bubonic plague had appeared, though quickly subdued without any cases among American troops; and in the Pacific, as we approached the coasts of Asia, where bubonic plague was present, the need for better agents and organizations for rodent control was appreciated. In addition, other chemicals of the same general nature as DDT were being developed and tested.

THE ARMY COMMITTEE FOR INSECT AND RODENT CONTROL

To meet these changed conditions, the DDT Committee was dissolved and the Army Committee for Insect and Rodent Control was established by War Department Memorandum 40–44, dated 8 November 1944. (Chart 5.)

Although the extent of responsibility for production, control, and development of the use of DDT was but slightly different from that of the DDT Committee, the scope of the Army Committee was extended to include the general field of insect and rodent control, irrespective of the agents used in control. Liaison arrangements were provided to include the Office of Scientific Research and Development, the Department of Agriculture, the Navy, and the Public Health Service.

The first meeting of the Army Committee was held 27 November 1944.[30] At this meeting past and present research, as well as current developments, were reviewed. In addition to the work being done by the agencies already discussed, many of the armed services played important roles in the insect and rodent control program. The Quartermaster Corps was developing insect-proof clothing, which promised to be of value. The Corps of Engineers and the Navy were carrying out some field tests of insect and rodent control measures; the Army Air Forces and the Chemical Warfare Service were assisting in studying and testing methods of insecticide dispersal.

The basic needs for the rodent control program of the Army were outlined at the first meeting of the Army Committee:

1. A manual of rodent control policy and practice, outlining recommended methods and equipment. (Such a manual was then in preparation and was published as TB Med 144 in April 1945.)

[30] *Minutes of 1st Meeting, Army Committee for Insect and Rodent Control, 27 Nov 44.* HD: 334.

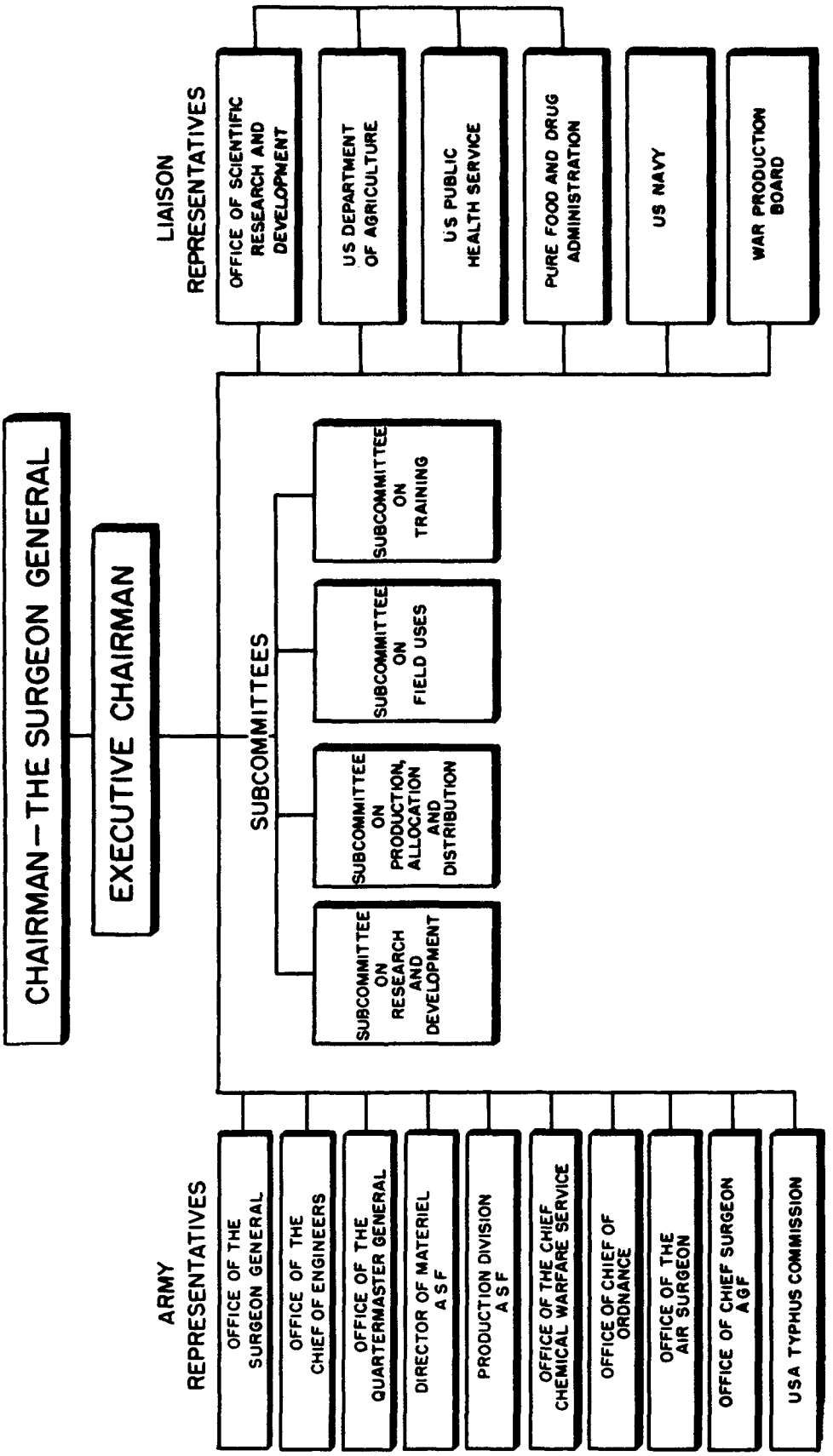


Chart 5. Organizational Chart of the Army Committee for Insect and Rodent Control.

2. Personnel trained in rodent control in each theater.

3. An organized program in each theater to meet any emergency.

4. A single all-purpose antidote effective against all rodenticides. (Studies on such an antidote were then being undertaken by the Medical Division of the Chemical Warfare Service.)

The Army Committee organized four subcommittees which were, in the main, continuations of similar subcommittees, both as to personnel and purpose, of the DDT Committee. These were: research and development; field uses; production, allocation, and distribution; and training.

Pyrethrum, which is of great value in insect control because of its knockdown properties, which DDT lacks, had been in very short supply. The status of this agent was reviewed at the second meeting of the Army Committee. Shipments from Africa, the main source of supply of high-grade flowers, were greatly reduced due to shipping and labor handicaps. Some Brazilian flowers of inferior quality were available and attempts had been made to grow the plant in the United States. An estimate of the situation, as of the end of 1944, was made by the War Production Board through the Subcommittee on Production, Allocation, and Distribution.[31] This showed a stock on hand, as of 1 November 1944, of 2,278,240 pounds of flowers; estimated arrivals for the remainder of 1944 of 2,238,000 pounds; and a use in November and December of 1,600,000 pounds. The year-end carryover was estimated at 2,917,000 pounds. In the first 9 months of 1945, it was estimated that the receipts would be 6,532,000 pounds, while consumption would be 8,880,000 pounds, leaving only about 570,000 pounds on hand as of 1 October 1945. The consumption for 1945 was estimated on the basis of requirements of 960,000 pounds per month for the first quarter and 1,000,000 pounds per month for the second and third quarters.

At a later meeting of the Army Committee,[32] the production story of DDT was summarized by a representative of the War Production Board. From 1,000 pounds in May 1943, and a total of 153,000 pounds for the whole of 1943, production was so expanded that, in 1944, 10,000,000 pounds were manufactured; and by August 1945, there were 15 producers with a total output of 3,000,000 pounds per month.

In a continuation of large-scale field tests of DDT dispersion by airplanes, results were reported from many areas. The British [33] used 5 percent DDT in crude kerosene in Burma and India; fighter aircraft were used for dispersion and the height of delivery was limited to 100 feet with winds greater than 10 miles per hour interfering with the work. Results were good. At Morotai,[34]

[31] Minutes of Meeting, Subcommittee on Production, Allocation, and Distribution, Army Committee for Insect and Rodent Control, 5 Dec 44. HD: 334.

[32] Minutes of 9th Meeting, Army Committee for Insect and Rodent Control, 28 Aug 45. HD: 334.

[33] Col J. W. Scharff, RAMC (Brit.) addressed 2d Meeting of Army Committee for Insect and Rodent Control, 12 Jan 45. HD: 334 (Mins of Mtg).

[34] Ltr, Lt Col G. L. Orth, Chief Malariologist to Chief Surg Hq USAFFE, 28 Oct 44, sub: Field trials, airplane spraying with DDT in oil. HD: 725 (DDT) SWPA.

the beachhead was sprayed on D-day and twice thereafter, using B–25 planes and relatively light applications of DDT. Lack of controls prevented definite evaluation of results, but it was believed that 1 heavy application would have been more effective than the 3 light ones. At Saipan,[35] C–47 planes were used to spray 15,650 acres of the island to control a dengue epidemic. Very good larval and adult kills were reported, with a quick reduction in the incidence of new cases of dengue. Much work was done in the Caribbean [36] by the Army Air Forces Board, the work being continued over a period of a year to determine the long-time effects of air spraying of DDT on an area.

OTHER PROBLEMS IN INSECT AND RODENT CONTROL

Air Transportation of Insect Vectors of Disease. The likelihood of airplanes conveying potential insect vectors of disease had been demonstrated in 1943, when a few *Anopheles gambiae* were reported in planes entering Brazil from West African airfields.[37] There was also the ever-present possibility that new and more effective carriers of disease might be brought into the United States by planes from overseas. A system of inspection and methods of disinsectizing planes, using the aerosol bomb were worked out. The matter of a DDT residual deposit for airplanes was investigated and tests were made by the Army Air Forces Tactical Air Command, by the Troop Carrier Command, by the Bureau of Entomology, and by the Public Health Service. Difficulties with deterioration of plastics and cables were reported and it was found difficult or impossible to treat all areas in which insects might rest. As a result, principal reliance was placed on aerosol disinsectization and mosquito control around airports of departure overseas.

New Insecticides. Other new insecticides were reported from time to time and were fully tested. These included: technical benzene hexachloride which was more difficult to use than DDT and had an offensive odor; para chlorphenyl chlormethyl sulphone (PMS), which was not as effective on lice as was DDT, was less resistant to washing in the case of impregnated garments, was an effective ovicide, had a fast knockdown, was less toxic to adults and larvae of *Anopheles* and to flies, and was not repellent to mosquitoes; and the gamma isomer of benzene hexachloride, which later was to be useful as a substitute for DDT when insects developed resistance to that chemical.

Control of Flies. Fly control on Pacific islands after they were captured presented a serious problem. Dead bodies, broken provision containers, smashed coconuts, and other objects offered profuse breeding possibilities.

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[35] Memo, Chief Sanitation and Hygiene Div SGO to Chief Prev Med Serv SGO, 10 Nov 44, sub: Report of spraying DDT from C–47 airplane on Saipan, with incl. HD: 710 Dengue (POA).

[36] Rpt, Army Air Forces Board, 11 Apr 45. HD: 725 (DDT Spraying, AF).

[37] See full report, Chapters V, pp. 221–222 and VII, pp. 307–312.

Sodium arsenite appeared to have qualities best suited for controlling fly production under these conditions and it was used extensively. No large-scale tests were made in this country, though the Orlando laboratory and the Chemical Warfare Service studied the matter and generally confirmed this material as an effective fly control agent. Thanite, orthodichlorobenzene (ODB), benzene hexachloride (BHC), and other material were also tested and found effective.[38] Fly breeding in pit latrines was another problem in the Pacific.[39] It was found there that paradichlorobenzene (PDB) was effective in fly control when added to the latrine contents in relatively small amounts. Tests of this chemical were made at Orlando, at stations in the Fourth Service Command, and elsewhere. Results were inconclusive and, in places, contradictory. It was believed that the humidity of the air and the type of soil were factors influencing effectiveness. However, all available PDB was sent to the Pacific for this purpose.

Rodent Control. The matter of rodent control became more important as our troops entered areas where plague was a potential menace. Red squill,[40] which is a fairly effective rodent poisoning agent, was in extremely short supply since most of the bulbs come from North Africa and Italy which were in enemy hands until early 1943. Even after that date, available bulbs were low in strength and the resulting poison was not very effective. Thallium sulfate, which is a satisfactory poison, was also seriously deficient. The annual wartime production in the United States probably did not exceed about 2,000 pounds per year and shipments from the Low Countries were cut off by the enemy occupation of that area. Barium carbonate was not an effective poison. Zinc phosphide was recommended by the Fish and Wildlife Service and was tested, with fair results, in several of the service commands in the United States. As a result, it was adopted as the standard rodenticide and thallium sulfate was held in reserve for overseas use in case of plague outbreaks. Alpha naphthylthiourea (ANTU) was tested extensively but was found to be ineffective under most conditions of Army use.

In the early part of 1944, the compound sodium monofluoroacetate (1080) was recommended as a rodenticide. It was tested extensively by the Fish and Wildlife Service and by several of the service commands. Samples were shipped to several overseas theaters by air and tests made under field conditions. Results were uniformly satisfactory. Experiences in the various service commands and theaters were presented in some detail at the 11th meeting of the Army Committee.[41]

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[38] OSRD Insect Control Committee Rpt No. 80, "Further Studies on the Destruction of Fly Larvae in Animal Carcasses." HD.

[39] Sherman, F., "Special Sanitary Problems following Battle," prepared 7 Aug 44 and 24 Mar 45. HD: 725 Fly Control.

[40] For further discussion of rodenticides see Chapter VI, pp. 241-244.

[41] Minutes of 11th Meeting, Army Committee for Insect and Rodent Control, 30 Oct 45. HD: 334.

Early in 1945 a letter [42] was sent to each theater requesting a general factual report as to the rodent problems in the command and the control measures in effect. Since special rodent control personnel were requested by several theaters, a tentative table of organization and equipment for a rodent control unit was prepared. Proposed organization plans were sent [43] to the oversea commands for comment. Requests were received for 36 such units. The end of the war in the Pacific eliminated much of the need for the rodent control units and none was ever actually organized.

Malaria control and survey units in the area were utilized for immediate rodent control problems. A War Department technical bulletin, TB Med 144, "Rodent Control," was prepared by the Surgeon General's Office and published in April 1945.

Miscellaneous Research Problems. Among the items of research that were initiated during 1944 and 1945 were the development of insect-proof packaging for overseas items, a matter of much interest to The Quartermaster General. A study of the use of DDT to termite-proof wooden structures was started by the Chief of Engineers. Results appeared to indicate that DDT, properly applied, is an effective agent against termite infestation, but the study was not completed until after the end of the war. The Chief of Engineers, whose office is responsible for the protection of stored materials, established an insect and rodent control section. Studies were also made of the impregnation of insect nettings with repellents, but effective agents and methods had not been developed by the end of 1945.

Cost of Research Program at Orlando Laboratory. The cost of the work done by the Orlando laboratory was amazingly low. Work began in March 1942, and was carried on with funds supplied by the Bureau of Entomology until 1 May 1942. Beginning on that date, the Office of Scientific Research and Development provided the money for the research program. This totaled $815,000 for the 41-month period.[44] It is believed that, aside from the use of equipment furnished by the Bureau, by the Army, and by the Air Force, the total cost of the research program at Orlando did not exceed a million dollars.

Research Plans for 1946. As the war closed, plans had been outlined for continued research in the fiscal year 1946, covering such projects as the development of materials for military insect control where materials then available were ineffective; the development of new repellents; better methods and materials for the impregnation of clothing and mosquito netting; methods for the area control of mites and ticks; the possibility of and methods for destroying fleas on rats and in rat habitats; the control of fly breeding over extensive areas; and other similar work.

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[42] Ltr, TAG to Comdrs All Theaters, Def Comds, Depts, and Base Comds, 14 Mar 45, sub: Rodent survey and control. HD: 729.5 (Overseas Theaters).

[43] Ltrs, SG to CG each Theater, attn Surg, 21 Mar 45, sub: Rodent control, with inclosure "A Proposed Infectious Rodent Survey and Control Team"; and all replies are filed in HD: 729.5 (Unit Orgn).

[44] See footnote 5, p. 253.

The work at the Orlando laboratory was discontinued as an Army research project in October 1945, but the Army Committee continued to function, despite many changes in personnel due to relief from military duties and to assignments to overseas theaters. Generally speaking, the story of research and development of materials, methods, and equipment to meet the problems of the armed services in a global war ended in late 1945.

CHAPTER VIII

Foreign Quarantine

*Phillip T. Knies, M. D.**

HISTORICAL DEVELOPMENT OF FOREIGN QUARANTINE

Some form of quarantine procedure undoubtedly has been practiced since the contagiousness of certain diseases was first recognized. Exclusion of lepers from organized social communities has been enforced since Biblical times. Justinian is usually credited with institution of the first official health measures governing travel, though no reference to them as applied in maritime traffic appears in his Codes. During the Middle Ages, when the great pestilences were decimating the cities and villages of Europe, each community remained dependent upon its own devices for protection. Unwarranted and frantic discrimination against the disease, with ineffectual results, was the custom of the day.

Not until plague had invaded Europe from the Levant in the 14th century were quarantine procedures instituted on a statutory basis. In 1403, Venice adopted a regulation requiring all vessels from infected ports to be detained for 40 days in the harbor, without communication with land or with other vessels. The term "quarantine" was thus derived from the Italian "quarana," meaning "forty." Because at the time of the decree the Lenten season was at hand, it is possible that not only was the vessel considered obligated to penance for its evil associations, but that the period of time was suggested by the religious season. Marseilles sometime later provided the first definite code of quarantine and introduced the "patente" or bill of health to be filled out by an official in ports of departure of vessels abroad, a practice which was to extend to modern times.

Most early quarantine measures were directed against plague, but the appearance of yellow fever in Spain in the early 19th century, and of cholera in Europe in 1831 and in America a year later, stimulated broader interest. In 1851 the first international convention met in Paris to decide on quarantine measures against plague, cholera, and yellow fever. Regulations establishing quarantine at the Suez Canal and in the pilgrimages to Mecca followed. More recently sanitary conventions were drawn up in Rome in 1920 and in Paris in 1926, when exanthematous typhus and smallpox were added to the list of quarantinable diseases. In 1924 the first Pan-American Sanitary Code was

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signed in Havana, and in 1933 the International Sanitary Convention adopted at The Hague established the first international regulations governing aerial traffic. These were slightly revised by an International Sanitary Convention in 1938, but basic changes in the international agreements were not made before the onset of World War II.

Administration of the international sanitary conventions was conducted from Paris, with the cooperation of the Far Eastern Office of the League of Nations at Singapore, and in close coordination with the Pan-American Sanitary Bureau in Washington. The fall of Paris in June 1940 and the capture of Singapore by the Japanese in 1942 greatly disrupted international sanitary administration and stopped dissemination from Paris and Geneva of epidemiologic data pertaining to Europe, Africa, and the Far East. Following its organization in November 1943, the United Nations Relief and Rehabilitation Administration (UNRRA) assumed responsibility for the international sanitary conventions and resumed publication of available epidemiologic data, coordinating its work with that of the Pan-American Sanitary Bureau.

It soon became apparent that deficiencies in the sanitary codes of both hemispheres must be corrected if the countries of the world were to be offered maximum feasible protection against introduction of diseases through wartime traffic. UNRRA therefore appointed a commission of experts composed of representatives of the Allied and liberated countries which met in London in March and April 1944 to revise the International Sanitary Convention of 1926 [1] and the International Sanitary Convention for Aerial Navigation of 1933.[2] These revisions became effective in January 1945 and administration of the conventions was provided within the structure of UNRRA.

In the United States, quarantine regulations were first imposed by the General Court of the Colony of Massachusetts Bay in 1647–48 against what was probably yellow fever in Barbados, and the first lazaretto or detention hospital was built on Spectacle Island, Boston Harbor, in 1717. Federal laws were enacted in 1796 and repeatedly modified thereafter, but an adequate basic act was not passed until 1893.[3] This was extended to cover aerial traffic in 1926,[4] but otherwise remained essentially unchanged until it was replaced in 1944.[5] Quarantine regulations published under authority of the basic act continued in force during the war period.[6]

The rapid developments in national and international regulation of quarantine during war years reflected the fact that advances in scientific

[1] International Sanitary Convention of 1944, Modifying Convention of June 21, 1926. HD: 720.4 UNRRA.

[2] International Sanitary Convention for Aerial Navigation, of 1944, Modifying the Convention for Aerial Navigation of April 12, 1933. HD: 720.4 UNRRA.

[3] Act of February 15, 1893, 52d Cong., ch. 114: An Act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service.

[4] Public Law 254, 69th Cong., approved 20 May 26.

[5] Public Health Service Act, Public Law 410, 78th Cong., approved 1 Jul 44.

[6] Code of Federal Regulations, Title 42—Public Health, sec. Foreign Quarantine Regulations, 15 Feb 1893, and subsequent amendments.

knowledge of causation and modes of transmission of disease necessitated revision of practices which had remained little changed from early days. The revised International Sanitary Conventions of 1944, revised Pan-American Sanitary Code of 1946, and the revised basic act of the United States, together with revisions of the United States Quarantine Regulations developed under its authority, all expressed a modern philosophy and practice in the light of scientific progress. In the field of human disease, quarantine regulations changed as the result of advances in immunology and epidemiology, fields of medical practice in which the Army Medical Department was particularly active both before and during the war.

International quarantine had long extended beyond simply the application of restrictive controls to human cases or carriers of disease. It now embraced aspects of disease prevention, and extended to control of plants and animals as well as man. Recognition of the fact that vessels and aircraft may influence the spread of diseases by means of rodent and insect infestation or water supply made sanitation of such conveyances an integral quarantine measure. Water supplies and sewerage systems aboard vessels and aircraft became important considerations. The interchange of rats between various countries by ships in harbor was mitigated by fumigation and harbor control, and the problem was materially lessened by methods of ratproofing vessels.[7] These latter practices also constituted an attack upon the rat flea, although the methods of insect control which were developed during the war probably far surpassed them in effectiveness.

The danger of introducing harmful insects into new areas caused much concern. Interest in insect control was greatly stimulated by the expansion of air travel. In fact, the often frantic emphasis placed on this problem presents a striking contrast with the little attention which had been given to it previously in association with travel by vessel, train, or automobile, although these vehicles had accounted for all the known important implantations of insects before World War II.[8] It had long been recognized that insect vectors of human disease may be disseminated by international traffic, and the United States Public Health Service pioneered in the study of this problem.

Emphasis on the control of those insects associated with human disease had at times been disproportionate to their importance, for they constituted only a small percentage of the insects and pests carried in international travel. Study of those insects of potential agricultural significance led to the development by the Department of Agriculture of insecticides and methods for utilizing them. In this case control measures were concerned less with adult forms than with insect eggs and larvae, and hence involved the exclusion of the flowers, fruits, and vegetables on which these were likely to be carried. Important

[7] Grubbs, S. B., and Holsendorf, B. E.: The Rat Proofing of Vessels. Supplement 93 to Public Health Reports. Washington, Government Printing Office, 1931.

[8] The problem here noted refers mainly to "stowaway" adult insects, and the comment does not detract from emphasis long placed by the Department of Agriculture on egg and larval stages in imported agricultural products.

examples of introduction into the United States of insects harmful to agriculture were the introduction of the cotton boll weevil into the Southern States,the European corn borer into the Midwest, and the Mediterranean fruit fly into Florida.

Animals and plants, introduced intentionally or by accident, had led at times to serious damage and even were responsible for basic revisions in the economy of large areas. The mongoose, intentionally brought into Trinidad to eliminate snakes by devouring their eggs, more effectively exterminated the ground-nesting birds. Japanese barberry, brought to the United States as a decorative garden plant, became an important host for one stage in the life cycle of stem rust of wheat. Introduction of breeding stock and of herds from abroad into previously unaffected areas brought with them such economically disastrous diseases as foot-and-mouth disease, blackleg of sheep, swine cholera, and equine encephalomyelitis. As a result, in all alert and organized agricultural communities, quarantine regulations were formulated and enforced by agricultural agencies.

Quarantine had thus developed into a broadly inclusive structure, and the details of its practice changed with advancing knowledge. Not only were new items brought under quarantine surveillance, but in many instances it was possible to modify the complete prohibition at first imposed upon an item to a discriminating control essential if trade was not to be seriously impeded.

FOREIGN QUARANTINE REGULATIONS AT THE BEGINNING OF WORLD WAR II

Agencies charged with enforcement of quarantine at the onset of the war varied from municipal to national.[9] In the United States, foreign quarantine provisions remained among the ordinances of certain port cities, and Florida, California, and the Territories of Hawaii and Puerto Rico had agricultural quarantine codes. The personnel enforcing the Federal and local regulations were frequently the same inasmuch as many of the local officers had been appointed by the Department of Agriculture to enforce the Federal restrictions under cooperative agreements with those States and Territories. In England, on the other hand, the enforcement of national policy in quarantine against the diseases of man was entrusted to municipal authorities of the port cities. Most commonly national law provided those restrictions considered essential to the national welfare, while special regional interests continued to be served by State and other local regulations. The division was not sharp, however, as shown by the complete prohibition on importation of parrots imposed by

[9] Mustard, Harry S.: Government in Public Health. New York, The Commonwealth Fund, 1945, pp. 50-58.

some States in the United States in contrast to the mere restriction imposed by regulations of the Public Health Service, and by the vigorous control of incoming dogs in the Territory of Hawaii although minor restrictions were placed by Federal agencies only upon sheepherding dogs.

Notwithstanding such regional variations, regulation of travel and importations into the United States, its territories, and its possessions was a responsibility of the following three Federal agencies and their subdivisions, within the limitations of authority indicated below. These several agencies employed the police powers of the Customs Service, United States Treasury Department, in the enforcement of their regulations.

United States Public Health Service, Federal Security Agency. Concerned with quarantinable diseases of man in accordance with international commitments of the United States (regarding cholera, plague, smallpox, louse-borne typhus, and yellow fever) and with national policy. The latter covered leprosy in aliens, birds likely to harbor psittacosis, and animal bristles likely to transmit anthrax to man. Closely related to these quarantine responsibilities were those concerned with immigration, which provided for examination of aliens and exclusion of those found suffering from ailments of a variety much wider than the above-named quarantinable diseases.[10]

Food and Drug Administration, Federal Security Agency. Concerned with foods, pharmacologic items, and cosmetics harmful to man. The interests of this agency embraced prohibition of entrance of specified raw or finished materials which might be imported from abroad rather than matters of quarantine, if that term is considered to mean introduction of living disease agents, disease carriers, or pests.[11] The close relation of these interests to quarantine so defined is evident.

Bureau of Animal Industry, United States Department of Agriculture. Concerned with diseases of epizootic interest, particularly those of ruminants, swine, and equines, or the intermediate hosts of such diseases. Under such broad definition control was extended to dogs which might introduce the tapeworm of sheep.[12]

Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. Concerned with plants and plant products considered risks as the possible means of introduction of plant diseases or insect pests. Items subject to quarantine control by this bureau or by the Bureau of Animal Industry did not include all animals and plants, and animal and plant products, of agricultural interest but only those which were specified in pertinent regulations from time to time.[13]

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[10] See footnote 6, p. 272.

[11] Federal Food, Drug and Cosmetic Act, 75th Cong., approved 23 Jun 39, sec. 801.

[12] US Dept of Agriculture, Bureau of Animal Industry Orders 352, 1 Aug 35; 368, 16 Jan 39; 373, 25 Oct 40.

[13] US Dept of Agriculture, Bureau of Entomology and Plant Quarantine, Service and Regulatory Announcements, Jun 1942, Sep 1942, Dec 1942, Mar 1943.

Fish and Wildlife Service, United States Department of the Interior. Concerned with all forms of animal wildlife, including tame specimens, except those of primary interest to the Bureau of Animal Industry. In the case of psittacine birds, control was shared with the Public Health Service, though basic authority remained with the Department of the Interior.[14]

It is axiomatic that effective quarantine at the borders of any country, particularly insofar as it affects control of the diseases of man and of conveyances engaged in international traffic, depends in large measure on international cooperation through such national agencies and international sanitary conventions as have been discussed. Such cooperation includes two important services—the exchange of epidemiologic data,[15] and the provision of expert assistance in handling of epidemiologic problems.

Such was the status of foreign quarantine at the onset of World War II. It was evident that much progress in concepts, fundamental procedures, and organization had been accomplished since the inception of quarantine in international traffic. It was also evident that advances in these concepts and methods and in both international and national organization had rendered archaic many provisions which were still statutory, and had created needs not yet formally satisfied. The examination of these matters and reintegration of the entire international quarantine program had become overdue at the onset of World War II.

FOREIGN QUARANTINE IN MILITARY TRAFFIC

Peacetime Practices

In peacetime, quarantine regulations were ordinarily observed in military traffic, and in view of the fact that such traffic constituted a relatively small percentage of general commerce, the regularly constituted civilian quarantine personnel and facilities were adequate to handle it. In fact, in view of the high standards of sanitation and health maintained in military forces, civil procedures were commonly modified for military traffic. Military vessels might be boarded in quarantine anchorage by civil quarantine officials, but sanitary inspections were generally omitted unless requested, and visits were usually limited to an exchange of compliments and receipt of reports from military officers. In many instances, docking was permitted without boarding and reports were forwarded by mail, reliance being placed on military medical officers and commanders to bring to the attention of quarantine officials any risks of which they should be cognizant. These practices fell within the reasonable exercise of discretion permitted quarantine officials in the execution of their duties.

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[14] Act of May 25, 1900 [Lacey Act], 56th Cong., ch. 553.

[15] In addition to reports from international organizations, epidemiologic information was gained through Consular Health Reports. Another means, the Bill of Health, completed abroad by consuls of countries to which vessels intended to travel, was never satisfactory in air travel and was discontinued by many countries in water travel.

Previous Wartime Practices

During previous wars, however, there had been the tacit, if unofficial, understanding that the observance of such relative luxuries as quarantine regulations was impracticable and intolerable. In wars of the United States prior to World War I, military movements across the seas had been limited, though in the war with the Barbary States troops were exposed in endemic areas to plague and typhus, and the Spanish-American War served as a background for the epochal work of Walter Reed in yellow fever. The distances involved, the relatively slow modes of travel, and medical care of the Armed Forces were the chief protections provided for the homeland against the introduction of these diseases by military traffic.

World War I subjected unprecedented numbers of troops to the risk of contracting quarantinable diseases by exposure to smallpox and typhus. Control of the latter disease was limited to traditional methods, and though field bathing and delousing installations were widely established and gratefully used, "trench-fever" became a considerable and much feared scourge of United States Army personnel abroad. Traffic to the United States, however, was relatively slow and involved considerable delays in ports both in Europe and the United States where there were extensive bathing and disinfesting facilities. There was no contact with cholera, plague, or yellow fever. Smallpox did occur, but vaccination had been made routine in the Army a few years prior to this war and what might have been a serious problem was effectively prevented and well controlled.

