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A STUDY OF MEDICAL MAINTENANCE AT SAN ANTONIO STATE HOSPITAL, SAN ANTONIO, TEXAS

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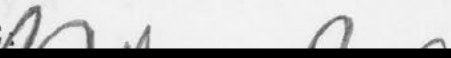
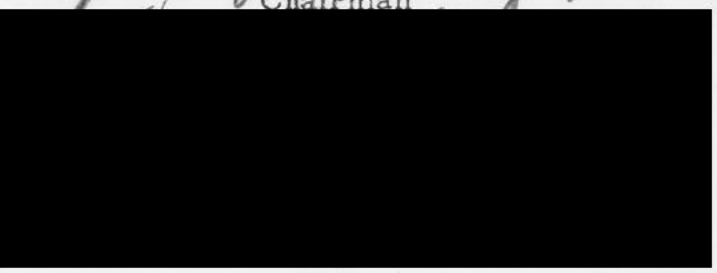
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A STUDY OF MEDICAL MAINTENANCE AT
APPROVED BY THE U.S. ARMY MEDICAL FIELD SERVICE SCHOOL:
SAN ANTONIO, TEXAS


Director of the Program

A Problem Solving Thesis
Submitted to the Faculty
APPROVED BY THE THESIS COMMITTEE: 
Baylor 
In Partial 
Requirements
Master of

APPROVED BY THE GRADUATE COUNCIL:


DATE: August, 1971

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Historically, the maintenance of medical equipment has been treated differently from that of other types of equipment found in the hospital. Medical equipment repair is an extremely sophisticated area, and highly specialized personnel are normally required to work in this area. Consequently, medical maintenance has often been ignored by the general type maintenance personnel, and many hospitals have failed to obtain properly trained personnel for medical equipment repair.⁶

Administrators are now realizing, however, that the maintenance of medical equipment is an area that cannot be ignored any longer. This realization has resulted from rising costs, the increased volume and

CHAPTER I

INTRODUCTION

General Information

There has literally been an "onrush" of electronic and other types of medical equipment into the hospital in recent years.¹ The medical equipment industry is currently experiencing annual sales of one billion dollars, and this is expanding up to 20 per cent per year.² With this expansion are reports of defective equipment,³ shortages of qualified operators, and a great need for bio-medical engineers⁴ and medical equipment repairmen.⁵

Historically, the maintenance of medical equipment has been treated differently from that of other types of equipment found in the hospital. Medical equipment repair is an extremely sophisticated area, and highly specialized personnel are normally required to work in this area. Consequently, medical maintenance has often been ignored by the general type maintenance personnel, and many hospitals have failed to obtain properly trained personnel for medical equipment repair.⁶

Administrators are now realizing, however, that the maintenance of medical equipment is an area that cannot be ignored any longer. This realization has resulted from rising costs, the increased volume and

complexity of medical equipment in the hospital, and, unfortunately, the increased possibility of law suits against the hospital resulting from accidents caused by faulty medical equipment.

Until recently all state operated institutions within Texas were exempt from prosecution for accidents or damages resulting within their facilities. However, the state legislature passed a state tort claims act that went into effect in 1969. This act will allow any party with a legal interest to sue and, if successful, collect for damages resulting from negligence in a state owned institution.

To discuss medical equipment repair within San Antonio State Hospital, one must first examine the physical facilities and the services provided to its patients.

Hospital Setting and History

San Antonio State Hospital is located on a 535 acre tract in the southern part of the city of San Antonio, Texas. The hospital serves an area populated by approximately 2,000,000 inhabitants covering forty-three counties. The hospital consists of thirty-two wards with an average patient load of approximately 2,000. This is a reduction from over 3,000 patients in 1958. The rated capacity of the hospital is 2,400 beds.

The hospital is staffed by approximately 564 physicians, psychiatrists, psychologists, nurses, and attendants. San Antonio State Hospital is a mental hospital with the primary mission of providing

psychiatric care to its patients. However, complete clinical facilities such as dentistry, dermatology, E.N.T., internal medicine, neuro-surgery, neurology, gynecology, obstetrics, ophthalmology, oral surgery, orthopedics, pathology, psychiatry, surgery, thoracic surgery, urology, and inhalation therapy are available as required within the hospital. Local professional services are utilized under contract arrangements when needed to provide these services.

There are seventy-four buildings on the hospital grounds with the hospital physically housed in thirty-three of these buildings. In addition six ward buildings and a new cafeteria are under construction. Eventually, 1,000 beds will be relocated from existing buildings to the new wards. A new \$400,000 administration building is programmed for fiscal year 1971.

Initial construction on the hospital was begun in 1892. Several of the buildings constructed in that year are still in use as administrative and patient treatment areas. The hospital operates its own power plant, warehouse, laundry, supply, maintenance shop, and motor pool. Many employees of the hospital live in hospital owned cottages located on the grounds.

Conditions Which Prompted the Study

The study was implemented for the following reasons:

1. The business manager of the hospital wanted to know: (a) the adequacy of the medical maintenance at present, (b) the cost of the

present system for the repair of medical equipment, and (c) the possibility of establishing a new system that would provide a cost savings, improve the quality of the maintenance of medical equipment, or both.

2. The superintendent of the hospital felt that the repair of medical equipment was important in the daily operation of the hospital, and the best system for the funds spent should be the one used. The superintendent realized that, historically, funds for new medical equipment have been difficult to obtain; this situation has increased the importance of a properly executed medical maintenance program.

Statement of the Problem

The problem is to determine the best method of performing maintenance on medical equipment at the San Antonio State Hospital, San Antonio, Texas.

Objectives

The objectives of the study are:

1. To study the present method of providing medical maintenance service to the hospital.
2. To propose alternative methods for providing medical maintenance.
3. To evaluate the advantages and disadvantages of the present system of medical maintenance and any proposed methods, and analyze all to determine the best method.

4. To recommend a solution to the problem as it exists at San Antonio State Hospital.

Criteria

Any proposed solution to the problem should:

1. At the minimum equal the quality of maintenance service being performed in the hospital at present.
2. Not exceed present costs unless a significant improvement in maintenance would result.

Limitations

To establish a personnel position of a medical equipment repairman in the maintenance department and remain within the operating budget, a currently filled position would have to be deleted.

Assumption

It is assumed that the mission of the San Antonio State Hospital will not change significantly in the next five years.

Definitions

The following words or phrases will be used as defined for the purposes of this paper:

In-House Maintenance Service is that maintenance service performed by members of the maintenance department of the hospital.

Maintenance is "all action taken to retain material in a serviceable condition or to restore it to serviceability. It includes inspecting,

testing, servicing, classifying, reporting, rebuilding, and reclaiming."7

Medical Equipment is that equipment peculiar to a medical institution used in the diagnosis, treatment, and routine care of a patient.

A Medical Equipment Repairman is one who performs maintenance on medical equipment.

Medical Maintenance is that maintenance limited to medical equipment.

Outside Maintenance Service is that maintenance service performed by individuals who are not organic to the hospital.

Preventive Maintenance (PM) is the care and servicing of equipment and facilities by providing for systematic inspection, detection, and correction of incipient failures before they occur or before they develop into major defects.⁸

Research Methodology

The initial step was to gain a working knowledge of hospital maintenance systems with emphasis being placed on the aspects of the maintenance of medical equipment.

A one-week visit was made to the San Antonio State Hospital in February, 1970. During this week, interviews were held; and a study of the existing system of the maintenance of medical equipment was conducted. Interviews were held with the following people:

1. Business Manager--to obtain the reasons or conditions which prompted the study and obtain background information on the setting

and history of the hospital.

2. Director of the Medical-Surgical Unit--to determine the scope of the medical-surgical operation of the hospital.

3. Chief Nurse, Medical-Surgical Unit--to determine the adequacy of current medical maintenance support.

4. Plant Engineer--to determine the scope of the maintenance department and the existing system of hospital maintenance functions.

5. Work Order Supervisor--to obtain a working knowledge of the medical equipment repair system and to determine what historical data was available.

6. Purchasing Officer--to determine the procedures for the local purchase of services and to determine what historical data was available.

7. Chiefs of Ancillary Services--to obtain the opinions of ancillary service personnel in regard to the existing system of medical maintenance.

8. Chief Nurses of East, South, and Central Units--to gain further knowledge of the views of nursing service regarding adequacy of maintenance service and to determine if the wards had any special problems in regard to the repair of medical equipment.

9. Personnel Director--to obtain a knowledge of the State of Texas system of job classification, to obtain salary levels for each job classification, and to obtain information in regard to establishing new personnel positions.

A second, two-week visit was made to the hospital in April, 1970. During this visit a study was made of all purchases of outside maintenance services for the medical equipment of the hospital over a period of thirty-one months between September 1, 1967, and March 31, 1970. A similar study was made of the man-hours spent and the dollar amount of repair materials used for all maintenance performed by in-house maintenance personnel for thirty-one months between September 1, 1967, and March 31, 1970.

Five hospitals in the San Antonio area were contacted to determine salaries paid to medical equipment repairmen. This information was used to determine a local wage level for medical equipment repairmen.

Three medical equipment repair firms in San Antonio were contacted in regard to contract services for individual items and/or groups of items of medical equipment. This information was used to determine the feasibility of contract maintenance services for the hospital.

Finally, a questionnaire was given to the chiefs of each ancillary service, the nurse supervisor of each ward, and the chief nurse of central supply. This questionnaire was designed to provide qualitative data on the existing system of medical equipment repair expressed in terms of customer satisfaction, timeliness of service, and emphasis on user maintenance.

The above information gathered was compared against three previously proposed alternatives. From this comparison, conclusions were

drawn and recommendations were made.

Literature Review

Introduction

Since 1963 more than 676 deaths and over 10,000 injuries resulting from medical devices have been reported in the United States. Forty-seven of the deaths resulted from faulty anesthesia machines alone, and over 2,000 injuries are associated with radiation equipment. Naturally, not all of these accidents are the result of medical equipment, and a large, but unknown, percentage can be directly attributed to use of poor technique by the operator.⁹ However, one method of possibly reducing these deaths and injuries is to implement an effective, productive system of maintenance of medical equipment in all medical care institutions.

