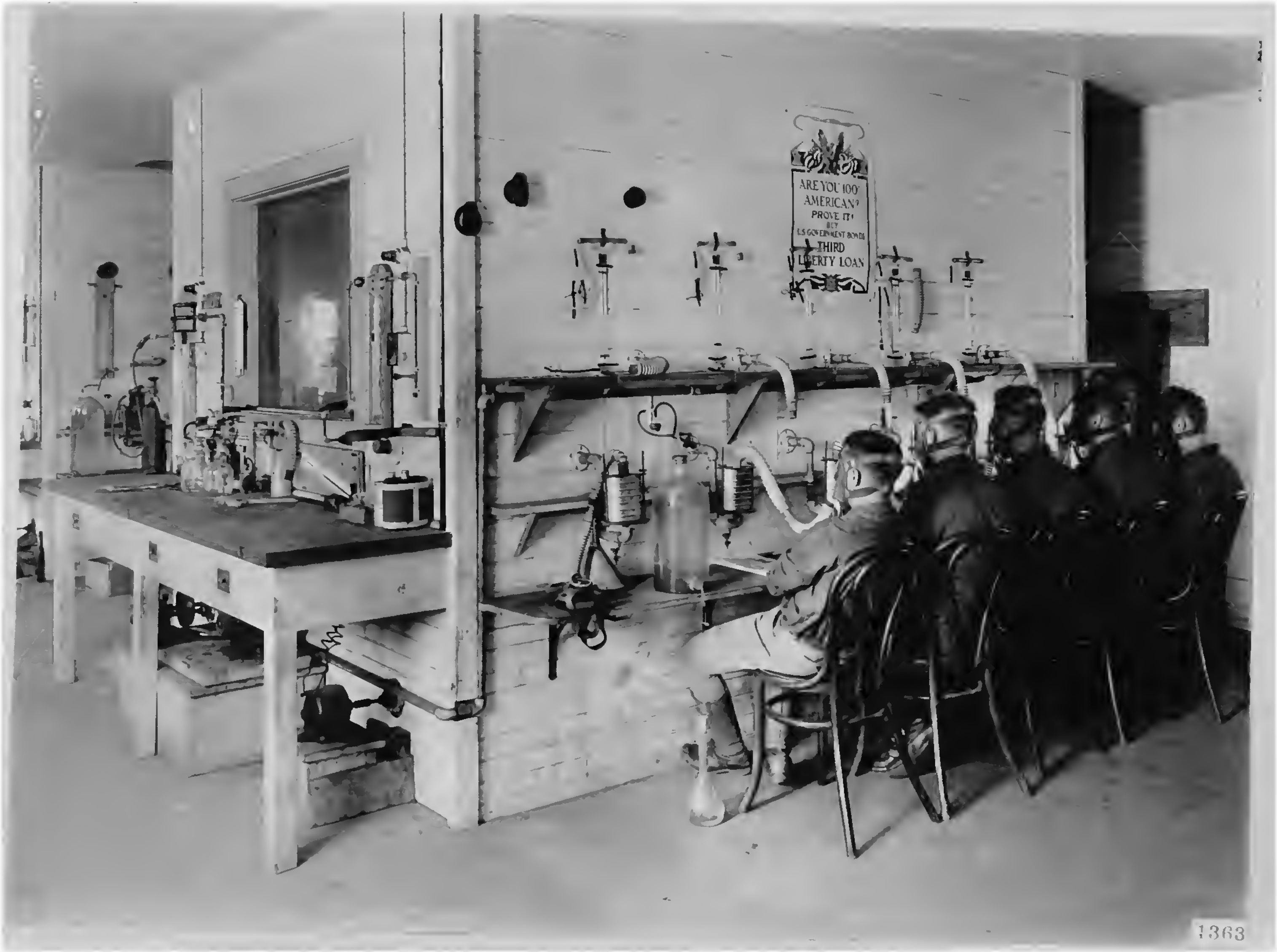


INTERIOR OF MAN TEST LABORATORY

U.S. Army. Chemical Corps.

WAR DEPARTMENT

CHEMICAL WARFARE SERVICE

RESEARCH DIVISION

AMERICAN UNIVERSITY EXPERIMENT STATION

WASHINGTON, D.C.

MAJOR GENERAL W. L. SIBERT, DIRECTOR

COLONEL G. A. BURRELL, CHIEF RESEARCH DIVISION

GAS MASK RESEARCH SECTION

A. C. FIELDNER, IN CHARGE

SUMMARY OF ACHIEVEMENTS

1917--1918.

GAS MASK RESEARCH SECTION.

TABLE OF CONTENTS.

GAS MASK RESEARCH SECTION.

1. METHODS OF TESTING GAS MASK ABSORBENTS:

Standard tube tests have been devised for determining the absorption value of charcoal and soda lime for various toxic gases. These methods have been introduced and are in daily use in the laboratories of the Gas Defense Division, as well as the Research Division. They have been of great value in the development of the superior absorbents in the U.S. mask. These methods include tests with the following gases: chloropicrin, phosgene, hydrocyanic acid, arsine, superpalite, cyanogen chloride, chlor- and bromacetone, benzyl and xylyl bromides chlorine, carbon monoxide and cyanogen.

Many of these methods were studied in considerable detail and reports issued showing the influence of such factors as the method of filling tubes, size of mesh, temperature and humidity of air-gas mixture, rate of flow, depth of absorbent column, etc.

2. ABSORPTION VALUES OF VARIOUS GAS MASK ABSORBENTS:

The Absorbent Testing Unit has conducted some 4000 tests on various kinds and grades of charcoal, soda-lime and other absorbents, to determine their precise value for absorbing toxic gases. From April 1 to Sept. 1, 1917, at which time the control laboratory at Astoria was established, this Unit tested all production samples. After this date and up to the present time, one daily check sample from Astoria was tested to insure accurate control of the quality of absorbents produced.

In Table 1 of the Appendix to this report will be found a compilation of results of representative absorbent tests.

3. ABSORBENTS FOR CC:

A wide variety of materials has been studied as possible agents for impregnating charcoal to improve its value for absorbing cyanogen chloride, without injuring its chloropicrin value. No impregnating agent was found, however, which would improve a charcoal in the dried condition. When the samples were equilibrated at 70% relative humidity before testing, impregnation in a 20% potassium carbonate solution showed an improvement of about 30% over the base charcoal.

The fact that German 1917 charcoal , containing hexamethylene tetramine and alkali, showed a very long service time against cyanogen chloride while wet, led to an attempt to impregnate American charcoal in this way. Hexamethylene tetramine alone lowered the service time, but in conjunction with alkali, an improvement of about 200% was obtained, several samples showing a service time of 200 minutes.

The conditions of impregnation, such as time, concentration of impregnating solution, washing, etc., were studied in detail, and the optimum conditions determined. Charcoals impregnated according to the final specifications retain much of their chloropicrin capacity.

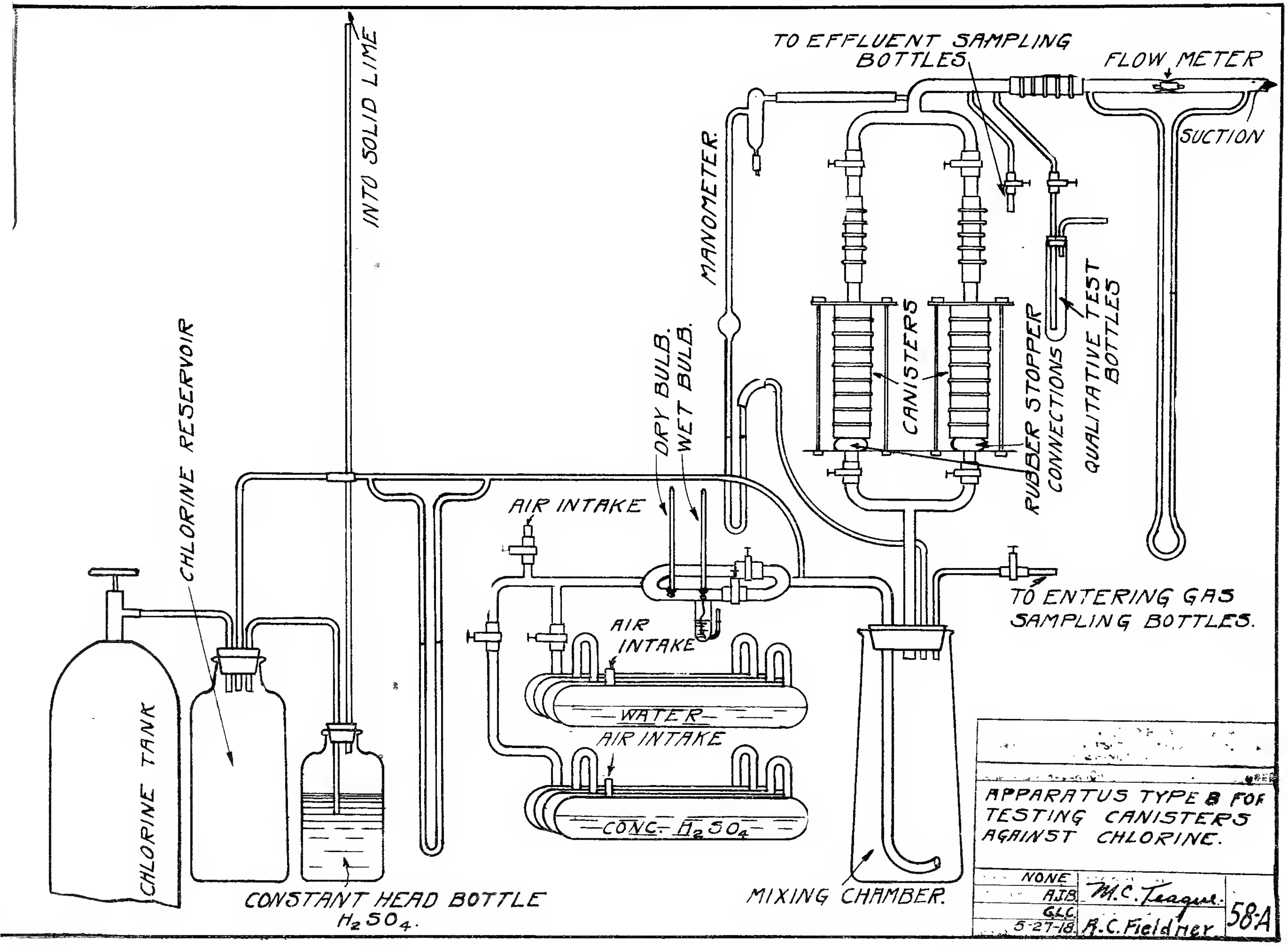
On impregnating a low grade whetlerite with hexamethylene tetramine and alkali, a service time of 75 minutes was obtained; although this was a 6-fold improvement over the base whetlerite, it did not indicate a high grade absorbent for cyanogen chloride. Attempts on better grade whetlerite have so far yielded poor results.

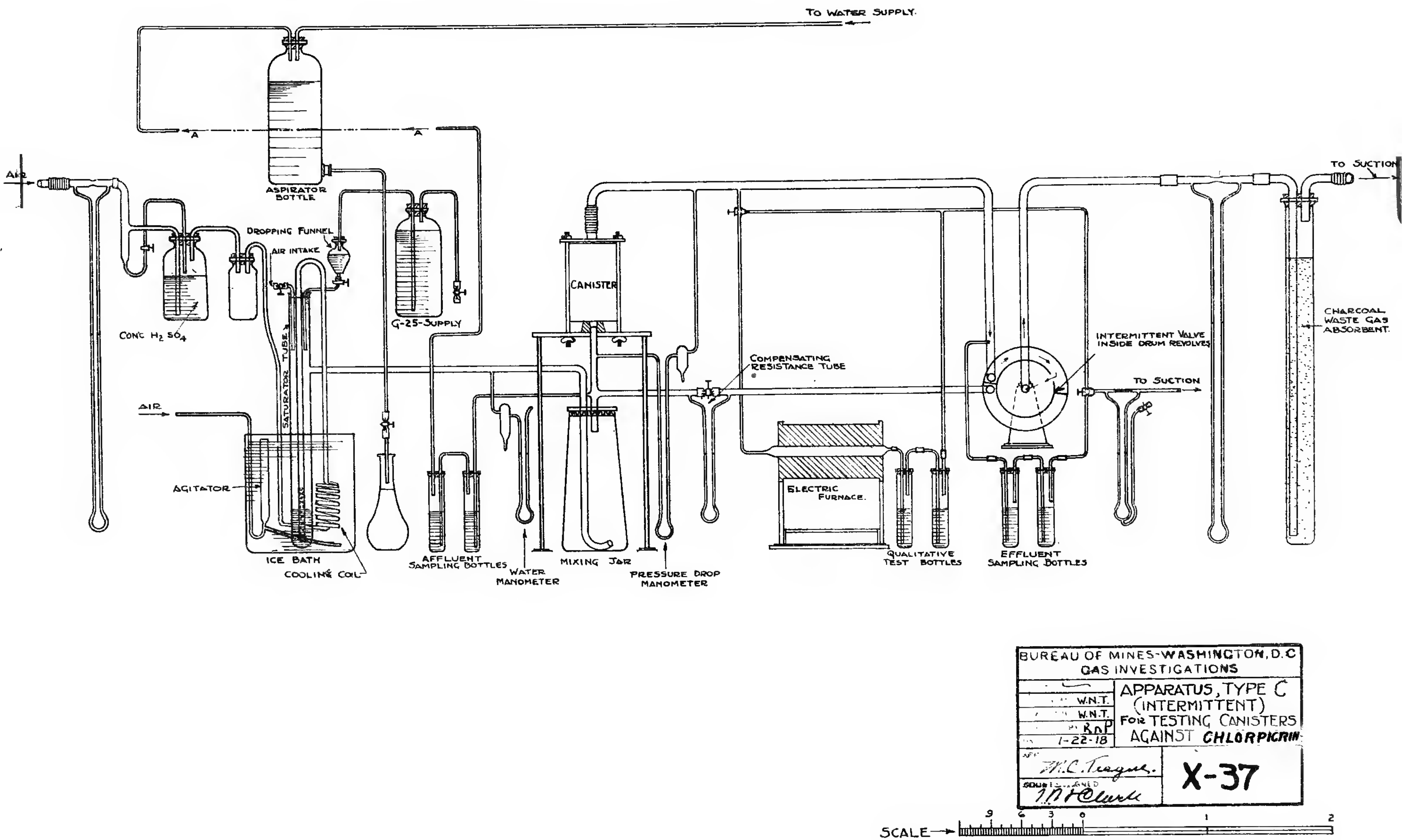
Gellite impregnated with hexamethylene tetramine and alkali, or with ferric hydroxide, proved to be a failure, though the former had a large capacity.

4. METHODS OF TESTING THE EFFICIENCY OF CANISTERS AGAINST VARIOUS GASES:

Methods have been devised and machines constructed for testing canisters with continuous flow against the following gases:

Acrolein	Diphenyl chloroarsine
Ammonia	Diphenyl cyanarsine
Ammonium chloride smoke	Ethyl chloride
Arsenic chloride	Gasoline (casing-head)
Arsine	Hydrogen chloride
Benzene	Hydrogen cyanide
Benzyl bromide	Hydrogen sulphide
Brom benzyl cyanide	Methyl dichloroarsine
Carbon bisulphide	Perchlormethylmercaptan
Carbon dioxide	Phenyl carbylamine chloride
Carbon monoxide	Phenyl dichloroarsine
Carbon tetra chloride	Phosgene
Chloracetone	Phosphorus trichloride
Chloracetophenone	Stannic chloride
Chloracetyl chloride	Sulphur dichloride
Chlorine	Sulphur dioxide
Chloropicrin	Sulphur monochloride
Cyanogen bromide	Sulphuric acid smoke
Cyanogen chloride	Trichlormethyl chloroformate
2-4 dichlor benzyl bromide	X_1
Dichlor diethyl sulphide	X_2
Dimethyl sulphate	Xylyl bromide
Thiophosgene	Tobacco smoke


TO EFFLUENT SAMPLING BOTTLES
FLOW METER
SUCTION
INTO SOLID LIME
MANOMETER.
CANISTERS
RUBBER STOPPER CONNECTIONS
QUALITATIVE TEST BOTTLES
CHLORINE RESERVOIR
DRY BULB.
WET BULB.
AIR INTAKE
AIR INTAKE
AIR INTAKE
TO ENTERING GAS SAMPLING BOTTLES.
WATER
CONC. H_2SO_4
CHLORINE TANK
CONSTANT HEAD BOTTLE H_2SO_4.
MIXING CHAMBER.
APPARATUS TYPE B FOR TESTING CANISTERS AGAINST CHLORINE.
NONE
AJB
GLC
5-27-18
M.C. Teague.
A.C. Fieldner
58-A