Policy of United States Army During the Early Years of the War

With the entrance of the United States into World War II, it at once became apparent that previous experience with regard to quarantine offered little guide, for unprecedented circumstances were involved. Problems which faced the Armed Forces stemmed from both the anticipated size and distribution of military effort and from the necessity for maintenance of military security. Not only would maritime traffic be of tremendous volume, but also for the first time air travel required consideration. Civilian aerial traffic had been subject to international quarantine for some 15 years, and policies of aerial quarantine had been defined in the International Sanitary Convention for Aerial Navigation in 1933 and applied at the borders of many countries. But the techniques involved had been based primarily on maritime experience, and had already proven inadequate and unfeasible even for the limited commercial air travel before the war. Furthermore, international traffic of all types was patently bound to exceed any previous experience not only in volume but also in the number of foreign areas involved, in the speed of travel by both air and water, and in the number of points of entry into this and other countries, especially by air. Never before had the national economy been so rigidly directed toward

the most effective use of all resources. In the light of this national policy it soon became apparent that physical facilities and personnel of the established quarantine agencies were not only inadequate to deal with the current and anticipated military traffic, but could not be expanded to do so.

Military operations, too, demanded the practice of strict security with respect to all information of possible value to the enemy. Border clearance agencies [16] of the United States were not on a military status at the onset, and only the Public Health Service achieved that status in the latter part of the war. It was therefore understandable that military authorities refused to divulge to civil agencies of this and other countries detailed data on departures and arrivals, cargoes, personnel, times of passage, and intermediate stops when they could not be assured that such information would be handled only by personnel and methods compatible with military safety. Military officers recalled the privileges normally accorded military traffic in time of peace and found it difficult to brook procedure which did not recognize military urgency and priority. At the same time it was natural that quarantine authorities were impressed with the unprecedented risks of the colossal farflung traffic of war and the possibility that precautions self-imposed by the military in times of peace might be disregarded in the stress of combat.

Its obligation to observe pertinent civil quarantine procedures was emphasized by the United States Army in directives published in 1942.[17] Care in this respect was taken in the purchase of agricultural supplies abroad and in the disposal of refuse and reserve supplies in United States ports. Even before the war, military mounts taken to the Philippines were not ordinarily returned to the United States because of the possible risk of the introduction thereby of epizootic disease.

The multiple problems involved were brought to the attention of the Secretary of War by the Chief, Preventive Medicine Division, Office of The Surgeon General, in April 1943 and discussions were held with personnel of the Bureau of Medicine and Surgery, United States Navy, the Foreign Quarantine Division of the Public Health Service, and other border clearance agencies in order to define responsibilities and develop feasible and satisfactory quarantine procedures.[18] Against this background, the Army program of foreign quarantine developed.

INTERDEPARTMENTAL QUARANTINE COMMISSION

Following preliminary discussions with representatives of the Army and Navy, the Division of Foreign Quarantine of the Public Health Service pre-

[16] Civil border clearance agencies, for the purpose of this discussion, are considered to include all the Federal agencies previously indicated, notwithstanding the equivocal position of the Public Health Service until 1945.

[17] AR 40-210, 15 Sep 42, par. 3b; and AR 55-485, 1 Sep 42, sec. VI.

[18] Ltr, SG to SecWar, 14 Apr 43, sub: Joint commission to study methods that may be used to protect the United States and other countries against infectious diseases or noxious insects that are not indigenous to the countries involved. HD: 334 IQC.

pared a memorandum presenting the problems of quarantine in military aerial traffic.[19] The Surgeon General of the Public Health Service suggested on 23 April 1943 to the Administrator of the Federal Security Agency the formation of a joint commission of representatives of the Army, Navy, and Public Health Service which would: (1) study the existing regulations and practices of quarantine with respect to military and naval aircraft, (2) formulate a basic plan for sanitation of aircraft and/or airports insofar as it related to quarantine, and (3) discuss quarantine problems with quarantine authorities of countries traversed by United States military traffic for the purpose of integrating efforts to develop sound quarantine procedure and eliminate unnecessary restriction upon movement of military aircraft.[20]

The Administrator, Federal Security Agency, formally proposed to the Secretaries of War and Navy that a commission to study quarantine in military traffic be formed, and requested that, in the event of agreement, they appoint representatives to it. He also suggested definitions of the purpose, functions, and authority of the commission.[21]

The Secretary of War concurred with this proposal on 11 May 1943 and suggested that a representative of the Department of Agriculture be included on the commission. Lt. Col. Karl R. Lundeberg, MC, of the Preventive Medicine Division was designated as representative of the War Department.[22] Later it became apparent that he could not be made available by the Office of The Surgeon General for sufficient time to perform such duties, and on 28 July the author was designated in his stead.[23] The Secretary of the Navy also concurred and named Capt. Thomas B. Magath (MC) as Navy representative.[24] The Administrator of the Federal Security Agency on 2 August 1943 appointed Gilbert L. Dunnahoo, Assistant Surgeon General, United States Public Health Service, as Chairman of the Interdepartmental Quarantine Commission.[25]

The Assistant Secretary of Agriculture declined the invitation to designate a representative since the study as outlined appeared to be confined to public health quarantine, but advised that the assistance of specialists of the Department would be made available to the commission upon request.[26]

During organizational meetings the objectives and plans of the Interdepartmental Quarantine Commission were further clarified, and its interests broadened to include all phases of quarantine in both aerial and marine traffic.

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[19] Memo, Asst Surg Gen USPHS for Surg Gen USPHS, 26 Mar 43. HD: 334 IQC.
[20] Ltr, Surg Gen USPHS to Admin Fed Sec Agency, 23 Apr 43. HD: 334 IQC.
[21] Ltr, Admin Fed Sec Agency to SecWar, 23 Apr 43. HD: 334 IQC.
[22] Ltr, SecWar to Admin Fed Sec Agency, 11 May 43. HD: 334 IQC.
[23] Ltr, SecWar to Admin Fed Sec Agency, 28 Jul 43. HD: 334 IQC.
[24] Ltr, SecNav to Admin Fed Sec Agency, 15 May 43. HD: 334 IQC.
[25] Ltr, Admin Fed Sec Agency to Dr. G. L. Dunnahoo (Asst Surg Gen USPHS), 2 Aug 43. HD: 334 IQC.
[26] (1) Ltr, Actg Adm'n Fed Sec Agency to Sec Agriculture, 25 May 43. HD: 334 IQC. (2) Ltr, Asst Sec Agriculture to Admin Fed Sec Agency, 8 Jun 43. HD: 334 IQC.

The final terms of reference and authority for it were included in letters from the Secretaries of War and Navy and the Administrator of the Federal Security Agency to their respective members.[27] Consideration of quarantine safeguards against possible enemy attempts to use biologic warfare was included as one of the commission's responsibilities.

Activities

The initial activity of the commission was the joint and individual field study of quarantine practices and problems in representative ports and airports of entry in the United States. This was followed by joint investigation of problems in the Caribbean area as a foundation upon which to base the further efforts of its several members. It had become evident that such studies must be carried out by individual officers of the commission if adequate observations were to be made throughout the geographic area involved by military transportation in the time proposed. In addition to its primary mission, the Interdepartmental Quarantine Commission was associated with certain closely related nonmilitary efforts in the field of international quarantine. Two interim reports and a final report were submitted by the commission as a whole as well as separate communications from members of the commission to their respective Services.

It should be emphasized that throughout its work, and particularly in the formulation of criticisms and recommendations concerning quarantine, the Interdepartmental Quarantine Commission maintained close liaison with officials of the Department of Agriculture employed in the Bureaus of Entomology and Plant Quarantine and of Animal Industry, and with representatives of the Department of the Interior working in the Fish and Wildlife Service.

Reports

The First Interim Report, submitted on 19 September 1943, summarized observations in the Caribbean area, and preliminary recommendations based thereon.[28] The Second Interim Report was submitted on 22 October 1943 and was based upon an intensive investigation of quarantine problems relative to the prevention of transmission of *Anopheles gambiae* mosquitoes by military aerial traffic from West Africa to Brazil.[29] Vigorous protests in respect to this problem had been made to the United States by the Brazilian Government, and the itineraries of the Army and Public Health Service members of the commission were altered in order to permit an intensive study upon which to base the subsequent quarantine practices of affected Armed Forces of the United States.

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[27] (1) Ltr, Actg SecWar to Maj P. T. Knies, MC, 28 Jul 43, sub: Interdepartmental Quarantine Commission. HD: 334 IQC. (2) Ltr, SecNav to Capt T. B. Magath, USNR, 2 Aug 43, sub: Interdepartmental Quarantine Commission. HD: 334 IQC. (3) See footnote 25, p. 279.

[28] First Interim Report of the Interdepartmental Quarantine Commission, 19 Sep 43. HD: 334 IQC.

[29] Ltr, Interdepartmental Quarantine Commission to SecWar thru SG, 22 Oct 43, sub: Interim report, with incl. HD: 334 IQC.

In early March 1944, its members having completed field studies abroad and at ports and airports in the United States, the commission reassembled in Washington, D. C., to prepare its final report and recommendations. While formulating its recommendations, the commission conferred with numerous technical and operational branches of the War and Navy Departments and consulted freely with many technical experts of the several civil border clearance agencies of the United States Government. Advice was also asked of civilian agencies, of which the International Division of the Rockefeller Foundation was especially helpful, as were civilian international transportation agencies. Close attention, too, was given to the quarantine aspects of possible biologic warfare. This was done in cooperation with authorities in that field in the War and Navy Departments and the Federal Security Agency. The Army member of the commission received special training in this subject from 6 February to 4 March 1944 at Camp Detrick, Maryland.

The final report was completed on 10 June 1944.[30] It included detailed observations, conclusions, and recommendations of the commission upon which the subsequent quarantine programs of the Army and Navy were based. Part I presented factual observations of the commission and detailed discussions of quarantine problems. Part II included recommendations as to quarantine with reference to (1) international considerations, (2) civilian and commercial planes entering the United States, (3) interstate traffic, and (4) the United States military services. Part III consisted of detailed recommendations for changes in the current regulations of the Army, Navy, and Public Health Service which pertained to foreign quarantine. These recommendations proved particularly helpful in the establishment later of the quarantine program within the Army. Appendices included a draft of a proposed revision of Army Air Forces Regulations 61–3, "Flying, Outside the United States, Quarantine," in which were incorporated the policies and technical procedures recommended by the commission.

A week after completion of this report The Surgeon General, United States Army, in letters to the Surgeons General of the Navy [31] and the Public Health Service,[32] proposed the appointment of a special committee to consider the final report of the Interdepartmental Quarantine Commission. This was done, and by a joint memorandum on 27 June [33] the committee reported its agreement on the desirability of the general objectives and recommendations of the commission and endorsed them in four categories as matters for (1) immediate coordinate action by the Army, Navy, and Public Health Service,

[30] Final Rpt, Interdepartmental Quarantine Commission, 10 Jun 44. HD: 334 IQC.

[31] Ltr, SG US Army to SG US Navy, 17 June 44. HD: 334 IQC.

[32] Ltr, SG to Surg Gen USPHS, 17 Jun 44. HD: 334 IQC.

[33] Memo, R. C. Williams, Asst Surg Gen USPHS, Col K. R. Lundeberg, MC, AUS, and Comdr V. C. Tipton, MC, USN, to SG. [27 Jun 44]. HD: 334 IQC. See Appendix B; particular attention is directed to the following: sec. I, pars. 1, 3, 4, 5, 6, 7; sec. II, pars. 1, 3, 4, 7, 8, 15; sec. III, pars. 1, 2, 3. 4, 6; and sec. IV, par. 6.

(2) immediate action by the Public Health Service, (3) immediate action by the Armed Forces, and (4) further action by the Public Health Service. The recommendations of the commission so endorsed by this special committee formed the basis for the entire program of foreign quarantine within the military services and for their cooperation with one another and with the civil border clearance agencies of the United States and other governments.

The final report of the commission was formally submitted by its Army member to The Surgeon General on 17 July 1944 for transmission to the Secretary of War.[34] The Surgeon General recommended acceptance of the report and approval of it in principle as the basis for future action by the Army and for cooperation of the three Services in the field of foreign quarantine, the details to be worked out as indicated by future developments. He further recommended that The Surgeon General be charged by the Secretary of War with the responsibility for quarantine throughout the Army, including maintenance of liaison in respect to it with the Public Health Service and the Navy, establishment and supervision of quarantine functions within the Army, and integration of quarantine procedures of the Army with quarantine requirements of foreign countries. It was also advised that The Surgeon General be provided with the necessary additional personnel to carry out these duties, including an officer to be designated Army Quarantine Liaison Officer. In a separate but accompanying letter,[35] The Surgeon General expressed his desire that the Army member of the Interdepartmental Quarantine Commission be so designated and assigned to the Office of The Surgeon General for duty in the Preventive Medicine Service.

On 26 August 1944 the Secretary of War indicated his approval of the final report of the Interdepartmental Quarantine Commission and these requests of The Surgeon General.[36] Similar action was taken within the Navy and the Federal Security Agency. On 11 November the Federal Security Administrator approved the final report (see Appendix B) and terminated the commission as of that date.[37]

Participation in Nonmilitary Activities

The relation of the Interdepartmental Quarantine Commission to certain nonmilitary endeavors in the field of international quarantine has been mentioned previously. Its activities in this respect formed a sufficiently important phase of its endeavor and were associated with undertakings of such magnitude as to deserve separate consideration. They were the informal participation

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[34] Ltr, Army Representative, Interdepartmental Quarantine Commission, to SecWar thru SG, 17 Jul 44, sub: Final report, Interdepartmental Quarantine Commission, with incl; 1st ind, Dep SG to CofSA thru CG ASF, 22 Jul 44. HD: 334 IQC.

[35] Ltr, Dep SG to SecWar thru CofSA and CG ASF, 22 Jul 44, sub: Appointment of an assistant to The Surgeon General in matters of quarantine. HD: 334 IQC.

[36] Ltrs, SecWar to SG, SecNav, Admin Fed Sec Agency, 26 Aug 44. HD: 334 IQC.

[37] Ltr, Admin Fed Sec Agency to Chairman Interdepartmental Quarantine Commission, 11 Nov 44. HD: 334 IQC.

in meetings of the Fifth Pan-American Conference of National Directors of Health, and representation on the Federal Security Agency Medical Advisory Committee. This committee was charged with responsibility for technical assistance to the State Department in the formulation of national policy concerning public health matters which were to be considered in the proposed International Sanitary Treaty for Aerial Navigation.

Fifth Pan-American Conference of National Directors of Health

On 8 May 1944 members of the Interdepartmental Quarantine Commission were informally invited to participate in meetings of the Committee on Quarantine of the Fifth Pan-American Conference of National Directors of Health at Washington, D. C. This afforded the commission an opportunity to discuss with this committee the key recommendations and policies proposed in the commission's final report. Received particularly well was the commission's proposal of a system for worldwide exchange of epidemiologic data through radio notification, employing a small number of central regional offices to receive, edit, exchange, and distribute such information weekly.[38] The committee recommended early adoption of this suggestion in the Western Hemisphere under the leadership of the Pan-American Sanitary Bureau. Cuban, Mexican, and Haitian delegates expressed concern over compliance of American military aircraft with quarantine requirements in their countries, and requested establishment of liaison between the United States military personnel on the fields involved and local public health authorities. It was pointed out that this need would be fulfilled by the Interdepartmental Quarantine Commission's recommendation of the appointment of a medical officer as quarantine officer at each American airport of entry for international traffic. The requirements for travel by military plane proposed by the commission, and the procedure to be described for disinsectization were reviewed. Drafts of recommendations by the International Health Committee of UNRRA for revision of the International Sanitary Conventions of 1926 and 1933 were also discussed by this committee.

A resolution was submitted to the Pan-American Conference by the Committee on Quarantine that the Director of the Pan-American Sanitary Bureau appoint a semipermanent committee to study quarantine problems of the American Republics in accordance with the general recommendations of the conference. This resolution was approved, and the Semi-Permanent Committee on Quarantine was instructed to submit an advisory report by June 1946 to the directors of health of countries signatory to the Pan-American

[38] This plan had been utilized in part by the Far Eastern Office of the League of Nations in Singapore. Boudreau, F. G.: International aspects of disease control. *In* Miller, James A.: Preventive Medicine in Modern Practice. New York, Paul B. Hoeber, 1942, pp. 814-828. See also Magath, T. B., and Knies, P. T.: Modern concepts of international quarantine with special reference to military traffic. Mil. Surgeon 96: 209-222, Mar 1945.

Sanitary Code.[39] It was a gratifying experience for members of the Interdepartmental Quarantine Commission to have had an opportunity to discuss quarantine problems and techniques with members of the International Health Committee and to note the development of agreement on concepts and policies.

International Sanitary Treaty for Aerial Navigation

In contemplation of new international treaties for aerial navigation, the Assistant Secretary of State informed the Administrator of the Federal Security Agency on 14 July 1944 that:[40]

> The Interdepartmental Committee on International Aviation Policy has been giving consideration to the question of adopting at an international conference a new multilateral convention on air navigation with annexes containing a number of international technical aeronautical regulations. As the work of drafting these annexes is of a highly technical nature, it is felt that experts available in the appropriate sections of this Government could best undertake the preparation of those technical regulations. . . .
>
> In this connection it would be greatly appreciated if the Federal Security Agency would cooperate in these studies by designating a working committee to prepare material relating to public health requirements.
>
> In view of the fact that it seems also to be appropriate to make a study of plant quarantine requirements in connection with the proposed international aeronautical regulations, the Department is suggesting to the Department of Agriculture that it designate a working committee to prepare material on this subject. However, it is suggested that it may eventually be found desirable to have a single working committee to deal with both public health requirements and those of the plant quarantine service, unless possibly it should be found necessary to have separate technical annexes on these subjects.

Preparations for the proposed international treaty had also been brought to the attention of the Secretary of War. On 7 September 1944 Lt. Col. Richard Meiling, MC, Office of the Air Surgeon, was designated Army representative on the Federal Security Agency Medical Advisory Committee, with the Army Quarantine Liaison Officer as alternate.[41]

The first meeting of the committee, attended by representatives of the Department of Agriculture, was held 29 September. It dealt with the problem of whether or not reference to quarantine and sanitation should be made in the air navigation treaty proposed by the State Department or whether such matters should continue to be covered by special international sanitary treaties. The committee was of the opinion that a short reference should be made to medical standards and to the obligation of signatory countries to observe

[39] Proposal of Delegate from Haiti, 5th Pan-American Conference of National Directors of Health, 25 Apr 44. HD: 720.4.

[40] Ltr, SecState to Admin Fed Sec Agency, 14 Jul 44. HD: 720.4 FSA.

[41] Ltr, Actg Admin Fed Sec Agency to Lt Col P. T. Knies, MC, SGO, 7 Sep 44. HD: 720.4 FSA.

the numerous national regulations and international treaties bearing on these matters. It was agreed that detailed directives in medical and quarantine matters should not be included in the treaty, and that such treaty should not contravene existing or future special international sanitary conventions.[42]

In a second meeting on 7 October the committee further considered its recommendations. Representatives of the Public Health Service felt that the treaty should be limited to considerations of quarantine, but at the request of the Army member and alternate member it was agreed that the latter should prepare additional material to be considered before final recommendations were transmitted to the Interdepartmental Committee on International Aviation Policy. This additional material was submitted to the chairman of the committee on 9 October [43] but was ultimately considered by him to be inapplicable. Accordingly, the statement eventually submitted to the Interdepartmental Committee was as follows: [44]

> The contracting parties agree to take effective measures to prevent the spread beyond national boundaries, by means of air transportation, of the following diseases: Cholera, typhus (epidemic), smallpox, yellow fever, and plague, and such other communicable diseases as the contracting parties shall from time to time determine as advisable to add.
>
> The application of effective measures should follow the provisions of the International Sanitary Convention for Aerial Navigation and amendments thereto.

A modification of this statement received from the Department of State on 22 November was considered unacceptable, and the following counterproposal was submitted on 23 November.[45] It was agreed that this statement satisfied the purpose of the committee and discharged the terms of its appointment:

> The contracting states agree to take effective measures to prevent the spread, by means of air navigation, of cholera, typhus (epidemic), smallpox, yellow fever, and plague, and such other communicable diseases as the contracting states shall from time to time determine advisable to designate, and, to that end, contracting states will keep in close consultation with the agencies concerned with international regulations relating to sanitary measures applicable to aircraft. Such consultation shall be without prejudice to the application of any existing international convention on this subject to which the contracting states may be parties.

With a few slight editorial changes the statement became Article 14 of the Convention on International Civil Aviation adopted at Chicago on 7 December 1944.

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[42] Memo for file, sgd Lt Col P. T. Knies, MC, 30 Sep 44, sub: Federal Security Agency committee to prepare medical recommendations for inclusion in multilateral treaty concerning aerial navigation. HD: 720.4 FSA.

[43] Supplementary Rpt, Medical Advisory Committee, Interdepartmental Committee of International Aviation Policy, 9 Oct 44. HD: 720.4 FSA.

[44] Abstract of Proceedings, Medical Advisory Committee, Interdepartmental Committee of International Aviation Policy, 10 Oct 44. HD: 720.4 FSA.

[45] Memo for file, Lt Col P. T. Knies, MC, 24 Nov 44, sub: Multilateral air navigation treaty. HD: 720.4 FSA.

ORGANIZATION OF QUARANTINE BRANCH EPIDEMIOLOGY DIVISION, PREVENTIVE MEDICINE SERVICE

The Secretary of War's approval of the final report of the Interdepartmental Quarantine Commission, as transmitted to The Surgeon General, read in part: [46]

> Accordingly, all matters concerned with foreign quarantine, as it touches upon the interest of the Army, are made responsibilities of The Surgeon General, including in that connection the maintenance of liaison in matters of quarantine with the United States Public Health Service and with the United States Navy, the establishment and supervision of quarantine functions within the Army, and the integration of quarantine procedures of the Army with quarantine requirements of foreign countries through cooperation with the respective Army commanders in those areas. It is believed that only in this manner can there be achieved the uniformity of Army action, with reference to this important subject, which will assure effective and efficient quarantine procedures throughout the Army.
>
> You will be provided such personnel, selected by yourself, as will be necessary to carry out these additional duties. It is agreed that this personnel should include an officer of suitable rank and qualifications to assist you in these matters and to be designated Army Quarantine Liaison Officer. It is understood that officer and clerical assistance required by this officer will not exceed one officer and clerk at this time.

This communication was forwarded to The Adjutant General, with the request that the Army Quarantine Liaison Officer assist The Surgeon General in matters pertaining to foreign quarantine, and remain assigned to the Army Air Forces in status of flight surgeon. It was considered that such assignment would facilitate the accomplishment of his duties, a large proportion of which would concern Army Air Forces operations.[47] The Air Surgeon concurred in this proposal, and on 18 September 1944 appropriate orders were published. Notification of the appointment of the Army Quarantine Liaison Officer was made to all appropriate military, civilian, and international agencies. Meanwhile, the Secretary of the Navy informed the Secretary of War [48] of the similar appointment of the Navy member of the Interdepartmental Quarantine Commission to be Navy Quarantine Liaison Officer.

Upon reporting in September 1944 to the Office of The Surgeon General for duty, the Army Quarantine Liaison Officer was assigned to the Epidemiology Division, Preventive Medicine Service. In order to provide adequate office and administrative facilities, a Quarantine Branch of the Epidemiology Division was created, with functions defined as follows:[49]

> Establishes policy and prepares directives for the prevention of the international spread of infectious diseases and pests in international United States military traffic; conducts inspection of, makes recommendations with regard to, and supervises quaran-

[46] See footnote 36, p. 282.
[47] 1st Ind, SG to TAG, 30 Aug 44, on ltr cited in footnote 36, p. 282.
[48] Ltr, SecNav to SecWar, 13 Sep 44. HD: 720.4 Navy.
[49] Annual Rpt, Epidemiology Div Prev Med Serv SGO, FY 1945. HD.

tine functions throughout the Army; maintains liaison i ters of quarantine with those echelons of the Army concerned with international traffic including Army Air Forces, Transportation Corps of Army Service Forc he several theaters and departments; maintains liaison in matters of quarantin with the U. S. Navy, U. S. Public Health Service, U. S. Department of Agriculture, the Department of the Interior, and with foreign governments concerned with United States military traffic.

Establishment of the Quarantine Branch in the Office of The Surgeon General provided for coordination within the War Department of the pertinent activities of the several commands which were concerned with entry of military traffic into the United States and which had previously dealt independently with the civil border clearance agencies. The channeling of all such communications through a single liaison office was of great advantage in attaining a consistent and uniform quarantine program.

A projected program of foreign quarantine was prepared by the Army Quarantine Liaison Officer. It included (1) revision and publication of additional War Department and other Army directives in order to establish and implement the recommendations of the Interdepartmental Quarantine Commission, (2) institution of a program of instruction and inspection conducted by personnel of the Quarantine Branch to insure adequate understanding and application of the measures covered by these directives both in the United States and in foreign theaters of operations, (3) establishment of a system for collection of quarantine data within the Army and provision of monthly summary reports of Army activities in quarantine to the Public Health Service, and (4) provision of special publications and educational activities.[50]

The Army Quarantine Liaison Officer suggested in November 1944 that he establish liaison with the Army Committee for Insect and Rodent Control because of the close relationship of interest.[51] He accordingly was appointed a member of the Army Committee, and since its personnel included representatives from the Public Health Service, the Department of Agriculture, the Navy, and the Army Air Forces, excellent opportunity was afforded to coordinate quarantine plans and procedures in the field of insect and rodent control with the other principal agencies concerned in quarantine.

Among the other agencies with which relations were established by the Quarantine Branch in dealing with epidemiologic problems, control of infectious disease, and matters related to quarantine were the Army Epidemiological Board and the United States of America Typhus Commission. The headquarters offices of both of these agencies were located in the Preventive Medicine Service of the Office of The Surgeon General.

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[50] Memo, Army Quarantine Liaison Officer for Dir Epidemiology Div, 26 Sep 44, sub: Projected program in foreign quarantine. HD: 720.4 Gen.

[51] Memo, Army Quarantine Liaison Officer for Asst Chief Prev Med Serv SGO, 22 Nov 44, sub: Army Committee for Insect and Rodent Control. HD: 720.4 Insects.

DEVELOPMENT OF THE ARMY QUARANTINE PROGRAM

Quarantine Directives

The development of directives to define military policy was of primary importance in the institution of the Army quarantine program. Previous references to quarantine in Army directives had been limited to the indication of the obligation to observe requirements of civil regulations as they pertained to Army activities—a policy no longer adequate. As basic authority Army Regulations (AR) 40–225, "Foreign Quarantine," was published on 21 November 1944. It defined the quarantine responsibilities of the War Department, The Surgeon General, the Army Quarantine Liaison Officer, and operational commands, and clarified relationships with established civil agencies concerned with foreign quarantine. This regulation expounded the fundamental obligations and authorizations outlined in the previously cited letter from the Secretary of War to The Surgeon General.[52]

Further exposition of operational detail and of specific procedures necessary to comply with quarantine requirements of the War Department was essential. These, together with definition of the Army's obligations to civil border clearance agencies concerned with quarantine in other countries and in the United States (since the War Department and these agencies had agreed to such cooperation), were incorporated in War Department Circular 453, "Foreign Quarantine," issued in 1944. This directive was a comprehensive presentation of the entire Army quarantine program and proved to be a most useful document of reference.

Although the need for such apparent duplication of directives was questioned at the time of publication of these two basic documents on quarantine, subsequent experience confirmed the desirability of this mechanism. The provisions of AR 40–225 did not require alteration during the war period and it is believed that any modification in the Army quarantine program, even to a complete suspension of Army participation in quarantine, will be possible without revision of this fundamental directive. The operational detail contained in the War Department circular rendered that publication susceptible to revision necessitated from time to time by changing conditions of actual practice. The lesser authority of this directive and the greater administrative ease of altering it expedited its modification.

Army Air Forces Regulations 61–3, "Flying, Outside the United States, Quarantine," was revised on 9 August 1944 to describe in considerable detail the quarantine procedure in Air Forces operations. Previous issues of this directive had referred only to disinsectization. In re-publication, specifications were provided for those aspects of quarantine of interest to air traffic, such as personnel, insects, and agricultural items. Because this directive, even if

[52] See footnote 36, p. 282.

limited, already existed and because suggested revision of it had been included in the final report of the Interdepartmental Quarantine Commission, re-publication of it was possible before that of the parallel War Department directives.

Publication of these documents allowed the recision of certain partial coverages of quarantine in previous directives not primarily devoted to this subject. In addition, the modification of other War Department publications and writing of new directives were phrased in the light of the existence of these directives or to implement the quarantine program. Thus, previous references to quarantine in AR 40–210, "Prevention and Control of Communicable Diseases," were altered, and emphasis in this directive was placed on immunization requirements before foreign travel aboard vessels and aircraft under United States Army control. The relation of immunization to foreign quarantine was expounded more specifically in War Department Technical Bulletin, TB MED 114, "Immunizations Required in Relation to Areas of Travel," 9 November 1944. Agricultural quarantines had already been covered in part in War Department Circular 335, 1944, "Inspection and Customs Clearance of Baggage," and this directive was partly revised in accordance with the new quarantine program by War Department Circular 31, 1945, Section IV. Particular consideration was given to matters of quarantine, also, in important directives pertaining to large-scale troop movements.[53]

International shipment by the War Department of infectious agents and vectors of disease for scientific, educational, or medical reasons, were given particular consideration in view of the quarantine program and commitments of the Army. In order to facilitate investigative projects of the Medical Department, special blanket permits were granted by the Department of Agriculture and by the Public Health Service. These were published in War Department Circular 43, 1945, which materially assisted in carrying out important military activities without conflict with quarantine regulations of the civil border clearance agencies of the United States. At the same time, military organizations and personnel were obligated to abide completely by requirements of the civil agencies in regard to private importations, as well as to comply with the more stringent policies of the Army, which often exceeded the minimal civil requirements.

Similar modifications of civil quarantine practice pertaining to a number of different items and world areas were put into military quarantine practice during the war. The purpose of imposing such additional requirements upon military practice was always to insure uniformity of practice and ease of administration in the presence of variation in civilian quarantine regulations pertaining to a given item or area of travel.

It had been hoped that aircraft quarantine directives of the Army, Navy, and Public Health Service might be completely coordinated and published

[53] Ltr, TAG to CGs AAF, AGF, ASF, and others, 16 Aug 44. sub: Procedure for return of individuals. AG: 370.5. Also WD Readjustment Regulations RR 1-2, 11 Apr 45.

simultaneously to assure maximum effectiveness, and the Army and Navy directives had been so published. The regulation of the Public Health Service, however, had been delayed, and when published, minor revision of Army Air Forces Regulations 61–3 was necessitated. On 7 February 1945, Appendix III of this regulation was revised (AAF Regulations 61–3A) to correspond with Foreign Quarantine Division Circular 71, Public Health Service, as published on 27 November 1944.

Consideration was given to publication of a comprehensive technical manual for the instruction of personnel assigned to foreign quarantine duties in the field. It was not clear by 1 January 1945 that this would serve a necessary or useful purpose, so only a preliminary draft was prepared. This was perhaps unfortunate, for subsequent experience clearly indicated the inadequacy of the presentation of quarantine policy by directives alone. While this deficiency was in part compensated by field work of officers of the Quarantine Branch, Preventive Medicine Service, it is believed that the reference manual would have been especially helpful in the instruction of new readjustment movements.

A complete list of directives bearing on the Army quarantine program, as of 1 February 1946, is appended (Appendix C).