To establish this effective, productive system of maintenance it is necessary to outline goals or objectives for the system. At a minimum the objectives of any maintenance program should include:

(1) minimum downtime and, thus, minimum lost production time of all equipment in the organization; (2) optimum utilization of personnel, equipment, tools, and materials involved in the performance of maintenance; and (3) achievement of better control by management of the quality of service performed, hours expended by personnel, and costs of materials used in the maintenance system.¹⁰

In examining any maintenance system the costs of the system should be analyzed. One author estimates that most organizations could reduce their present maintenance cost by one-third, or possibly

even more, and still increase the level of output per person in the maintenance division. Incorporated in this one-third savings on total maintenance costs is an estimated 40 per cent savings through proper utilization of personnel alone.¹¹ Other obvious savings could result from better use of materials.

There are several types of maintenance systems traditionally found in hospitals, each system having good and bad points often determined by the size of the institution, its locality, and the type of hospital it is by ownership.

In-house maintenance

A system used in many hospitals for the performance of medical maintenance is that of an in-house medical maintenance section. An in-house maintenance section should, at a minimum, include the performance of maintenance on most electrical, mechanical, and optical medical equipment within the hospital. Professional services or departments that should be serviced by the maintenance section should be the laboratory, X-ray, intensive care, surgery, electroencephalograph and electrocardiograph, pulmonary function, and others such as E.N.T.¹²

Often one of the main problems with in-house maintenance sections is in locating the proper personnel for staffing the section. In most geographical areas with the salaries paid by hospitals it is difficult to attract competent, qualified medical equipment repairmen. If, however, the staffing problem can be overcome, the following advantages can be

realized: (1) continuous maintenance service is provided which results in less downtime of equipment; (2) in-house maintenance staff can provide invaluable information on the performance levels of various items of equipment under consideration for purchase; (3) full-time repairmen free professional personnel from having to attempt to calibrate and repair equipment that should be maintained by qualified technicians; and (4) personnel are readily available to assist users in the proper operation of equipment. All of the above contribute to the ultimate objective of the hospital--to enhance good patient care.¹³

Contract service

Another system of maintenance used in hospitals is that of contract maintenance service for either all, or part of, the total maintenance requirement of the hospital. In 1969 it was estimated that 3 per cent of the hospitals in the United States were using contract service for all maintenance, and a much higher percentage were using some form of contract service.¹⁴ For example, many of the hospitals in the Veterans Administration hospital system are using contract service for emergency repair and preventive maintenance.¹⁵

There are several conditions that might exist in a hospital that could result in contract service being desired. Some of the conditions are: (1) an absence of qualified personnel or the lack of proper justification for qualified personnel; (2) the lack of adequate space or equipment to support a proper maintenance program; (3) a shortage of experienced managerial personnel; and (4) a management that does not want the

responsibility for maintenance of equipment.¹⁶

When the management of a hospital is considering contract maintenance, the extent of service desired must be determined. There are many types of plans available. The four most common plans are: (1) emergency service with labor and materials charged for each call; (2) scheduled preventive maintenance with repairs made as needed with required materials charged for as used; (3) plan 2, plus emergency service with materials charged for as used, and (4) full coverage of preventive maintenance, emergency, and routine service with all labor and materials covered.¹⁷

Selecting a firm to provide contract service is a most important process. First, the integrity of the firm must be considered. Whether or not the firm will live up to the conditions of the contract and its reliability can be indicated by the integrity and reputation of the management of the firm. The knowledge and skill levels of the firm's employees must be appraised to adequately determine the quality of service to be received. This can be done by examining past performance by the employees. The control of the system is also an important factor. Is the firm selected willing to give to the management of the hospital partial or complete control over the contract personnel? The question of control can be most important, especially with such possibilities as medical emergencies that occur in the hospital environment. Management must retain some control to meet these emergencies in a proper, timely manner. Last, the loyalty of the firm's employees to their employer

should be investigated. Indicators of loyalty are turnover rates and strike records.¹⁸

Traditionally, contract maintenance service has been an expensive method of obtaining required maintenance. In many areas, contract service has not been available to hospitals because contractors, like hospitals, also experience difficulty in obtaining qualified personnel. Experience has also shown that contracts can be unreliable, often with either party able to dissolve the agreement on a one or two month notice or through refusal by the contractor to renew an agreement without a substantial price increase.¹⁹

Preventive maintenance

Any system of medical maintenance being established or analyzed should include preventive maintenance. The American Hospital Association's Preventive Maintenance Guide states: "For both the hospital administrator and the engineer, knowledge of effective preventive maintenance is essential."²⁰ The Guide goes on to list four values of a preventive maintenance program in a hospital. These values or objectives are: "(1) to extend the life of equipment and buildings, (2) to prevent costly breakdowns, (3) to control costs, and (4) to help save lives of patients by guaranteeing that any equipment emergency can be met."²¹

In establishing an in-house preventive maintenance system one of the key factors of success is rigid planning and proper scheduling. Yet the entire system must remain simple and clear or the cooperation

of all personnel involved will be lost. Historically, too much paper work has been emphasized; thus, administrative procedures seemingly become more important than the actual inspecting of equipment.²²

Preventive maintenance when conducted properly should reduce other maintenance costs such as emergency maintenance, and should result in a minimum downtime of equipment. With an effective preventive maintenance program, not only are needed repairs identified and increased reliability of equipment gained, but equipment alignment and adjustments are made in the process.²³

Footnotes

¹Murray Altman, "The Hospital's Electronic Metamorphosis," Hospitals, XLIII (December 1, 1969), 42.

²John E. Abele, "Administration of Medical Electronics," Hospitals, XLIII (December 1, 1969), 53.

³Hans A. Mosel, "Electrical Safety and Our Hospitals," Journal of the Association for the Advancement of Medical Instrumentation, IV (January-February, 1970), 4.

⁴Altman, "Hospital's Electronic Metamorphosis," p. 45.

⁵Harold I. Cohen, "Benefits, Methods of Establishing an Instrumentation Department," Hospital Topics (February, 1970), 36.

⁶Mosel, "Electrical Safety," p. 4.

⁷Headquarters, Department of the Army, Dictionary of United States Army Terms, Army Regulation 310-25 (Washington, D.C.: Government Printing Office, 1969), pp. 258-259.

⁸Ibid., p. 341.

⁹"Medical Devices," Medical World News, April 24, 1970, p. 29.

¹⁰John J. Wilkinson, "How to Manage Maintenance," Harvard Business Review, XLVI (March-April, 1968), 103.

¹¹Ibid., p. 100

¹²Cohen, "An Instrumentation Department, " p. 33.

¹³Ibid., p. 36.

¹⁴Thomas R. O'Donovan, "Contract Service, Some Pros and Cons," Hospital Progress, XLVIII (February, 1969), 82.

¹⁵James O. Wear, "Equipment Maintenance, Repair in VA Hospital System," Hospital Topics (February, 1970), 29.

¹⁶O'Donovan, "Contract Service," p. 71.

¹⁷"How Can Contract Maintenance Help?" Modern Hospital, XLI (December, 1968), 66.

¹⁸O'Donovan, "Contract Service, " p. 72.

¹⁹Marguerita Florentino, "Central Control of Equipment Management," Hospitals, XLIII (September 1, 1969), 115.

²⁰American Hospital Association, Preventive Maintenance Guide (Chicago: American Hospital Association, 1959), p. iii.

²¹Ibid.

²²Walter E. Williams, "The Preventive Maintenance Hurdle," Hospitals, XLIV (January 16, 1970), 75.

²³G.A. Weidemier, "Four Forms and Ten Steps to PM," Hospitals, XLII (August 1, 1968), 76.

CHAPTER II

DISCUSSION

The solution to the problem of determining the best method of the performance of medical maintenance at San Antonio State Hospital was limited to three primary alternatives. It was decided that the final solution would be one of the three alternatives, or possibly a combination of two or more of the alternatives. The three alternatives, as formulated, were: (1) to continue with the present system of using in-house maintenance personnel when possible and outside service as required; (2) to establish an in-house medical maintenance section with a medical equipment repairman employed by the hospital; and (3) to use all contract maintenance service with one or more contracts to cover the maintenance requirements for all medical equipment in the hospital.¹

Existing Medical Maintenance System

To select the best alternative or combination of alternatives, the existing system of medical maintenance had to be analyzed and evaluated. It must be noted that San Antonio State Hospital is primarily involved with the treatment and rehabilitation of mental patients, therefore, requiring minimal use of the medical equipment in the hospital. Most

of the medical equipment available at the hospital is for the treatment and care of the physically sick and not the mentally sick.

The hospital has approximately ninety-five different major line items of medical equipment distributed throughout the ward areas and the medical-surgical center. The more sophisticated items of equipment are generally located in the medical-surgical center where most of the medical diagnosis and treatment by the hospital staff is rendered.

The current system of medical maintenance involves primarily three sections or parties: the user or the individual responsible for the equipment requiring maintenance, the maintenance department, and the purchasing section. Organizationally, the users of medical equipment are generally under the control of the clinical directors of either the central, south, east, or west units (see Appendix A). The maintenance department is under the direction of the plant engineer, and the purchasing section is under the supply division. Both the maintenance department and purchasing section are under the control of the hospital business manager (see Appendix B).

The maintenance department is staffed with the plant engineer, a secretary, record clerk, and work order supervisor. Patients and part-time personnel have been used in the past for various administrative duties such as assisting in maintaining records, but this is no longer being done. The hospital purchasing agent, who heads the purchasing section, has two clerks on his staff for processing all purchases, including any purchases for outside services.

Work orders (Form B-14 in Appendix C) are initiated by the department desiring repairs or service on an item of equipment. Nursing service personnel are required to route work orders through the office of the hospital supervisor to the business manager while other departments send work orders directly to the business manager's office. The work orders are then sent to the work order supervisor in the maintenance department. No editing or approving is done by the business manager before the work orders are sent to the maintenance department.

