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Report on

Methods of Destruction of Documentary Contents of Safes in Sunken Vessels

by

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report

on

Methods of Destruction of Documentary Contents of Safes in Sunken Vessels.

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ABSTRACT

This report considers a variety of methods for destroying or rendering illegible the types of secret and confidential documents now carried on board Naval vessels in the event of such vessels being stranded, sunk, wrecked or captured. It is concluded that of the several methods for effecting this which have been suggested, none gives promise of buing suitable for use with the quantities of documents which would have to be destroyed. Some of the methods are suitable for a limited quantity of paper documents. It is suggested that consideration be given to the feasibility of using a radically different method of preparing some of the secret and confidential documents, namely, by making them of photographic film, which is very readily destructible.

AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter reference (a); other material pertinent to this problem is listed as reference (b).

Reference: (a) BuEng. 3rd end. C-A7-3(5-29-Ds) of 19 June 1935.
(b) RPS 4.

STATEMENT OF PROBLEM

2. The regulations for handling of secret and confidential publications, reference (b), state that in the event a Navy vessel carrying secret or confidential documents is wrecked, stranded, or destroyed, every endeavor shall be made to dispose of the registered publications and devices thereon beyond a possibility of compromise. Experience having shown that under certain circumstances it is impossible positively to prevent compromise by methods now available, it is desirable to find other means whereby these documents can be destroyed or otherwise rendered illegible. Appropriate methods should be available for each of the several types of ship:

1. Surface ships
2. Submarines
3. Aircraft.

KNOWN FACTS BEARING ON THE PROBLEM

3. The experience of the several navies in the World War showed that reliance could not be placed upon throwing overboard confidential and secret documents as a means of preventing them from falling into enemy hands. For example, sunken German submarines were repeatedly entered by divers of the British navy who were able to salvage codes, ciphers, maps, etc. When the German cruiser S.M.S. MAGDEBURG was stranded in the Baltic, secret documents were likewise salvaged.

4. The experience of the United States Navy since the War has confirmed the war-time experience. For example, when the S-51 was raised, certain confidential publications were recovered and returned to the Navy Department. Although these had been submerged in salt water for a period of nine months, they were, when dried out, as legible as new books.

5. Advances in the art and materiel of deep sea diving increase the possibility of salvaging confidential documents in the future not alone from sunken vessels but also, in certain cases, from the sea bottom where they have been thrown overboard.

6. In considering the feasibility of any method for rendering illegible confidential documents, account must be taken of the advances recently made, especially by scientific criminologists, in the art of restoring or reading altered, defaced, or partially destroyed printed material. It must further be supposed that this art is as highly developed in foreign countries as in our own.

THEORETICAL CONSIDERATIONS

7. The principal pertinent theoretical consideration in connection with this problem is that energy is required to destroy the organic chemical materials of which the subject documents are composed. In the case of destruction of paper material by burning in air, this energy is supplied by the heat of combustion; in destruction by chemical methods, the energy is that of the chemical reaction. The energy changes in these cases can be calculated from theoretical considerations and give us a theoretical idea of the feasibility of any suggested method.

8. Further, the chemical reactions involved in suggested methods enable estimates to be made of the amount of destroying agent required.

9. To illustrate the application of these theoretical methods, we may consider the feasibility of one of the most hopeful of the suggested methods, namely, the use of Thermite. Setting off a charge of Thermite within a closed space liberates 380,000 calories per pound of Thermite. In a closed space containing but little air, the chemical reaction which would occur in the paper would be substantially as follows:

$$(C_6H_{10}O_5)_x \longrightarrow 6xC + 5xH_2O$$

a process which requires 770,000 calories per pound of paper. Therefore, about 2 pounds of Thermite are required completely to destroy one pound of paper book, provided that none of the heat generated by the Thermite is lost. In actual practice, most of the heat would be wasted.

10. Another theoretical factor of significance to the heat destruction methods is the very low thermal conductivity of paper. This means that even if the outer portion of a paper book were subjected to the high temperature of the Thermite reaction, for example, it would take a long time for the inner portions of that book to become heated to the temperature at which destructive decomposition would ensue. During this long time the Thermite would, in fact, itself be losing heat rapidly by radiation to its surroundings. The reduction in temperature of the Thermite mass would be much more rapid than the transmission of heat from the outer portions of the book to the inner.