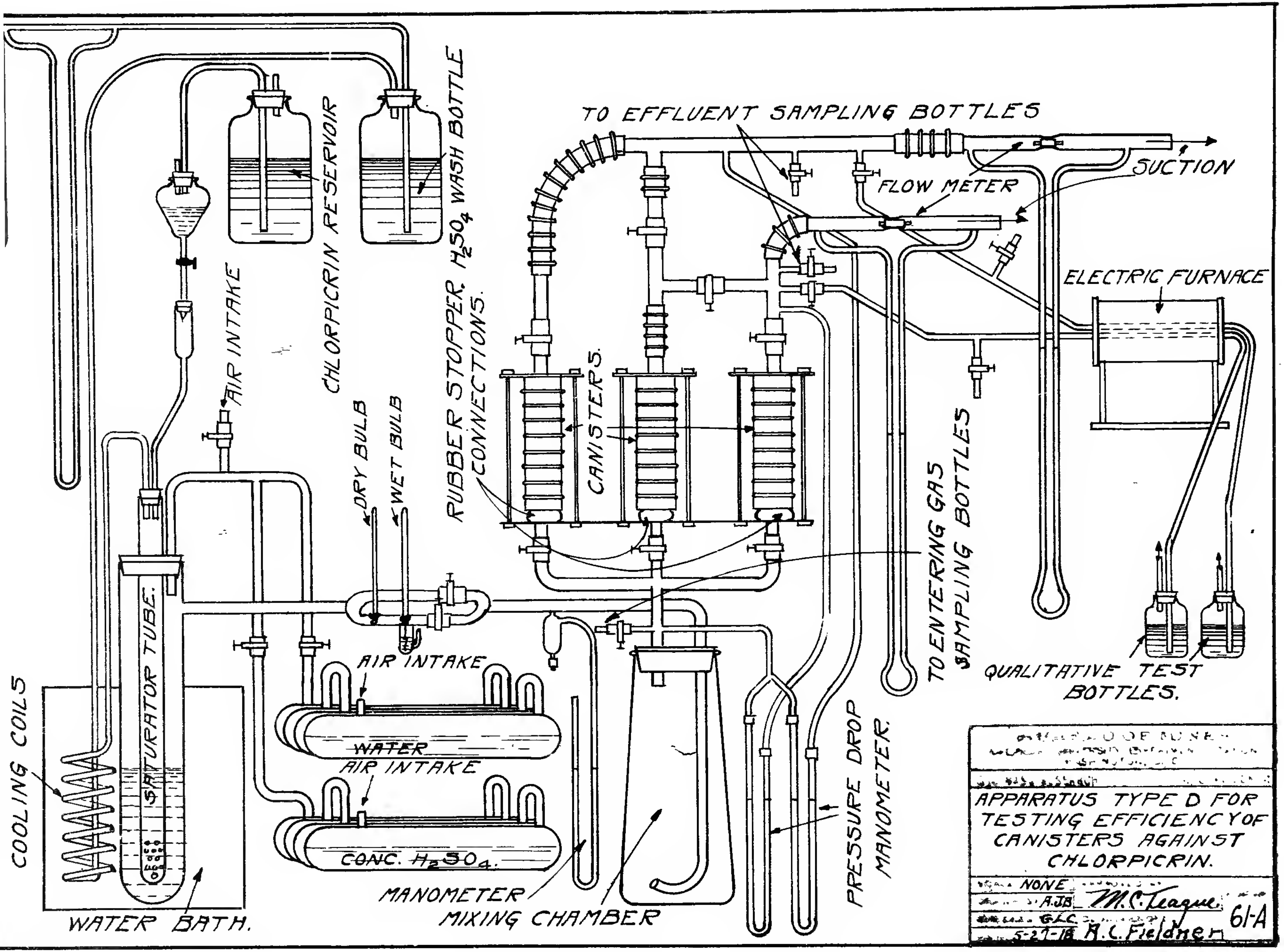
BUREAU OF MINES-WASHINGTON, D.C
GAS INVESTIGATIONS

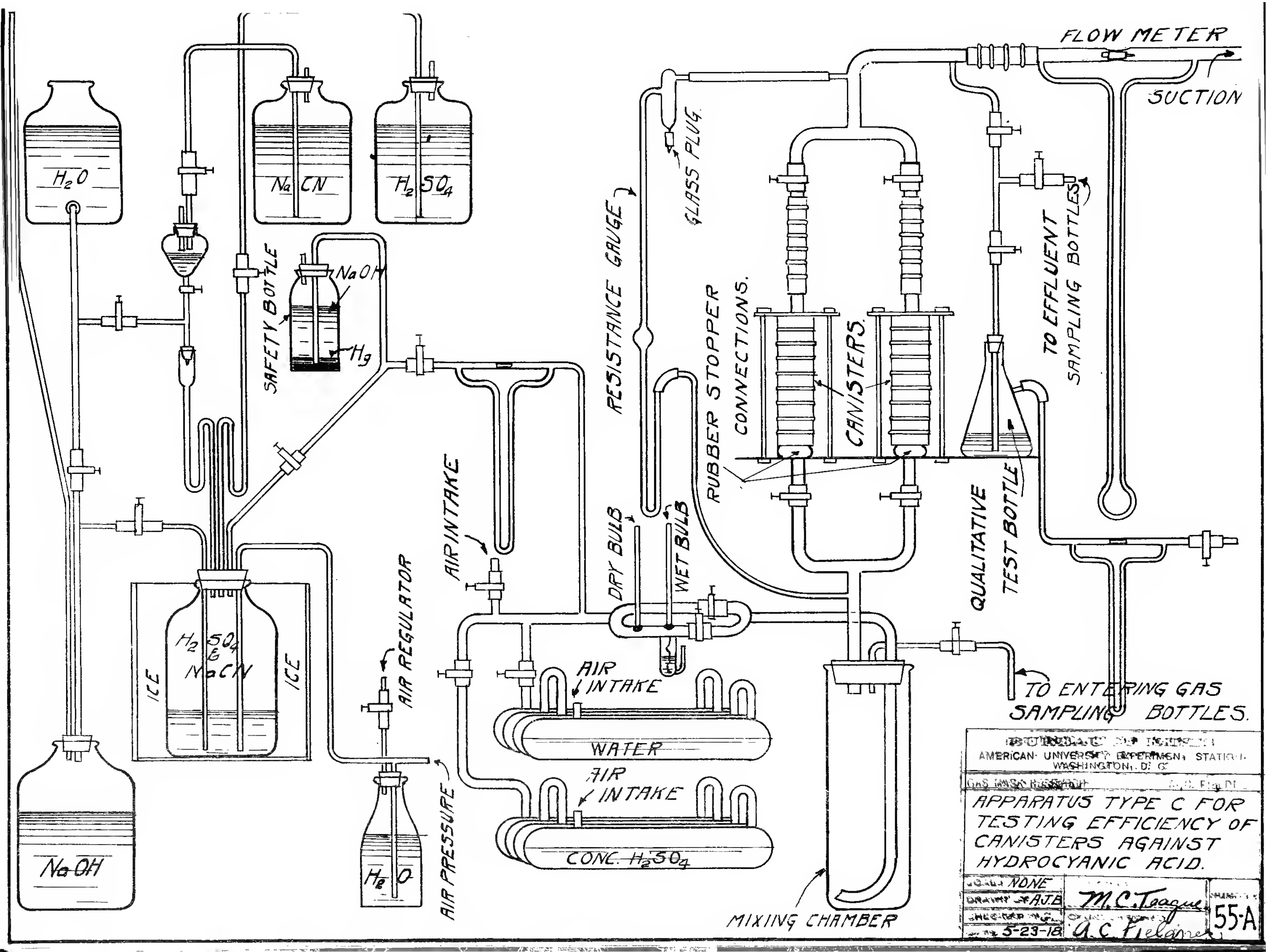
APPARATUS, TYPE C
(INTERMITTENT)
FOR TESTING CANISTERS
AGAINST CHLORPICRIN

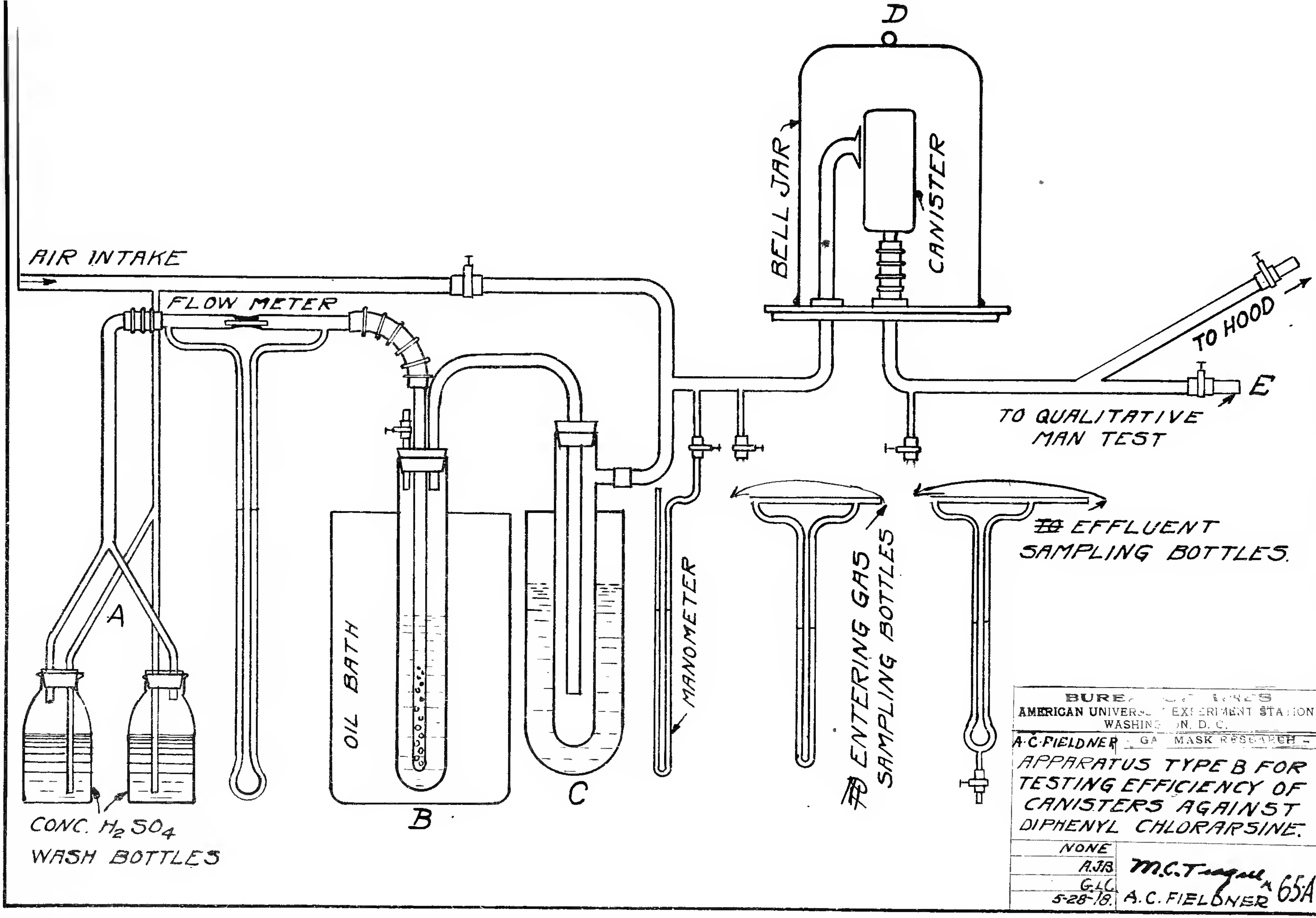
W.N.T.
W.N.T.
R.n.P
1-22-18

W. C. Teague.
T. B. H. Clark

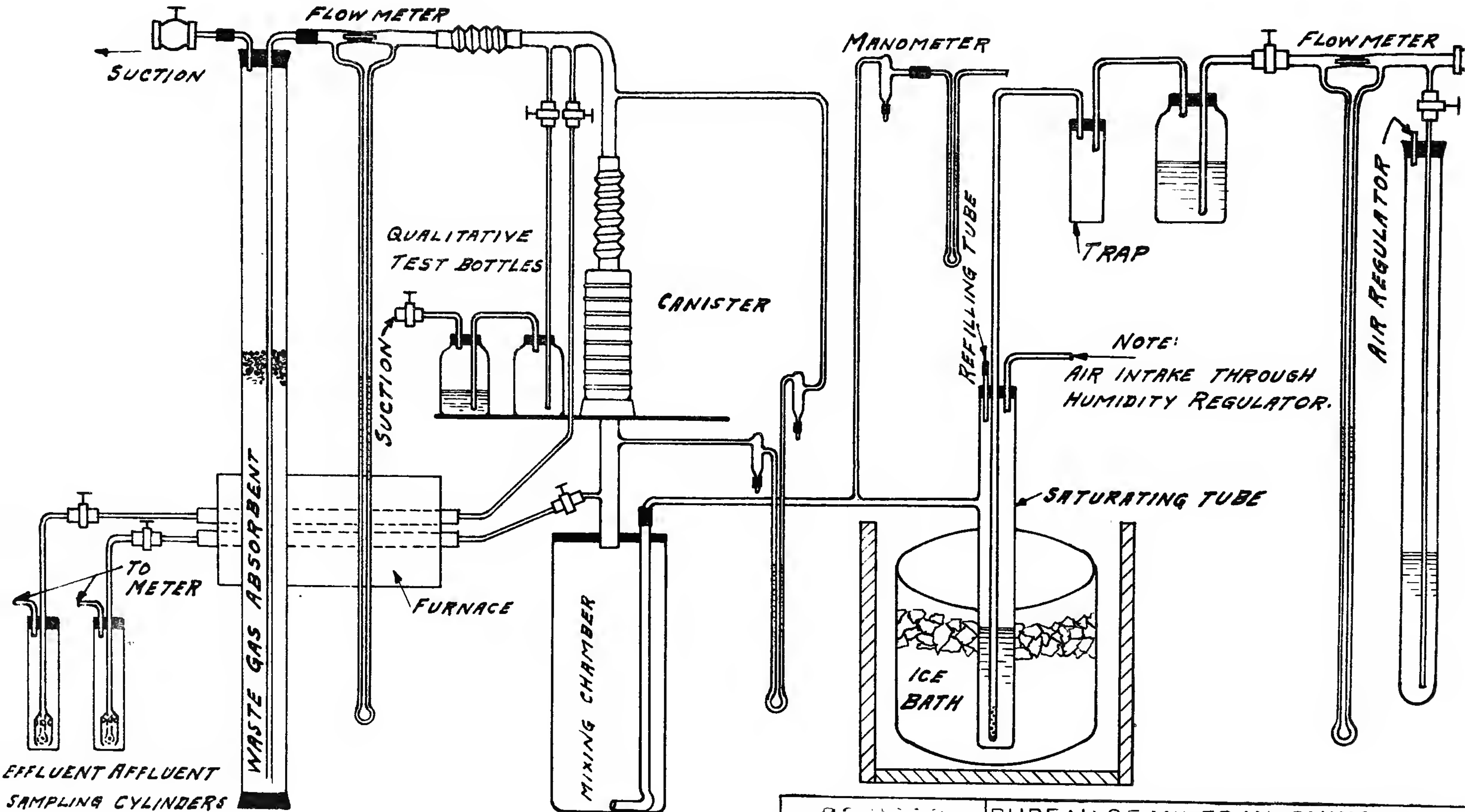
X-37


TO EFFLUENT SAMPLING BOTTLES
SUCTION
FLOW METER
ELECTRIC FURNACE
CHLORPICRIN RESERVOIR
H2SO4 WASH BOTTLE
AIR INTAKE
RUBBER STOPPER CONNECTIONS.
CANISTERS.
DRY BULB
WET BULB
TO ENTERING GAS SAMPLING BOTTLES
QUALITATIVE TEST BOTTLES.
AIR INTAKE
WATER
AIR INTAKE
CONC. H2SO4.
COOLING COILS
SATURATOR TUBE.
WATER BATH.
MANOMETER
MIXING CHAMBER
PRESSURE DROP MANOMETER.
APPARATUS TYPE D FOR TESTING EFFICIENCY OF CANISTERS AGAINST CHLORPICRIN.
NONE
A.J.B.
G.L.C.
5-27-18
M.C. Teague
A.C. Fieldner
61-A


FLOW METER
SUCTION
GLASS PLUG
RESISTANCE GAUGE
RUBBER STOPPER CONNECTIONS.
CANISTERS.
TO EFFLUENT SAMPLING BOTTLES
QUALITATIVE TEST BOTTLE
H_2O
Na CN
H_2SO_4
SAFETY BOTTLE
NaOH
Hg
AIR INTAKE
DRY BULB
WET BULB
ICE
H_2SO_4 & NaCN
ICE
AIR REGULATOR
AIR INTAKE
WATER
AIR INTAKE
CONC. H_2SO_4
TO ENTERING GAS SAMPLING BOTTLES.
NaOH
H_2O
AIR PRESSURE
MIXING CHAMBER
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
APPARATUS TYPE C FOR TESTING EFFICIENCY OF CANISTERS AGAINST HYDROCYANIC ACID.
NONE
A.J.B.
5-23-18
M.C. Teague
A.C. Fieldner
55-A



AIR INTAKE
FLOW METER
A
CONC. H_2SO_4
WASH BOTTLES
OIL BATH
B
C
MANOMETER
BELL JAR
CANISTER
D
TO HOOD
E
TO QUALITATIVE MAN TEST
ENTERING GAS SAMPLING BOTTLES
EFFLUENT SAMPLING BOTTLES.
AMERICAN UNIVERSITY EXPERIMENT STATION
A.C. FIELDNER
MASK RESEARCH
APPARATUS TYPE B FOR TESTING EFFICIENCY OF CANISTERS AGAINST DIPHENYL CHLORARSINE.
NONE
A.J.B.
G.L.C.
5-28-18.
A.C. FIELDNER
65A

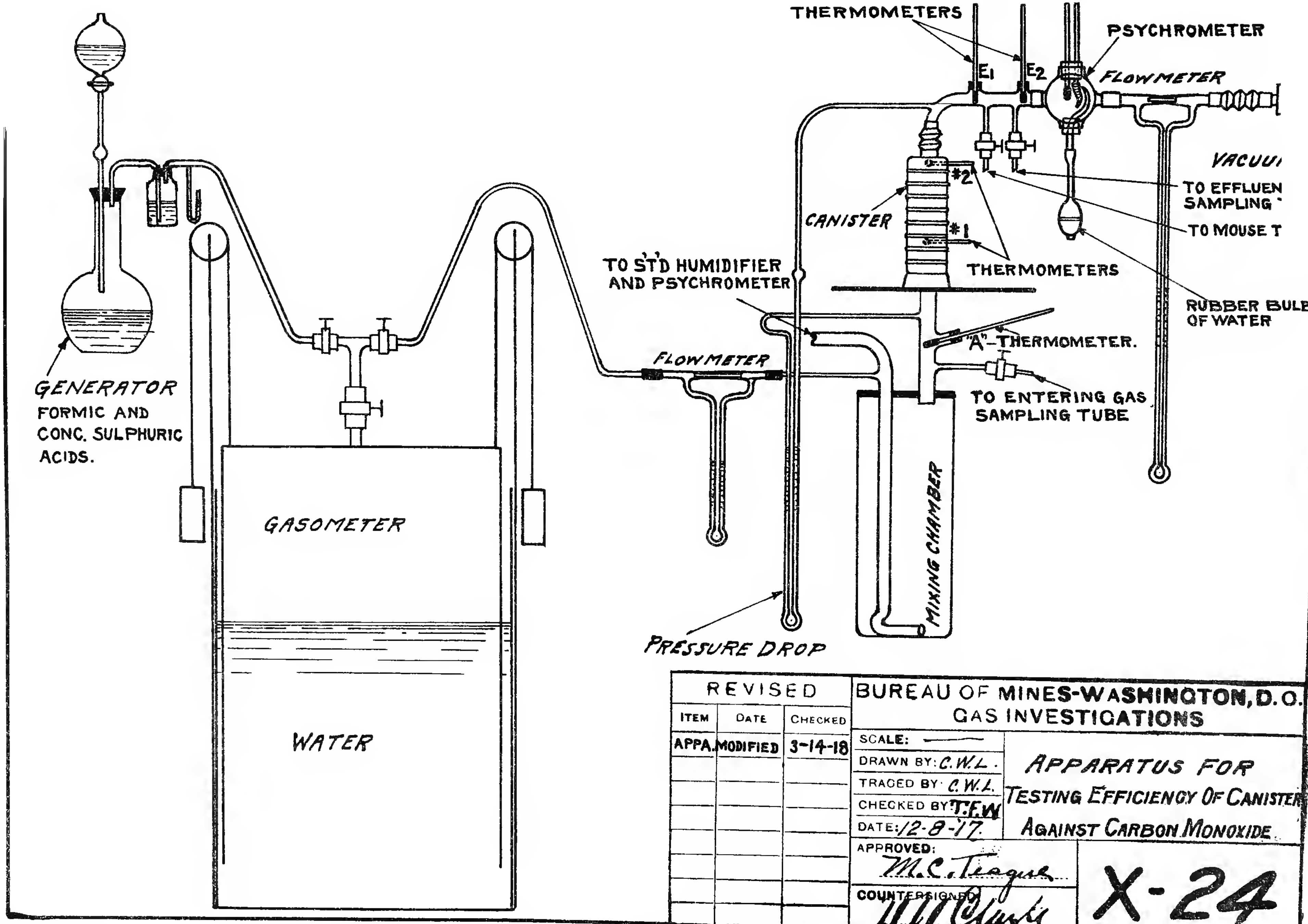


BUREAU OF MINES-WASHINGTON, D.C.
GAS INVESTIGATIONS

APPARATUS FOR TESTING THE EFFECTS OF CANISTERS AGAINST ACROLIN

SCALE: ——
DRAWN BY C.W.L.
TRACED BY C.W.L.
CHECKED BY J.H.Y.
DATE: 12-8-17
APPROVED: M. C. Teague
COUNTERSIGNED: [illegible]

X-23



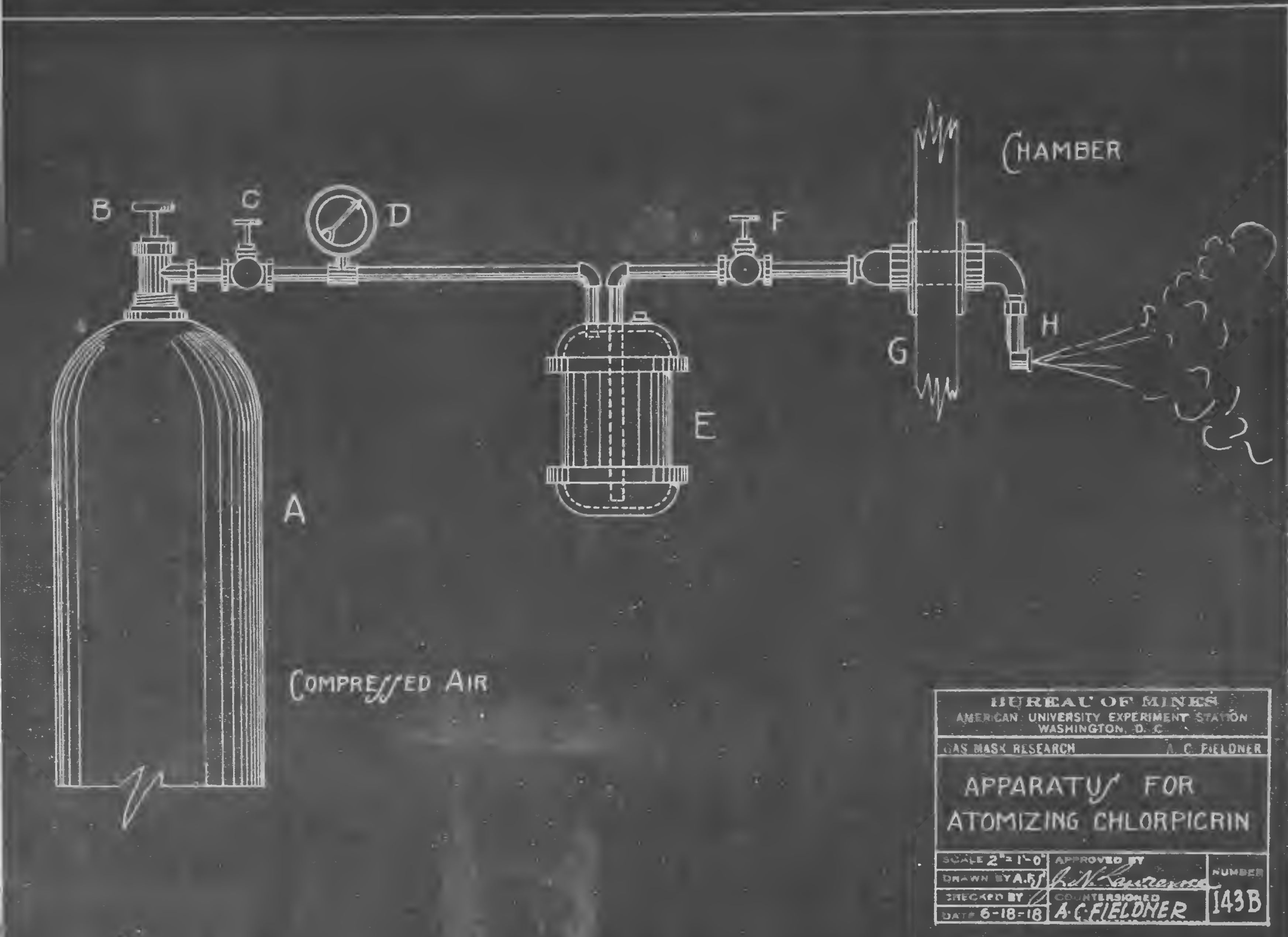
REVISED		
ITEM	DATE	CHECKED
APPA.	MODIFIED	3-14-18

BUREAU OF MINES-WASHINGTON, D.C.
GAS INVESTIGATIONS

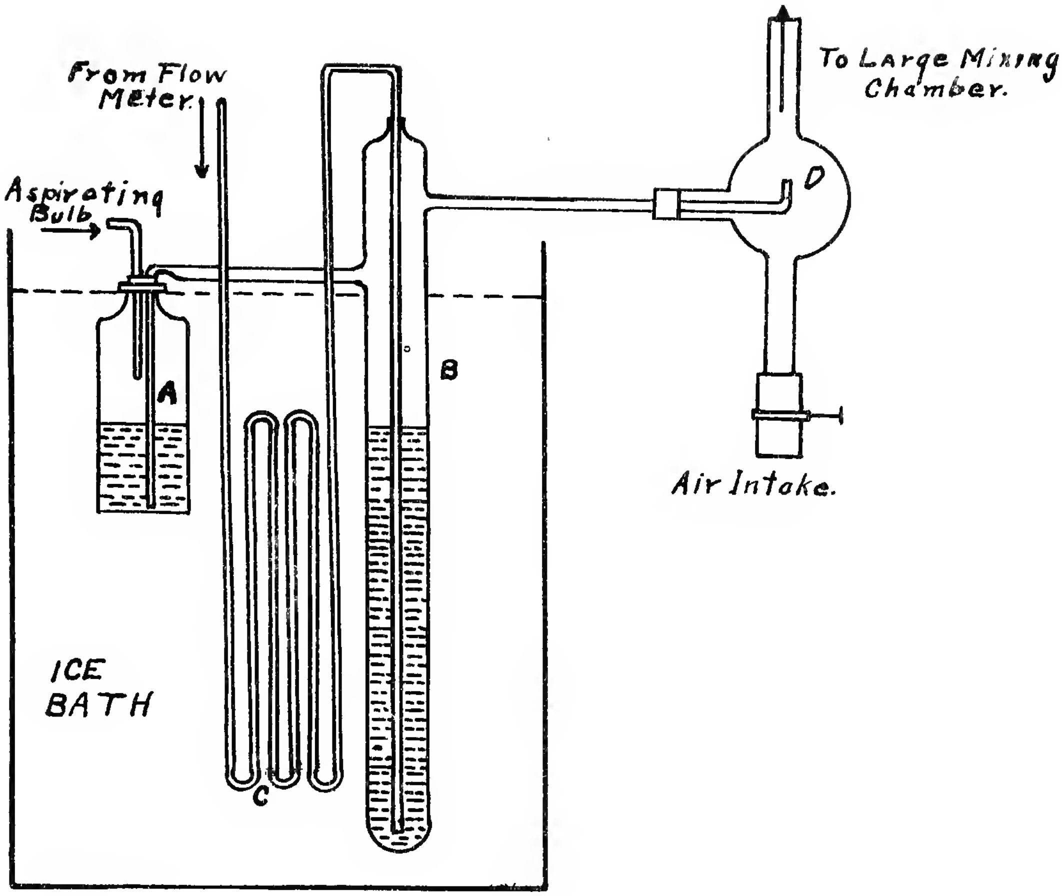
SCALE: ——
DRAWN BY: C.W.L.
TRACED BY: C.W.L.
CHECKED BY: T.F.W.
DATE: 12-8-17.
APPROVED: M.C. Teague
COUNTERSIGNED: W.W. Clark

APPARATUS FOR
TESTING EFFICIENCY OF CANISTERS
AGAINST CARBON MONOXIDE.