As work orders arrive in the maintenance department, the work order supervisor divides them into two categories: those identifying problems that can be repaired with in-house personnel, and those identifying problems which require outside maintenance service. On occasion an on-site inspection of the item of equipment is required to determine if the hospital maintenance staff is capable of accomplishing the repair. Normally, however, this can be determined from the information on the work order and the knowledge that the work order supervisor has of the item.

There are certain categories of equipment such as electric typewriters, television sets, and audio equipment for which the hospital has contract maintenance service. If a work order comes in on an item covered by contract service, the contractor is notified and the work order is completed.

Work orders for items that are to be repaired with in-house personnel are used for maintenance scheduling purposes. The work orders

are divided by job category such as electrical, carpentry, or plumbing, and then scheduling is done by each section.

For items that cannot be repaired by the hospital maintenance staff, a Request for Procurement of Non-Warehouse Stock Items (Form B-17 in Appendix D) is prepared by the maintenance department and forwarded to the purchasing section in supply. This request might or might not have a recommended vendor listed by name. Often certain types of purchases automatically go to certain vendors. For example, maintenance service for General Electric X-ray equipment goes to the General Electric Company representative in San Antonio.

If an item of equipment must be removed from the hospital for repair service, hospital maintenance personnel are responsible for moving the item from its usual location in the hospital to the supply warehouse. Here it is picked up by the vendor providing maintenance service. When the item is returned by the vendor after repairs are made, hospital maintenance personnel inspect the item in the supply warehouse to determine if it works properly before it is returned to the user.

At present the maintenance of medical equipment is the same as for any other type equipment with the exception of preventive maintenance. Preventive maintenance on the physical plant and non-medical equipment is performed on a scheduled basis. No formal preventive maintenance program has ever been initiated for medical equipment. The hospital does not have a medical equipment repairman, and no one individual on the maintenance staff specializes in the repair of medical equipment.

Cost analysis of the existing system

To do a cost analysis of the present medical maintenance system, two cost areas had to be examined: the cost of in-house maintenance service, including personnel and the repair parts and materials used by in-house personnel; and the outside maintenance services purchased by the hospital.

To obtain the cost of in-house maintenance service for medical equipment, past work orders had to be examined. A completed work order should contain the number of man-hours required to complete the job and the quantity and cost of any repair parts or materials. Files are maintained on work orders for the current fiscal year and for, at least, two past fiscal years. A fiscal year for the San Antonio State Hospital begins on the first day of September of one calendar year and ends on the last day of August of the next calendar year. Work orders are filed under codes which determine the nature of the item being repaired such as furniture and equipment, plumbing, and preventive maintenance. All work orders submitted on medical equipment are placed in the furniture and equipment (F & E) file.

On examining data of thirty-one months beginning with September 1, 1967, and ending with March 31, 1970 (the last full month of information available at the time of this study), ²it was found that the maintenance department for medical equipment has processed and completed with in-house personnel an average of 11.9 work orders per month, requiring 21.85 man-hours per month and \$20.63 in repair parts and materials

per month. Table 1 depicts the breakdown of the averages per year for approximately two and one-half years. A monthly breakdown is found in Appendix E.³

TABLE 1
IN-HOUSE MAINTENANCE ON MEDICAL EQUIPMENT
SAN ANTONIO STATE HOSPITAL

Period	Monthly Averages		
	Workorders	Man-hours	Repair Parts Cost
Sept. 1, 1967- Mar. 31, 1968	8.43/month ^a	17.00/month ^a	\$ 5.67/month ^a
April 1, 1968- Mar. 31, 1969	13.00/month	26.38/month	14.68/month
April 1, 1969- Mar. 31, 1970	12.92/month	20.17/month	35.30/month
Averages for 31 Month Period	11.93/month	21.85/month	\$ 20.63/month

^aReflects only a seven month data base.

SOURCE: Data collected from San Antonio State Hospital work orders by the writer.

To obtain the cost of outside maintenance service on medical equipment for the San Antonio State Hospital, past invoices to the hospital from vendors were examined. All invoices for major vendors are filed by vendor's name, and invoices for minor vendors are filed in a miscellaneous file. Past records to cover the same thirty-one months used in the analysis of in-house maintenance costs were available.

Outside maintenance service purchases for the repair of medical equipment for thirty-one months beginning September 1, 1967, and ending March 31, 1970, averaged 4.77 work orders per month, with an average monthly cost for labor and repair parts and materials of \$166.30. Table 2 depicts a breakdown of averages per year for approximately two and one-half years. A monthly breakdown is found in Appendix F.³

TABLE 2

OUTSIDE MAINTENANCE SERVICE ON MEDICAL EQUIPMENT
SAN ANTONIO STATE HOSPITAL

Period	Monthly Averages	
	Workorders	Cost of Service
Sept. 1, 1967- Mar. 31, 1968	5.29/month ^a	\$ 132.53/month ^a
Apr. 1, 1968- Mar. 31, 1969	5.50/month	232.20/month ^b
Apr. 1, 1969- Mar. 31, 1970	3.75/month	120.09/month
Averages for 31 Month Period	4.77/month	\$ 166.30/month ^c

^aReflects only a seven month data base.

^bReflects a single expenditure of \$1,235.00 on an X-ray tube. Average for 2nd 12 months without this expenditure is \$129.28 per month.

^cBy using the average expenditure of \$129.28 per month for the 2nd 12 month period (see footnote "b") the average for the 31 month period is \$126.45

SOURCE: Data collected from San Antonio State Hospital invoices by the writer.

It was impossible to distinguish between labor and repair parts and materials for outside maintenance service from records in the purchasing section since the two categories are not listed separately on record copies of the invoices to vendors.

The hospital uses an average man-hour rate for maintenance personnel of \$2.25 per hour for accounting purposes. At the hospital rate, average monthly cost for hospital personnel performing maintenance for the thirty-one month period was \$49.16. Combining the in-house personnel cost with the average monthly cost of repair parts and materials, \$20.63, and the average monthly cost of outside maintenance service, \$166.30, the overall average cost per month for maintenance of medical equipment for San Antonio State Hospital has been \$235.09.

User acceptance of the existing system

To determine how individuals using the medical equipment being maintained through the existing system of medical maintenance felt about the system, a questionnaire (see Appendix G) consisting of eight questions was distributed. Recipients were the following people: supervisors of the central and north units, E.N.T. and gynecology clinics, central supply, laboratory, X-ray (who is also in charge of the electroencephalograph machine), and dental service. Thirteen questionnaires were distributed; all were returned and reviewed.

Individuals receiving the questionnaires were assured that only the consolidated results of the questionnaires would be available to the business manager and superintendent of the hospital. At the suggestion of the

business manager, the name of the individual preparing the questionnaire was not required. A definition of medical equipment similar to that found on page six of this paper was attached to the questionnaire.

The following information was extracted from the returned questionnaires:

1. Ten individuals felt that in their experience with San Antonio State Hospital no patient had ever suffered or been inconvenienced as a result of faulty medical equipment or a failure of an item or items of medical equipment. Three individuals felt that patients had been inconvenienced. Reasons as listed included an excessive repair time for the electroencephalograph machine, the X-ray machine being out of order for two days on one occasion, and obsolete or non-availability of equipment, which in this instance was not a result of the existing maintenance system.

2. In regard to length of waiting time in days for repair service, four people reported a one-day waiting period before an item needing repair was serviceable again. Four people reported a two-day waiting time; two reported a seven-day waiting time; and two reported a twelve- to fourteen-day waiting period. One questionnaire reflected a twenty-day waiting time and one a thirty-day waiting time. One questionnaire reflected two different waiting times, one each for two different areas of responsibility and the equipment in each area.

3. Eleven individuals felt that they had never had to wait what they felt was an excessive length of time for maintenance of medical equipment.

Two people reported that some repairs did require excessive time in the opinion of the individuals answering the questions.

4. All thirteen individuals completing the questionnaires pointed out that no preventive maintenance program for medical equipment had ever been stressed in the hospital.

5. After preventive maintenance was defined, each individual was questioned as to approximately how much time per month was spent in his area performing preventive maintenance. Eight people answered zero hours; one reported one hour; two reported two hours; and two reported eight to sixteen hours.

6. In response to a question as to how the maintenance system could be improved, the following suggestions were submitted by some of the individuals who completed the questionnaire:

a. The maintenance department should establish an equipment float that would provide, whenever possible, a serviceable item of equipment in place of an item turned in for repair.

b. A contract maintenance service should be established for the more sophisticated medical equipment such as that found in the laboratory.

c. A preventive maintenance program should be established for all medical equipment.

d. An in-service training program on the proper use and care of equipment should be established and given to all users of medical equipment.

7. Eleven of the thirteen questionnaires reflected that the individuals in the hospital felt that the present system of medical maintenance was adequate. One individual said that the system was not adequate, and one individual would not give a definite answer.

8. On a four-category rating of the existing system of medical maintenance, excellent, good, fair, and poor, ten individuals said the system was good, and three said the system was fair. No excellent or poor ratings were reported.

Advantages

The existing system of medical maintenance at San Antonio State Hospital has the advantage of being a simple, well-defined system with a minimum of time involved in its administration. The existing method of medical equipment repair is a subsystem of the overall maintenance program of the hospital, and the existing method of operation allows for certain specialists to perform maintenance. For example, painters spot paint equipment; electricians repair cracked or loose electrical cords; and factory-trained X-ray personnel maintain the X-ray equipment. The existing system does not constitute a large portion of any budget as the average annual total dollar expenditure for medical maintenance is only \$2,821 of an annual hospital budget that is in excess of \$6,000,000.

While the present system does not require too much of any one individual's productive time, it does assist in the full utilization of the entire maintenance staff of San Antonio State Hospital. By not depending on a single individual the present system assures that someone is normally

available to perform repairs or an outside repairman may be called in. Also, by utilizing much of the existing maintenance staff, management is in complete control of the existing system. This certainly adds to the dependability of the present system.

Disadvantages

The disadvantage of the present system of medical maintenance is that no preventive maintenance is currently being performed on medical equipment. The existing system, though accepted as adequate by most users of the medical equipment in the hospital, was certainly not felt to be the best system possible by those people. Three of the thirteen users of medical equipment questioned felt that the existing system had allowed patients on occasion to be inconvenienced, and there was a clear indication that maintenance response had been rather slow on some occasions in the past.

