PHOTOGRAPH THIS SHEET

AD-A955 054

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

1

REPORT 865
WATER QUALITY CONTROL
SET FOR FIELD USE

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR		
NTIS	GRA&I	☐
DTIC	TAB	☐
UNANNOUNCED		☒
JUSTIFICATION		

BY

DISTRIBUTION /

AVAILABILITY CODES

DIST	AVAIL AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

UNANNOUNCED

QUALITY INSPECTED 3

DTIC ELECTE JAN 29 1986 S D

D

DATE ACCESSIONED

DECLASSIFIED
DOD DIR 5200.9

DATE RETURNED

86 1 28 049

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NO.

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

DTIC FORM 70A DEC 83

DOCUMENT PROCESSING SHEET

PREVIOUS EDITION MAY BE USED UNTIL STOCK IS EXHAUSTED.

UNCLASSIFIED

~~RESTRICTED~~

ATI 79999
PB 7212
ADF 560179

AD-A955 054

WAR DEPARTMENT

Report 865

WATER QUALITY CONTROL SET FOR FIELD USE

15 September 1944

UNCLASSIFIED
Changed to ______
Cancelled ______
Date 17/2/59
By authority of Ch, Mil E
5/5/58

FOR TECHNICAL INFORMATION ONLY

Does not represent recommendations or conclusions of the Office, Chief of Engineers

DECLASSIFIED
DOD DIR 5200.9

TECHNICAL STAFF
THE ENGINEER BOARD
Corps of Engineers, U. S. Army
Fort Belvoir, Virginia

UNCLASSIFIED

UNCLASSIFIED

~~RESTRICTED~~

Report 865

WATER QUALITY CONTROL SET

FOR FIELD USE

Project WS 315 C

15 September 1944

Changed to UNCLASSIFIED

Classified
Cancelled
Date 17/2/59
By authority of Ch, Mil E
5/5/58

Submitted to

THE ENGINEER BOARD

Fort Belvoir, Virginia

and/or

The Chief of Engineers

U. S. Army

Washington, D. C.

FOR OFFICIAL ACTION

by

Water Supply Equipment Branch
Technical Division III
The Engineer Board
Fort Belvoir, Virginia

~~RESTRICTED~~

UNCLASSIFIED

UNCLASSIFIED

TABLE OF CONTENTS

UNCLASSIFIED

SYLLABUS

1. Scope. This report covers the development of a water quality control set for routine control testing at each water point, a description of the set, including lists of equipment for the tests, a brief discussion of the tests included in the set, and the recommended basis of issue for the sets.

2. Conclusions. There is a definite need for field laboratory equipment for routine control testing at each water point. The water quality control set, covered by this report, is suitable for the purpose.

3. Recommendations. The report recommends that the water quality control set proposed herein, and covered by Corps of Engineers Tentative Specification No. T-2024A, be adopted as a Standard item of equipment and issued on the following basis:

a. 1 each for Water Supply Equipment Set No. 1 (Engineer)

b. 1 each for Water Supply Equipment Set No. 4 (Topo Battalion)

c. 2 each for Water Supply Equipment Set No. 5 (Water Supply Company)

WATER QUALITY CONTROL SET FOR FIELD USE

I. SUBJECT

1. Subject. This report covers the development of a field water quality control set for routine control testing at each water point.

II. AUTHORITY

2. Authority.

a. Letter from the Chief of Engineers to the Engineer Board, dated 29 September 1941, subject: Modification of Engineer Board Projects, stated that the directive for SP-315, Water Supply, General, be changed to the following: "In this sub-project will be included those miscellaneous water supply investigations on items of equipment, manuals, and instruction sheets not elsewhere provided for".

b. Letter of 2 February 1943, subject: Water Treatment Control Tests, from the Chief of Engineers to the Engineer Board directed the Board to complete the development of the water control testing kits, other than the mobile laboratory.

Copies of these letters are included in Appendix A.

III. INVESTIGATION

3. History.

a. The procedure for water supply quality control in the field was a matter of considerable controversy during 1942, especially relative to the responsibilities of the Medical Department, the Chemical Warfare Service, and the Corps of Engineers. The lack of direct responsibility of field water quality control resulted in no laboratory equipment being available in the field. Various Engineer organizations, including the Office of the Division Engineer of the South Atlantic Division and the 80th Engineer Water Supply Battalion, initiated the development of field laboratory equipment. The need of field laboratory equipment was recognized by the Engineer Board, and development of such equipment was initiated. Plans were made for four echelons of water control:

(1) First echelon equipment, to consist of a small chest with minimum laboratory apparatus for control by the operator of the purification unit, portable or mobile.

(2) Second echelon equipment, to consist of a small chest about the size of a suitcase for control by the officer in charge of a group of purification units, either of the divisions or of a company of the Water Supply Battalion.

(3) Third echelon equipment, to consist of a chemical chest and a bacteriological chest for control work by a qualified officer in a higher unit, such as the Corps or the Water Supply Battalion.

(4) Fourth echelon equipment, to consist of a truck-mounted mobile laboratory for use by an officer of a unit such as an Army.

b. The Chief of Engineers, in a letter dated 2 February 1943, outlined the respective responsibilities of the Medical Department, the Chemical Warfare Service, and the Corps of Engineers relative to water treatment control tests, and directed the Engineer Board to complete the development of the water control testing kits, other than the proposed fourth echelon equipment. Inasmuch as the responsibility for bacteriological tests was placed with the Medical Department, bacteriological apparatus was deleted from the proposed third echelon set. First, second, and third echelon sets of field laboratory equipment were assembled. Lists of the equipment and photographs of same (See Appendix A) were forwarded to the Chief of Engineers in April 1943.

c. The proposed third echelon set included equipment for conducting certain toxicity tests for the detection of chemical warfare agents in water. The tests involved the use of complex equipment, and required specially trained personnel. Simultaneous with Engineer Board development of field laboratory equipment, development work on toxicity sets was being conducted by the Medical Department Research Laboratory and the National Defense Research Committee. The latter organization developed a simplified toxicity kit designated as "Kit, Water Testing, Screening". This kit is covered by Office of Scientific Research and Development Report No. 1732, dated 20 August 1943, subject: Field Kit, Screening, for the

Detection of Chemical Warfare Agents in Water. This screening kit, due to its compactness and simplicity in operation, is more suitable for the field water quality control set than the originally proposed equipment for toxicity tests. The simplification of toxicity testing and the elimination of bacteriological work from the duties of the Corps of Engineers caused a third echelon set, requiring specially trained personnel, to be unwarranted. It was concluded that a single set of field laboratory equipment suitable for use at each water point would be more satisfactory for Corps of Engineers general military field use. Development work was continued on such a set.

4. Present Investigation.

a. Tests. The water quality control set was designed to include the following tests: flocculation; turbidity; hydrogen ion (pH); free chlorine; chloride; alkalinity; sulfate; soap hardness; and toxicity tests for arsenic, mustard, chlorine demand, and pH (a simplified field test). A Medical Department "Kit, Water Testing, Screening", is included in the set for the determination of the toxicity tests. A method for the determination of each test was established, apparatus to be used was tentatively planned, and an experimental model set was assembled from available laboratory equipment.

b. First Pilot Model. Inasmuch as the set included many items of laboratory equipment, all of which no single company would have in stock or be in a position to produce, it was decided that the assistance of a large laboratory supply house would be highly beneficial in determining the availability of the items, and in giving pertinent information relative to production problems. The Engineer Board solicited and secured the cooperation of Arthur H. Thomas Company, Philadelphia, Pennsylvania, which is one of the largest laboratory supply houses on the Eastern Seaboard, on the development project. A pilot model laboratory chest was procured from this company.

c. Availability of Component Parts. Contacts were made by Arthur H. Thomas Company and the Engineer Board with numerous commercial organizations to determine the availability of the items for the proposed water quality control set. It was found that the production of many standard items was discontinued, thereby requiring substitute items. The latter items, being of different dimensions than the originally proposed items, necessitated changes in the loading plan and revisions to the internal structure of the chest. Sources of various component parts are as follows:

(1) Bottle, glass - Armstrong Cork Company, Lancaster, Pennsylvania.

(2) Funnel, plastic, 2½-in. - L. Hutzler Manufacturing Company, Long Island City, New York.

(3) Ammonium alum and sodium carbonate in gelatin capsules - McNeil Laboratories, Philadelphia, Pennsylvania.

(4) Pipette, dropping with rubber bulb, for 4-oz bottles - Kimble Glass Company, Vineland, New Jersey.

(5) Pipette, dropping, 1-ml, Ives - Arthur H. Thomas Co., Philadelphia, Pennsylvania.

(6) Bulb, rubber, 2 ml capacity, for Ives pipette - West Company, Philadelphia, Pennsylvania.

(7) Clip, spring, for holding 50-ml graduate cylinder, Gibson Good Tools, Inc., Orange, Massachusetts.

(8) Indicator solutions, comparator discs and comparator tubes for pH and free chlorine determinations - Wallace and Tiernan Co., Inc., Newark, New Jersey.

(9) Measure, graduated, 32-oz (1 liter) Vollrath Co., Sheboygan, Wisconsin.

(10) Zeolite, synthetic (Zeo-Karb-Na) - Permutit Co., New York, New York.

(11) Miscellaneous standard laboratory items and chemical solutions - Arthur H. Thomas Co., Philadelphia, Pennsylvania.

d. Final Pilot Model. Using the Arthur H. Thomas Company model as a basis of design, the Engineer Board constructed a chest and assembled all the component parts of the set. Drawings and specifications (See Appendix B) for the set were prepared and forwarded to the Chief of Engineers 27 April 1944.

e. Description. The water quality control set consists of items of laboratory equipment necessary to make the determinations listed in paragraph 4 a. A plywood chest having overall dimensions of 21½ in. x 17 in. x 12 in. is provided for the equipment. The weight of the set complete with chemicals is 80 pounds.

(1) Flocculation. The equipment for the flocculation test includes a flocculator, consisting of a wooden

bottle holder and four 8-oz. bottles for shaking the water samples; capsules of ammonia alum and soda ash for making up standard solutions; two 4-oz. bottles, one each for the alum and soda ash solutions, respectively, each bottle being provided with a calibrated dropping pipette fitted into a plastic screw cap; and a graduated 32-oz. white porcelain cup for measuring dosages of alum and soda ash.

(2) Turbidity. Turbidity testing equipment includes a turbidimeter consisting of a viewing box complete with flashlight and four 4-oz bottles for water samples and turbidity standards. The necessary funnels, dropping pipette, filter paper, alum solution, and standard turbidity solution are provided for the preparation of turbidity standards. The white porcelain measuring cup, listed in paragraph 4. e. (1), above, is provided with a solid black circle 1½ inches in diameter in the bottom which serves for rough estimates of turbidities.

(3) Free Chlorine and Hydrogen Ion (pH). Space has been provided in the chest for the color comparator for water purification units which is now being issued as a standard item of equipment. The standard comparator is provided with a color disc for determination of free chlorine from 0.0 to 2.0 ppm and with a bromthymol blue color disc (pH range 6.0 to 7.6) for hydrogen ion determinations. Two additional color discs for hydrogen ion determinations, bromcresol-purple-green (pH range 4.4 to 6.0) and aqua-purple (pH range 7.6 to 9.2) respectively, are provided in the water quality control set. Four ounces of each of the indicator solution for pH determinations and four ounces of orthotolidine solution for determination of free chlorine are provided.

(4) Chloride. Supplies for the chloride test include a 4-oz wide mouth bottle, a 1-ml (Ives) dropping pipette, two ounces potassium chromate indicator solution and twelve ounces standard silver nitrate solution (1-ml = 5-mg Cl ion).

(5) Alkalinity. Apparatus and chemicals provided for the alkalinity test include a 4-oz wide mouth testing bottle, 1-ml (Ives) dropping pipette, two ounces phenolphthalein solution, two ounces methyl orange solution, and 12 ounces 0.1 N sulfuric acid.

(6) Hardness. Apparatus and chemicals for hardness tests include a 4-oz testing bottle, a 1-ml graduated

dropping pipette, 12 ounces of standard soap solution, 50 grams of synthetic Zeolite (Zeo-Karb-Na), and a 25-ml graduated cylinder.

(7) Sulfate. Apparatus and equipment for sulfate tests include four 4-oz wide mouth bottles, a 1-ml (Ives) dropping pipette, filter paper, funnels and 12 ounces of standard barium chloride solution.

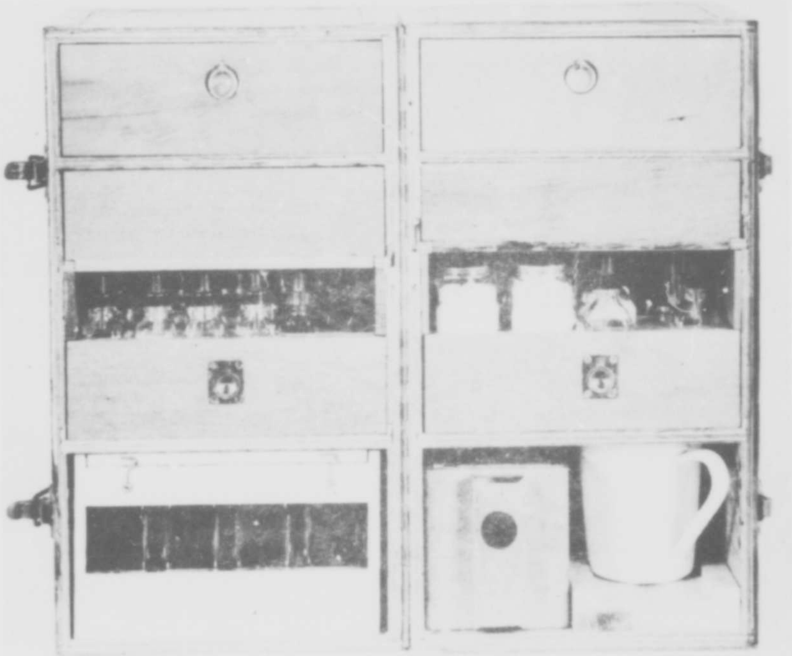
(8) Toxicity Tests. A standard Medical Department "Kit, Water Tests, Screening", is provided in the set for making the toxicity tests. The overall dimensions of the kit are 5½ in. x 3 3/4 in. x 1 3/4 in. The chemical reagents, which are all in dry form, include DB-3 reagent pellets for the detection of nitrogen mustards; zinc granules, potassium acid sulfate tablets and mercuric chloride test papers for detecting arsenic, halazone and orthotolidine tablets for the chlorine demand test; and nitrazine papers for determination of pH. Sufficient reagents are supplied to perform 15 determinations of each test.

(9) Miscellaneous Equipment and Spare Parts. Miscellaneous equipment provided in the set include two test tube brushes, one towel, one notebook, one wax marking pencil, and one lead pencil. The following spare parts are provided in the set: 14 assorted bottle caps, three 1-ml dropping pipettes (Ives) with bulbs, six dropping pipettes with bulb and plastic cap, two color comparator tubes, one 2-oz dropping bottle, and one 8-oz flocculation bottle.

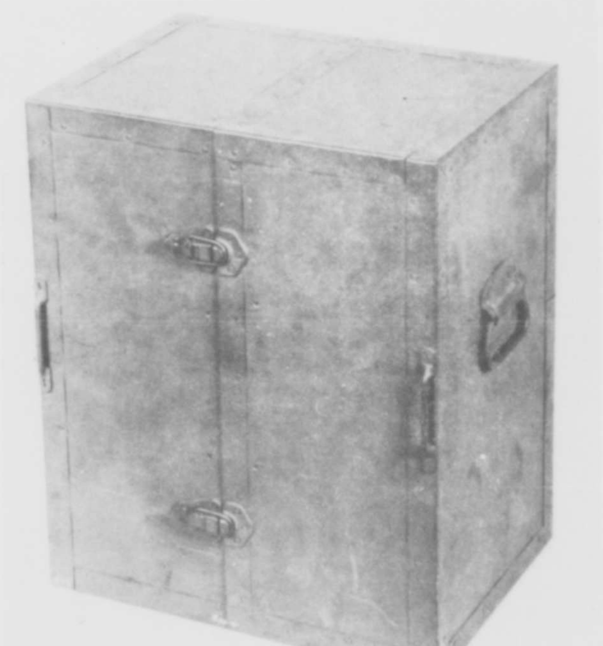
IV. DISCUSSION

5. General. The principal purpose of the water quality control set is to provide sufficient laboratory equipment for routine control testing at each water point. The set can also be used for reconnaissance purposes in selecting new sources of water supply. Free chlorine and hydrogen ion (pH) are the only tests for which equipment is available in the field at the present time. These tests provide only a partial check on water quality. In view of the short interval between the time that the water source is selected and the water is treated and consumed, any necessary tests must be performed while the water is being processed. Tests performed after water has been produced and consumed are of little significance for control in the field. Water testing in the field results in a better quality of water effluent, a more accurate report on water conditions, and a more efficient approach to new water problems.

FIG. 1. WATER QUALITY CONTROL SET. Showing component parts of set.



(a) Component parts in chest



(b) Chest closed

FIG. 2. WATER QUALITY CONTROL SET

6. Tests. Tests that can be made with the equipment provided in the set can be divided into three groups: a. Routine control tests, which include flocculation, turbidity, free chlorine, and hydrogen ion (pH); b. Salinity tests, which include chloride, alkalinity, hardness, and sulfate: c. Toxicity tests, which include nitrogen mustard, arsenic, chlorine demand, and pH (a simplified field test). A brief discussion of the various tests, placing emphasis on the purpose of the tests and on deviations from standard practice to adopt the tests to field use, are given in the following paragraphs. Wherever practicable, test solutions are of higher concentration than those normally used for water analyses in order to increase the number of determinations that can be made with the limited amounts of solutions that can be carried in the set. Instructions for performing these tests with the water quality control set are included in Appendix C.

7. Flocculation. The flocculation test is used to determine the optimum chemical dosages for best flocculation. The ammonium alum and soda ash are provided in capsules, as this form is the most convenient for field handling. Filling of capsules is done by machine, and some materials requre the addition of an inert material to secure proper weights by this method of filling. Hence, if it is found necessary to add an inert material to the alum and soda ash, sodium chloride is specified, owing to its limited effect on the flocculation process. To determine the keeping characteristics of the gelatin capsules when stored at temperatures higher than 70F, a number of capsules were kept at 150 F for a period of two weeks, at the end of which there was no evidence of softening or sticking together. No stock dropping pipettes of the required length and calibration are available for the chemical solution bottles. It was necessary to secure specially made pipettes for the purpose.

8. Turbidity. The turbidity test indicates the amount of suspended matter present in the water. The turbidimeter, which can be used either with a flashlight or direct sunlight, is suitable for the determination of turbidities from 0.5 to 10 ppm. The method of estimating turbidities by the use of the white porcelain measuring cup is based on the appearance of the $1\frac{1}{2}$-in. diameter solid black circle in the center of the bottom of the cup, the apparent color of the circle changing from black to gray as the turbidity increases. Visual memory can be relied on to detect turbidities of 5 ppm or over by this method.

9. Free Chlorine and Hydrogen ion (pH). The primary purpose of pH determinations is as a control measure for proper coagulation. Free chlorine determinations are necessary to assure that a minimum chlorine residual remains in the water after a specified length of time, to insure that the water is properly

sterilized. Sufficient amounts of the four indicator solutions for pH determinations, and of orthotolidine solution for the free chlorine test, are provided in the set for approximately 200 determinations of each test. To avoid bulkiness in the present set, and to keep changes in the existing issue of supplies to a minimum, the reserve stocks of the foregoing solutions are retained as part of the water supply equipment sets.

10. Chloride. Chlorides may be present in a water supply without being of any sanitary significance, but chlorides of a concentration higher than is found in the natural waters of the locality is an indication of present or past pollution. Well waters in certain areas are extremely brackish and unsatisfactory for drinking purposes. The chloride content either by itself, or in conjunction with the other salinity tests, indicates which of these waters are suitable for use. The test is also beneficial in checking possible sources of water supply that may be affected by ocean backwater. The silver nitrate solution provided in the set is of such concentration that 1 ml is equivalent to 5.0 mg of chloride ion instead of the standard silver nitrate solution normally used for water analyses, in which 1 ml is equivalent to 0.5 mg chloride ion. The potassium chromate indicator solution used for the test is five times the concentration of the standard solution normally used for chloride determination.

11. Alkalinity. The alkalinity test gives the amount of carbonates, bicarbonates, and hydroxides present in the water. The alkalinity determination indicates the carbonate hardness of the water, the extent to which the water is buffered, and the amount of free carbon dioxide present when the pH is known. Alum, when added to the water, reacts with an equivalent amount of alkalinity, therefore a drop in alkalinity indirectly measures the amount of alum that has been added. The sulfuric acid solution used for the test is five times the concentration of that normally used for water analyses. The phenolphthalein and methyl orange indicator solutions are two times the concentration of the standard indicator solutions. The Ives dropping pipette is especially adapted for use with the stronger solutions, as it delivers one milliliter of solution over approximately 3 inches of its calibration. Fractions of a milliliter can be readily measured with this pipette, thereby giving a sufficient degree of accuracy for field tests.

12. Hardness. The hardness test is a measure of the calcium and magnesium salts in the water. Hard water tends to destroy soap by forming an insoluble curd before a lather is produced, and such water also causes formation of scale in boilers, automobile radiators, and hot water heaters. The standard soap method is used in this set for the determination of hardness, except that the concentration of the soap solution (1 ml = 2.5 mg $CaCO_3$) is 2.5 times as

great as that used for laboratory water analyses in which 1 ml is equivalent to 1 mg of calcium carbonate. Distilled water is normally used as dilution water in making hardness determinations where more than a certain amount of soap is required to form a lather. To avoid carrying distilled water for this purpose, a synthetic zeolite is provided for preparing zero hardness water from waters that may be available in the field.

13. Sulfate.

a. Purpose. The primary purpose of the sulfate test is to determine if sulfates are present in sufficient quantity to produce physiological effects. Magnesium sulphate is the most objectionable of the sulphate salts in this respect. A simplified field method for determining magnesium is not available, but normally a low sulfate content indicates a low magnesium content. The amount of sulfate, when interpreted with the alkalinity and soap hardness, gives a measure of the non-carbonate hardness of the water, and indicates the type of scale that might be formed on heating surfaces.

b. Procedure. The sulfate test, which was developed for simplicity and to be of sufficient sensitivity for field use, deviates considerably from the gravimetric and turbidimetric methods normally used in the laboratory. The latter tests are conducted by using a barium chloride solution of approximate concentration, that is a solution that is not standardized in terms of its sulfate equivalent. An excess of the solution is used to insure that all of the sulfate ion is precipitated as barium sulfate. The sulfate present is read in terms of the weight of precipitate formed, or of the turbidity produced. In the sulfate test, as provided in the set, a standard barium chloride solution having a known sulfate equivalent is added to the water sample to precipitate a definite amount of sulfate ion. The precipitate is removed by filtration and the resulting solution is tested with more barium chloride solution to determine if all the sulfate has been removed. This procedure is continued with fresh samples of water using increasing amounts of barium chloride solution until the addition of barium chloride after filtration gives no precipitate, showing that all of the sulfate ion has been removed. The lowest concentration of sulfate which can be determined by this method is 50 ppm. Likewise the smallest increment of sulfate content that can be determined by each successive trial is 50 ppm. The instructions for performing the test recommend starting at 100 ppm sulfate and making successively higher determinations in steps of 100 ppm sulfate. The test is outlined in this manner to enable it to be performed in a minimum period of time and still provide the sensitivity required for a field test. Barium sulfate is normally precipitated in a solution mildly acid with hydrochloric acid. To avoid the necessity of providing an additional supply of hydrochloric acid in the set, the barium chloride solution is prepared in a 2.0 normal hydrochloric acid solution.