Philosophy and Operation of the Program

General Basic Principles of the Army Program

The general principles incorporated in the Army quarantine program, and published in directives of the War Department, Transportation Corps, Army Air Forces, and the several major geographic and functional commands were primarily those contained in the final report of the Interdepartmental Quarantine Commission. Certain considerations upon which they were based should be discussed, however, in order to clarify the program ultimately established. Although practice based upon them may have varied somewhat from previous experience, the Army quarantine program was founded on the principles of a fairly generally accepted philosophy of quarantine. Exigencies of war and the nature of military services and their operations necessitated some compromise with preexisting quarantine procedure—compromise evolved from rather different considerations in regard to (1) personnel and disinsectization of aircraft, and (2) plants, animals, and their products. The ultimate success of the program attests to the soundness of the philosophy upon which it was based, and to the efficacy of its methodology.

In conformity with existing international agreements on quarantine, the Army acknowledged its obligation to observe civil regulations of foreign territories when pertinent or enforced, and when such cooperation did not endanger the military situation. Experience indicated that quarantine procedures such as physical inspection and certification were more certain and easy of accom-

plishment at the point of departure rather than that of arrival. As far as physical inspection was concerned, quarantine requirements involved little more than standard military practice previously outlined in directives not primarily related to quarantine. Recognition of the high standard of preventive medical practice in the military services lead civil agencies to accept certification in lieu of physical inspection. Since pertinent regulations of other nations varied widely in respect to control of traffic in plants, animals, and their products, Army quarantine procedure concerning these items was especially stringent. Medical Department responsibility for the technical supervision of quarantine was discharged through personnel of the Quarantine Branch, Office of the Surgeon General, and through those responsible for medical care at the point of origin and for the handling of traffic.

In some instances civil regulations were negligible or unenforced, notwithstanding ratification of international sanitary agreements by the country concerned. In others, particularly in countries very much alert to epidemiologic problems, and occasionally under circumstances more difficult to comprehend, meticulous requirements were placed on Army traffic. It was evident that Army routine had to be sufficiently stringent to satisfy authorities of the more demanding nations (except in a zone of active fighting), and yet remain sufficiently flexible to allow relaxation where actual risk and civil regulation permitted.

An important function of the Army Quarantine Liaison Officer, in consultation with the authorities of such countries, was to point out the considerable modification, if not actual elimination of risk incident to military travel resulting from military sanitation, immunization, and other practices of the Army medical program. Such consultation often resulted in obtaining for United States military travel either formal or informal suspension or modification of normal quarantine requirements. The high regard accorded the Army medical program by many other nations was proved by the fact that privileges afforded the United States Army traffic were at times withheld from parallel traffic of civilian airlines and even Allied military traffic.

It therefore became Army quarantine policy that all obligations undertaken or procedures actually established should be the least necessary to (1) meet pertinent and applied civil requirements; (2) reduce to a practical minimum the actual risk of introduction of disease or pest; and (3) administer with ease. This represented a compromise between two major considerations: maximum possible reduction of risk, and minimum interference with and delay of urgent military operations. Such a compromise was not new in quarantine, for it was long recognized that maximum protection must seriously hamper international travel. Nor was compromise incompatible with satisfactory epidemiologic goals, for it was well established that rarely is complete elimination of risk requisite to effective protection, and practice was based on reduction of risk below critical levels. This viewpoint is extremely important, and lack

of appreciation of it was at times responsible for criticism directed at all quarantines on the basis of individual hazards observed. It is axiomatic that local circumstances at points of departure or entry affect the degree of risk, and more stringent measures are proper in otherwise identical traffic in some routes of travel than in others.

Quarantine measures must be limited to those significant risks for which effective control measures are available. This principle had long been recognized in international quarantine practice. Thus not all infectious and communicable diseases had been considered subject to provisions of international quarantine or even to local quarantine procedures. This policy was realistic. It was based on recognition that many communicable diseases, by virtue of prolonged incubation periods, asymptomatic phases, or atypical manifestations, were not amenable to epidemiologic control by feasible and available procedures or quarantine. It also took into consideration that in international traffic there was little justification for restrictive barriers against diseases already present to a significant degree in both the area of departure and the area of entry. Medical experience of centuries, however, had shown the importance of travel in respect to those diseases which came to be known as the quarantinable diseases (cholera, smallpox, plague, yellow fever, and louse-borne typhus). The quarantine regulations of most countries, therefore, referred only to these diseases.

Australia and the United States, respectively, added influenza and leprosy to this list. The ineffectiveness of rigid quarantine in the control of influenza in Australia following World War I indicated the futility of such regulation and the statute persisted simply because it had never been rescinded. The policy of the United States toward leprosy was concerned more with immigration than with quarantine, as the disease was not considered quarantinable when occurring in a citizen of the United States.

Army quarantine, therefore, was applied only to the generally recognized quarantinable diseases, in accordance with international codes. Because most of the tropical diseases to which American troops were exposed were not amenable to epidemiologic control by feasible and available techniques of international quarantine, reliance for protection against their introduction in military traffic had to be placed on other preventive measures. Such measures included in particular the inspection of military personnel before travel was undertaken, in contradistinction to standard practice in civilian international quarantine whereby all quarantine procedures were accomplished at the point of entry with the single exception of their application to immigrant persons. Disinsectization and disinfestation constituted important techniques in military as in civilian international quarantine but were applied in manners which varied considerably from previously accepted civilian practices.

The problem of the questionable efficiency of certain quarantine methods was well illustrated by the disinsectization of aircraft. At the onset of war only

pyrethrum spraying was employed for this purpose because of the obviously limited usefulness of fumigation or heat sterilization. It would have been desirable, of course, to be able to assure all areas of entry of the complete absence from aircraft of viable insects, but the limited value of pyrethrum sprays made this an impossibility. Therefore, the standard of efficiency in the application of this method in any given instance was of necessity governed by its known and very definite limitations: namely, the elimination only of delicate insects, particularly mosquitoes. It was observed at times that numerous living beetles, moths, cockroaches, and other hardy insects were recovered alive after disinsectization of aircraft in accordance with prescribed techniques.[54] With the introduction of DDT, it was hoped that more effective methods for the control of insect life in international transportation would be developed. Extensive studies were carried on in this direction, but satisfactory methods of application of DDT for such purpose had not been devised by the end of the war. The program for disinsectization of aircraft which was adopted was that advised by the Interdepartmental Quarantine Commission. It was devised to assure reasonable protection to countries of entry against risks for which efficacious and practicable measures were available. Additional procedures were added at times on the insistence of certain countries of entry, such measures ordinarily being carried out by officials of those countries.

The place of application of quarantine measures constituted a matter for serious consideration. It was decided that such activities could be carried out at the point of departure of military traffic with more assurance of their completion and ease of execution than if performed at the point of entry. This was particularly evident at the height of military operations, when a great premium was placed on immediate clearance of vehicles, cargo, and personnel from points of entry, and when advantage could be taken of the necessary and unavoidable delays due to marshaling of traffic at points of departure. The only exceptions to this practice were when an arrival procedure was implacably demanded by civil regulations. In practice this pertained only to disinsectization of aircraft entering Brazil from Africa [55] and India from the West,[56] and to medical inspection and certification by civil authorities of personnel arriving by aircraft in New Zealand [57] and India.

Normal civil quarantine procedure for personnel in international traffic was based on physical inspection (in contradistinction to examination) to detect those apparently ill, in order that definitive examination might then be made. Certification was another time-honored quarantine procedure. It was gener-

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[54] Extract from Annual Report of F. X. Williams, Associate Entomologist, Hawaiian Sugar Planters' Association, 1 Jun 45, sub: New insect pests and parasites in Hawaii—Project E-5. HD: 720.4 Field Trips.

[55] Decree Law 5181 of 11 January 1943, Ministry of Education and Health Official Diary 13 January 1943, Rio de Janeiro, Brazil. HD: 720.4 Brazil.

[56] Ltr, Army Quarantine Liaison Off to CG USF IBT, 6 Aug 45, sub: Foreign quarantine in traffic under jurisdiction of USF-IBT. HD: 720.4 CBI.

[57] Quarantine Regulations 1942, Amendment No. 3, 2 Aug 44, Wellington, New Zealand. HD: 720.4 POA.

ally agreed that in the case of military personnel, the high degree of physical selection, the continuing medical care afforded, and the extensive immunizations carried out, reduced risk of quarantinable disease to a minimum. The attitude that no qualification other than United States military status should be necessary for quarantine clearance might have been justified. This viewpoint, however, was not acceptable to certain civil authorities who insisted on inspection at the time of travel, even though it be carried out by military examiners.

As already indicated, an essential part of the quarantine program involved certification, primarily in order to meet the traditional requirements of civil agencies. Although the necessity for certification is at times burdensome, it is admitted that the effectiveness of any procedure is probably increased when compliance with regulation must be indicated in a signed statement. As it developed in the Army quarantine program, certification was required of those operational personnel most intimately concerned with the preparation and acceptance of personnel for transportation, with security inspection of baggage, and with the normal details of transportation. Certification for personnel was therefore required of surgeons at points of departure; for traveling groups, of traffic regulating officers; for baggage and personal belongings, of officers handling those items for other purposes; for disinsectization of aircraft, of operational personnel assigned to the aircraft; and for mail, of censors otherwise required to inspect it. Thus no additional personnel was required for this purpose.

The Army quarantine program introduced no new or additional medical requirements for personnel and, in fact, amounted almost entirely to an administrative and clerical procedure so far as the quarantinable diseases were concerned. It should be emphasized that quarantine clearance of American military personnel came to be based entirely on the requirements imposed by medical directives having no primary relation to quarantine and undertaking only to protect the individual and group health of United States troops. The only procedures added for quarantine clearance were (1) recheck, in compliance with the basic directives, under some circumstances in which recheck would not otherwise have been required and (2) certification that certain procedures had been carried out. Even actual predeparture inspection of personnel and immunization records was unnecessary so long as the certifying officer was satisfied that the following three fundamental requirements had been met:

1. Immunization in accordance with War Department policy [58] (therefore no likely recent exposure to quarantinable disease).

2. Freedom from vermin [59] (and therefore no likelihood of spread of vermin-transmitted disease, whether or not the individual himself might be ill with such a disease).

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[58] (1) AR 40-210, 25 Apr 45, Prevention and Control of Communicable Diseases of Man, par. 10 f. (2) TB Med 114, 9 Nov 44, Immunization.

[59] AR 615-250, 24 Jul 42, Physical Inspection—Enlisted Men, par. 5.

3. Freedom from quarantinable illness at the time travel was undertaken.[60]

The proposal that certification to these three qualifications be accepted in ı of inspection of personnel on arrival was accepted by all countries in which ıited States military traffic operated, with the reservation that inspection ght be made by civil authorities if considered necessary by them. Actually civil agency insisted on this prerogative, and even in India only immuniza- n records were inspected. That this practice was effective and justifiable s indicated by the occurrence in United States military traffic of only three own cases of quarantinable disease in United States military personnel during)rld War II, none of which afforded risk to the country of entry under the cumstances involved.

As might be expected there were exceptions to and modifications of usual arantine procedure in respect to personnel. Transportation of patients ving quarantinable diseases (except those ill with pneumonic plague) was not bidden, as long as they were not certified as described above and were ated as exceptions to standard practice. However, transportation of persons ested with vermin capable of transmitting diseases was not permitted, being ıtrary to AR 615–250, 24 July 1942, "Physical Inspection—Enlisted Men." :dical evacuation of Army personnel and transportation of civilians or foreign litary personnel when their immunization had been refused or was unfeasible s allowed. Standard procedure was further modified because certain countries isted on immunization against yellow fever and, in the absence of such munization, on the possible quarantine of persons and their contacts on ival from yellow fever areas and application of quarantine measures to the ıveyances in which they had arrived. Because such quarantine measures ght have imposed upon military traffic unnecessary expense, inconvenience, d delay, United States Army requirements for immunization against yellow 'er were designed to assure freedom from such restriction of traffic as well as protect United States personnel.

The immunization status required by the United States for its personnel fered from that required by other countries. T is was in accordance, not th quarantine standards, but with the obligation of the Army to protect the alth of United States citizens, and the greater responsibility and burden ıich would devolve on the Army should such persons become ill and require re. The same immunizations were available to foreign personnel traveling United States carriers.

It has been pointed out that Army policy with respect to quarantine of ınts, animals, and those of their products which were capable of transmitting ıease or becoming pests in areas of entry was based on somewhat different nsiderations from those pertaining to personnel and disinsectization, more ight being given to factors of military convenience and expedience. As in

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[60] See footnote 59, p. 294.

other phases of quarantine, the Army was obligated to observe those civil requirements which pertained to United States military traffic. In the case of plants, animals, and their products, these requirements were found to vary widely in accordance with the agricultural economy of countries of entry. In view of the several areas which might be traversed in a single flight or in the complete journey of cargo or baggage, it was not possible to adopt a uniform policy other than total exclusion from United States Army traffic of all animals, plants, and of certain animal and plant products for which there was no legitimate military purpose. Legitimate military purpose was defined to include scientific, educational, or military uses approved by the Army, but not extended to include transportation of the same items for purposes of the individual, even when such transportation was not forbidden by civil law.

Civil quarantine regulations in the United States generally class animal and plant products and specimens (other than those to which no requirement pertains) as "restricted" or "prohibited." Transportation of "prohibited" items was forbidden in Army traffic. Carriage of "restricted" items was permitted, but declaration of them was required, as well as presentation to civil quarantine authorities, on entry. In certain urgent and homogeneous traffic, such as the return to the United States of large numbers of troops by air, it became militarily unfeasible to provide such inspection of "restricted" items, which accordingly were made "prohibited" by military regulations.[61]

The contrasting policy is apparent: on the one hand, foreign quarantine in military traffic with respect to personnel and disinsectization, as well as living animals and plants and their "prohibited" products, was carried out by military personnel at points of departure. On the other, in the case of "restricted" products, reliance was placed upon the discretion of civil agencies at points of entry. Civil agents were permitted to "sample" Army traffic at will with reference to any quarantine consideration, in order to satisfy themselves that the military program was being carried out according to agreement. These agencies, however, usually were satisfied with military procedure, and rarely resorted to sampling. Even when deficiencies were observed and reported, the military program was generally complimented on its high degree of general effectiveness.

It is certain that such general interdiction of the transportation of pets, attractive plants, and other items of curiosity or general interest was not unreasonable and was, in fact, mandatory in urgent military traffic in which only essential transportation could be justified. Human nature, however, did not permit the complete enforcement of this policy, and numerous breaches were reported. Nevertheless, considering the gigantic proportions of Army travel during the war, the total amount of contraband materials transported compared very favorably with that which would admittedly not have been intercepted in

[61] (1) WD Cir 453, 29 Nov 44. (2) AR 40-225, 21 Nov 44.

the normal civil technique of quarantine. It is believed that civil requirements on the whole were better met under this system than had the Army attempted to follow to the letter the various restrictions and prohibitions imposed by the many civil codes.

Technical supervision of all quarantine had been made a Medical Department responsibility by AR 40–225. A major function of the Quarantine Branch, Preventive Medicine Service, was the exercise of this supervisory responsibility of The Surgeon General. By appropriate military directives, this responsibility was extended to medical officers of all organizations originating or handling traffic. It was argued by some that technical supervision, particularly of disinsectization and of baggage inspection, might more properly have been the responsibility of operational and technical personnel. While it was agreed that procedural execution must and should be delegated to such persons, the position was maintained that only Medical Department personnel, and especially medical officers, could adequately appreciate the importance of quarantine. It was insisted upon that supervisory and inspectional responsibility remain with the Medical Department throughout the war.

In order to allow evaluation of the United States Army quarantine program in light of military practice then current, it seems appropriate to describe the quarantine practices of certain other nations during the war. With respect to personnel, the British services observed quarantine restrictions as enforced by the civil agencies in all areas of entry, including the several Dominions and India. Their own participation was purely passive. Enforcement varied greatly in degree and effectiveness, and was most meticulous in India, Australia, and New Zealand. In 1943, New Zealand published a special regulation for quarantine control of all entering military traffic.[62] Because of this decentralization of quarantine enforcement, no uniform plan was adopted throughout the British military services, and many local arrangements were highly informal.[63]

In Japanese operations, quarantine had been carried out by completely autonomous Army, Navy, and civil services with separate personnel, uncoordinated regulations, no mutual responsibilities, and duplicated installations. The dual Army and Navy control was extended to overseas areas as well as the homeland.[64] The meticulous procedure prescribed involved much laboratory work for the detection of enteric infections other than cholera, Japanese quarantine having always paid great attention to the bacillary dysenteries, although before the war that country was signatory to the international sanitary convention which did not cover enteric infections other than cholera.

[62] Quarantine (Armed Forces) Emergency Regulation, 1943, Wellington, New Zealand. HD: 720.4 POA.

[63] (1) Ltr, Army Quarantine Liaison Off to CG USAFIME, 10 Feb 45, sub: Foreign quarantine in traffic under jurisdiction of USAFIME. HD: 720.4 Field Trips. (2) See also footnote 56, p. 293.

[64] (1) Memo, Army Quarantine Liaison Off for Chief Surg GHQ AFPAC, 27 Sep 45, sub: Japanese quarantine procedures: civil. HD: 720.4 Repatriation. (2) Memo, Army Quarantine Liaison Off for Chief Surg GHQ AFPAC, 26 Sep 45, sub: Japanese quarantine procedures: Army. HD: 720.4 Repatriation. (3) Memo, Army Quarantine Liaison Off for Chief Surg GHQ AFPAC, 4 Oct 45, sub: Japanese quarantine procedures: Navy. HD: 720.4 Repatriation.

The degree of effectiveness of the British and Japanese practices cannot be evaluated through lack of data. It is not known to the writer whether quarantine was formally observed by other military forces during World War II.

In summary, the United States Army quarantine program was based on the principles of a generally accepted philosophy of quarantine. Within the limitations of military expediency, it adhered to civilian quarantine regulations. Aside from participation in interdepartmental study of wartime problems of foreign quarantine, it was largely administrative in nature, requiring little beyond usual military preventive medical practice and utilizing almost no special personnel. Yet in spite of this apparent lack of complexity, or perhaps because of it, this program proved itself to be effective beyond doubt.

Army Quarantine Program in the Field

Following the establishment of quarantine policy in military directives issued by the War Department, Transportation Corps, Army Air Forces, and Air Transport Command, a principal activity of the Quarantine Branch, Preventive Medicine Service, Office of The Surgeon General, was field work in all areas of Army transport operation. The aims of this field work included: (1) analysis of quarantine problems encountered in specific channels of transportation (previously done by the Interdepartmental Quarantine Commission but now necessary in greater detail for the application of the new directives), (2) consultation with responsible personnel in area and operational commands to assure comprehension of the quarantine program and familiarity with techniques and methods for its execution, and (3) development of directives for field commands in order to implement Army quarantine policies where local circumstances required consultation with civil quarantine authorities of the United States and other countries to assure understanding of Army policies and techniques and to coordinate Army practices with civil requirements. A list of studies of this category is as follows:[65]

1. Inspection of quarantine facilities in New York area, 10 October 1944
2. Visit of Army Quarantine Liaison Officer to New York Port of Embarkation, 13 October 1944
3. Inspection of quarantine facilities at Washington Port of Aerial Embarkation, Washington National Airport, 21 October 1944
4. Quarantine inspection of Army Air Forces stations in Southeastern United States, 5 December 1944
5. Report of inspection of New Haven Army Air Field, Connecticut, 14 December 1944
6. Foreign quarantine in traffic under jurisdiction of United States Army Forces in the Middle East, 10 February 1945
7. Foreign quarantine in traffic under jurisdiction of Mediterranean Theater of Operations, United States Army, 23 February 1945

[65] Filed in HD: 720.4.

8. Foreign quarantine in traffic under jurisdiction of European Theater of Operations, United States Army, 23 February 1945

9. Foreign quarantine in traffic under jurisdiction of North Atlantic Division, Air Transport Command, 31 March 1945

10. Foreign quarantine at United States Army facilities within Antilles Department, 8 May 1945

11. Foreign quarantine at United States Army facilities within Panama Canal Department, 13 May 1945

12. Foreign quarantine at United States Army facilities within United States Army Forces in South Atlantic, 25 May 1945

13. Foreign quarantine in traffic under jurisdiction of Africa-Middle East theater, 8 June 1945

14. Observation of border clearance procedures in "White Project," 13 June 1945

15. Foreign quarantine in traffic under jurisdiction of United States Forces, India-Burma theater, 6 August 1945

16. Foreign quarantine in traffic under jurisdiction of United States Forces in China theater, 6 July 1945

17. Foreign quarantine in traffic under jurisdiction of Army Forces in the Pacific, 4 September 1945

18. Observation of foreign quarantine and other medical procedures at New York Port of Embarkation, 21 September 1945

19. Observation of quarantine procedure at Hampton Roads Port of Embarkation, 9 October 1945

20. Foreign quarantine in Territory of Hawaii, 17 December 1945

Field work by Quarantine Branch staff was occasionally necessary in the investigation of specific problems which were anticipated or reported to have arisen. Such investigations included: an investigation of a report of mites in clothing received from overseas at Patterson Field, Ohio; a study of the quarantine control of ammunition salvage; and one on the contamination of salvage by soil. Perhaps the most important field work in this category was the study of quarantine problems in Japan, Korea, and coastal China, with special reference to repatriation of displaced persons.[66] This was undertaken at the request of the Public Health and Welfare Section of General Headquarters, Supreme Commander Allied Powers, and the Chief Surgeon, Army Forces in the Pacific, and led to publication by the Supreme Commander Allied Powers of quarantine requirements for the return of Japanese, Korean, and Chinese personnel to their homelands.[67]

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[66] File, Repatriation in Japan, Korea, China, and other Pacific areas. HD: 720.4.

[67] (1) Memo, SCAP for Imperial Japanese Govt, 22 Sep 45, sub: Public health measures. HD: 720.4 (2) Memo, SCAP for Imperial Japanese Govt, 15 Oct 45, sub: Reception centers in Japan for processing repatriates. HD: 720.4. (3) Memo, SCAP for Imperial Japanese Govt, 20 Oct 45, sub: Medical and sanitary procedures for debarkation and port sanitation in repatriation. HD: 720.4.

In addition to investigations carried out by members of the Quarantine Branch, numerous similar studies were conducted by various Army commands in all areas of military operations. An outstanding example of the latter was an inspection of medical quarantine activities of the Sunset Project (return of military personnel to the United States from the Pacific areas) reported on 10 November 1945.[68] Prior to this Project, the Pacific Division of the Air Transport Command had initiated in 1945 a program to reduce the risk of accidental transportation of insect pests by aircraft under the jurisdiction of Air Transport Command from one island group to another, or from Pacific areas to the mainland of the United States. To prevent such transportation, areas surrounding important landing fields used as major bases in the Air Transport Command transportation system, or whole islands upon which such bases were located, were sprayed methodically and systematically with DDT by means of C–47 aircraft. Thus, Atsugi Field, Honshu, Japan; Kadena and Yontan Fields, Okinawa; Nichols Field, Luzon, Philippines; all of Saipan and Guam, Marianas; Henderson Field, Guadalcanal, Solomons; and all of Kwajalein, Marshalls, were sprayed in such a way that those insect populations affected by the insecticide were reduced below the point where (1) insect-borne disease transmission would occur, (2) possibility of accidental transportation by aircraft was prevented, and (3) annoyance was eliminated. The attempt was based on the theory that the place to prevent accidental introduction of a biologic entity into a protected area should be at the point of origin, not to wait until the introduction has taken place. The plan as devised was ready and in full existence when the Sunset Project began in 1945.

Another responsibility of the Quarantine Branch was the maintenance of liaison in respect to field problems with the United States Navy through the Navy Quarantine Liaison Officer, and with the Public Health Service, through the chief of its Foreign Quarantine Division. Beginning 1 October 1944, monthly summary reports of Army quarantine activities were forwarded to these officers.[69] These reports included data from the previously mentioned special studies, and current information received in monthly and special sanitary reports of Army commands responsible for quarantine procedures. Additional formal and informal special reports were forwarded to these officers as circumstances dictated. Similar relations were maintained with responsible personnel in the Department of Agriculture, the Department of the Interior, and the Food and Drug Administration, Federal Security Agency. The Quarantine Branch acted as a distribution center for information of interest to the major Army commands and civil border clearance agencies from which numerous personnel had been withdrawn upon the establishment of quarantine procedures by the United States Army.

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[68] Ltr, Lt Col D. D. Todorovic, MC, Mather Fld, Calif., to CofS Pac Div ATC, 10 Nov 45, sub: Inspection of medical quarantine activities of the Sunset Project. HD: 720.4 ATC.

[69] File, Monthly rpt of quarantine activities, US Army, to USPHS. HD: 720.4.

Despite the tremendous traffic, quarantine station complements were generally reduced. Civilian officials were entirely removed from military airports. At joint commercial-military fields, practice varied in accordance with special agreements and local traffic. In water ports of entry, quarantine processing remained in the hands of civil agencies, but due to certification of quarantine clearance for military traffic, the work of these civilian officers was much reduced. Since most Army vessels and others wholly allocated to the War Department were cleared routinely on the basis of certification required by Army Service Forces,[70] Public Health Service officers boarded only a portion of the entering ships.

The cooperative relationship which existed at all times between the Army and the several border clearance agencies contributed immeasurably to the success of this military undertaking. It permitted conservation of critical personnel, whose unavailability had been an important factor leading to the policy of military administration of quarantine in military traffic wherever possible. The technical advice and assistance of civil experts was always available when desired or necessary in special problems.

Publicity and Education

Restrictive regulations are often disregarded unless the reasons for them are understood. It was therefore believed that appreciation of the purposes and provisions of the Army program in foreign quarantine was essential to its effective accomplishment. It was observed that most breaches of quarantine regulations during the war were due to ignorance or prejudice which could be corrected only by adequate education. Directives are notoriously deficient as educational media. Furthermore, their distribution is limited. Those of the type utilized in the quarantine program commonly did not reach the attention of most of the individuals whose actions they were designed to regulate.

Thus War Department and Air Forces directives pertaining to quarantine which were issued in the United States were commonly no more widely distributed overseas than to theater and area headquarters. Their implementation frequently depended upon their reissue within an area or command, at times in a different form. Such revisions were not uncommonly ineffective in accomplishing the purpose of the basic documents because of lack of comprehension of the latter by authorities responsible for their modification for reissue. Sometimes War Department directives were implemented by name only, procedure was not designated in local orders overseas, and copies of the directives were not available to those whose work they affected. Inasmuch as War Department and Air Forces directives pertaining to quarantine dealt with matters of interarea and intertheater concern, quarantine operations in many areas would have been facilitated by the establishment of an accepted

[70] Transportation Corps Cir 80-18, 24 Feb 45, Quarantine Inspection of Army Vessels, Personnel, and Cargo Arriving at Ports of Embarkation.

policy for the implementation of quarantine regulations by overseas commanders which did not so carefully maintain the local autonomy of such commanders.

In recognition of these two phases of the problem, constant efforts were made to inform the public and interested groups of individuals as to the nature of the Army's quarantine program, and why it was necessary. Numerous addresses to professional groups, both in civilian life and in the military service, articles in lay and professional journals, and press releases were utilized for the purposes of education and publicity for the program. More routine "briefing" in quarantine regulations for personnel about to travel overseas or return to the United States would have been of considerable value. Nevertheless, the efforts made to reassure the public and instruct military personnel were of inestimable value, and although undoubtedly incomplete, were notable for their results.

Specific Problems in Foreign Quarantine

Among the outstanding problems encountered during the development and execution of the Army quarantine program were the actual hazards arising from operations in areas where quarantinable diseases existed. They affected the handling of pets and mascots of military personnel, the control of baggage, and the disposition of displaced persons, as well as control of military personnel. In variable degree, they included all the internationally quarantinable diseases of man. In various degrees, impossible to estimate accurately, United States military personnel was exposed to plague, cholera, typhus, smallpox, leprosy, and yellow fever. Although no case of yellow fever occurred among troops, quarantine procedure in respect to this disease constituted a knotty international problem.

Quarantinable Diseases of Man

Plague. Military operations were conducted in numerous officially declared areas of plague, but quarantine risk was encountered mainly in Dakar,[71] in the Mediterranean area including Suez,[72] in Central Burma,[73] in the Loyalty Islands,[74] and to a lesser degree in the island of Hokkaido, Japan.[75] That no plague ever was reported among United States military personnel indicated the effectiveness of the preventive measures employed rather than absence of exposure to the disease, for infection did occur among others in the same area. For this reason, and because no plague-infected rodent was ever recovered from a United States military vessel or aircraft, it is justifiable to conclude that quarantine risk of the disease, i. e., risk of its spread by United States military services in international traffic, was negligible.

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[71] Lewis, P. A.; Buehler, M. H., and Young, T. R.: A report on plague in Dakar, Senegal, French West Africa, 1944. HD: 710.

[72] (1) Ltr, Lt Col T. B. Ward, Med Inspector to Chief Surg USAFIME, 31 Mar 44, sub: Epidemic of plague in Suez, Egypt. HD: 710. (2) Memo for file, 26 Jan 45, sub: Plague in Oran—1945. HD: 720.4.

[73] See footnote 56, p. 288.

[74] Abstract, Plague in Loyalty Islands. *In* Pacific Islands Monthly 16: 71, Sep 1945. HD: 720.4.

[75] Interview, Army Quarantine Liaison Off with Surg IX Corps, Hokkaido, 14 Nov 1945.

Cholera. Cholera was encountered in India, Burma,[76] and China,[77] and the value of the sanitation program of the Army was again strikingly demonstrated by the occurrence of only 13 cases among all United States Army personnel. Certainly the quarantine risk of this disease, too, was insignificant.

Typhus. Louse-borne typhus was encountered extensively in Europe, North Africa, Japan, Korea, and China, yet up to 1 January 1946 only 102 cases, none of them fatal, were identified among United States Army personnel, some of which were among research personnel working with the disease and exposed to it far in excess of the average individual.[78] Only one known case of epidemic typhus in a soldier was brought into the United States; he was transported by air from Japan to Washington during the incubation period of the disease. Though it is possible that many more cases may have developed which were atypical because of partial protection by immunization, and therefore unrecognized, the small total number evident was a tribute to the typhus-control program of the Army. When, in addition, the low rate of louse-infestation among United States troops at time of travel is considered, it is evident that no real risk of this disease was contributed by them in international traffic.

Although epidemic typhus fever was not spread by United States military personnel in international traffic, outbreaks of the disease, ranging from small local outbreaks to large epidemics, occurred in connection with movements of refugees, displaced persons, and repatriated groups. The outbreaks in Italy, Germany, France, Japan, and Korea were traceable to these movements of people. In addition, there were constant threats of international spread of typhus among civilian populations in the Middle East and Mediterranean countries, and a risk of the introduction of typhus into the United States through the importation of Mexican laborers. In dealing with the outbreaks and prevention of spread of the disease, the United States of America Typhus Commission, established by Executive Order 9285 on 24 December 1942, collaborated with agencies of the Army quarantine program and other military and civilian organizations concerned with typhus control.