In-House Medical Maintenance Section

To determine the feasibility of adding a personnel position or converting an existing personnel position to that of a medical equipment repairman, an estimation of the salary level for this type position had to be made for the San Antonio area. To formulate an estimate for an average annual salary level, Brooke Army Medical Center, Bexar County Hospital, Santa Rosa Medical Center, Methodist Hospital, and Baptist Memorial Hospital were contacted to determine, first, if they employed medical equipment repairmen in a formal personnel position

and, if so, at what annual salary levels. It was found that the average annual salary level for medical equipment repairmen in the San Antonio area at the time of this study was \$7,570. This average salary level was based on the fact that Brooke Army Medical Center had five civilian medical equipment repairmen with an average annual salary of \$7,188, Bexar County Hospital had three medical equipment repairmen with an average annual salary of \$7,500, and Santa Rosa Medical Center had eight medical equipment repairmen with an average annual salary of \$7,834. Baptist Memorial and Methodist Hospitals had no in-house medical equipment repairmen. Individual salaries ranged from a high of \$11,028 at Santa Rosa Medical Center to a low of \$5,355 at Bexar County Hospital. Table 3 depicts the sample hospitals with the number of personnel positions and the salary level of each position.

The position of a medical equipment repairman for San Antonio State Hospital would be listed as a Maintenance Mechanic II under the State of Texas Job Classification Code. A Maintenance Mechanic II is authorized a Salary Group (SG) 08 pay position with a starting annual salary of \$5,808. The determination of a medical equipment repairman fitting into the job description of a Maintenance Mechanic II (see Appendix H)⁴ was made after consulting the plant engineer and the chief of the personnel division and analyzing the job description.

Space for an in-house medical maintenance section is available in the hospital, and tools and equipment on-hand at present, with few exceptions, would suffice for any maintenance service performed on

the medical equipment on the hospital inventory.

TABLE 3

ANNUAL SALARY LEVEL FOR MEDICAL
EQUIPMENT REPAIRMEN IN THE
SAN ANTONIO AREA

Institution	Annual Salary	Number of Employees At Salary Level	Total Salaries
Brooke Army Medical Center	\$ 7,546	1	\$ 7,546
	7,248	2	14,496
	6,950	2	13,900
Bexar County Hospital	9,145	1	9,145
	8,000	1	8,000
	5,355	1	5,355
Santa Rosa Medical Center	11,028	1	11,028
	8,598	2	17,196
	7,590	2	15,180
	6,732	1	6,732
	6,270	2	12,540
Methodist Hospital	_____	None	_____
Baptist Memorial Hospital	_____	None	_____
Total Employees in Sample		16	
Total Annual Salary of all employees in Sample			\$121,118
Average Annual Salary of all employees in Sample			7,570

SOURCE: Sample taken from five institutions in San Antonio area by the writer.

Disadvantages

However, in-house medical maintenance service with a full-time

Advantages

An in-house medical maintenance section would maintain the simplicity of the overall organization of the maintenance department. It would provide a professionally trained medical equipment repairman on a full-time basis for the requirements of the hospital. Also, an in-house medical maintenance section would provide the capability for an excellent preventive maintenance program for the medical equipment in the hospital. Based on historical averages, the maintenance of medical equipment would involve completing the repair of items listed on 16.70 work orders per month, which would require 21.85 man-hours per month. In the past these man-hours have been distributed throughout the maintenance division, plus the time spent on hospital equipment by outside service personnel. With an average work month consisting of twenty-one days with eight hours in each work day, the total of 168 man-hours per month would certainly leave plenty of time available for proper records, work scheduling, and preventive maintenance. *see 16 Emmons*

In-house medical maintenance would offer a rapid response to failures of key items of equipment such as X-ray, electroencephalograph, or electrocardiograph machines. This rapid response would certainly influence the acceptability of an in-house system to the user. Also, by the in-house medical equipment repairman being on the staff of the hospital, control is retained thus increasing the dependability of the system.

Disadvantages

However, in-house medical maintenance service with a full-time

medical equipment^{fulltime} repairman would greatly increase the current cost for medical maintenance. The salary alone for a medical equipment repairman would more than double the cost of the existing program.

Under present conditions there does not seem to be enough work available to require a full-time individual for medical maintenance, even with the addition of a preventive maintenance program for medical equipment. This situation could easily result in expensive projects being established under the pretense of good, effective maintenance for the sole purpose of keeping an employee occupied. Also, 21.85 man-hours per month currently being required of members of the maintenance staff would have to be scheduled into other areas of the overall maintenance operations. A final disadvantage of an in-house medical maintenance section would be that it might be difficult to obtain a medical equipment repairman willing to work for approximately \$1,762 below the average community salary level and have him be the type of individual motivated enough to maintain proper records and carry out an effective preventive maintenance program without close supervision. This salary differential could result in a high turnover in this position.

At the time of this study, the hospital had three Maintenance Mechanic II positions authorized, and all were occupied. It was the opinion of the plant engineer that each of the three positions was critical in accomplishing the mission of the maintenance department and that none could be converted to a medical equipment repairman position. The alternative would be to justify an additional Maintenance Mechanic II position

and obtain funds for this position. This move would certainly be a disadvantage to the alternative of an in-house medical maintenance section.

Contract Service

San Antonio State Hospital has contracts for maintenance service for several categories of nonmedical equipment such as electric typewriters, audio equipment, and television sets. This service, from all indications, has functioned well, and both the users of the equipment and the personnel in the maintenance department and purchasing section seemed very pleased with the contract system. No contract service is being used for medical equipment. Records are maintained by the purchasing section on all equipment service warranties. However, for medical equipment this is minimal since so little new equipment is ever purchased. The warranties are used when they do apply, however.

To determine the feasibility of contract maintenance service for the medical equipment, three San Antonio medical equipment repair firms were contacted. The firms were questioned in regard to comprehensive contract maintenance service to include the maintenance of all medical equipment or partial contract service to include at least enough medical equipment to be economical for the hospital. Two of the firms, the Physicians and Surgeons Supply Company and Hope Medical Supply of Texas, had previously performed much maintenance for the hospital. Both have been in the San Antonio medical supply and equipment repair business for many years and are respected firms in the business community. The third firm contacted, Sinclair Associates, began operations

in the medical equipment repair field in March, 1970.

The Physicians and Surgeons Supply Company, 121 Broadway, San Antonio, Texas, was not interested in any form of contract maintenance service. The policy of the firm is that no contracts are let for maintenance service for any of the hospitals in the San Antonio area. The reasons for this "no contract" policy were that in the past much of the equipment included in maintenance contracts for hospitals was uneconomically repairable, and medical equipment repairmen were too difficult to obtain. Also, with several of the larger hospitals in San Antonio establishing in-house medical maintenance sections, the overall volume of business has dropped to a level that prohibits the covering of required overhead costs such as adequate work areas, office space, specialized equipment, and proper training of personnel.

Hope Medical Supply of Texas, 821 Dallas Street, San Antonio, Texas, was also not interested in a contract for the maintenance of medical equipment with the hospital. Hope Medical Supply did, at the time of this study, have a few maintenance contracts, but these were primarily for equipment sold with a contract for service as a part of the agreement. Hope Medical Supply does not have any comprehensive contracts that cover all medical equipment at any one hospital, nor does it have the capability or the desire to have such contracts.

The third firm contacted was Sinclair Associates, Division of Rothe Developments, Incorporated, 4614 Sinclair Road, San Antonio, Texas. Sinclair Associates is a newly organized medical equipment

repair firm that performs routine, emergency, and preventive maintenance in a forty county area in and around Bexar County. All maintenance services are available on a contract basis with emergency service priced at \$16.00 per hour and scheduled and preventive maintenance priced at \$14.40 per hour.⁵ An estimate of the time required to perform the preventive maintenance service for San Antonio State Hospital could not be made, but on examining an equipment inventory list of the medical equipment of the hospital, the maintenance personnel at Sinclair Associates felt that the firm had the capability to service all equipment on the list.

Sinclair Associates, at the time of this writing, had plans to establish a maintenance float of medical equipment to provide an item of equipment to a customer while the customer's like item was in for repair service. Naturally, this would only be possible for portable equipment. Also, a consultant service was being planned so that hospitals desiring to establish an in-house medical maintenance section could obtain all the necessary guidance and assistance required.

Advantages

Contract maintenance service such as that which is offered by Sinclair Associates would probably be the simplest method by which the hospital would have routine, emergency, and preventive maintenance service by professionally trained personnel available with no increase in personnel authorizations or conversion of a currently filled position to that of medical equipment repairman. Contract service would provide

highly trained personnel to work on the more complicated medical equipment such as that found in the laboratory.

Contract service should provide a rapid response to most maintenance requests thereby resulting in a contract maintenance service being more acceptable to the users of medical equipment. Complete contract service would also free some time now spent by the existing maintenance staff for other duties.

Disadvantages

Exclusive contract maintenance service would, however, cost more than the present system as the only cost figure quoted was \$14.40 to \$16.00 per hour, depending upon the type of service received. A well-planned preventive maintenance program, resulting from contract service, should eventually reduce the routine and emergency maintenance time required on all medical equipment as well as prolong the life of the equipment. However, it would be difficult to initiate a comprehensive maintenance program, including preventive maintenance for a hospital such as the San Antonio State Hospital, and attempt to compete with an average monthly historical cost of \$235.09. This would be true even though the maintenance system on which the historical costs are based did not provide for preventive maintenance for medical equipment. There is also the distinct disadvantage of contracting with an unknown and untried firm such as Sinclair Associates.

Summary

To determine the best method of performing maintenance on medical equipment at the San Antonio State Hospital three primary alternatives were considered. The first alternative, to continue with the existing system of maintenance has the advantages of being a simple, well-defined system, and allows for specialists to perform maintenance. It also assists in the full utilization of the maintenance staff, insures continuity of service, and does not constitute a large portion of the total budget. Hospital management is in complete control of the present system which adds to its dependability.