X-24



B
C
D
F
CHAMBER
H
G
E
A
COMPRESSED AIR
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
APPARATUS FOR
ATOMIZING CHLORPICRIN
SCALE 2" = 1'-0"
DRAWN BY A.F.
CHECKED BY
DATE 6-18-18
APPROVED BY
COUNTERSIGNED
A. C. FIELDNER
NUMBER
143B



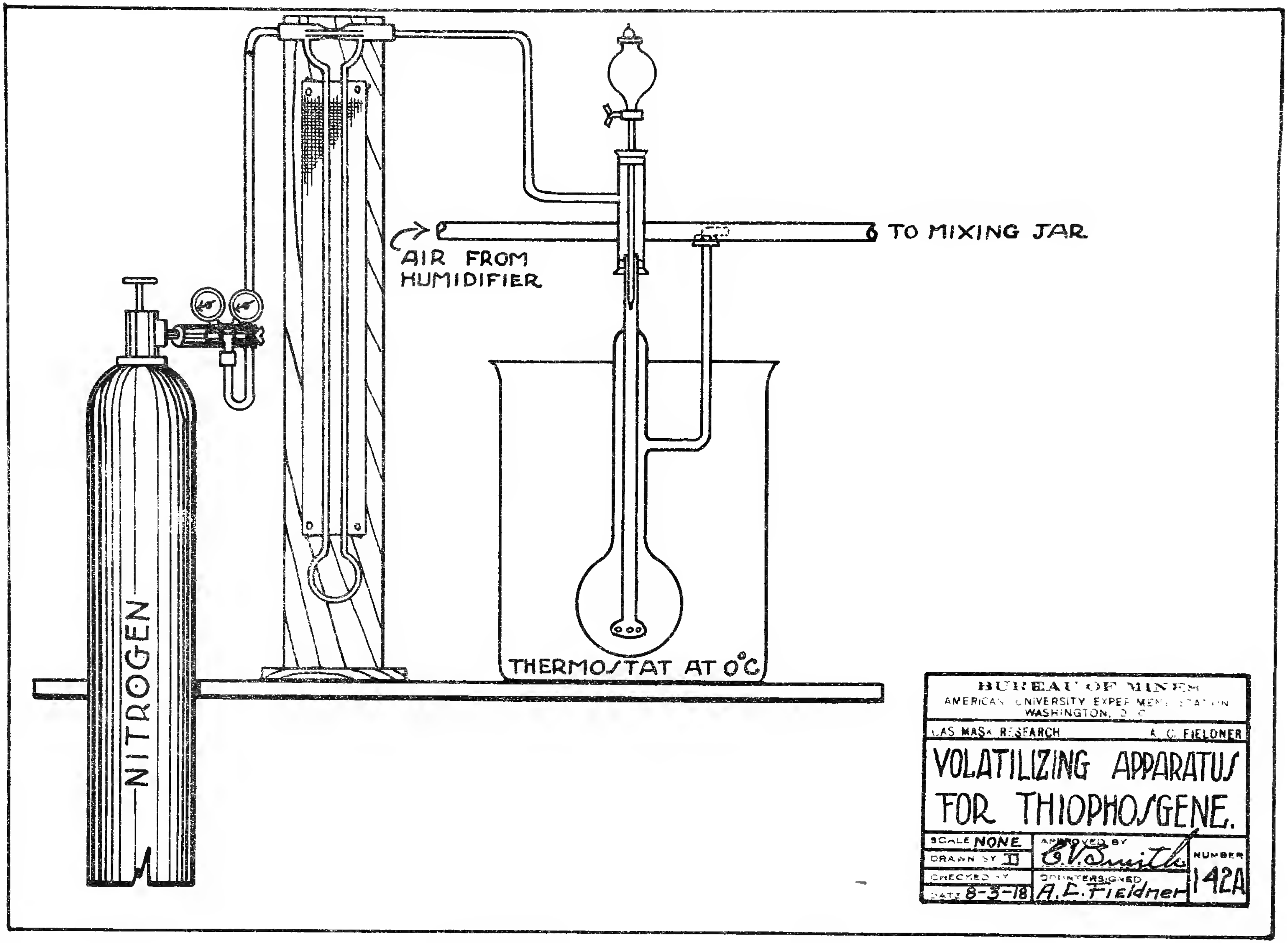
BUREAU OF MINES - WASHINGTON, D.C.
GAS INVESTIGATIONS.

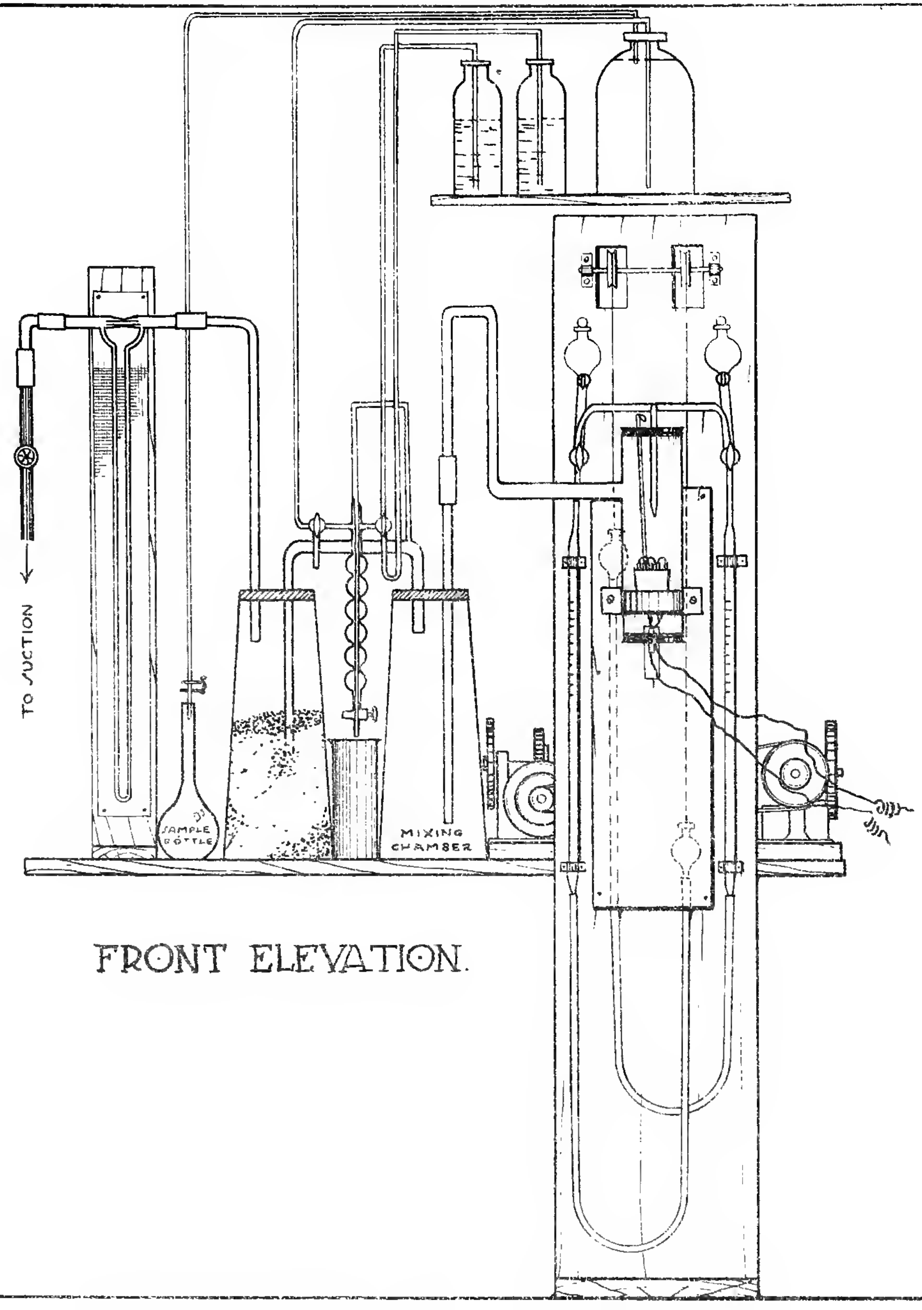
SCALE
DRAWN BY J.C.O.
TRACED BY J.C.O.
CHECKED BY R.A.P.
DATE 7-25-18

VAPORIZER FOR CYANOGEN CHLORIDE

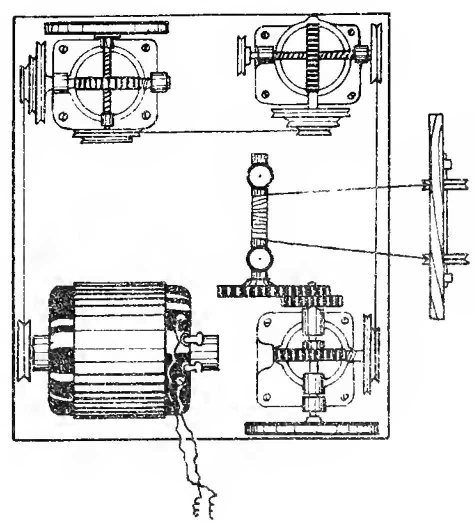
APPROVED M.C. Teague
COUNTERSIGNED. A.C. Fieldner

40A


NITROGEN
AIR FROM HUMIDIFIER
TO MIXING JAR
THERMOSTAT AT 0°C
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
VOLATILIZING APPARATUS
FOR THIOPHOSGENE.
SCALE NONE
DRAWN BY II
CHECKED BY
DATE 8-3-18
APPROVED BY
G.V. Smith
COUNTERSIGNED
A.C. Fieldner
NUMBER
142A



FRONT ELEVATION.



PLAN OF REDUCTION GEARS.
SCALE 3" = 1'

APPARATUS FOR PRODUCING GAS MIXTURES FROM SMALL AMOUNTS OF LIQUIDS.

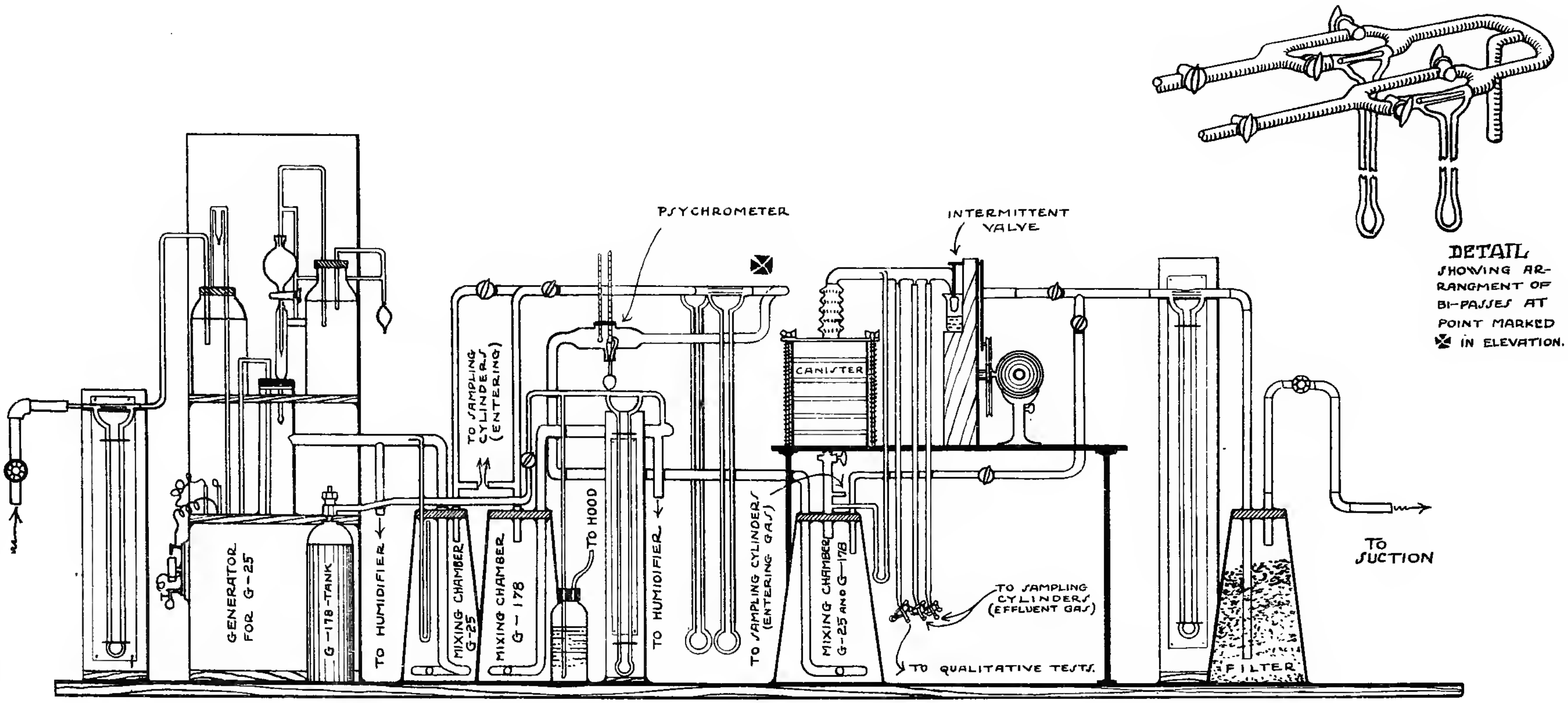
BUREAU OF MINES

DRAWN BY R.F.D.

DATE 8-23-18

A.C. FIELDNER

1039A

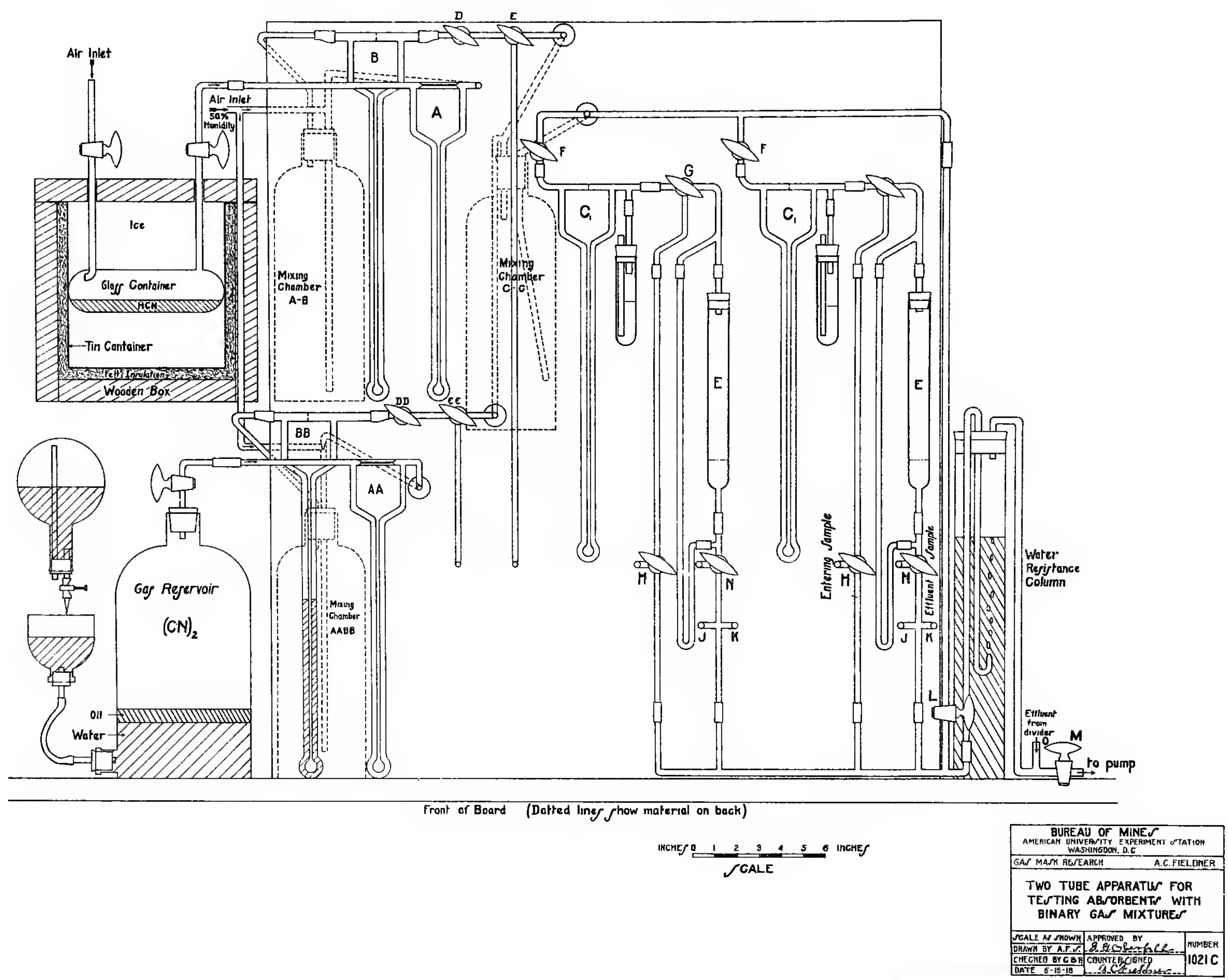


BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

MACHINE FOR TESTING THE EFFICIENCY OF CANISTERS AGAINST MIXTURES of G178 & G25

SCALE NONE	APPROVED BY	NUMBER
DRAWN BY JJ		1041-A
CHECKED BY Y	COUNTERSIGNED BY A. C. Fieldner	
DATE 9-7-18		


Air Inlet
Air Inlet
50% Humidity
Ice
Glass Container
HCN
Tin Container
Felt Insulation
Wooden Box
Mixing Chamber A-B
B
A
D
E
DD
CC
BB
AA
Mixing Chamber C-C
Mixing Chamber AABB
F
G
F
C1
C1
E
E
H
N
J
K
H
N
J
K
L
M
Entering Sample
Effluent Sample
Water Resistance Column
Effluent from divider
O
to pump
Gas Reservoir
(CN)2
Oil
Water
Front of Board (Dotted lines show material on back)
INCHES 0 1 2 3 4 5 6 INCHES
SCALE
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D.C.
GAS MASK RESEARCH A.C. FIELDNER
TWO TUBE APPARATUS FOR TESTING ABSORBENTS WITH BINARY GAS MIXTURES
SCALE AS SHOWN
DRAWN BY A.F.S.
CHECKED BY G.B.R.
DATE 6-15-18
APPROVED BY
COUNTERSIGNED
NUMBER
1021 C

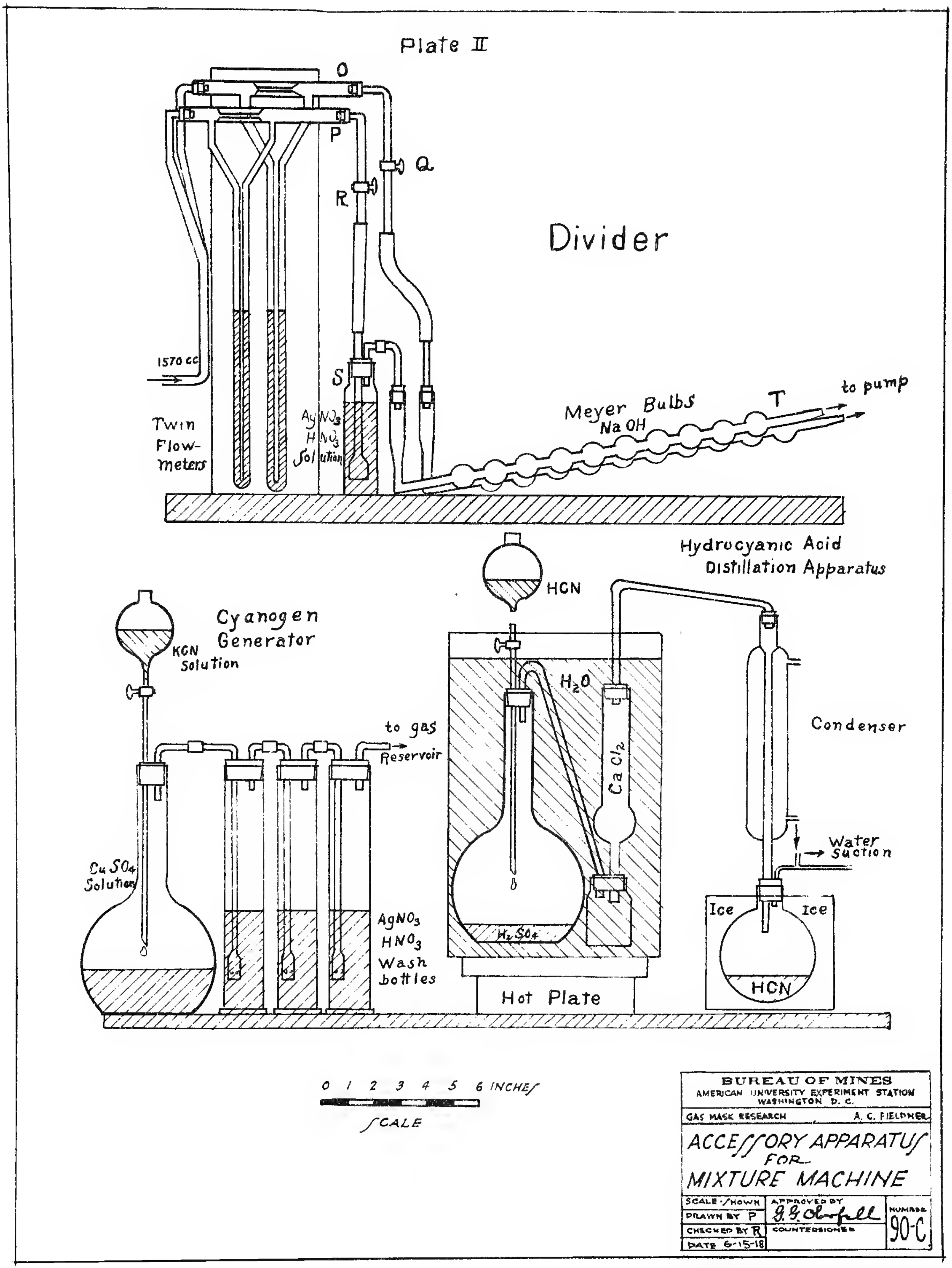
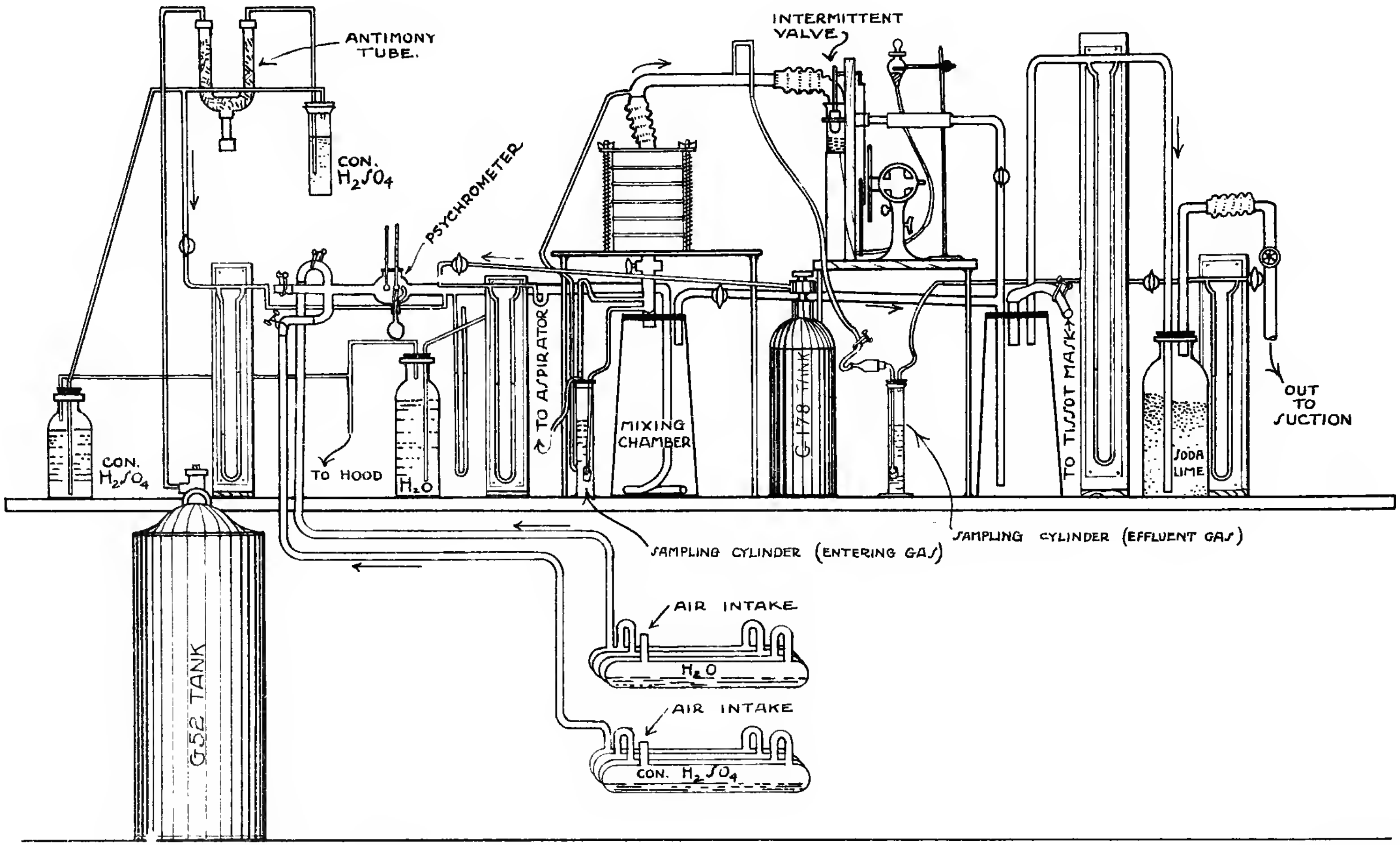