14. Toxicity Tests. The Medical Department "Kit, Water Testing, Screening", is included in the set for the purpose of checking raw water supplies for the presence of the chemical warfare agents which are most likely to be found in areas where war gases have been used. As the name of the kit implies, the kit is for "screening" purposes only, or in other words, it is for the elimination of water sources which are unsatisfactory due to being contaminated with chemical warfare agents. Materials are provided in the kit for the following tests:

a. Arsenic. The arsenic test is performed by a modification of the well known Gutzeit method, the modification being made to simplify the test to make it suitable for field use. The test is used for the detection of the arsenical group of warfare agents, the most common of which is Lewisite.

b. Nitrogen Mustard. A special reagent, which is termed DB-3 by the Medical Department in lieu of its actual formula, is required for the detection of nitrogen mustard. The test is simple to perform, and is capable of detecting nitrogen mustard in concentrations as low as 5 ppm.

c. Chlorine Demand. A number of chemical warfare agents, including Lewisite and mustard, consume free chlorine at a rapid rate and in quantities roughly equivalent to the amount of chemical agent present. A water having a high chlorine demand should be regarded with suspicion. A 5-minute chlorine demand of 5 ppm or greater is taken as evidence of contamination by chemical warfare agents. The chlorine demand test does not specify any particular substance.

d. Hydrogen Ion (pH). Certain chemical agents, especially Lewisite and mustard, hydrolyze readily in water to form acids, and in so doing lower the pH. Based on the normal pH trends in natural waters a pH below 6.0 is indicative of contamination.

V. CONCLUSIONS

15. Conclusions. It is concluded that:

a. There is a definite need for field laboratory equipment for routine control testing at each water point.

b. The water quality control set, covered by this report, is suitable for the purpose.

VI. RECOMMENDATIONS

16. Recommendations. It is recommended that:

a. The water quality control set proposed in this report be adopted as a standard item of equipment.

b. Basis of issue be as follows:

1. 1 each for Water Supply Equipment Set No. 1 (Engineer)

2. 1 each for Water Supply Equipment Set No. 4 (Topo Battalion)

3. 2 each for Water Supply Equipment Set No. 5 (Water Supply Company)

c. Corps of Engineers Tentative Specification No. T-2024A, "Water Quality Control Set, No. 1, Field Use" be used in effecting procurement.

Submitted by:

Ernest H. Sievka
Ernest H. Sievka
Assistant Engineer, Chemical
Water Supply Equipment Branch.

Hayse H. Black
Hayse H. Black
Captain, Corps of Engineers
Chief, Water Supply Equipment Branch.

Forwarded by:

Karl F. Eklund
Lt. Colonel, Corps of Engineers
Director, Technical Division III

APPENDIX A

AUTHORITY

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON

671 (SP 315)-1A
400.112

6-D
September 29, 1941

Subject: Modification of Engineer Board Subprojects.

To: The President,
The Engineer Board,
Ft. Belvoir, Virginia.

1. Reference is made to the attached Report, dated September 22, 1941, of a Board of Officers on Engineer Board Subprojects, which was approved by General Kingman on September 24, 1941.

2. Necessary administrative action will be taken, without delay, to carry out the approved recommendations contained in the report.

* * *

By order of the Chief of Engineers:

C. L. Adcock,
Lt. Colonel, Corps of Engineers,
Executive Officer.

1-Incl. in dup.
Report "Board of Officers"
noted in par. 1 above.

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON

671 (SP 315)-1A 6-D
400.112 September 22, 1941

Subject: Report of Board of Officers on Engineer Board Projects.

MEMORANDUM for the Chief of Engineers:

1. In accordance with the instructions contained in a memorandum dated July 25, 1941, the Board of Officers appointed by that memorandum has considered all projects now before the Engineer Board. After a thorough study of the development work being prosecuted, it was concluded that very few of the subprojects should be eliminated and, further, that there are only a small number that should be moved from an "active" to an "inactive" status.

* * *

Paragraph 3e (14). That the directive for SP-315, Water Supply, General, be changed to the following:

> In this subproject will be included these miscellaneous water supply investigations on items of equipment, manuals, and instruction sheets not elsewhere provided for. This subproject will be carried in Priority G-2.

* * *

R. F. Fowler,
Colonel, Corps of Engineers,
Chief, Operations & Training Section.

APPROVED Sept. 24, 1941.

/s/ J. J. Kingman
Brig. Gen.
Assistant to the Chief of Engrs.

R. G. Moses,
Colonel, Corps of Engineers,
Chief, Supply Section.

C. H. Chorpening,
Major, Corps of Engineers,
Chief, Development Branch, Supply Section.

WAR DEPARTMENT
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA

671 (WS 315 C) December 29, 1942.

Subject: Examination of Water and Water Control in the Field.

To: THE CHIEF OF ENGINEERS, U. S. Army.
(Attention: Lt. Col. F. S. Besson, Jr., Engineering and Development Branch Supply Division).

1. Attached hereto is a memorandum prepared by Lt. Col. Jack J. Hinman, Jr., which pertains to the subject of examination of water and water control in the field.

2. The Engineer Board has done considerable work on developing portable field laboratory equipment designed for use by technical personnel charged with the responsibility of producing potable water for troops in the field. Portable equipment has been divided into three sets in the interest of flexibility and to limit the weight of each unit so that it may be readily handled. The objective in this work is to make available field laboratory facilities having application in an echelon system of water control as described in Colonel Hinman's memorandum.

For the Board:

Peter P. Goerz,
Colonel, Corps of Engineers,
Executive Officer.

1 Incl. (in dup.)
Memo Lt. Col. J. J. Hinman, Jr. to Col. Goerz.

671 (WS 315 C) SPESD.

Subject: Examination of Water and Water Control in the Field.

1st Ind.

Office, C. of E., Room 1403, Temporary Bldg. G, 23rd & C Streets, N. W., January 23, 1943.

To: The President, The Engineer Board, Fort Belvoir, Virginia.

1. This office has informed the Operations and Training Branch as to the contents of Lt. Colonel Hinman's memorandum on the subject of examination of water and water control in the field.

2. The scope of future work in the development of field laboratory equipment by the Engineer Board has not as yet been determined. However, this office is trying to obtain an expression from the Operations and Training Branch on this subject. As soon as this point has been clarified, the Engineer Board will be notified.

By order of the Chief of Engineers:

R. F. Harvey,
Captain, Corps of Engineers,
Acting Executive Officer,
Engineering and Development Branch,
Supply Division.

1 Incl.
n/c.

JJH/mcf
December 18, 1942.

Memorandum to: Colonel Goerz.

Subject: Examination of Water and Water Control in the Field.

1. There has been considerable discussion concerning the procedure for water supply control in the field. Studies have been made concerning the organization of Engineer Water Control Organizations and discussions have been held concerning them. The general opinion has been that they were unduly large and unwieldy. There has been reluctance to establish such organizations. The O & T of the O. C. E. initiated a series of letters looking to a clarification of the division of responsibility between the Medical Department, the Chemical Warfare Service, and the Corps of Engineers. The final results of this work are not definitely known by the Water Supply Branch of the Engineer Board at the present time. However, it seems generally agreed that the Medical Department will be responsible for the inspection of water supplies, including bacteriological testing and detection of Chemical Warfare agents, leaving the Corps of Engineers chiefly free chlorine determinations and routine chemical tests. The boundary line of duties, however, remains uncertain.

2. The feeling of the Medical Officers and Sanitary Corps Officers who have been contacted seems to be essentially that the Medical Department, in line with its usual assigned duty of safeguarding the health of the troops, will make inspections and analyses to assure the safety of drinking water supplied to military personnel. They do not expect to furnish the routine chemical and bacteriological investigations which are generally considered necessary in water works practice to insure safe water at all times and assure the regular functioning of the purification equipment. The analogy in civilian life is the control exerted by the state departments of health over the water purification performance of city water departments. In general the state control can be a most useful factor, but it does not go into the detail necessary to insure satisfactory functioning of water supply equipment and consequently most city water departments of any size have their own laboratories and personnel who do many more water analyses than the state departments can undertake for them.

3. During World War I mobile and portable water purification equipment aside from lyster bags, was not generally supplied to Engineer organizations as it is today. The front was sufficiently

stable to permit Companies of the 26th Engineers, the Water Supply Regiment, to undertake area control, furnishing water in bulk to water points from which the water was taken forward to the lines. The Engineers were responsible for the character of the water up to the water points. The Medical Department was responsible for the quality of the water from the water point to the consumer. Officers of the Sanitary Corps were assigned to Companies of the 26th Engineers, to Divisions, to Armies, to Corps, to Base Sections, and to other designated areas. These officers supervised water supply matters minutely. The officers assigned to the Base Section areas and companies of the 26th Engineers supervised water purification in detail, specifying doses of chemicals and frequently being responsible for plant operations. The present decentralized method of procuring and purifying water places a much heavier burden on the Engineers. They will need close control over water treatment. It is unofficially understood that the original plans to supply Sanitary Corps officers down to and including Divisions have been tentatively set aside in view of a plan of providing Sanitary Corps officers for water control down to Corps. So far no information is available as to whether such officers will be supplied to Water Supply Battalions.

4. In view of the indeterminate status of this matter it has been Colonel Baker's suggestion that the Engineer Board, while awaiting decision as to the personnel to do this work, concentrate upon the development of equipment for analytical work and on what work is to be done rather than who is to do it. Tentatively, plans have been made for four echelons of water control as follows: First echelon, control by the operator of the purification unit, portable or mobile. Second echelon, control by the officer in charge of a group of purification units, either of the Divisions or of a Company of the Water Supply Battalion. Third echelon, control by some officer in a higher unit such as the Corps or the Water Supply Battalion. Fourth echelon, control by an officer of a unit such as an Army.

5. Equipment for the echelons would be: First echelon, a small chest with minimum equipment. Second echelon, a chest about the size of a suitcase with somewhat more equipment. Third echelon, a large chemical chest and a large bacteriological chest. Fourth echelon, a truck-mounted mobile laboratory, probably capable of being demounted from the truck for temporary use in place.

6. Concerning the various determinations to be made: First echelon. Present equipment provides for pH (6.0 to 7.6), free chlorine (0.05 to 1.0). Formerly the U. S. Geological Survey turbidity rod was supplied with mobile units. This permits determination of turbidity down to 25 ppm which is a very noticeable turbidity. Consequently, this turbidity rod is of no use in measuring

the turbidity of treated water, which is the important question. Proposed equipment to determine, (1) pH 4.5 to 8.5, (2) Free chlorine 0.1 to 2 and in larger steps to a probably maximum 20.0, (3) Turbidity down to 1.0 or 2.0 using a modified St. Louis turbidimeter, (4) Determination of optimum flocculation point, (5) Two or three sample bottles and data blanks for sending specimens back to next higher echelon. Second echelon. No existing water supply control set. Proposed equipment for the following determinations: (1)pH (4.0 to 11.0), (2) Free chlorine (0.1 to 2.0) and in larger steps to 20.0 as above, (3) Turbidity from 1.0 ppm upward as above, (4) Optimum flocculation point as above or by slightly more appropriate device, (5) Chlorine demand for the detection of war gases, (6) Qualitative or rough quantitative salinity (combined chlorine), (7) Qualitative or rough quantitative of sulfate ion (SO_4), (8) Qualitative or rough quantitative for sulfite (SO_3), (9) Two or three sample bottles with data blanks for sending samples back to next higher echelon. Third echelon. No existing set. Proposed equipment represents that necessary for a higher trained technical water laboratory man, for field use. It is intended that this equipment be set up in a carryall, in two chests capable of operating in the carryall or being demounted for setting up in semi-permanent location. Additional chests of smaller size may be required for reserve stocks of reagents and culture media.

(A) Chemical determinations: (1) pH (4.0 to 11). (2) Free chlorine (0.5 to 1.0) and in larger gradation to 20.0 as above, (3) Turbidity 0.1 ppm upward as above, (4) Optimum flocculation point: Same apparatus as above or simple device with mechanical stirrer, (5) Chlorine demand for detection of war gases, as above, (6) Quantitative determination of alkalinities and hardness, (7) Quantitative determination of chlorides (Cl), (8) Quantitative determination of sulphates (SO_4), (9) Quantitative determintaion of sulphites (SO_3), (10) Quantitative determination of nitrates (N as NO_3), (11) Quantitative determination of nitrites (N as NO_2), (12) Quantitative determination of iron (Fe), (13) Quantitative determination of manganese (Mn), (14) Quantitative determination of arsenic (As), (15) Quantitative determination of heavy metals, especially lead and mercury (Pb, Hg), (16) Quantitative determination of oxygen consumed by permanganate, (17) Possibly quantitative determination of the following: phosphates, (PO_4), silicon (SiO_2), selenium (Se), ammonia (N as NH_4), alkaloids.

(B) Bacteriological determinations: (1) Fermentation in lactose broth with one and ten ml. quantities of water, (2) Confirmation of positive fermentation tests in lactose broth by the use of lactose brilliant green peptone bile medium, (3) Possible further confirmation of coliform bacteria on plates or slants of eosine methylene blue agar, (4) Possible microscopic examination of agar slant cultures for spores, (5) Bacterial counts on plain agar or litmus lactose agar after incubation for 24 hours at 37°C, (6) Several sample bottles suitable for sending samples back to next higher echelon.

Fourth echelon. This is equipment which will permit very complete study of water problems incapable of solution in the lower echelons and will also permit the checking of any work conducted by a lower echelon and extending inquiries into unexpected fields requiring higher trained personnel and extensive experience and facilities for solution.

(A) Chemical determinations: All of the determinations capable of being made by the third echelon set plus the following: total organic nitrogen, thallium, chromium, dissolved oxygen. The Jackson and U. S. Geological Survey turbidity rod should supplement the St. Louis turbidimeter. The optimum flocculating point apparatus should be power driven.

(B) Bacteriological determinations: As in the third echelon, with the addition of facilities for work on plankton including protozoa, (ameba), worms, etc. Several sample bottles should be supplied for sending specimens back to base laboratories, where even more elaborate equipment may be provided or to special research laboratories operated under the control of the National Defense Research Council or similar bodies.

7. The plan of this scheme of control provides for the handling of routine water plant checking in the first echelon, with each higher echelon equipped to repeat and control the accuracy of the work of subordinate echelons and to handle increasingly difficult problems which may be expected in the field. Appropriate rank for the individuals in charge of each echelon would be somewhat as follows: First echelon, Sergeant in charge of purification unit with the assistance of other personnel at the producing water point. Second echelon, Lieutenant or Captain, Corps of Engineers, in charge of purification units of Division, Organizations of Water Supply Companies, Water Supply Battalion. Probably one enlisted technician. Third echelon, Lieutenant or Captain, highly trained officer of the Sanitary Corps or the Corps of Engineers assisted by one or two qualified technicians and driver of carryall. Fourth echelon, Major, highly trained officer of Sanitary Corps or Corps of Engineers assisted by several highly trained technicians, possibly a highly qualified junior officer of the Sanitary Corps or Corps of Engineers and the driver of the mobile laboratory truck.

Jack J. Hinman, Jr.,
Lt. Colonel, Corps of Engineers,
Chief, Water Supply Branch.

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON

671 (WS 315 C) SPESD   February 2, 1943.

Subject: Water Treatment Control Tests.

To: The President,
The Engineer Board,
Fort Belvoir, Virginia

1. Attention is invited to the Engineer Board's November 1942 report on Research and Development. On page 38, of the above report, under Serial No. WS 315 C, there is shown a project entitled "Field Water Quality Control".

2. It is realized that the responsibility for field water treatment control has been in a state of indecision until December 11, 1942 when the Commanding General, Services of Supply, charged the Medical Department with the responsibility for all tests of water, except chlorine demand, to determine potability. In view of the uncertainty as to the responsibility for the testing of field water and the development of adequate equipment for so testing, the Engineer Board is to be commended for initiative displayed in developing field kits for the above purpose.

3. In view of the directive from the Commanding General, Services of Supply, in which the responsibility for testing water was clearly defined, the Troops Division was asked to inform this office if further work was desired in developing the field water control kits under construction at the Engineer Board.

4. A brief statement of directives issued by the Commanding General, Services of Supply, relative to the policy regarding Water Treatment Control Tests and tests for Contaminated Water, as shown in a memorandum from General Sturdevant to General Fowler, dated January 16, 1943, is as follows:

a. The Corps of Engineers is responsible for the routine control tests required for the production of a potable water in the field, such as hardness, alkalinity, pH, turbidity, color, odor and taste; also for routine tests of chlorine residual and chlorine demand of the water. When the routine testing indicates a chlorine demand of greater than 4 ppm, poisoning of the water by chemical agents is to be suspected, and the matter brought to the attention of the Medical Department.

b. The Medical Department is responsible for all necessary laboratory tests to determine the potability of water in the field, including bacteriological tests, mineralogical tests, tests for the presence of chemical warfare agents, toxic compounds, and deleterious substances, other than by the routine test of chlorine demand. One Sanitary Corps officer is to be assigned to each Division Corps and Army Staff and each Task Force Headquarters for this purpose. These officers are to be given a one month course in general sanitation at the Medical Field Service School and a short orientation course at the C.W.S. school prior to assignment to such duties.

c. The Chemical Warfare Service has no responsibility for the production, analysis, or control of water in the field.

5. In the memorandum mentioned in paragraph 4 of this letter, it is further stated: "In view of the fact that the Engineer Board has so nearly completed the development of the field water testing equipment, it is recommended that this project be completed at an early date, but that no procurement beyond the pilot models be made. It is further recommended that no action be taken by the Engineer Board on the development of a mobile laboratory for water testing purposes, as this is now a function of the Surgeon General's Office."

6. Information on this project has been forwarded to the Commanding General, Services of Supply, with a request that the Surgeon General be informed of the availibility of the results of the testing equipment as developed by the Corps of Engineers if the Medical Department cares to avail itself of the data assembled.

7. In view of the decisions reached by the Commanding General, Services of Supply, and the Troops Division, it is directed that the Engineer Board complete the development of the water control testing kits, other than the mobile laboratory. In the event the Medical Department desires to avail itself of the data assembled by the Corps of Engineers, the Engineer Board will be so informed.

8. Copies of pertinent correspondence relative to this subject are inclosed for the Engineer Board's information.

By order of the Chief of Engineers:

F. C. Kendall,
Major, Corps of Engineers,
Executive Officer,
Engineering and Development Branch,
Supply Division.

2 Incls. (Copy).
History of Determination of Policy Regarding Water Treatment Control Test & Tests for Contaminated Water. dtd 1-15-43 w/incl. SPRMD 2nd Ind. to C of E. dtd 12-2-42.

SPESD
671 (WS 315 C)

Subject: Water Treatment Control Test.

1st Ind.

The Engineer Board, Fort Belvoir, Virginia, April 19, 1943

To: THE CHIEF OF ENGINEERS, U. S. ARMY.

1. Complying with the basic communication, the Engineer Board has completed the water control testing kits as directed. Inclosed herewith are pictures showing this portable field laboratory equipment.

2. Colonel Stone and Major Clarke, Office of the Surgeon General, have inspected this portable field laboratory equipment at Fort Belvoir. These officers were promised pictures of these water control testing kits. Extra prints of these pictures are inclosed for forwarding to the Office of the Surgeon General.

3. Analytical determinations which may be performed with this laboratory equipment are listed in the inclosed table. A report on this project is in process of preparation and will be submitted, at an early date, to the Office, Chief of Engineers.

For the Board:

Peter P. Goerz,
Colonel, Corps of Engineers,
Executive Officer.

9 Incls.
Incls. 1 and 2 - n/c
Incls. 3-8 - Photo. Nos.
61-3-11 to 16 (in quad.)
Incl. 9 - Table (1st, 2nd,
3rd Echelon) (in dup.)

671 (WS 315 C) SPESD   Subject: Water Treatment Control Tests.

2nd Ind.

Office, C. of E., Room 1401, Tempo Bldg. G., 23rd & C Streets, N. W., May 14, 1943.

To: The President, The Engineer Board, FORT BELVOIR, VIRGINIA.

1. The pictures inclosed with the 1st indorsement showing the portable field laboratory equipment developed by the Engineer Board have been forwarded to the office of the Surgeon General.

2. The report being prepared by the Engineer Board on this project should be of considerable interest to the Surgeon General's office. It is therefore directed that the report in question be submitted to this office at the earliest practicable date, in order that pertinent information contained therein can be made available to the office of the Surgeon General.

By order of the Chief of Engineers:

E. L. Knutson,
Captain, Corps of Engineers,
Assistant, Engineering and Development Branch,
Supply Division.

3 Incls.
Incls. 1 & 2 - n/c.
Incl. 3 - Table (1st, 2nd, 3rd Echelon). (1 Cy w/d)
Other Incls. w/d

WAR DEPARTMENT
HEADQUARTERS, SERVICES OF SUPPLY
Washington, D. C.

SPRMD 671

PAK:EM
71795

September 26, 1942.

Subject: Water Treatment Control Tests.

To: Chief of Engineers - Attention: Development Branch Supply Division.

1. Reference is made to letter, above subject, from Office of the Chief of Engineers to Commanding General, Services of Supply, dated August 22, 1942, file CE 671 SPETO.

2. The Surgeon General states that under field water supply conditions primary reliance for safety of the water must be placed on the test for chlorine residual. Bacteriological tests are of value as a check on the effectiveness of chlorine residuals but are of very limited use as an acceptance test for troops in the field since 24 to 48 hours must elapse before results of the tests are available, by which time a new source of water may be in use. These chlorine residual tests can be conducted in a few minutes and performed readily by the Engineer personnel operating the portable and mobile water purification units. Therefore development and standardization of bacteriological equipment for field use is not favorably considered.

By command of Lieutenant General SOMERVELL:

W. A. WOOD, JR.,
Brigadier General, General Staff Corps,
Director, Requirements Division.

/s/ R. R. ROBINS,
Colonel, General Staff Corps,
Chief, Development Branch.