The present system has the disadvantages of not allowing for preventive maintenance, is not considered by the users of medical equipment in the hospital to be the best system possible, and has at times caused patients to be inconvenienced. Maintenance response has been slow on occasion.

The second alternative, that of establishing an in-house medical maintenance section with a medical equipment repairman employed by the hospital has the advantage of allowing for a simple system with professionally trained personnel. Preventive maintenance service could easily be provided. Rapid response to maintenance needs should be available thus influencing the acceptability of the system to the equipment user. Management would retain complete control of an in-house system.

The disadvantages of this alternative are that costs for medical equipment repair would certainly increase and maintenance staff now

being utilized might not be fully utilized with the addition of a full-time medical equipment repairman. It might also be difficult to obtain a medical equipment repairman at the salary authorized by the Texas state system.

The final alternative, complete contract maintenance service would be a simple system to operate and would provide for emergency and preventive maintenance services. Other advantages are that professionally trained personnel would be utilized and personnel authorizations for the hospital would not have to be converted or increased. A rapid response to maintenance needs would be provided which should make the system more acceptable to equipment users.

The disadvantages of contract service are that a complete contract system would probably cost more than the present system, and any contract let might have to be with an inexperienced and untried firm. Management would also lose some control of a system based on contract

service.

Footnotes

¹The alternative of sending one of the existing maintenance personnel to a comprehensive medical equipment repair school was not considered. The writer was unable to locate any civilian course that offered instruction on all types of medical equipment. The only civilian courses found were those offered by individual medical equipment manufacturers and these were for specific items of equipment. Since no small group of items of medical equipment could be identified as creating the most maintenance costs the alternative of sending existing maintenance personnel to maintenance classes for specific items of equipment was eliminated. On-the-job trained personnel have always been used for all in-house medical maintenance. This has not been completely satisfactory as enough problems still existed in the

medical maintenance system at the time of this study that it was requested. Sending existing maintenance personnel to other hospitals for on-the-job training was not considered feasible.

²The thirty-one month period used for the analysis of the in-house and outside service purchase expenses was selected as it was the only period in which clean data could be obtained. Work order data prior to September, 1967, even though available, was not clearly filed. It was recommended by the records clerk in the office of the plant engineer that data prior to September, 1967, not be used because its accuracy was questionable.

³In comparing the data presented in Appendixes E and F certain seasonal variations have occurred over the 30 month data base period. By using a simple sign test and comparing the work orders completed per month with the average for the annual period in which each month falls the seasonal variations for the entire 30 month base were identified. For in-house medical maintenance a definite decrease in the number of work orders completed occurred in the months of December and an increase in work orders completed by in-house maintenance personnel occurred during the months of January and August. A simple explanation for the decrease in December is that this is a month when many personnel are on annual vacation and as many jobs as possible are delayed. The increase consequently in work orders completed in January is to make up for the reduced number in December. The increase trend in August is based on only two months of August in the data base but a possible explanation is that August is the last month in the fiscal year and efforts to adjust inventory levels prior to a new fiscal year could be reflected.

For work orders completed by outside maintenance service there was a below average trend reflected in the months of January, February and July and an above average trend reflected in April and August. No obvious reasons appear for any of these trends except that perhaps the increase in August months is for the same reason as for the increase in the same month for in-house maintenance service. The trends for the months of April, July, and August are based on only two months of each in the data base.

⁴Letter from Richard S. Robertson, Position Classification Division, The State Auditor's Office, Austin, Texas, to all Agencies in Articles I, II, III, and the Central Education Agency, Deaf and Blind Schools in Article IV, September 30, 1969.

⁵A comparison of the costs of an in-house medical equipment repairman to the cost of contract service can be made by computing the hourly cost of the in-house service and comparing it with the stated charges of

contract service. The hourly cost of an in-house employee would equal 242 working days per year multiplied by eight hours per day divided into \$5,808 annual salary or \$3.00 per hour. The stated charges for contract services are \$16.00 per hour for emergency service and \$14.40 per hour for scheduled and preventive maintenance. To compare these hourly costs as they are it would have to be assumed that a full time in-house employee would be fully utilized. Previous workload data does not allow for this assumption to be made. An in-house medical equipment repairman could be justified in relation to contract service if more than 403.3 hours of scheduled maintenance service are required per year.

Conclusions

The best method of performing maintenance on medical equipment at the San Antonio State Hospital, San Antonio, Texas, is to continue with the present system of medical maintenance with certain modifications.

The existing system of medical maintenance must be modified in order to provide a preventive maintenance program for medical equipment and to allow for a more rapid response to maintenance requirements for medical equipment. The present maintenance staff, however, does not have the capability to provide a comprehensive preventive maintenance program for medical equipment or to provide for in-house repair of the more sophisticated medical equipment.

Contract service should be used to augment the existing system with a preventive maintenance program and provide emergency and routine maintenance service for the more sophisticated medical equipment such as X-ray, EEG, and some laboratory equipment.

Recommendations

It is recommended that the present system of medical maintenance

at San Antonio State Hospital be continued with the following modifications:

1. Work orders (B-14's) should be identified as medical when they are submitted for medical equipment.

CHAPTER III

2. Medical equipment repair should have priority over the repair of other types of equipment for bona-fide emergencies.

CONCLUSION

3. Work orders for medical equipment should be filed separately

Conclusions

in the maintenance department rather than with furniture and equipment work order files to facilitate future cost analysis.

The best method of performing maintenance on medical equipment at the San Antonio State Hospital, San Antonio, Texas, is to continue with the present system of medical maintenance with certain modifications.

The existing system of medical maintenance must be modified in order to provide a preventive maintenance program for medical equipment and to allow for a more rapid response to maintenance requirements for medical equipment. The present maintenance staff, however, does not have the capability to provide a comprehensive preventive maintenance program for medical equipment or to provide for in-house repair of the more sophisticated medical equipment.

Contract service should be used to augment the existing system with a preventive maintenance program and provide emergency and routine maintenance service for the more sophisticated medical equipment such as X-ray, EEG, and some laboratory equipment.

8. A contract should be let with a qualified firm for a preventive maintenance program for medical equipment. This contract service

should initially be limited to determine if the program will

Recommendations

It is recommended that the present system of medical maintenance

at San Antonio State Hospital be continued with the following modifications:

1. Work orders (B-14's) should be identified as medical when they are submitted for medical equipment.

2. Medical equipment repair should have priority over the repair of other types of equipment, except for bona-fide emergencies.

3. Work orders for medical equipment should be filed separately in the maintenance department rather than with furniture and equipment work order files to facilitate future cost analysis.

4. A feasibility study should be conducted to determine if a direct exchange maintenance float of commonly used items of medical equipment should be established and, if so, what items of equipment should be included.

5. In-service training in the proper use and care of equipment should be conducted by either in-house personnel or consultants.

6. Equipment repair time limitations should be placed on vendors when outside maintenance service is requested.

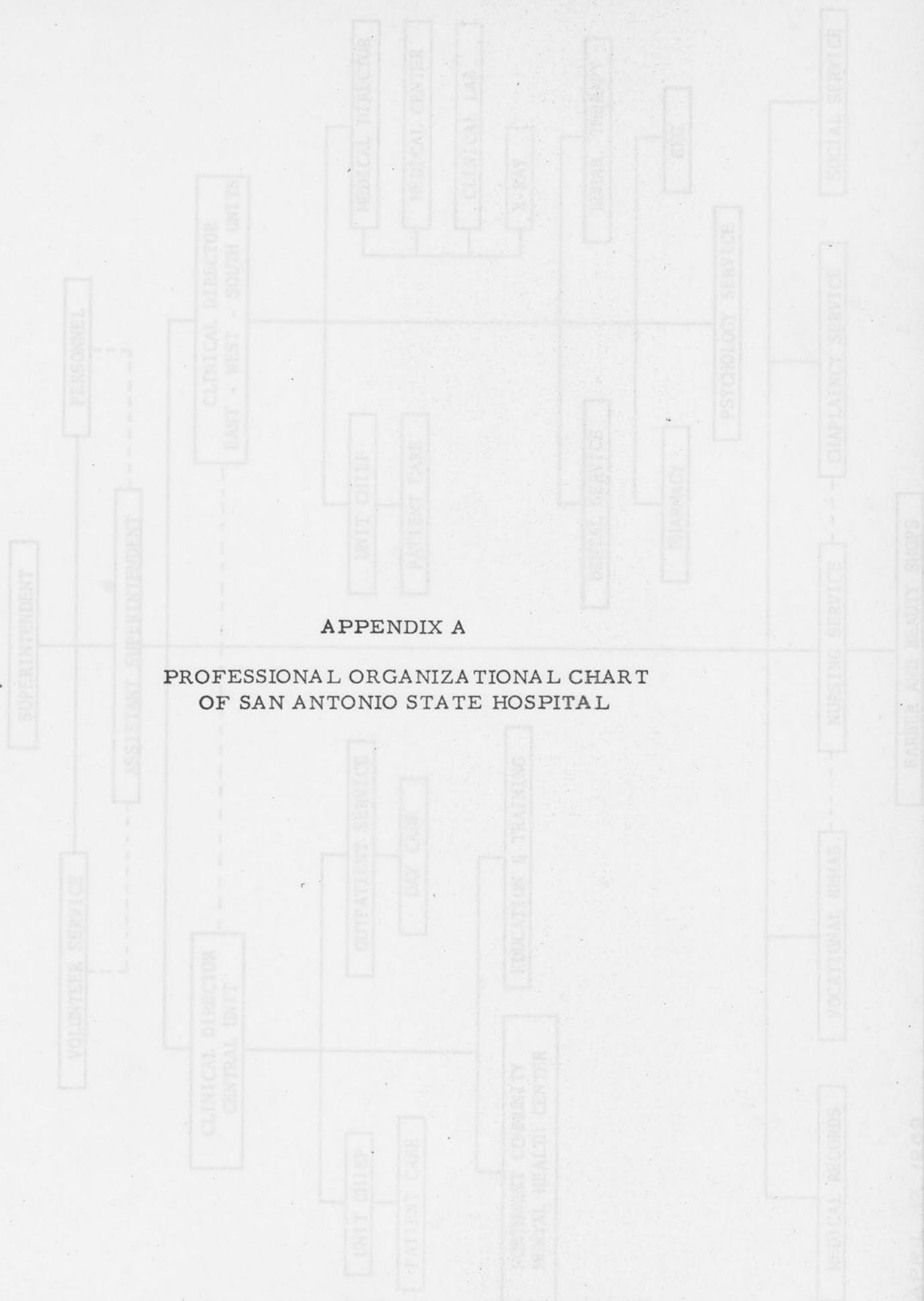
7. To determine the actual costs of repair services received vendors should be required to state charges for labor and repair parts separately on bills. This would also be beneficial for a future cost analysis.