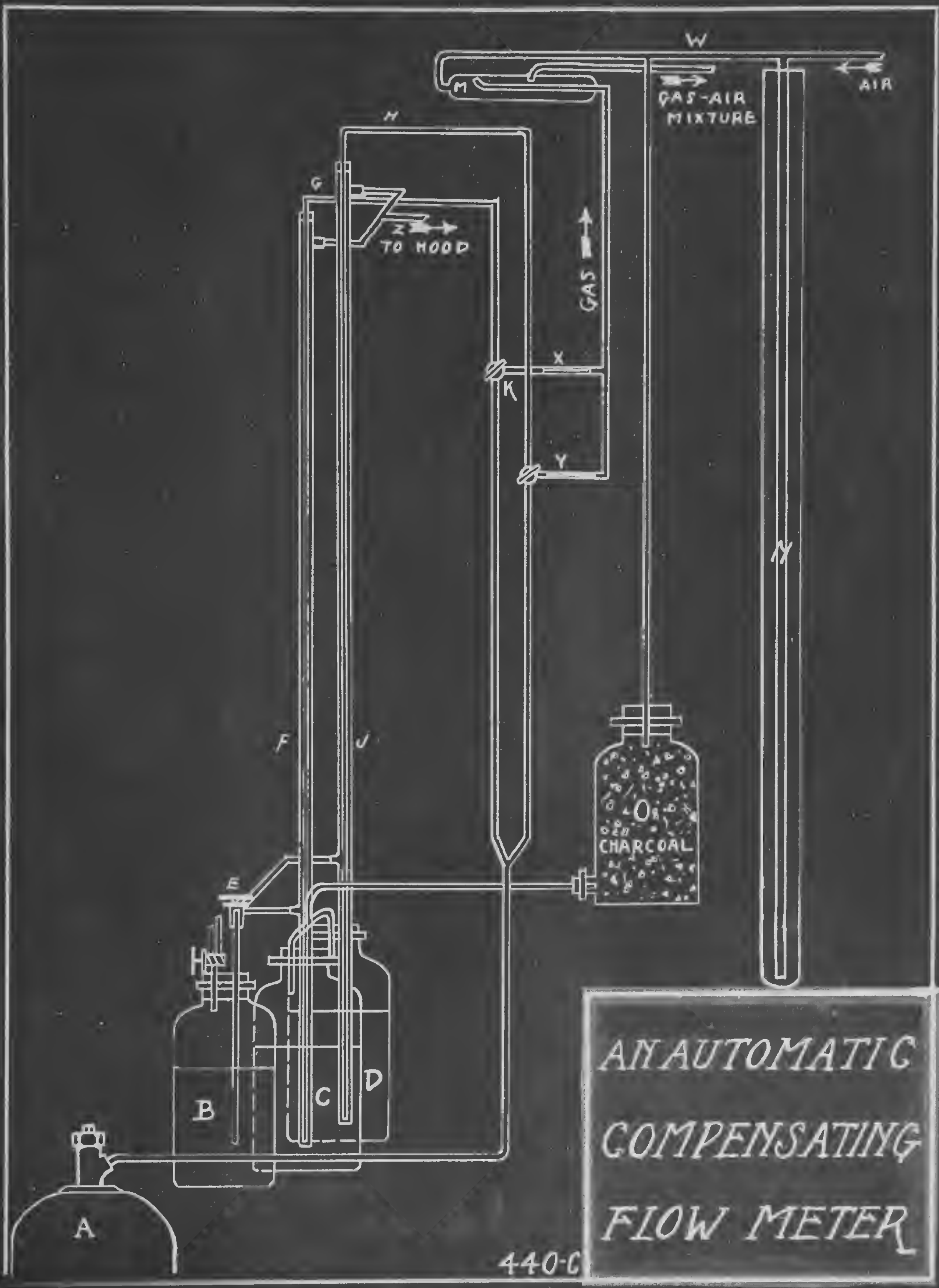
Plate II
O
P
Q
R
Divider
1570 cc
S
Twin Flow-meters
AgNO3 HNO3 Solution
Meyer Bulbs
Na OH
T
to pump
Hydrocyanic Acid Distillation Apparatus
HCN
Cyanogen Generator
KCN Solution
H2O
Condenser
to gas Reservoir
Ca Cl2
CuSO4 Solution
Water Suction
Ice
Ice
AgNO3 HNO3 Wash bottles
H2SO4
HCN
Hot Plate
0 1 2 3 4 5 6 INCHES
SCALE
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON D. C.
GAS MASK RESEARCH
A. C. FIELDNER
ACCESSORY APPARATUS FOR MIXTURE MACHINE
SCALE-SHOWN
DRAWN BY P
CHECKED BY R
DATE 6-15-18
APPROVED BY
COUNTERSIGNED
NUMBER
90-C



FRONT ELEVATION.

INTERMITTENT MACHINE FOR TESTING U.S. CANISTERS AGAINST MIXTURES OF G-52 AND G 178.

NONE | P.F.J. | 6-20-18 | A.C. Fieldner | 1038-A



AN AUTOMATIC COMPENSATING FLOW METER

In nearly all cases these methods involve the necessity of finding a suitable method of analysis for air mixtures of the gases.

In order that the conditions of testing canisters might more nearly resemble those encountered when masks are actually worn in gas, several different types of so-called intermittent machines were devised. These are susceptible to wide variations in the volume and number of oscillations per minute, being thus adjustable to simulate any type or rate of breathing. Comparison tests on men have shown that the intermittent machines give results in excellent agreement with man tests and are much more precise and convenient to operate. Multiple machines capable of testing eight canisters simultaneously have been installed, to facilitate routine testing, against phosgene, chloropicrin and hydrogen cyanide.

Methods of establishing, controlling and determining the concentrations of gases in the man test chamber have been thoroughly investigated, and a standard method devised for obtaining smokes by detonation.

5. PROTECTION AFFORDED BY VARIOUS CANISTERS AGAINST TOXIC GASES:

Approximately 40,000 canister tests have been made to date by this section, both on men and on machines, to determine the absorbent value of the canisters for various toxic gases. About 0.2% of all canisters manufactured by the Gas Defense Division, or roughly 6000 canisters have been tested as controls, to maintain a high standard of efficiency. The other canisters were tested for purposes of development to determine the protection against new gases, to decide the optimum canister filling, etc. A considerable number of these canisters was packed by this section.

In Table II of the Appendix to this report, will be found a summary of all tests made by this Section to determine the protection afforded by various U.S.Army, Navy and special canisters, and proposed industrial canisters, against toxic gases. A brief description of the various canisters is there included.

6. PROTECTION AFFORDED BY FOREIGN CANISTERS AGAINST VARIOUS GASES:

A large number of foreign canisters have been examined by this Section, on men and on machines, to determine the protection afforded against toxic gases. In many cases tube tests have been made on the various absorbents; these are reported under the results of tube tests.

A summary table of the results of canister tests made by this Section on foreign canisters is included in the Appendix to this report, Table III; the average results of standard Types H and J, U.S. Army canisters are included for comparison.

7. IMPROVEMENTS IN THE NAVY DRUM:

The Navy drum or head canister, which is similar in a general way to the German drum, was originally rather deficient in general protection against gases and offered no protection against smokes such as stannic chloride. The plan of filling was as follows:

1. Toweling,
2. 5 cu. in. charcoal,
3. Iron screen,
4. 5 cu. in of granules (possibly the Gibbs lime absorbent)
5. Iron screen,
6. 5 cu. in charcoal,
7. Screen.

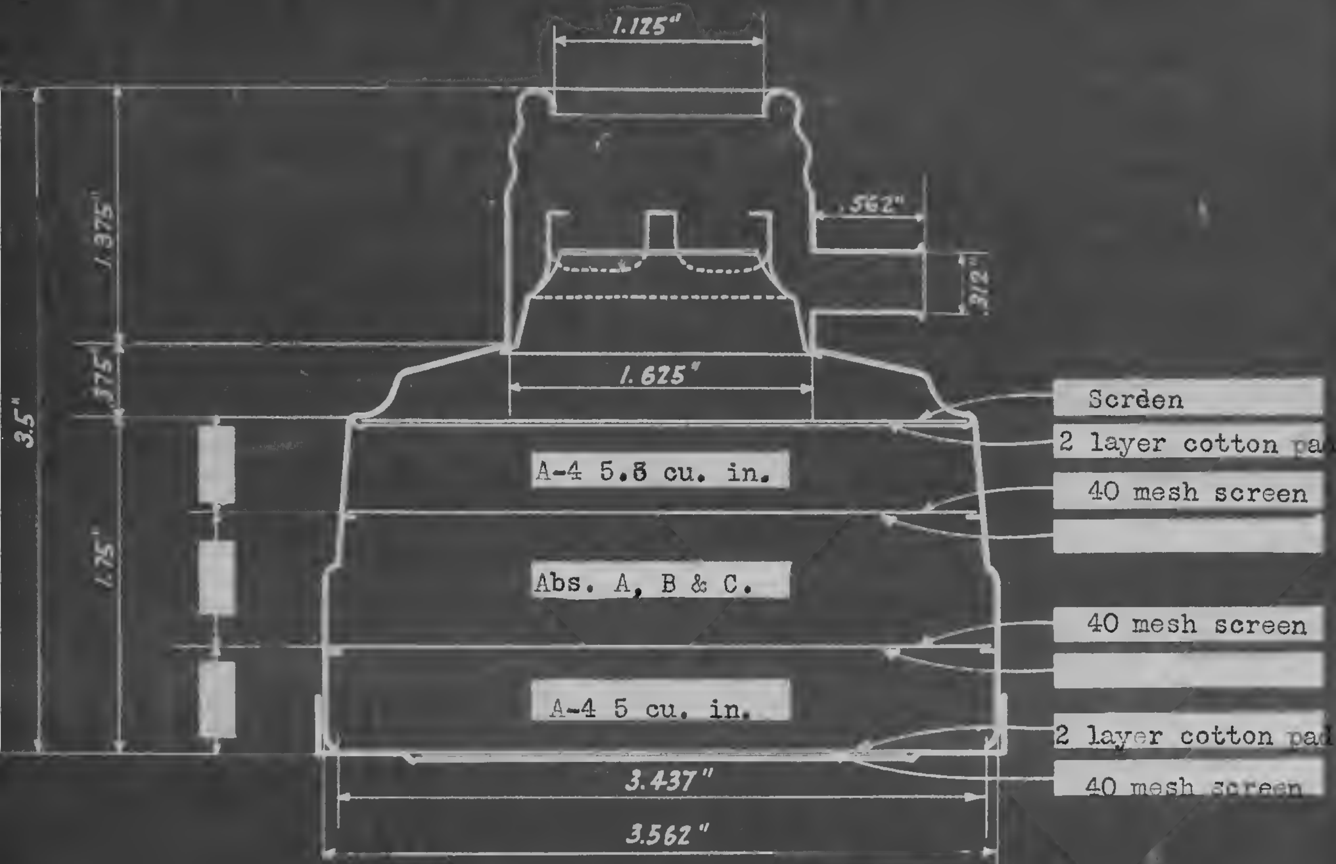
The Man Test Unit has been able to improve materially on this filling. Canisters filled in the manner indicated below have been found to be generally much more satisfactory than the original filling:

Recommended filling:

Absorbent mixture: 2/5 A-4; 35 A-25 (Easton) 6-14 mesh.
Canister painted inside with asphalt paint,
2 layer cottonpad,
6 cu. in absorbent mixture,
Iron screen
2 layer cotton pad,
7 cu. in, absorbent mixture,
Screen.

The amount of improvement in efficiency is shown in the results of man tests tabulated as follows:

Gas	Pressure drop mm H_2O @ 85 l/m Old	Recommended	Conc. p.p.m.	Life-Minutes Old	Recommended	Percent Improvement
S-25	30	46	300	0	60 (no break)	∞
PS	30	40	500	19	36	90
CG	30	40	1000	12	24	100



CROSS SECTIONAL VIEW
of NAVY CANISTER

TYP A, B, nd C

BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D.C.

GAS MASK RESEARCH - A.C. FIELDNER

CROSS-SECTIONAL VIEW OF NAVY CANISTER

SCALE - FULL SIZE	APPROVED BY M.C. Teague	NUMBER 28-A
DRAWN BY L.F.H		
CHECKED BY	COUNTERSIGNED A.C. Fieldner	
DATE		

Part of this improvement is due to the war gas mixture and part to the prevention of channeling by the asphalt paint.

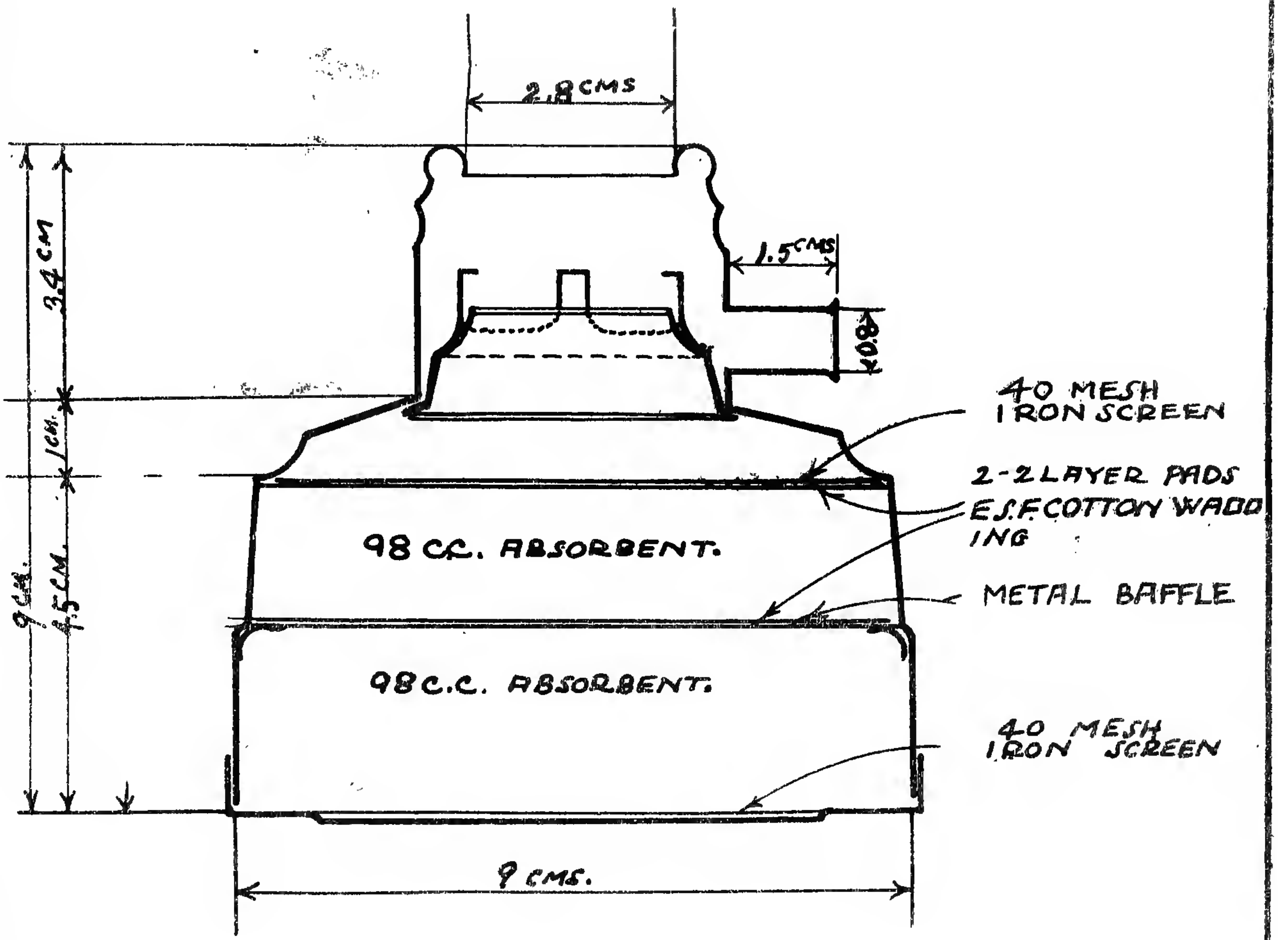
It has also been shown that a ring baffle placed half way between top and bottom of the canister will materially improve on the life of the drum. Thus two sets of canisters, each containing 12 cu. in. of mixture of 3/5 A-4 and 2/5 A25B and two 2-layer cotton pads, one set having a ring baffle in the middle of the drum, gave the following results on man tests:

Gas	Pressure drop mm. H_2O @ 85 l/m: Without Baffle	With Baffle	Conc. p.p.m.	Life-Minutes Without Baffle	With Baffle	Percent Improvement
PS	44	48	1000	38	57	50
CG	51	40	5000	20	40	100

Three later types of Navy drums have been submitted and the possibility of improving on them, by the addition of a ring baffle and substitution of a mixture of 3/5 Astoria A-4 and 2/5 Astoria Purple Granules, Type B (A25B) for the Navy filling of equal layers of charcoal with a layer of some type of granule in between, has again been proven.

The three original types A, B and C are thought to differ in the type of granule used but nothing definite is known. The packing of these canisters may be represented as follows:

Type A, B and C	Type D (Proposed) Absorbent mixture 3/5 A4; 2/5 A25B
2 layer pad	2 layer pad
5 cu. in charcoal	6 cu. in mixture
Screen	2 layer pad
5 cu. in granules	Screen
Screen	Metal ring baffle
5 cu. in. charcoal	6 cu. in mixture
2 layer pad	Screen



RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

STANDARD NAVY TYPE D DRUM

SCALE FULL DRAWN BY D CHECKED BY RMB DATE 11-26-18	APPROVED BY J.H. Yoe COUNTERSIGNED BY M.S. Teague	NUMBER 309-A

Below are compared the 99% efficiency points as indicated by machine tests on the canisters:

32 l/m continuous flow
50% relative humidity

Gas	Conc. p.p.m.	99% Eff. point A	B	C	D	Initial press. drop @ 85 l/m, mm. H_2O A	B	C	D
PS	4000	3	3	4	3.5	145	140	114	38
	1000				9.5				40
CG	2000	12	13	11	30	140	180	150	33
	1000				66				38
	5000				10				36
G43	2000	6	6.5	26	4	84	178	137	38
	1000				7				40
G49	2000	8	8	8.5	12	147	127	185	41
	1000				26				38
G7	225	5.5	5.5	6	0.7	163	170	135	38
	100				1				36
	1000				0				33

The pressure drop is seen to be cut to 25-30% of its former value and the efficiency to equal or better the old canister with the exception of protection against G-7.

Further work on Navy drums has been done with the idea of increasing the quantity of absorbent mixture. Drums containing 20 and 25 cu. in. of standard absorbent mixture, 1-2 layer pad and a ring baffle have been tested at high breathing rates and on the intermittent machines with the following results:

Gas	Rate l/m.	Conc. p.p.m.	Life--- Minutes Absorbent 20 cu.in.	25 cu.in.	Percent Improvement
PS.	32 lit.	1000	13	21	62
	man-hard breathing	2500	1	1.5	50
CG.	32 lit.	2500	36	43	19
	man-hard breathing	10000	0.7	1	40
G43	32 lit.	500	18	28	55

Average pressure drop at 85 l/m - 52-65 mm. H_2O

It will be seen that the added absorbent has materially increased the life, i.e. for 25% increase in volume of absorbent there has been 19 to 62% increase in life.

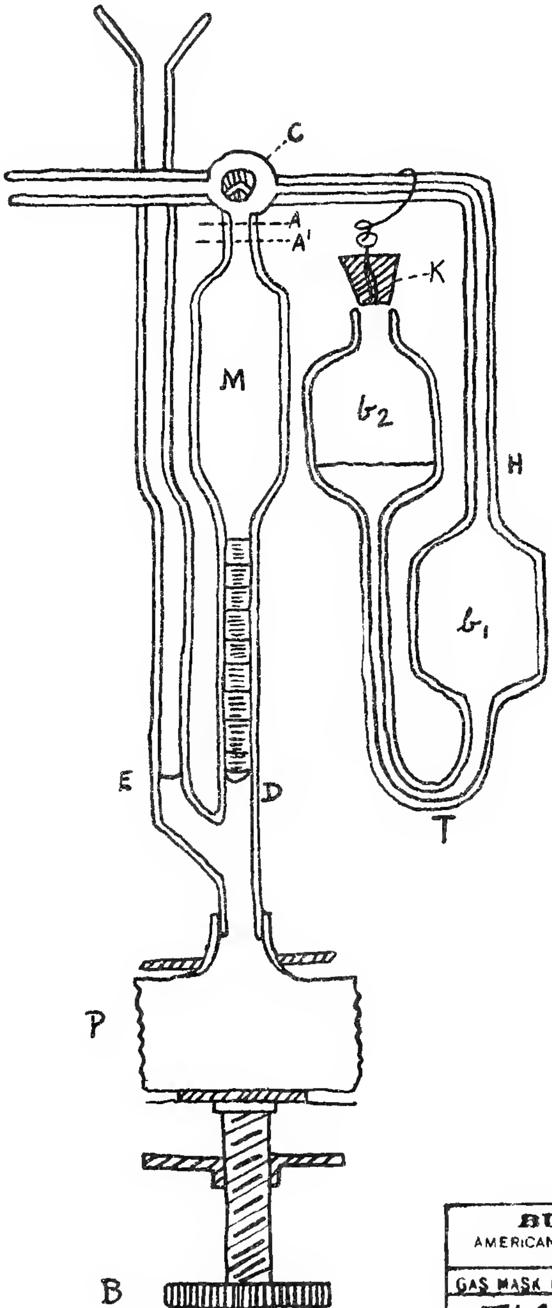
The use of whetlerite as absorbent in the Navy drum gives the following results against CG. The drum contains:

2 layer pad,
6 cu.in. whetlerite, 14-20 mesh,
2 layer pad,
Screen,
Ring baffle,
6 cu.in. whetlerite.

Life @ 32 l/m. continuous flow and 5000 p.p.m. CG. is 13 minutes. The pressure drop @ 85 l/m. is 55 mm. H_2O.