December 2, 1942

Subject: Water Treatment Control Tests and Tests for Contaminated Water.

SPRMD 720.21 (9-26-42) 2nd Indorsement PAK:em 71795

Headquarters, Services of Supply, Washington, D. C.
To: Chief of Engineers.

Attention: Operations and Training Branch, Troops Division.

Chief of Chemical Warfare Service
Attention: Preventive Medicine Division IN TURN

1. The recommendations contained in Paragraph 5, 2nd Indorsement, Inclosure No. 1, as modified by the 1st Indorsement hereto, are approved.

2. In view of the above, Chemical Warfare Service, Development Project D 3.6-1, "Methods of Tests of Contaminated Water" will be cancelled.

By command of Lieutenant General SOMERVELL:

W. A. Wood, Jr.,
Brigadier General, General Staff Corps,
Director, Requirements Division.

2 Incls. n/c

R. R. Robins,
Colonel, General Staff Corps,
Chief, Development Branch.

FOR RECORD:

1. Action initiated by this Hq. to CG, AGF, Subject, "Water Treatment Control Tests and Tests for Contaminated Water", File SP 720.21, dated 9-26-42, forwarding 2 incls. & inviting special attention to par. 5, 2nd Ind. of incl. No. 1, states Ch/Engrs has been informed that it is unnecessary to continue development and standardization of bacteriological equipment for field use.

2. 1st Ind. fr. Hq., AGF to CG, SOS, dated 11-10-42, concurs in recommendations contained in par. 5, 2nd Ind., incl. No. 1, except that par. 5a (3) should read as follows: "The Medical Department be charged with making the necessary additional Laboratory tests to insure a safe water, these to include bacteriological tests,

mineralogical tests, and other tests, other than chloride demand for the presence of chemical warfare agents, toxic compounds and deleterious substances". 1st Ind. states Sanitary Corps Officer should be provided only on Army Staff or separate Task Force Hq.; Officers detailed should be given one month refresher course in general sanitation at Med. Field Service School & short orientation course at CWS school prior to duty.

3. Incl. No. 1 is a ltr fr Ch/Engrs. to CG, SOS, subject, "Water Treatment Control Tests", dated 8-22-42, suggesting that TSG be designated as sole agency in charge with water sampling and testing and with the necessary further development and standardization of bacteriological equipment, that a Sanitary Corps Officer be added to Med. Dept. of Engr. organizations, both utilities and tactical units, which would use the proposed control tests; in 2nd Ind. to this Inc., TSG states that bacteriological tests under field conditions are unnecessary. Par. 5, 2nd Ind., incl recommends that: "a. In Theaters of Operation (1) C/E personnel be charged with responsibility for routine testing for chlorine residuals to insure that water delivered by the purification equipment, whether portable or mobile units, or fixed plants, contain at all times the prescribed amount of chlorine; or to determine that such chlorine residual cannot be maintained with the addition of 5 ppm of chlorine to filtered water. (2) C/E personnel be charged with the performance of routine physical & chemical tests as outlined in Par. 1, c. (3) The Med. Dept. be charged with making the necessary additional tests to insure a safe water, these to include bacteriological tests & tests, other than a chlorine demand, for the presence of chemical warfare agents or other toxic compounds." "b. No change be made in existing arrangements for water treatment control tests in the Z of I." "c. Sanitary Corps Officers not be assigned to Med. Detchmts of Engr. organizations". "d. An officer of the Sanitary Corps be provided in each Army, Corps, Division, & Task Force, as Asst. to Med. Inspector, to discharge the responsibilities of the Med. Dept. with reference to the quality of water supplies."

4. Incl. 2 is a ltr. fr Hq., EA to Ch/Med. Res. Div., subject, "Test for Contaminated Water (Proj. D 3.6-1)", dated 8-12-42, SP 720.21 stating that the Ch/Med. Res. Div. asked to have this project cancelled on the basis that it is a responsibility of TSG; states that CWS & TSG are to furnish technical aid to C/E in the field; states CWS is responsible in field for having suitable tests developed which can be applied by field lab. personnel to examine water; in 2nd Ind. TSG states AR 40-205, Par. 10, imposes upon Med. Dept. such responsibility; 2nd Ind. states tests have been developed by TSG that are sensitive to detect the presence of harmful amts. of chemical warfare agents & simple enough to be used under front line conditions; in 6th Ind. TSG inclosed a copy of 2nd Ind. to Incl. 1, explained above.

5. This paper transferred informally on 11-14-42 from this Hq. to Dir. of Training, SOS for necessary action; paper returned on 11-28-42 by memo stating correspondence is returned for necessary action as subject matter does not come within purview of Training Div., SOS.

6. Distribution: CG, AGF (Att: Dev. Div., Req. Sect.);
Ch/Engrs (Att: Operations & Training Br., Troops Div.);
Ch/CWS (Att: Tech. Div.);
TSG (Att: Preventive Med. Div.)

2 Incls. n/c

January 15, 1943

History of the Determination of Policy Regarding

Water Treatment Control Tests and Tests for Contaminated Water

1. Reference is made to a letter from the Chief of Engineers to the Commanding General, S.O.S., subject: "Water Treatment Control Tests", dated August 22, 1942 requesting clarification of the responsibility for Water Treatment Control Tests, the development of field methods for these tests, and suggesting that the Surgeon General be designated as the sole agency charged with sampling and testing, both as to the proposed water treatment control tests and the acceptance for use tests. This letter was indorsed by the Commanding General, S.O.S., to the Surgeon General (Col. Hardenbergh, Sn. Corps), who, in turn, returned it to the Commanding General, S.O.S. by second indorsement. This second indorsement recommended that:

"a. In Theaters of Operation:

"(1) Corps of Engineers personnel be charged with responsibility for routine testing for chlorine residuals to insure that water delivered by the purification equipment, whether portable or mobile units, or fixed plants, contain at all times the prescribed amount of chlorine; or to determine that such chloride residual cannot be maintained with the addition of 5 parts per million of chlorine to filtered water.

"(2) Corps of Engineers personnel be charged with the performance of routine physical and chemical tests, including those for pH, chlorine residual, turbidity, color, alkalinity, hardness, taste and odor.

"(3) The Medical Department be charged with making the necessary additional tests to insure a safe water, these to include bacteriological tests and tests, other than a chlorine demand, for the presence of chemical warfare agents or other toxic compounds.

"b. No change be made in existing arrangements for water treatment control tests in the Zone of Interior.

"c. Sanitary Corps officers not be assigned to Medical Detachments of Engineer organizations.

"d. An officer of the Sanitary Corps be provided in each Army, Corps, Division, and Task Force as Assistant to the Medical Inspector, to discharge the responsibilities of the Medical Department with reference to the quality of water supplies."

2. Reference is made to a letter from the Headquarters, Services of Supply to the Chief of Engineers, file SPRMD 671, subject: "Water Treatment Control Tests", dated September 26, 1942, a copy of which is inclosed, which states that "....Therefore development and standardization of bacteriological equipment for field use is not favorably considered."

3. a. Reference is made to a letter from Headquarters, Edgewood Arsenal to the Chief, Medical Res. Division, subject: "Test for Contaminated Water (Proj. D3.6-1)", dated August 12, 1942, file SP 720.21, which requested that Proj. D3.6-1 be cancelled on the basis that it is a responsibility of the Surgeon General, states that the Chemical Warfare Service and the Surgeon General are to furnish technical aid to the Chief of Engineers in the field, and further states that the Chemical Warfare Service is responsible in the field for having suitable tests developed which can be applied by field laboratory personnel to examine water.

b. By 1st indorsement, dated August 17, 1942, that letter (3a above) was sent to the Surgeon General for information and appropriate action.

c. By 2nd indorsement, dated August 25, 1942, the letter was sent by the War Department, Services of Supply, to the AG with comments and a clarification of policy in regard to responsibility for the testing and approval of the quality of water contaminated by chemical warfare agents or other toxic compounds.

d. By 3rd indorsement dated August 27, 1942, the letter was sent to the Chief of Engineers by the AG and returned to the Commanding General, S.O.S. by the Chief of Engineers by 4th indorsement dated September 3, 1942. This 4th indorsement suggested that the correspondence be forwarded to the Surgeon General for consideration along with the letter mentioned in par. 1 above. This was done and the Surgeon General indorsed the letter back to the Commanding General, S.O.S. with a copy of the second indorsement quoted, in part, in par. 1 a, b, c and d above.

4. a. Reference is made to letter from Commanding General, S.O.S. to the Commanding General, Army Ground Forces, subject: "Water Treatment Control Tests and Tests for Contaminated Water", file SP 720.21, dated September 26, 1942 in which the

letters and indorsements mentioned in paragraphs 1 and 3 above were referred to the Army Ground Forces for comment. The first indorsement, to this letter from the Commanding General, A.G.F. to the Commanding General, S.O.S., dated November 10, 1942 concurred in the recommendations given in quoted paragraphs 1 a, b, c, and d above except that 1a (3) above to read as follows:

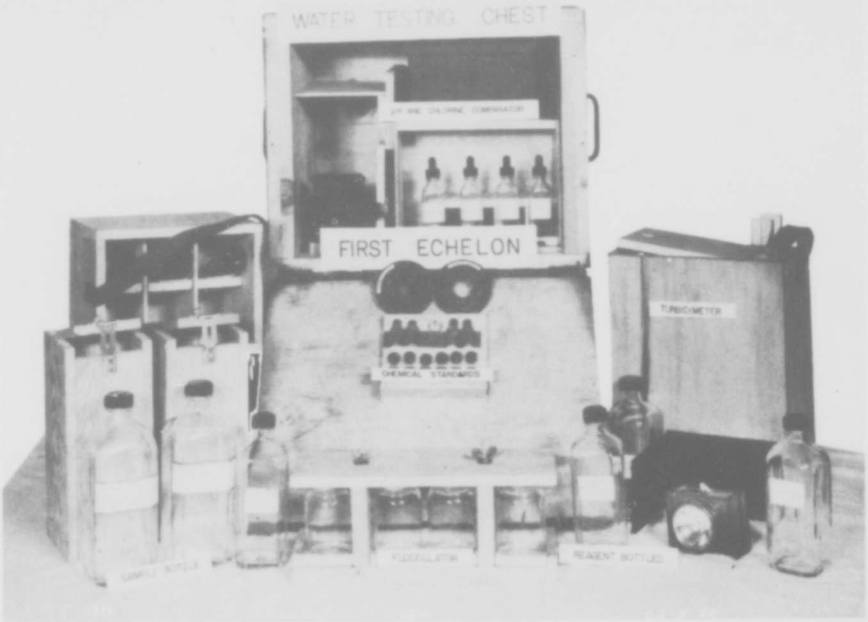
"The Medical Department be charged with making the necessary additional laboratory tests to insure a safe water, these to include bacteriological tests, mineralogical tests, and other tests, other than chloride demand for the presence of chemical warfare agents, toxic compounds and deleterious substances".

and, except that par. 1d above be changed to state that Sanitary Corps officers should be provided only on Army Staff or Separate Task Force Headquarters and that officers so detailed should be given one month refresher course in general sanitation at Medical Field Service School and a short orientation course at Chemical Warfare Service School prior to duty.

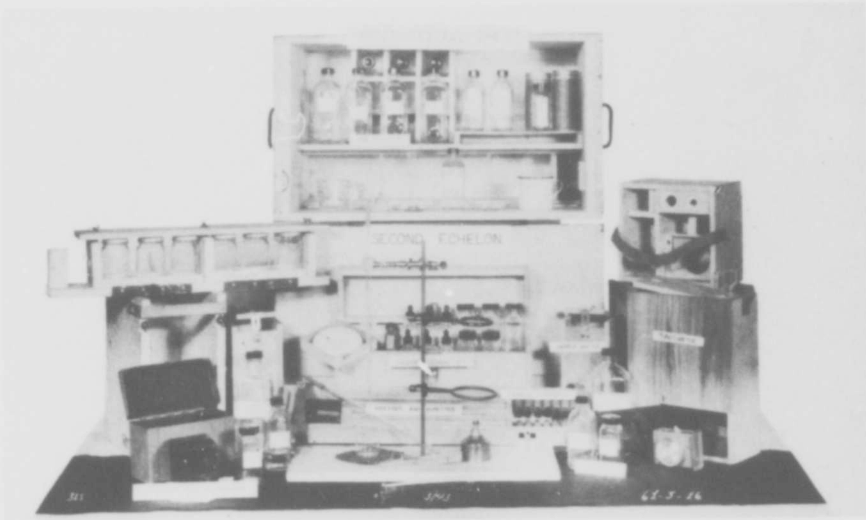
b. By 2nd indorsement, that letter (par. 4a above) was sent by Headquarters, S.O.S. to the Chief of Engineers (O&T Branch, Troops Division) and the Chief of the Chemical Warfare Service (Preventative Medicine Division), in turn; approved the recommendations as given in paragraphs 1 a, b, c, and d above, and as amended by the 1st indorsement mentioned in paragraph 4a above; and directed the Chemical Warfare Service to cancel their Development Project D 3.6-1, "Methods of Tests of Contaminated Water".

/s/ George H. Taylor,
Lt. Col., Corps of Engineers,
Assistant, Operations and Training Branch,
Troops Division.

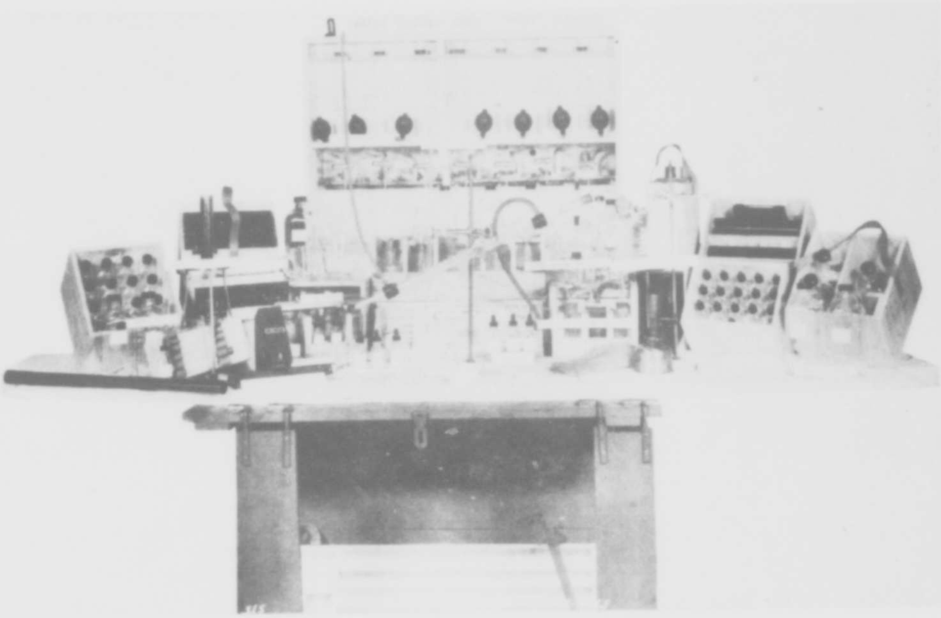
1 Incl.
Cy ltr 9-26-42
fr Hq. SOS to C of E.



FIRST ECHELON WATER TESTING CHEST



SECOND ECHELON WATER TESTING CHEST



THIRD ECHELON WATER TESTING CHEST

ECHELON CHESTS, CLOSED VIEW

Portable Field Laboratory Equipment
Developed by
The Engineer Board, Fort Belvoir, Virginia

April 1943

I. First Echelon

a. Hydrogen ion (pH) 4.4-8.8

b. Turbidity 0-5 ppm

c. Flocculation - optimum dosage

d. Free chlorine 0.0-20 ppm

II. Second Echelon

a. Hydrogen ion (pH) 4.4-8.8

b. Turbidity 0-5 ppm St. Louis Turbidimeter

c. Flocculation - optimum dosage

d. Free chlorine 0-20 ppm

e. Chlorine demand

f. Chlorides

g. Sulfates

h. Thiosulfate

III. Third Echelon

a. Hydrogen ion 4.4-10.2

b. Turbidity 0-5 ppm St. Louis Turbidimeter
Higher turbidities Jackson Turbidimeter

c. Flocculation

d. Free chlorine 0-250 ppm

e. Chlorine demand

f. Chlorides

g. Sulfate

h. Thiosulfate

The above except for Jackson turbidimeter are included in second echelon.

i. Soap hardness

j. Alkalinity

k. Magnesium

l. Nitrite

m. Nitrate

n. Ammonia

o. Dissolved oxygen

p. Iron

q. Phosphates

In addition to the chlorine demand test mentioned above, the following toxicity tests can be performed.

r. Arsenic

s. Heavy metals

t. Cyanide

APPENDIX B

SPECIFICATIONS AND DRAWINGS

CORPS OF ENGINEERS
TENTATIVE SPECIFICATION

No. T-2024A
WATER QUALITY
CONTROL SET
17 August 1944
Superseding No. T-2024
12 June 1944

WATER QUALITY CONTROL SET, NO-1, FIELD USE

A. APPLICABLE SPECIFICATIONS AND DRAWINGS.

A-1. Specifications. - The following specifications of the issue in effect on date of invitation for bids, unless otherwise indicated, form a part of this specification, except that in case of conflict, the requirements of this specification shall govern.

A-1a. Federal Specification. -
DD-B-591. Bottles; Prescription.

A-1b. Emergency Alternate Federal Specification. -
E-H-B-126. 20 May 1942. Brushes; Beaker, Burette, Cylinder, and Test Tube.
E-W-F-421a. 4 Feb. 1942. Flashlights; Electric, Hand (without Batteries).

A-1c. U. S. Army Specifications, Nos. -
23-1. Boxes, Chests and Crates, Engineer Equipment.
87-3. Color Comparator for Water Purification Units.

A-1d. Corps of Engineers Tentative Specifications, Nos. -
T-1739. Standard Requirements for Marking Corps of Engineers Shipments.
T-2123. Color Discs for pH Determinations.
T-2124. Indicator Solutions for pH Determinations.

A-1e. American Chemical Society Specifications. -
Specifications for Analytical Reagents.

A-1f. American Public Health Association Standards. -
Standard Methods for the Examination of Water and Sewage.

A-2. Drawings. - The following drawings of the issue in effect on date of invitation for bids form a part of this specification.

A-2a. Corps of Engineers Drawings, Nos. -
D 3898-1 to 7 inclusive. Chest, Field Water Quality Control.

B. TYPE.

B-1. This specification covers one type of water quality control set, complete with chest.

C. MATERIAL AND WORKMANSHIP.

C-1. Material. - The materials used in the composition of the set shall be as specified herein and as shown on the applicable drawings. Material not definitely specified shall be of the best quality normally used in good commercial practice for this type of work. Materials shall be free from all defects and imperfections that might affect the serviceability of the finished product.

C-1a. Chemicals. - Unless otherwise specified herein, all chemicals shall be reagent grade and shall conform to the Specifications for Analytical Reagents as recommended by the Committee on Analytical Reagents of the American Chemical Society.

C-2. Workmanship. - Shall be of the highest grade throughout and in accordance with best standard practice for this type of commodity.

D. GENERAL REQUIREMENTS.

D-1. See Section E.

E. DETAIL REQUIREMENTS.

E-1. Bottles. - The bottles shall be either hand-made or machine-made of selected quality clear glass, thoroughly annealed. The glass shall be colorless, unless otherwise specified. The bottles shall be furnished clean and dry and ready for use. Closures for the bottles shall be chemically resistant molded plastic screw caps, with chemically resistant liners acting as gaskets, except that the 4-ounce and 8-ounce square wide-mouth bottle caps shall be equipped with rubber or rubber-substitute gaskets. The bottles shall withstand the shock and boiling test requirements of Federal Specification DD-B-591. The bottles shall conform to the following requirements:

Capacity (ounces)	Shape	Height (inches)	Width or Diameter (inches)	Cap size (millimeters)
8	Square, wide-mouth	5-1/8	2-1/4	48
4	Square, wide-mouth	4-5/16	1-13/16	43
8	French square, narrow-mouth	5-5/8	2-3/16	24
4	French square, narrow-mouth	4-11/16	1-11/16	22
2	French square, narrow-mouth	3-7/8	1-3/8	22
4	Round, tall-form	4-3/8	1-7/8	22
1/2	French square, narrowmouth	2-9/16	1	18

E-2. Plywood chest. - The chest shall be constructed according to Corps of Engineers Drawings Nos. D 3898-1 to 7 inclusive and the applicable requirements of U. S. Army Specification No. 23-1.

E-2a. The following shall be stenciled on the outside of cover of the chest, in accordance with U. S. Army Specification No. 23-1:

U. S. WATER QUALITY CONTROL SET FOR FIELD USE

The normal position of the chest shall be identified by stenciling the word TOP in at least two appropriate locations near the top of the chest.

E-3. Set. - The quality control set shall consist of the following items which shall be packed in the plywood chest as shown on the loading plan of the applicable drawings.

E-3a. Glassware and miscellaneous items. -

Item	Quantity	Description
Bottle, with screw cap.	5	Square, wide-mouth, 8-ounce. Marked at 100-ml and 200-ml capacities.
Bottle, with screw cap.	4	Square, wide-mouth, 4-ounce. Marked at 50-ml and 100-ml capacities.
Bottle, with screw cap.	1	French square, narrow-mouth, 8-ounce and labeled: SAMPLE BOTTLE
Bottle, with screw cap.	1	French square, narrow-mouth, 4-ounce. Marked at 25-ml and 50-ml capacities.
Bottle, with screw cap.	2	French square, narrow-mouth, 4-ounce. Marked at 25-ml and 50-ml capacities and labeled: HARDNESS TESTING BOTTLE
Bottle, with screw cap having rubber bulb and dropper.	1	French square, narrow-mouth, 4-ounce and labeled: ALUM
Bottle, with screw cap having rubber bulb and dropper.	1	French square, narrow-mouth, 4-ounce labeled: SODA ASH

Item	Quantity	Description
Bottle, with screw cap.	4	Round, tall-form, 4-ounce.
Bottle, with screw cap having rubber bulb and dropper.	1	Amber-colored glass. French square, narrow-mouth, 2-ounce.
Bottle, with screw cap having rubber bulb and dropper. Dropper shall be marked at 1/2-ml capacity with circular ring.	2	Amber-colored glass, French square, narrow-mouth, 1/2-ounce.
Brush, test tube.	2	Conforming to Emergency Alternate Federa Specification E-H-B-126, type V.
Bulb, rubber	12	2-ml capacity - to fit Ives type pipette hereinafter described.
Cap, screw	11	48-mm size.
Cap, screw	6	43-mm size.
Cap, screw	9	24-mm size.
Cap, screw	19	22-mm size.
Cylinder, glass graduated	1	25-ml capacity, graduated at 1-ml intervals, 5-1/2 inches high by 1-3/4-inch base diameter.
Filter paper, boxes	3	Double-washed, quantitative grade, suitable for separating fine precipitates such as $BaSO_4$; 12.5 cm in diameter 100 sheets per box.
Flashlight, with batteries	1	The flashlight shall be prefocused, right angle, 2-cell flashlight, conforming to Federal Specification E-W-F-421a, type I, Code No. PRF-2-D, except that nonconducting cases meeting the requirements for type II flashlights will be acceptable. The lens ring shall be round and the overall head diameter shall be not more than 2 inches. The flashlight case shall have a dull finish.