8. A contract should be let with a qualified firm for a preventive maintenance program for medical equipment. This contract service should initially be limited to 180 days to determine if the program will meet the needs of the hospital. After preventive maintenance has been

performed at least twice, a cost analysis of the service should be conducted to determine if it is economically feasible for the hospital to continue with contract service.

APPENDIX A

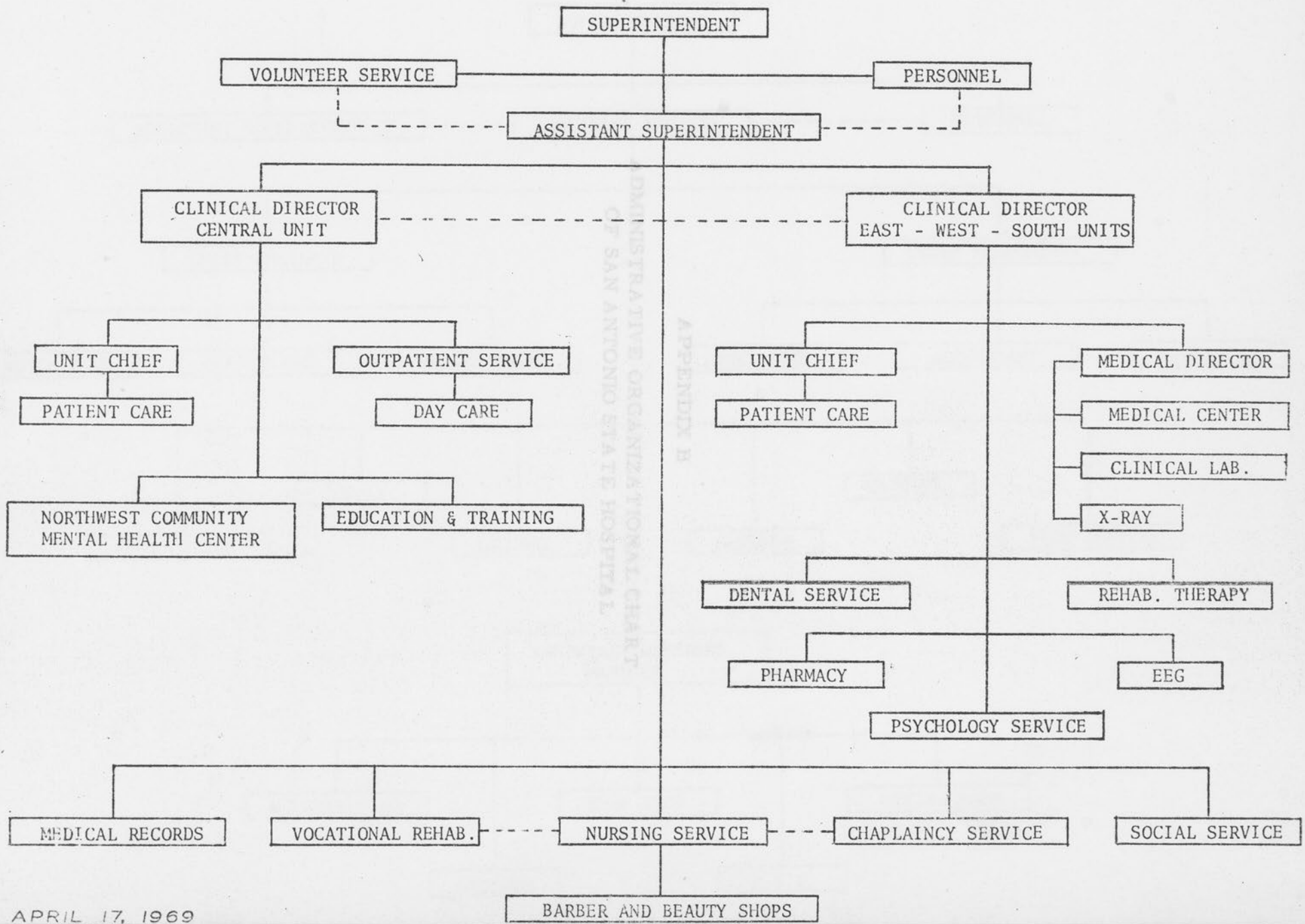
PROFESSIONAL ORGANIZATIONAL CHART OF SAN ANTONIO STATE HOSPITAL

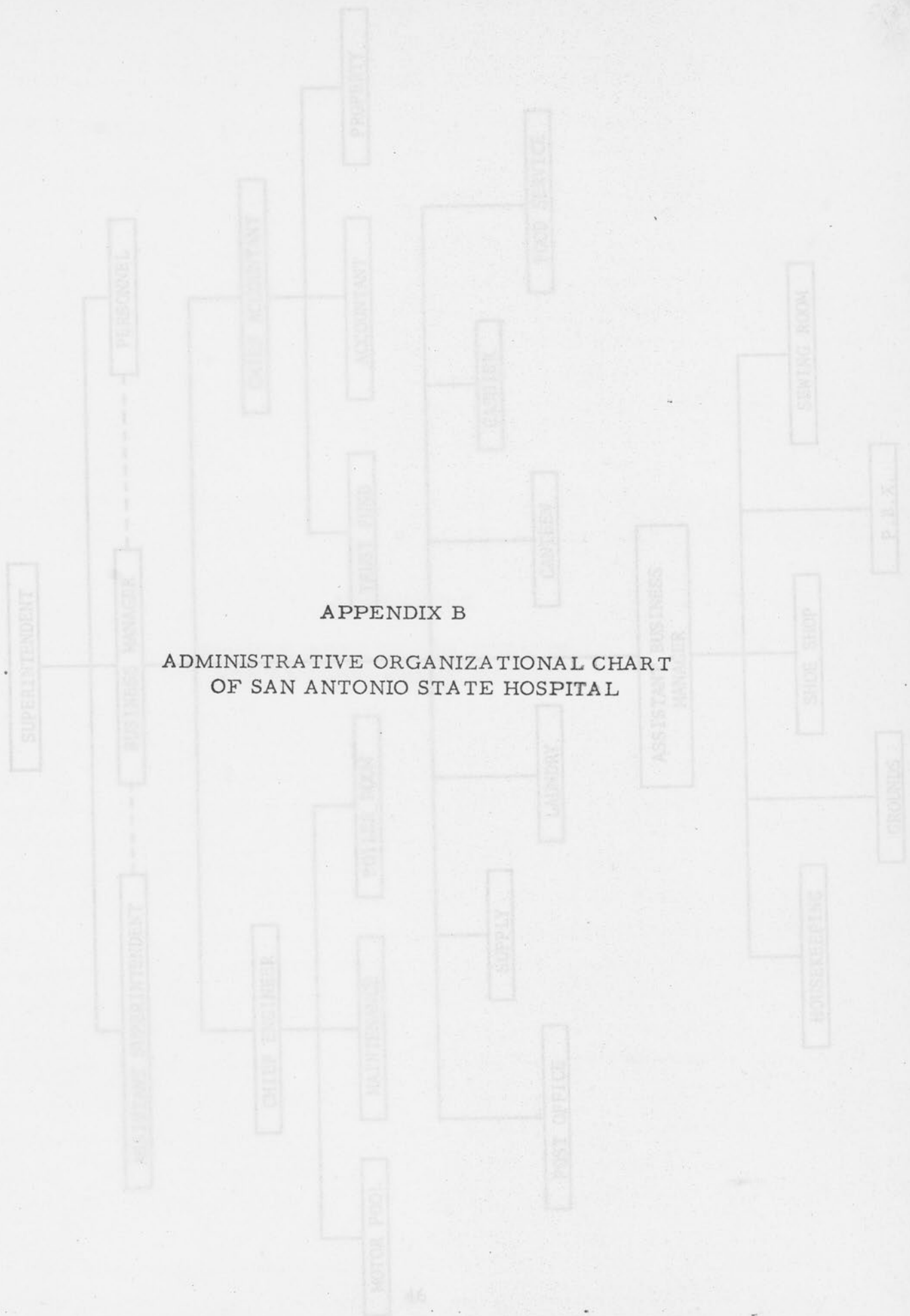


APPENDIX A

PROFESSIONAL ORGANIZATIONAL CHART OF SAN ANTONIO STATE HOSPITAL

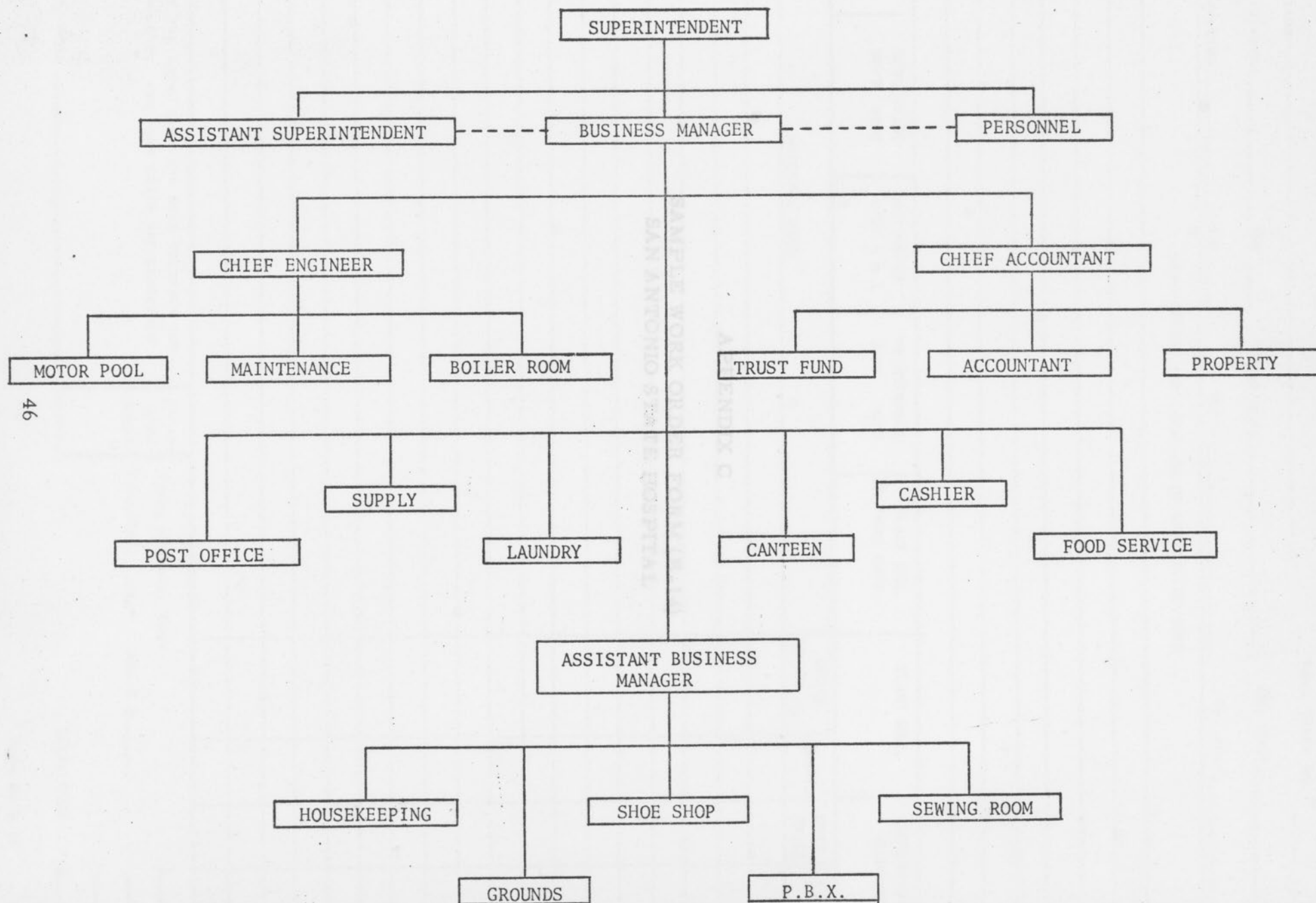
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APPENDIX B

ADMINISTRATIVE ORGANIZATIONAL CHART OF SAN ANTONIO STATE HOSPITAL



APRIL 17, 1969

INSTITUTION _____ WORK ORDER NO. _____
 DATE ORIGINATED _____ 195 _____ FOR DEPT. _____ DR. ACCT. _____
 DATE COMPLETED _____ 195 _____ BY DEPT. _____ CR. ACCT. _____

DESCRIPTION AND LOCATION OF WORK TO BE DONE

INITIATOR	REQUESTING DEPT. HEAD	ESTIMATED COST M & L	MAINTENANCE DEPT. HEAD	PLANT ENG. OR FAIR SUPV.	PLANT NO.	SUPERVISING ARCHITECT		
MATERIAL USED					REQ'D OR P. O.	QUANT.	UNIT PRICE	AMOUNT
APPENDIX C								
SAMPLE WORK ORDER FORM (B-14)								
SAN ANTONIO STATE HOSPITAL								

WORK ORDER No.

FOR DEPT. _____

DR. ACCT.

BY DEPT. _____

CR. ACCT.

DESCRIPTION AND LOCATION OF WORK TO BE DONE

[illegible]ESTIM-
ATED
HOURS

TOTAL MATERIAL COST

ACT. LABOR _____ HRS. @ \$ _____

\$

MAINTENANCE DEPT. HEAD

TOTAL COST \$_____

SAMPLE REQUEST FOR PROCUREMENT OF
NON-WAREHOUSE STOCK ITEMS (B-17)
SAN ANTONIO STATE HOSPITAL

No. _____

CHARGE DEPT. _____

YOU ARE HEREBY REQUESTED TO PROCURE THE FOLLOWING MATERIALS:

APPENDIX E		
MONTHLY WORK ORDERS, MAN-HOURS, AND COST OF REPAIR PARTS FOR IN-HOUSE MEDICAL MAINTENANCE		
SAN ANTONIO, TEXAS		

NOT LATER THAN _____

DEPT. HEAD APPROVAL

NONE OTHER

SUPPLY
OFFICER

PROCURED ON _____ AND _____

SIGNED: _____ SUPPLY OFFICER

MONTHLY WORK ORDERS, MAN-HOURS, AND COST OF REPAIR
PARTS FOR IN-HOUSE MEDICAL MAINTENANCE
FOR SEPTEMBER, 1967, THROUGH MARCH, 1970,
SAN ANTONIO STATE HOSPITAL

Month	Year	Work Orders	Man-hours	Repair Parts Cost
September	1967	8	14.5	\$ 9.90
October	1967	8	14.0	14.20
November	1967	10	16.5	11.11
December	1967	3	8.0	4.00
January	1968	13	31.5	8.52
February	1968	8	18.5	3.09
March	1968	7	12.0	5.67

APPENDIX E

MONTHLY WORK ORDERS, MAN-HOURS, AND COST OF REPAIR
PARTS FOR IN-HOUSE MEDICAL MAINTENANCE
SAN ANTONIO STATE HOSPITAL

April	1968	14	15.0	\$ 6.20
May	1968	17	33.5	22.45
June	1968	2	3.0	-----
July	1968	4	5.0	-----
August	1968	14	29.0	24.40
September	1968	14	16.0	2.18
October	1968	17	46.0	8.47
November	1968	14	24.5	28.34
December	1968	13	28.5	1.85
January	1969	15	24.5	27.87
February	1969	15	52.5	33.17

MONTHLY WORK ORDERS, MAN-HOURS, AND COST OF REPAIR
PARTS FOR IN-HOUSE MEDICAL MAINTENANCE
FOR SEPTEMBER, 1967, THROUGH MARCH, 1970,
SAN ANTONIO STATE HOSPITAL

Month -	Year	Work Orders	Man-hours	Repair Parts Cost
September	1967	8	14.5	\$ 9.90