8. <u>TESTING OF CARBON DIOXIDE CANISTERS</u>:

Six Gibbs rescue apparatus canisters and six small Salvus carbon dioxide canisters have been tested for the Defense Chemical Research Section, against 3% CO_2 at 32 l/m. continuous flow, 90% relative humidity and room temperature. The efficiencies of the four regular Gibbs canisters were very irregular, ranging from 2½ to 6½ hours (to the 50% point). Less than half of the absorbent appeared to have been used. A modified Gibbs canister, about 2/3 as large, and packed with a special absorbent, remained above 90%

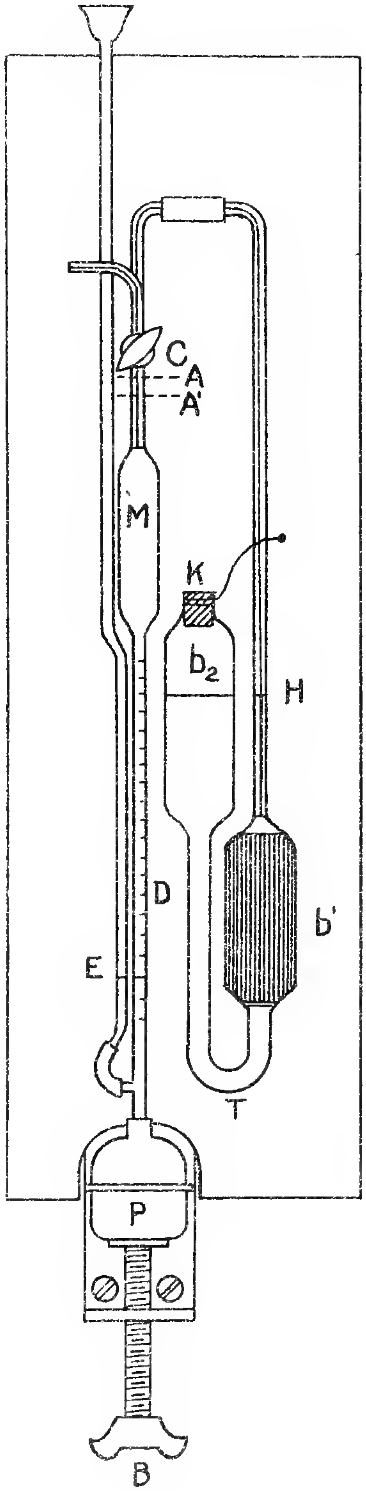


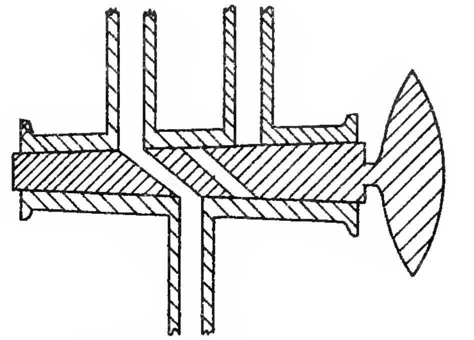
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT S
WASHINGTON, D. C

GAS MASK RESEARCH — A. C. FIELDNER

TISSOT APPARATUS FOR DETERMINATION OF CO_2 IN AIR. REPRODUCTION OF FRENCH SKETCH.

DRAWN BY D	APPROVED BY	NUMBER 119-C
CHECKED BY H	COUNTERSIGNED A-C-FIELDNER	
DATE 7/23-18		





STOPCOCK C
Full Size

BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C

GAS MASK RESEARCH — A. C. FIELDNER

TISSOT APPARATUS FOR DETERMINATION OF CO_2
TYPE USED AT AMERICAN UNIVERSITY

SCALE 1/4"=1"	APPROVED BY	NUMBER
DRAWN BY A.F.H.		113-C
CHECKED BY	COUNTERSIGNED	
DATE 7-22-18	A. C. FIELDNER	

efficiency for about 6 hours. The absorbent was uniformly used up and showed no caking as did the Gibbs absorbent. Another canister of the same type but containing a different absorbent had a life to the 50% of about 4-1/3 hours.

The results of tests on Salvus canisters are given in the following table:

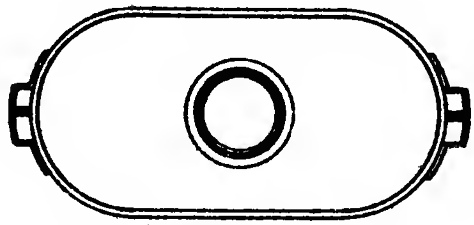
Can No.	Description	Percent Efficiency Minutes 90	50	Capacity = % X time to 50% efficiency	Max. rise in temp of effluent gas over entering gas. °C
1	Regular Salvus CO_2	52	72	6750	50
2	" " "	47	73	6500	50
3	Modified " "	80	115	9900	10
4	" " "	103	(193)	12680	18
5	1 hr. rescue canister	120	(147)	12740	16
6	1 hr. " "	37	71	5680	19

9. DEVELOPMENT OF CARBON MONOXIDE CANISTERS:

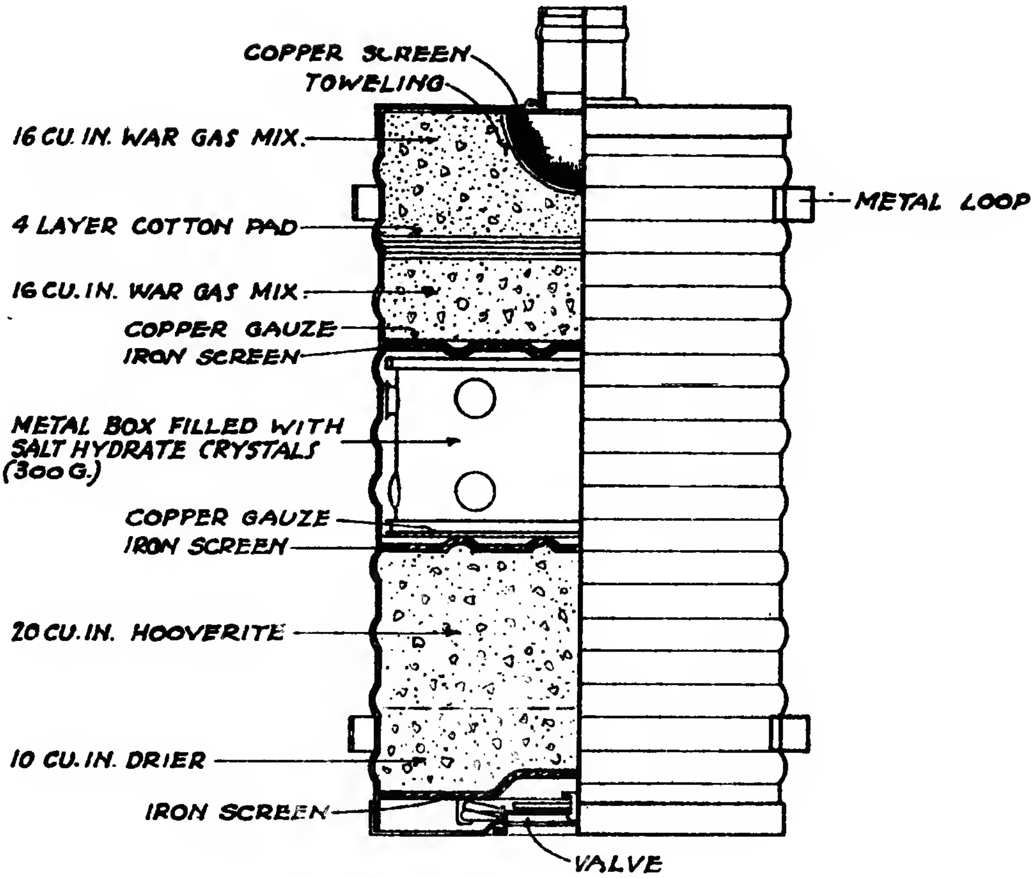
Two types of CO absorbent (known as HL and HC) have been developed by the Defense Chemical Research Section, Lieut. Col. A.B. Lamb in charge. Both of these absorbents remove CO by oxidizing it to form a non-toxic gas. When these absorbents are employed in the standard U.S. Army canisters in the usual way the heat of oxidation causes the temperature of the effluent gas to rise to such an extent that it is impossible to breathe through the canister. It was, therefore, necessary to develop a canister that would make the use of the CO absorbents practical. (NOTE: The canister was developed for HL and later adapted to HC). The investigation took three general lines of procedure: (1) experiments on lowering the temperature by mechanical means, (2) experiments on lowering the temperature by chemical means and (3) experiments on lowering the temperature by a combination of mechanical and chemical means.

By varying the shape of the canister to lower the effluent temperature by increased radiation, the minimum rise (8°C.) was obtained from a thin flat canister 8"x10"x1" fitted with 10 inside horizontal fins and 22 outside vertical fins. The test was made against 1% CO at 32 l/m. continuous

CANISTER DIAGRAM
CMA-1



TOP VIEW

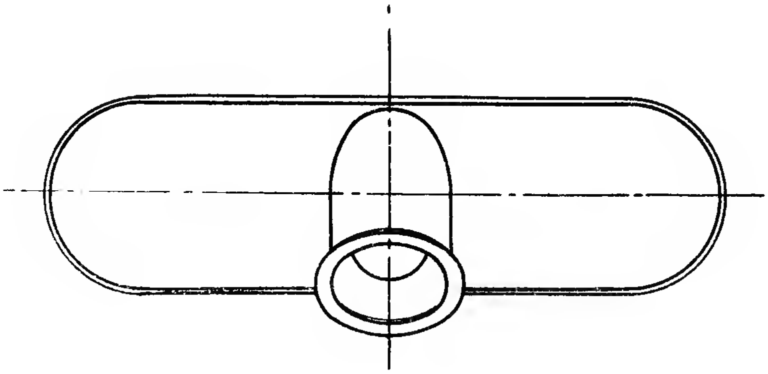


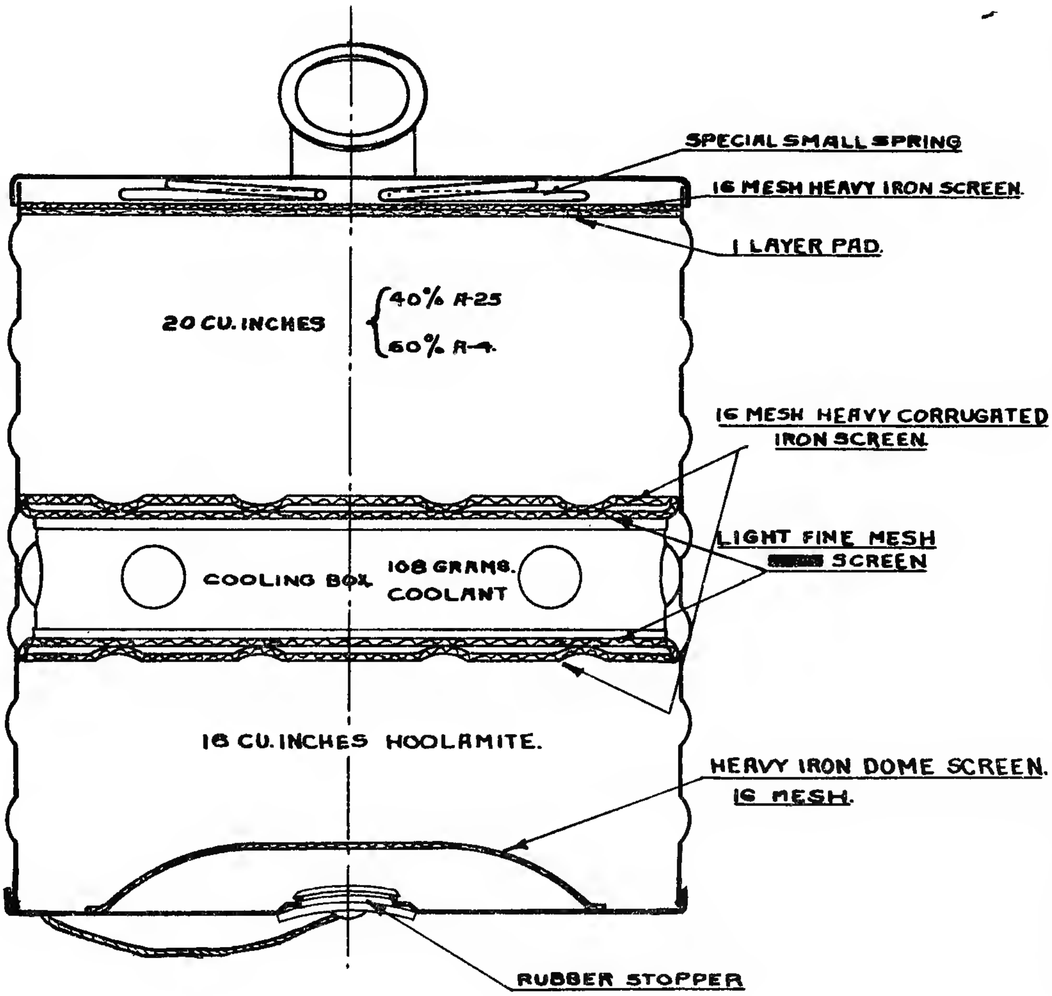
Scale ½" = 1"

PARTIAL REPORT NO. [redacted].
BY- [redacted].

INVESTIGATION CMA-1
TYPE THREE CANISTER.
METHOD USED IN PACKING CANISTERS NO [redacted]-[redacted].

SK-241.





SK-241.

flow. This type of canister would be very hard to pack uniformly and would be clumsy to wear.

The minimum rise in temperature obtained by chemical means was found by taking advantage of the negative heat of transformation of sodium thiosulphate pentahydrate to the anhydrous salt. The most practical method of using the hydrate was to place it in a sealed metal box inside the canister immediately above the HL (or HC) zone. Placed thus in an 8½ inch standard cross-section canister, the rise was 8°C. at the 90% efficiency point when run against 1% CO at 32 l/m continuous flow.

Attempts to lower the effluent temperature by a combination of mechanical and chemical means resulted in a maximum rise of 5°C. from a double canister connected by a non-heat conducting material and each part surrounded with a jacket containing the above salt hydrate. This canister would be clumsy to use and expensive to build.

A canister employing a sealed metal box of sodium thiosulphate pentahydrate was selected as the most efficient and practical. Three sizes have been made and are designated as CMA-1, CMA-2, and CMA-3.

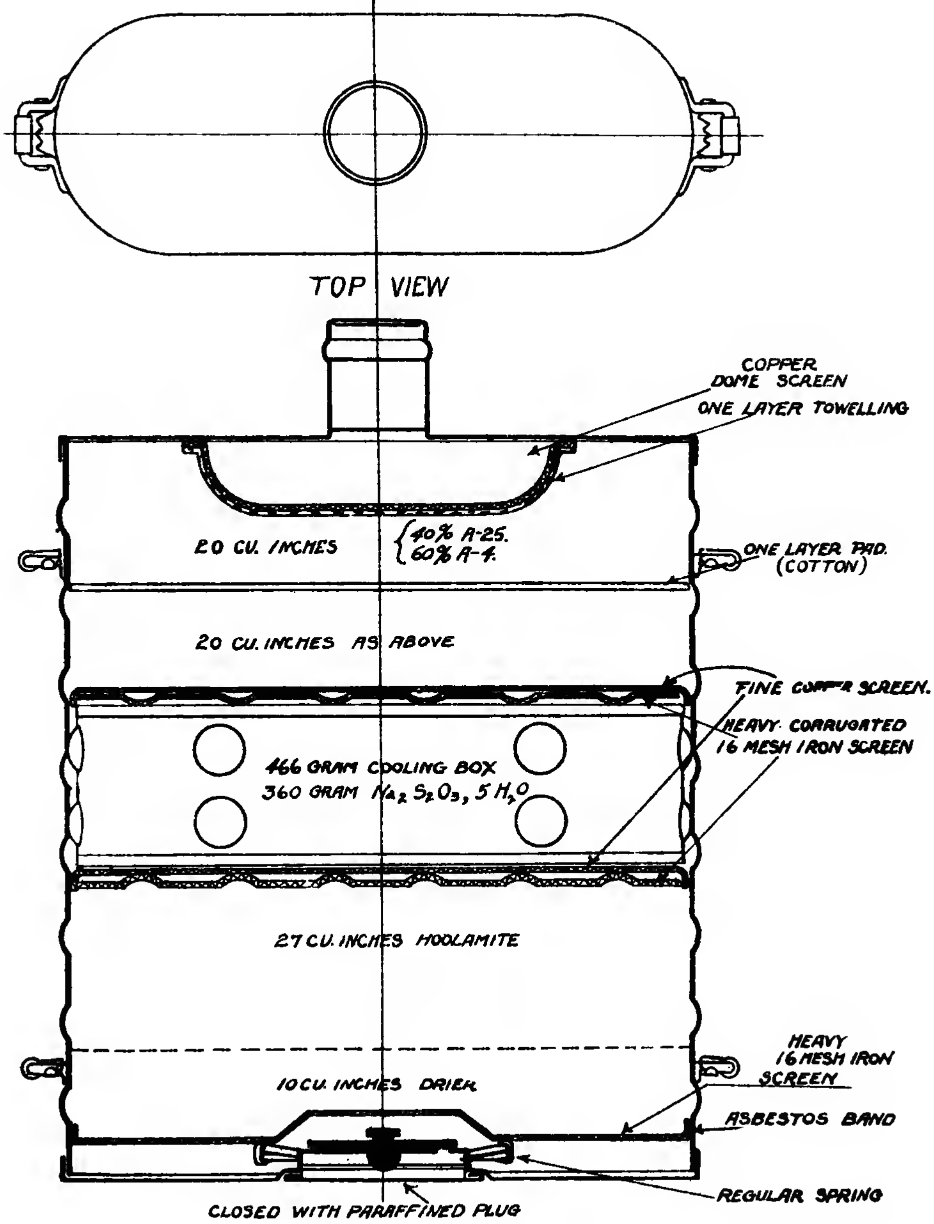
CMA-1 CANISTERS

This canister is 8½ inches high with a standard oval cross-section of 10 sq. in. Packed with 333 c.c. of HL-I (old type) it will hold up (90% efficiency point) about 35 minutes against an air mixture of 1% carbon monoxide at 32 l/m continuous flow, 50% relative humidity at room temperature. The rise in temperature (effluent) at the "break" (90% point) is from 7° to 8°C. Its resistance (at 85 l/m) is about 90 mm. (water).

CMA-2 CANISTER

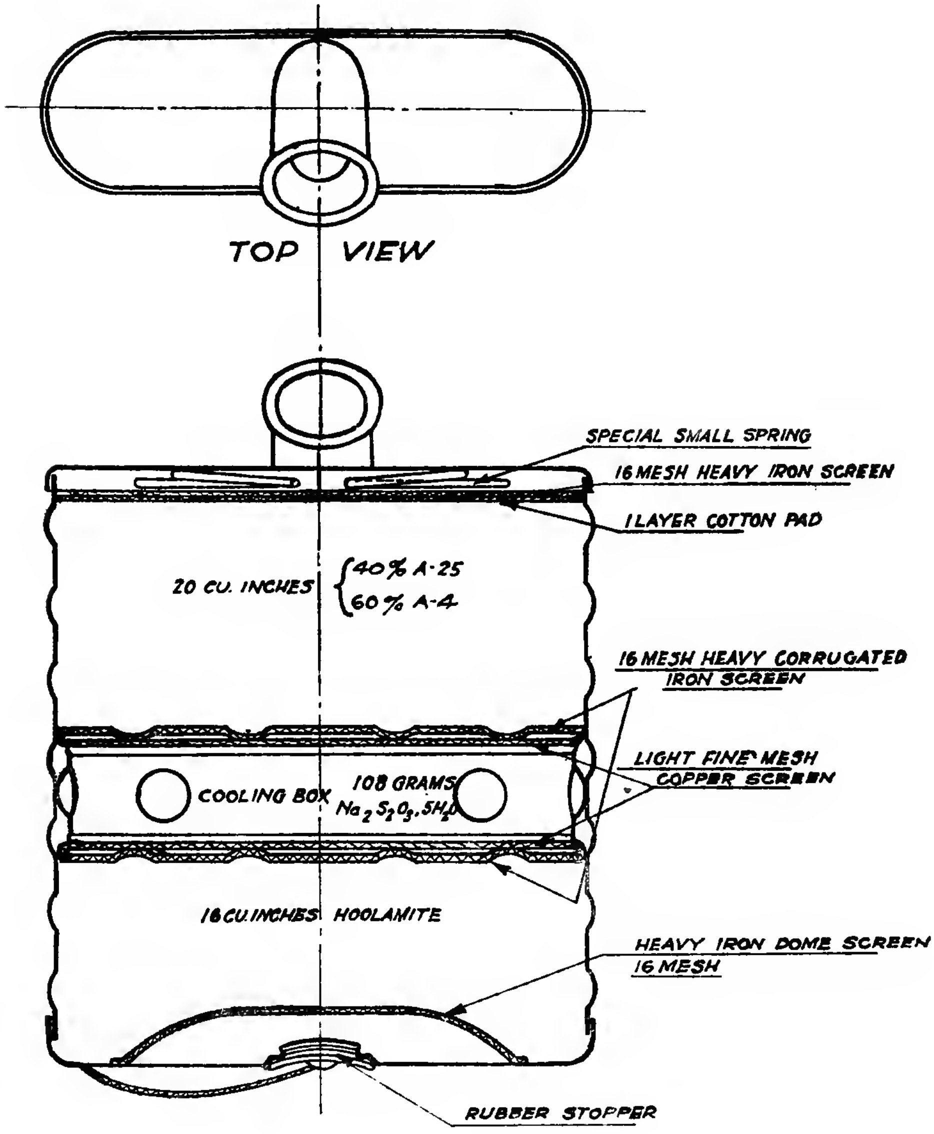
CMA-2 is a large canister of oval cross-section, 2½"x6½"x7½" and is intended to be used primarily for rescue work. When packed with 443 c.c. of HL-I this canister, under the same conditions as above mentioned for CMA-1, has a life of 45 minutes. The temperature rise is about 8°C. and a resistance (at 85 l/m) of 45 mm. (water).

CANISTER DIAGRAM
CMA 2



BUREAU OF MINES AMERICAN UNIVERSITY EXPERIMENT STATION WASHINGTON D. C.	
	A. C. FIELDNER
CANISTER DIAGRAM CMA 2	
SCALE ½" = 1"	APPROVED BY
DRAWN BY I. P. F.	
CHECKED BY Y	COUNTERSIGNED BY A. C. FIELDNER
DATE 6-24-18	NUMBER 1021A

CANISTER DIAGRAM
CMA 3



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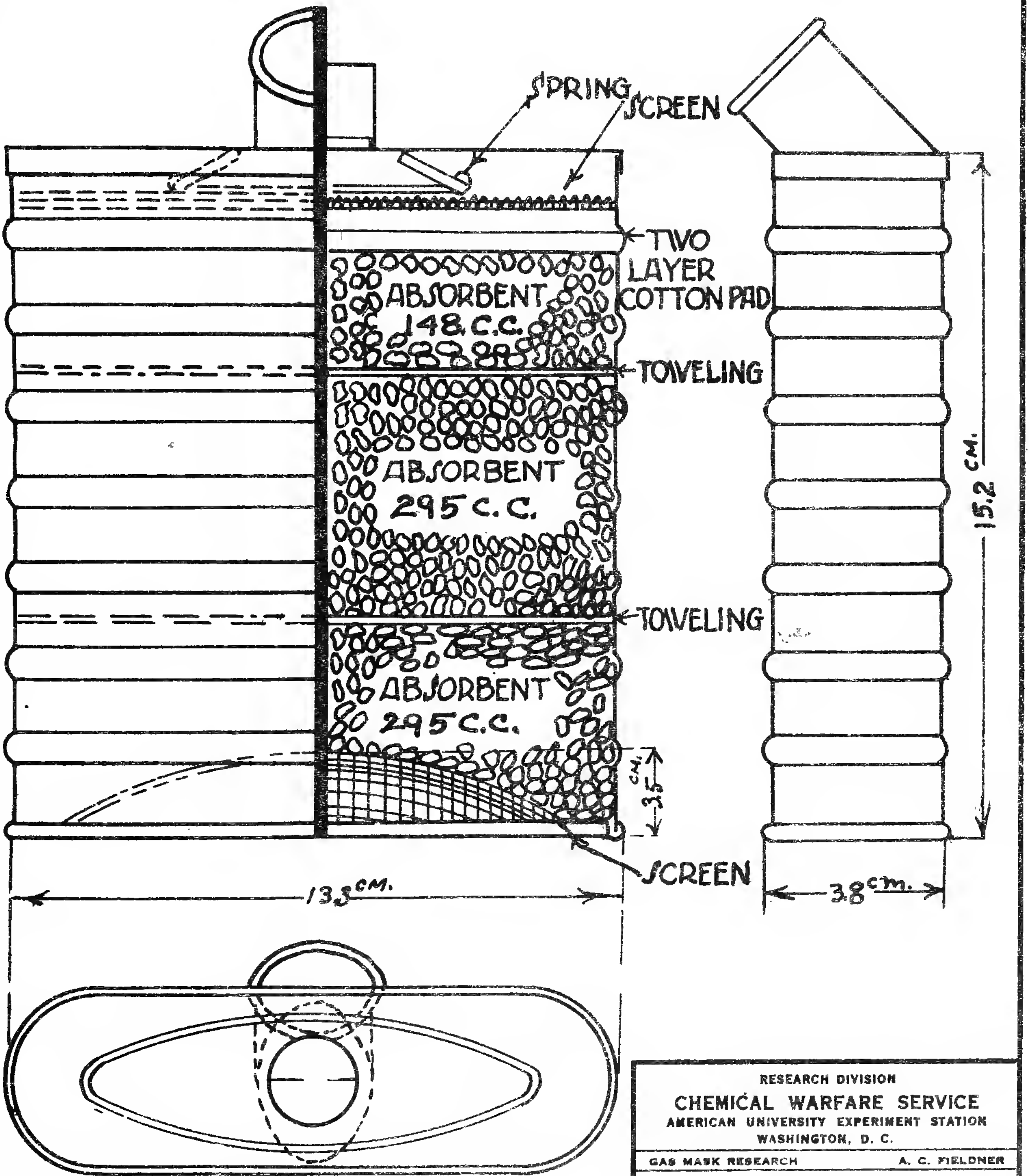
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

CANISTER DIAGRAM CMA 3

SCALE	APPROVED BY	NUMBER 1021A
DRAWN BY P		
CHECKED BY Y	COUNTERSIGNED BY A. C. FIELDNER	
DATE 6-24-18		



RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

"C-M-A-3" CANISTER.