Smallpox. Endemic smallpox was encountered in many areas, including North Africa[79] and India, and at times was found in epidemic form, as in Korea,[80] but until 1 January 1946 only 92 cases were observed in Army personnel overseas.[81] These cases represented inadequate protection for one or another cause, but it was apparent that little potential risk was offered in travel. For further discussion of smallpox see the chapter specifically devoted to that disease in another volume of this series.

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[76] See footnote 56, p. 293.
[77] Telegram, American Embassy in China to SecState, 21 Jun 45. HD: 720.4 Cholera.
[78] HD: 710 Typhus, Geographical Distribution.
[79] Memo for file, 9 Feb 45, sub: Smallpox among natives in Dakar, Senegal, French West Africa. HD: 720.4 Smallpox.
[80] Ltr, Army Quarantine Liaison Off to Chief Foreign Quarantine Div USPHS, 9 Jan 46. HD: 720.4 Smallpox.
[81] Five cases occurred in the United States.

Leprosy. Thirteen cases of leprosy were encountered among American Army personnel overseas during the war.[82] All but one were accompanied by a family history of the disease and almost certainly were not contracted during military service. Furthermore, since only approximately one-third of the 1,200 odd lepers in the United States were then segregated or even liable to detention under State laws (Federal law did not make detention mandatory), no quarantine risk was offered by the few patients returned to this country from foreign service.

Yellow Fever. Perhaps the most serious problem in respect to foreign quarantine encountered during the war, both from the point of view of its possible implications to the public health and the magnitude of the administrative difficulties which it produced, was that raised over the possible introduction of yellow fever into Brazil and India. For this reason it is worthy of more extensive consideration.

No case of yellow fever was incurred by United States Army personnel in any area during the war, and during this time epidemiologic reports did not indicate the occurrence of that disease within several hundred miles of any transport or tactical operations. While as a result it might have been felt that quarantine for yellow fever was not a significant problem, policy was actually developed in accordance with previous epidemiology of the disease, and in further accordance with the requirements of certain countries of entry, notably Egypt and India. This policy stressed immunization against yellow fever of all persons on duty along or traversing routes of travel in possible proximity to yellow fever.[83] In the light of subsequent epidemiologic reports,[84] this was a most fortunate policy, which may well have prevented infection among troops and travelers by military conveyances in Africa. In addition, it was a most important measure in reducing the difficulties of troop movements through Africa to Egypt and India. These regional problems represented two of the most important quarantine obligations met by the War Department during the war.

Before World War II began, yellow fever had become restricted to much smaller areas of the earth than at the turn of the century, but it was immediately apparent that during the war much traffic, especially aerial, must traverse extremely broad regions of South America and Africa which (for quarantine purposes) had been internationally declared to be endemic areas of yellow fever. In the Western Hemisphere, such travel involved especially military stations located in the Panama Canal Zone, Republic of Panama, Colombia, and the Caribbean and Atlantic coasts of Venezuela, the Guianas, Surinam, and Brazil; and in Africa, the stations in Senegal, Liberia, Gold Coast, and along

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[82] In addition 13 cases were diagnosed in troops in the United States.

[83] See footnote 58 (2), p. 294.

[84] Third report of expert commission on quarantine. UNRRA Health Div, Epidemiological Bull. 1: 687-692, 30 Sep 45. Also, see Yellow fever areas. Ibid.: 693-700.

the route of aerial traffic across Central Africa. Patently, quarantine risk from yellow fever did occur, especially through air traffic over routes of inestimable importance in the early phases of the United States' participation in the war.

Risk was related mainly to the transportation from endemic to nonendemic areas of persons infected with the disease, or of infected insects. With respect to persons, quarantine was easily maintained by not transporting to or from a declared yellow fever zone any person who had not been properly immunized against yellow fever,[85] unless requirement for immunization and the application of quarantine procedures were officially waived by countries of entry.[86] It should be pointed out that no country made immunization against yellow fever an unconditional requirement for entry, but almost all reserved the right to apply quarantine restrictions within their discretion,[87] which varied from mere inspection at time of entry or observation for 5 days thereafter to detention for as long as 9 days in screened quarters under guard as in India.[88] Transportation agencies, furthermore, were charged with definite obligations, and at times the expenses of quarantine could be collected from them when uncollectable from the persons quarantined. Aircraft, too, were susceptible to processing and delay. The United States Army could not be liable for the care of personnel who might be quarantined in countries of entry, nor could it permit delay of traffic. As a result, immunization against yellow fever became the only immunization procedure which could not be waived without the consent of countries into which personnel might enter either during or after transit through yellow fever zones. Little difficulty was actually encountered with these provisions except in the case of diplomatic personnel. This, however, became especially important at the conclusion of the United Nations Conference at San Francisco when numerous persons were about to be returned to their native countries along routes traversing yellow fever zones. After exploring the possibility of obtaining blanket exemptions from countries of entry, it was decided that the best policy was to require immunization in accordance with standard Army practice.[89]

Quarantine problems concerning the possible introduction of yellow fever into land areas free of the disease arose chiefly in respect to its introduction into India, Egypt, and Brazil by United States military traffic, and the

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[85] See footnotes 58 (2), and 59, p. 294.

[86] Yellow fever zones are defined principally by the international sanitary conventions and the Pan-American sanitary conventions, but certain countries, in addition, define the zones for purposes of their own quarantine requirements. Some variation thus occurs, and in order to satisfy all countries concerned, United States Army policy was obliged to define zones inclusive of all nationally and internationally designated areas. (See TB Med 114, 9 Nov 44.)

[87] See footnotes 1 and 2, p. 272.

[88] (1) Indian Aircraft (Public Health) Rules, New Delhi, 1940, and amendments. HD: 720.4 CBI. (2) See also footnote 56, p. 293.

[89] (1) Memo for file, 19 Jun 45, sub: Immunization of foreign diplomats. HD: 720.4 Gen. (2) Memo for file, 26 Jun 45, sub: Request of The Surgeon General to the Secretary of War for authorization to modify medical requirements for travel. HD: 720.4 Gen.

passage of personnel through Egypt. India, in particular, insisted on strict observance of quarantine controls which were in excess of those prescribed by the international convention.[90] This was at least partly understandable, considering the freedom of that country from yellow fever and its probable great susceptibility to the disease.

The difficulties which arose in connection with this situation as it affected India hinged mainly on differences of opinion on (1) the length of time before immunization becomes effective, (2) the duration of dependable immunity, and (3) the period of infectivity to mosquitoes of infected persons after immunization. International policy considered immunity effective on the 10th day after vaccination; Indian practice was based on 16 days, until modified in 1944. Immunity was considered to be dependable for at least 4 years by other countries; India accepted only 2 years until regulations were changed in 1945. International practice also considered that the immunity resulting by the end of 10 days after immunization rendered an individual incapable of transmitting yellow fever infection to mosquitoes even though the individual had become infected after immunization and had not completed the incubation period of the disease before the 10th day after immunization. Indian policy considered the individual capable of transmitting the infection for the entire incubation period when infection had been incurred before completion of 10 days after immunization. Numerous persons, therefore, who met international requirements were nonetheless rigidly isolated on arrival in Karachi from Africa. Indian authorities were also more strict in evaluation of risks of exposure incurred by travelers en route to India than was necessary by international agreement.[91]

A second problem in Indian quarantine against yellow fever concerned disinsectization of aircraft arriving from zones where the disease had been declared endemic. Disinsectization was required by numerous countries. The disinsectization policy of the Army Air Forces provided for spraying of aircraft with standardized pyrethrum preparations, using generally accepted dosages and techniques, before departure to countries considered at risk. This practice was found satisfactory with respect to yellow fever by all countries except India which considered additional safeguards necessary. Indian quarantine officials refused to honor prearrival spraying and certification, and insisted on disinsectization by Indian spray-crews immediately on arrival of the plane and before discharge of passengers, cargo, or crew. Protest was made by military authorities responsible for rapid movement and for preservation of security concerning armament and other materials carried, but acquiescence to Indian requirements was dictated by the policy of observing civil regulations as these were made to pertain to United States military traffic.

[90] These conventions ordinarily define the maximum which may be required by a country of entry, but India, in signing the international sanitary convention, reserved additional discretion in the case of yellow fever.

[91] Memo for file, Army Quarantine Liaison Off, 16 Jul 45, sub: Prevention of introduction of yellow fever into India. HD: 710.

Efforts to secure relaxation of the regulations of the Indian Government were begun in 1941, shortly after Pearl Harbor, when it became evident that there would be an increased flow of personnel to India. From 1941 to 1943 negotiations with the Indian Government were conducted by the War Department, on recommendations of The Surgeon General, through the State Department. No satisfactory progress was made during 1942 and the first half of 1943. In September 1943 the Indian Government announced that its quarantine laws would thenceforth be strictly enforced against American personnel arriving in India via the yellow fever zones of Brazil and Africa. The Indian Government took the stand that immunity following yellow fever vaccination required 14 to 23 days to develop and lasted no more than 2 years. The American position, based on the more recent studies of the International Health Division of the Rockefeller Foundation was that immunity developed 10 days after vaccination and lasted 4 years. The announcement of the Indian Government implied interference with movements of troops. The Chief of Staff directed compliance with the regulations of the Indian Government and authorized further negotiations, through military channels, with a view to securing acceptance of the American opinion. A representative of The Surgeon General was sent to London in November 1943 for conferences with the British Interdepartmental Committee on Yellow Fever Control. The International Health Division of the Rockefeller Foundation furnished convincing reports of its experience with yellow fever immunization. As a result of these direct conferences and presentation of evidence the Indian Government, on 22 February 1944, accepted the opinion that immunity developed in 10 days after yellow fever vaccination and lasted 4 years. This settled the matter as far as American troop movements were concerned.

Subsequently, the remaining disputed points in yellow fever quarantine theory and practice were discussed with the Indian authorities by the Army Quarantine Liaison Officer in June, July, and August 1945. Material assistance was provided by recognized international authorities, toward better understanding between the two countries.[92] Following these conferences, joint recommendations were submitted for final approval by the Indian Government, though their application was made to some degree dependent upon further tests of certain insecticides. The War Department had not been notified by 1 January 1946 whether these recommendations had been approved.

Mosquito Control in Air Traffic Between Africa and Brazil. A second important regional quarantine problem during the war concerned air traffic from Africa to Brazil, and the resultant risk to Brazil of possible introduction of *Anopheles gambiae* mosquitoes. The firm Brazilian attitude on the problem was based on the country's unfortunate previous experience with the introduc-

[92] (1) Ltr, Dr. G. K. Strode, International Health Div Rockefeller Foundation to Lt Col P. T. Knies, Army Quarantine Liaison Off, 2 Jul 45. HD: 720.4 Yellow Fever. (2) Ltr, Dir Health UNRRA to Army Quarantine Liaison Off, 5 Jul 45. HD: 720.4 UNRRA.

tion of *A. gambiae* at about the time commercial trans-Atlantic air travel had been established from Africa in 1929–30, although it was authoritatively considered that the mosquito was introduced at that time by water rather than by air. Since *A. gambiae* had been completely eliminated from Brazil by the strenuous efforts of that Government, assisted by the International Division of the Rockefeller Foundation, it was understandable that Brazil should require the most careful measures in order to avoid reintroduction of the mosquito during the war.[93]

Despite publication of the first important Army quarantine directive on 14 October 1941 (AAF Regulations 61–3, "Quarantine Inspection and Treatment of Aircraft"), lack of appreciation of the tremendous importance to Brazil of this problem during the hectic early days of war led to an important sequence of events from the standpoint of quarantine. On 20 October 1941, a representative of the International Health Division of the Rockefeller Foundation reported to the American Embassy in Brazil that a Pan-American Airways plane bearing an American military mission had entered at Fortaleza on 9 October from West Africa without disinsectization.[94] On 22 October 1941, the War Department was notified of the incident by the Military Attaché in the American Embassy in Rio de Janeiro.[95] This report immediately received the serious consideration of The Surgeon General. On 30 December 1941, in a letter to the Secretary of War, the Assistant Secretary of State referred to a telegram from the American Ambassador in Brazil which recommended that personnel of the National Malaria Service of that country be appropriately stationed to spray American aircraft arriving from Africa. The proposal was disapproved.[96] This was perhaps unfortunate for much subsequent difficulty, later resolved by almost identical practice, might have been avoided, and certain problems of security could probably have been solved then as easily as later. Certainly the investment of the full time of numerous American personnel and considerable expense might have been saved.

Difficulty continued due to lack of cooperation of American aircrews with Brazilian health authorities. On 9 January 1942, the American Embassy in Brazil again reported to the Secretary of State that Brazilian authorities requested definite instructions be given to crews to assure their cooperation.[97] On the following 18 February, the Secretary of War indicated to the Secretary of State that a revision of AAF Regulations 61–3 had been published on 11

[93] Soper, Fred L., and Wilson, D. Bruce: *Anopheles gambiae* in Brazil 1930–1940. New York, The Rockefeller Foundation, 1943.

[94] Ltr, F. L. Soper, Rockefeller Foundation to Col E. L. Sibert, US Embassy Rio de Janeiro, 20 Oct 41. HD: 720.4 Brazil.

[95] Ltr, Col E. L. Sibert, US Embassy Rio de Janeiro, to ACofS G–2 WDGS, 22 Oct 41. HD: 720.4 Brazil.

[96] Ltr, Asst SecState to SecWar, 30 Dec 41, with 2d ind, SG to AG, 6 Jan 42. HD: 720.4 Brazil.

[97] Ltr, US Ambassador, Rio de Janeiro to SecState, 9 Jan 42, sub: Disinsectization of American planes at Natal. HD: 720.4 Brazil.

bruary 1942 providing for disinsectization of aircraft by United States litary personnel. He also stated:[98]

> It is the established policy of the War Department to cooperate at all times with local government officials both at home and abroad, in all matters pertaining to the health and welfare of the civilian population. Accordingly, the War Department will welcome surveillance of its antimosquito measures by such sanitary officers as the Brazilian Government may assign for this duty. It is felt, however, that the payment of their salaries is not a proper responsibility of the War Department. Labor and materials used for the treatment of our aircraft will be furnished by the United States Army.

The Department of State reported to The Surgeon General that the ckefeller Foundation had agreed to underwrite the ex nse of Brazilian sonnel stationed at Natal for disinsectization of American military air-ft.[99] Army Air Force Regulations 61–3 was again revised on 30 November that year (1942), but inadequate cooperation on the part of American crews was still reported on 11 December to the American Ambassador to azil by the Brazilian Minister of State,[100] who repeated the request that equate corrective measures be taken. The Brazilian Government subsently published Decree Law 5181 which placed total responsibility for insectization in the hands of Brazilian personnel. Despite this law and es imposed under its provisions, American lack of cooperation continued. ually, in June 1943, *A. gambiae* were recovered from aircraft arriving at tal, Brazil from Africa (probably dead, though this point was not clearly icated).[101]

From 27 July to 17 August 1943, the Director of the Brazilian Port Health vice and the Surgeon, United States Army Forces, South Atlantic, jointly died disinsectization and quarantine problems in United States military ial traffic in Northeast Brazil and West Africa. They reported that American craft did not comply with existing AAF Regulations 61–3, and that planes iving in Brazil from Africa were not complying with certain sections of azilian Decree Law 5181.[102] Brazilian authorities proposed that Brazilian ay crews be stationed at American airports of departure in Africa. This posal, too, was resisted by United States military authorities.

During September 1943, the Director for Brazil of the International Health vision, Rockefeller Foundation, notified the American Embassy that 8 *A. nbiae* mosquitoes had been recovered from 6 American aircraft at Natal.[103]

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[98] Ltr, SecWar to SecState, 18 Feb 42. HD: 720.4 Brazil.
[99] Memo for file, 4 Mar 42, sub: Telephone call re stationing of medical personnel in Brazil. HD: 720.4 Brazil.
[100] Ltr., Minister of State, Brazil to US Ambassador, Rio de Janeiro, 11 Dec 42. HD: 720.4 Brazil.
[101] Ltr, J. A. Kerr, Field Rep Rockefeller Foundation, Rio de Janeiro to Mil Attaché, US Embassy Rio de Janeiro, 1 43. HD: 720.4 Brazil.
[102] (1) Ltr, Surg USAF South Atlantic to CG USAF South Atlantic, 24 Aug 43, sub: Report of visit to Africa as aid r. Mendonca. HD: 720.4 Brazil. (2) Ltr, Surg USAF South Atlantic to CG USAF South Atlantic, 31 Aug 43, sub: rt of visit to Africa. HD: 720.4 Brazil.
[103] Ltr, R. M. Taylor, Field Rep Rockefeller Foundation, Rio de Janeiro to Brig Gen C. N. Adams, US Mil Attaché le Janeiro, 6 Sep 43. HD: 720.4 Brazil.

Viability of the insects was not indicated. When later reporting to the Rockefeller Foundation, New York, that 23 *A. gambiae* had been so recovered to that date, he added: [104]

> There seems therefore to be abundant evidence that the United States Army disinfestation service is not operating effectively and that there is a real and continuing hazard of the introduction of gambiae and other noxious insects into Brazil.

Efforts of American military personnel to displace Brazilian operators in disinsectization of aircraft on arrival in Brazil evoked the following statement from the Director, Brazilian Port Health Service: [105]

> I wish to state that if, in the present situation, disinsection is no longer made by the Port Quarantine Service, our country will again be invaded by *Anopheles gambiae*, and our agriculture as well will certainly be contaminated by all sorts of parasites which infest the African agriculture.

In view of these statements it is pertinent to point out that probably less than 6 specimens of *A. gambiae* had yet been reported to have arrived alive aboard aircraft entering Brazil from Africa. Disinsectization had been conducted routinely before search for insects, 47 of which were reported recovered during September 1943. On 16 September 1943, the American Ambassador was informed that 2 *A. gambiae* had been captured "alive" in the city of Natal.[106] Three more were later reported.[107] The matter was taken up by the newspapers on 24 September 1943.[108]

During October 1943, in accordance with special instructions from the War Department, all members of the Interdepartmental Quarantine Commission studied the problem in both Brazil and West Africa. Findings were summarized and recommendations submitted on 22 October.[109] This report was studied and the entire problem again reviewed by two members of the commission, a special committee appointed by The Surgeon General, and other American military and Brazilian authorities at Recife, Brazil, from 3 to 5 November, and again at Rio de Janeiro on 9 November 1943.[110] At these conferences Brazilian authorities again requested that Brazilian personnel be placed on American airbases in West Africa to supervise disinsectization of aircraft departing for Brazil. (The American Ambassador had reported on the first of the month that the Brazilian President had signed a Decree Law authorizing

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[104] Ltr, R. M. Taylor, Field Rep Rockefeller Foundation, Rio de Janeiro to Dr. W. A. Sawyer, Dir International Health Div, Rockefeller Foundation, 14 Sep 43. HD: 720.4 Brazil.

[105] Ibid.

[106] Ltr, R. M. Taylor, Field Rep Rockefeller Foundation, Rio de Janeiro to US Ambassador, Rio de Janeiro, 16 Sep 43. HD: 720.4 Brazil.

[107] Ltr, R. M. Taylor, Field Rep Rockefeller Foundation, Rio de Janeiro to Dr. W. A. Sawyer, International Health Div Rockefeller Foundation, 28 Sep 43. HD: 720.4 Brazil.

[108] El Globo (Rio de Janeiro), "In Africa, Brazil's Sanitary Frontier," 24 Sep 43. Translation in HD: 720.4 Brazil.

[109] Interdepartmental Quarantine Commission, Special Report on African-Brazilian Traffic with Interim Recommendations, 22 Oct 43. HD: 720.4 Brazil.

[110] Ltr, Col W. A. Hardenbergh, SnC, SGO, and others, to SG, 4 Dec 43, sub: Mosquito and malaria control at West African airfields. HD: 725 (*A. gambiae*) (Brazil-Africa).

this action by the Port Health Service, "in accordance with understandings reached." [111] Apparently this action had been taken in order to implement immediately the agreements anticipated as a result of these conferences.)

Procedure in African-Brazilian traffic thereafter included disinsectization on both departure and arrival, the former by Americans under observation by Brazilian representatives, and the latter in reverse. Intensive *A. gambiae* control was also undertaken about West African airports of departure to Brazil, under supervision of a specifically designated control officer.[112] No additional significant difficulty was reported, nor were additional live *A. gambiae* found.[113] In November 1944, the Brazilian representatives were withdrawn from Africa, reflecting the complete satisfaction of Brazilian authorities with mosquito control about the West African airfields of departure, and with the technique of disinsectization.[114]

Predeparture disinsectization by ground crews at the West African base had meanwhile been provided for by an authorized exception to the procedure routinely prescribed for disinsectization of aircraft in AAF Regulations 61–3, 9 August 1944.[115] Continuation of this policy was strongly recommended by the Army Quarantine Liaison Officer in May 1945, when observations in West Africa determined that the procedure had been abandoned 6 months previously in Accra, and was about to be discontinued at Dakar in favor of spraying by flight personnel.[116] As a result, disinsectization by ground crews continued throughout the remainder of American war activity in West Africa.

Experience amply demonstrated the necessity of observing this disinsectization technique under such circumstances, and the advisability of its supervision by Medical Corps personnel. When disinsectization was an extremely critical procedure, the high level of performance necessary could not be guaranteed when the work was done by flight personnel. It was equally evident that the conditions legitimately requiring so high a level of effectiveness must indeed be rare. Controlling the risk of introduction of *A. gambiae* into Brazil also showed the value of area mosquito control as a safeguard to quarantine. There could be no doubt that the small number of *A. gambiae* recovered dead from American aircraft during the remainder of the war was due in large measure to the splendid control of *A. gambiae* breeding achieved about the West African airfields. This again emphasized the military concept of quaran-

[111] Telegram, American Embassy Rio de Janeiro to SecState, 1 Nov 43. HD: 720.4 Brazil.

[112] Memo, Dir Epidemiology Div SGO for Mil Pers Div SGO, 30 Jan 44, sub: Malariologist, West Africa. HD: 725 (*A. gambiae*) Brazil-Africa).

[113] Five adult female *A. gambiae* were reported to have been recovered dead in and near the city of Natal in February 1945, after spraying of houses and a Brazilian warship by Brazilian malaria control personnel. It was later advised this report be disregarded. Ltrs, Rockefeller Foundation to Brig Gen J. S. Simmons, SGO, 12 Mar and 5 Apr 45. HD: 720.4 Brazil.

[114] Farrell, E.: The *Anopheles gambiae* problem in Brazil and West Africa, 1941–44. Bull. U. S. Army M. Dept. 8: 110–124, Feb 1948.

[115] Ltr, Army Rep Interdepartmental Quarantine Commission to CG AAF, 12 Aug 44, sub: Special modification of provisions of AAF Regulations 61–3, 9 Aug 44 (Flying, Outside the United States; Quarantine). HD: 720.4 Brazil.

[116] Ltr, Army Quarantine Liaison Off to Chief Surg AMET, 8 Jun 45, sub: Foreign quarantine in traffic under jurisdiction of AMET. HD: 720.4 Rpts of Inspection.

tine as a defense in depth wherein all the pertinent resources of preventive medicine are employed, rather than a traditional ritual to be carried out on crossing a declared quarantine border.

Summary. Not only were total numbers of cases of the quarantinable diseases among Army personnel low, but most cases which did occur were not extant at time of travel. Only 2 cases of smallpox and 1 of typhus were known to have been carried internationally by Army personnel by 1 January 1946.[117] The smallpox patients arrived in the United States in patient status having become ill en route, when among immunized personnel who were reimmunized en route [118] and the typhus patient,[119] who had contracted the disease during survey work in Japan, was not louse-infested. These cases, therefore, presented no quarantine risk.

Diseases Encountered in other than United States Military Personnel. It is also interesting to note the quarantinable diseases encountered among other than United States military personnel carried to the United States in Army air or water transportation during the war. These occurred mainly among prisoners of war and consisted of 4 cases of leprosy,[120] and 11 of typhus.[121] The number of cases was lower than was anticipated in view of the inherent risk of such disease among this personnel, probably because prisoners received the benefits of preventive medicine practices of the United States Army for variable periods of time before travel.

Quarantine Control of Pets and Mascots

Transportation of animals proved to be another particularly difficult problem in the Army quarantine program. The soldier has traditionally possessed pets, but their international transportation at once raised problems of compliance with the quarantine requirements of countries entered. Many countries made no issue of the problem, at least in practice; others insisted on the most stringent exclusion of animals, and in one instance even the unloading of a shipment of United States Army-owned mules was prohibited.[122] It was necessary to observe fully this wide variety of civil requirements and also to protect the health of troops; to conserve weight, space, material, and effort in

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[117] One additional case of smallpox and one of typhus occurred among Merchant Marine crewmen of vessels under Army contract. These cannot be charged against the Army record, for War Shipping Administration had preferred not to apply the Army immunization or quarantine routines to personnel under their jurisdiction.

[118] (1) Telegram, USPHS Quarantine Off Seattle to Surg Gen USPHS, 21 Dec 45. HD: 720.4 POA. (2) Ltr, Army Quarantine Liaison Off to SG, 7 Feb 46, sub: Monthly report on foreign quarantine, U. S. Army. HD: 720.4 USPHS.

[119] Case history, Col Joseph F. Sadusk, Jr., MC, 10 Dec 45. HD: 710 Typhus.

[120] Memo, POW Liaison Unit OPMG to Quarantine Br, Prev Med Serv SGO, 4 Oct 45, refers to 3 cases of leprosy among Japanese prisoners of war. HD: 720.4 Leprosy. Statistical Health Rpts (WD AGO Form 8-122) show 1 case of leprosy in an Italian prisoner of war at San Luis Obispo, California, in April 1945.

[121] (1) Ltr, Army Quarantine Liaison Off to CofTrans, 13 Apr 45, sub: Foreign Quarantine, with 5 inds, refers to 1 case of typhus in a German prisoner of war in May 1943. HD: 720.4 Typhus. (2) Statistical Health Report for period August 1943 through August 1945 reports 8 cases of typhus among prisoners of war in the United States, 7 cases among German prisoners and 1 case in an Italian prisoner.

[122] Ltr, Dir-Gen of Health, Commonwealth of Australia, to CG USASOS SWPA, 13 Jan 43. HD: 728 EBM 102-C.

transportation; and to avoid needless destruction of animals at ports and airports of entry. Army policy therefore (AR 55–485 and AAF Regulations 61–3) in effect prohibited the transportation of animals unless expressly intended and and approved for scientific, educational, or military purposes. Even then, when a country which imposed restriction on the transportation of animals was to be entered, their transportation by United States military personnel was permitted only in accordance with special permits.

It could not be contended that this policy was not violated, for numerous reports were received of animals (particularly dogs, monkeys, and parrots) carried in military traffic, especially during short intratheater movements and upon return of their owners to the United States. It was certain, however, that the total amount of such illicit traffic was very small compared with what would surely have occurred, with much resultant inconvenience, compromise of sanitation, and possible introduction of serious pests and diseases, had strict prohibition not been the official Army policy.

Of all violations of these regulations, the transportation of dogs was the most common, and because of sympathetic public opinion it was extremely difficult to enforce strict disciplinary measures in this respect. Instances of detention or destruction of dogs were criticized severely by the public press. A firmer attitude was feasible and possible in the case of other animals. It might have been preferable to permit greater latitude in the transportation of pet animals; theater and base commanders could have been required to define limitations necessary to comply with civil requirements in areas within their command. However, decision on transportation of animals was largely based on operational rather than medical considerations, a fact recognized by the publication of the original restrictive policy in an Army regulation (AR 55–485) primarily concerned with operational matters.

Quarantine Control of Baggage

As well as the problem of transportation of animals, that of control of agricultural products subject to quarantine regulation assumed greater proportions than had been anticipated, and for similar reasons, i. e., the marked variation in civil regulations in accordance with local crops, monopolies, and vested interests. Regulations of States (Florida, California) and territories (Hawaii, Puerto Rico) were especially harassing, though it was found possible to meet these various restrictions in the transportation of plant products by incorporating regulations of the United States Department of Agriculture [123] into War Department directives. In order to achieve uniformity, it was necessary to prohibit transportation of living plants and the "prohibited" classes of plant products.[124] Agricultural quarantines, of course, applied mainly to baggage and mail.

[123] US Dept of Agriculture, Foreign Plant Quarantine Memos.

[124] See footnote 61, p. 296, and WD Memo 850-45, 1 Feb 45.

While technical supervision of the quarantine handling of baggage (as well as all other phases of quarantine) remained a Medical Department responsibility, it was particularly necessary to utilize the services of nonmedical personnel who were otherwise concerned with acceptance and handling of baggage and personal effects. Such quarantine processing was carried out as far as possible before departure rather than on arrival.[125] Similarly, reliance was placed on the military censors for quarantine handling of mail. Though censors were primarily interested in violations of security, they were in a position to look for items subject to military and civil quarantine restrictions. Control of transportation of plant products by mail became much more difficult upon relaxation and virtual suspension of censorship after cessation of hostilities, and greater reliance had to be placed on the education of military personnel in respect to pertinent regulations. Civil inspection of mail was continued throughout the war, but necessarily on a sampling basis, in the regular channels of the United States Post Office. It was well recognized that these practices did not completely stop the transportation of restricted or prohibited plant products, but the total amount of importation was unquestionably far less than if no restrictive policy had been in effect and the resultant risk of introduction of pest or disease was diminished proportionately.

Special Regional Problems in Quarantine of Displaced Persons

Special regional problems in quarantine were encountered during repatriation of displaced persons following their liberation or capture by advancing United States military forces. In Europe, the occurrence of typhus was of prime concern, and its control was effected through immunization and disinfestation of travelers [126] as well as United States military personnel, though in 1945 epidemic typhus was introduced into France through repatriates and in 1945 and 1946 severe epidemics of louse-borne typhus followed repatriation into Korea and Japan. However, because national boundaries had become meaningless, strict observance of their quarantine regulations was for the most part neither feasible nor necessary. Predeparture quarantine processing was carried out more formally in satisfying medical requirements for the travel of certain specific groups, such as those entering Palestine from Europe.

In the Pacific, on the other hand, repatriation occurred across well-defined national borders. From 19 September to 11 December 1945, the Army Quarantine Liaison Officer studied quarantine risks and problems in movements of Japanese, Koreans, Chinese, and Formosans. Disease incidence, sanitation, public health facilities, and transportation were observed in numerous ports in Japan, China, and Korea, and quarantine policies were developed for applica-

[125] WD Ltr (AG 524 (13 Aug 45) OB-S-D-M), 23 Aug 45, sub: Processing of baggage. AG: 524.

[126] Gordon, J. E.: *History of preventive medicine in the European Theater of Operations, United States Army, 1941-1945.* HD: 314.7-2.

tion in the various lanes of travel.[127] Policies for Japan were defined in special directives to the Japanese Imperial Government.[128] Previous to American occupation, reliable epidemiologic data for Japan, Korea, and China had been lacking for several years and a principal concern of the quarantine survey was the evaluation of actual disease risks. These were found to consist primarily of typhus and smallpox in Japan and Korea. In northern Chinese ports, slight risk of plague was also encountered, and in South China, cholera.[129]

It was necessary to employ two distinct techniques of quarantine clearance in repatriation of nationals in the Western Pacific. In traffic where both departure and arrival were under the direct control of American military personnel, predeparture processing was feasible and was employed. It embodied immunization, disinfestation, and physical inspection. This procedure was also utilized when departure alone was under American control. When departure was not under American surveillance, however, it was necessary to apply an arrival procedure similar to that of peacetime quarantine practice, but extended to include minimal immunization, and disinfestation, according to risks estimated by knowledge of the areas from which travel was undertaken.