October	1967	8	14.0	14.20
November	1967	10	16.5	-----
December	1967	3	8.0	4.00
January	1968	13	31.5	8.52
February	1968	8	16.5	3.09
March	1968	9	18.0	-----
Monthly Averages for 1st 7 Months		8.43	17.0	\$ 5.67
April	1968	14	15.0	\$ 6.20
May	1968	17	33.5	22.45
June	1968	2	3.0	-----
July	1968	4	5.0	-----
August	1968	14	29.0	24.48
September	1968	14	16.0	2.18
October	1968	17	46.0	8.47
November	1968	14	24.5	28.34
December	1968	13	28.5	1.85
January	1969	15	24.5	27.87
February	1969	15	52.5	33.17

MONTH -	Year	Work Orders	Man-hours	Repair Parts Cost
March	1969	17	39.0	\$ 21.14
Monthly Averages 2nd 12 Months		13.0	26.38	\$ 14.68
April	1969	5	6.0	2.00
May	1969	11	32.0	69.03
June	1969	15	23.5	50.19
July	1969	17	22.5	63.23
August	1969	21	32.5	52.06
September	1969	9	14.0	25.88
October	1969	14	20.0	39.38
November	1969	11	16.0	19.45
December	1969	12	19.0	52.13
January	1970	14	19.0	2.78
February	1970	7	9.5	-----
March	1970	19	28.0	47.43
Monthly Averages for 3rd 12 Months		12.92	20.17	\$ 35.30
Monthly Averages 30 Months		11.93	21.85	\$ 20.63

SOURCE: Data collected from San Antonio State Hospital Work Orders by the writer.

MONTHLY WORKORDERS AND COST OF OUTSIDE MAINTENANCE
SERVICE FOR SEPTEMBER, 1967, THROUGH MARCH, 1970,
SAN ANTONIO STATE HOSPITAL

Month	Year	Work Orders	Cost of Service
September	1967	8	60.50
October	1967	10	123.01
November	1967	4	35.50
December	1967	8	166.25
January	1968	1	2.00
February	1968	3	185.45
March	1968	3	354.95

APPENDIX F

MONTHLY WORK ORDERS AND COST OF OUTSIDE MAINTENANCE
for last 7 months SERVICE FOR MEDICAL EQUIPMENT
SAN ANTONIO STATE HOSPITAL

April	1968	5	\$ 100.00
May	1968	6	238.90
June	1968	7	219.29
July	1968	3	37.00
August	1968	9	1,354.05 ^a
September	1968	4	164.10
October	1968	4	64.75
November	1968	4	62.15
December	1968	5	124.80
January	1969	1	26.75
February	1969	5	282.40

**MONTHLY WORKORDERS AND COST OF OUTSIDE MAINTENANCE
SERVICE FOR SEPTEMBER, 1967, THROUGH MARCH, 1970,
SAN ANTONIO STATE HOSPITAL**

Month	Year	Work Orders	Cost of Service
September	1967	8	\$ 60.50
October	1967	10	123.01
November	1967	4	35.50
December	1967	8	166.25
January	1968	1	2.00
February	1968	3	185.45
March	1968	3	354.95
Monthly Averages for 1st 7 months		5.29	\$ 132.52
April	1968	6	\$ 100.00
May	1968	6	238.90
June	1968	7	219.29
July	1968	5	37.00
August	1968	9	1,354.05 ^a
September	1968	4	164.10
October	1968	4	64.75
November	1968	4	62.15
December	1968	5	124.80
January	1969	1	26.75
February	1969	5	282.40

SOURCE: Data collected from San Antonio State Hospital invoices by the

Month	Year	Work Orders	Cost of Service
March	1969	10	\$ 112.20
Monthly Averages for 2nd 12 months		5.50	\$ 232.20
April	1969	4	\$ 122.35
May	1969	3	193.85
June	1969	3	55.05
July	1969	2	57.55
August	1969	15	468.53
September	1969	1	55.00
October	1969	5	181.20
November	1969	4	130.42
December	1969	1	15.35
January	1970	0	-----
February	1970	2	50.50
March	1970	5	110.35
Monthly Averages for 3rd 12 months		3.75	\$ 120.09
Monthly Averages for 31 months		4.77	\$ 166.30

^aReflects a single expenditure of \$1,235 on an X-ray tube. Average for 2nd 12 months without this expenditure is \$129.28 per month.