FILLED WITH STANDARD WAR GAS MIXTURE.

SCALE ½" = 1"	APPROVED BY	NUMBER
DRAWN BY A.B.		315-A
CHECKED BY R.N.P.	COUNTERSIGNED BY M.C. Teague	
DATE 11-9-18		

SUMMARY TABLE OF RESULTS

EXPT. NO.	CANISTER AND HOOLAMITE	DURATION ABOVE 90% EFFICIENCY MIN.	TEMPERATURE IN °C. A	AT 90% E_2	TEMP. RISE E_2-A	RELATIVE HUMIDITY MAX. H_2	CAPACITY = % x MIN. TO 85%
26	CMA-1 Std. H	27	19	27	8	63	3235
27	CMA-1 H No. 26	49	18	36	18	87	4620
27B	do.	40	21	30	9	66	4540
28	CMA-1 H No. 27	21	23	29	6	61	2150
28B	do.	17	23	28	5	57	1910
29	CMA-1 H No. 28	24	19	26	7	61	2585
29B	do.	25	18	25	7	64	2885
30	CMA-2 Std. H	46	19	27	8	65	5670
30B	do.	41	18	27	9	61	4380
31	do.	47	18	27	9	66	5310
31B	do.	25	23	28	5	56	4255
32	CMA-1 Std. H	7½	21	22	1	54	2235
33	CMA-3 Std. H	22	25	33	8	67	2580
33B	do.	21	22	30	8	68	2190
34	CMA-3 H No. 26	31	23	44	21	44	3225
35	CMA-2 Std. H	46	20	28	8	63	5090
36	CMA-1 H No. 26	33	22	36	14	81	4140
36B	do.	32	22	39	17	81	3390
37	CMA-3 H No. 36	27	22	37	15	—	3180
38	CMA-3 H No. 37	29	23	44	21	—	3575
39	CMA-2 Std. H	36	23	28	5	—	4195
40	do.	35	23	29	6	—	4040
41	do.	37	25	34	9	—	4075
42	CMA-3 H No. 38	17	26	32	6	—	2050
43	CMA-3 H No. 39	15	25	34	9	—	1940
43B	do.	10	27	29	2	—	1155
44	CMA-3 H No. 42	0	25	—	—	—	—
45	CMA-2 Std. H	8	27	28	1	—	3250
46	CMA-3 H No. 26 + $FeSO_4$	20	24	33	9	—	1930
47	CMA-2 Std. H	0	23	—	—	—	—
48	CMA-3 Std. H	0	25	—	—	—	—

AFS

CMA-3 CANISTER

CMA-3 is a small canister of oval cross-section, 1½"x5½"x6", and is designed to be worn on the head. It is commonly known as the G-31 head canister. Packed with 262 cc. of HL-I, this canister has a life of about 21 minutes when tested under the same conditions as given under CMA-1. The rise in temperature is about 8°C. and its resistance (at 85 l/m) is 50 mm. (water). When packed with the same amount of HL-II its life is about 50 minutes. An HL-III has been developed and is expected to have a somewhat longer life in canisters than HL-II. Tests with HL-III will be reported in the near future. CMA-3 canisters packed with 250 cc. of HC will hold up (90% point) 3½ to 4 hours. Since the action of HC on CO is catalytic, the canister will hold up indefinitely, provided the CO is dried before it reaches the HC layer. Hence, the life of canisters packed with HC is limited only by the capacity of the drier. In the above canister 350 cc. of $CaCl_2$ are employed.

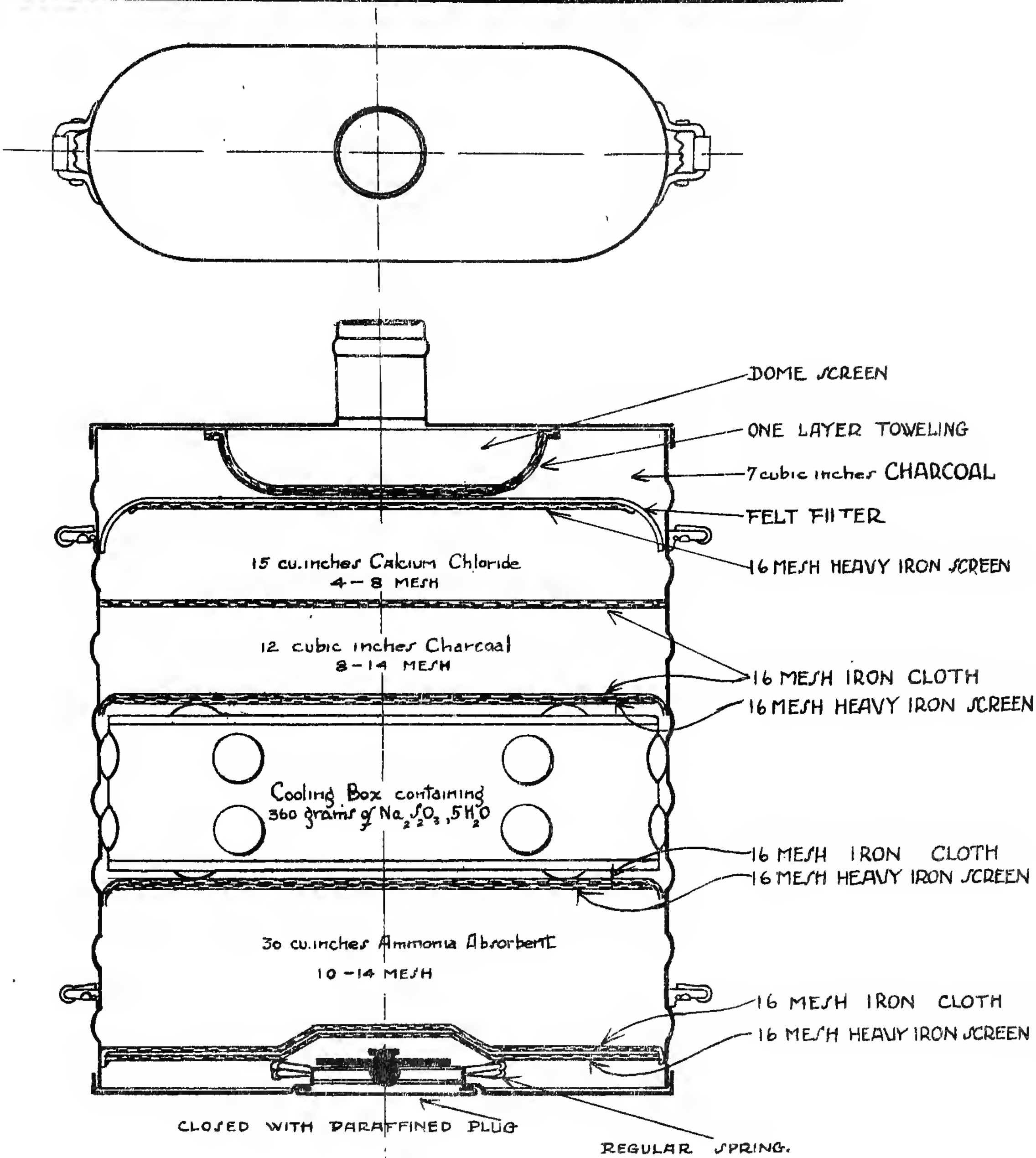
CMA-3 canisters packed with HC are now being manufactured on a large scale. Several of these canisters have just been received from the plant and preliminary tests indicate that they are satisfactory.

9. DEVELOPMENT OF CANISTER FOR PROTECTION AGAINST AMMONIA:

The need for protection against ammonia in certain industrial plants, as well as by the Navy Department, was first met by the development of ammonia canister #1, which employed pumice soaked in sulphuric acid as an absorbent. A cooling box, containing sodium thiosulphate pentahydrate was made necessary by the intense heat developed during the absorption, and a felt filter had to be provided to remove the ammonium sulphate fumes. At 32 l/m continuous flow this canister afforded complete protection against 1% ammonia for about 40 minutes, and against 2% for about 20 minutes. Its life as shown by man tests was about 2½ hours against 2% and 4 minutes against 4%. Skin irritation was, however, found to be unbearable in four or five minutes at a concentration of 2%, and immediately at 4%.

Two new classes of absorbents were then investigated, viz., crystalline acids (boric, etc.) and metallic salts, which readily form metal-ammonia compounds. The relative values of a number of such substances were determined in rough tube tests, with the following results:

DIAGRAM OF AMMONIA CANISTER NO. 1



BUREAU OF MINES
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WASHINGTON, D. C

GAS MASK RESEARCH — A. C. FIELDNER

AMMONIA CANISTER.
NO. 1

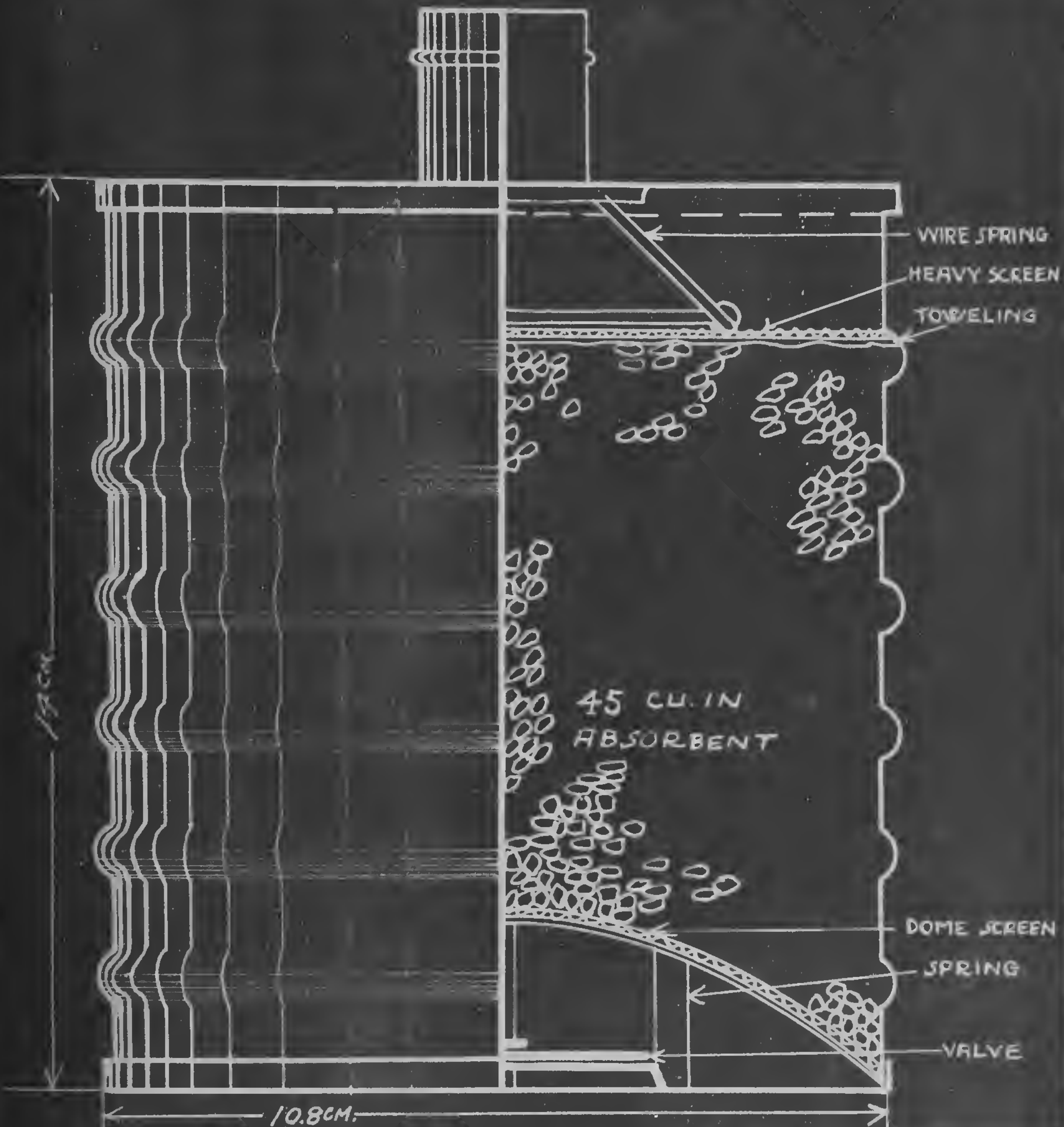
SCALE ½" = 1"	APPROVED BY [signature]	NUMBER 1047-A
DRAWN BY R.F.H.		
CHECKED BY K.	COUNTERSIGNED BY A. C. Fieldner	
DATE 8-30-18		

Material	Heat effect	Time to odor of ammonia. MINUTES
Boric acid	0	8
Chlorine acid	0	0.5
Oxalic acid	0	3
Silicic acid	warm	8
Tannic acid	0	0
Succinic acid	0	0
Citric acid	0	0
Sulphuric acid on pumice	hot	2
Calcium chloride (anhydrous)	0	0
Zinc chloride (anhydrous)	0	0
Copper sulphate	warm	1
Copper sulphate. $5H_2O$	slightly warm	10
Zinc sulphate. $5H_2O$	" "	6
Cobalt nitrate. $6H_2O$	" "	10
Nickel nitrate. $6H_2O$	" "	10
Ferrous sulphate. $7H_2O$	" "	10
Charcoal	0	1

The most promising of these materials were packed in canisters (44 cu.in. of absorbent), and tested on men and by machine, with these results:

Man tests (8 l/m).

Filling	Conc	Pressure drop mm.H_2O at 85 l/m: Start	Finish	Life in Mins	Remarks
$CuSO_4.5H_2O$ on pumice 8-14 mesh	3%	(a) 45	58	240	
		(b) 47	60	240	
ditto	5%	(a) 54	58	120	
		(b) 52	58	110	
ditto	5%	42	53	48	20 l/m
$CuSO_4.5H_2O$ crystals 8-14 mesh	5%	50	--	180	½ material
ditto	2%	50	80	150	used up no break.
Boric acid plus kieselguhr	2%	50	60	120	canister 2/3 full
Ferrous sulphate on charcoal	2%	50	65	150	No break
SiO_2H_2O	2%	50	58	120	



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CHEMICAL WARFARE SERVICE
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GAS MASK RESEARCH — A. C. FIELDNER

KUPRAMITE AMMONIA CANISTER

SCALE FULL	APPROVED BY G. St. J. Perrott	NUMBER 301-E
DRAWN BY D.		
CHECKED BY C.S.F.	COUNTERSIGNED BY A. C. Fieldner	
DATE 11-15-18		

Machine Tests (32 l/m Continuous flow)

Filling	Conc	Pressure Drop mm. H_2O at 85 l/m Start	Finish	Temp Rise oC	Life Mins	Remarks
$CuSO_4 \cdot 5H_2O$ on pumice	3%	(a) 56	64	8.7	45	
ditto	3%	(b) 51	56	4.1	31	
ditto	3%	(a) 50	57	6.5	26	0.5% penetration from start.
ditto	5%	(b) 51	47	14.0	21	Perfect protection
Sulphuric acid on pumice	2%	169	90	34.9	30	Fumes in 8 mins.

Of the various absorbents investigated, pumice stone impregnated with $CuSO_4 \cdot 5H_2O$ appears to best combine efficiency of protection, simplicity of preparation and cheapness. Salts of cobalt and nickel seem to afford slightly better protection, but are more expensive, as well as hygroscopic, than $CuSO_4 \cdot 5H_2O$. That the protection given by the latter is sufficient for any possible use to which it may be put will be seen from the following results of man tests with the "Kupramite" canister (H Type, 44 cu. in. of the absorbent, viz. pumice stone impregnated with its weight of $CuSO_4 \cdot 5H_2O$): Complete protection against 3% ammonia for four hours, and for over 2½ hours against 5%, with men breathing at rest. With men doing severe exercise the life in 5% ammonia was over 25 minutes. Even at the highest breathing rates used the temperature rise accompanying absorption was never over 15°C. The resistance of the canister at 85 l/m is less than 50 mm. of water, which is approximately 2/3 that of the Type J, U.S. Army canister.

10. OFFENSIVE VALUE OF VARIOUS GAS MIXTURES:

From the standpoint of canister penetration the following 17 mixtures would be less effective in gas shell than their components would be if used separately at the same liquid volume: PS and CO, PS and CG, PS and G28, PS and S4, PS and SO_2, PS and G43, PS and S25, CG and CC, CG and G28, CG and SO_2, CC and G10. CC and G28, CC and SO_2, G49 and PS, G40 and CH_3CHO, G49 and PCl_3, G49 and G55. Conversely the protection afforded by U.S. canisters against these mixtures is better than against the separate components alone. A mixture of PS and S22 of approximately equal volumes

in the shell are considerably more effective than PS alone. provided the humidity is very low. A mixture of PS and S22 in the proportion of 15:1 (by liquid volume) is no more effective than PS alone. Gas shell filled with equal parts by volume (liquid) of CG and G10 are somewhat more effective than shell filled with CG alone.

MACHINE TESTS

Humidity - 50% Relative

Type of Canister	Mixture	Concentration: p.p.m.	Concentration: mg/l.	Parts by volume (of liquid) in shell	Time to break-mins. Alone	Time to break-mins. in mixture
U.S. (J)	PS	1000	6.72	3.97	45	44
	CC	500	1.26	1.03	15	13
U.S. (H)	PS	2500	16.80	9.93	42	40
	CC	500	1.26	1.03	21	21
U.S. (J)	PS	1000	6.72	3.97	37	38
	CG	2500	10.11	7.06	38	38
German	PS	1000	6.72	3.97	3	2
	CG	1000	4.04	2.82	10	7
U.S. (J)	PS	1000	6.72	3.97	37	31
	G-28	2000	5.80	3.95	46	37
U.S. (J)	PS	1000	6.72	3.97	37	21
	G-28	4000	11.80	7.90	23	21
U.S. (J)	PS	1000	6.72	3.97	37	35
	S-4	1000	0.69	1.11	2	2
U.S. (J)	PS	1000	6.72	3.97	37	34
	S-4	2000	1.39	2.22	1	1
U.S. (J)	PS	1000	6.72	3.97	37	36
	SO_2	1000	2.62	1.82	56	46
U.S. (J)	PS	1000	6.72	3.97	38	38
	G-43	1500	1.66	2.30	17	17

Type of Canister	Mixture	Concentration: p.p.m.	Concentration: mg/l.	Parts by volume (of liquid) in shell	Time to break-mins. Alone	Time to break-mins. in mixture
U.S.(J)	PS	1000	6.72	3.97	37	11
	S-22	1000	6.96	4.57	--	--
U.S.(J)	PS	1000	6.72	2.97	38	32
	S-22	1000	6.96	4.57	--	--
This series run at 80% relative humidity -						
U.S.(J)	PS	2000	13.45	7.94	23	22
	S-22	100	0.69	0.46	--	--
U.S.(H)	CG	5000	20.06	14.12	50	42
	CC	500	1.26	1.03	22	16
U.S.(J)	CG	2500	10.03	7.06	42	43
	CC	500	1.26	1.03	9	5
U.S.(J)	CG	5000	20.06	14.12	28	13
	G-28	3500	10.19	6.91	26	14
U.S.(J)	CG	5000	20.06	14.12	28	16
	SO_2	3500	9.17	6.37	16	9
U.S.(J)	CG	5000	20.06	14.12	28	10
	G-10	3200	23.73	10.75	29	21
U.S.(J)	CG	8200	33.88	23.1	17	
U.S.(J)	CG	5000	20.06	14.12	28	25
	G-10	500	6.72	1.6		
U.S.(J)	CC	500	1.26	1.03	9	6
	G-10	2000	26.90	6.7		64
U.S.(J)	CC	500	1.26	1.03	9	6
	G-28	3500	10.19	6.91	26	23
U.S.(J)	CC	500	1.26	1.03	9	5
	SO_2	3500	9.17	6.37	16	11
U.S.(L)	G-49	3000	24.28	14.37	20	12
	PS	3000	20.18	11.91	19	--
U.S.(L)	G-49	3000	24.28	14.37	20	12
	CH_3CHO	6000	11.79	13.44	7	3
U.S.(J)	G-49	2500	20.23	11.97	20	8
	PCl_3	4000	22.48	13.94	15	10
U.S.(J)	G-49	3000	24.28	14.37	15	9
	G-55	2000	15.21	8.82	16	9

MAN TESTS

Type of Canister	Mixture	Single Gas	Conc. p.p.m.	Conc. mg/l.	Parts by volume (liquid) in shell	Time to break - Mins. Alone	Time to break - Mins. Mixture
U.S.(J)	PS		2160	14.53	8.58		53
	CC		984	2.47	2.03		53
		PS	2000	13.44		115	
		CC	1000	2.51		72	
U.S.(H)	PS		2246	14.96	8.92		
	CC		1032	2.59	2.13		115
		PS	2000	13.44		278	
		CC	1000	2.51		131	
U.S.(J)	PS		2624	17.65	10.42		110
	CG		5026	20.43	14.17		
		PS	2000	13.44		115	
		CG	5000	20.06		196	
U.S.(H)	PS		2180	14.76	8.66		171
	CG		5189	21.00	14.63		
		PS	2000	13.44		278	
		CG	5000	20.06		285	
U.S.(J)	PS		2145	14.43	8.52		128
	S-25		295	3.15	1.38		
		PS	2000	13.44		115	
U.S.(H)	PS		2735	18.30	10.86		280
	S-25		691	7.37	3.23		
		PS	2000	13.44		278	
U.S.(J)	CG		4474	18.12	12.62		
			787	1.97	1.62		37
		CG	(5000	20.06		197	
		CC	(100	2.51		72	
U.S.(H)	CG		3693	14.96	10.42		
	CC		1325	3.33	2.73		113
		CG	(5000	20.06		285	
		CC	(1000	2.51		131	

11. EFFECT OF TEMPERATURE ON THE EFFICIENCY OF CANISTERS AGAINST VARIOUS GASES:

Inasmuch as canisters are actually used in the field over a considerable range of temperature, experiments have been made to determine the effect of temperature on Type H, U.S. Army canisters, with the following results:

Against CG the life increases with decrease in temperature, being 60% greater at -13°C. than at 40°. However, the time required to pass from the break to the 90% efficiency point is greater at the higher temperatures.

Between -13°C and 40°C. the life of canisters against PS was found to be independent of temperature.