11. Such theoretical considerations indicate that the Thermite method would not suffice. Similar calculations for other suggested methods show how difficult it is to destroy paper material.

NARRATIVE OF ORIGINAL WORK DONE AT THIS LABORATORY ON THE PROBLEM

12. This Laboratory has considered a wide variety of methods for destroying secret and confidential documents. The more promising of these were studied experimentally.

METHODS

13. The following methods of rendering secret and confidential documents illegible to prevent their compromise were considered by this Laboratory:

(a) Use of paper that would be disintegrated by water.
(b) Use of chemicals to destroy paper.
(c) Water soluble inks.
(d) Fugitive inks.
(e) Incendiary devices.
(f) Explosives.
(g) Gas torch devices.
(h) Electric furnace.

Also, there was considered a radically different system of Naval secret and confidential documentation which will be discussed in detail later.

14. Each proposed system was considered from the twofold standpoint of (a) the possibility of making it automatic, and (b) the possibility of its manual operation. Further, each system was analysed as to its (a) "foolproofness," (b) positiveness of action, and (c) safety to personnel.

15. The above methods will now be discussed in detail; the objections to each will be stressed.

(a) Use of paper that would be disintegrated by water.

16. Some types of paper tend to disintegrate when submerged in water. However, while this disintegration may be nearly complete when a single sheet or two is exposed to water, a closely bound book made up of such paper will disintegrate very slowly and would be recoverable even after prolonged submergence. Another type of "paper" which would be destroyed by water is thin sheet metal, as aluminum, zinc or magnesium. These would corrode destructively in sea water, especially if in contact with other metals lower in the E.M.F. series. Some experients were made with this method. Even if substances easily destroyed by water were used for the pages of the books, means would have to be provided for destruction in the case of capture or stranding of the vessel where submergence of the confidential documents might not occur. Paper having this characteristic would require careful handling in actual use. This method may therefore be ruled out as not feasible.

(b) Use of chemicals to destroy paper.

17. It has been suggested that a means be provided for spraying the documents with strong acid or alkaline solutions for the purpose either of completely destroying the paper or so discoloring it that it would be difficult to read. Experiments show that a bound book can be immersed in concentrated sulphuric acid for a period of several weeks without complete destruction of the book. The acid first acts upon the outer

exposed portions of the book, and the action produces a chemically inert layer of carbon which tends to prevent any further action of the acid. For this and other reasons sulphuric acid penetrates but slowly into the inside of a bound volume; even if methods could be devised for bringing the acid into intimate contact with all parts of the book, a prohibitive amount of acid will be required. Strong caustic solutions of sodium hydroxide were also tried. These changed the paper into a jelly-like mass which, however, could, on drying, be separated into sheets and the print still read. The use of caustic solutions in this manner can therefore be ruled out.

18. In general, therefore, as a result of theoretical and experimental work, it can be concluded that such chemical methods as these are not practicable.

(c) Water soluble inks.

19. The work of chemical criminologists indicates that it is quite futile to attempt to find water soluble inks and methods of using them that would not permit a competent chemist to render the matter legible. Here, again, this method would be limited in its application to the case of a sunken vessel so flooded that water would reach the contents of the documentary safes.

(d) Fugitive inks.

20. Chemical agents are known which will render illegible colored inks, but here again the work of criminological chemists indicates that in almost every case the bleached print can be redeveloped by the use of suitable chemical developing agents or by suitable physical methods.

(e) Incendiary devices.

21. It was suggested that a charge of Thermite be so arranged as to be set off automatically by the ingress of water in the case of sinking or manually in the event of capture, wrecking or stranding. Experiments on this method will be described below.

(f) Explosives.

22. Smokeless powder could be arranged to be ignited automatically or manually. A principal objection to this is one noted by representatives of the Office of the Chief of Naval Operations, namely, the danger to personnel involved in the presence of such a system. Further, it is probable that the result of setting off an explosive charge within a closed safe would be merely to open the safe and scatter its contents without completely destroying them. No experiments were made on this method.