Since these repatriation movements in the Pacific were anticipated to be of long duration, it was requested that an experienced Public Health Service officer continue the investigations and formulation of policies begun by the Army Quarantine Liaison Officer. Such an officer was made available and was detailed to the Public Health and Welfare Section, General Headquarters, Supreme Commander Allied Powers, in November 1945.[130] Similar long-term assignments of personnel of the Public Health Service were arranged for military and repatriation traffic in North Africa, where continuous detailed inspection, supervision, and coordination were required,[131] and in the Philippines, where quarantine control was oriented toward rehabilitation of the prewar quarantine responsibilities of the Public Health Service.[132]

Results and Evaluation of the Program

As already mentioned, the small number of cases of quarantinable diseases which occurred among United States Army personnel and the negligible number which were carried in United States military transportation during the war resulted primarily from the nature of the practice of preventive medicine in the Army. This was clearly indicated by the active spread of certain of these diseases among the natives and other troops in areas occupied by the United States Army. The quarantine program of the United States Armed

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[127] See footnote 66, p. 299.

[128] See footnote 67 (3), p. 299.

[129] Memo for record, Col J. E. Gordon, Consultant in Prev Med and Lt Col P. T. Knies, Army Quarantine Liaison Off, 6 Dec 45, sub: Health problems in repatriation under jurisdiction of USAFCT, with appendices. HD: 720.4.

[130] Memo for file, 16 Oct 45, sub: Assignment of US Public Health Service officer to Army. HD: 720.4 USPHS.

[131] Ltr, TAG to CG ATC and CofT, 13 Aug 45, sub: Travel orders, shipments IJ-Cairo-GC. HD: 720.4 USPHS.

[132] Ltr, TAG to CG ATC and CofT, 13 Aug 45, sub: Travel orders, shipment IJ-Manila-GI. HD: 720.4 USPHS.

Forces demonstrated the rationale and necessity, under conditions of tremendous and widespread traffic, of basing international protections on a broad program of preventive medicine in both areas of departure and of entry, rather than relying on a traditional quarantine ritual at the time borders are crossed. Continuation of these new policies became a primary responsibility of international health organizations and covenants after the war.

Since the total number of cases of quarantinable diseases among United States Army personnel was negligible, Army traffic offered no significant actual quarantine risk with respect to human disease. It is believed that formal quarantine clearance procedure with respect to Army personnel might have been entirely eliminated without danger, so long as the practice of preventive medicine in the Army was maintained at the level of efficiency which it attained during the war.

A presentation of the Army's activities with respect to enforcement of quarantine regulations would be incomplete without consideration of those factors which impaired its maximum effectiveness. Furthermore, policies considered correct when they were established were subject to criticism in the light of experience in their application.

One such policy was the Army's insistence on complete autonomy in all matters related to its transportation, including those of quarantine. At times, under the pressure of urgent and critical military necessity, the then relative luxury of observance of quarantine regulations was challenged legitimately. However, this viewpoint was permitted to be extended to circumstances where, though the expedition of traffic was still of great importance and the preservation of security essential, reasonable attention might have been given to critical quarantine risks, and to the legal responsibilities of civil agencies, without compromise of military interest. To disregard these civil agencies invited actual risk, serious criticism, recrimination, jeopardy of cooperation, and liability for quarantine breach, which were probably far more detrimental to the war effort than realistic cooperation from the onset of the war would have been.

This was particularly true in the case of the quarantine problems which arose in Brazil and India. A peremptory attitude on the part of the Army in Brazil challenged the legal prerogatives of the established civil agency, and led only to retraction of military action and establishment of the civil regimen. In the United States the nonmilitary character of the civil border clearance agencies (including, until very late in the war, the Public Health Service), and the unwillingness of some such agencies to submit to security survey were interpreted as arguments for military autonomy in matters of quarantine. Yet, on the whole, the cooperation of these agencies should have been subject to little question; indeed, the Bureau of Entomology and Plant Quarantine

initiated excellent security control, including the discharge in Hawaii of its employees of Japanese nativity (who were frequently hired by the Armed Forces as quickly as released by the Department of Agriculture).[133]

In a number of instances, delay in cooperation with the Army on the part of field personnel of civil border clearance agencies jeopardized the smooth functioning and effectiveness of the quarantine program. The civil agencies' traditionalism and insistence on prerogative gave impetus to formation of the Interdepartmental Quarantine Commission, which was established to develop mutually acceptable compromises based on reexamination of the entire question. Even after approval of the quarantine program of the Army on high administrative levels, however, its smooth application and full advantages were not realized at times because field representatives of the civil agencies did not appreciate the simplification of quarantine clearance which it provided. Their tendency to traditional inspection on arrival instead of clearance on the basis of certified predeparture processing, and the repeated necessity to review with them the entire cooperative program in order to secure extension of its provisions to handle minor additional details, resulted in confusion and duplication of effort which at times induced military officers to question the advantage of the Army system. This was due primarily to inadequate instruction of field personnel by directors of the civil agencies. Such instruction was usually limited to distribution of the military directives without interpretation.

Another factor which reduced the effectiveness of the quarantine program was the delay following the onset of war before formal Army quarantine policies were instituted. This must be ascribed to failure in prewar planning to consider the inability of the civil border clearance agencies to process traffic of such volume by traditional methods of quarantine clearance with its attendant delay, not excessive in civilian traffic, but intolerable in the urgency of military movements.

Realization of these factors apparently required more than 2 years after Army deployment began and 1 year after onset of actual war. Further delay was occasioned by the long period devoted to research by the Interdepartmental Quarantine Commission before a plan was recommended in 1944. The extensive study undertaken by the commission was desirable, of course, but it is evident in retrospect that little more was learned after 2 months of field investigation than the enormity of the problem. Establishment of a military quarantine program based on a shorter period of study might have resulted in procedures which subsequently required more modification. It is probable, however, that the time saved would have implemented the program.

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[133] Interview, Army Quarantine Liaison Off with Field Dir Territory of Hawaii, Bureau of Entomology and Plant Quarantine, US Dept of Agriculture, Dec 1945.

The results of failure in peacetime planning for international border clearance, lack of effective procedures, and ignorance of military and civil personnel of the techniques involved were keenly felt by those responsible for the development and implementation of the military quarantine program. One of these results was the amount of negotiation required by the Interdepartmental Quarantine Commission, and later by the Quarantine Liaison Officers, in order to arrange suitable delegation of authority by the civil border clearance agencies. They, in turn, would have profited had they made plans previously for handling a large volume of military traffic, possibly involving use of military personnel detailed to their administration. In general, these agencies were satisfied with the quarantine program as ultimately evolved, and it is felt that advantage should be taken of their satisfaction in order to preserve the working arrangements so laboriously developed. The legal basis of these agencies' responsibilities and prerogatives was never challenged. The goal of military policy in quarantine was not an invasion of domain, but assistance and cooperation with civil agencies. Peacetime planning and military practice in quarantine would have led to the development of workable relationships capable of expansion in wartime without delay, confusion, and compromise which attended such developments undertaken during stress, urgency, and public peril.

Another deterrent to rapid and effective execution of the military quarantine program was the gross inadequacy of military directives pertaining to quarantine. In view of the farflung and integrated character of military transportation, the definition of basic principles of quarantine was necessarily a responsibility of the War Department. Implementation of those principles, however, required their adaptation to meet the peculiar requirements of certain regional and operational commands through the development of secondary directives in all echelons concerned with transportation. This was well carried out in high headquarters, including the Transportation Corps, Army Service Forces, Army Air Forces, and Air Transport Command, but was long delayed in some theaters and overseas operational units.

Much of this delay undoubtedly was caused by limited distribution of the War Department directives. It was common to find no copies of those directives in the files of medical or operational officers whose responsibilities included supervision or execution of quarantine procedures. The limited number of copies reaching a command often appeared to find their way only into files of the commanding officer and the adjutant rather than into circulation to the operational and medical personnel intimately concerned with meeting their requirements. Certainly they were often not brought to the attention of new personnel who were charged with their continued application. Possibly a faulty medium of dissemination was employed, and operational manuals should have been used, though it must be recalled that these often did not carry command authority. The viewpoint was sometimes encountered in the field that only directives of the proximate command should be expected

to be available. In such cases, the deficiency in appreciation and implementation of War Department policy in respect to quarantine was the more glaring for rarely had the proximate command developed quarantine directives. Furthermore, when quarantine was discussed in directives of commands lower than the War Department, there was often reference to details in the basic War Department directives which were not available. In these secondary directives, direct quotation from the parent War Department documents was employed in rare instances,[134] it being an apparent policy that paraphrase but not quotation should be admitted. Such paraphrase commonly lost the exactness and often the flexibility of the original document.

It was the general observation of the Army Quarantine Liaison Officer that few commands in the field specifically adapted the War Department quarantine directives to operations under their jurisdiction by adjustment to problems peculiar to those operations. The result was confusion and dissatisfaction on the part of those charged with carrying out quarantine procedures. As an example, War Department directives prescribed quarantine procedures in "international" traffic. Yet in some areas real risk required establishment of quarantine barriers within a given national jurisdiction, as between the continental United States and Puerto Rico or the Territory of Hawaii. In others, many national areas could be included in a single quarantine zone because national regulations either did not exist or were not applied, and because quarantine risk was uniform throughout the several national jurisdictions. Such definition of "international" for quarantine purposes was particularly useful in the China and India-Burma theaters, both of which were included in a single quarantine zone. In the Pacific area, definition of "international" zones for disinsectization of aircraft and for processing of personnel [135] eliminated much quarantine procedure in short journeys between areas of different national jurisdiction where such procedure was correct but unnecessary, and at the same time met the requirements of the actual quarantine risks involved. This failure to adapt the provisions of War Department directives to meet local circumstances resulted mainly from lack of appreciation of responsibility and prerogative to do so. Certainly the directives alone did not adequately instruct personnel in these responsibilities. In most instances when the need for regional implementation was pointed out, prompt action was taken.

The principle that the importance of all other activities of the Army is secondary to that of combat cannot be challenged. Yet the frequently encountered disregard of and even resistance to quarantine procedures without tactical justification suggested the need for discussion of quarantine and other civil obligations in the indoctrination and instruction of officers, particularly those intended for service with the Transportation Corps and Army Air Forces.

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[134] A notable exception was 1539th AAF Base Unit, Pacific Div ATC, Base Reg 25-1, 26 Sep 45. HD: 720.4 ATC.
[135] AFPAC Reg 50-60, 30 Sep 45, sub: Foreign quarantine. HD: 720.4 POA.

Inadequate appreciation of the purposes of quarantine underlay the unwillingness of some commanding officers to insist on strict compliance with regulations, and appropriate disciplinary action if necessary. In many instances such action, if applied early and judiciously, would have gone far to assure observance. However, it is not known that disciplinary action was taken in any case of quarantine breach during the war, except that fines were assessed upon some pilots who disregarded quarantine regulations in entering Brazil from Africa.[136] Even when these fines were suspended or remitted, they were imposingly effective in assuring observance of the regulations. Numerous animals were carried to the United States and elsewhere with the full knowledge of officers at ports of departure and entry, and of the commanders of vessels and aircraft concerned, yet disciplinary action was never reported.

It was therefore understandable that, while on the whole effective, quarantine directives were frequently disregarded by the traveling soldier. Command often failed to support the military quarantine program through neglecting to educate, failing to take executive action, and refusing to take disciplinary action when plainly indicated. Failure to support the program was indicated also by occasional personal disregard of regulation by high ranking officers, especially in the transportation of pet animals and curios, and in the disinsectization of their private planes.

When, in August 1944, the Secretary of War indicated his approval of the War Department quarantine program, he granted authority for the designation of an Army Quarantine Liaison Officer, an assistant, and a clerk "at this time."[137] This personnel might well have been expanded during the subsequent phases of field study and liaison. During 1945, the Army Quarantine Liaison Officer devoted 10½ months to constant field work outside the United States, and the Assistant Army Quarantine Liaison Officer made numerous visits to ports and airports within the United States and in the Caribbean area. Yet only one theater could be visited twice during the entire year, another was not reached at all, and numerous authorized ports and airports within the United States could not be visited. A group of 4 to 6 officers actively engaged in field work under the supervision of the Army Quarantine Liaison Officer would have assured far greater effectiveness of the program.

It was also authorized that the Army Quarantine Liaison Officer be "of suitable rank."[138] This rank was not limited by a table of organization but throughout his tour of duty he was in rank of lieutenant colonel. There were probably few instances in which this rank failed to obtain proper audience, although the Army Quarantine Liaison Officer was called on to work with numerous colonels and with general officers as high as lieutenant general in both the United States and Allied military commands, and with persons of

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[136] Ltr, Army Quarantine Liaison Officer to Chief Prev Med Serv SGO, 25 May 45. HD: 720.4 Field Trips.
[137] See footnote 36, p. 282.
[138] See footnote 36, p. 282.

equally high rank, including cabinet ministers, in the United States and Allied civil agencies. It is believed, however, that greater effectiveness might have been assured had the rank of full colonel been provided the Army Quarantine Liaison Officer. The rank of an officer engaging in such activities, rather than being related to that of other personnel in the headquarters to which he is assigned, might well be related to the contacts he makes in his field work where his rank may be interpreted to reflect the importance attached to his work by his own headquarters.

The Army quarantine program cannot be evaluated without considering instances of new diseases or pests appearing in the areas entered by United States military traffic during World War II. Some of these, perhaps, may be properly considered to have been introduced through that traffic, with or without blame to it. It is doubtful if others were so introduced. Recognized transportation of persons ill with the quarantinable diseases of men, illicit transportation of animals, and interception of prohibited or restricted articles in the possession of persons traveling by military conveyance or in baggage or mail have already been mentioned. Implantations of diseases or pests had not been reported to follow the importation of such quarantine risks by 1 January 1946, though they may come to light in the future.

Several factors must be considered in determining the responsibility of United States military traffic for these introductions, and in attributing them to faulty quarantine procedure or to innate limitations of available techniques. Newly described pests may not have been newly introduced, but rather newly discovered through the intensive scrutiny to which all areas of operation were subject during the war. Certain introductions, if indeed new, obviously occurred before the Army quarantine program was established.

While individual cases of smallpox, epidemic typhus, scrub typhus, and leprosy were imported, they resulted in secondary spread only in the case of smallpox on the west coast of the United States and in no area did significant extension occur. Dengue appeared in Hawaii in the early phases of the Pacific war and continued until the autumn of 1945. This disease had been known previously in the Islands but had not been recognized for several prewar years. From the epidemiology of its recurrence, it was assumed to have been introduced by personnel evacuated by air from forward combat areas during the incubation period of the disease. Spread was due to infection of native *Aedes aegypti* mosquitoes.

A very difficult quarantine problem in repatriation between China, Korea, and Japan consisted in extensive though irregular and largely clandestine traffic in very small fishing vessels, which plied between changeable and unrecognized ports and coves, in frank breach of established regulations. Due to the circumstances surrounding the termination of hostilities, the Japanese Government was not in position to control the waters involved, and this activity was not immediately undertaken by United States forces.

The report of recovery of 5 "live" *Anopheles gambiae* mosquitoes in Natal, Brazil, during the war has been previously described.[139] The fact that no breeding was found despite intensive search, and that recoveries were limited to 2 mosquitoes on one day and 3 on the succeeding, suggests that the specimens recovered may have been stowaway adult forms which had escaped on landing, rather than a true implantation. Separation of the point of recovery by several miles from the nearest airfield of entry further challenges credibility of the report.

A single larva of *Anopheles albimanus* was reported identified in Florida during the war [140] and though traffic from areas in the Caribbean to which *A. albimanus* is native was not limited to military conveyances, the location of the recovery suggested introduction by military aircraft. The species did not spread, however, and in view of the known occurrences of *A. albimanus* in Florida in the past and its apparent spontaneous elimination at that time, it is evident that little risk was involved.

The importance of war traffic in the spread of agricultural pests is illustrated by the experience of the United States in previous wars. During World War II, 13 insects were newly reported in Hawaii, and were apparently introduced from the United States and from the South and Southwest Pacific.[141] The prominence of these forms and their rapid spread strongly indicated recent importation. Other forms were newly identified during the same period but, because of their insignificant nature and failure to spread, were considered to have been merely newly identified rather than newly introduced. Methods of introduction were not apparent, for though some were recovered in traps at airfields of entry, traps were maintained nowhere else. It is entirely possible that some were introduced in the larval or egg form rather than the adult.[142] It was considered that at least 2 of the 13 forms would probably prove of economic advantage rather than harm, but this did not mitigate the fact that several of the remainder were definitely harmful, and that all indicated inadequacies or breaches in quarantine. None of these insects were susceptible to concentration of pyrethrum even in excess of those called for in pertinent civil and military directives or feasible in disinsectization procedures.

Certain ticks (*Boophilus microplus*) were newly reported in New Caledonia during the war, and their introduction was attributed to animals brought by the United States Army from Australia.[143] Quarantine of these animals on

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[139] See footnotes 106 and 107, p. 310.

[140] Carpenter, S. J.: Anopheline surveys in the Fourth Service Command. J. Nat. Malaria Soc. 4: 115–121, Jun 1945.

[141] See footnote 54, p. 293.

[142] (1) Ltr, Dir Plant Quarantine Div US Dept of Agriculture to Chief Prev Med Serv SGO, 8 May 45. HD: 720.4 DA. (2) The Hessian fly, which has been reported to damage the wheat crop of this country up to one hundred million dollars in a single year, is believed to have reached the United States in straw used as bedding during the Revolutionary War. The Colorado potato beetle, which became established in France and subsequently spread to adjoining countries, is thought to have been shipped from this country in potatoes sent to the United States Expeditionary Forces during the First World War.

[143] Ltr, Chief Vet Br 18th Med Gen Lab POA to CG USAFPOA, 8 Mar 45, sub: Ticks and piroplasmosis investigations, APO 502. SG: 710 Piroplasmosis.

arrival was not observed; their importation was not in accord with pertinent civil laws, and dipping was not carried out before departure from Australia. Though tick-borne disease was not reported up to 1 January 1946, an additional hazard to the agriculture and health of New Caledonia may have been afforded by this importation.

Censure was at times directed at quarantine when dead insects, usually mosquitoes, were recovered from incoming aircraft.[144] While the number of insects so recovered may have indicated the relative risk attached to the operation, the fact that the insects were dead was to the credit of the disinsectization applied. Large collections of dead insects also may have represented the fact that the aircraft had been in the endemic areas for a considerable period of time, rather than any local relaxation of mosquito control at points of departure. When planes were swept out before departing from Africa, for example, the number of dead *A. gambiae* recovered on arrival in Brazil dropped precipitately. Nor, as already stated, was it believed that even live insects recovered indicated more than innate limitations of methods available. For example, living insects reported recovered from Army aircraft arriving in Hawaii during a given period were of types not susceptible to the most meticulous application of methods at hand for disinsectization.[145]

Before the war, civil quarantine requirements of Australia forbade the importation of fresh pork because of risk of swine cholera. It was agreed, however, that pork might be imported by American forces provided the refuse was incinerated.[146] Later the Australians insisted that this requirement be modified to provide that the refuse be merely heat-treated [147] by purchasers in order to destroy the virus and permit use of the refuse for rendering or feeding. Considering the difficulty of assuring that this procedure was properly carried out, it is not surprising nor to be laid to the fault of American practice that hog-cholera developed in Australia and required the sacrifice of thousands of animals before it could be controlled.[148]

Rats were reported to have been brought into the United States from abroad in salvage returned to various depots. In every instance careful investigation of these reports showed no basis for such allegation. In one instance the presence of rats was concluded from a foul odor associated with the salvage, but this was shown due to deterioration of rubber parachute pads.[149] One rat was recovered from an aircraft arriving 7 November 1945 at Mather

[144] Memo for file, Army Quarantine Liaison Off, 29 Jan 46, sub: Meeting of the Army Committee for Insect and Rodent Control—29 January 1946. HD: 720.4 Insects.

[145] Rpt, Army Quarantine Liaison Off, 17 Dec 45, sub: Foreign quarantine in Territory of Hawaii. HD: 720.4.

[146] Ltr, CG USAF in Australia to COs all Base Secs and Unit Comdrs USAF in Australia, 25 Feb 42, sub: Quarantine restrictions. HD: 728 EBM 102-C.

[147] Ltr, CO Base Sec 3 USASOS to Chief Surg USASOS, 22 Mar 43, sub: Swine fever, Western Australia, 1942. HD: 728 EBM 102-C.

[148] Diary notes, Army Rep Interdepartmental Quarantine Commission, Australia, 21 Jan 44. HD: 334 IQC.

[149] Memo, Lt Col P. T. Knies for Prev Med Serv SGO, USA Typhus Commission, Interdepartmental Quarantine Commission, 10 Aug 44, sub: Investigation of report of mites in clothing received from overseas at Patterson Field, Ohio. HD: 720.4 Rpts of Inspection.

Field, California; examination showed no evidence of plague and therefore no quarantine risk.[150] This was the only confirmed report of introduction of rodents by military aircraft during the war, though it was rumored that they were observed aboard other aircraft during flight but could not be recovered after landing.

It is evident that the Army program of quarantine clearance in transport operations by water and by air had certain deficiencies, and that the results achieved were not perfect. It is believed, however, that on the whole it was effective, and that principles and techniques of quarantine were evolved which should prove of value not only in event of another war, but also in peacetime operations of the military forces and, with necessary adaptation, in civil quarantine processing of commercial traffic, particularly with respect to diseases of man. Employment of the full range of preventive medicine to achieve the essential goal of quarantine (prevention of introduction of disease) demonstrated the value, indeed the essentiality, of a defense in depth, especially at points of departure and in areas of entry. A broad but critical program of immunization, a high level of personal and environmental sanitation, and an adequate medical care program offer a resilient, elastic, and highly effective protection far beyond the capacity of any momentary routine carried out at the time national borders are crossed. Viewed from this aspect, international quarantine is no longer a restricted traditionalistic and nationalistic prerogative, but an international opportunity.

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[150] Ltr, Lt Col D. D. Todorovic, MC, 2622d AAF Base Unit, Mather Fld, Calif, to Col P. T. Knies, Prev Med Serv SGO, 11 Jan 46. HD: 720.4 ATC.

CHAPTER IX

Preventive Medicine in Ports of Embarkation and for Persons in Transit

Colonel Ralph R. Cleland, MSC, USA

It has been said that the history of ports is, in a measure, the history of civilization itself.[1] Development of the speed and size of vessels, improvement of ports, the deepening of harbors, and the opening of the Suez Canal in 1869 and the Panama Canal in 1914 contributed to a worldwide advancement in social culture at an unprecedented rate. While it is acknowledged that intercontinental air transport of passengers and cargo continues to make its contribution to this advancement today, seagoing transportation and the necessary supporting ports have been and remain the backbone of international travel and commerce.

In early times the transmission of disease was connected with travel, and during the medieval period this knowledge was given practical application in the development of quarantine procedures. The effects of the introduction into various countries, intentionally or by accident, of diseases affecting human beings, animals, and plants are described in detail in Chapter VIII. The degree to which these quarantine procedures had been built up until the outbreak of World War II was sufficient, in part, to prevent major epidemics; however, there was concern as to their continued efficiency during wartime when the element of troop and supply movement would take precedence over the element of the control of the health of troops.

A historical example of the relationship between requisite troop movements and the control of epidemics is the experience in the Port of Hoboken, New Jersey, at the height of the influenza epidemic during World War I. In the port surgeon's report,[2] it is stated that the period from September to December 1918 constituted dark days for the United States Army, both at home and abroad, but nowhere was the situation more trying than at the ports of embarkation. Overcrowding existed at embarkation camps and aboard transports but the situation abroad was such that the flow of troops could not be arrested. Perhaps at no time in American military history had the military and sanitary situations been so carefully weighed as at Hoboken during this period. In view of the fact that a disaster would result in case of an influenza epidemic aboard ship, it was the recommendation of the port surgeon that the crowding aboard transports be reduced by 30 percent and that the hospital accommodations be

[1] Morgan, Frederick W.: Ports and Harbours. London, Hutchinson's University Library, 1952.

[2] Annual Rpt, Med Activities Hoboken POE, FY 1919. HD: 720.

extended 100 percent. The recommendation extending the hospital facilities was approved, but the troop-carrying capacity, in view of the military situation, was reduced only 10 percent. Shortly thereafter a cable message was received reporting 100 deaths on the *Olympic* which had just arrived in a British port. The port surgeon again recommended that the 30 percent reduction in troop concentration be put into immediate effect. The proposed reduction was eventually achieved.

A port of embarkation is a distinctive and highly specialized branch of the military organization, which in wartime plays a vital part in the accomplishment of the military mission. It can be likened physically to a large funnel through which troops and supplies from all parts of the country are loaded into ships, with a degree of concentration unequalled in any other military operation. The magnitude of the military transportation task is illustrated by the fact that during a 19-month period in 1917–18, slightly over 2,000,000 troops were carried to Europe and that during a 45-month period of World War II, the Army embarked roughly 7,293,000 passengers for overseas destinations.[3]

Ports of embarkation in operation during World War II were of various categories and sizes. As classified and defined by existing regulations, they were as follows: [4]

1. *A port of embarkation*, established by War Department orders for the embarkation of troops and shipment of supplies to overseas destinations. A port of embarkation included all component parts of the port, staging areas, ammunition backup storage points, prisoner of war detention camps, and animal depots.

2. *A subport of embarkation*, established by War Department orders and operated under the jurisdiction of a port of embarkation.

3. *A mobile port of embarkation*, a port for which the need was temporary.

4. *A cargo port of embarkation*, a port operated primarily for the shipment of Army cargo and incidentally for the embarkation of Army troops.

5. *A port of debarkation*, a port established outside the continental limits of the United States primarily for the debarking of troops and supplies.

6. *The term "home port"* referred to any War Department port which was the headquarters for any particular Army transport.

7. *The term "foreign port"* referred to any port outside the continental limits of the United States other than an established port of debarkation.

The global military operations of World War II necessitated the operation of ports of embarkation around the entire coastal perimeter of the country, in contrast with World War I operations when Hampton Roads, Virginia, and Hoboken, New Jersey, were the 2 primary ports of embarkation in the United

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[3] Wardlow, Chester: The Transportation Corps: Responsibilities, Organization, and Operations. *In* U. S. Army in World War II, Washington, Government Printing Office, 1951.

[4] AR 55–75, 1 Jun 44.

States. At the close of World War II the Transportation Corps was operating 8 ports of embarkation, 3 cargo ports, and 2 subports through which traffic was being moved regularly to overseas destinations. The relative importance of these installations, as measured by the number of passengers and the tons of cargo embarked during the period December 1941 and August 1945 inclusive, is shown in the following tabulation: [5]

Port	Number of passengers	Measurement tons of cargo
All ports	7, 293, 354	126, 787, 875
Boston Port of Embarkation	740, 705	8, 927, 363
Searsport Cargo Port	----------	470, 584
New York Port of Embarkation	3, 172, 778	37, 799, 966
Philadelphia Cargo Port	----------	5, 893, 199
Hampton Roads Port of Embarkation	725, 880	12, 521, 868
Baltimore Cargo Port	----------	6, 504, 029
Charleston Port of Embarkation	35, 495	3, 215, 981
New Orleans Port of Embarkation	166, 696	7, 240, 687
Los Angeles Port of Embarkation	188, 270	8, 644, 847
San Francisco Port of Embarkation	1, 657, 509	22, 735, 244
Seattle Port of Embarkation	523, 290	10, 204, 760
Portland Subport	51, 827	1, 689, 075
Prince Rupert Subport	30, 904	940, 272

ORGANIZATION OF PORTS OF EMBARKATION

The operation of a major port of embarkation was a tremendous undertaking and required large numbers of personnel. At the New York Port of Embarkation, for example, there were over 50,000 military and civilian personnel engaged in its operation at the height of activity.[6] On the staff of the commanding general of the port was the port surgeon whose responsibilities for medical service included not only the port itself, but also the vessels assigned to and sailing to and from the port.

There was no standard organization for ports of embarkation during World War II, or for the port surgeon's office, and there was, therefore, considerable variation throughout the country. The Chief of Transportation issued only a "typical organization chart" for the guidance of port commanders. This lack of uniformity eventually became a handicap to the Chief of Transportation in his effort to establish uniform procedures and thereby simplify the relations of ports with his office and other elements of the Army Service Forces.[7]

Charts 6 and 7 illustrate the manner in which this lack of uniformity was carried to division level. Chart 6 portrays the organization of the Surgeon [Medical] Division, New York Port of Embarkation, 1944, while Chart 7 shows the organization at the San Francisco Port of Embarkation for the same period.

[5] See footnote 3, p. 326.
[6] Ibid.
[7] Annual Rpt, Med Activities NYPOE, 1944. HD.

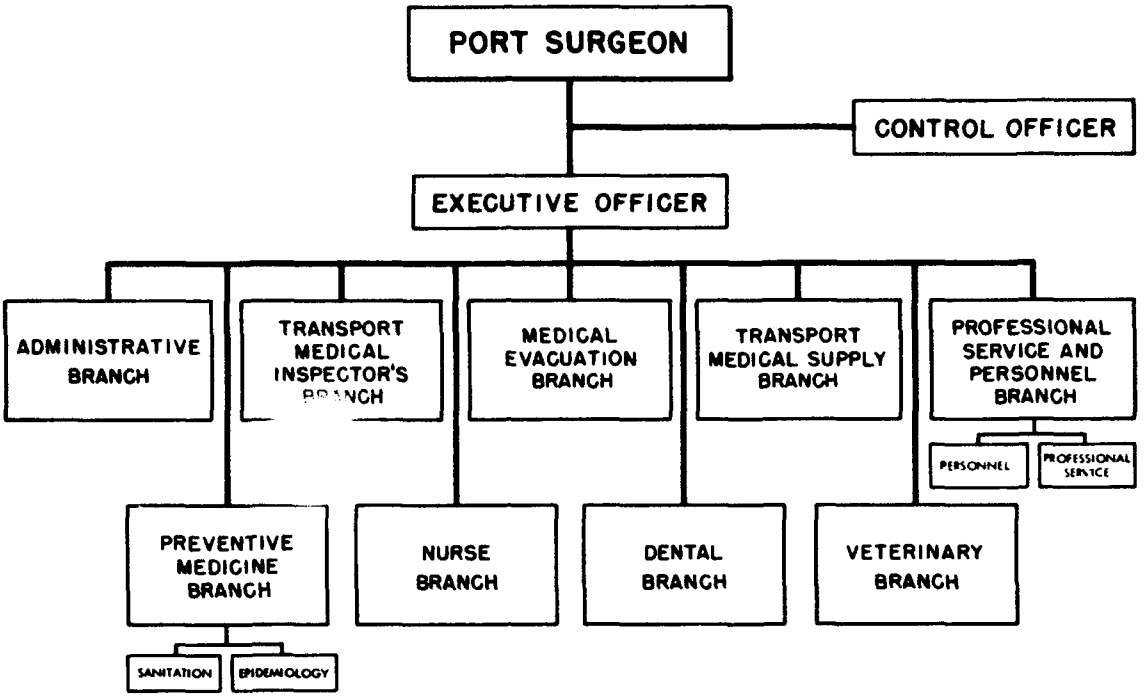


Chart 6. Organization Chart, Surgeon Division, New York Port of Embarkation, 1944

At the New York Port of Embarkation it appears that the Preventive Medicine Branch was relegated to relative obscurity in comparison with the duties assigned to the Transport Medical Inspectors Branch: [8]

Transport Medical Inspector's Branch

Inspects:

Messes, galleys, sleeping quarters, and other parts of vessels occupied or used by Military personnel and ship's crew, on troop-carrying vessels, other than US Navy, upon arrival at NYPE, and prior to departure from NYPE. This inspection is conducted in conjunction with the IGD.