Against G-43 the protection increased with decreasing temperature, the life at -13°C. being more than double that at 40°C. Moreover, the time required to pass from the break to the 99% point is much increased with decrease in temperature.

The temperature coefficient of standard canisters tested against CC was found to be very large. At -10°C the canisters remained 100% efficient for 62 minutes, while at 20°C. they broke in 21 minutes. At 40° they broke in 11 minutes.

For offensive purposes it appears that CC will give very much better results during hot weather.

12. EFFECT OF TEMPERATURE ON THE ABSORBING POWER OF VARIOUS ABSORBENTS:

Against G-43 the life of canisters filled with charcoal was found to increase with decreasing temperature. At -13°C. the time to break was four times as great as at 40°C., the time to 90% was approximately five times as great as at the higher temperature. Similar results were obtained in tube tests on charcoal, where it was found that for normal changes in room temperature the variation in service time is about 3.7% per degree deviation in temperature from a 25°C basis.

Against G-43, the life of canisters packed with soda lime increased with decrease in temperature (except between 10°C. and 0°C). The life at -11°C. was approximately 50% greater than that at 40°C. Between 15°C and 30°C. the temperature coefficient of soda lime is about 1% per degree, based on the standard temperature of 25°C. Corrections can be made accordingly.

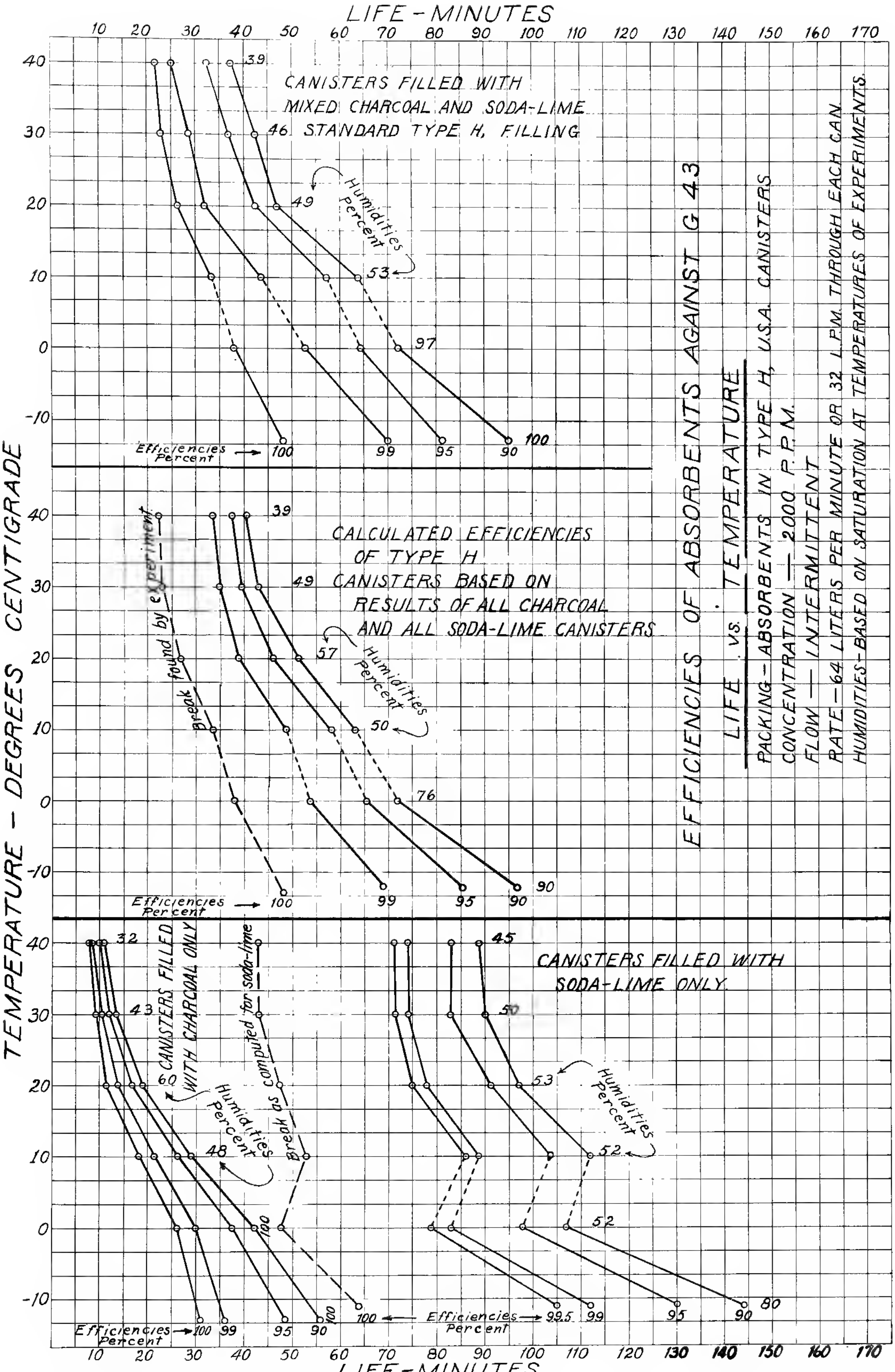


FIGURE 2.

U. S. BUREAU OF MINES 11233

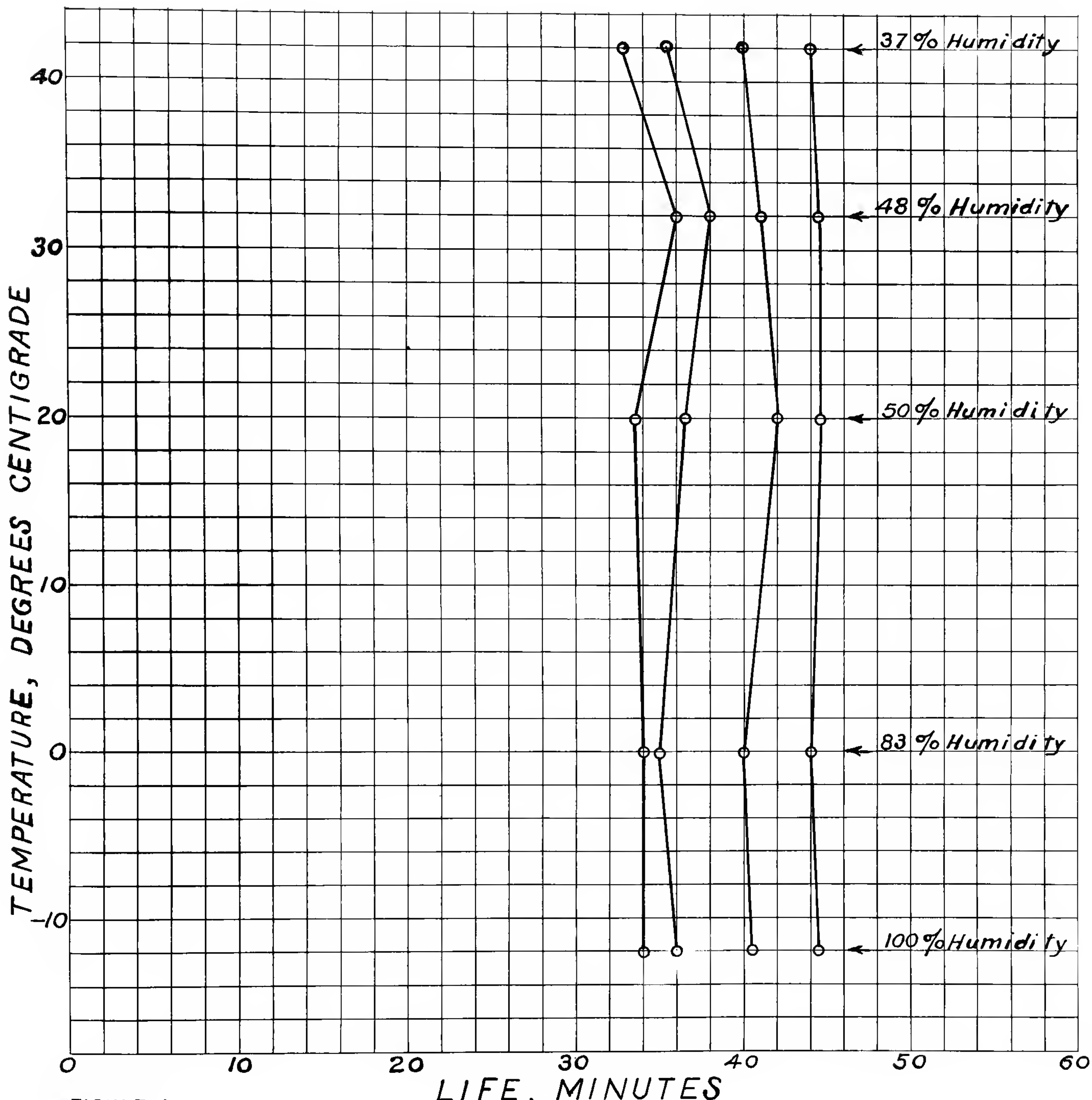


FIGURE 1.

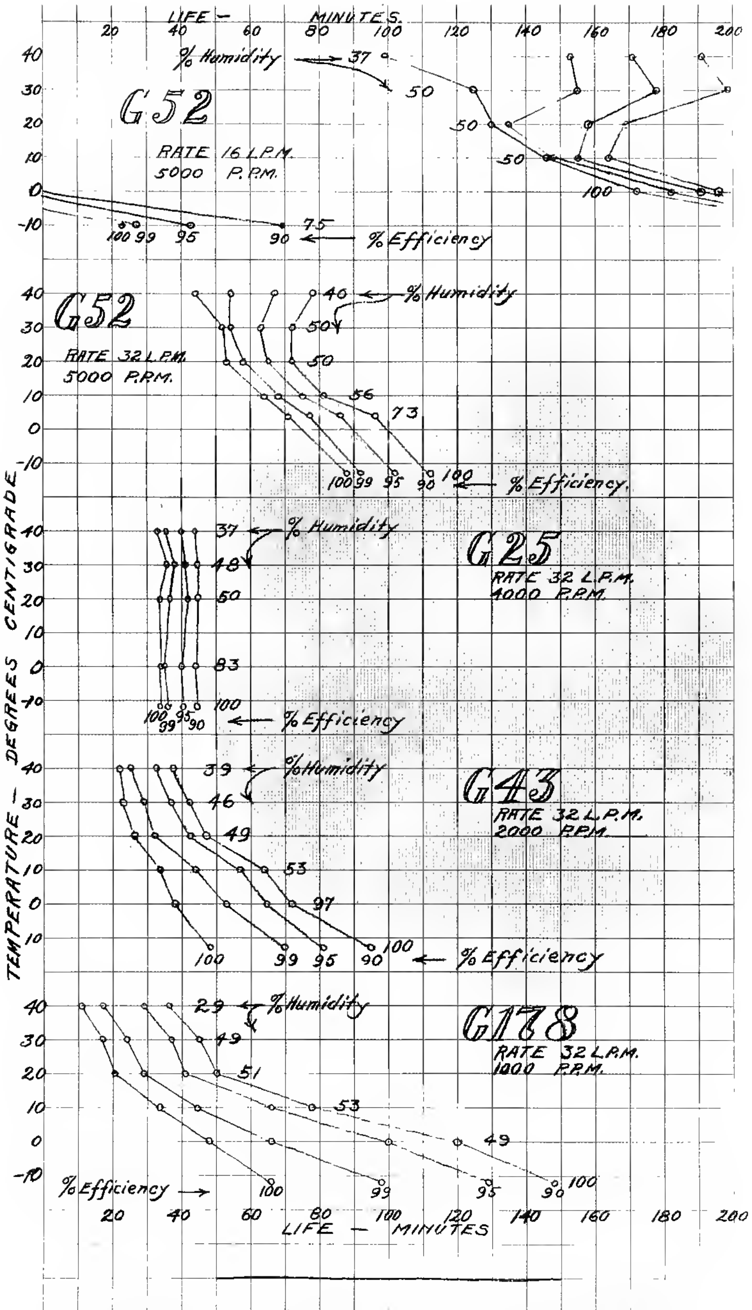
EFFICIENCIES OF U.S. ARMY CANISTERS.

LIFE vs TEMPERATURE.

Gas — G 25

Concentration — 4000 P.P.M.

Rate — 64 liters through two canisters, intermittently, equivalent to 32 liters per minute continuously.



LIFE VS TEMPERATURE

INTERMITTENT FLOW

CANISTERS KEPT IN DRY ROOM AIR.

HUMIDITIES BASED ON TEMPERATURE OF EXPERIMENTS.

STANDARD U.S.A. CANISTERS

Against CC, the life of canisters filled with charcoal changes about 3% per degree Centigrade, between 18° and 29°C., the life being greater the lower the temperature. Against CC, the life of canisters filled with whetlerite increases greatly with decrease in temperature. At 40°C. the life was 19 minutes, while at -12°C. it was 163 minutes. It is apparent that tests of whetlerite against CC should be made at a uniform temperature.

Against G-7 the activity (time to break) decreases with increasing temperature, but the capacity (time to 80% efficiency point) increased with increasing temperature. This second effect is probably that of temperature upon the catalytic decomposition of G-7, produced by deposition of the element or its compounds in the charcoal.

Against G-7 the service time of soda lime was found to increase 30% due to an increase in temperature from 10°C. to 20°C.

13. EFFECT OF HUMIDITY AND AGING ON CANISTERS AND ABSORBENTS:

Extensive investigation has been made of the effect of exposure to atmospheric conditions on various absorbents and canisters. Standard canisters, exposed to the air for six months, underwent the following changes in efficiency: an increase of 35% and a decrease of 13% and 56% in the case of CG, PS and G-43, respectively. The moisture content of the charcoal was found to have increased from 0.5% to 6.6%, while that of the soda lime decreased from about 4% to 2%. There was no appreciable change in resistance, nor marked deterioration in the canisters.

Similar results were obtained with charcoal and soda lime. It was found that an increase of moisture content of charcoal is generally accompanied by an increase in the absorption value for CG and G-43, but by a decrease in absorption value for PS and G-7. The moisture content of charcoal varied with the relative humidity of the atmosphere to which it was exposed, and lay generally between 3% and 7% for CODC. The maximum amount of moisture found in any sample of the latter was 14%.

Astoria soda lime, exposed to the air for 3 months at an average humidity of 50%, deteriorated in service time 74% for CG, 65% for SF, 72% for G-43 and 42% for G-7. However, mixtures prepared from the exposed soda lime and unexposed charcoal, showed practically no deterioration in absorbent power for CG. During the exposure the moisture content of the soda lime decreased from 11.6% to 4.9%, while the CO_2 content increased from 4.8% to 27.1%.

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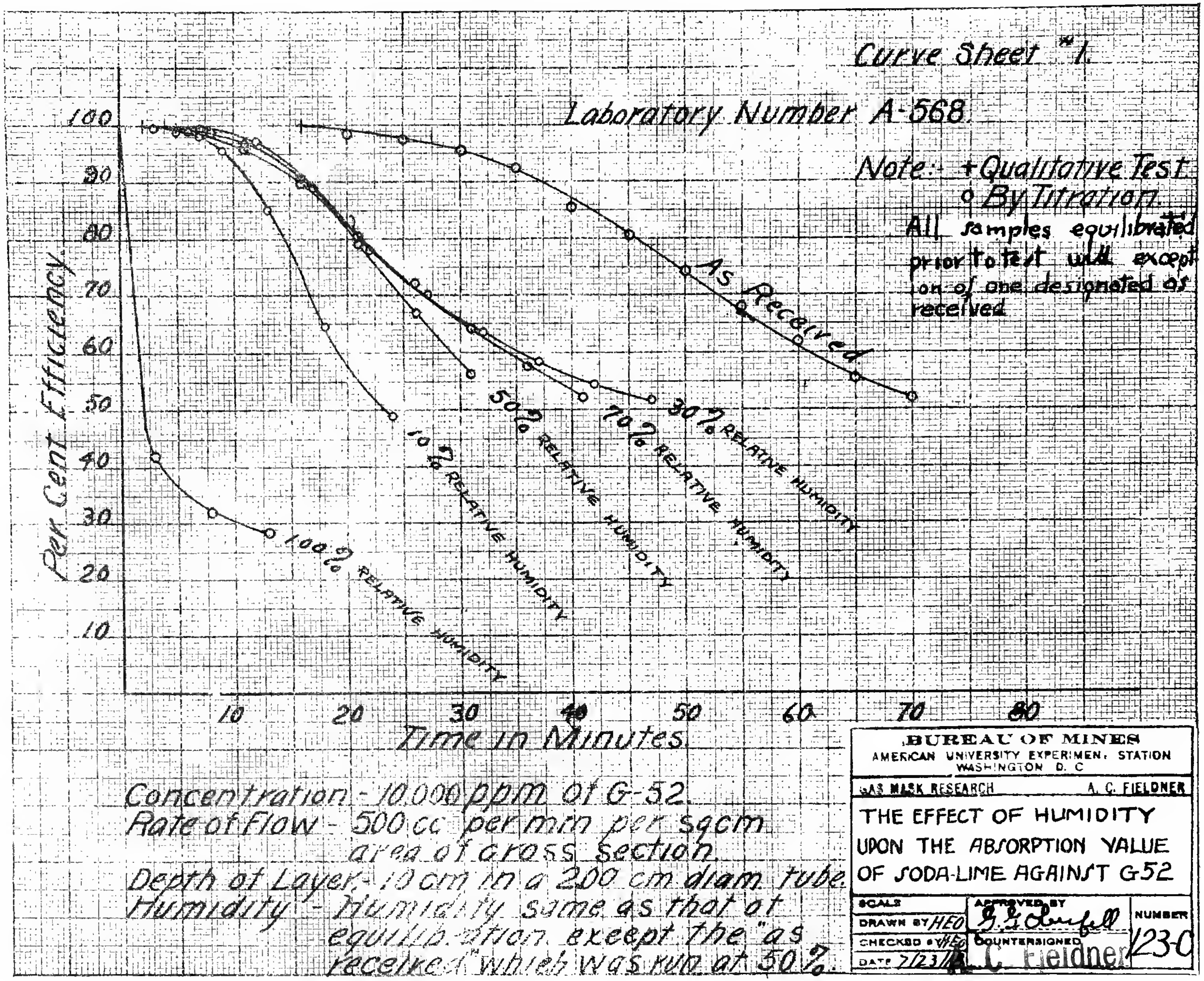
Curve Sheet #1.
Laboratory Number A-568.
Note: + Qualitative Test
o By Titration
All samples equlibrated prior to test with exception of one designated as received
Per Cent Efficiency
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
Time in Minutes
As Received
30% RELATIVE HUMIDITY
70% RELATIVE HUMIDITY
50% RELATIVE HUMIDITY
10% RELATIVE HUMIDITY
100% RELATIVE HUMIDITY
Concentration - 10,000 ppm of G-52
Rate of Flow - 500 cc per min per sqcm area of cross section
Depth of Layer - 10 cm in a 2.00 cm diam. tube
Humidity - humidity same as that of equilibration except the "as received" which was run at 50%
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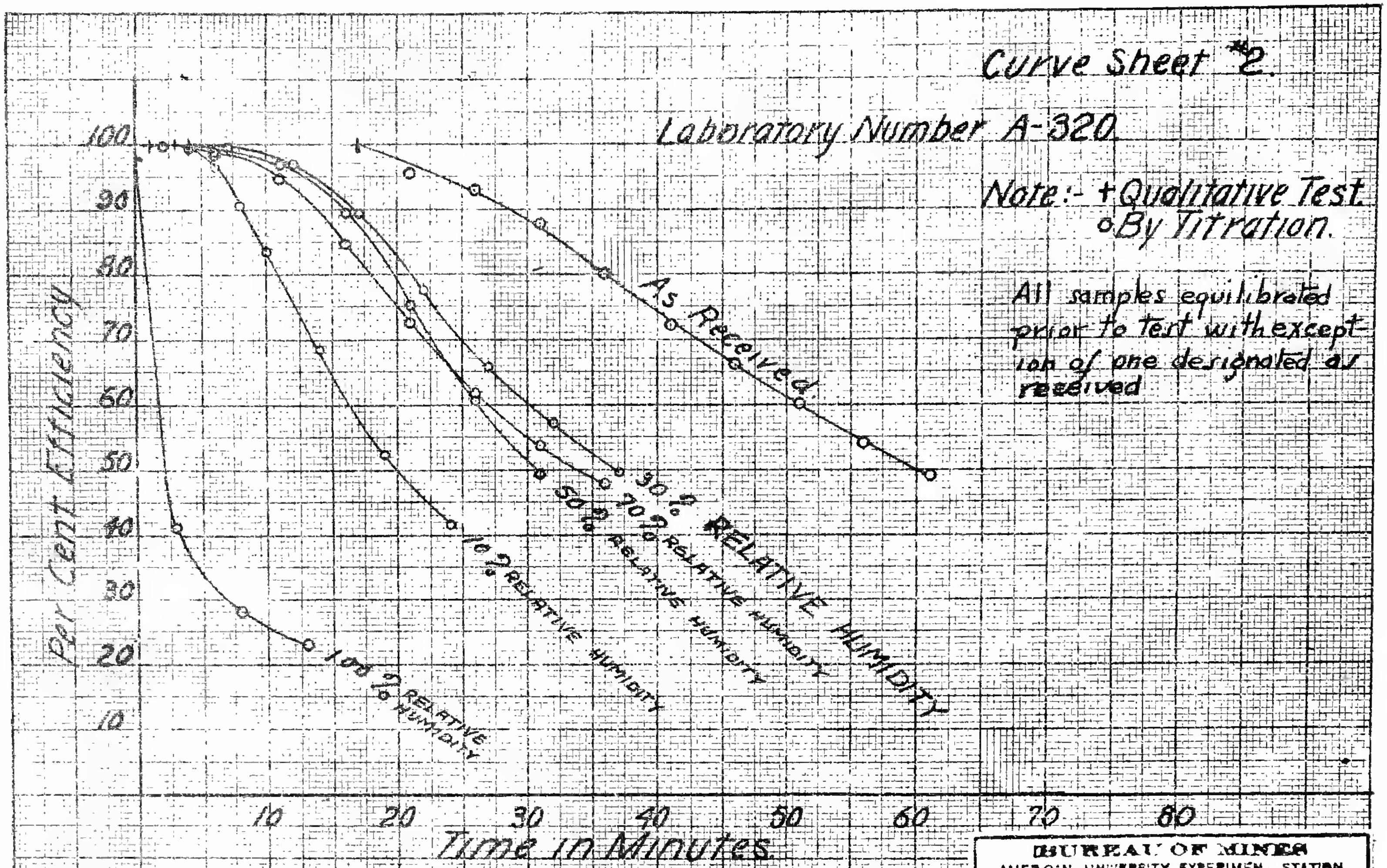
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON D. C.
GAS MASK RESEARCH
A. C. FIELDNER
THE EFFECT OF HUMIDITY UPON THE ABSORPTION VALUE OF SODA-LIME AGAINST G52
SCALE
DRAWN BY HEO
CHECKED BY HEO
DATE 7/23
APPROVED BY
COUNTERSIGNED
A. C. Fieldner
NUMBER
123-C



Concentration - 10,000 PPM of G-52.
Rate of Flow - 500 cc per min per sqcm. area of cross section.
Depth of Layer - 10 cm in a 2.00 cm diam tube.
Humidity - Humidity same as that at equilibration. The "as received" was run at 50 % relative humidi[ty]

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GAS MASK RESEARCH — A. C. FIELDNER

THE EFFECT OF HUMIDITY UPON THE ABSORPTION VALUE OF SODA-LIME AGAINST G52

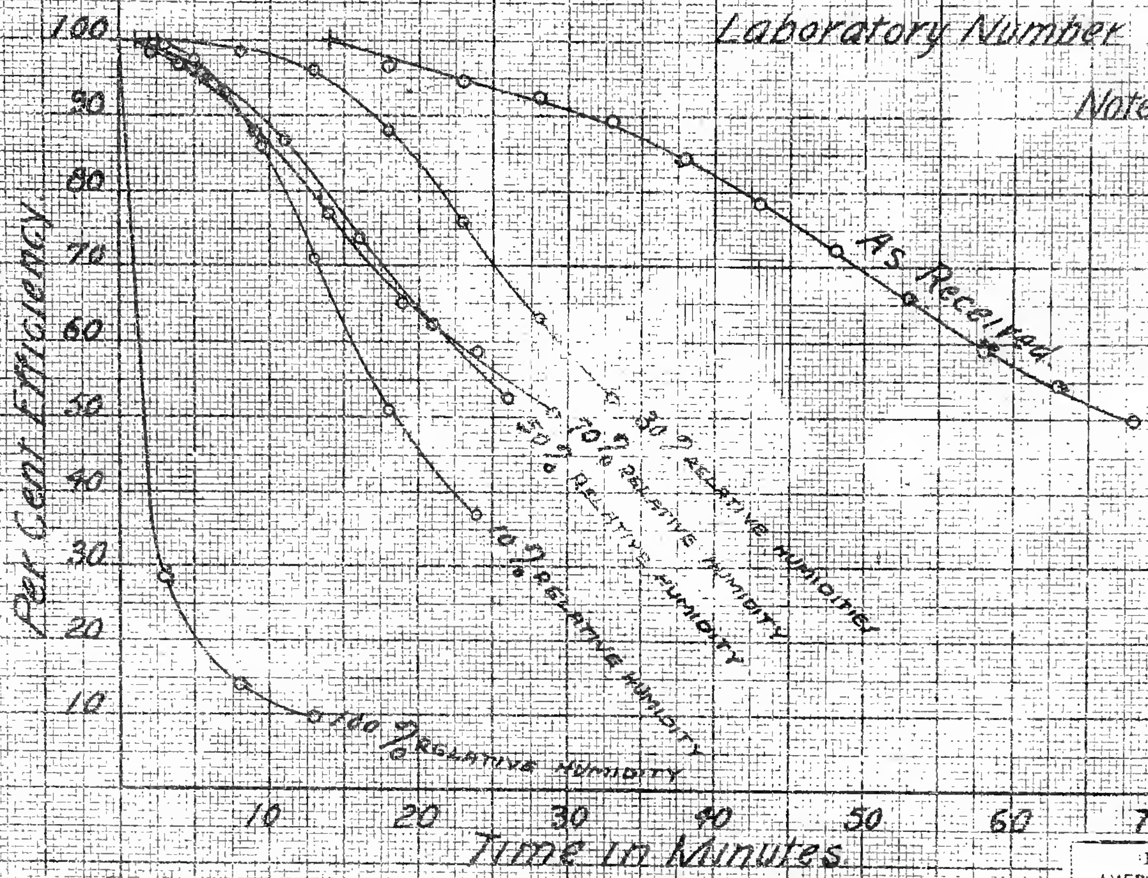
SCALE	APPROVED BY G. G. Oberfell	NUMBER
DRAWN BY HEO		123-C
CHECKED BY HEO	COUNTERSIGNED A. C. Fieldner	
DATE 7/23/18		

Curve Sheet #3.