Item	Quantity	Description
Flashlight holder	1	As shown on Corps of Engineers Drawing No. D 3898-4.
Flocculation set, box	1	As shown on Corps of Engineers Drawing No. D 3898-6. All interior surfaces shall have a dull black finish.
Funnel, filter	2	2-1/2-inch diameter funnel with 1-inch stem. Funnel shall be made of shock-resistant plastic not affected by the chemicals listed herein.
Measure, graduated	1	32-ounce capacity; bottom diameter 3-3/4 inches, top diameter 5 inches, 5-1/4 inches high. Graduated on interior wall in steps of 100 mls and 2 ounces. Measure shall be made of white vitreous enameled steel and shall have a solid black circle of 1-1/2-inch diameter in the center of the bottom on the inside. Measure shall have handle and pouring lip.
Note book	1	Bound, 50 to 100 pages, approximately 8-1/2 x 7 inches in size.
Pencil	1	Wax, red.
Pencil	1	No. 2 lead pencil.
Pipette, dropper	8	Ives type glass pipette. Over-all length 6-1/2 inches plus or minus 1/2 inch. Capacity 1 ml graduated in 0.1 ml from the delivery tip, and the graduated portion extending not less than 3 inches.
Pipette, dropper with rubber bulb	6	Pipette shall be of glass and shall fit in a 2-ounce French square bottle through a 22-mm screw cap.
Pipette, dropper with rubber bulb	6	Pipette shall be of glass and shall fit in a 4-ounce French square bottle through a 22-mm screw cap. The bulb shall be of such size as to exhaust not more than 1.25 ml nor less than 1.1 ml. The pipette shall deliver 1 ml and shall be marked by a circular ring at 1/2-ml and 1-ml capacities. The drawn-down portion of the dropper tip shall be included in

Item	Quantity	Description
		the calibration. The distance from the delivery tip of the pipette to the 1-ml capacity mark shall be 2-3/4 inches. The overall length of the pipette shall be 4 inches.
Towel	1	Good commercial grade of laboratory towel, 14 by 20 inches in size.
Tube, color comparator	2	26-mm glass tubes, U. S. Army Specification No. 87-3.
Turbidimeter	1	As shown on drawing No. D 3898-5. All interior surfaces, including viewing port, shall have a dull black finish.
Disc, color, brom-cresol purple-green	1	In accordance with Corps of Engineers Tentative Specification No. T-2123, type I.
Disc, color, aqua purple	1	In accordance with Corps of Engineers Tentative Specification No. 2123, type II.

E-3b. Chemicals and test solutions. -

Item	Quantity	Description
Ammonia alum, capsule	80	Shall be chemically pure $(NH_4)_2 SO_4 Al_2 (SO_4)_3 24H_2O$. Capsules shall be of colorless, transparent gelatin or plastic material. Each capsule shall contain 0.99 gram, plus or minus 0.05 gram, of alum, and the 80 capsules shall be packed in an 8-ounce wide-mouth square bottle, labeled: ALUM If an inert material must be added to secure proper weights in machine filling of the capsules, it shall be sodium chloride.
Barium chloride solution, ounces	8	This solution shall be made by dissolving barium chloride in 2.0 normal hydrochloric acid. The concentration of the solution shall be such that 1 ml is

Item	Quantity	Description
		equivalent to 10 mg of sulfate radicle (SO_4). The solution shall be put up in a French square 8-ounce bottle, labeled: BARIUM CHLORIDE 1 ml = 10 mg SO_4
Barium chloride solution, ounces	4	Same as above. It shall be put up in a French square 4-ounce bottle, labeled: BARIUM CHLORIDE 1 ml = 10 mg SO_4
Methyl orange solution, ounces	2	This solution shall be made by dissolving 1.0 gram of methyl orange in one liter of distilled water. It shall be put up in same type of bottle as used for the potassium chromate solution. Bottle shall be labeled: METHYL ORANGE
Phenolphthalein solution, ounces	2	This solution shall be made by dissolving 1.0 gram of phenolphthalein in 100 ml of 50 per cent ethyl alcohol solution and shall be neutralized with 0.02 normal sodium hydroxide. It shall be put up in the same type of bottle as used for the potassium chromate solution. Bottle shall be labeled: PHENOLPHTHALEIN
Potassium chromate solution, ounces	2	This solution shall be made by dissolving potassium chromate in distilled water. The concentration shall be 250 grams of potassium chromate per liter of solution. It shall be put up in a 2-ounce French square bottle fitted with a screw cap having a dropper pipette with a rubber bulb attached. Bottle shall be labeled: POTASSIUM CHROMATE
Silver nitrate solution, ounces	8	This solution shall be made by dissolving silver nitrate in distilled water. The concentration shall be such that 1 ml of the solution is equivalent to 5 mg

Item	Quantity	Description
		of chloride radicle (Cl). The solution shall be put up in an amber colored French square 8-ounce bottle, labeled: SILVER NITRATE 1 ml = 5 mg Cl ION
Silver nitrate solution, ounces	4	Same as above. It shall be put up in an amber colored French square 4-ounce bottle, labeled: SILVER NITRATE 1 ml = 5 mg Cl ION
Soap solution, ounces	8	This solution shall be prepared as prescribed for the standard soap solution in "Standard Methods for the Examination of Water and Sewage", Eighth Edition, page 60, except that the concentration of the solution shall be 2.5 times greater than the standard soap solution described therein. The solution shall be put up in a French square 8-ounce bottle, labeled: SOAP SOLUTION 1 ml = 2.5 mg $CaCO_3$
Soap solution, ounces	4	Same as above. It shall be put up in a French square 4-ounce bottle, labeled: SOAP SOLUTION 1 ml = 2.5 mg $CaCO_3$
Sodium carbonate, capsules	80	Capsules shall be the same type as used for the alum except that they shall be colored. Each capsule shall contain 0.9 gram, plus or minus 0.05 gram, of anhydrous sodium carbonate, and the 80 capsules shall be packed in an 8-ounce wide-mouth square bottle, labeled: SODA ASH If an inert material must be added to secure proper weights in machine filling of the capsules, it shall be sodium chloride.

Item	Quantity	Description
Sulfuric acid solution ounces	8	The solution shall be 0.100 normal. It shall be put up in a French square 8-ounce bottle, labeled: SULFURIC ACID 0.1 NORMAL
Sulfuric acid solution, ounces	4	Same as above. It shall be put up in a French square 4-ounce bottle, labeled: SULFURIC ACID 0.1 NORMAL
Turbidity solution ounces	8	This solution shall be prepared as prescribed for the standard turbidity solution in "Standard Methods for the Examination of Water and Sewage", Eighth Edition, page 10. It shall have a turbidity of 120 parts per million as SiO_2. The solution shall be put up in a French square 8-ounce bottle, labeled: TURBIDITY SOLUTION (120 ppm SiO_2) SHAKE WELL BEFORE USING To prevent bacterial growth in the solution, 50 mg, plus or minus 10 mg, of mercuric chloride and 0.5 gram, plus or minus 0.1 gram, of mercury shall be added to the bottle of solution.
Zeolite synthetic, grams	50	Similar and equal to Zeo-Karb-Na synthetic zeolite manufactured by the Permutit Company, 330 West 42nd Street, New York, New York. The zeolite shall be washed free of fines with distilled water and placed in a French square 8-ounce bottle and the bottle filled with distilled water. The bottle shall be labeled: ZERO HARDNESS WATER

E-3c. Indicator solutions. - Shall be standardized for use with the color comparator covered by U. S. Army Specification No. 87-3. The color comparator shall not be included in the set supplied by the contractor. They shall be put up in amber-colored, French square, 4-ounce bottles properly labeled. The special-purpose mixed indicators, bromcresol purple-green and aqua purple, shall conform to Corps of Engineers Tentative Specification No. T-2124, types I and II respectively.

Item	Quantity
Bromcresol-purple green	4 ounces
Bromthymol-blue	4 ounces
O-tolidine	4 ounces
Aqua purple	4 ounces

E-3d. Kit, water-testing, screening. - A kit, water-testing, screening (Medical Department Item 99310) indicated on drawing No. D 3898-7, as a toxicity set, will be furnished by the Government, and shall be packed in the chest as indicated on the drawing.

E-4. Labeling. - All bottle labels shall be protected by a chemically resistant clear lacquer.

E-5. Technical bulletins. - Technical bulletins will be furnished by the Office of the Chief of Engineers through the Contracting Officer. Two of the technical bulletins shall be packed in each chest containing the water quality control set.

F. METHODS OF INSPECTION AND TESTS.

F-1. Inspection. - Equipment furnished under this specification shall be subject to inspection, during and after the process of manufacture, by authorized Government Inspectors, who shall be afforded proper facilities for determining compliance with the specification.

F-2. Tests. - Equipment furnished under this specification shall be given such tests as may be necessary to determine compliance with the specification requirements. For all tests made prior to final acceptance, the contractor shall supply all necessary facilities and supplies required for the testing procedure.

G. PACKING AND MARKING FOR SHIPMENT.

G-1. Packing. - Packing for shipment shall be in accordance with instructions issued by the Contracting Officer.

G-2. Marking. - Marking for shipment shall conform to the requirements of Corps of Engineers Tentative Specification No. T-1739, except as may be modified by the Contracting Officer.

H. NOTES.

H-1. The Contracting Officer shall furnish the contractor the required number of technical bulletins to be packed in each chest containing the water quality control set.

H-2. Copies of this specification and other Corps of Engineers Tentative Specifications and Drawings may be obtained from Army Service Forces, Office of the Chief of Engineers, Washington 25, D. C.

H-3. Copies of U. S. Army Specifications may be obtained as indicated in the "Index of United States Army and Federal Specifications Used by The War Department". Copies of this index may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

H-3. Copies of the other specifications listed in Section A may be obtained from the following sources:

Federal Specifications.
Superintendent of Documents,
Government Printing Office,
Washington 25, D. C.

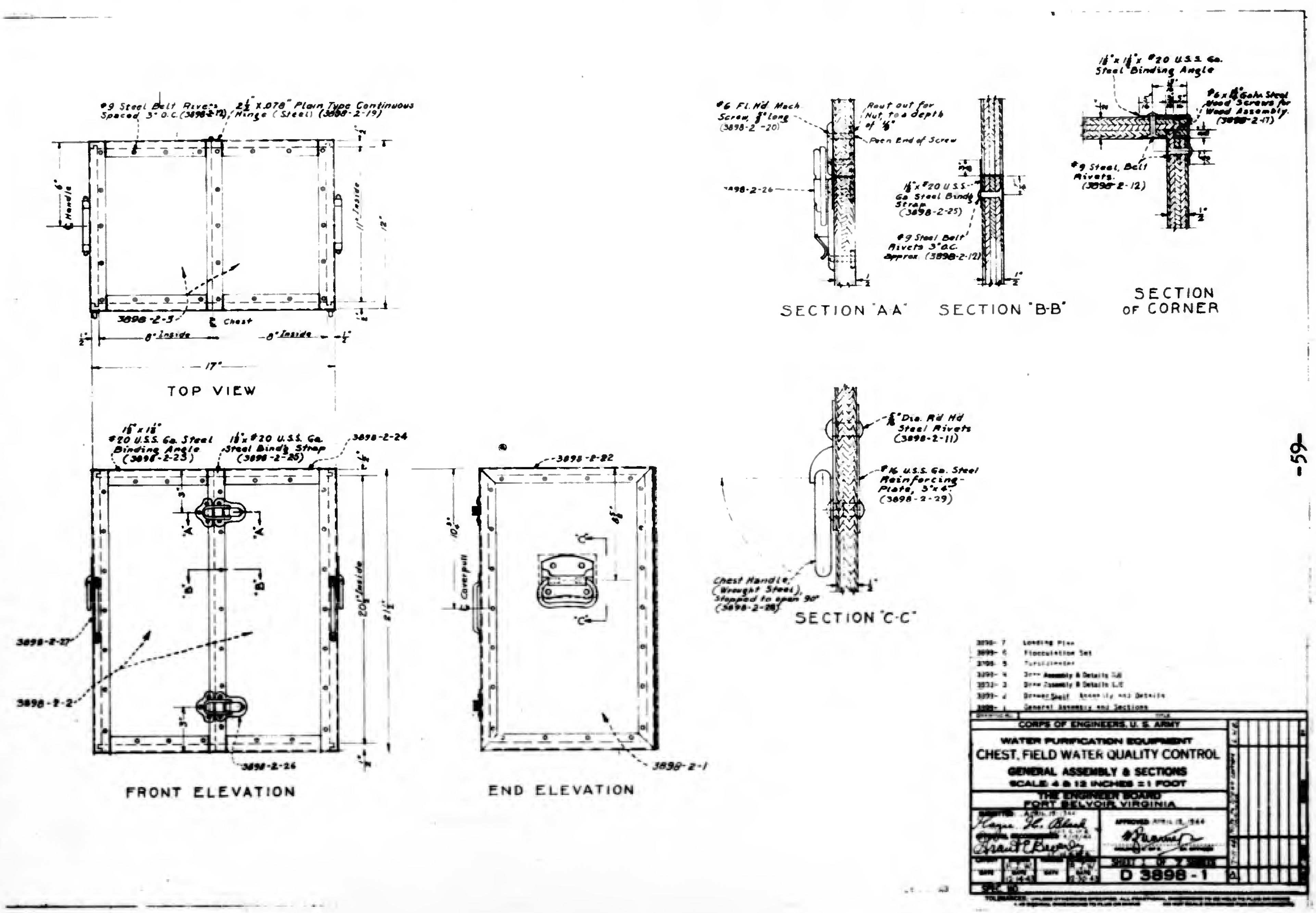
Emergency Alternate Federal Specifications. -
Catalog Office, Procurement Division,
Treasury Department, 7th & D Sts., S. W.
Washington 25, D. C.

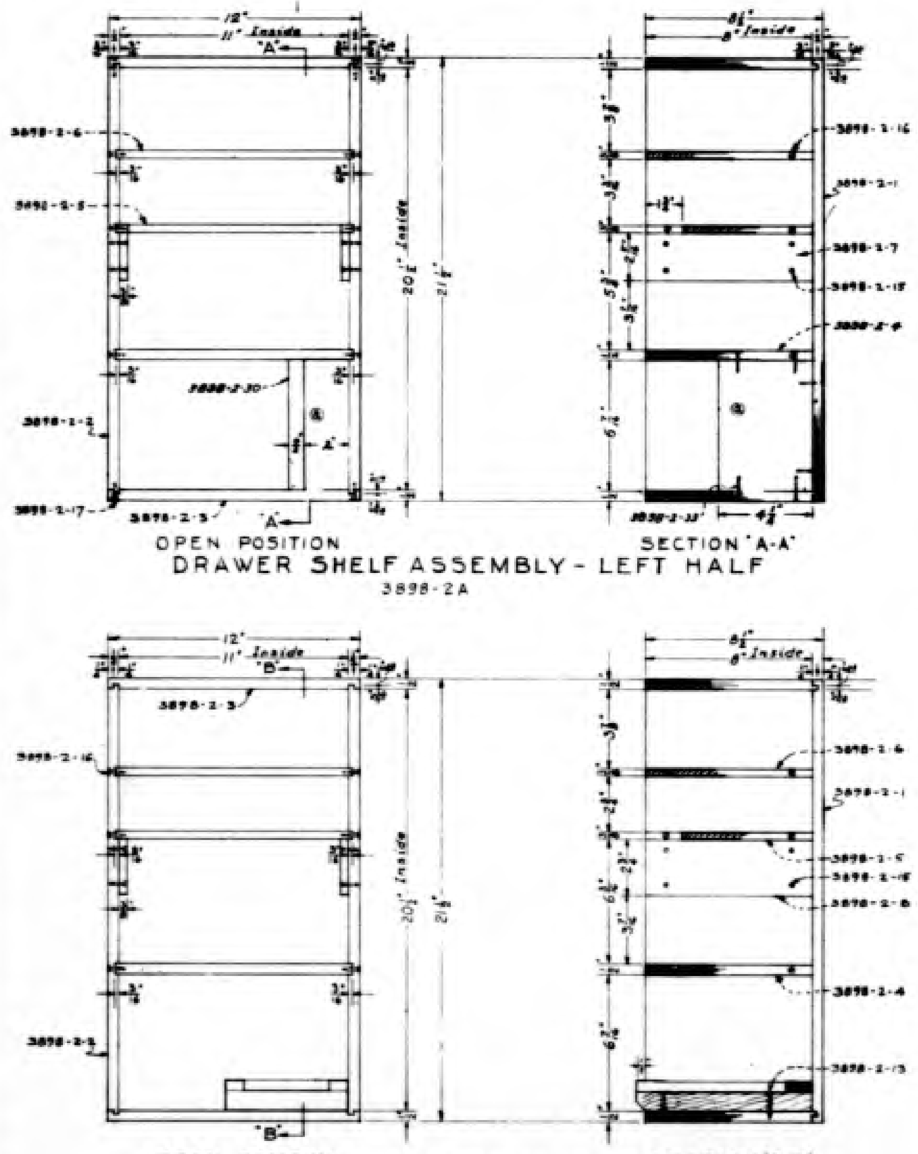
American Chemical Society Specifications. -
American Chemical Society,
1155 16th St., N. W.
Washington 5, D. C.

American Public Health Association Standards. -
American Public Health Association,
1790 Broadway,
New York 18, New York.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

92-8747-200


#9 Steel Belt Rivets Spaced 3" O.C. (3898-2-12)
2½" X.078" Plain Type Continuous Hinge (Steel) (3898-2-19)
Handle
3898-2-3
Chest
8" Inside
17"
TOP VIEW
1½" x 1½" #20 U.S.S. Ga. Steel Binding Angle (3898-2-23)
1½" x #20 U.S.S. Ga. Steel Bindg Strap (3898-2-25)
3898-2-24
3898-2-27
3898-2-2
3898-2-26
FRONT ELEVATION
3898-2-22
Coverpull
3898-2-1
END ELEVATION
#6 Fl. Hd. Mach Screw, ⅜" Long (3898-2-20)
Rout out for Nut, to a depth of ⅛"
Peen End of Screw
3898-2-26
1½" x #20 U.S.S. Ga. Steel Bindg Strap (3898-2-25)
#9 Steel Belt Rivets 3" O.C. Approx. (3898-2-12)
SECTION "A-A"
SECTION "B-B"
1½" x 1½" x #20 U.S.S. Ga. Steel Binding Angle
#9 Steel, Belt Rivets. (3898-2-12)
(3898-2-17)
SECTION OF CORNER
Dia. Rd Hd Steel Rivets (3898-2-11)
#16 U.S.S. Ga. Steel Reinforcing Plate, 5"x4" (3898-2-29)
Chest Handle, (Wrought Steel), Stopped to open 90° (3898-2-28)
SECTION "C-C"
CORPS OF ENGINEERS, U. S. ARMY
WATER PURIFICATION EQUIPMENT
CHEST, FIELD WATER QUALITY CONTROL
GENERAL ASSEMBLY & SECTIONS
SCALE 4 & 12 INCHES = 1 FOOT
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA
D 3898-1



OPEN POSITION

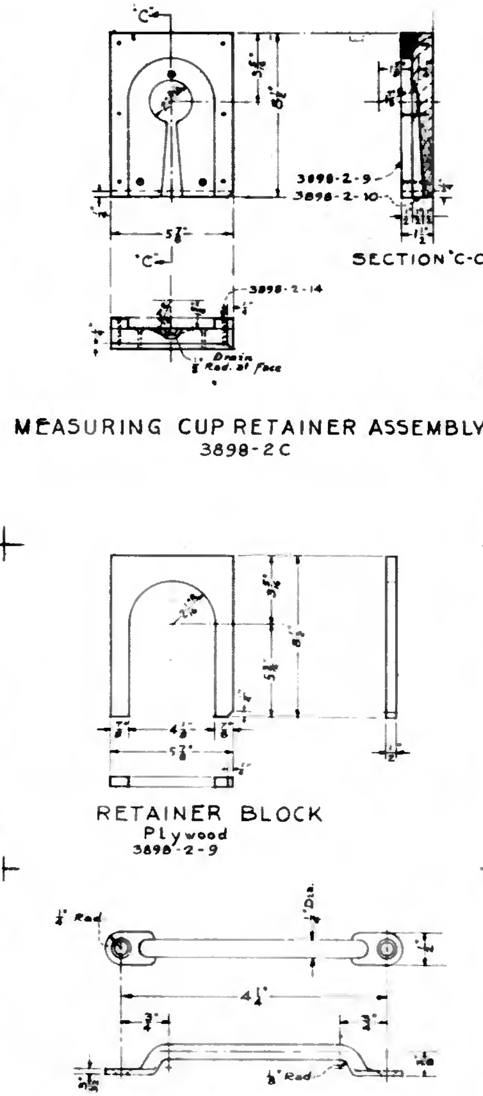
SECTION 'A-A'

DRAWER SHELF ASSEMBLY - LEFT HALF
3898-2A

OPEN POSITION

SECTION 'B-B'

DRAWER SHELF ASSEMBLY - RIGHT HALF
3898-2B

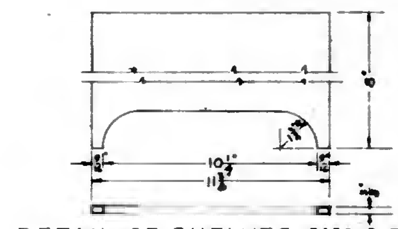


SECTION 'C-C'