Hospital, sanitary and medical facilities of vessels.

Recommends to the Port Surgeon, alterations of hospital, sanitary and medical facilities.

Performs liaison between Surgeon Division and:

Army Transport Service.

British Ministry of War, Sea Transport Office.

Instructs and supervises newly assigned, and temporarily assigned, transport surgeons, in duties and responsibilities.

Supervises:

Planning, installation, maintenance and repair of medical equipment on board vessels in port under control of NYPE.

Medical aspects of embarkation.

Potability of water supply on vessels under control of NYPE.

Maintains files and records of data concerning Medical Department activities on vessels under control of NYPE.

[8] See footnote 7, p. 327.

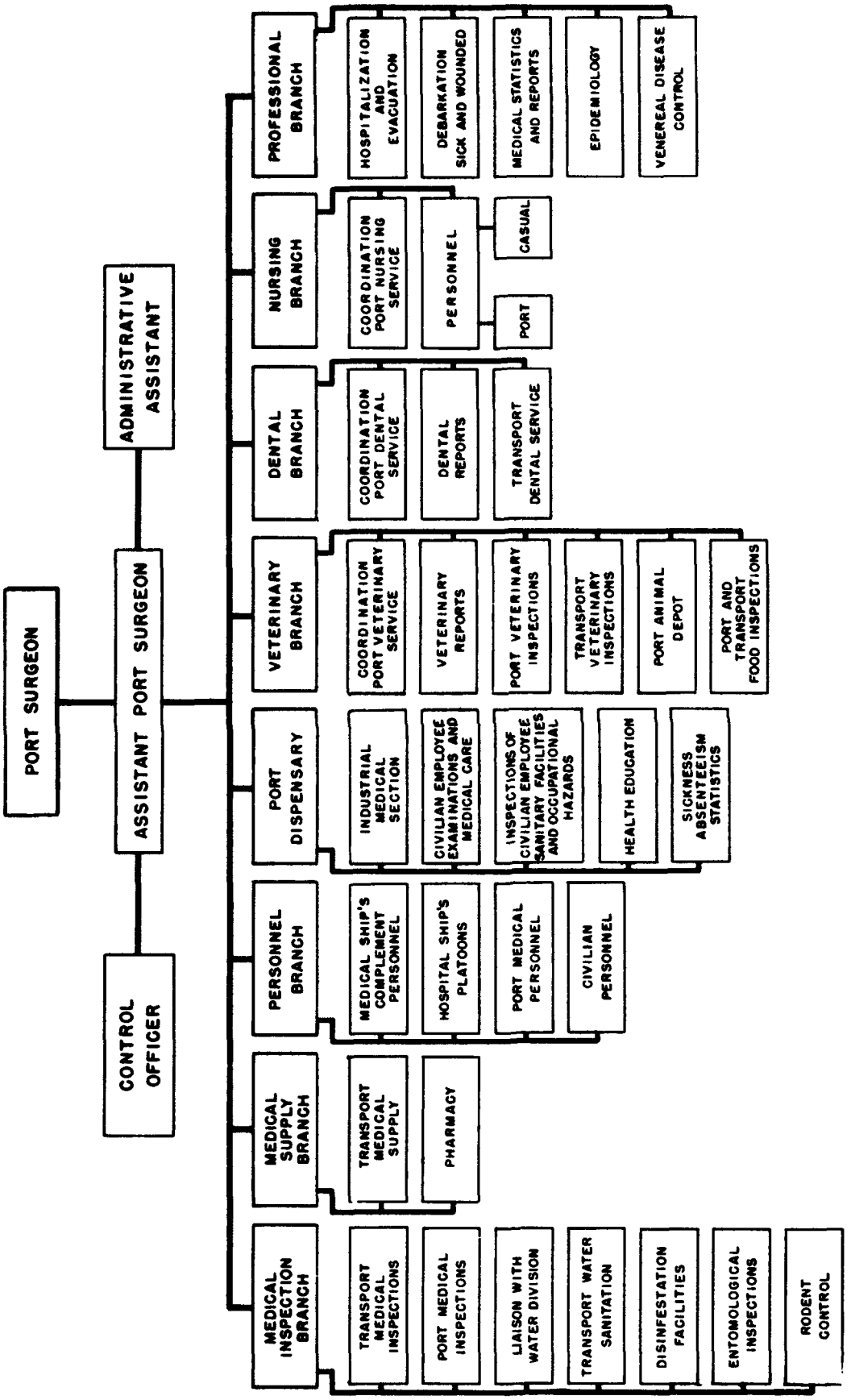


Chart 7. Organization Chart, Office of the Port Surgeon, San Francisco Port of Embarkation, 1944.

Preventive Medicine Branch

Sanitary

Supervises disinfestation of troops and prisoners of war debarking at NYPE.

Conducts special sanitary inspections, as required, of installations under control of NYPE.

Prepares preventive medicine programs.

Epidemiology

Maintains statistics and charts on diseases and injuries in installations including all transports under control of NYPE.

It would seem that several of the functions of the Transport Medical Inspectors Branch, particularly those of inspection, recommendation, and liaison, and the supervising of medical aspects of embarkations and potability of water, would more appropriately have been placed under the Preventive Medicine Branch. The planning, installation, maintenance, and repair of medical equipment on board vessels is more apt to be a function of the Supply Branch.

There appears to have been no preventive medicine branch at the San Francisco Port of Embarkation for the year 1944,[9] although the Medical Inspection Branch might have been so designated. More effective control and operation might have resulted from the removal of epidemiology and venereal disease control from the Professional Branch and providing for their inclusion with other preventive medicine functions.

The provision of a sanitary environment within a port of embarkation and on vessels involves special knowledge with respect to the responsible contributory factors. Problems of water supply, waste disposal, food sanitation, and rodent control are peculiar to the locale of each port and their importance was not appreciated by many agencies prior to the outbreak of hostilities. The safeguarding of ship and port water supplies was one of the most difficult problems encountered by the Sanitary Engineering Division, Office of The Surgeon General, during the war. It was not until 1943 that a Sanitary Corps officer, assigned to the San Francisco Port of Embarkation, in cooperation with commercial concerns, developed superchlorinating and dechlorinating equipment for use aboard vessels—one of the most noted advancements in the field of vessel sanitation to come out of the war. That this difficult situation was not peculiar to the Medical Department in World War II, and had already been experienced in World War I is borne out in the official history which states:[10]

> . . . that the Port of Embarkation is a distinctive and highly specialized branch of the military organization; that the Medical Department commissioned and enlisted personnel should be trained for their duties at the outbreak of a war; that it is a grave mistake to wait until war is on before training 95 percent of the medical personnel that must take part in it; that indiscriminate transfers of medical personnel between port and other stations are not in the best interests of the service.

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[9] Annual Rpt, Med Activities SFPOE, 1944. HD.

[10] See footnote 2, p. 325.

There was an early and continued need for Medical Department personnel trained in port and vessel operation. Sanitary engineers and entomologists were not utilized to the extent possible and medical officers performed environmental sanitation work that could have been done by these specialists. Service by the Veterinary Corps within ports was well organized and performed effectively. At the New York Port of Embarkation, a veterinary officer accompanied the Inspector General's party aboard vessels and made recommendations as to the condition, construction, location and size, lighting and ventilation, possibility of contamination, and nonessential storage of the coolers, freezers, and dry storerooms. Included in these inspections were the galleys and the thawing and meat-cutting rooms.[11]

INDUSTRIAL MEDICAL PROGRAM

A most important activity within a port of embarkation, from the point of view of preventive medicine, was the industrial medical program. Although extensive work in this field had been carried on by The Surgeon General both before and after the outbreak of war, the first general directive giving authority to the program was issued 24 February 1943, in War Department Circular 59. This stated that the Army was to furnish safe and hygienic working conditions for the employees of their arsenals, depots, and industrial plants. The Surgeon General was directed to make all necessary provisions for the supervision of industrial hygiene and for the emergency treatment of military and civilian employees at Army-operated industrial plants.

The functions of the Occupational Hygiene Branch (later Occupational Health Branch), Office of The Surgeon General, and those of the Army Industrial Hygiene Laboratory, Baltimore, Maryland, which had been established by The Surgeon General to conduct surveys and investigations concerning occupational health hazards, were further delineated in the directive. The program was implemented through the service commands, and a medical officer qualified in industrial medicine and a Sanitary Corps officer qualified in industrial hygiene served on the staff of the service command surgeon.

After the issuance of War Department Circular 59, it was brought to the attention of the Chief of Transportation that some ports were not complying with its instructions. On 24 September 1943 the Chief of Transportation issued a letter[12] stating that ports were Class IV installations (industrial, arsenals, Quartermaster and Ordnance depots, et cetera) and as such were directed to undertake adequate industrial medical programs.

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[11] See Miller, Everett B.: Army Veterinary Service. *In* Medical Department, United States Army in World War II. To be published.

[12] Ltr, Chief of Transportation to CGs POEs, 24 Sep 43, sub: Industrial medicine program at ports of embarkation. AG: 701.

Among the industrial activities at ports of embarkation were: (1) the loading and unloading of war materiel, (2) processing of such materiel for shipment overseas, and (3) transferring this cargo to ships.

An additional letter was issued by the Chief of Transportation on 14 December 1943 [13] giving further instructions on this subject and directing attention to the fact that ports of embarkation are active 24 hours a day and that industrial medical service must be in operation at all times. War Department Circular 198, 20 May 1944, broadened the scope of the previous circular by the inclusion of a section pertaining to the Chief of Transportation. His functions listed therein which were considered to be an essential basis for the industrial medical service at ports of embarkation were:

1. To utilize the assistance of the Office of The Surgeon General and of the Army Industrial Hygiene Laboratory as required.

2. To authorize the employment of civilian medical, nursing, and technical personnel essential for the operation of the industrial medical service.

3. To designate a qualified medical officer as industrial medical officer at each port of embarkation.

4. To designate a qualified Sanitary Corps officer as industrial engineer at those ports of embarkation where one was deemed necessary and approved by the Office of The Surgeon General.

While detailed accounts of the accomplishments of personnel engaged in this type of work are given in another volume in this series, worthy of mention in this chapter are some of the outstanding events occurring at the New York Port of Embarkation, the largest port operated during the war, during its busiest period, the year of 1944.[14] The Industrial Medicine Branch had just been organized 1 month prior to the beginning of the calendar year. Its mission, as was the case at other ports, was to secure and keep civilian workers on the job. It operated as the one medical agency of the port that devoted full time to their care and treatment. Each civilian was given a preemployment examination to determine his capability of performing the job for which he was hired. Any employee taken ill or injured while working was treated either in the central industrial medical dispensary or in one of the strategically located dispensary aid stations.

All employees who were ill for more than 3 consecutive days were examined before returning to work. Special consultation service was afforded to pregnant women working at the base. This entitled them to receive emergency care at the dispensary at any time. They also reported to the dispensary monthly, bringing certificates of examination from their private physicians, to insure that proper precautions were being taken. Care was taken to see that they were assigned to work commensurate to their physical condition.

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[13] Ltr, Chief of Transportation to CG SFPOE, 14 Dec 43, sub: Industrial medicine program at ports of embarkation. AG: 701.

[14] See footnote 7, p. 327.

Many times it was felt necessary to have some civilians examined by a psychiatrist. Arrangements were made in these cases for appointments for consultation with the psychiatrist assigned to the station hospital at Fort Hamilton, a satellite station of the port. The procedure was considered most satisfactory.

In an attempt to discourage unnecessary absenteeism, a visiting nursing service was instituted. Nurses visited employees who were absent to give medical aid when necessary, and to determine whether or not the absence was really due to illness.

During 1944 the Industrial Medicine Branch, in cooperation with the United States Public Health Service, conducted a tuberculosis survey of all civilian employees at the New York Port of Embarkation. Approximately 20,700 chest roentgenograms were taken, interpreted, and diagnosed. Disposition was made of the active cases while those showing inactive disease were followed locally with periodic roentgenograms to assure their continued health.

Surveys were made in cooperation with representatives of the Army Industrial Hygiene Laboratory to determine the presence of occupational hazards in the port. Carbon monoxide tests were made to determine the adequacy of ventilation in offices and shops. Protective devices were installed in marine repair shops and were of value, as evidenced by the low accident rate. Close liaison was maintained with the port safety director to prevent as many accidents as possible. Similarly, daily reports were exchanged with the United States Employees Compensation Commission giving the names of those who had not returned for treatment and those who had returned to duty or had other disposition accomplished.

At the close of 1944, a total of 50 civilians were working for the Industrial Medicine Branch, of whom 11 were physicians and 19 were nurses.

SANITARY PROBLEMS WITHIN PORTS OF EMBARKATION

Problems of environmental sanitation within the Zone of Interior ports were in most cases typical of those encountered in military installations located in corresponding areas.

Insect Control

Potentially, the problems of malaria and typhus control were the greatest threats.[15] The possibility of malaria dissemination was present because of the importation of prisoners of war, many of whom were Italians and Germans captured in North Africa, Sicily, and Italy who were infected with malaria. Where these prisoners were confined in camps, which were a part of ports of embarkation, special emphasis was placed on mosquito control and quarantine procedures. In this connection valuable assistance was given by the United

[15] See Chapter VI, pp. 251-257.

States Public Health Service with their programs of Malaria Control in War Areas.[16] Similarly, the danger from the importation of typhus was lessened by effective foreign quarantine procedures and the use of DDT lousicidal spray and disinfestation. In the latter case the use of methyl bromide in chambers replaced obsolete steam disinfestors at ports. At the Boston Port of Embarkation, for example, in addition to the provision of necessary inspection, dressing rooms, and showers, 4 batteries of 3 methyl bromide fumigation chambers each were installed. The plant was set up to handle a maximum of 480 men per hour in groups of 60 each; however, in practical operations, the number seldom exceeded 400 men per hour.

With the advent of DDT, flies, roaches, and bedbugs became less of a problem in ports of embarkation. In respect to flies, it is of interest to note a comparison with the problems experienced during World War I where, at the Port of Embarkation, Newport News, Virginia,[17] corrals contained a daily average of 7,000 horses and mules for shipment overseas. This concentration of animals produced 1,000 tons of manure a month. Owing to warm moist climatic conditions, limited railroad service to haul manure, no large open areas except swamps for disposal, and with a very limited agricultural demand, disposal was a real problem. The official history states that:

> . . . The manure was hauled direct from the corrals to the cars on a spur track at the animal embarkation depot when cars were available; however, the slowness with which these cars were finally moved is shown in the fact that during the period from August 23 to 31, 1918, inclusive, there were 46 carloads on the sidetrack (practically in the heart of Newport News) with an average of over three days' retention each, and 8 remained for the entire period of nine days.

The number of horses and mules shipped overseas during World War II was, of course, much less significant and presented few problems in respect to insect control.

Water Supply

The safeguarding of the potable water supply within ports of embarkation presented problems, one of which was not typical of those encountered at other military posts, camps, and stations. Specifically, it pertained to the protection of the potable supply from contaminated harbor water. A serious health hazard existed at ports where actual or potential connections existed between the potable water supply drawn from the city water distribution system and a supply drawn from a polluted harbor, bay, or river for use on board vessels or for external fire-fighting purposes. A number of epidemics of intestinal disease resulting from this practice were reported by the Sanitary Engineering Committee of the National Research Council.[18]

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[16] Annual Rpt, Sta Hosp Camp Patrick Henry, Va., 1943. HD.

[17] The Medical Department of the United States Army in the World War. Washington, Government Printing Office, 1928, vol. IV, p. 375.

[18] See Chapter III, p. 121.

Largely through the initiative and efforts of the Sanitary Engineering Division, Office of The Surgeon General, Army Service Forces Circular 234, 26 July 1944, was prepared and issued, defining these hazards and directing their correction. Three general types of hazards were potential:

1. *At Piers.* Through pier or warehouse fire-protection lines carrying unsafe water, including so-called Siamese connections, a hazard was created when any connection, with or without a check valve, existed between the drinking water and the fire-fighting supply systems.

2. *Vessels With Power.* When vessels having power to operate pumps were moored to docks and connected to the pier water system for additional fire protection, operation of the fire pumps, either for testing or because of fire, would force harbor water into shore mains because the pump pressure was invariably higher.

3. *Vessels Without Power.* When vessels temporarily without power to operate pumps would connect to the pier water supply system for fire protection or sanitary purposes, pollution of the potable water system was considered probable if power later becomes available and the pumps were started for testing or fire use.

Directions were given to eliminate these hazards by various means, outstanding of which was the requirement for the provision of doublecheck valves to act as backflow preventers. By the end of 1944, a large number of piers were equipped with backflow-prevention devices, notably at the San Francisco [19] and Boston Ports of Embarkation.[20]

Rodent Control

Rodent control within ports was a continuous operation; however, it presented no unusual problems not found in other military installations. Control programs were carried out regularly with the cooperation of the Public Health Service. Conventional methods of fumigation, trapping, and poisoning were employed and, where possible, rats were examined for evidence of plague. At the San Francisco port such examinations were made at the Public Health Service Plague Control Laboratory. No rodent disease problem of a serious nature ever developed, although the Army was ready with trained personnel and the necessary equipment to meet with any emergency.[21]

Waste Disposal

Problems in respect to garbage and refuse disposal were minimal. Central can-washing facilities having adequate hot water and steam enabled the ports

[19] See footnote 9, p. 330.
[20] Annual Rpt, Med Activities Boston, POE 1944. HD.
[21] See Chapter VI, pp. 244-248.

to keep clean the large numbers of cans required on the piers to support the vessels in berth. After the close of the war, however, in the interest of economy, War Department orders were issued disallowing central can-washing plants.

Sewage invariably went directly into the harbors to be carried out by the tides. The fact that one of the largest sewers in Brooklyn, New York, emptied into the harbor beneath one of the piers in the port created a serious hazard. Waterloading hoses sometimes fell into the contaminated harbor water, and harbor water was used aboard ship, being pumped through the salt water system, for such purposes as toilet flushing.

OVERSEAS PORTS OF DEBARKATION

Preventive medicine practices in ports overseas varied with the climate and location. Ports in western Europe (Glasgow, Liverpool, Bristol, Southhampton, Cherbourg, Le Havre, Antwerp) had few real problems in preventive medicine in comparison with those in Africa and the Mediterranean region (Casablanca, Algiers, and the ports of southern Italy). In the latter group the problems were serious and constant. Plague, smallpox, and typhus were all serious threats to our troops and the bottleneck of a port enhanced the danger of their spread.

Housing for port personnel varied from private billets and Nissen huts to tentage and the foxhole. In Europe, where used, the Nissen hut was considered successful, even though some discomfort and danger of spread of respiratory disease resulted from the fuel shortage and limited ventilation due to blackout requirements.

Water supplies were usually from the municipality encompassing the port. Because of water shortages due to drought or to bomb damage to the systems, it was often necessary to restrict the hours of supply. This in turn increased the danger of contamination of the supply through existing cross connections and back siphonage. There were no major epidemics of disease attributable to these supplies.

In the Pacific area, the problems of environmental sanitation facing port personnel were similar to those encountered by the combat troops. For example, in one area occupied by the 23d Port Company,[22] environmental sanitation was deplorable as a result of Japanese occupation and recent combat action. Dead bodies of the enemy and debris consisting of iron sheeting, Japanese clothing, and rotting food littered the area. Old Japanese latrines were uncovered and were breeding countless flies. Engineer labor and equipment assisted in filling in latrines and wells, razing and burning the Japanese structures, levelling off the area, and a sanitary environment resulted.

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[22] Sanitary Rpt, 23d Port Hq & Hq Co, Sep 1943. HD: 721.5.

The 387th Port Battalion operating in New Guinea had, as another example, preventive medicine problems which were characteristic of the geographic location: [23]

> The diseases most prevalent among the personnel were malaria, diarrhea, and typhus. Malaria ratio was rather high, as all of the men had been stationed at Milne Bay where malaria was endemic and the malaria control was poor. There was never a severe epidemic of diarrhea, but sporadic cases were present most of the time. Scrub typhus made its appearance soon after the troops moved onto Angau Ridge. This ridge overlooks Oro Bay and was covered with Kunai grass which had to be cleared off. Three deaths resulted from this disease.
>
> A meeting was held and it was decided that in order to eradicate scrub typhus, an intensive program against the rats and mice would have to be instituted. As many rat traps as possible were obtained. Native labor was obtained and all Kunai grass and shrubbery was cleared from the area. A distance of several hundred feet around the area was also cleared. The sanded floors of the mess halls were replaced with concrete. Rigid sanitation was enforced. As a result of the above measures, the rat and mouse population was materially reduced. No new typhus cases have developed since this program was started.

Similarly in North Africa and Italy the problems in preventive medicine corresponded to the geographic area and the indigenous population. In 1943 there was a rise in typhus fever among the Arabic population and great emphasis was placed on physical examinations, checking of immunization records, and the quarterly administration of stimulating doses of typhus vaccine.[24] Also, the promiscuous defecation habits of the natives created heavy breeding of flies and rigorous control programs were instituted which included the hiring of Arabs to police the surrounding areas. Here and in Italy the problem was somewhat alleviated by the construction of "over-the-side" latrines on the piers.

During the autumn months of 1944, there was an increase in the prevalence of smallpox in the vicinity of the 8th Port of Embarkation operating in Naples, Italy. The decision was made to vaccinate the Italian laborers and, with the aid of an Italian medical team from the Allied Control Commission, over 20,000 Italians were vaccinated. During the same period, all merchant seamen entering the port, regardless of nationality, were vaccinated if they could not produce evidence of a successful vaccination within that year. The number so treated was approximately 2,500 seamen. During the last 6 months of 1944, over a million people passed through this port and over 40,000 patients were processed without a mishap. Hundreds of ships of all types had been in and out of the harbor having all nationalities in their crews and with all this activity no communicable disease was brought in or carried out.[25]

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[23] Annual Rpt, 387th Port Bn(TC), 1943. HD.
[24] Annual Rpt, Port Surg 6th Port Hq(TC), 1943. HD.
[25] Annual Rpt, Port Surg 8th POE, 1944. HD.

VESSEL SANITATION

If all of the troop-carrying vessels used during the war had been newly constructed and in accordance with the best possible design to meet normal health requirements, the problems in the field of preventive medicine would still have been tremendous. When it is realized that the numbers of troops carried far exceeded any design factor (the *Queen Mary* and *Queen Elizabeth* carried between 14,000 and 15,000 troops on each of many trips)[26] the maintenance of even minimal environmental health standards was most difficult considering the fact that facilities such as galleys, troop compartments (Fig. 24), bathing and toilet rooms, and recreational facilities could not be expanded to a fraction of the proportions required.

It was obvious that there could be little standardization because cargo-carrying ships had to be hastily converted to passenger carriers, and a number of the large transports were veterans of World War I.[27] In addition to the United States vessels, several enemy ships were seized in American ports and also about 20 Dutch, Norwegian, French, and Chilean ships became available for use. The water supply and distribution system and the galley equipment



Figure 24A. Enlisted men's messhall on board ship, 1942. Food was served twice daily with standing room only.

[26] See footnote 3, p. 326.

[27] Charles, Roland W. Troopships of World War II. The Army Transportation Association, Washington, D. C., 1947.



Figure 24B. Typical view of troop quarters aboard Army transport.

on one vessel would, therefore, be at great variance with the same facilities on another transport.

Time and availability of men and materials did not allow for only the construction of new vessels for transport of troops. The immediate requirement had to be met by the conversion of passenger liners to troop transports. For well over a year this program provided the United States with the only source of troop lift. The next resort was to convert cargo vessels to troopships and for this purpose standard designs of the Maritime Commission were utilized.

Many ships of the Liberty class were also altered for use. During the Mediterranean campaign, to meet General Eisenhower's needs in returning several hundred thousand German and Italian prisoners of war, these ships were fitted with standee-type bunks that could be set up in the cargo between decks after the vessel had been unloaded. Later in the campaign when more troops were required in the Mediterranean, Liberty ships were pressed into service and carried in excess of 200,000 badly needed reinforcements. "It was

tough going for the men who had to ride them but as an emergency measure their use was more than justified." [28]

The conversion of ships took time—from several days for an emergency conversion, to months for a complete job. It was with difficulty that the Medical Department was at all able to participate in this program, because of the intricate chains of command and responsibility for new ships under construction and those under charter and the lack of time due to urgent military situations. Considerable time and effort was expended in an attempt to improve existing conditions for water sterilization, for example.[29]

In addition to the provision for troop-carrying spaces, it was necessary to provide hospital sections within these ships and, of equal importance, to construct hospital ships for the evacuation of sick and wounded to the Zone of Interior. Some of the problems involved were:[30]

1. Lack of water storage caused large quantities of linen to be required until the water supply was increased and adequate laundries installed.

2. Most of the converted ships were equipped with generators for direct current. Almost all electrically operated equipment supplied by the Army Medical Department operated on alternating current. Converters therefore had to be obtained for roentgenographic and other equipment, even as the war ended, surgeons of some ships were reporting that electrical equipment gave particular trouble.

3. Sterilizers were a problem because space limitations precluded installations of the larger sizes. This resulted in the operation of smaller sizes of sterilizers in large numbers, with increased maintenance.

4. Early in the war the necessity for maintaining radio silence on hospital ships made it impossible to use certain roentgenographic equipment which had either to be converted or discarded. It was necessary to install roentgenographic equipment for which repairs could be made easily and which would take adequate pictures.

5. The addition or removal of any equipment which would change the external appearance or contour of the ship necessitated delay because the enemy had to be notified, through neutral diplomatic channels, of such changes.

In addition to the problems arising in the construction and conversion program, there were those in connection with deployment of troops on vessels under foreign control. Approximately 21 percent of the troops embarked at United States ports throughout the war were on vessels under control of the British Ministry of War Transport. Until January 1944, there appeared to be no written agreement covering the acceptance of troop accommodations aboard these ships which were at variance with our standards. This lack of specific agreement led to many stalemates as the United States made demands for

[28] Stokes, M. B.: Shipping in war. Hist Res Office, OCT.

[29] See Chapter III, pp. 118–120.

[30] Memo, G. R. Allan, Med Facilities Branch SGO, to Col Cleland, 4 Aug 53, sub: Notes on hospital ships. HD: 705 (Hosp Ships).

vessel alterations, which, if carried out, involved a departure from prescribed standards of the British Ministry of War Transport. A similar situation occasionally arose when British troops were to be transported on American troopships. These differences culminated in a refusal by the United States authorities to use any space on one British ship and in accepting only a percentage of the "as fitted" capacity in another ship. It was apparent that there needed to be established a scale of minimum standards aboard vessels which could be jointly used. Accordingly, the Combined Military Transportation Committee at its 82d meeting on 18 February 1944, approved a scale of minimum standards for troopships under war conditions. It was agreed that troopships meeting these minimum standards would be accepted for the carriage of troops. Some of the scales, which pertained to the health and morale of troops follow:[31]

United States or United States Controlled	*British or British Controlled*
SLEEPING	
The accommodations for all officers (other than for a few of high rank) is in cabins or dormitories in three (3) tier beds.	The accommodations for officers is in cabins or dormitories with beds in not more than two (2) tiers.
The accommodation requires about 3 square feet per man when berthed three (3) high and 6 square feet when berthed four (4) high.	The accommodation for lower ranks varies from about 8¼ square feet to 7 square feet on the hammock mess deck system.
Spaces unsuitable for daytime recreation.	Spaces designed for good daytime recreation.
* * * * * * *	
MESSING	
The messing accommodation averages about one (1) square foot per man. The mess space is centralized in one compartment well above waterline.	As sleeping spaces are used for messing there is no loss of area for messing. The mess spaces are distributed throughout ship, including sections too near the waterline for overboard discharges.
Messing is in relays, involving almost continuous daytime service. Men are individually served by cafeteria in their individual field mess kits, which they carry to tables; the serving being assisted by men drawn from the transient service personnel.	Messing is simultaneous. Orderlies (two per table) carry food (served in the galleys by the ship's catering staff) in large mess utensils to the individual tables where the food is served into individual crockery (supplied by ship) and stowed in a mess rack at that table.
The men use their field cutlery.	The men use cutlery provided by the ship and stowed in a drawer in the mess rack at each table.
Standing at tables is the normal practice and seating is rarely provided.	Simultaneous seating (for all men) at tables is provided.

[31] Minimum Standards for US Army and British Troop Transports, 21 Feb 44. OCT.