(g) Gas torch devices.

23. It was suggested that a device similar to the acetylene water cutting torch with automatic control be provided to burn up the

documentary material. The cylinders of compressed gas and the valve and igniting devices for this system would be prohibitively complicated and heavy and the operation of the device uncertain at best. Even if a suitable torch were devised, it would have to burn for several hours in order to destroy any quantity of bound volumes.

(h) Electric furnace.

24. In this, the interior of the safe containing secret documents would be fitted with high temperature electric heaters connected to the emergency sources of electric power. In emergency, these heaters would be manually or automatically turned on to destroy the documents by heat. The difficulties with this device are first, its dependence upon electric power under all circumstances, and second, that the documents might not be sufficiently destroyed to become illegible. Experiments on this method are described below.

DESCRIPTION OF EXPERIMENTS

25. As a striking illustration of the difficulty of destroying a book, the following experiment was made. A typical cloth-bound book measuring about 6"x9" with about 1,000 thin paper pages was thrown into the Laboratory's electric steel furnace containing a bath of molten steel at a temperature of 3,000°F. At the end of 5 minutes, the remainder of the book was removed from the furnace. Several hundred pages in the middle of the book were recovered and of these about half of the area of each page was practically unchanged and perfectly legible.

26. Next, a large obsolete safe was wired with electric heating element resistance wires capable of dissipating about 5 kilowatts. Inside it was then stacked about 15 pounds of books simulating the normal contents of such a safe (an actual safe would, of course, contain much more than 15 pounds). The current was turned on and continued for several hours, at the end of which time the safe was allowed to cool and opened. The books in the middle of the pile were practically unchanged. The outer ones were completely charred, the pages remaining being merely thin sheets of carbon. While these charred books were extremely brittle and fragile, nevertheless, by the exercise of great care, the pages could be separated almost intact and the printing readily made out for the reason that the charred ink was of a different color from the charred paper. The results of this experiment confirm the experience of (1) fire insurance authorities in recovering the contents of safes in office buildings following severe fires, (2) the United States Treasury Department in reclaiming burned money, and (3) the Bureau of Investigation of the United States Department of Justice in reading burned paper documents.

27. The Thermite method was studied in two experiments. In the first, about ten pounds of books were stacked in the normal manner in a refractory brick enclosure. A twenty-pound charge of Thermite contained in a refractory vessel was so arranged that the molten mass poured onto the books. When the Thermite reaction was complete, the

whole mass was covered with an insulating layer of sand and permitted to cool down. When the solidified iron was removed, it was found that the outer portions of the pile of books were charred beyond recognition, but in the center of the pile the pages were unchanged and easily legible. Next, a similar pile of books was arranged with a charge of Thermite resting on them. The charge of Thermite was set off and, when the reaction was complete, the whole mass was covered with sand and permitted to cool. Here, again, when the books were examined, it was found that the external portions had been destroyed but that a large portion of the interior of the book pile was unchanged. These experiments confirmed the theoretical prediction that the low thermal conductivity of paper and the large quantity of energy requisite to decompose it would defeat any attempts at destruction by Thermite of more than a limited quantity of paper material.

28. It is considered that the suggestion for using Thermite may rest on a misconception of its function in incendiary bombs. In those, the Thermite, because of its high temperature, ignites any inflammable material with which it comes in contact and the combustion of that material continues in the surrounding air. In inflammable material contained in a relatively airtight enclosure such as a safe, these conditions would not obtain, and the amount of destruction of those materials would be limited by the energy content of the Thermite itself.

29. No experiments were carried out on methods of destroying the Electric Cipher Machines aboard ship.

30. Since the possibility of success in finding a suitable system for destroying the present types of confidential and secret matter in the quantities now contained in safes aboard ship appears from the above discussion and experiments to be rather remote, this Laboratory has considered some radically different methods for publishing the Naval confidential and secret documents. One of these methods will now be considered.