MEASURING CUP RETAINER ASSEMBLY
3898-2C

RETAINER BLOCK
Plywood
3898-2-9

DETAIL OF COVER PULL
Steel
3898-2-27



DETAIL OF SHELVES-3898-2-5
Plywood

Part Number	Quan. Required for one complete Chest D3898-2	Description	Material
3898-2-30	1	Panel 3/4" x 4⅝" x 6 3/16" 5 Ply	Plywood
3898-2-33	24	Brads, 7/8" (3898-2-15)	Steel
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
3898-2-29	2	Plate, Reinforcing, 3x4, #16 U.S.S. Ga.	Steel
3898-2-28	2	Chest Handle	Wr.Steel
3898-2-27	2	Cover Pull (See Detail)	Steel
3898-2-26	2	Drawbolts, Suit Case, 1 7/8" x 3 1/8"	Steel
3898-2-25	1	Binding Strap, 1 1/8" x 3'-8 1/2", #20 USS Ga.	Steel
3898-2-24	4	Binding Angle, 1 1/8"x1 1/8"x8 5/8", #20 USS Ga.	Steel
3898-2-23	4	Binding Angle, 1 1/8"x1 1/8"x8 11/16", #20 USS Ga.	Steel
3898-2-22	2	Binding Angle, 1 1/8"x1 1/8"x1'-7", #20 USS Ga.	Steel
3898-2-21	4	Screws, #8 x 1" F.H. Wood, for Cover Pulls	Galv.Steel
3898-2-20	12	Screws, Machine, #8 x 5/8" F.H. with Nut	Steel
3898-2-19	1	Hinge, Continuous, 2 1/8"x2 1/8"x.078"	Steel
3898-2-18	24	Screws, #8 x 1/2" F.H.Wood for Hinge	Galv.Steel
3898-2-17	30	Screws, #8 x 1 1/4" F.H.Wood for Chest Assembly	Steel
3898-2-16	24	Screws, #8 x 1" F.H.Wood for Shelves	Steel
3898-2-15	16	Brads, 7/8" Long	Steel
3898-2-14	8	Brads, 1 1/8" Long	Steel
3898-2-13	3	Screws, #8 x 1 1/2" F.H. Wood	Steel
3898-2-12	182	Rivets, #8 Belt for Binding Angles	Steel
3898-2-11	8	Rivets, 3/16" Dia.	Steel
3898-2-10	1	Retainer Block, Base 1" x 5 7/8" x 8¼"	Softwood
3898-2-9	1	Retainer Block, 1/2" x 5 7/8" x 8½" 5 Ply	Plywood
3898-2-8	1	Drawer Guide, 3/8" x 2 3/4" x 8"	Hardwood
3898-2-7	1	Drawer Guide, 3/8" x 2 5/16" x 8"	Hardwood
3898-2-6	2	Shelves, 3/8" x 8" x 11 3/8", 3 Ply	Plywood
3898-2-5	2	Shelves (As Shown in Detail), 3 Ply	Plywood
3898-2-4	2	Shelves, 1/2" x 8" x 11 3/8", 5 Ply	Plywood
3898-2-3	4	Top and Bottom, 1/2" x 8 3/16" x 12", 5 Ply	Plywood
3898-2-2	4	Sides, 1/2" x 8 1/2" x 20 7/8", 5 Ply	Plywood
3898-2-1	2	Backs, 1/2" x 11 3/8" x 21 1/2", 5 Ply	Plywood
3898-2-C	1	Measuring Cup Retainer Assembly	
3898-2-B	1	Drawer Shelf Assembly, Right Half	
3898-2-A	1	Drawer Shelf Assembly, Left Half	

CORPS OF ENGINEERS, U. S. ARMY

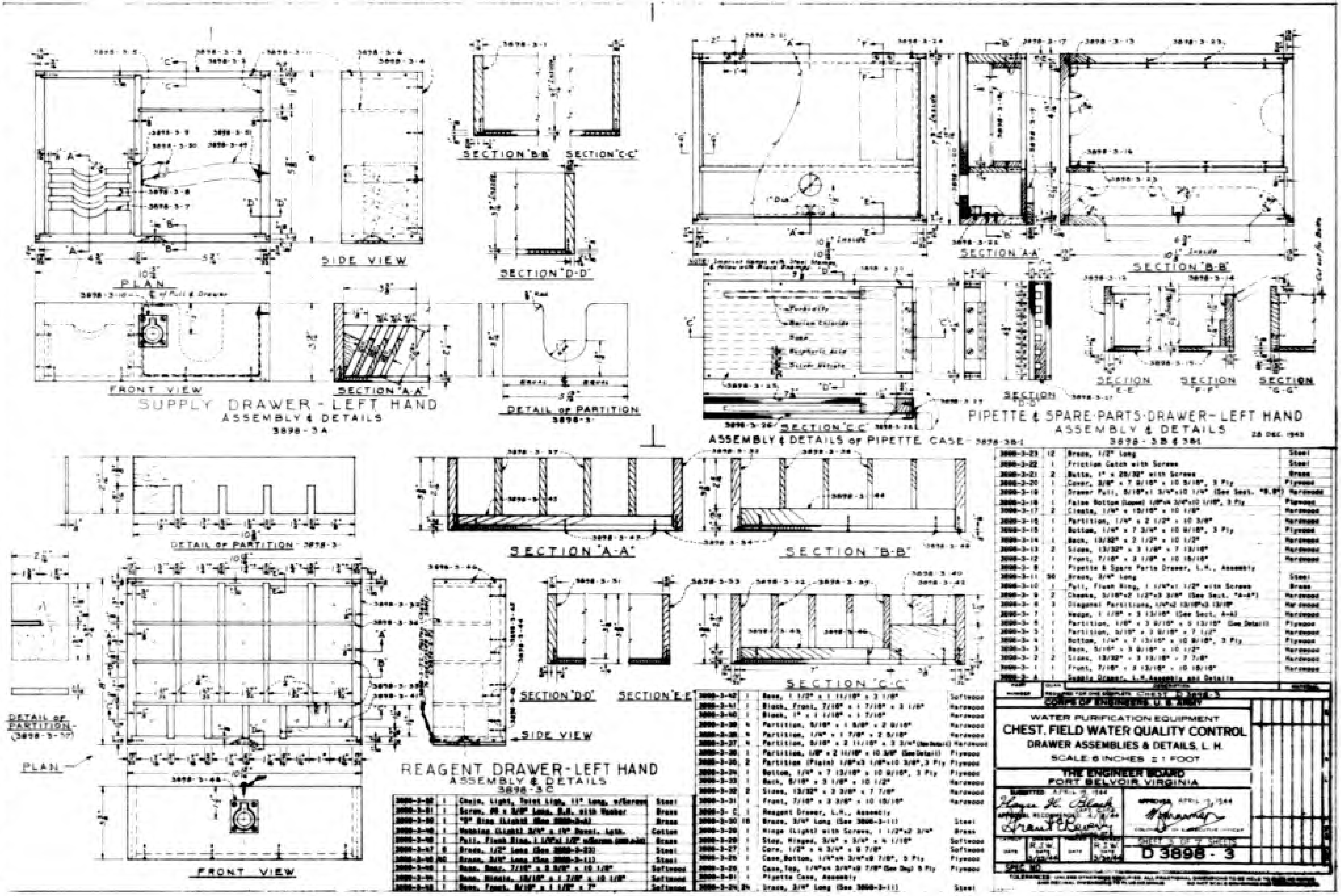
WATER PURIFICATION EQUIPMENT
CHEST, FIELD WATER QUALITY CONTROL
DRAWER SHELF ASSEMBLY & DETAILS
SCALES: 4 & 12 INCHES = 1 FOOT

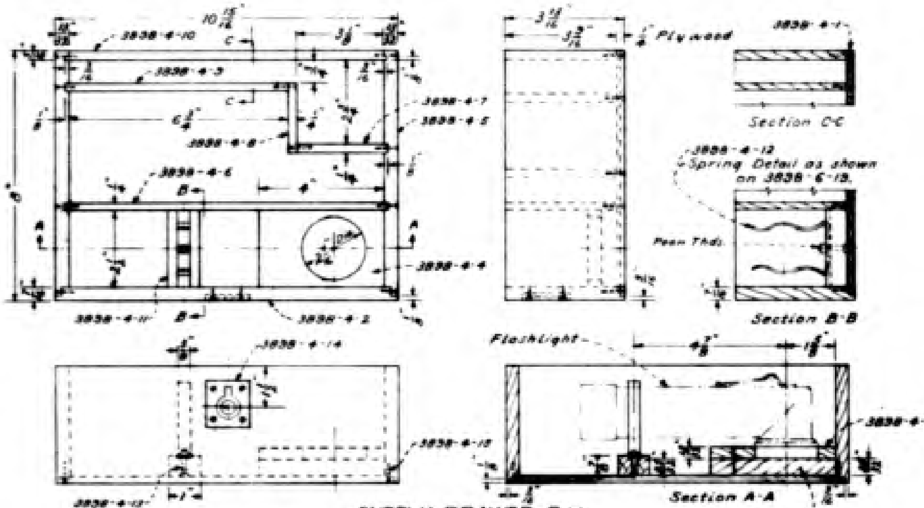
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA

SUBMITTED APRIL 13, 1944

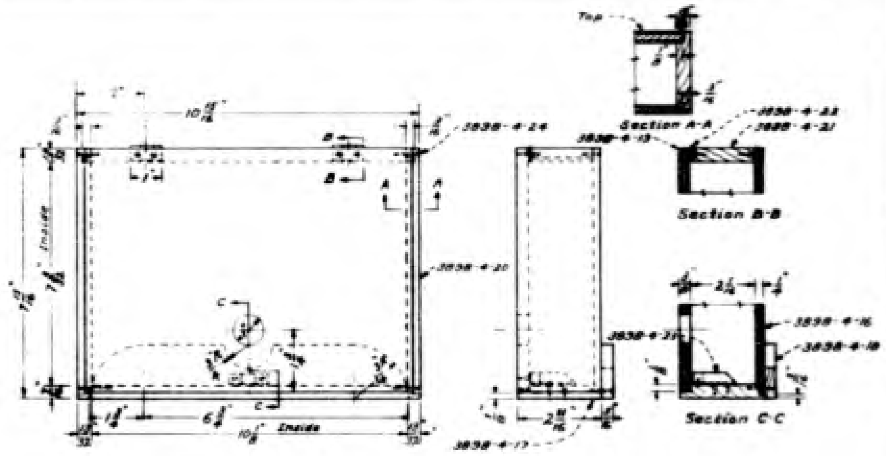
APPROVED APRIL 13, 1944

D 3898 - 2

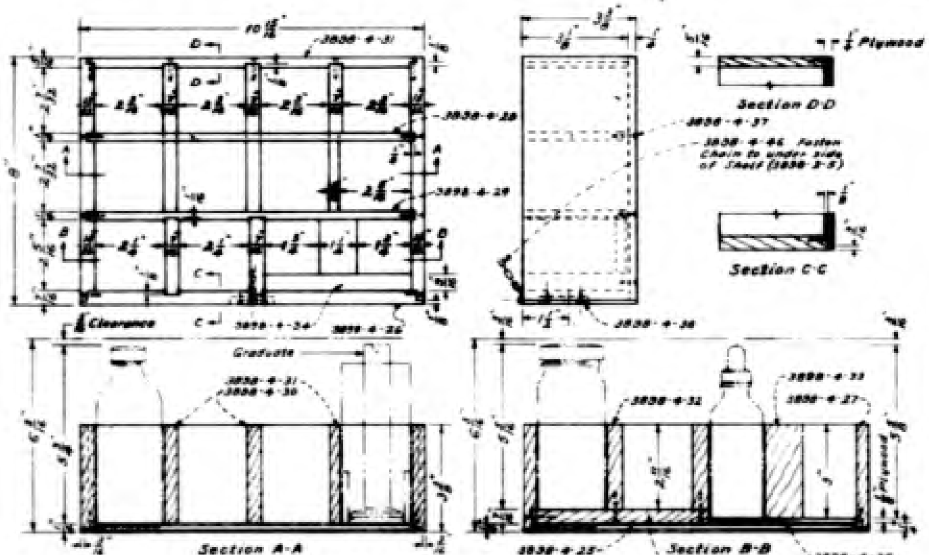

PLAN
SIDE VIEW
SECTION 'B-B'
SECTION 'C-C'
SECTION 'D-D'
FRONT VIEW
SECTION 'A-A'
DETAIL of PARTITION
SUPPLY DRAWER - LEFT HAND
ASSEMBLY & DETAILS
3898-3A
SECTION 'A-A'
SECTION 'B-B'
SECTION 'C-C'
SECTION 'D-D'
SECTION 'E-E'
SECTION 'F-F'
SECTION 'G-G'
ASSEMBLY & DETAILS of PIPETTE CASE
PIPETTE & SPARE-PARTS-DRAWER - LEFT HAND
ASSEMBLY & DETAILS
3898-3B & 3B1
28 DEC. 1943
DETAIL of PARTITION
SECTION 'A-A'
SECTION 'B-B'
SECTION 'C-C'
SECTION 'D-D'
SECTION 'E-E'
SIDE VIEW
PLAN
FRONT VIEW
REAGENT DRAWER - LEFT HAND
ASSEMBLY & DETAILS
3898-3C
CORPS OF ENGINEERS U. S. ARMY
WATER PURIFICATION EQUIPMENT
CHEST, FIELD WATER QUALITY CONTROL
DRAWER ASSEMBLIES & DETAILS, L. H.
SCALE: 6 INCHES = 1 FOOT
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA
D 3898 - 3



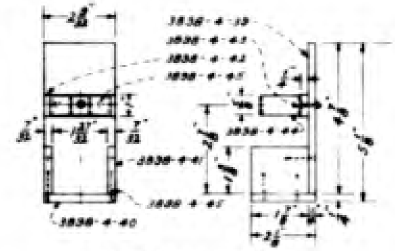
SUPPLY DRAWER R.H.
ASSEMBLY & DETAILS
3898-4-A



INSTRUCTIONS DRAWER R.H.
ASSEMBLY & DETAILS
3898-4-B



REAGENT DRAWER R.H.
ASSEMBLY & DETAILS
3898-4-C



GRADUATE HOLDER
Hardwood
3898-4-D

Part Number	Reqd.	Description	Material
3898-4-46	1	Chain, Light, Twist Link, 11" Long, with Screws	Steel
3898-4-45	8	Brads, 5/8" Long	Steel
3898-4-44	1	Spring Clip, 1/2" (For 7/8" Graduate Tube)	Spring Steel
3898-4-43	1	Bolt, F.H. Stove, 3/16" x 5/8" Long + Nut	Steel
3898-4-42	1	Spacer Block, 1/4" x 1" x 2 9/32"	Hardwood
3898-4-41	2	Sides, 7/32" x 1 7/8" x 1 3/8"	Hardwood
3898-4-40	1	Base, 1/4" x 2 1/8" x 2 9/32"	Hardwood
3898-4-39	1	Back, 7/32" x 2 9/32" x 5"	Hardwood
3898-4-D	1	Graduate Holder	Hardwood
3898-4-38	1	Pull, Flush Ring (See 3898-4-14 and 3898-3-10)	Brass
3898-4-37	30	Brads, 3/4" Long (See 3898-4-15)	Steel
3898-4-36	1	Base, Front, 7/16" x 2 5/16" x 5 3/8"	Hardwood
3898-4-35	1	Base, 1/8" x 1 3/4" x 4 3/4", 3 Ply	Plywood
3898-4-34	1	Blocking, 9/16" x 3 1/8" x 4 3/4"	Hardwood
3898-4-33	1	Partition, 1 1/4" x 1 3/4" x 3"	Hardwood
3898-4-32	2	Partition, 7/16" x 2 11/16" x 2 1/2"	Hardwood
3898-4-31	1	Partition, 7/16" x 3 1/8" x 4 13/16" (See Dwg.)	Hardwood
3898-4-30	2	Partition, 7/16" x 3 1/8" x 4 13/16"	Hardwood
3898-4-29	1	Partition, 1/4" x 3 1/8" x 10 3/8" (Plain)	Hardwood
3898-4-28	1	Partition, 1/4" x 3 1/8" x 10 3/8" (Cut Crossways)	Hardwood
3898-4-27	2	Sides, 13/32" x 3 3/8" x 7 7/8"	Hardwood
3898-4-26	1	Front, 7/16" x 3 3/8" x 10 15/16"	Hardwood

Part Number	Reqd.	Description	Material
3898-4-25	1	Bottom, 1/4" x 7 13/16" x 10 9/16", 3 Ply	Plywood
3898-4-C	1	Reagent Drawer, R.H., Assembly	
3898-4-24	16	Brads, 3/4" Long (See 3898-4-15)	Steel
3898-4-23	1	Friction Catch with Screws	Steel
3898-4-22	2	Butts, 1" x 25/32" with Screws	Brass
3898-4-21	1	Back, 13/32" x 2 1/16" x 10 1/2"	Hardwood
3898-4-20	2	Sides, 13/32" x 2 11/16" x 7 13/32"	Hardwood
3898-4-19	1	Top, 3/8" x 7 9/16" x 10 9/16", 3 Ply	Plywood
3898-4-18	1	Drawer, Pull, 9/16" x 1 3/4" x 10 1/4"	Hardwood
3898-4-17	1	Front, 7/16" x 2 11/16" x 10 15/16"	Hardwood
3898-4-16	1	Bottom, 1/4" x 7 13/16" x 10 9/16", 3 Ply	Plywood
3898-4-B	1	Instructions Drawer, R.H., Assembly	
3898-4-15	30	Brads, 3/4" Long	Steel
3898-4-14	1	Pull, Flush Ring, 1 1/4" x 1 1/2" w/Screws (3898-3-10)	Brass
3898-4-13	1	Bolt, F.H., Stove, 3/16" x 1" with Nut	Steel
3898-4-12	1	Flashlight Spring, (Detail 3898-5-4)	Spring Brass
3898-4-11	1	Spring Blocking, 7/8" x 1" x 2 1/2"	Hardwood
3898-4-10	1	Back, 9/16" x 3 9/16" x 10 1/2"	Hardwood
3898-4-9	1	Partition, 1/4" x 3 9/16" x 5 7/8"	Hardwood
3898-4-8	1	Partition, 1/4" x 2 1/4" x 3 9/16"	Hardwood
3898-4-7	1	Partition, 1/4" x 3 9/16" x 3 1/4"	Hardwood
3898-4-6	1	Partition, 1/4" x 3 9/16" x 10 3/8"	Hardwood
3898-4-5	2	Sides, 13/32" x 3 13/16" x 7 13/32"	Hardwood
3898-4-4	1	Flashlight Holder Socket, 13/32" x 2 1/2" x 4"	Hardwood
3898-4-3	1	Flashlight Holder Base, 25/32" x 2 1/2" x 4"	Hardwood
3898-4-2	1	Front, 7/16" x 3 13/16" x 10 15/16"	Hardwood
3898-4-1	1	Bottom, 1/4" x 7 13/16" x 10 9/16", 3 Ply	Plywood
3898-4-A	1	Supply Drawer, R.H., Assembly	

Required for one complete Chest D 3898-4

CORPS OF ENGINEERS U. S. ARMY

WATER PURIFICATION EQUIPMENT

CHEST, FIELD WATER QUALITY CONTROL

DRAWER ASSEMBLIES & DETAILS, R. H.

SCALE 6 INCHES = 1 FOOT

THE ENGINEER BOARD

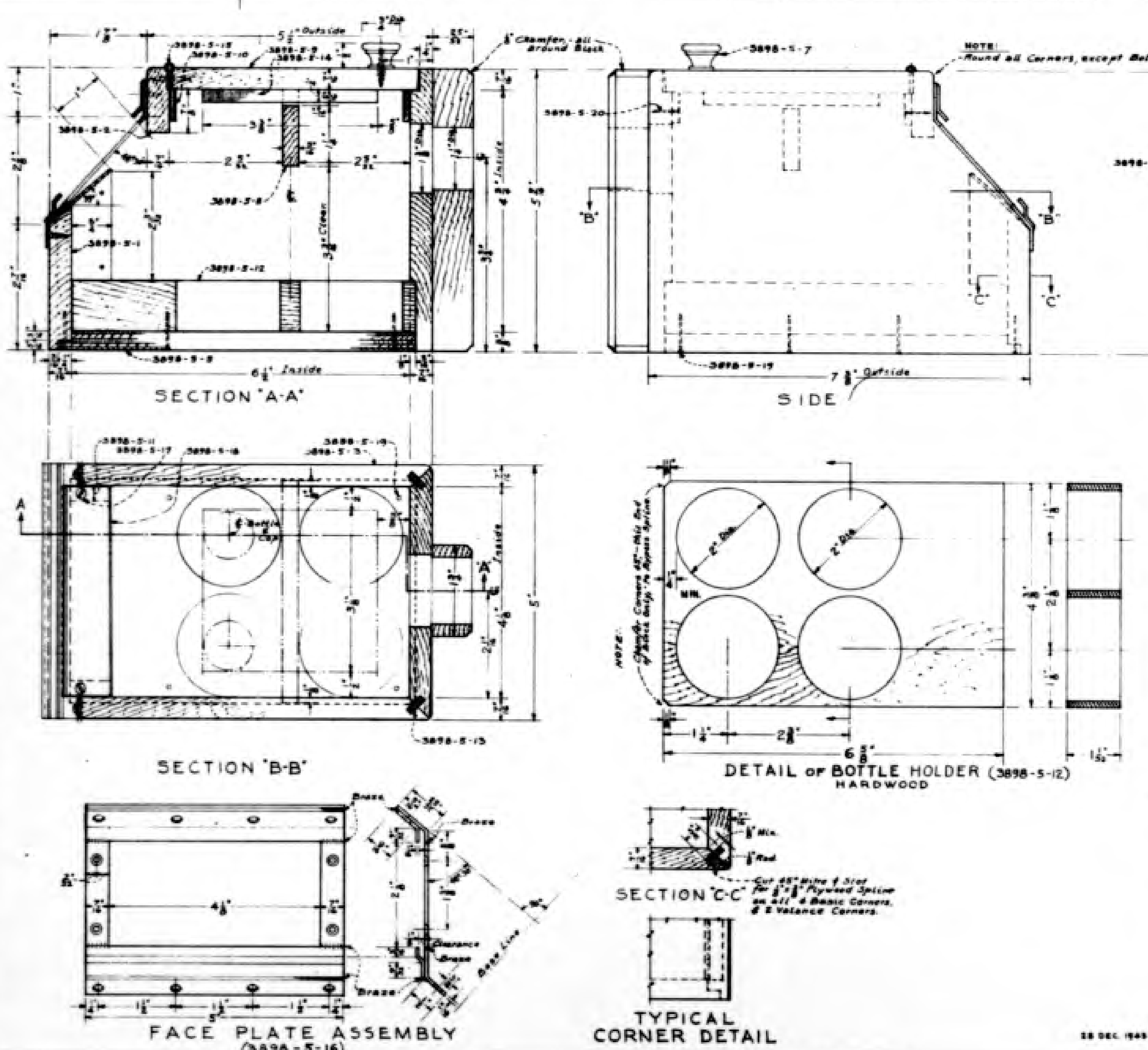
FORT BELVOIR, VIRGINIA

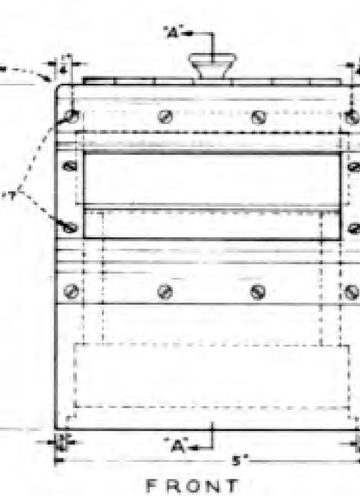
SUBMITTED APRIL 15, 1944

APPROVED APRIL 15, 1944

SHEET 4 OF 7 SHEETS

D 3898 - 4





Part Number	Req'd	Description	Material
3898-5-20	8	Brads, 1/2" Long	Steel
3898-5-19	12	Brads, 3/4" Long	Steel
3898-5-18	2	Bars Plate, 1/16" x 1 1/8" x 4 1/8" (See Dwg.)	Steel
3898-5-17	16	Screws, #4 x 1/2" F.H. Wood	Brass
3898-5-16	1	Face Plate Assembly (See Detail)	Brass
3898-5-15	1	Hinge, Continuous, 7/8" x 4 1/8" With Screws	Brass
3898-5-14	1	Cushion, 1/8" x 3 1/8" x 3 3/8"	Sponge Rubber
3898-5-13	6	Splines, 1/8" x 3/8" (See Dwg. to Determine Lgth.)	Plywood
3898-5-12	1	Bottle Block, 1 1/32" x 4 3/8" x 6 5/8" (See Dwg.)	Hardwood
3898-5-11	2	Cheeks, 5/16" x 3/4" x 2 3/32" (See Dwg.)	Hardwood
3898-5-10	2	Light Seal, 1/8" x 5/8" x 4 1/8", 3 Ply	Plywood
3898-5-9	1	Cover, 7/16" x 4 7/16" x 4 3/4" Long	Hardwood
3898-5-8	1	Light Block, 5/16" x 1 5/16" x 4 3/8"	Hardwood
3898-5-7	1	Knob, 1/2" x 3/4" Dia. (See Sect. A-A)	Hardwood
3898-5-6	1	Port Block, 25/32" x 1 3/4" x 3 5/16"	Hardwood
3898-5-5	1	Bottom, 3/8" x 4 5/8" x 6 7/8", 3 Ply	Plywood
3898-5-4	1	Back, 7/16" x 5" x 5 5/16"	Hardwood
3898-5-3	2	Sides, 7/16" x 5 5/16" x 7 3/8" (See Dwg.)	Hardwood
3898-5-2	1	Valance, 7/16" x 1 5/16" x 5"	Hardwood
3898-5-1	1	Front, Base, 7/16" x 2 13/16" x 5" (See Dwg.)	Hardwood