SOURCE: Data collected from San Antonio State Hospital invoices by the writer.

QUESTIONNAIRE

The answers to the following questions are to be utilized in evaluating the present system for the performance of maintenance of medical equipment in SASH and possibly proposing a new system for the hospital. The overall, consolidated results of these questionnaires will be reported to the Business Manager but individual questionnaires will not. Your cooperation in answering these questions to the best of your ability will be greatly appreciated. If additional space is required, please write on the back of the questionnaire or on a separate sheet of paper.

1. Department, Service, Section, Ward, etc.
2. During your experience with SASH has a patient in your section ever suffered or been inconvenienced as a result of faulty medical equipment or a failure of an item or items of medical equipment? If yes, please identify the equipment and the cause of the problem.

APPENDIX G

3. How long do you **SAMPLE QUESTIONNAIRE** pairs to be made on a piece of medical equipment? Please answer in number of days.
4. In your opinion have you ever had to wait for repairs for an excessive length of time? If yes, please identify the equipment and the period of time you had to wait.
5. Has any one to your knowledge ever stressed a preventive maintenance program for medical equipment in the hospital? (Preventive maintenance as used here is, for example: checking for cracks or splits in electrical cords and rubber tubes, chipped paint on equipment, loose dials, etc.)
6. Approximately how much time do you spend monthly performing preventive maintenance as described above?
7. What are your recommendations or suggestions as to how maintenance for the medical equipment in the hospital can be improved?

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8. Do you consider the QUESTIONNAIRE for the maintenance of medical equipment adequate?

The answers to the following questions are to be utilized in evaluating the present system for the performance of maintenance of medical equipment in SASH and possibly proposing a new system for the hospital. The overall, consolidated results of these questionnaires will be reported to the Business Manager but individual questionnaires will not. Your cooperation in answering these questions to the best of your ability will be greatly appreciated. If additional space is required, please write on the back of the questionnaire or on a separate sheet of paper.

1. Department, Service, Section, Ward, etc:
2. During your experience with SASH has a patient in your section ever suffered or been inconvenienced as a result of faulty medical equipment or a failure of an item or items of medical equipment? If yes, please identify the equipment and the cause of the problem.
3. How long do you usually have to wait for repairs to be made on a piece of medical equipment? Please answer in number of days.
4. In your opinion have you ever had to wait for repairs for an excessive length of time? If yes, please identify the equipment and the period of time you had to wait.
5. Has any one to your knowledge ever stressed a preventive maintenance program for medical equipment in the hospital? (Preventive maintenance as used here is, for example: checking for cracks or splits in electrical cords and rubber tubes, chipped paint on equipment, loose dials, etc.)
6. Approximately how much time do you spend monthly performing preventive maintenance as described above?
7. What are your recommendations or suggestions as to how maintenance for the medical equipment in the hospital can be improved?

8. Do you consider the present system for the maintenance of medical equipment adequate?
9. Please rate the present system on the following scale. Circle the word which best describes the present system of maintenance of medical equipment.

EXCELLENT

GOOD

FAIR

POOR

APPENDIX H

JOB DESCRIPTION - MAINTENANCE MECHANIC II
STATE OF TEXAS JOB CLASSIFICATION CODE

GENERAL DESCRIPTION

Performs skilled work in one or more maintenance and building construction trades. Work involves maintaining and repairing buildings, utility systems, stationary equipment, and motorized equipment; requisitioning material and supplies; and keeping simple records. Occasional supervision is required to inspect and advise on work being performed and to insure safety precautions are being observed.

EXAMPLES OF WORK PERFORMED

Works from simple drawings or sketches.
Performs skilled maintenance and repair work such as plumbing, masonry, welding, carpentry, painting, electrical work, refrigeration, and elevator repair.
Repairs laundry machines, maintains and repairs kitchen equipment, boiler and boiler feed pumps, repacks water and sewer pumps.
Requisition materials and supplies; keeps simple records.
May act as working foreman on construction and equipment installation projects.
Performs related work as assigned.

GENERAL QUALIFICATION REQUIREMENTS

APPENDIX H

Experience and Training

JOB DESCRIPTION - MAINTENANCE MECHANIC II
STATE OF TEXAS JOB CLASSIFICATION CODE

Some vocational or trade school training.

Education

Completion of the eighth grade.

Knowledge, Skills, and Abilities

Working knowledge of building maintenance, plumbing and heating systems, sanitation, refrigeration, elevator maintenance, electric systems, fire and safety regulations.

Skill in the use of tools and equipment.

Ability to work from simple drawing or sketches; follow oral or written instructions; work with others.

Physical

Physical stamina to work in inclement weather and sufficient equilibrium to work some distance from the ground.

GENERAL DESCRIPTION

Performs skilled work in one or more maintenance and building construction trades. Work involves maintaining and repairing buildings, utility systems, stationary equipment, and motorized equipment; requisitioning material and supplies; and keeping simple records. Occasional supervision is required to inspect and advise on work being performed and to insure safety precautions are being observed.

EXAMPLES OF WORK PERFORMED

Works from simple drawings or sketches.
Performs skilled maintenance and repair work such as plumbing, masonry, welding, carpentry, painting, electrical work, refrigeration, and elevator repair.
Repairs laundry machines, maintains and repairs kitchen equipment, boiler and boiler feed pumps, repacks water and sewer pumps.
Requisition materials and supplies; keeps simple records.
May act as working foreman on construction and equipment installation projects.
Performs related work as assigned.

GENERAL QUALIFICATION REQUIREMENTSExperience and Training

Should have experience of a varied nature in repair and installation.
Some vocational or trade school training.

Education

Completion of the eighth grade.

Knowledges, Skills, and Abilities

Working knowledge of building maintenance, plumbing and heating systems, sanitation, refrigeration, elevator maintenance, electric systems, fire and safety regulations.

Skill in the use of tools and equipment.

Ability to work from simple drawing or sketches; follow oral or written instructions; work with others.

Physical

Physical stamina to work in inclement weather and sufficient equilibrium to work some distance from the ground.

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Field Service School, Fort Sam Houston, Texas, he served as Administrative Officer of the U.S. Army Medical Department Test and Evaluation Activity, Brooke Army Medical Center, Fort Sam Houston, Texas. While in this assignment, he attended the Medical Supply Procedures Course, again at the U.S. Army Medical Field Service School.

In June of 1968 he went to Vietnam where he served with the 7th Surgical Hospital (S&S) until its deactivation, as Chief of Supply and Services and Commanding Officer and with the 29th Evacuation Hospital as Chief of Supply and Services.

From August, 1968, to June, 1970, Captain Beverly attended the Health Care Administrative Course, U.S. Army Medical Field Service School. He completed his administrative residency at Martin Army Hospital, Fort Benning, Georgia, in June, 1971.

BIOGRAPHICAL SKETCH

Captain Ken Boynton Beverly [REDACTED]

[REDACTED] He received his Bachelor of Business Administration Degree (Finance) in [REDACTED] from the University of Georgia, Athens, Georgia.

Immediately upon graduation from college he entered the United States Army as a second lieutenant in the Medical Service Corps. After graduation from the Officers' Basic Course at the U.S. Army Medical Field Service School, Fort Sam Houston, Texas, he served as Administrative Officer of the U.S. Army Medical Department Test and Evaluation Activity, Brooke Army Medical Center, Fort Sam Houston, Texas. While in this assignment, he attended the Medical Supply Procedures Course, again at the U.S. Army Medical Field Service School.

In [REDACTED] he went to Vietnam where he served with the 7th Surgical Hospital (MA) until its deactivation, as Chief of Supply and Services and Commanding Officer and with the 29th Evacuation Hospital as Chief of Supply and Services.

From [REDACTED] [REDACTED] [REDACTED], Captain Beverly attended the Health Care Administration Course, U.S. Army Medical Field Service School. He completed his administrative residency at Martin Army Hospital, Fort Benning, Georgia, in [REDACTED] [REDACTED].

ABSTRACT

A STUDY OF MEDICAL MAINTENANCE AT SAN ANTONIO STATE HOSPITAL, SAN ANTONIO, TEXAS

A Problem Solving Thesis Submitted to the Faculty of Baylor University
in Partial Fulfillment of the Requirements for the Degree of
Master of Hospital Administration

by
Captain Ken B. Beverly, MSC

August 1971

65 pages

A copy of this document may be obtained on interlibrary loan from Stimson Library, United States Army Medical Field Service School, Brooke Army Medical Center, Fort Sam Houston, Texas.

The problem was to determine the best method of performing maintenance on medical equipment at San Antonio State Hospital, San Antonio, Texas.

The methods of research included: (1) an observation of the hospital's present medical maintenance system, including user appraisal of the system; (2) a cost analysis of the present system; (3) a determination of the local wage level for medical equipment repairmen in the San Antonio area; and (4) a determination of contract maintenance service available in the local community.

The major findings of the study were: (1) the present system was adequate, but users of medical equipment were far from being completely satisfied; (2) the historical average cost of the present system was \$235.09 per month or \$2,821 per year; (3) in-house maintenance service with a medical equipment repairman employed by the hospital was not feasible since the local wage level for this type employee was \$7,570 and the probable starting salary at the hospital would have been \$5,808; (4) contract service was offered by only one firm, and the cost of this service for a comprehensive maintenance contract was excessive. It was concluded that the present system combined with contract preventive maintenance offered the best system at the lowest cost for comprehensive maintenance service.

Recommendations were to continue with the present system with certain minor modifications and to attempt to obtain contract preventive maintenance service.