31. In a conference with the Office of the Chief of Naval Operations concerning this subject problem, this Laboratory suggested that the Office consider the feasibility of printing some of its confidential documents on motion picture film for use aboard ship, the destruction of such film being very easy and positive in the event of the sinking, stranding, etc., of the vessel. At the time of the conference, it was known that the Eastman Kodak Company had developed equipment - called the Recordak System - for printing documents on film and devices for reading this film. The Recordak System is in extensive use in banking and business establishments for the recording and filing of documentary material, but it was appreciated that the Eastman equipment was not well adapted to Naval use.

32. This Laboratory has recently learned that Lieutenant Rupert H. Draeger (MC) USN has developed a system for the photographic reproduction of documents under the auspices of Science Service and with the collaboration of several of the government departments, including the library of the Naval Medical School. The development has reached the

stage where his system is in wide use. It is considered that it is well adapted to a number of Naval uses, among which is the one studied in this report.

33. In the Draeger System, a specially developed camera, shown in Plate 1, is used to photograph documents, pages of books, letters, drawings, etc., on to standard motion picture film. This film is then developed and either used in that form or else positives in any quantity are prepared from it. By the use of special reading equipment, shown in Plate 2, which comprises means for projecting the image of this film onto a small ground glass screen, the reproduction can very easily be read. The reading machine, as at present developed, is slightly larger than a typewriter. A 1500 page book can be reproduced on a reel of motion picture film less than 3 inches in diameter (35 mm wide) at a cost of one-tenth of a cent per page for the original film.

34. In the opinion of this Laboratory, the use of the Draeger System motion picture film to carry confidential data aboard ship would have the following advantages:

(a) Secrecy. It is recognized that to minimize the possibility of compromise of code books, etc., all stages in the production of such books must be under control of the Chief of Naval Operations. When the typesetting, printing, and binding are done by an outside agency, as at present in the case of certain of these documents, the danger of compromise is increased. With the Draeger System, a master book could be typewritten or printed in the Office of the Chief of Naval Operations, then photographed, printed and distributed by Naval personnel under close supervision.

(b) Ease of Distribution. In the event that the known compromise of a code made necessary the replacement of the code books in service, the distribution of these to the ships of the Fleet would be a difficult matter. With the code book printed on film, the requisite number of copies could be carried in a suitcase and airplane transportation could be used to expedite the procedure as, for example, in reaching the Hawaiian Islands.

(c) Rapidity of Production. If the known compromise of a code system made necessary the immediate adoption of new code books, their production under the Draeger System could be very rapid.

(d) Ease of Use. Once the personnel became trained in the use of this system, it is believed that it would be almost equal in rapidity to the standard books. With the collaboration of Dr. Draeger, the rapidity of using the system was tested by comparing the time required to obtain data from a film with the time required to use the book from which the film was made. The film system was only slightly slower, even with an inexperienced operator. In certain cases, the Draeger System

would be much easier to use. For example, a lightweight reading device could be developed by the use of which a tactical officer on the bridge could have a set of the significant tactical signals immediately available throughout an action. Similarly, suitable reading machines could be disposed in convenient parts of the ship.

(e) Ease of Destruction. The destruction of film confidential documents would be very easy and positive. Nitrate film could be used, in which case they could be ignited by a match or cigarette lighter, while safety film could be destroyed almost as easily. In the event of sinking of the vessel, the action of sea water would soon destroy the legibility of the film. If the film were thrown overboard, the chance of its being found by a diver would be most remote, owing to its small quantity. On the other hand, if standard movie film should prove to be too perishable, as from frequent handling, a satisfactory film could without doubt be developed.

(f) Weight and Space Saving. The use of motion picture film to carry confidential data would save a great deal of space and, by greatly reducing the size of the safe necessary, would save considerable weight.

(g) Economy. By the use of the Draeger System, a complete set of code books could be produced and distributed at a fraction of the cost of the present ones. This would be economical and would as well permit more frequent change of the codes without much added expense. However, the initial investment in equipment to make this system effective would be rather high. But it is considered that the importance of the subject problem might justify this initial expense.