CORPS OF ENGINEERS, U. S. ARMY

WATER PURIFICATION EQUIPMENT
CHEST, FIELD WATER QUALITY CONTROL
TURBIDIMETER

SCALE: 12 INCHES = 1 FOOT

THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA

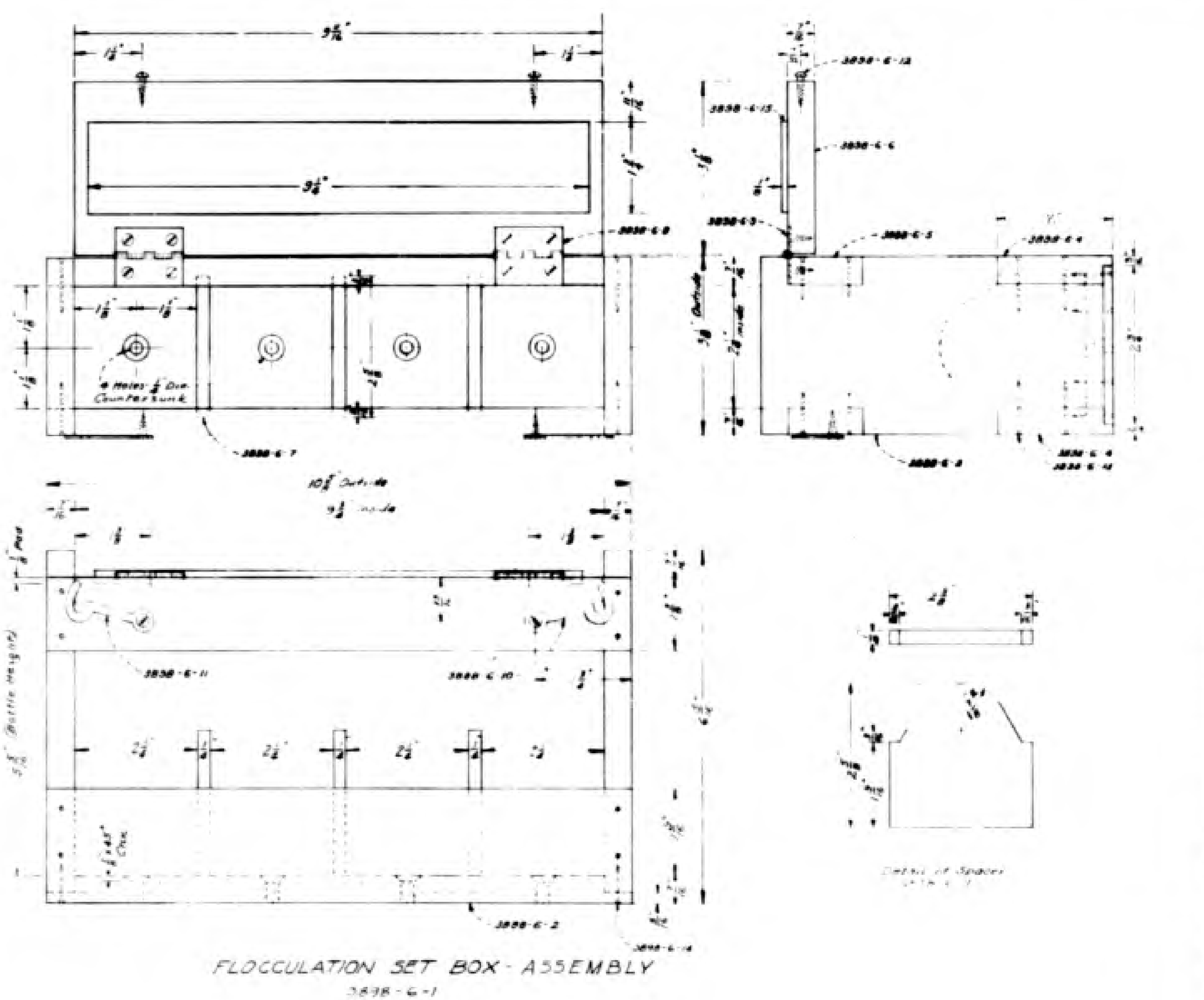
SUBMITTED APRIL 13, 1944

APPROVED APRIL 13, 1944

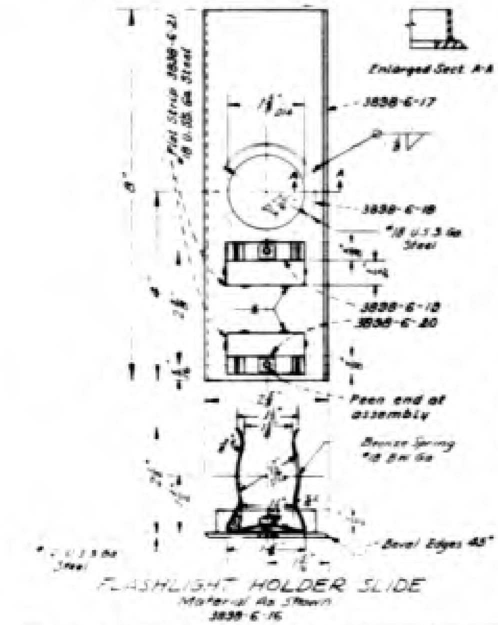
SHEET 5 OF 7 SHEETS

D 3898 - 5

28 DEC 1949



FLOCCULATION SET BOX - ASSEMBLY
3898-6-1



FLASHLIGHT HOLDER SLIDE
Material As Shown
3898-6-16

Part Number	Quan.	Description	Material
3898-6-21	2	Spring Lock #18 USS Ga.	Steel
3898-6-20	4	Mach. Screw, F.H., #8 - 32 x 3/8" Lg. - Sq. Nut	Steel
3898-6-19	4	Flashlight Spring	Spring Bronze
3898-6-18	1	Lens Holder, #18 USS Ga.	Steel
3898-6-17	1	Slide Base, 4 5/8" x 8" x #18 USS Ga.	Steel
3898-6-16	1	Flashlight Holder Slide (Assembly)	
3898-6-15	1	Top Cushion, 1/8" x 1 3/4" x 9 1/4"	Sponge Rubber
3898-6-14	12	Wire Brads, #15 x 5/8"	Steel
3898-6-13	18	Wire Brads, #15 x 1"	Steel
3898-6-12	4	Wood Screw, R.H., #3 x 1/2"	Brass
3898-6-11	1	Hook, 1 1/2" Long (Right Hand)	Brass
3898-6-10	1	Hook, 1 1/2" Long (Left Hand)	Brass
3898-6-9	8	Wood Screws, F.H. #5 x 3/8"	Steel
3898-6-8	2	Hinges 1 1/4" Lgth. x 1 1/16" Width x .25 Ga.	Wgt. Iron
3898-6-7	3	Partitions, 1/4" x 2 5/8" x 2 5/8", 3 Ply	Plywood
3898-6-6	1	Top, 7/16" x 3 1/8" x 9 11/16"	Softwood
3898-6-5	2	Top Side Pieces, 7/16" x 1 3/4" x 10 5/8"	Softwood
3898-6-4	2	Bottom Side Pieces, 7/16" x 3" x 10 5/8"	Softwood
3898-6-3	2	Ends, 7/16" x 3 1/8" x 5 5/16"	Softwood
3898-6-2	1	Bottom, 7/16" x 2 3/4" x 13 5/8"	Softwood
3898-6-1	1	Flocculation Box Set (Assembly)	

Required for one complete Chest D 3898-6

CORPS OF ENGINEERS, U. S. ARMY

WATER PURIFICATION EQUIPMENT

CHEST, FIELD WATER QUALITY CONTROL

FLOCCULATION SET

SCALE 6 & 12 INCHES = 1 FOOT

THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA

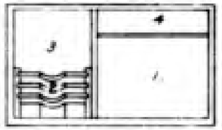
Submitted April 1944
Approved April 1944

SHEET 6 OF 7 SHEETS

D 3898 - 6

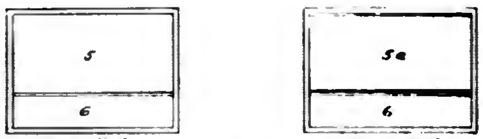
SPEC. NO.

28 DEC 1944



SUPPLY DRAWER L.H.

NO.	ARTICLE	COMP.	REMARKS
3	Boxes Filter Paper	1	
2	pH Color Discs	2	
2	Funnels	3	
3	pH Comparator Tubes	3	
4	Screw Cap, 8 oz. Jar	4	
2	Screw Cap, 4 oz. Jar	4	
2	Screw Cap, 8 oz. Bottle	4	
4	Screw Cap, 4 oz. Bottle	4	

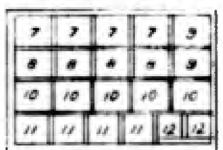


Upper Half

Lower Half

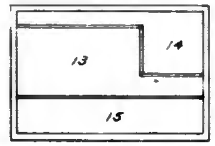
PIPETTE & SPARE PARTS DRAWER

NO.	ARTICLE	COMP.	REMARKS
8	Dropper Pipettes with Bulbs	5	In Case
4	Dropper Pipettes, Screw Cap, Bulb, 4 oz. Bottle	5a	
2	Dropper Pipettes, Screw Cap, Bulb, 2 oz. Bottle	5a	
2	Dropper Pipettes, 1 ml., Ives, Dropping	5a	
8	Rubber Bulbs	5a	
2	Test Tube Brushes	6	



REAGENT DRAWER L.H.

NO.	ARTICLE	COMP.	REMARKS
4	Bottles, Titrating, 4 oz. Empty	7	
4	Bottles, Indicator, 4 oz., O-Tolidine, Brom Thymol		
	Blue, Brom Cresol Purple Green, Aqua Purple	8	
2	Bottle, Soap Titrating, 4 oz., Empty	9	
5	Bottles, 4 oz. Sulfuric Acid, Silver Nitrate, Soap,		
	Barium Chloride, Empty Bottle	10	
4	Bottles, Dropping, 2 oz., Phenolphthalein, Methyl		
	Orange, Potassium Chromate, and Empty Bottle	11	
2	Bottles, Dropping, 1/2 oz., Aqua Purple, Empty Bottle	12	

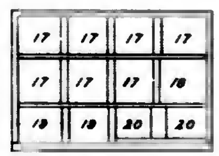


SUPPLY DRAWER R.H.

NO.	ARTICLE	COMP.	REMARKS
1	Jar, 8 oz.	13	
1	Towel	13	
1	Flashlight Holder	14	
1	Flashlight	15	

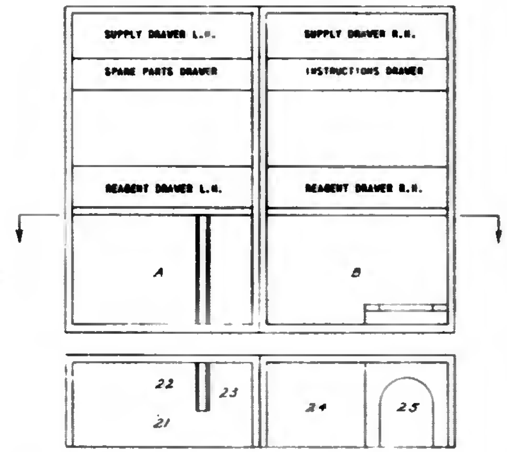
INSTRUCTIONS DRAWER

NO.	ARTICLE	COMP.	REMARKS
	Instructions, Notebook, Pencils	16	
	Loading Plan		Folded



REAGENT DRAWER R.H.

NO.	ARTICLE	COMP.	REMARKS
7	Bottles, Reagent, 8 oz., Sulfuric Acid, Soap, Silver		
	Nitrate, Barium Chloride, Turbidity, Zeo-Karb No.		
	Sample Bottle	17	
1	Graduate, 25 ml, Pipette, 1 ml.	18	
2	Bottles, Reagent, 8 oz., Alum, Soda Ash	19	
2	Bottle, 4 oz., Empty	20	



A

NO.	ARTICLE	COMP.	REMARKS
1	Flocculator	21	
1	pH and Chlorine Comparator	22	
1	Toxicity Set	23	

B

NO.	ARTICLE	COMP.	REMARKS
1	Turbidimeter	24	
1	Measuring Cup, 1000 ml.	25	

28 DEC 1943

CORPS OF ENGINEERS U. S. ARMY

WATER PURIFICATION EQUIPMENT

CHEST, FIELD WATER QUALITY CONTROL

LOADING PLAN

THE ENGINEER BOARD

FORT BELVOIR, VIRGINIA

SHEET 7 OF 7 SHEETS

D 3898 - 7

APPENDIX C

INSTRUCTIONS FOR PERFORMING TESTS IN WATER QUALITY CONTROL SET

INSTRUCTIONS FOR PERFORMING TESTS IN WATER QUALITY CONTROL SET

1. Flocculation Test. The purpose of this test is to determine the correct pH and the proper alum and soda ash dosages for best flocculation. Standard alum and soda ash solutions are to be made up in the field, using the capsules provided. These capsules contain a measured amount of chemical. A solution of the same strength is obtained each time it is prepared. A reliable measure of the alum and soda ash dosage being added is obtained in this way. Capsules of each chemical and dropper bottles in which the solutions are to be prepared are found in the right hand reagent drawer. The actual test is performed in the square wide mouth bottles and shaker holder provided in the lower left hand compartment. A graduated porcelain cup is provided for measuring out the amount of alum and soda ash needed for treating 3000 gallons of water with a given dosage. Grains per gallon (gr. p. g.) is the customary unit used in expressing dosages of flocculating chemicals.

a. Preparation of Standard Alum and Soda Ash Solutions.

(1) Alum solution.

(a) Remove the dropper pipette from the alum dropper bottle and place a funnel in the empty bottle.

(b) Fill one of the empty bottles provided in the chest with clear water and have available for step (d).

(c) Open one of the alum capsules (clear) directly over the funnel and squeeze or shake out all of the chemical possible. Try to transfer all of the powder from the capsule to the dropper bottle with as little loss of chemical as possible.

(d) Wash the alum powder from the funnel into the dropper bottle with the water at hand. Wash free any chemical remaining in the capsule with a little water.

(e) Complete filling the dropper bottle with water after all alum has been washed into it.

(f) Replace dropper and screw cap and shake thoroughly before using.

(g) When refilling bottle after the solution has been used up, pour out any small portion that may be left, and rinse the bottle before preparing a new solution in it.

(2) Soda ash solution.

(a) Prepare the soda ash solution exactly as the alum solution, using the colored soda ash capsule.

b. <u>Procedure for the Flocculation Test</u>.

(1) Fill the four bottles in the flocculating set with raw water to be treated.

(2) Add a different alum dosage to each of the four bottles. As a first trial try 2, 3, 4, and 5 gr. p. g. dosages. To add a dosage of 1 gr. p. g., fill the dropper (Fig. 1.) exactly to the upper mark and force out alum solution down to the lower mark. To add 2 gr. p. g. start at the upper mark and empty the dropper completely.

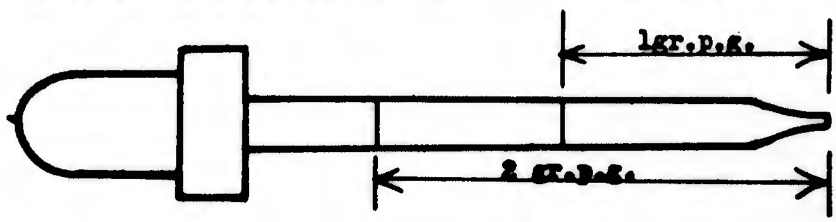


Fig. 1

(3) Place the bottles in the holder and shake vigourously for two minutes.

(4) Hold the shaker up, preferably in the shade, and look through the bottles against the light to determine if a satisfactory floc has formed. A satisfactory floc is one that produces flakes of sufficient size to gather in and carry down most of the suspended matter in the raw water, leaving a clear solution after the floc has settled. If a satisfactory floc has formed check the pH according to (7), below.

(5) If a satisfactory alum floc is not obtained in any of the samples, empty the bottles and repeat the test, using fresh water samples and a higher series of alum dosages. As a second trial try 6, 7, 8, and 9 gr. p. g. alum dosages.

(6) If alum alone does not produce a good floc, repeat the tests, using fresh raw water samples. Add the same alum dosage as before but in addition add half as great a dosage

of soda ash. The soda ash solution is of the same strength as the alum solution. Hence the dropper markings represent the same dosage in grains per gallon as with the alum solution. For example, 2, 3, 4, and 5 gr. p. g. of alum would require 1, 1½, 2, and 2½ gr. p. g. of soda ash, respectively. The dropper is not marked for a ½-gr. p. g. dosage. When adding solution from the upper graduation mark, the midpoint between the upper and lower graduation mark represents ½ gr. p. g. Estimate this point as closely as possible. The soda ash dosage to be added should be noted with a pencil before starting the addition of solution to avoid confusion in dosing.

(7) Check the pH of the water in the bottle which gives the best floc. If a number of dosages give a good floc, select one of the lower dosages for the purpose of saving chemicals. Consider this pH and the corresponding alum and soda ash dosage to be optimum for flocculation.

c. Measuring the dosage of alum and soda ash required for precoagulation of 3000 gallons of water.

(1) Method used for weighing alum.

When it is desired to obtain a certain dosage of alum in a tank of water, a definite amount of chemical must be weighed out. A simple method for weighing alum when no scale is available is given in the following procedure. The weight of alum is obtained by measuring the volume of water which the alum lumps replace. The white porcelain measuring cup is used for this purpose. The cup is always filled to the same level with water (the 16-oz mark). Alum lumps are added to raise the water level. Alum is 1.6 times as heavy as the same volume of water. For example, when the water level has been raised 10 ounces (from 16 oz to 26 oz) on the graduated scales, 16 ounces or 1 pound of alum has been measured. By always using the 16-oz mark as the beginning water level in the measuring cup and 3000 gallons of water as the amount to be treated, the water level in the cup corresponding to 1, 2, 3 and 4 gr. p. g. can be given directly without calculation to convert from pounds to gr. p. g. For the convenience of the man in the field, the Table in Fig. 3 gives the dosage directly in gr. p. g.

(2) Procedure.

(a) Obtain the optimum dosage of alum according to the procedure for the flocculation test under b, above.

(b) Fill the porcelain measuring cup to the 16 oz mark with water as shown in Fig. 2.

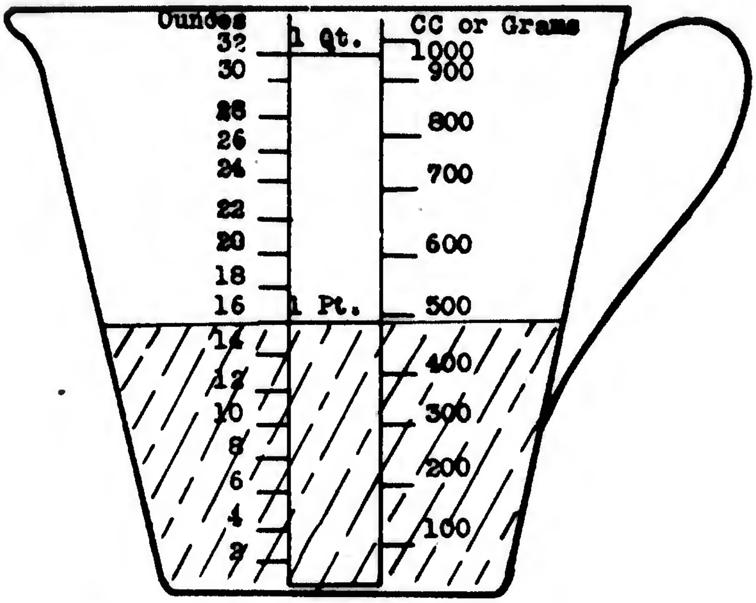


Fig. 2

(c) From the Table Fig. 3, below, determine the height to which the water level must be raised to obtain the desired dcsage.