United States or United States Controlled	*British or British Controlled*
MESS KIT WASHING	
Each man individually washes his field mess kit and cutlery as he leaves the mess section in a Finland Messkit Washer.	The individual crockery and cutlery are washed and dried by the men orderlies, at the mess table, and then replaced in the mess racks.
* * * * *	When American troops are transported in British controlled transports the American troops are given their choice of either using their own mess kits or using the vessel's crockery.
Each mess kit washer is equipped with H. S. [hot sea] water to rinsing and washing compartments for use at sea, and H. F. [hot fresh] water for use in port and the sterilizing compartment is equipped with H. F. water for both sea and port use. Washers are fitted with steam jets in washing and sterilizing compartments and an overboard discharge.	Hot water for this purpose is carried from the galley to the table and the soiled water and garbage are carried by the mess orderlies to rubbish shoots on deck, located usually one (1) forward and one (1) aft.
* * * * * * *	
LATRINES AND WASHROOMS	
Toilet, basin and shower rooms are located in or adjoining each troop section, for convenience and for sea sickness, etc., but necessitate considerable mechanical ventilation.	Toilet, basin and shower compartments are usually centralized into two (or more) groups, located forward and aft on the weather decks, where they are easy to ventilate and wash down.
For sergeants and men, toilets are provided on the basis of 4%, basins on the basis of 5% and showers on the basis of 2½%.	For sergeants and men, toilets are provided on the basis of 2% plus 8, wash basins on the basis of 4% plus 3, and showers on the basis of 2% plus 2.
* * * * * * *	
HOSPITAL CAPACITY	
The hospital capacity comprises about 3%, plus an expansion area of 4% for mental cases.	The hospital capacity comprises about 2%, plus a separate isolation hospital of about 4 to 8 beds.
HOSPITAL WARDS	
The wards comprise one medical, one surgical, three isolation and two mental wards, all grouped within the hospital area, in addition to the officers' cabins selected for the mental expansion area. Two to four padded cells are provided in the hospital group, counting on the capacity of the mental wards.	The wards comprise two in the main hospital and one or two in the separate isolation hospital. The isolation hospital is located remotely—usually at the stern or on the top deck. No mental wards or padded cells are provided.
* * * * * * *	

United States or United States Controlled	*British or British Controlled*
HOSPITAL LAVATORIES	
In United States transports, lavatory accommodation is provided as follows: One shower stall per 15 hospital beds. One washbasin per 8 hospital beds. One toilet per 10 hospital beds. (The above are arranged in separate groups for the medical and surgical wards, adjoining each ward.)	In British transports, lavatory accommodation is provided as follows: One tub bath for each 20 hospital beds. One washbasin for each 12 hospital beds. One toilet for each 12 hospital beds. One basin for use of hospital staff. A separate lavatory of "special" cases with 2 washbasins and 2 urinals.
One washroom with one toilet, one washbasin and one shower stall for each isolation ward.	One bathroom with toilet and washbasin leading off the isolation hospital.
One washroom for each mental ward excepting where a washroom lobby or private mental corridor is provided; the washroom containing one shower stall, one washbasin and one toilet.	Excepting for those attached to the separate isolation hospitals and the separate lavatory fitted for "special" cases, all other bath, basin and toilet facilities are concentrated usually into one group of hospital lavatories for general use of all wards.
* * * *	* * * *
RECREATION SPACES, ETC.	
In United States transports, no recreation rooms are required to be provided, though in some cases, an officers' lounge is arranged.	In British troop transports, the following spaces are provided: (a) Lounge for Officers (b) Lounge for Warrant Officers (sometimes also allocated to Sergeants) (c) Troop Recreation Room (d) Canteen Service Rooms, with seating space outside for troops These rooms have been found to be essential for troops on long voyages, in addition to the recreational facilities provided by hammock mess decks.
Canteen (Post Exchange) service rooms are provided, and in some cases where space permits a small lounge room is arranged adjoining.	
* * * *	* * *
GALLEY EQUIPMENT	
In United States troop transports, roasting ovens are used almost solely for officers' food, and practically all cooking for other troops is handled by steam kettles (stock pots); the production of which is standardized in noncorrosive metals.	In British transports, the range ovens are used for both officers and troop messing, and fewer stock pots (steam kettles) are therefore necessary. The stock pots are built of cast or wrought iron, though some have noncorrosive metal linings.

Note. In many British troop ships, the United States authorities have pressed for the replacement of British standard type steam kettles by those of United States type.

United States or United States Controlled	*British or British Controlled*
HEATING	
In United States troop transports, all officers and troop spaces, troop lavatories, etc., are provided with heating by hot air ventilation ducts, or steam or electric heaters to temperatures generally accepted in United States living quarters ashore; the temperature in several cases being thermostatically controlled.	In many British transports, heating by hot air ventilation or steam or electric radiator is provided to officers and troop spaces upon a more limited temperature basis, largely dependent upon the ship's normal peacetime vocation but rarely thermostatically controlled.
Note. In many British troop ships, the United States authorities have pressed for increased heating in troop spaces, and in most ships for heating of troop lavatories, including cases where no surplus steam or electric generation was available for this purpose.	
VENTILATION	
In United States troop transports, troop sections are ventilated on a basis of 30 to 50 cubic feet of air per man per minute. Lavatories are ventilated by a separate system and inclusive of exhaust ventilation.	In British transports, the volume of ventilation of troop sections varies considerably, and usually is on a much lower basis than in U. S. transports. Troop lavatories (usually on deck) are naturally ventilated.
* * * * * * *	
GARBAGE	
In United States transports, a garbage room is provided below deck for accumulation of garbage during the day, and fitted with one or two garbage chutes led overboard.	In British transports, garbage is not stowed internally, but on the weather deck wherever practicable, and garbage chutes provided through the bulwark, usually one (1) forward and one (1) aft.

From these scales, it appears that there was considerable difference in methods of operation aboard United States ships and those under British control. It is acknowledged that there were numerous instances where friction between the forces existed; however, from the viewpoint of preventive medicine, it is questionable whether morbidity rates for American troops on United States vessels were at great variance with rates aboard vessels under British control.

Water Supply

The provision of safe water aboard vessels was recognized by the Sanitary Engineering Division, Office of The Surgeon General, early in the war as a problem of great magnitude. An outstanding contribution to the field of vessel sanitation was made in 1942 when a directive from The Adjutant General was issued requiring 0.3 part per million chlorine residual in the water supply of ships transporting military personnel. In the manuals issued to transport surgeons appeared directions to the effect that, "drinking water, taken aboard ship at any port, must be regarded with suspicion."

Water supplies aboard ship were of three essential categories (not including boiler feed water). The first, the "potable supply," was used for drinking,

cooking, dishwashing, and hospital purposes essentially. While some vessels had but one system of fresh water, the majority had another known as the "wash water system" which was used for other purposes where a potable water was not considered by maritime personnel to be essential. Such uses included slop sinks, garbage grinders, laundry facilities, bathtubs, showers, and for deck-flushing purposes except for areas in the galley. The third category was the "sanitary" or "overboard" water system which was sea water intended for use primarily in the sanitary system for toilet flushing, bedpan washers, and was to a large degree used for bathing purposes aboard troop transports.

The potable water used aboard ship was meant to be that which met the requirements of the United States Public Health Service Drinking Water Standards.[32] According to these, the water was preferably to be taken from approved shore supplies. Where not so secured, the water was required to have purification. The water taken from an approved source was to be loaded through a separate hose, which was not used for any other purpose aboard and which was preferably to have different hose fittings and adapters so that the possibility of its use other than for the purpose intended was minimized. Furthermore, the hose and such adapters were to be stored in a closed cabinet, on a rack or reel, or in the upper part of a passageway bulkhead and the cabinet or storage space labeled "Potable Water Hose Only." If the hose was not stored in a closed cabinet, its ends were to be capped. Next in order was the independent filling line to which the hose could connect with the shore supply. This line was not to be cross-connected with any line of a nonpotable system nor pass through a nonpotable liquid. The tanks in which the potable water was to be stored were preferably "inboard" tanks not having a common wall with other tanks holding nonpotable water or other liquids. The tanks were to be independent of the shell of the ship unless the bottoms were 2 feet above the maximum load waterline and had welded rather than riveted seams. According to the United States Public Health Service, if all these requirements were followed, the water did not need chlorination.

Definition was lacking as to what clearly constituted an approved source of supply; the possibility, and in most cases probability, of cross connections aboard ship; the inadvertent or careless handling of the loading hose which oftentimes allowed one end to be submerged in polluted harbor water; and the apathetic attitude of the ship's personnel toward the whole subject of potable water constituted potential health hazards on all transports. The easiest and most practicable method of minimizing these hazards appeared to be the chlorination of all water taken aboard, regardless of the source of supply.

The separate wash water system aboard ship was always a matter of concern for the Medical Department because attention to the loading of the water was often haphazard and cross connections with the potable system invariably

[32] Handbook, Principles of Sanitation Applicable to the Construction of New Vessels. Federal Security Agency, Public Health Service, Washington, D. C., 1949.

existed. The ship's engineers were reluctant to remove these connections for fear that the flexibility of water supply might be needed at sea for emergency purposes. Again, wash water tanks were usually those constituting a portion of the bulk of the vessel, i. e., port or starboard tanks, fore and aft peak tanks and double bottoms, and with the possibility of a leaking seam and a cross connection to the potable water system, additional hazards existed.

While there appeared to be concentrated attention paid to the treatment of "drinking water" aboard ship, the scope was broadened to include the entire fresh water system (except boiler water). The following is from the instructions issued to transport surgeons at the New York Port of Embarkation:[33]

> SGO letter, subj, "Protection of Water . . . on Army Transports," dated 16 April 1941 is quoted as follows: "Water—In addition to strict compliance with army regulations, *unusual care* should be taken to safeguard the fresh water supply against contamination of any sort and the water supply for drinking, cooking, and bathing should be so treated with chlorine that a residual chlorine content of 0.2 to 0.3 PPM is *maintained at all times.*" Water taken aboard at any port as well as water tanks and systems of all transports must be regarded with suspicion. Chlorination will be accomplished by the chief engineer of the ship under the technical supervision of the transport surgeon. A record will be kept by the transport surgeon listing places where water was taken on, tons of water present, amounts of chlorine chemical used and the results of daily chlorine residual tests on water drawn at taps and weekly tests of water in the tanks. This record will be submitted by all transport surgeons to the Preventive Medicine Branch of the Port Surgeon's office at the end of each voyage.

The use of salt water aboard ships for sanitary purposes was essential. The lack of sufficient water storage tanks and the limited capacity of evaporators precluded the provision of an entire fresh water system sufficient to provide water for flushing of toilet fixtures, and bathing and laundry facilities. Here again cross connections were often found, a common one being in the galley where both flush and salt water would be piped to the vegetable peelers with the planned procedure being that the salt water would be "turned off before 40 miles from port and remain off while in the harbor."

Most of the water treatment was manual, using high test (70 percent) calcium hypochlorite, and the ship's tanks were chlorinated at the time of filling. At the same time as the tanks were being treated, the sounding tubes would also receive a heavy dosage of chlorine solution to aid in cleansing. Normally, potable water tanks were equipped with a series of petcocks arranged vertically to allow the ship's engineer to gauge the depth of water; however, wash water tanks had to be gauged with sounding lines, which introduced an additional hazard.

Automatic chlorinators were installed on a number of vessels. These were actuated by a watermeter and operated on the principle of a diaphragm pump. Calcium hypochlorite solution was used and as a consequence operational problems resulted. It was difficult to secure a clear decanted solution because of the ship's motion, and the chlorinator mechanisms would frequently

[33] Instructions for Transport Surgeons. New York POE Pamphlet No. 4, 1 May 45. HD: 560.

become clogged with the resulting insoluble sludge. This condition was later rectified by the use of sodium hypochlorite solution which was loaded aboard the transports in gallon containers. Coast Guard safety regulations would not permit the use of gaseous chlorine aboard vessels. On some of the large British ships (*Queen Mary*) chlorine used for water treatment was made by means of an apparatus which electrolyzed common salt. This method was investigated for possible use aboard American vessels; however, Coast Guard permission could not be obtained because the gaseous hydrogen which was produced as a byproduct in the process would create a shipboard hazard.

Chlorinators were usually installed in duplicate and in a number of cases followed by tanks containing granular carbon which acted as dechlorinators. With this installation, it was possible to superchlorinate the ship's water between 5 to 10 parts per million without its resulting in objectionable water. In order to maintain a residual throughout the vessel, a bypass was constructed around the dechlorinators to allow sufficient superchlorinated water to be remixed with the fully treated water. Suitable detention tanks were placed between the chlorinators and dechlorinators to allow for effective water sterilization. With this installation aboard, it proved satisfactory to combine the wash water system with the potable water system thereby assuring more effective control over possible contamination.

It was essential to have bacteriologic knowledge of ship and port water supplies and to accomplish this, laboratories were made available to or constituted a part of the port surgeon's organization. Samples of water were normally taken from each of the ship's fresh water tanks and the analyses indicated the necessity for and the justification of the chlorination policy adopted by the Army—that, regardless of the source of supply, water taken aboard or purified at sea by means of evaporators should be chlorinated.

Waste Disposal

While it might appear that the disposal of wastes from shipboard was a relatively simple procedure when compared with that necessary in the field, such was not the case. The subject could not be dismissed with the statement that "all wastes go overboard" which, although true, did not tell the entire story. From the reports of ships' surgeons and inspectors, the clogging of toilet fixtures and drains created many nuisances and health hazards. Many times the causes for these conditions seemed to be intentional as well as inadvertent. For example, towels and other pieces of clothing, as well as rolls of toilet paper, were sometimes found to be the obstructing agents. When liquid wastes could be discharged by gravity flow this was accomplished in "lines" through the hull which were equipped with flap valves to prevent the backflow of sea water. When such disposal was not feasible, liquid wastes could be drained to sumps and discharged through the hull by means of pumps

or steam-operated ejectors. These at times would create odor nuisances, especially if these sumps were not cleaned regularly.

Garbage disposal was often difficult. While some of the vessels had garbage grinders aboard, it was necessary on many ships to carry garbage cans up several decks and to the rear of the ship where it could be dumped into the sea over the fantail. This was frequently a hazardous operation because of the ship's movement and because it had to be done at night for security reasons. Spillage of garbage with this method of disposal was often inevitable.

Rodent Control

The control of rodents aboard ships was given active supervision not only by the ship and port personnel but also by the United States Public Health Service quarantine officials. As previously stated, there was no rodent disease problem of a serious nature throughout the war insofar as our ships, ports, and troops were concerned. This is not to imply that rats were not present in numbers aboard ships and in ports. That the contrary was true is shown in a letter from the United States Quarantine Station, Charleston, South Carolina:[34]

> During the months of February and March four U. S. Army Hospital Ships were fumigated at this port for the destruction of cockroach and rodent infestation. 101 rats were recovered from these vessels as follows:
>
> | | |
> |---|---|
> | U. S. A. H. S. Larkspur | 16 |
> | U. S. A. H. S. Acadia | 11 |
> | U. S. A. H. S. Algonquin | 39 |
> | U. S. A. H. S. John L. Clem | 35 |
>
> Many more rats would have been recovered which were undoubtedly killed in overhead ceiling and double walls and ballast if access to these places had been possible.
>
> There are 17 Hospital Ships assigned to this port and 7 of these vessels are infested with rats. Extensive rat harborage exists on most of these vessels. Ratproofing has been recommended at various times while vessels were at shipyards for repairs but nothing has been done in this respect.

The statement that rat harborage existed on many of the vessels was more true of those constructed prior to the outbreak of the war and which had been converted. For example, in the list of four above, the *Larkspur* was built in 1901 and the *John L. Clem* in 1918. Converted cargo ships by reason of their unfinished interiors did not afford harborage found in the older passenger carriers which had been used for troop transports.

The control of rats aboard vessels lies largely in their being ratproof in construction. Denying rats entrance aboard is an endless and almost hopeless job, especially during war. Rat guards placed on the ship's hawsers are frequently ineffective, not only because of the manner in which they are placed but also because the hawsers so often cross themselves that paths can be found to get aboard. Add to this the fact that many times the cargo safety nets are

[34] Ltr, Med Dir US Quarantine Station, Charleston, S. C., to SG, 5 Apr 45. AG: 729.5 (BB).

left in place, the gangplank is left down and is poorly—if at all—lighted, water-hose connect the ship with the pier, and lastly, numbers of rats board ship hidden in cargo. If harborages are denied aboard ship through ratproofing, the problem of rodent control is minimized.

Fumigation with hydrocyanic acid proved the most effective method of extermination. At the close of the war, powerful rodenticides, such as "1080" (sodium monofluoracetate) were under development,[35] which, had they been available earlier, would have been of great value in controlling rats within the ports proper. Here again the task of control is seemingly endless, in that rat migration continually takes place and the movement along waterfronts provides an environment much to their liking.

Heating, Lighting, and Ventilation

The provision of heating, lighting, and ventilation adequate for the control of communicable disease, and the maintenance of morale aboard transports, was at all times difficult and complicated. Problems were most acute on the cargo-type vessels which were converted or later constructed for use as transports. The provision of portholes was not undertaken, primarily for reasons of security at sea. These allow for improved ventilation, particularly when airscoops are attached; similarly, the problem of lighting is increased and the effect on morale, insofar as the feeling of confinement is concerned, is appreciable.

Heating and ventilation systems were of varied types; a conventional method of the former was the use of heaters installed in the ventilation duct system. Because of improper design, lack of necessary insulation, and manipulations by the troops, heat and cold extremes were often evident. There was the tendency on the part of the soldier to stuff towels or articles of clothing into ventilator outlets if too much hot air seeped through; this in turn increased the airflow into other sections of the ship. In hospital and other areas, sheets of gauze would be tied over the ventilator outlets to remove soot which was drawn into the duct system by the suction fans on deck; this in turn would throw the ventilation system out of balance.

In view of the concentration of troops aboard transports and the ever-present danger of explosive outbreaks of respiratory infections, The Surgeon General at an early date investigated the possibility of air disinfection by means of germicidal vapors and ultraviolet radiation. A meeting was held in Brooklyn, New York, on 19 November 1942 to study and investigate these possibilities. Among those present were Dr. Francis G. Blake, President, Board for the Investigation and Control of Influenza and other Epidemic Diseases in the Army (later called Army Epidemiological Board); Dr. O. H. Robertson, Director of the Commission on Cross-Infections in Hospitals, and Col. S. Bayne-Jones, Preventive Medicine Division, Office of The Surgeon

[35] See Chapter VI, pp. 241-244 and Chapter VII, pp. 267-268.

General.[36] It was then the opinion of Doctor Robertson that the use of glycol vapors and of ultraviolet radiation offered potentialities in the field of the control of cross-infections, particularly those being airborne. While technical details covering the use of these agents and the subsequent experiments which were made are found in Chapter II, it is significant to note that shipboard application of these principles was not deemed practicable and they were consequently not so employed during the war.

Galley Sanitation and Food Preparation

Probably the largest single problem faced by transport surgeons in keeping troops healthy aboard ship was that of proper supervision of the preparation and serving of food. On most transports in World War II, food preparation was under the control of the chief steward's department which was, as a rule, staffed with the poorest type of help, many of whom did not have the slightest conception of the principles of personal hygiene or mess sanitation. In spite of the desire of most chief stewards to keep the preparation of food in line with approved sanitary measures, it was frequently dirty and unappetizing. Transport surgeons, through transport commanders, made many constructive recommendations regarding food preparation, but these would often be ignored because of lack of military control of the galley crew as well as the arbitrary and obstructive tactics of the cooks and stewards' union.[37]

Many of the sanitary problems in galleys aboard ships were similar to those of messes on land installations insofar as the proper cleaning of utensils and equipment, insect and rodent control, food storage and handling, and other procedures were concerned. Aboard ship, however, there was more gross overburdening of facilities and personnel. Messes had to function almost continuously without necessary intervals for cleaning utensils, equipment, and the surrounding areas.[38]

PERSONS IN TRANSIT

This subject has been given a wider coverage than a discussion of preventive medicine for only military personnel in transit since many other categories in addition to troops were involved. These included mass migration of displaced persons resulting from hostilities; prisoners of war; recovered Allied military prisoners; hospital patients, both our own and those of the enemy; and finally, the return of war brides and families acquired by our troops abroad. That each of these categories of persons presented problems of preventive medicine will be shown here and elsewhere in this history; however, specific contributing factors, or those suspected or alleged, should be first considered.

[36] Notes Taken at Conference of Representatives of the Surgeon's Office, Washington, D. C., and Representatives of the New York Port of Embarkation, at Brooklyn, New York, 19 Nov 42. HD: 337.

[37] Linné, F. B.: Preventive medicine in ports of embarkation and troops in transit. HD: 314.7-2.

[38] For further detail of mess sanitation in connection with troops in transit, see Chapter I.

The shortage of physical facilities was universally acknowledged not only during transit but in stationary locations. Oftentimes, there were not enough toilet facilities; there were shortages of water; due to overcrowding, there was insufficient ventilation and lighting; satisfactory cooking equipment was lacking, as well as the space and the utensils for feeding; lack of berthing accommodations necessitated "around the clock" sleeping in shifts; and there was exposure to the elements due to insufficient shelter.

Over and above the shortage of physical facilities are factors known to or believed to be contributory to morbidity when people or animals are in movement. Outstanding among these is sickness due to motion and for this, no satisfactory preventive drug was developed during the war. The disturbance of their equilibrium aboard ship incapacitated many troops for temporary periods with the resulting overtaxing of the sanitary facilities and the creation of an insanitary environment. One of the unusual oddities recorded in this respect applied to birds rather than persons and was recorded in the report of a voyage of a medical section of a port headquarters en route from Australia to New Guinea: [39]

> We left Townsville 11 p. m., 1 September 1943, and arrived in Oro Bay at 2 p. m., 9 September 1943. Here, all our supplies and equipment were unloaded, including 500 white leghorn chickens which, by the way, did not lay one single egg during the trip, but setting them ashore, began laying 15 to 17 dozen daily.

The weather has been long suspected of influencing morbidity; however, there is insufficient data to support many of these allegations. After the war, the liner *Queen Mary* docked at Southampton, England, with 100 persons who suffered stomach upsets during the voyage from New York.[40] A Cunard Line official said tests showed the drinking water aboard to be pure. The medical officer attributed the ailment to a sudden change of humidity as the liner went through the Gulf Stream. While this particular case is not applicable to troops, it illustrates a tendency to incriminate such environmental factors as weather without having complete epidemiologic data in support. Troops in transit in the tropics and in cold climates were subjected to extremes of weather; however, by observance of the rules of hygiene and, where required, wearing the proper type of clothing, the morbidity rates due to weather were far less significant than those due to plant or animal causative agents.

With troops in transit, it is believed that the greatest hazards and the highest incidences of disease were those caused by common respiratory infections and diarrheal diseases. Considerable trouble was experienced in the European theater during 1942 with the high incidence of upper respiratory infections acquired on the voyage from the United States. This topic is dealt with in

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[39] Ltr, Surg 23d Port Hq to Surg Hq USASOS SWPA, 1 Oct 43, sub: Information report of activities. HD: 720 POE (Troops in Transit).

[40] New York *Herald Tribune*, 14 Jul 53.

detail in another volume of this series in a chapter entitled "Common Respiratory Disease," by Dr. Philip E. Sartwell.

There was a high incidence of diarrheal diseases on board transports bound for the European theater during the early part of the war. Col. John E. Gordon, MC, Chief, Division of Preventive Medicine, European Theater of Operations, has reported [41] that the conditions on troop transports favored such epidemics. Crowding was always great and reached extreme proportions during the autumn of 1943 and the early part of 1944, when troop strength was being built up rapidly for the coming operations in France. Messing facilities were almost always inadequate for the number of men carried. Field-trained troops often found difficulty in accommodating themselves to the discipline and restriction of a ship. Transport commanders and transport surgeons were frequently inexperienced and it was, furthermore, not at all uncommon for a medical officer to be assigned this responsibility with little or no previous notice and with meager instructions as to his duties. Latrine and ablution facilities often left much to be desired. Overcrowding not only increased the opportunities for contact infection, but required messes to function almost continuously without proper intervals for policing.

The specific agent in these outbreaks was in no instance determined because of the absence of laboratories aboard ships capable of dealing with epidemics of the size that occurred. At least one outbreak was suggestive of bacillary dysentery; but the clinical course and the fact that only a single death occurred among thousands of cases suggested that most infections were of the type of common diarrhea. The first major epidemic of intestinal infection involved the *USAT Argentina* which arrived at Glasgow, Scotland, on 4 September 1943. In fact, this was the largest single outbreak of diarrheal disease in the history of the European theater.

The *Argentina* had sailed from New York shortly after the middle of August with 6,153 troops aboard, together with the usual complement of officers and ship's company, and the naval guncrew. The ship was grossly overcrowded. Only 3 medical officers were included in the troop movement. Sleeping accommodations were such that soldiers slept in shifts and, since the shifts were rotated, the 3 messes were further overloaded by the succession of meals. The inherent potentialities for an outbreak of intestinal disease were early recognized by the transport surgeon. In his first report to the transport commander, he described the inadequacies in bathing and toilet facilities; the multiple sanitary deficiencies in galleys, pantries, and the troop mess; and the lack of proper facilities for washing and sterilizing mess equipment.

During the night of 29 August 1943, some 400 patients were treated for acute diarrhea at the ship's hospital and dispensary. Three subsequent waves of infection occurred during the course of the next week and the number of

[41] Material concerning outbreaks of diarrhea on board transports is based on, Gordon, J. E.: History of preventive medicine in the European Theater of Operations. HD: 314.7-2.

patients approximated 3,000. The epidemic involved enlisted passengers, officer passengers, and the permanent personnel of the ship. In addition to the estimated 3,000 patients who reported for treatment, many more soldiers were known to have mild infections. The attack rate was estimated to have been well in excess of half the ship's population. One soldier died of acute intestinal infection. The specific infectious agent involved in the epidemic was never determined. Bacteriologic examination of stools from some of the more seriously ill patients, who were removed to hospitals after the ship docked, failed to demonstrate any of the pathogenic bacteria commonly involved in such epidemics.

The port physician, reporting his observations made on boarding the ship shortly after arrival, had this to say: [42]

> The first impression was of gross overcrowding; the second, of filth and dirt everywhere. A long queue of soldiers waited outside the door of the dispensary, some so weak they had to sit or lie on the deck. The epidemic of dysentery had begun four days out of New York. All galleys, including that of the Navy gun crew and the civilian crew were in a deplorable state of sanitation. The main troop galley was the worst of the lot. The supposedly clean kitchen utensils had dirt, grease, and decaying food stuck to them. The stoves and tables were very dirty with old burnt grease and decayed food particles. The garbage disposal was extremely unsanitary. Garbage cans were coated with decaying organic matter and had not been washed for a long time. They were piled helter-skelter in a corner of the kitchen and their contents were spilled all over the deck. The troops were messing in the main mess hall. Half-eaten food was thrown over the tables and floor. In fact, the floor was so covered with waste food that one had to be careful not to slip and fall. The garbage cans just outside the main mess hall were the most nauseating scene I have seen on board a ship. Half a dozen soldiers were standing in garbage two to three inches deep around five or six garbage cans filled to overflowing with uneaten food. Sterilization and washing of trays was unsatisfactory. There was not enough soap in the water and the water was not hot enough to really clean the trays in the very brief period that they were immersed. Inspection of the rest of the ship—troop quarters, decks, and latrines—revealed conditions just as unsanitary as in the kitchens. The troop quarters reeked with vomitus and diarrheal fecal matter from those who were ill and could not find a place in the latrines to relieve themselves. The latrines themselves were beyond description. I can truly say that I have never seen a United States Transport in such deplorable sanitary condition.

The *Argentina* epidemic was by no means an isolated experience during the month of September 1943. There were four serious outbreaks of diarrhea in that month. The *USAT Shawnee* arrived at Bristol, England, 15 September 1943 with the report of an outbreak of 362 cases of diarrhea. The epidemic had first become manifest on 9 September 1943. It lasted 2 days, and had completely subsided by the time the ship docked. This transport carried 1,843 military personnel. The history of the outbreak was particularly significant, and the control measures that were put into effect gave evidence of good epidemiologic sense. An investigation by the transport surgeon showed

[42] Ibid.

that the cooks, bakers, and butchers of the permanent ship's personnel ate their food in the galley and had remained unaffected throughout the voyage. This led to the conclusion that the food was contaminated somewhere between the galley and the messroom. An inspection showed no evident contamination of food. It developed, however, that the kitchen police of the 2190–S Task Force had been relieved by men of the 2190–K Task Force on 9 September 1943. No diarrhea had been reported up to that time. The epidemic began on the 10th of September, the day after 2190–K took over. It was thereby deduced that a bacterial carrier probably existed among the personnel of that detachment of kitchen police. Clinical histories and physical examinations directed suspicion to three members as having had diarrheal disturbances. The whole of the kitchen police of 2190–K were relieved of duty, the old detail of 2190–S was put back to work, and no further difficulties occurred during the remainder of the voyage.

A third major outbreak, on board the *USAT Cristobal*, was considered to have resulted from the fact that only 200 compartment steel trays were available to serve approximately 3,000 troops, while the rate of feeding was from 700 to 900 per hour. Facilities for proper washing and sterilizing trays were unsatisfactory.

The fourth outbreak in September involved the transport *Capetown Castle*. An epidemic of 170 cases of diarrhea developed the third day out, with 20 cases reported the following day. The epidemic was thought to result from an inadequate system for washing messgear. The outbreak was brought under control when chlorine was added to the final rinse water.

This grouping of epidemics within a period of a few weeks served to center attention on the need for added precautions if freedom from epidemics of common diarrhea was to be insured on board transports. The military situation happily permitted a lesser degree of crowding. Measures were instituted at ports of embarkation to remedy the specific deficiencies brought out by these experiences, with the result that no serious difficulties were encountered throughout the rest of the year. The continued survey of health reports of transports showed only 8 instances of excess incidence of diarrhea to have occurred in the course of 378 overseas troop movements to the theater from 1 January to 10 June 1944. Only 3 were of any moment and none was of outstanding seriousness until the eastward voyage of the *HMT Nieuw Amsterdam* in early June. The aid of authorities in the Zone of Interior was again sought. The approaching summer season made repetition of such occurrences more likely, and the existing military situation required more than ever that troops arriving in the theater be in a good state of health and morale.

Only one serious epidemic of common diarrhea on board a transport was noted thereafter. The *SS Mariposa* brought 9,326 troops into Liverpool, England, on 13 August 1944. Diarrhea had broken out among the men on the second day of the voyage. The total number of persons involved was in

excess of 2,000, excluding those who failed to report at sick call. Clinically, the illness was not severe, although 200 or more patients were still under treatment several days after arrival at their station in Great Britain. The ship was greatly overcrowded and messing facilities were taxed beyond the limit of their capacity.

By contrast with the epidemics aboard ship which involved many persons, it is of interest to note that there was but one case of psittacosis recorded among United States Army personnel during World War II and that it occurred aboard a transport. The case, reported by Dr. J. E. Smadel in another volume in this series, involved a transport commander and resulted in death. In the epidemiologic studies that followed, it could not be established that the ship had ever been used to transport birds nor was it known that the individual had bird contact although it was common practice for members of the crew to bring home canaries and other birds for pets. The transport in question was the *John Sykes* and the relevant voyage was out of New York City, 20 December 1943, with arrival in San Francisco on 15 February 1944.

TROOPS IN STAGING AREAS

Staging of troops was accomplished under varying conditions and for various purposes insofar as their ultimate disposition or destination was concerned. From his final training camp in the United States the soldier was transported, usually by rail, to his first staging area near a port of embarkation. (See Fig. 25.) Examples of these were Camp Kilmer, New Jersey (one of several serving the New York Port of Embarkation); Camp Stoneman, California (serving the San Francisco Port of Embarkation); and Fort Lawton, Washington (serving the Seattle Port of Embarkation). En route to these and other similar camps by train, because of military needs, troops were sometimes subjected to the discomforts of overcrowding, difficulty in getting rest, insufficient water for normal needs, and a change in the type of food normally served to them. As stated by Linné:[43]

> Soldiers being transported long distances on trains failed to drink sufficient water and obtain sufficient exercise to keep them feeling well. This was most commonly found in recruits, who, as a result, were half sick on arrival at their destination.

Upon arrival at the Zone of Interior staging area, troops were quartered in barracks in which double bunking usually had to be employed. Here they were given medical examinations to insure that, insofar as possible, each soldier was physically and mentally fit for combat on arrival overseas. Immunizations not previously given were carried out in accordance with current War Department instruction (or completed as far as time permitted) and the soldier was given further instruction to prepare him for his voyage aboard the crowded trans-

[43] See footnote 37, p. 350.



Figure 25. Troops eat "K" rations in a freight car before pulling out for assembly area for redeployment, France, 1945

ports. Generally speaking, the problems in preventive medicine in these staging areas were much the same as those encountered in the cantonment-type camps.