CONCLUSIONS AND RECOMMENDATIONS

(a) Facts Established

35. It is considered that the above discussion, theoretical considerations and experiments have shown that:

(1) There is no positive practicable method for the destruction of the quantities of secret and confidential material now contained in the safes of Naval vessels in the event of their being stranded, sunk, wrecked or captured.

(2) The chemical and physical nature of paper is such as to make difficult its destruction, especially in large masses.

(3) The prevention of the compromise of secret and confidential documents aboard ship would be simplified if the quantity of such documents could be reduced to a minimum.

(4) Small quantities of paper documentary material, preferably stored as sheets rather than bound in books, could be destroyed:

(a) By Thermite in sufficient quantity.

(b) By burning the paper and carefully disintegrating the resulting sheets.

(c) By violent agitation in a caustic solution so that the paper is entirely disintegrated into its component fibers.

(b) Opinions

36. It is considered that the importance of positively preventing the compromise of secret and confidential material aboard ship in the event of its being stranded, sunk, wrecked or captured is so great as to justify the Office of the Chief of Naval Operations making a comprehensive study of means for reducing the quantity of such material to a minimum, for only by minimizing the quantity can its destruction to prevent compromise be insured.

37. In a conference on this problem in the Office of the Chief of Naval Operations, one of the representatives of that Office pointed out what seemed to him the futility of destroying books descriptive of some of the Naval materiel about the ship under conditions where it would be impossible to prevent the materiel itself from falling into enemy hands. He pointed out, for example, how difficult it would be to prevent the torpedoes from falling into enemy hands in case the vessel were sunk or stranded in shallow water and that it would appear to be immaterial whether the books describing those torpedoes also were disclosed. He considered that this applied equally to other books under the cognizance of all the materiel bureaus.

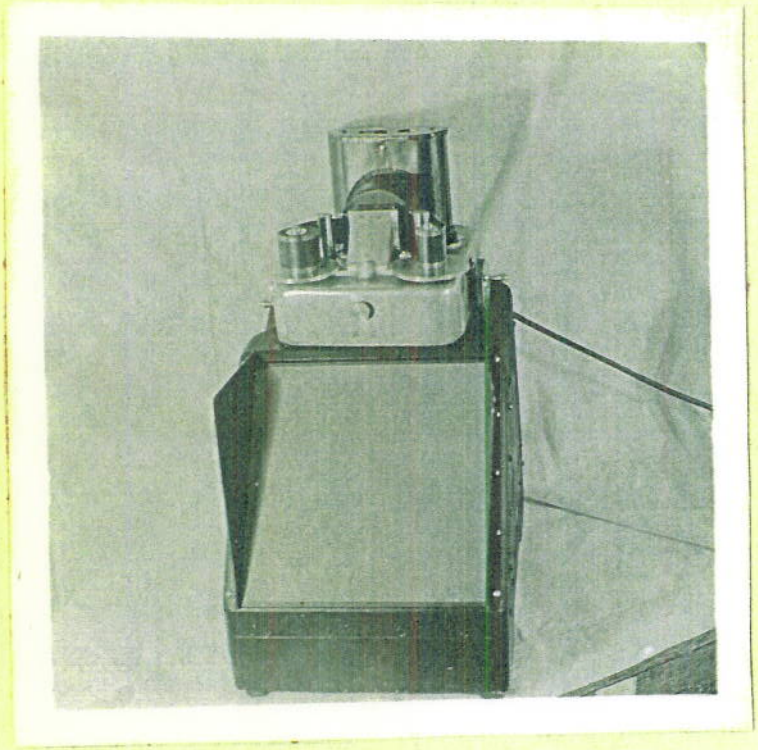
(c) Recommendations

38. It is recommended:

(a) That the Office of the Chief of Naval Operations ascertain the feasibility of using the motion picture film method developed by Lieutenant Draeger (MC) USN for the dissemination of certain secret and confidential Naval data for use aboard ship. If the Office considers this method feasible and that the expense of putting it into use justified, this Laboratory could investigate the practical details of using it.

(b) That the attempt be made to reduce to a minimum the quantity of secret and confidential material, the compromise of which would be most serious.

Camera for photographing documents onto motion picture film, Draeger system.



Reading machine for Draeger system motion picture film demonstration..