Alum Dosage in 3000 Gal. Water (gr.p.g.)	Water Level in Cup
4	1000 cc.
3	29 oz.
2	24.5 oz.
1	20. oz.
Initial Water Level	

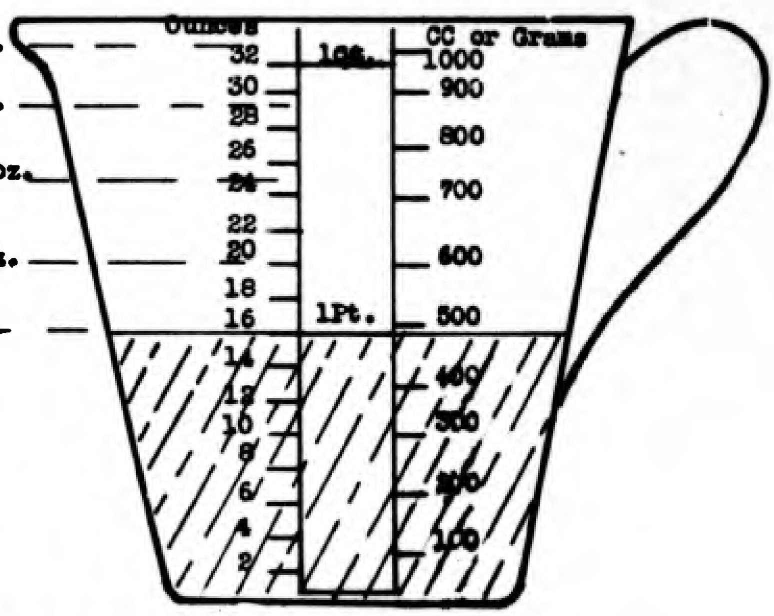


Fig. 3

When treating more or less than 3000 gallons of water change the above dosages accordingly.

For dosage above 4 gr. p. g. make two separate measurements and add the two dosages together to obtain the higher value.

(d) Add lumps of alum until the water reaches the level as determined from Fig. 3. Make certain that all alum lumps are below the surface of the water when the final level is checked.

Example:

Fig. 4 below is an illustrated example showing the measuring of a 2-gr. p. g. dosage of alum.

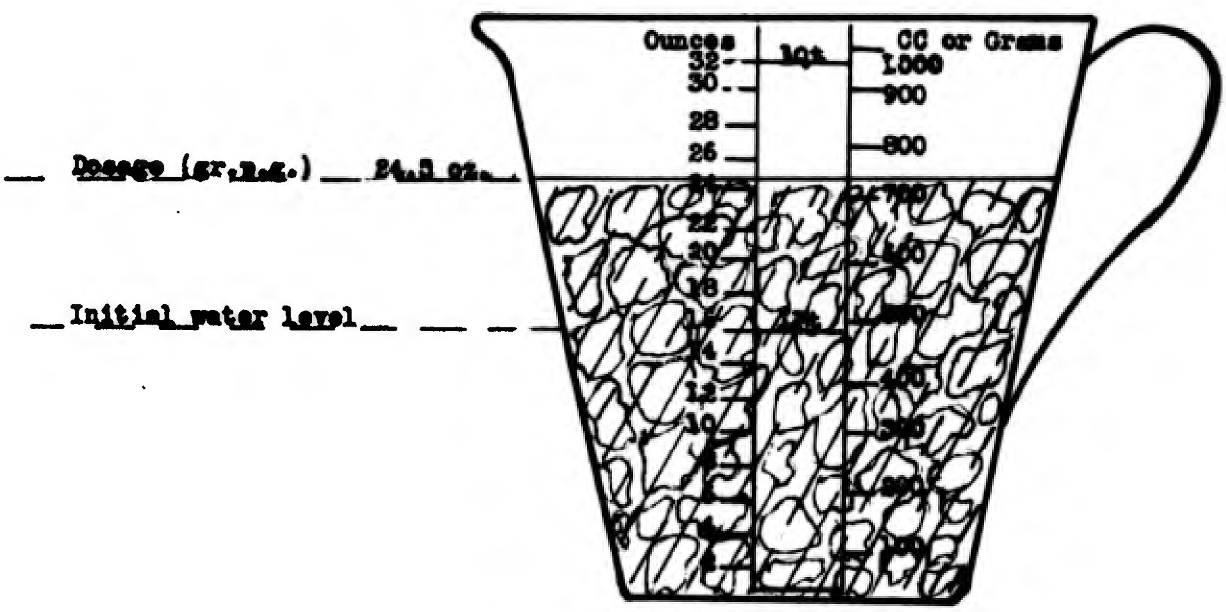


Fig. 4

(3) Measuring the soda ash dosage.

(a) First method: Four briquets of soda ash dissolved in 3000 gallons of water will give a dosage of approximately 1 gr. p. g.

(b) Second method: Measure broken pieces of briquets in the same manner as alum. Note the following Table (Fig. 5).

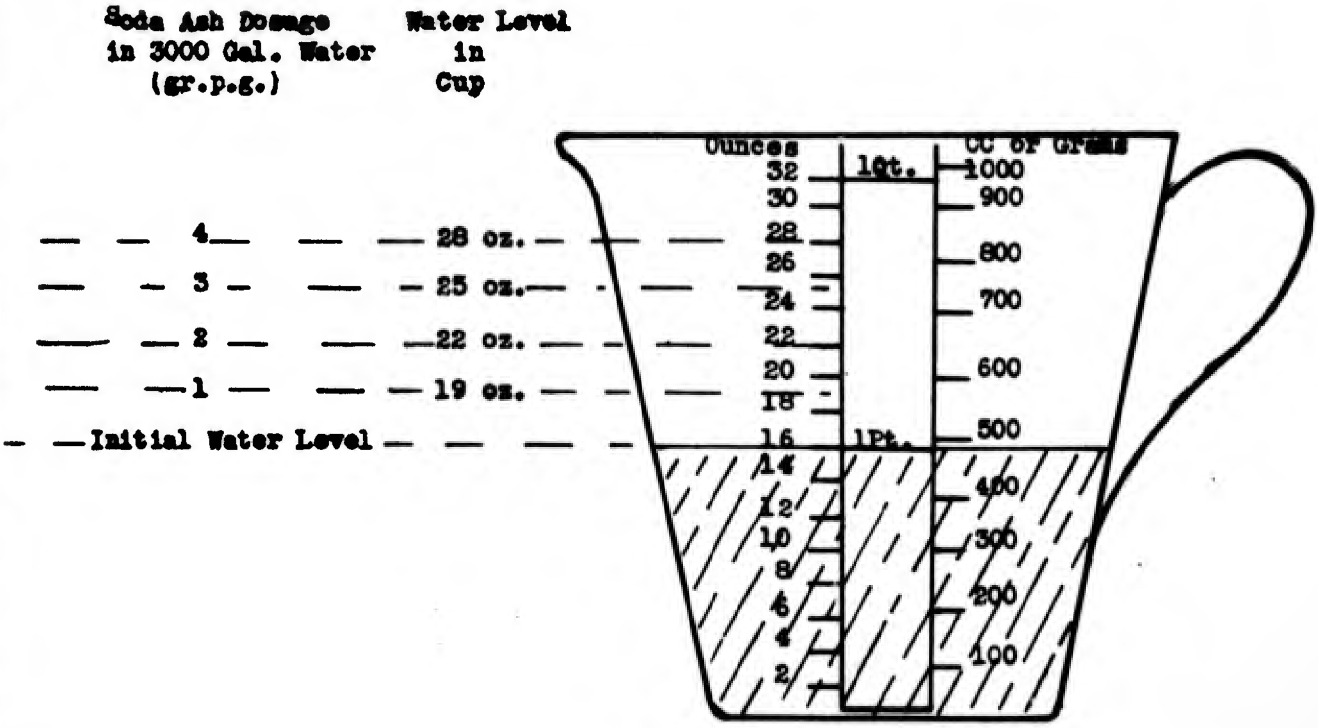


Fig. 5

d. Notes on Flocculation Test. Grains per gallon (gr. p. g.) is the customary unit used in expressing dosages of flocculating chemicals. One pound is equal to 7000 grains. One pound of alum or soda ash in 3000 gallons of water corresponds to a dosage of 2.33 gr. p. g. The following equation gives the weight of chemical to be used for a given dosage in a given amount of water.

$$\text{Pounds of chemical required} = \frac{\text{Gallons of water treated X dosage in gr. p. g.}}{7000}$$

For example: a dosage of 8 gr. p. g. in 3000 gallons of water will require $\frac{3000 \times 8}{7000} = \frac{24000}{7000} = 3\ 3/7$ pounds

The soda ash dosage in the above procedure is fixed at one half that of the alum dosage. Smaller amounts of soda ash may be used successfully, but this rule of thumb ratio has been found quite satisfactory in general flocculation treatments, and is further supported by the fact that this ratio of soda ash to alum provides the theoretical amount of soda ash needed to react with the alum.

In the procedure above a maximum of 9 gr. p. g. is suggested for trial purposes. Dosages of as much as 12 gr. p. g. have been used. Alum dosages in municipal water plants vary considerably but run as low as one gr. p. g. Overdosing is often as unsatisfactory as underdosing. Hence the value of determining optimum flocculation conditions.

2. Salinity Tests. The four tests, chlorides, alkalinity, soap hardness, and sulfates are known as the salinity tests. Two bottles of reagents are provided for each test, a small bottle in the left hand reagent drawer and a large bottle in the right hand reagent drawer. It is intended that the small bottle is to be used first for the tests and is to be refilled from the larger bottle as the solution is used up.

The test bottle in which the water sample is to be checked are found in the left hand reagent drawer. For the soap test the test bottle is marked "hardness testing bottle." The test bottles for sulfates, chlorides, and alkalinity are the four unlabeled, square, wide mouth jars in the left hand reagent drawer. These bottles have two marks, the lower one at 50-ml capacity and the upper one at 100-ml capacity. The abbreviation ml. stands for milliliters and will be used throughout the instructions.

Indicators (potassium chromate, methyl orange, phenolphthalein) for the chlorides and alkalinity tests provided in dropper bottles in the left hand reagent drawer.

The test solutions are measured out with a dropper pipette provided in the pipette case. These pipettes deliver a total of one ml from the upper graduation mark and are further calibrated in 1/10 ml divisions as shown below.

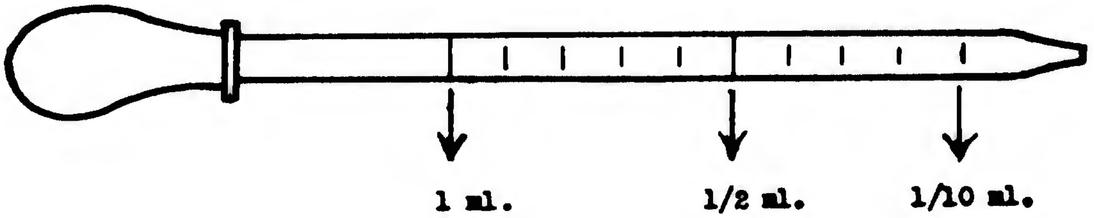


Fig. 6

Each pipette is to be used only for the test for which it is marked in the pipette case and is to be returned directly to its place in the pipette case after the test is completed.

This pipette is conveniently manipulated by placing the pipette in the palm of the right hand with the rubber bulb between the thumb and forefinger. When making the alkalinity and chloride test, the left hand is left free to rotate the test bottle while the chemical is being added, and the amount of chemical added can be carefully measured.

The amount of a substance present in the water is generally given as parts per million (ppm) meaning one part of chemical in a million parts of water. Alum and soda ash dosages are more often given in grains per gallon (gr. p. g.). A grain per gallon is 17.1 times as large as a part per million.

The four salinity tests, hardness, chlorides, sulfates, and alkalinity each serve to give the mineral characteristics of the water but when taken together an estimate of the total dissolved solids is obtained. The total dissolved solids are commonly used to classify various waters as to mineral content. An approximation of the total dissolved solids may be calculated as follows:

$$\text{Total dissolved solids ppm} = (\text{ppm alkalinity as } CaCO_3) + (\text{ppm sulfates as } SO_4 \times 1.4) + (\text{ppm chlorides as } Cl \times 1.6)$$

Sample calculation of total dissolved solids:

Salinity test on water:
Alkalinity = 200 ppm
Sulfates = 100 ppm
Chlorides = 300 ppm

$$\begin{aligned}\text{Total dissolved solids} &= 200 + (100 \times 1.4) + (300 \times 1.6) \\ &= 200 + 140 + 480 \\ &= 820 \text{ ppm}\end{aligned}$$

The above method for calculating the salinity is based on certain assumptions, and does not represent an exact calculation but is sufficiently close to the true value for general use.

The analyses in the Table in Fig. 3 show the general variation of ground and surface waters used for drinking purposes in the United States. Results obtained on water being tested may be compared with this table.

a. Test for Chlorides.

(1) Fill one of the test bottles to the lower mark (50 ml) with the water sample.

(2) Add 3 drops of potassium chromate (yellow) indicator solution. Place the test bottle over a white towel or other white surface so that a color change in the solution can be easily seen.

VARIOUS SURFACE AND GROUND WATERS OF THE UNITED STATES

(Approx. Mineral Content)

TABLE III

WELL WATERS [1]
(Used as City Supplies)

City	Total Dissolved Solids	Total Hardness ($CaCO_3$)	Chloride (Cl)	Alkalinity ($CaCO_3$)	Sulfate (SO_4)	Remarks
Pensacola, Florida	27	7	6	3	3	
Memphis, Tenn.	87	39	2	66	4	
Savannah, Georgia	180	120	6	114	7	
Long Beach, Calif.	222	33	28	199	1	
Lincoln, Nebr.	230	135	12	94	53	
Baton Rouge, La.	260	3	6	202	11	
Enid, Oklahoma	292	187	26	183	19	
Alexandria, La.	298	5	20	196	4	
Madison, Wis.	339	336	9	291	35	
Lansing, Mich.	394	401	16	321	49	
Clarksdale, Miss.	424	51	64	284	5	
Peoria, Illinois	456	386	21	344	52	
Amarillo, Texas	514	305	20	381	63	
Sioux Falls, S.D.	515	408	6	267	159	
Aurora, Illinois	517	298	130	266	36	
Fort Dodge, Iowa	573	459	5	387	139	
Santa Monica, Calif.	610	353	54	240	184	
Jamestown, N. D.	780	362	40	356	241	
Sioux City, Iowa	792	548	10	316	298	
Galveston, Texas	825	68	299	298	0	
St. Augustine, Fla.	947	520	225	143	291	
Galesburg, Illinois	1,030	231	175	246	314	
Aberdeen, S. D.	1,969	799	74	138	1,199	

1. From "The Industrial Utility of Public Water Supplies in the United States - 1932" U. S. G. S. Water Supply Paper - 658

SURFACE WATERS

Source	Total Dissolved Solids	Total Hardness ($CaCO_3$)	Chloride (Cl)	Alkalinity ($CaCO_3$)	Sulfate (SO_4)	Remarks
Atlantic Ocean	40,100	4,736	18,885	143	3,050	
Great Salt Lake	203,490	23,840	112,896	305	13,593	
Lake Michigan	157	125	4	120	12	Used as water supply for Chicago
Rainwater	18	8	4	5	3	
Rivers: [1]						
Delaware	70	43	3	38	12	Used as water supply for Philadelphia, Pa.
Hudson	108	68	4	60	16	" " " " " Poughkeepsie, N.Y
Potomac	130	79	6	29	58	" " " " " Washington, D.C.
Mississippi	202	139	9	106	43	" " " " " St. Louis, Mo.
Ohio	207	110	22	37	72	" " " " " Louisville, Ky.
Rio Grande	791	354	164	146	228	" " " " " Laredo, Texas
Arkansas Low Flow	1,900	322	610	148	211	Great variation in mineral content of water. Formerly used as water supply by Little Rock, Ark. Diluted with well water during period of low flow to reduce chloride content.
Average	630	191	203	121	93	
Saline	2,908	543	1,012	265	479	Not desirable as a city water supply.
Pecos	3,652	1,778	944	69	1,400	Not desirable as a city water supply.

1. From "Composition of River and Lake Waters of the United States - 1924" U. S. G. S. - Prof. Paper 135

WELL WATERS
(Considered unsatisfactory for Drinking Purposes)

Source	Total Dissolved Solids	Total Hardness ($CaCO_3$)	Chloride (Cl)	Alkalinity ($CaCO_3$)	Sulfate (SO_4)	Remarks
"Alkali" Wells of [2] North Dakota	4,590	1,400	200	290	614	Inhabitants living in region of these wells consider them unsatisfactory as a regular source of drinking water.
"	3,580	1,880	95	410	978	
"	3,940	2,390	145	530	1,344	
"	2,870	1,175	282	380	1,737	
Well Waters of [3] Central Valley of California	3,600	910	1,740	124	5	Used as a domestic supply but later abandoned.
"	4,100	1,760	460	600	1,640	Used in cook wagon for a year but abandoned when better water was obtained.
"	2,900	1,280	145	124	1,680	Owner of well did not consider it usable for cooking or drinking
"	2,452	477	492	1,604	Trace	Inhabitants of region consider this water to be of poor quality

2. From "Journal of American Public Health Assoc. - Oct. - 1913"

3. From "Mineral Resources of the United States - 1911 - Part II"

Fig. 7 VARIOUS SURFACE AND GROUND WATERS OF THE UNITED STATES

(3) Add silver nitrate solution with the dropper pipette marked "silver nitrate" in the pipette case, until the sample being tested just begins to change from a yellow to a definite reddish color. Give the water sample a mild agitation after each addition of silver nitrate by rotating the bottle back and forth a couple of times.

(4) Record the total number of milliliters of silver nitrate used.

(5) Calculation of chlorides.
ppm chlorides = 100 x (total number of milliliters of silver nitrate required)

Sample calculation:

Silver nitrate added for 50 ml water sample

	1 ml
	1 ml
	0.3 ml
Total silver nitrate required	2.3 ml

ppm Chlorides = 100 x 2.3 = 230 ppm

NOTE: The above chloride value is in terms of the chloride radical (Cl).

b. Test for Alkalinity. The alkalinity of a water is divided into two parts: the total or methyl orange (M.O.) alkalinity and the phenolphthalein alkalinity. Very few natural surface or ground waters will show a phenolphthalein alkalinity. All except acid waters will show a M.O. alkalinity. Methods for determining each are as follows:

(1) Methyl orange alkalinity.

(a) Fill the test bottle to the lower (50 ml.) mark with the water sample to be tested.

(b) Add 2 drops of methyl orange indicator solution. Place the test bottle over a white towel or other white surface so that a color change in the solution can be easily seen.

(c) Add sulfuric acid solution with the dropper pipette, marked "sulfuric acid" in the pipette case, until the test sample just begins to turn from a yellow to a pinkish - red color.

(d) Record the total number of milliliters of acid used to reach the endpoint.

(e) Calculation of Methyl orange alkalinity:

ppm methyl orange (M.O.) alkalinity = 100 x (total milliliters of sulfuric acid required)

Sample calculation:

Sulfuric acid added to 50 ml water sample

	1 ml
	1 ml
	0.5 ml
Total ml of acid required	2.5 ml

ppm M.O. alkalinity = 100 x 2.5 = 250 ppm

(2) Phenolphthalein alkalinity.

(a) Fill the test bottle to the lower (50-ml) mark with the water sample to be tested.

(b) Add 2 drops of phenolphthalein indicator solution. Place over a white surface as in previous test.

If no color forms in the sample record the value for the phenolphthalein alkalinity as zero and consider the test completed.

(c) If a pink color forms in the solution add sulfuric acid solution to the test sample a drop at a time, until the pink color just disappears.

Record the total number of milliliters of sulfuric acid required to reach the endpoint.

(d) Calculation of Phenolphthalein alkalinity:

ppm phenolphthalein alkalinity = 100 x (total milliliters of sulfuric acid required)

c. Soap Test for Hardness.

(1) Fill the "hardness testing bottle" to the upper (50-ml) mark with the water sample to be tested.

(2) Add soap solution to the sample as explained below. Each time soap solution is added record the amount used.

(a) Using the dropper pipette, marked "soap" in the pipette case, add 1/2 ml of soap solution to the water sample. Give the bottle a short vigorous shaking and place it on its side allowing it to rest on a table top or similar fixed surface.

If no lather forms continue the addition of soap solution in 1/2-ml portions shaking the bottle and placing it on its side after each addition as directed above. As soon as a lather is obtained allow the test bottle to remain undisturbed on its side until the surface of the lather begins to "break" or, if the lather does not break, allow it to remain for a total of 5 minutes.

Note: A "break" in the lather surface means that the layer of soap bubbles has broken enough so that the water below shows plainly through the opening in the lather film. After the first addition of soap, unless the water is very soft, nearly all of the soap bubbles will disappear from the surface. As more soap is added the break in the lather film will become smaller and may be roughly one square inch or less before a 5-minute permanent lather is reached.

(b) If the lather surface remains unbroken after 5 minutes consider the test completed. Add up the total number of milliliters of soap required to obtain a permanent lather and calculate the hardness according to (3), below.

(c) If the lather surface breaks before 5 minutes has elapsed, add another 1/2 ml of soap solution and repeat the test exactly as before. Continue the addition of soap solution 1/2 ml at a time until a 5-minute lather is obtained.

Add up the total number of milliliters of soap required to obtain a permanent lather and calculate the hardness according to (3), below.

If more than 6 ml. (12 $\frac{1}{2}$-ml additions) are required to obtain a permanent lather see (4) below.

(3) Calculation of hardness (50-ml sample):

ppm hardness = 50 x (total milliliters of soap solution required for a permanent lather)

Sample calculation:

Soap solution added to 50-ml sample of water

	$\frac{1}{2}$ ml
	$\frac{1}{2}$ ml
	$\frac{1}{2}$ ml
	$\frac{1}{2}$ ml
Total ml of soap required	2 ml

ppm hardness = 2 x 50 = 100 ppm

(4) If more than 6 ml of soap solution are required to obtain a permanent lather the test should be repeated with a fresh sample of water which has been diluted with equal parts of zero hardness water. Proceed as follows:

(a) Prepare sample.

/1 Measure out 25 ml of water to be tested in the graduated cylinder (located in the right hand reagent drawer) and pour into the hardness testing bottle.

/2 Measure out 25 ml of solution into the graduated cylinder from the bottle labeled "zero hardness water" (located in the right hand reagent drawer). Pour the zero hardness water carefully from the top of the bottle to avoid the loss of any of the solid material. Add this portion of zero hardness water to the sample already in the hardness testing bottle.

(b) Proceed with the test in exactly the same manner as outlined above.

(c) Calculation of hardness (25-ml sample):

ppm hardness = 100 x (Total ml soap solution required for permanent lather

(5) After using as much of the zero hardness water as is needed for the test being performed, refill the bottle with a clear drinking water, to prepare it for later use, before replacing it in the reagent drawer.

If all of the zero hardness water is used while making the tests and more is needed immediately, refill the bottle with a clear drinking water and shake mildly for 10 minutes before using.

The solid in the bottom of the zero hardness bottle will soften only a certain amount of hard water. Roughly 40 or more of the 25-ml portions can be softened before the chemical will become exhausted. To check the zero hardness water place 25 ml of it in the hardness testing bottle and add to it ½ ml of soap solution. A 5-minute lather should be obtained. If the zero hardness water fails to meet this consider the chemical exhausted.

The solid chemical will soften very hard waters, but the length of time it can be used will be increased by refilling the bottle, after a part of it has been used, with a water known to be relatively soft. None of the zero hardness water should be wasted.

d. Test for Sulfates. This test does not give the exact quantity of sulfate in the water, but tells whether there is more or less than a certain amount present. Since the approximate sulfate value is found by trial, the test may have to be repeated several times. The following procedure starts the test for sulfates at 100 ppm.