En route to their next staging area (overseas), troops were subjected to the conditions aboard ship previously described herein. Here their environment, and their well-being, from the medical viewpoint, was under the charge of the transport surgeon who was a member of the staff of the transport commander and, in addition, was the commanding officer of the hospital medical detachment aboard ship. In order to bring about improvements affecting troop welfare, the transport surgeon was required to make daily sanitary inspections of the ship (oftentimes using transient Medical Department personnel as assistants) which included the following:[a] the quantity and quality of the water supply; the quantity, quality, variety, cooking, and serving of food; ventilation of berth decks, including staterooms, hospital, and quarters of the crew; cleanliness and adequacy of bedding and clothing; presence of vermin; condition of refrigeration and storerooms; and the presence of communicable diseases and of infestation with animal parasites. In addition to these duties, the transport surgeon was responsible for the administration of additional immunizations required by troops or the crew; for the examination of food handlers; and the observance of quarantine regulations at home and at foreign ports. These, with other duties,

[a] See footnote 33, p. 346.

made him an outstanding competitor for the rating of the busiest man aboard ship.

During the buildup for the invasion of the European and North African continents, the British Isles had to be used as a large staging and training area. Troops were debarked in the large ports of England, Scotland, and Northern Ireland and taken by truck or train to their designated locations wherein housing accommodations were of many varieties. The speed of this buildup in the United Kingdom during the summer and early autumn months of 1942 necessitated the waiving of customary standards of accommodation. Troops were housed in hutments, billets, barracks, and tents. Hutments ranged from the double-walled Nissen hut to those fabricated from tarred paper. Vertical-walled huts were widely used and were constructed of bricks, concrete blocks, asbestos, wood, and tarred paper. In general, the huts made satisfactory quarters although overcrowding usually prevailed. Ventilation was always a problem during the long and cold winter nights.

The barracks loaned to the American forces by the British also varied greatly in type and construction. Those of modern design consisted of wooden spider barracks with quarters, washing and latrine facilities, and drying rooms all under one roof. Older barracks which served the peacetime British Army were also employed.

Billets were provided in almost any building having walls and a roof, and included castles, manor houses, theaters, stores, armories, schools, and churches. Some had been severely damaged by bombing and in general, remodeling and repairing were to some extent necessary before they served satisfactorily. Shortage of building materials and the need for shelter often required that these buildings be used before repair work could be done. Nevertheless, most troops of the theater were adequately housed in permanent or semipermanent installations during the first 6 to 8 months of 1943, except for some engineer general service regiments and engineer aviation battalions which were quartered in tents, usually winterized. The great influx of troops during the latter part of 1943 necessitated the extensive use of tented camps during the winter of 1943-44.

There were many problems in the field of preventive medicine during the months troops were quartered in these areas. One outstanding event took place during this period: the American soldiers' first encounter with bucket latrines. The utilization of this type of equipment and the ever-present problem of disposing of its contents led many to the opinion that it was an abomination and was unacceptable for our use. It was a method of disposal foreign to the American soldier and he often ridiculed its use.

Preparatory to the invasion of Normandy, a large number of temporary camps were established near the ports of embarkation. These were known as marshalling areas and were in a sense another type of staging area. Troops entered these areas in the pink of condition and it was imperative that incapacitating effects such as an explosive outbreak of diarrhea not occur. Special

instructions were issued on the subject of sanitation, and teams of specialists from headquarters and base section medical divisions supervised the feeding of these troops both insofar as their diet was concerned and the sanitary aspects of cleaning their messkits. A "rolling-boil" of the water in the GI cans was made obligatory and emphasis was placed on the fact that supervision of this operation was a command responsibility. Individual directions were given on matters concerned with water, waste disposal, the control of respiratory and intestinal diseases, the management of insects and rodents, immunization, and general hygienic requirements. The fact that these troops were in proper condition on D-day was a credit to both command and Medical Department personnel.

STAGING AREAS ON THE EUROPEAN CONTINENT

Camps for Troop Replacements

Staging areas on the Continent were first used to contain troop reinforcements and replacements brought directly from the United States. Here, for the most part, field methods of sanitation were employed and troops were housed in tents. One problem in the field of preventive medicine not heretofore encountered was the high incidence of trenchfoot which occurred during the winter months of 1944–45. The cold, wet environment, the fact that many of the troops had not been properly indoctrinated in the care of the feet, and the inadequacy of the supply of arctic overshoes were all responsible for many casualties from this injury, not only among frontline troops, but in replacement training centers and other staging areas. Directives relative to the indoctrination programs which troops were to be given had been issued many months before, nevertheless, cases continued to occur as late as February 1945. The Surgeon,[45] Channel Base Section, Communications Zone, reported:

> Trench foot became a real problem on the Continent in the winter months of 1944–45. Our Base Section was not exempt from this problem due to the large staging area camp, Lucky Strike, which accommodated newly arrived troops on their way to the front lines. On 3 February 1945, an outbreak of an alarming number of trench foot cases occurred at this camp. A thorough investigation was made by the Preventive Medicine Section and report submitted to the Chief Surgeon. The Chief Surgeon's Office had already initiated an extensive preventive educational program. Insuring command compliance with the program, and the provison of adequate facilities and proper footwear for the troops, virtually eliminated the trench foot problem.

Camps for Displaced Persons and Prisoners of War

The subject of camps for displaced persons and prisoners of war can be epitomized by stating that almost without exception there were too many people for the facilities available. Prisoner of war camps fared well enough

[45] Hist of Med Sec, Channel Base Sec, ComZ ETOUSA, 1 Jan–1 Jul 45. HD: 319.1-2

during the orderly progress of operations in France and in the early days in Germany. The difficulty came with the end of the war, when the number of prisoners overwhelmed existing facilities. As Gordon has written,[46] the debacle was too great for the many services of the Army in the early days of May. German soldiers surrendered by armies, hundreds of thousands within days. One camp, built for 30,000 men, had to take care of 170,000. The enclosures for these prisoners met their name—they were cages and little more. So great were the numbers that scarcely more than a pretext of proper care could be provided. Water supplies were all right as far as they went, but the amount of water available per man was hopelessly small. Messing equipment and messgear were greatly overtaxed. Some cages were so crowded that the men scarcely had room to lie down; prisoners slept in pup tents, improvised shelters, or in the open. The approaching warm weather led to an increase in flies, but never to the extent that would have existed without the aid of DDT spray. The situation was further aggravated in some areas by a series of unprecedented rains which turned the enclosures into a morass and the prisoners into shivering wretches. Dysentery was inevitable.

The provisions that were made for displaced persons were always extemporized. In general, use was made of vacated German installations previously used for troops. Many were former casernes, far from modern, and, almost without exception, tremendously overloaded. The problem was further complicated by the mixed population of men, women, and children. Lack of sufficient military personnel to provide the necessary supervision served to aggravate the situation, because most of the people had been so unaccustomed to proper provisions that pride in environmental surroundings had largely disappeared.

Redeployment Areas

The redeployment of troops from Europe directly to the Pacific theater, indirectly to that area through the Zone of Interior, or to the United States for discharge, brought up many health considerations in respect to transport staging areas and ports of debarkation. After the war ended the construction of tented camps to house transient populations of over 750,000 men in connection with redeployment activities placed an excessive demand on all facilities, especially on the available equipment for field water treatment. Although standard scales provided 5 gallons of potable water per man per day, experience indicated that a minimum of 10 gallons was desirable. The available equipment was insufficient to treat the required quantity of water. Wells were drilled where satisfactory supplies of ground water could be obtained at a reasonable depth, and treatment plants for surface waters were installed where equipment was available. Coagulant was added to the water, mixed, and settled in tanks having a detention time of from 1 to 2 hours. The treated

[46] See footnote 41, p. 352.

water was passed through pressure filters at a rate of 3 gallons per square foot per minute and chlorinated.

TRANSPORTATION OF FEMALE DEPENDENTS AND INFANTS TO AND FROM OVERSEAS COMMANDS

With the advent of V–E and V–J Days, the initial effort was concentrated on the return to the Zone of Interior of combat troops and their supporting personnel. Priority of passage to the United States was based on a point system and in order to meet the requirements, vessels were again loaded to their capacities and speed of action in respect to travel time was given top priority. By the reconversion of hospital ships to troop transports, by utilizing practically every available "bottom" and reducing the "turn around" time in port, phenomenal results were obtained.

Beginning in 1946, another problem facing the command, more specifically the Transportation Corps and the Medical Department, was the movement of the soldiers' dependents. While these movements were simultaneous in both directions, they were of greatest importance in the European theater where the greater numbers of war brides and infants awaited transportation to the United States. Again, delay could not be countenanced and vessels already described as deficient in many respects for troop transports, had to be used for dependents without major reconversions.

Transportation of war brides was made with a minimum number of complaints on their part. In many instances, under trying circumstances, they were good passengers and, as was to be expected, their morale was high on coming to a new country to make their home. However, in the spring of 1946, at which time this program was at its height, there occurred explosive outbreaks of infant diarrhea aboard transports during which a number of infants died aboard ship or at staging areas such as Fort Hamilton, New York, subsequent to debarkation. The worst of these outbreaks was one occurring aboard the *USAT Zebulon Vance* which arrived at New York City on 20 May with 3 infants dead and 12 requiring further hospitalization. Other transports likewise were involved although not to the same extent of the *Vance* which by 25 May had a total infant death report of 7.[47] Among others were the *USAT's Brazil*, *Ericcson*, *Goethals*, and *Tyler*. Investigation by New York Port of Embarkation authorities failed to reveal the cause of these infant diarrhea cases and deaths. A résumé of autopsies performed on infants was made by the Commanding Officer, Second Service Command Laboratory which covered 7 cases; namely, from the *USAT Zebulon*, 4; *USAT General Goethals*, 2; *USAT John Ericcson*, 1. A tentative diagnosis of "pneumo-

[47] New York *Times*, 20, 23, 25, 26 May 46.

enteritis acute, possibly virus" was made.[48] The report of the Army Medical Center stated that they had been unable to recover any virus agent from specimens of autopsy material from the *Zebulon Vance* cases.[49] Subsequent reports by the Army Institute of Pathology indicated a number of these cases to be pneumonitis and enteritis, probably both of viral origin.[50]

In addition to the sanitary inspections made by the port authorities, a complete sanitary inspection was made of the *Zebulon Vance* by a representative of the United States Public Health Service.[51] The findings stated that no evidence of vermin or rat infestation was to be found aboard the vessel, the food handling facilities revealed proper dishwashing and refrigeration facilities, and that after a survey of the drinking water facilities and the statement of the medical officer of the ship that all water used in infant feeding was boiled 20 minutes, drinking water and drinking water facilities were not involved in the explosive outbreak. This and other inspections made by Army authorities failed to disclose that poor sanitation aboard ship was the responsible factor, as had been alleged.

The return of war troops, war brides, and children continued at a high and rapid rate throughout the summer and fall of 1946 with the intensity of infant diarrheal outbreaks somewhat diminishing. During November 1946, The Surgeon General again entered the field of vessel sanitation when, with the concurrence of the Chief of Transportation, Col. Tom F. Whayne, MC, Deputy Chief of the Division of Preventive Medicine, made a study at the New York Port of Embarkation of conditions aboard recently acquired Army transports influencing health, sanitation, and morale. His inspections covered essentially the C–4 and P–2 types of vessels. In his report[52] were summarized many unsatisfactory conditions and defects which included:

1. Accommodations—lack of adequate covering on the floors and walls, troop compartments without portholes and poorly ventilated, crowding of bunks arranged in tiers of 4, latrine facilities poorly located (in 1 instance travel involved going up 4 decks and down 3 before a latrine was reached);
2. Lack of suitable galley and messing facilities;
3. Deficient recreation facilities;
4. Complete absence of automatic chlorinating equipment necessitating injection of the chlorine solution into the ship's tanks through small petcocks by means of a medical syringe;

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[48] Ltr, CO 2d SvC Lab to Dir Army Institute of Pathology, 17 Jun 46, sub: Résumé of autopsies performed on infants. Filed as Exhibit 22 to Report of Board of Officers Investigating Conditions on US Army Transports. TC: 510 (Weed Rpt).

[49] Ltr, Army Med Ctr to CO 1st Army Area Med Lab, 23 Jul 46, sub: Report of virus studies. Filed as Exhibit 26 to report cited in footnote 48.

[50] Ltr, Dir Army Institute of Pathology to Chief Lab Serv, 1st Army Lab, 11 Dec 46, sub: Pathologic reports. Filed as Exhibit 28 to report cited in footnote 48.

[51] Rpt, Sanitary Investigation of the U. S. Army Transport *Zebulon B. Vance*, by J. L. Dermody, USPHS, 24 May 46. Filed as Exhibit 29 to report cited in footnote 48.

[52] Rpt, Col T. F. Whayne, MC, to SG, 21 Nov 46, sub: Study of conditions aboard recently acquired Army transports influencing health, sanitation, and morale. Filed as Exhibit 3 to report cited in footnote 48.

5. Hospital facilities, while adequate in space, needed to be redesigned to provide facilities for the care of infants and children; and

6. The need for laundry facilities, especially for the clothing of infants and children.

It was the conclusion of the inspecting medical officer that actual health hazards existed aboard these ships; that conditions were conducive to the spread of respiratory and diarrheal diseases; and that the three types of ships observed in this inspection, having been designed for the wartime movement of military personnel, were not well adapted to comfortable and satisfactory transport of troops and officers and dependents of military personnel under peacetime conditions without possible prejudice to health and morale. It was recommended that:

1. Immediate reconversion of these ships be carried out, at least to the extent of obviating health hazards and providing essential comforts and convenience for military passengers and their dependents under peacetime conditions.

2. Complete reconversion of these ships be planned and accomplished by stages and as rapidly as possible.

The author was assigned to the New York Port of Embarkation for a period of temporary duty with the specific purpose of determining practical solutions to some of the problems cited in the report. A report made 21 January 1947 made recommendations in connection with these problems, among which was one to the effect that a sanitary engineer be assigned to the New York Port of Embarkation during the period of these reconversions to assist the Transportation Corps and advise them as to the requirements of the Medical Department in respect to vessel sanitation.[53]

Following the submission of these reports and at the instigation of the Chief of Transportation, a board of officers was appointed for the purpose of investigating conditions aboard United States Army transports carrying dependents.[54] Included on the board were a pediatrician and a sanitary engineer. For a period of several weeks, members of this board inspected vessels in the New York Port of Embarkation and took testimony from many of the ship and port personnel. Again, many recommendations were made relative to the improvement of dependent carrying ships and insofar as the control of the spread of infant diarrhea was concerned was a recommended berthing allowance for infants and children aboard USAT's:[55]

1. Infants (6 months to 2 years of age)
   a. 2-berth stateroom
      (1) One family unit consisting of a mother and her infant.

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[53] Rpt, Lt Col R. R. Cleland, PC, to Chief Prev Med Div SGO, 21 Jan 47, sub: Vessel sanitation aboard Army transports with particular reference to reconversion problems. Filed as Exhibit 4 to report cited in footnote 48.

[54] Letter Orders TCADM 334, 11 Feb 47, sub: Board of officers. TC: 510 (Weed Rpt).

[55] Report of Investigation of Conditions Aboard U. S. Army Transports Carrying Dependents, submitted by Board of Officers, 31 Mar 47. TC: 510.

b. 4-berth stateroom.
   (1) One family unit consisting of father, mother, and infant, or father and mother with an infant and one additional child.
   (2) One family unit consisting of a mother, and infant and one or two children.
   (3) Two family units (without fathers) consisting of not more than two mothers with one infant each.

c. 6-berth stateroom
   (1) One family unit only, up to the capacity of the 6 berths.

2. Children (from 2 years to 6 years inclusive)

a. 2-berth stateroom
   (1) A mother with her child.

b. 4-berth stateroom
   (1) One family unit consisting of parents and not more than 2 children or a mother and not more than 3 children.
   (2) Two family units consisting of two mothers having one child each

c. 6- or 8-berth stateroom
   (1) One family unit.
   (2) Two, three or four family units, without fathers, up to the berth capacity.

These recommended berthing allowances for infants and children were used by the authorities in ports of embarkation insofar as practicability would allow. At the same time, the provision of facilities for the care of infants and children aboard ship, in the form of isolation rooms, formulae rooms, nurseries, and laundries, brought about vastly improved conditions. Education of the mothers during the presailing period, preembarkation examination, including the taking of temperatures of all infants and children scheduled to embark, and a general alertness of all ship and port authorities may have been contributing factors to the subsidence of epidemic infant diarrhea aboard ship. While it is acknowledged that the mass movement of war brides gradually diminished over the following 2 years, there were no serious outbreaks of disease aboard United States Army transports until and through the period of late 1949, at which time, by order of the Secretary of Defense, the Military Sea Transport Service was created and the responsibility for seagoing transports became that of the Department of the Navy.

APPENDIX A

Study on Control of Respiratory Disease by Oiling Floors and Bedding

EXTRACT FROM MINUTES OF MEETING, NRC COMMITTEE ON SANITARY ENGINEERING, 4 JUNE 1945

At Fort Bragg, North Carolina, a more careful experiment on the control of respiratory disease by oiling the floors and bedding was conducted in collaboration with the Army Commission on Acute Respiratory Diseases. The observations were made upon recruits admitted to the Field Artillery Replacement Training Center during the winter of 1944–45. Five battalions were selected for study. Recruits for a particular battalion arrived over a period of 7 to 14 days from reception centers in all parts of the country. They received 17 weeks of basic training as a group. When the training cycle was completed the men left the study group and new recruits arrived. Careful record was kept of the approximate strength of each battalion and the flow of men through it. Each battalion consisted of 4 batteries. Each battery was provided with four standard 2-story barracks designed for 63 men, a supply room, and a messhall. Batteries A and C of each battalion received the complete oiling treatment (*floors and blankets*), while alternate batteries B and D remained untreated. During the entire period of study there were 20 batteries under observation, 10 oiled and 10 controls. The air of the oiled barracks constantly yielded from 75 to 90 percent fewer organisms than were obtained from the air of untreated barracks. Cultures from blankets having an oil loading of 2 percent or more oil as dry weight grew out from 90 to 95 percent fewer organisms than did those from unoiled blankets. Of 307 cultures from oiled beds, 8.5 percent were positive for hemolytic streptococci. Of 441 samples from unoiled beds, 36.3 percent yielded similar streptococci. The effect of oiling upon respiratory disease was measured by recording the number of admissions to sick call and the number of admissions to the hospital. The period of observation was divided into two parts. During the first, beginning 22 October and ending 30 December, the incidence of acute respiratory diseases was regarded as being within the usual or endemic limits. During the second period, from 31 December to 17 March, acute respiratory diseases were regarded as being epidemic in incidence. During the endemic period there appeared to be a reduction of between 30 and 40 percent in the cases of acute respiratory disease from the oiled group as compared with the control group. During the epidemic period the reduction was in the neighborhood of 6 to 12 percent. The investigators concluded that from a practical

point of view the results indicated that oiling of floors and bedding had a moderate effect in reducing acute respiratory disease during a period of low endemic incidence. The measures were ineffectual, however, in controlling an epidemic of acute respiratory disease in new recruits. From a theoretical point of view, the results throw light on the mode of sperad of respiratory disease among troops. It would appear that contaminated dust in barracks was a contributing factor in the spread of the endemic illnesses but that this mode of spread was relatively unimportant during the epidemic. There was some evidence to suggest that dust was more important in the spread of hemolytic streptococcus disease than it was in the spread of acute respiratory diseases of unknown etiology.

APPENDIX B

Joint Memorandum Concerning Final Report of the Interdepartmental Quarantine Commission

MEMORANDUM TO THE SURGEONS GENERAL:

In a meeting held on June 27, 1944, at the Office of The Surgeon General of the Army, Assistant Surgeon General R. C. Williams, representative of the Surgeon General of the Public Health Service, Colonel Karl R. Lundeberg, representative of The Surgeon General of the Army, and Commander Van C. Tipton, representative of the Surgeon General of the Navy, considered recommendations submitted by the Interdepartmental Quarantine Commission. These recommendations are divided into four major headings:

I. Immediate coordinate action by the United States Army, Navy and Public Health Service.
II. Immediate action by the Public Health Service.
III. Immediate action by the armed services.
IV. Future action by the United States Public Health Service.

These representatives were in agreement at this meeting as to the desirability of the general objectives of the recommendations of the Interdepartmental Quarantine Commission as indicated below.

(I) *Immediate coordinate action by the United States Army, Navy and Public Health Service.*

1. Certain quarantine procedures relative to the armed services and prisoners of war, including necessary sanitary measures, such as disinfestation of personnel, clothing and conveyance shall be performed in the United States, its territories and possessions, by qualified members of the Army and Navy, in accordance with plans agreed upon with the Public Health Service.

2. Commanding officers shall

a. Take steps necessary on airfields controlled by the Army or Navy to prevent implantation of insects arriving by aircraft from abroad.
b. Enforce current military and other Federal regulations governing the importation of psittacine birds and other animals.
c. Take steps necessary to detect quarantinable diseases among persons (military and civilian) arriving by military conveyance, and to prevent the importation and spread of these diseases.
d. Enforce quarantine procedures with the technical advice of the senior medical officer and the authority of the United States Public

Health Service, and shall designate medical officers to carry out these duties. Under certain circumstances the United States Public Health Service may designate such officers Acting Assistant Surgeons without additional compensation. When this is done, the designation will apply to a superior officer who may specifically delegate the authority to the officer actually carrying out the duties.

3. Designated officers of the Public Health Service shall from time to time visit Army and Navy units where quarantine procedures are performed to confer with responsible officers, to insure uniformity and effectiveness of measures employed, and to act as consultants and advisers.

4. Measures to prevent the introduction of quarantinable diseases by military aircraft arriving at civilian airports may be carried out by officers of the armed services in a manner approved by the Public Health Service when mutually agreed upon by the Army or Navy with the Public Health Service.

5. Reports of quarantine activities by officers of the Army and Navy will be transmitted to the Surgeon General of the United States Public Health Service through the proper military channels and will indicate, subject to security regulations, the number of conveyances inspected, the cases of quarantinable diseases detected, and other pertinent information.

6. Vessels of the Army, Navy and Coast Guard will continue to be exempted from quarantine inspection provided the vessel is from a clean port and carries a commissioned medical officer. Vessels from ports classified by the Public Health Service as having quarantinable diseases present or suspected of being present may also be exempted provided a commissioned medical officer aboard certifies the behavior of the vessel in the infected port precluded the danger of introduction of quarantinable diseases.

7. The Army and Navy shall each designate one qualified medical officer to (See III, Immediate action by the Armed Services, par. I, page 5):

a. Act as liaison officer for quarantine with the United States Public Health Service.

b. Supervise quarantine functions carried out by the respective armed service in the United States, its territories and possessions, and in other areas in which the armed forces may undertake similar responsibilities.

(II) *Immediate Action by the United States Public Health Service.*

1. Foreign Quarantine Circulars Numbers 77 and 71 should be revised in accordance with the preceding principles, and should provide for the use of a simplified Aircraft Quarantine Declaration (see form suggested by the Commission). They should require disinsectization of planes from all dangerous places. Spraying should be permitted just prior to take-off, during flight, or on landing. Proof of the distribution of a prescribed dose of an approved insecticide is all that should be required.

The provision of AAF Reg. 61–3 and BuMed Form Letter Number 28, revised, should be comparable and should be accepted as satisfactory for quarantine and disinsectization in military aerial traffic. Passengers of aircraft should be canvassed at times to determine if the proper procedure has been carried out in the disinsectization of planes, and inspectors should occasionally check on the procedures by riding the route incognito.

2. Consultation should be held with manufacturers of aircraft regarding the screening of openings into spaces of planes outside the cabin, with a view to satisfactorily protecting them against entrance of insects.

3. Periodic surveys of insect breeding about airports of entry should be continued. Searching of planes and identification of recovered insects should be continued by periodic sampling.

4. Study of the effect of airplane flight upon viability and breeding of insects should be undertaken. This may be done in conjunction with the Department of Agriculture, Bureau of Entomology and Plant Quarantine.

5. A notice should be published enumerating those immunizations required of travelers before entry into the United States and other countries, and the advantages offered to entrants if immunized.

6. The traveler, before or on arrival in the United States should complete a form showing the character and dates of his immunizations, and the places of his travel or residence during the preceding 2 weeks. This form may later be replaced by an International Immunization Record and Travel Log (see form suggested by the Commission).

7. Quarantine procedure should be determined by the history of possible exposure, and by immunization records, and with less emphasis on physical inspection and taking of temperature.

8. Maximum use should be made of non-medical personnel for the performance of quarantine in accordance with the principles of the preceding paragraphs. Physicians will be utilized for consultation when necessary.

9. Criteria for detention of persons under observation upon entry in this country should be restated.

10. The remaining quarantine hospitals and detention spaces should be decommissioned as such, and provision made for the care of persons under observation or treatment for quarantinable diseases in Marine, federal, state, county, municipal or private hospitals or facilities.

11. Criteria for surveillance of persons should be restated and a revised method of surveillance should be instituted. If a bond is not required, the system should nevertheless provide a definitive report to the Public Health Service.

12. The American Bill of Health should be discontinued.

13. Foreign Quarantine Division Circular Number 83 should be republished if Bills of Health are required of vessels of the armed services.

14. Radio or signal pratique should be adopted for specified vessels on specific routes arriving in ports of the United States, on the basis of the Marine Quarantine Declaration and with extension as rapidly as carriers meet requirements.

15. Control of insects on surface vessels should be enforced when indicated.

16. Consultation should be held with the State Department in order to promote more frequent and prompt consular reports on health. The possibility of routinely sending these by radio or cable should be discussed.

17. Dissemination of quarantine data to quarantine stations by telegram or teletype should be instituted, reserving the published Public Health Report for confirmation, summary and general distribution.

18. The names of ports and zones considered infected with quarantinable diseases should be published every 3 to 6 months. These areas should be restricted as much as possible in the light of information available.

19. Consideration should be given by the Panama Canal Company to the substitution of rat inspection, along with fumigation if a sufficient number of rats are found, for the routine requirements that all vessels passing through the canal be fumigated unless possessing a deratization certificate valid within 6 months.

Many of the above suggestions will be provided in the revisions of the United States Public Health Service regulations offered by the Interdepartmental Quarantine Commission in Part III of its Final Report:

(III) *Immediate Action by the Armed Services:*

1. Each service should designate an officer to effect liaison with the Public Health Service with duties as follows:

   a. These officers together with an officer of the Public Health Service, should be authorized to consider inter-service relations and to keep their respective services informed on matters of quarantine.

   b. Establishment and supervision of quarantine functions within the respective armed forces, including the instruction of military personnel performing quarantine duties, the preparation of directives and forms, the collection of pertinent reports, and the inspection of operations and installations concerned with these functions.

   c. Integration of quarantine procedures of the armed services with quarantine procedures of foreign countries and areas beyond the domain of the United States Public Health Service.

2. AAF Reg. 61–3 and BuMed Form Letter Number 28 should be revised in a manner acceptable to the three services.

3. Quarantine regulations and directive should be applied to all military planes, rather than primarily to those of the transportation commands.

4. Directives clarifying the transportation of pets and animals by military aircraft should be published.

5. Comprehensive and prompt distribution of epidemiological data to military quarantine officers should be undertaken.

6. Proper military regulations and directives should be promulgated to give effect to these recommendations, and consideration should be given to revisions in military regulations and directives to be suggested by the Interdepartmental Quarantine Commission in its final report.

7. Education of ground, flight and passenger personnel should be instituted regarding requirements and methods of quarantine and disinsectization in international flights.

(IV) *Future action by the United States Public Health Service.*

1. An international conference should be proposed to consider uniformity of quarantine procedures and adoption of

a. A regional system such as that called the "Singapore system," with a special code, for international exchange of epidemiological data.

b. A method of emergency dissemination of health information utilizing existing airways communications systems.

c. An international Travel Log and Immunization Record.

d. The eventual establishment of international sanitary and health observers and reporters.

2. Routine consular health reports should be abandoned after establishment of the "Singapore system." This should not eliminate emergency reports of epidemiological data by consuls.

3. The use of radio pratique should be extended.

4. International agreement should be reached on privileges to be extended to rat-proofed vessels.

5. International agreement should be reached on maximal and minimal standards of sanitation in marine and aerial ports.

6. Practice, including disinsectization, should be aimed at accomplishing as much of the quarantine procedure as is practicable before departure of the conveyance.

/s/R. C. Williams
R. C. WILLIAMS
Assistant Surgeon General
U. S. Public Health Service

/s/Karl R. Lundeberg
KARL R. LUNDEBERG
Colonel, M. C., Army of
the United States

/s/Van C. Tipton
VAN C. TIPTON
Commander, M. C.–V(S)USNR

APPENDIX C

List of Directives Pertaining to Army Quarantine Program

1. General:

AR 40–225, 21 Nov 44, Foreign quarantine.
WD Cir 453, 1944, Foreign quarantine (amended by sec III, WD Cir 483, 1944).
Ltr WD AGO, file AG 370.5, 10 Aug 44, OB–S–SPMOT–M, 16 Aug 44, sub: Procedure for return of individuals.
WD Readjustment Regulations, RR 1–2, 11 Apr 45.
AAF Reg 61–3, 9 Aug 44, Flying, outside the United States; quarantine (amended by AAF Reg 61–3A, 7 Feb 45).
ATC Memo 25–11, 1945, Foreign quarantine for military aircraft.
ATC Memo 37–4, 1945, Procedure for movement by air of personnel between theaters of operation or to the Zone of Interior.
ASF, TC Cir 80–18, 1945, Quarantine inspection of Army vessels, personnel, and cargo arriving at ports of embarkation (United States), C 1, 25 Jun 45, and C 2, 27 Sep 45.

2. Special:

a. Personnel:
AR 40–210, par 10 f, Immunizations required for international travel.
TB Med 114, 9 Nov 44, Immunizations required in relation to areas of travel or station.
WD Memo W40–7–43, Disinfestation.
AR 615–250, par 5, Physical inspection and certification in travel outside the United States.
WD Cir 198, 1945, rescinding WD Cir 276, 1943, Physical inspection and certification for return to the United States.
AR 55–435, C 1, par 11, 9 Oct 44, Troop inspection. Medical surveillance and physical inspections of troops on transports (Water).
TB Med 180, Jul 45, Medical procedure to be followed at reception stations or other designated facilities for military personnel returning from foreign duty. Implements WD Cir 198, 1945, by prescribing medical examinations to be performed.
TB Med 184, Jul 45, Disinfestation procedures. Pertinent sections of general directives above.

b. Baggage:
WD AGO, Ltr 524, 13 Aug 45, OB–S–D–M, 23 Aug 45, Processing of baggage.
Pertinent sections of general directives above.

c. Mail:
WD Cir 398, 1945, sec II, Plant materials and insects.
Pertinent sections of general directives above.

d. Animals, Plants, Animal or Plant Products:
WD Cir 453, 1945, secs VI, VII, VIII; lists of items prohibited or restricted.
WD Cir 43, 1945, sec IV, for importation into the U. S. in exception to above.
AR 55–485, C 2, pars 30 and 31, 7 Jan 44, Transportation of animals on transports. Restrictions on transportation of pets, mascots, and psittacine birds on Army transports or vessels wholly allocated to the War Department.
WD Cir 386, 1945, extension of USPHS permit in WD Cir 43, 1945.

e. Conveyances:
Pertinent sections of general directives above.

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