(1) Test for 100-ppm sulfates.

(a) Fill a clean test bottle to the upper (100 ml) mark with the water to be tested.

(b) Add 1 ml of barium chloride solution to the sample and shake intermittently for 10 minutes.

(c) Tear a piece of filter paper into small pieces. Remove cap from the bottle and place paper pieces in the solution.

(d) Shake the sample for about 5 minutes, or until the filter paper becomes fluffy and gelatinous.

(e) Set up a second test bottle with a funnel and filter paper.

(f) Filter about one-fourth of the sample from the first into the second bottle. Rinse the second bottle with this small portion of filtrate, and discard. Replace the funnel and continue the filtration.

(g) Collect about one-half bottle (50 ml) of filtrate.

(h) Add 1 ml of barium chloride solution to the filtrate, shake for five seconds and observe immediately for a precipitate, or a clear solution.

(i) Reading the test.

/1 If a clear solution is obtained, the sulfates are less than 100 ppm. Discontinue the test and record the sulfates as less than 100 ppm.

/2 If an immediate precipitate or milky solution is obtained, the sulfates are greater than 100 ppm. In this case proceed with the test for 200-ppm sulfate as given below.

(2) Test for 200-ppm sulfates.

Use a fresh sample of water. Perform all steps in the procedure in exactly the same manner as the test for 100-ppm sulfate, except steps (b) and (i) which will read as follows:

(b) Add 2 ml of barium chloride solution to the sample, and shake intermittently for 10 minutes.

(i) Reading the test.

/1 If a clear solution is obtained, the sulfates are less than 200 ppm. Discontinue the test and record the sulfates as between 100 and 200 ppm.

/2 If an immediate precipitate or milky solution is obtained, the sulfates are greater than 200 ppm. In this case repeat the test with a fresh sample of water for 300-ppm sulfate.

(3) Test for sulfates above 200 ppm

The sulfate test starts at 100 ppm, and is repeated in steps of 100 ppm until a clear solution is obtained in step (h), above, the only changes in the test being the number of milliliters of barium chloride added in (b), and the answer obtained under (i). One ml of barium chloride is equal to 100-ppm sulfate; hence, to test for 300-ppm sulfate, add 3 ml of barium chloride in (b); likewise, to test for 400-ppm sulfate, add 4 ml of barium chloride in (b), etc. Note that the 1 ml of barium chloride added in the final step, (h), of the test after the filtration has been performed is not changed. This amount is merely added to show if any sulfate remains in the solution.

(4) Notes on sulfate test:

When it is desirable to check a water for sulfates below 100 ppm, ½ ml may be used in step (b) to determine if the sulfates are above or below 50 ppm. All other steps in the procedure remain the same. Efforts should not be made to read sulfates in steps of less than 50 ppm.

3. Turbidity. Standards for turbidity are prepared by using a turbidity free water and adding to it a known amount of a standard turbidity solution. A water which appears clear to the eye may still contain several ppm of turbidity, which must be removed before making up the turbidity standards. A turbidity viewing box and four bottles are provided in the lower right hand compartment. Flashlight and holder are in the right hand supply drawer. A stock bottle of standard turbidity solution is provided in the right hand reagent drawer.

a. Preparation of Turbidity Free Water.

(1) Fill the square, 8-oz bottle found in the right hand supply drawer, and a similar bottle from the flocculation set, with a clear drinking water.

(2) To each of the bottles add a piece of filter paper which has been torn into about 10 or 15 small pieces.

(3) Shake each bottle intermittently for about 10 minutes. The filter paper will become fluffy and gelatinous.

(4) Add approximately 5 ml of alum solution (one dropperful = 1 ml) to each bottle, and shake immediately. Use the same alum solution provided for the flocculation test. Continue shaking for about 5 minutes.

(5) Set up two of the round bottles in the turbidimeter with a funnel and filter paper. Make sure that these bottles are clean.

(6) Filter about 1/4 of a bottleful, remove the funnel, rinse the bottle with this portion and discard. Replace the funnel and continue filtering until the bottle is full to the neck.

(7) The zero turbidity water prepared should be checked in the turbidimeter to make certain that all turbidity has been removed. Complete reading the instructions before checking these samples.

(8) Prepare 0 ppm and 3 ppm turbidity standards as follows:

(a) Turbidity standard for 0 ppm.

Use the zero turbidity water exactly as prepared above without further treatment. Seal immediately with plastic screw cap to avoid getting dust into the sample, and mark as 0 with wax pencil.

(b) Turbidity standard for 3 ppm.

To the second bottle of zero turbidity water add 3 ml of standard turbidity solution from the stock solution bottle in the right hand reagent drawer. Thoroughly shake the stock turbidity solution just before any portion is drawn from it. Not more than one minute should elapse between the time the solution is shaken and the necessary number of milliliters are withdrawn. Mark the bottle as 3 with a wax pencil.

b. How to Use Turbidimeter to Compare Turbidities.

(1) The standard and the sample to be compared are placed in the turbidimeter side by side next to the light opening, as shown in Fig. 8 below. Remove the other two bottles from the back of the turbidimeter while making comparisons. Each bottle should be wiped clean with a towel before placing in the turbidimeter. Place the eye close against the port in the back of the box to view the samples. When comparing by sunlight, point the opening in the front of the turbidimeter toward the sun. For

night or indoor comparisons, place the flashlight in the holder as shown, and move the flashlight from one bottle to the next. In the direct rays of the sun or by flashlight the suspended particles will sparkle and the path of the light rays can be plainly seen. Under cloudy skies the suspended particles merely give a milky white color to the sample. A water having zero turbidity will show no light rays or milky color whatsoever. The original zero turbidity water, as prepared in the procedures (1) to (7), above, should be checked in the turbidimeter before standards are made up, to make certain that all turbidity has been removed.

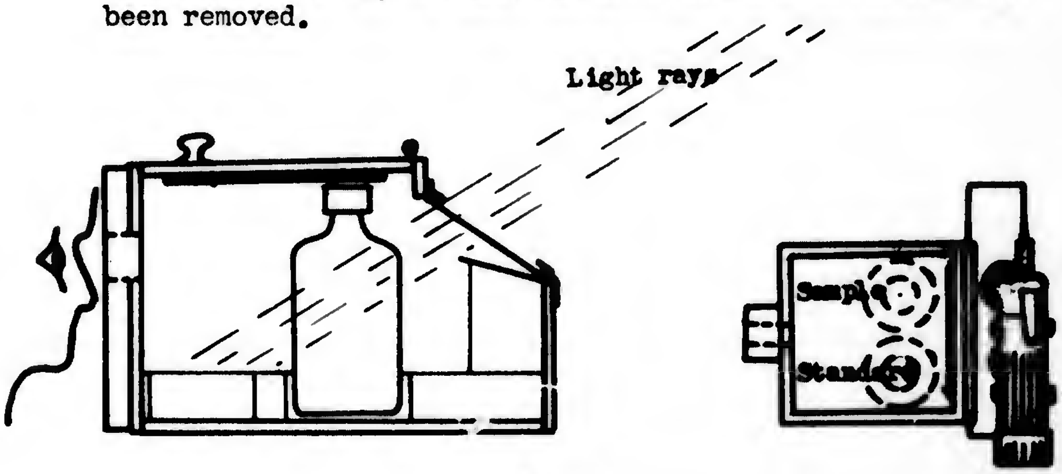


Fig. 8

c. Procedure for Routine Testing.

(1) Collect the water sample to be tested in one of the empty turbidity bottles. Both water sample and standard bottles should be clean inside and outside.

(2) Place the water sample and zero standard in the turbidimeter as directed above.

The purpose of this comparison is not to make a turbidity reading but to give the observer the contrast between a water sample in which turbidity is present and one in which it is absent.

(3) Remove the zero standard and replace it with the 3 ppm standard. Determine if the sample shows more or less turbidity than the standard and record the turbidity as one of three values: equal to 3 ppm, less than 3 ppm, or greater than 3 ppm.

d. Practice Procedure.

If the turbidimeter is being used for the first time, and if the operator is not familiar with the appearance of a turbidity for practice purposes, the following standards should be made up: 0 ppm, 1 ppm, 3 ppm and 10 ppm. The 1 ppm standard will require 1 ml of standard turbidity solution, the 10 ppm standard will require 10 ml of solution, etc. Each bottle should be marked with a wax pencil. Compare various combinations of four standards in the turbidimeter.

e. Checking Low Turbidities with White Porcelain Measure.

The white porcelain cup with its black enameled spot on the bottom may be used to make rough but very rapid turbidity readings. This method can be employed to advantage in checking the water coming from a purification unit to determine if the clarity is being maintained.

To perform test, fill the cup with about ½ inch of the water to be tested, and note the appearance of the black spot. Continue filling the cup to the top and observe again. If the black spot is still as "black" as before a reasonably low turbidity has been obtained (below 5 ppm). Turbidities above 5 ppm will produce a graying or milky hue in the black spot. Several waters having various turbidities should be read both with the regular turbidimeter and with the white cup to acquaint the eye with changes in color of the spot with turbidity.

f. Raw Water Turbidity.

No turbidimeter for use on surface waters is provided in the set. The white porcelain measuring cup can be used to determine whether a river water has more or less than 100-ppm turbidity. Proceed as follows:

(1) Fill the cup to the top with water.

(2) If the black spot disappears from sight the turbidity is 100 ppm or over.

(3) If the outline of the black spot is still visible the turbidity is less than 100 ppm.

g. Notes on Turbidity Test.

The chief reason for recommending only one standard in routine checks of turbidity is to get as many tests as possible from the stock bottle or standard turbidity solution. A single turbidity standard of 3 ppm was chosen for routine use because this value is sufficiently low to serve as a goal to be attained in a treated water to be used for drinking purposes.

The zero standard need not be used in every comparison as prescribed under sub-paragraph c, above, but should be available.

Low turbidity standards (1 to 10 ppm) deep for only a short period of time. New standards should be prepared each week.

If the standard stock solution is shaken well each time before any solution is withdrawn, it will remain approximately at the same strength. It is recommended that the solution be discarded when the level reaches about 1 inch from the bottom of the bottle.

4. Free Chlorine and pH Determinations.

a. Equipment Provided.

In the lower left hand compartment, space is provided for the regular pH and chlorine comparator supplied with the water purification units. Place the comparator in this compartment when the testing set is received in the field. In addition to the chlorine and bromthymol blue color discs initially provided with comparator, two more pH discs, bromcresol purple-green (pH 4.4 - 6.) and aqua purple (pH 7.6 - 9.2) are supplied in the left hand supply drawer. One bottle of each of the four indicators and two dropper bottles are supplied in the left hand reagent drawer. Reserve stock bottles of indicator are supplied in the water supply equipment sets.

b. Need for Checking pH Readings at the End of the Range of the Indicator.

When using the bromcresol purple-green indicator, readings of 5.8 or 6.0 should be checked on the bromthymol blue disc to make certain that the readings are not above the range of the lower disc. Likewise pH readings of 7.8 and 7.6 on the aqua-purple disc should also be checked on the bromthymol blue disc. The reason for this check is that most colorimetric indicators undergo a pronounced change over a short interval of the pH range, but once the end of this range has been reached little change in the color is noted, even though a considerable change in the pH has taken place.

c. Use of Methyl Orange and Phenolphthalein as pH Indicators.

The two indicators used in the alkalinity determinations are not intended for regular pH work, but the pH at which these indicators change colors is given here as information to be applied as desired. These indicators may be used to check water samples as follows:

(1) If a water is suspected of having a rather high pH, it is possible to determine whether this pH is above or below 8.3 by filling a test bottle to the 50-ml mark with the water to be tested, and by adding 2 drops of phenolphthalein indicator. Observe color against a white background. Interpret the color of the water sample as follows:

Pink = pH above 8.3
Colorless = pH below 8.3

(2) If a water is suspected of having a very low pH, it is possible to determine if this pH is above or below 4.3 by filling a test bottle to the 50-ml mark with the water to be tested, and by adding 2 drops of methyl orange indicator. Observe color against a white background. Interpret the color of the water sample as follows:

Pinkish-red = pH below 4.3
Yellow = pH above 4.3

5. Toxicity.

a. "Screening" Kit for Chemical Warfare Agents.

(1) In the lower left hand compartment is provided "Kit, Water Testing, Screening, for Detection of Chemical Warfare Agents". This kit provides all necessary equipment needed to "screen" out waters contaminated with chemical warfare agents. Instructions for its use are included in the kit.

(2) The tests are intended to identify in a raw water supply chemical warfare agents such as Lewisite, Mustard, Nitrogen Mustard, etc., which would be most likely to occur in areas where war gases are being employed.

(3) Samples of water for these tests should be taken directly from the stream to be used.

(4) Tests should not be made on water which has already been put through the purification units.

(5) As the name indicates, these tests are for "screening" purposes. They point out raw waters which should be considered contaminated. When such raw water is discovered, another source giving a satisfactory test should be found.

(6) Nearly all natural waters have a pH well above 6.0. A number of chemical agents are able to lower the pH of the water considerably. When the pH has been lowered to less than 6.0 it is cause for suspicion.

In the case of highly colored swamp waters the normal pH of the surface waters of the region may be below 6.0. In this case a considerable drop in pH from the average or normal should be considered suspicious.

B. The instructions included with the kit are as follows:

DIRECTIONS FOR USE OF KIT, WATER TESTING, SCREENING, FOR DETECTION OF CHEMICAL WARFARE AGENTS.

I. Purpose

1. The field kit for water testing is designed as a reconnaissance kit. Its purpose is to screen out sources of water so contaminated with chemical agents that they cannot be rendered potable by customary field treatment methods, such as chlorination in the Lyster bag.

2. Negative tests indicate water suitable for chlorination and may thereafter be used by troops.

3. If any of the tests are positive, the water should not be used until a more complete analysis can be made.

4. The main purpose of the kit is to detect contamination by chemical agents in raw water. It is not designed for use in the control of treated water. Chemical reactions during water treatment invalidate the interpretations.

II. Procedures for Tests

A. <u>General Directions.</u>

1. Read directions thoroughly.

2. Obtain water sample in canteen cup without excessive disturbance of water source.

3. Start arsenic test (par. B, 1 below). While arsenic test is developing, carry out the other tests.

B. Procedures.

1. Arsenic Test.

a. Pour suspected water into the bottle up to mark on bottle.

b. Place 2 tablets from vial A into the bottle. Shake to dissolve.

c. Take a test strip from vial B by the top end. Carefully insert into the tube (H), bending the strip near the top so that it will remain in the upright tube. Touch only the top end of the strip. Keep dry.

d. When the tablets from vial A have disintegrated, add 5 pellets from vial C to the contents of the bottle P.

e. Promptly fit the test paper assembly into the bottle.

f. If cold, warm the bottle in your hands. Let react for 20 minutes.

g. Remove the strip and note the length of the yellow to brown stain. A stain 1/4 inch or more indicates a positive test. A stain less than 1/4 inch indicates a negative test.

2. pH Test.

Dip a strip of test paper from vial G into the suspected water until it becomes wet. Remove and compare resulting color with color chart on case lid. pH less than six (6) indicates possible contamination.

3. Mustard Test.
(Including Nitrogen Mustard and Cyanogen Chloride).

a. Rinse test tube with suspected water.

b. Carefully fill test tube to ½-inch depth with suspected water.

c. Add one tablet from vial D.

d. Shake for 3 minutes, to break up the tablet. Allow to stand for 5 minutes.

e. During cold weather, warm tube in hand or inside pocket for additional 5 minutes. NOTE: Yellow color after d or e is positive test for Cyanogen Chloride.

f. Break one tablet from vial E in half and add both halves to same test tube.

g. Shake until broken up. While shaking watch for the development of any color.

h. Observe for ½ minute against white background.

i. Even a slight blue or red color (mainly in curd) indicates a positive test for mustard or nitrogen mustard.

j. A yellow color indicates Cyanogen Chloride. In heavy contamination the yellow color appears before step f.

k. White or light gray color indicates a negative test for mustards.

4. Chlorine Demand Test.

a. Fill canteen with water to within an inch of the top.

b. Add three (3) tablets from vial F, screw cap on and shake to dissolve. (2-5 min.)

c. Five (5) minutes after tablets have dissolved transfer treated water from canteen to plastic tube with yellow band of vial X testing set, filling to bottom of yellow band.

d. Add one tablet from Vial X, shake, and note color when dissolved.

e. A positive test is indicated by no color or color lighter than yellow band in plastic tube.

f. A negative test is indicated by an orange color or color as deep as the yellow band.

5. <u>Taste and Odor</u>.

If test B(1), arsenic; B(3), mustard; B(4), chlorine demand; are negative, and pH is six or above, carefully smell and taste a small sample of the suspected water.

A positive test is indicated by:

i. a lacrimating or chlorinous odor.

ii. a biting and/or peppery chlorinous taste.

iii. any taste or odor of a known war gas.

Absence of all tastes or odors will indicate a negative result but not necessarily a safe water. A negative test is also indicated by the presence of only those odors and/or tastes normally characteristic of natural waters.

C. Interpretations.

Test

Contaminated Water

(Water will be considered contaminated if one or more of the tests gives results as indicated in this column.)

Arsenic Test (BI)	Positive
pH Test (B2)	pH below 6
Mustard Test (B3)	Positive
Chlorine Demand Test (B4)	Positive
Taste and Odor (B5)	Positive

Non-Contaminated W[illegible]

(Water will be considered suitable, after bacterial disinfection by usual methods, for one week if all the tests give results indicated in this column.)

Negative
pH above 6
Negative
Negative
Negative

APPENDIX D

INFORMATION REQUIRED FOR STANDARDIZATION

INFORMATION REQUIRED FOR STANDARDIZATION OF WATER
QUALITY CONTROL SET

1. Military Characteristics.

a. The water quality control set shall include equipment for making the necessary physical, chemical, and toxicity determinations for routine control testing at each water point.

b. A suitable chest of sufficient strength to permit handling in field transport shall be provided for this equipment.

c. Tests prescribed for the set shall be made as simple and easy to perform as is consistent with the results desired.

d. Adequate instructions or manuals of testing procedures shall accompany each set of equipment.

e. Sufficient reserve chemicals shall be provided to permit a reasonable number of determinations to be made without reservicing.

2. Dimensions and Weight.

a. Chest closed: 17" x 12" x 21½"

b. Chest open for use: Height: 21½"
Width: 24 "
Depth: 8½"

c. Weight: 80 pounds.

3. Photograph attached.

4. Estimated cost of single item $300.00.

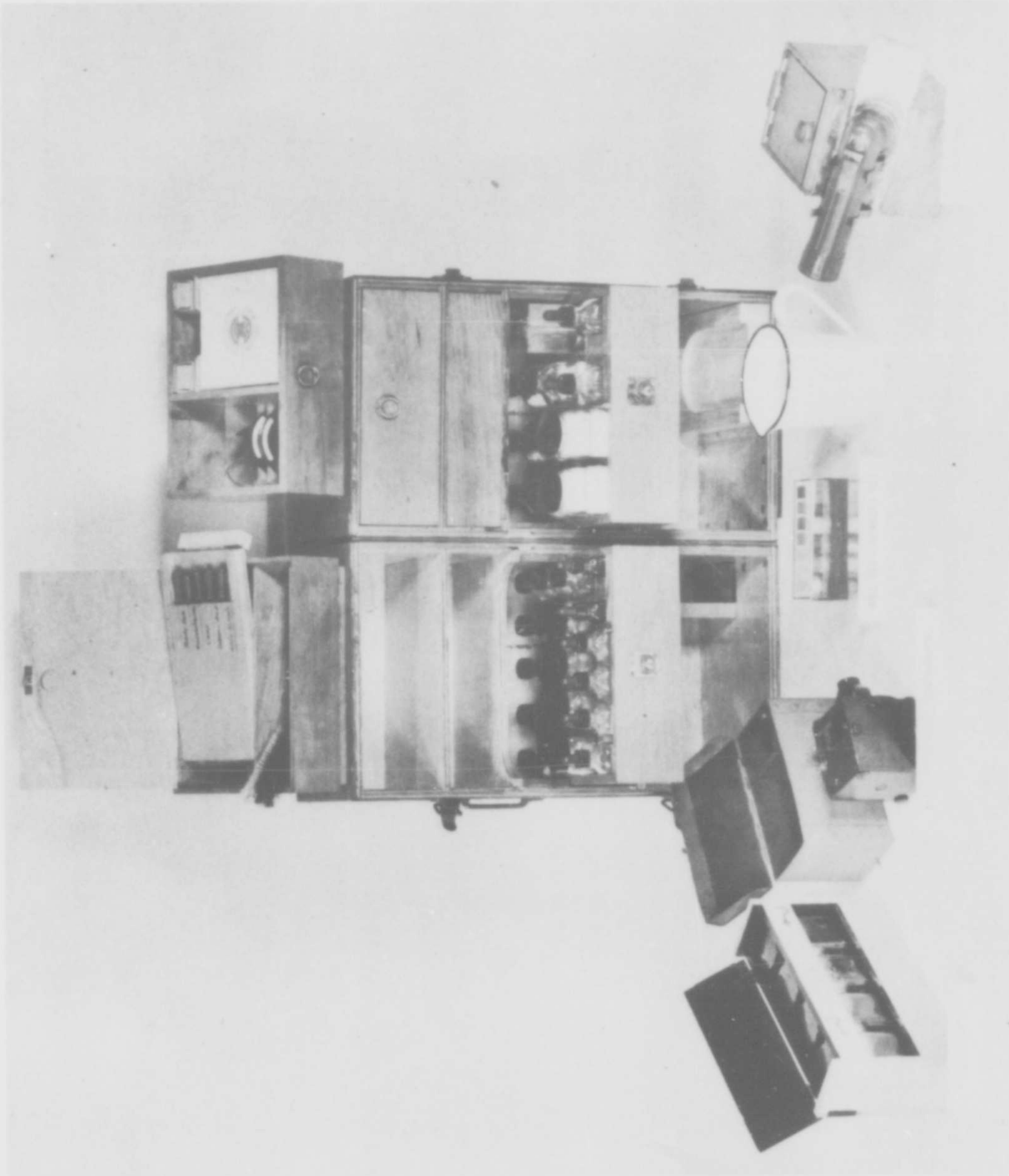
5. Estimated cost in quantity production $100.00.

6. a. Production can begin 60 days from receipt of order.

b. Rate of production - 100 per month,

7. The item is satisfactory from a development point of view for use overseas.

8. Set is new item of equipment but does incorporate standard items where possible.



WATER QUALITY CONTROL SET View showing component parts of set

UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED

Changed to ______

Classified

Cancelled ______

Date 12/2/59

By authority of Ch, Rest E

5/5/57

UNCLASSIFIED