Laboratory Number A-431

Note:- + Qualitative Test.
o By Titration.

All samples equilibrated prior to test with exception of one designated as received.



Concentration - 10,000 P.P.M. of G-52.
Rate of Flow - 500 cc. per min. per sq cm. area of cross section.
Depth of Layer - 10 cm in a 2.00 cm diam. tub
Humidity - Same as that of equilibration.
The "as received" was run at 50% relative humidity.

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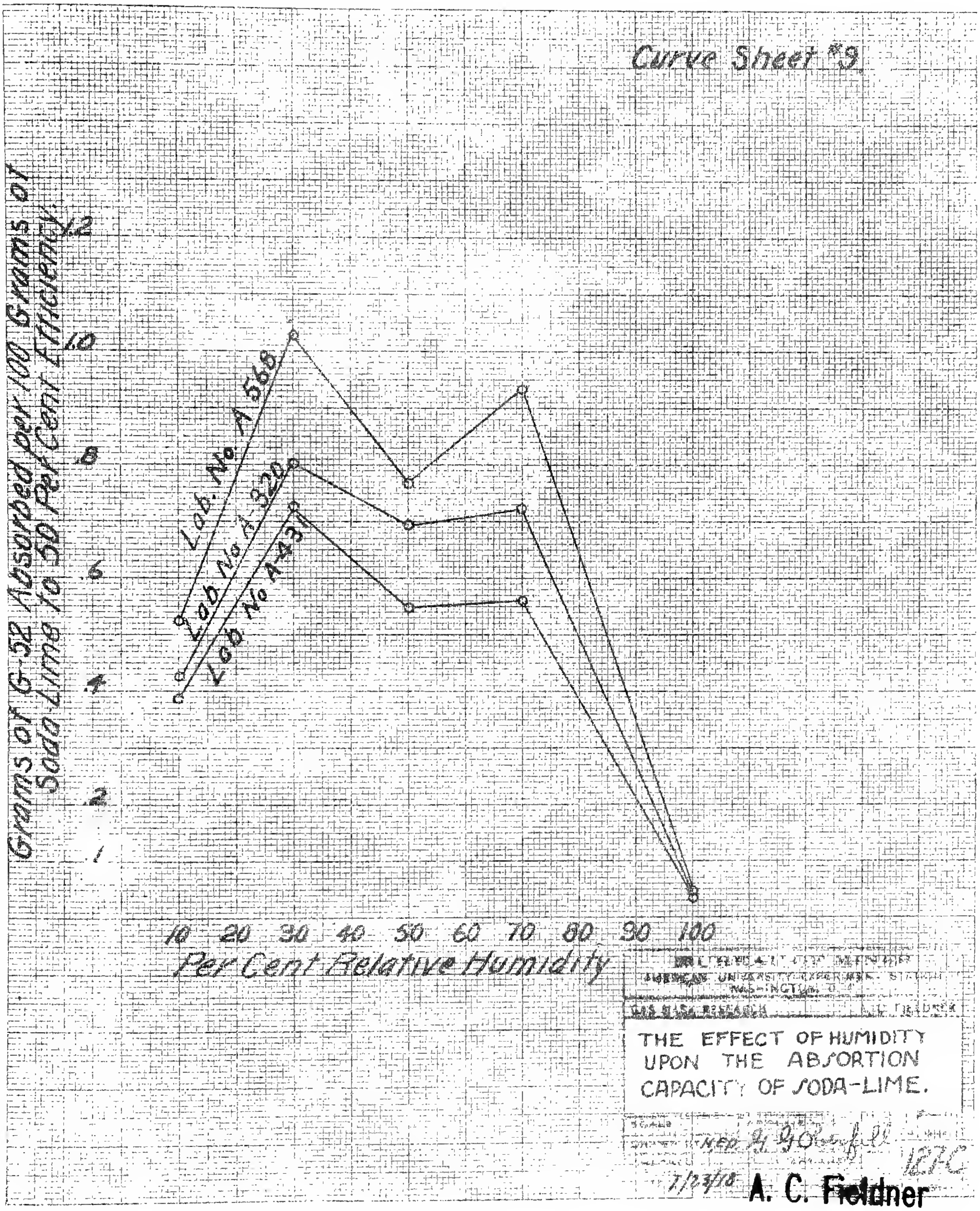
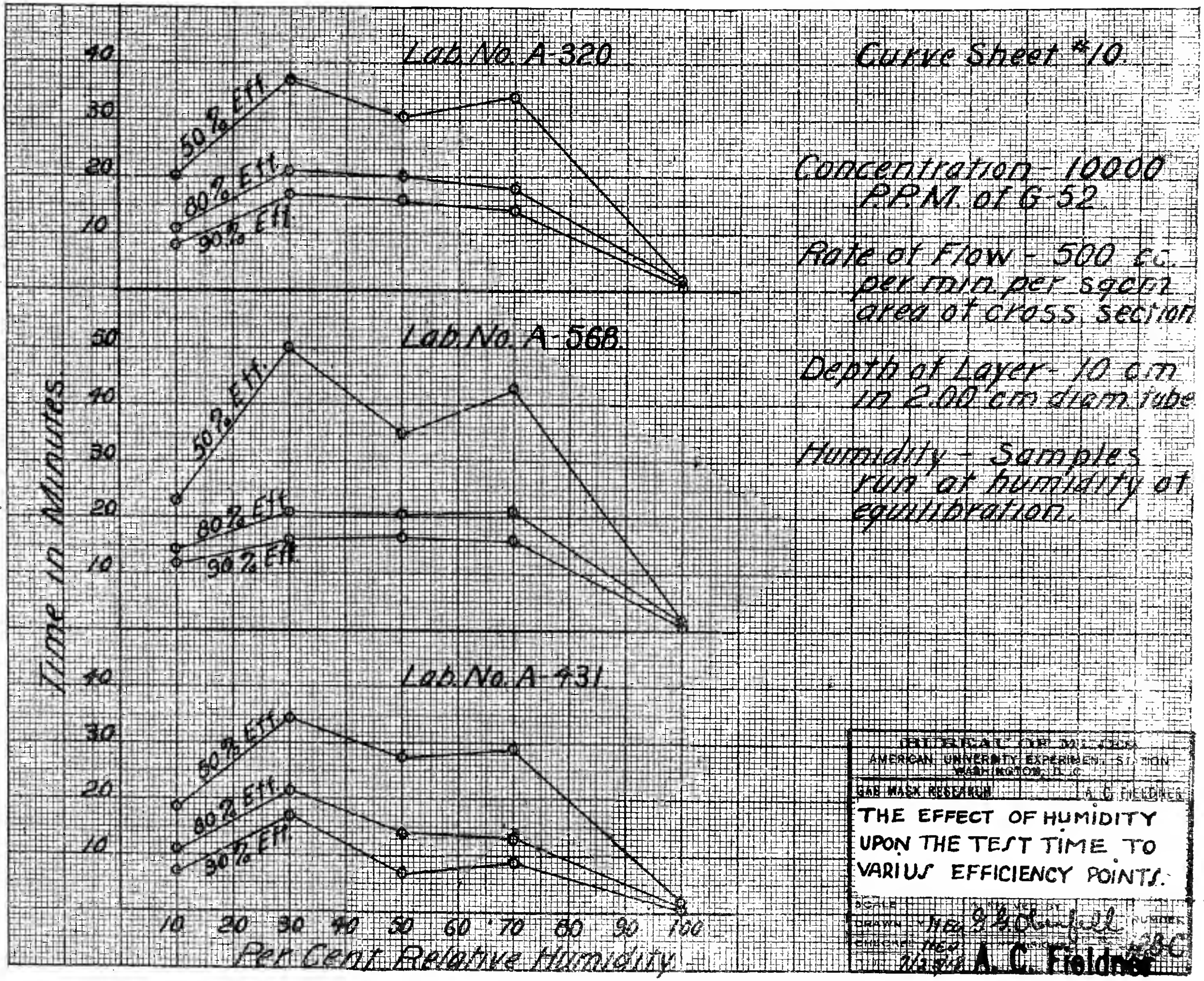
GAS MASK RESEARCH	A. C. FIELDNER
THE EFFECT OF HUMIDITY UPON THE ABSORPTION VALUE OF SODA-LIME AGAINST G-52	
SCALE	APPROVED G. G. Oberfell
DRAWN BY HEO	NUMBER 123C
CHECKED HEO	
DATE 7/23/18	A. C. Fieldner


Curve Sheet #9.
Grams of G-52 Absorbed per 100 Grams of Soda Lime to 50 Per Cent Efficiency.
12
10
8
6
4
2
Lab. No. A 568
Lab No A-320
Lab No A-431
10 20 30 40 50 60 70 80 90 100
Per Cent Relative Humidity
THE EFFECT OF HUMIDITY UPON THE ABSORTION CAPACITY OF SODA-LIME.
7/23/18
A. C. Fieldner



Curve Sheet #10.
Concentration - 10000 P.P.M. of G-52
Rate of Flow - 500 cc. per min. per sq.cm area of cross section
Depth of Layer - 10 cm in 2.00 cm diam. tube
Humidity - Samples run at humidity of equilibration.
Lab. No. A-320
Lab. No. A-568.
Lab. No. A-431
50% Eff.
80% Eff.
90% Eff.
Time in Minutes.
Per Cent Relative Humidity
10
20
30
40
50
60
70
80
90
100
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
THE EFFECT OF HUMIDITY UPON THE TEST TIME TO VARIUS EFFICIENCY POINTS.
A. C. Fieldner

It was very early found necessary to control the humidity of the air-gas mixture when testing the absorption power of canisters or absorbents. The absorption of water vapor is very rapid at first, and varies with the humidity, thus causing appreciable differences in service time unless the humidity is carefully controlled. For example, the efficiency of charcoal against PS was found to decrease rapidly with increase of relative humidity of the air-gas mixture. Experiments with standard canisters showed that changing the relative humidity from 50% to 70% decreased their life 11% for PS and 6% for G-43, and increased it 12% for CG.

Inasmuch as the humidity on certain sectors of the battle front in France is said to average as high as 70%, it seemed desirable to find what effect continued breathing of such air would have on a canister when subsequently used in gas. Accordingly canisters were equilibrated with air of 70% relative humidity and then tested on machines. As a result the efficiency decreased about 50% for PS, but increased 18% for G-43 and 69% for CG. There was very little caking of the absorbent mixture except at the bottom, but the interior of the canister as well as the wire screens were heavily corroded. The pressure drop, however, increased only about 10%.

Two further sets of canisters were equilibrated, by man test, one set at 70% humidity, the other at 90%. Subsequent man tests of these canisters showed that equilibration with air of 70% humidity increased the life 44% against CG, and decreased it 41% against PS. When air of 90% humidity was used for equilibrating the increase in life against CG was 54%, and the decrease with PS was 58%. All these tests showed that in spite of the marked reduction in life of canisters against PS, the protection was still adequate.

Similar experiments were conducted with charcoal equilibrated at 70% and at 30% relative humidity. Equilibration at 70% humidity decreased the service time of charcoal 75% for PS and 95% for G-7, but increased its life 79% for CG and 31% for G-43. Equilibration at 30% humidity decreased the efficiency 8% for PS and 44% for G-7, and increased it 5% for CG. With G-43 there was no change in service time.

Soda lime as received at the laboratory contains about 13% moisture and is in equilibrium with air of about 70% humidity. Considerable reduction in activity is observed, however, in samples equilibrated at 70% humidity, although the moisture content is not appreciably affected.

A considerable number of canisters of the earlier types, withdrawn from training camps in this country, were examined to determine their resistance to deterioration. Types A and B canisters containing wood charcoal offered no protection against either PS and CG. The canisters were in very bad condition, the resistance was much increased, and many were completely plugged, apparently due to the disintegration of the Easton green granules. Canisters containing wood charcoal were in fairly good condition, and though they gave but little protection against PS, they hold up longer against CG than similar canisters received direct from the filling plant. Unfortunately nothing was known of the previous history of any of these canisters.

Another lot of canisters (Type G), whose history was known, was tested in the same way. They had been used two to three hours in gas, but had been breathed through for much longer periods. Though the life against PS was somewhat reduced, they still gave good protection, and showed marked improvement in absorbent power for CG over those received direct from the plant. Their condition was much better than the earlier types examined, largely due to the fact that they contained Astoria purple granules instead of the Easton.

14. RELATION OF CONCENTRATION OF GAS TO THE LIFE OF STANDARD CANISTERS AND ABSORBENTS:

Considerable work has been done on the protection given by the standard canister over a wide range of gas concentration, such as might be expected to be met in field use. In order to simplify the manipulation, these tests were run with a continuous rate of flow and the relation between tests with this type of flow and tests with intermittent flow-simulating breathing-was determined at some standard rates and concentrations.

Below are tabulated the summarized results of the concentration-time relation investigations. The times taken are those during which the canisters in each case gave complete protection and are the averages of three to five results.

It should be noted that the results obtained on different gases are not exactly comparable even when the same type of canister is used as the value of the absorbent may vary by as much as 200%.

All runs were made 32 l/m continuous flow and 50% relative humidity unless otherwise indicated under remarks.

Gas	mg/l. equiv. 1000 p.p.m.	Type Can.	100	250	500	1	2.5	5	10	15	25	50	100	250	Remarks
			Time at 100% efficiency -- minutes at concentration in parts per million			(IN THOUSANDS)									
AsH_3	3.2	HHPD 12Y	113	(45)	21	8	6	3							Intermittent 22 inhal/min.
PS	6.72	H			195		29	15		6					ditto
		J			79		13	7		2					ditto
Cl_2	2.90	F			227	145	44	21	13	9					ditto
HCN	1.10	164		217	114	64	30	17							ditto
		HH													ditto
CG	4.05	H						47			12	6	3.3	1.3	ditto
		J						19			5	2.4	1.7		ditto
		H					23		7			1.7	1		@ 85 l/m cont.
						57		7	2		0				@ 150 l/m cont.
		J					10		3.2			1	0.5		@ 85 l/m cont.
					36	12	5	1	0						@ 150 l/m cont.
		G						220	89						Man test
CC	2.51	G	144		31	22	(8)	4							
		H			77		55	24							All charcoal
					TIME TO 99% EFFICIENCY										
G-43			34			10.5			3.5			2.5(40000)			Tube test all charcoal, cross sect. 3.14 sq.cm. 500 cc/sqcm/min. 10 cm. layer, 10-14 mesh
G-43			65			20			5		2.5	1.5			Tube test all A-25 3.4 sq.cm. 500 cc/sqcm/min. 5 cm. layer 10-14 mesh.

It will be seen that for the 32 l/m rate the life of a canister is approximately inversely proportional to the concentration, the times for the lower concentrations being for the most part a little shorter than the times at the high concentrations indicate. For all-charcoal canisters against CC and tube tests of charcoal and soda lime against G-43, there is much less variation than for the tests of standard cans, the time varying inversely as the 1/2 or a lower power of the concentration.

15. RELATION BETWEEN RATE OF FLOW AND LIFE OF STANDARD CANISTERS:

In order to facilitate the establishment of a proper standard rate of flow in testing canisters, a series of experiments was carried out to measure the rate and volume of breathing and the rate of inhalation of men, both at rest and while performing different amounts of work. For men at rest the averages of a large number of tests gave about 8 l/m for breathing rate, and 15 inhalations per minute. Tests made with subjects performing various measured amounts of work showed that for light exertion, the average breathing rate had increased to 18 l/m, but the respiration rate only to 17. At moderate exertion the values were 31 l/m and 22 inhalations per minute. The highest averages obtained for severe work, were 38 l/m and 24 inhalations per minute. The maximum individual values, observed for short periods, were 51 l/m and 37 inhalations per minute.

The rate of flow adopted for routine canister tests was 32 l/m.

Owing to the fact that canisters are used in the field by men at all stages of activity, it seemed desirable to examine canisters at various representative rates of flow. This has been done for Standard Types H and J, U.S. Army canisters, against PS and CG. The results are given below. The tests were all made at continuous flow, 50% relative humidity and room temperature.

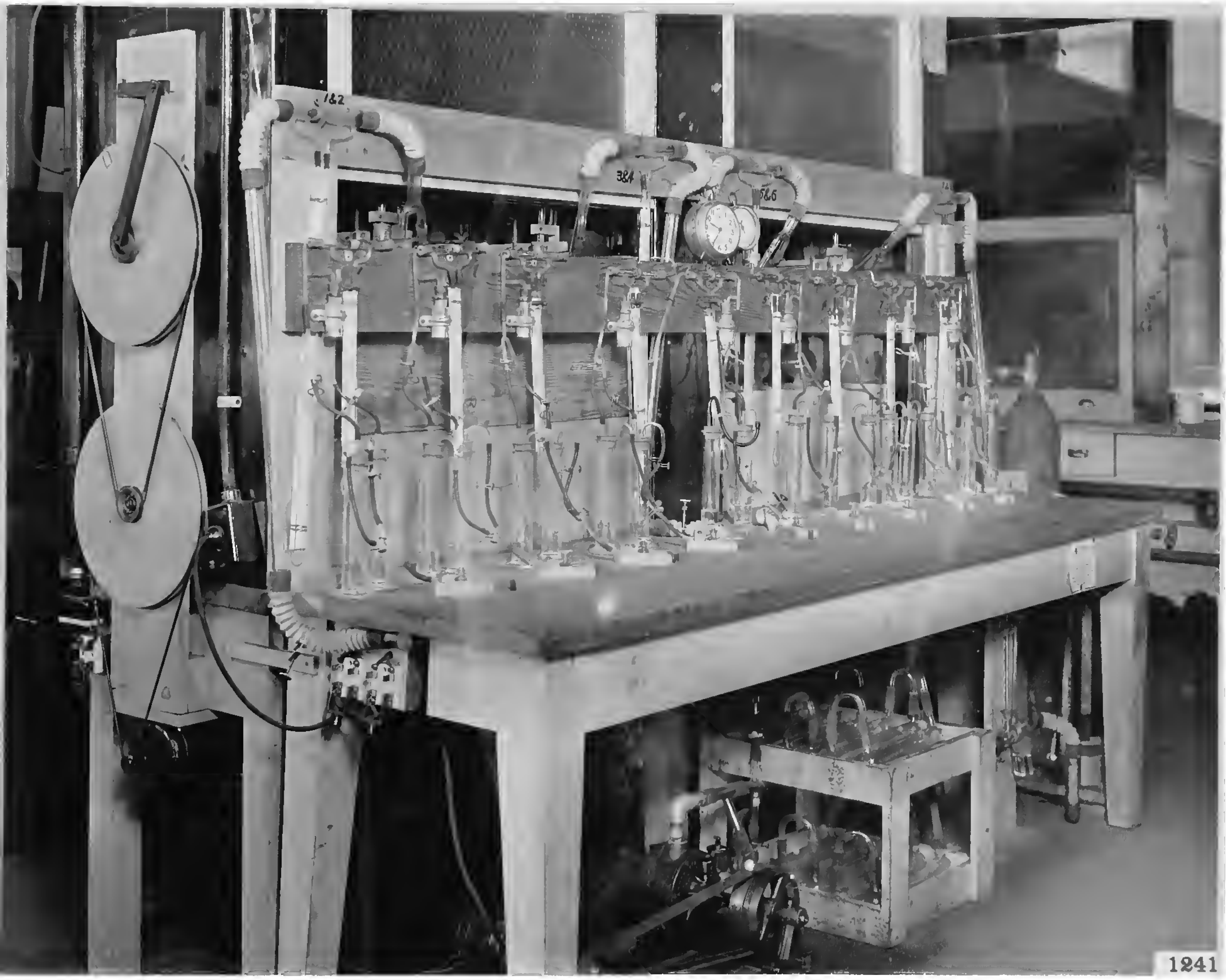
	PS (2000 ppm) Mins. to break		CG (5000 ppm) Mins. to break	
Rate l/m	Type H Can	Type J Can	Type H Can	Type J Can
8	254	128		
16	85	44		
32	33	19	47	19
85	11	5	13	6
150			7	1

The relation between rate of flow and life is not a simple one. The life is approximately inversely proportional to the 1.5 power of the rate -- it decreases much faster than the rate increases -- for the lower rates. It decreases much faster than this for the higher rates-- 85 l/m and above.

16. COMPARISON OF CONTINUOUS AND INTERMITTENT MACHINE TESTS AND MAN TESTS ON STANDARD CANISTERS:

It was appreciated rather early in the work that the establishment of factors by means of which continuous flow machine tests could be compared with man tests or converted to intermittent tests, which simulate rather closely actual use by a man, should become an important part of the work of the Canister Research Unit. Accordingly tests were run at different rates against chlorine, chlorpicrin, phosgene, hydrocyanic acid, superpalite and chlorcyanogen. The results obtained and the factors calculated are tabulated below.

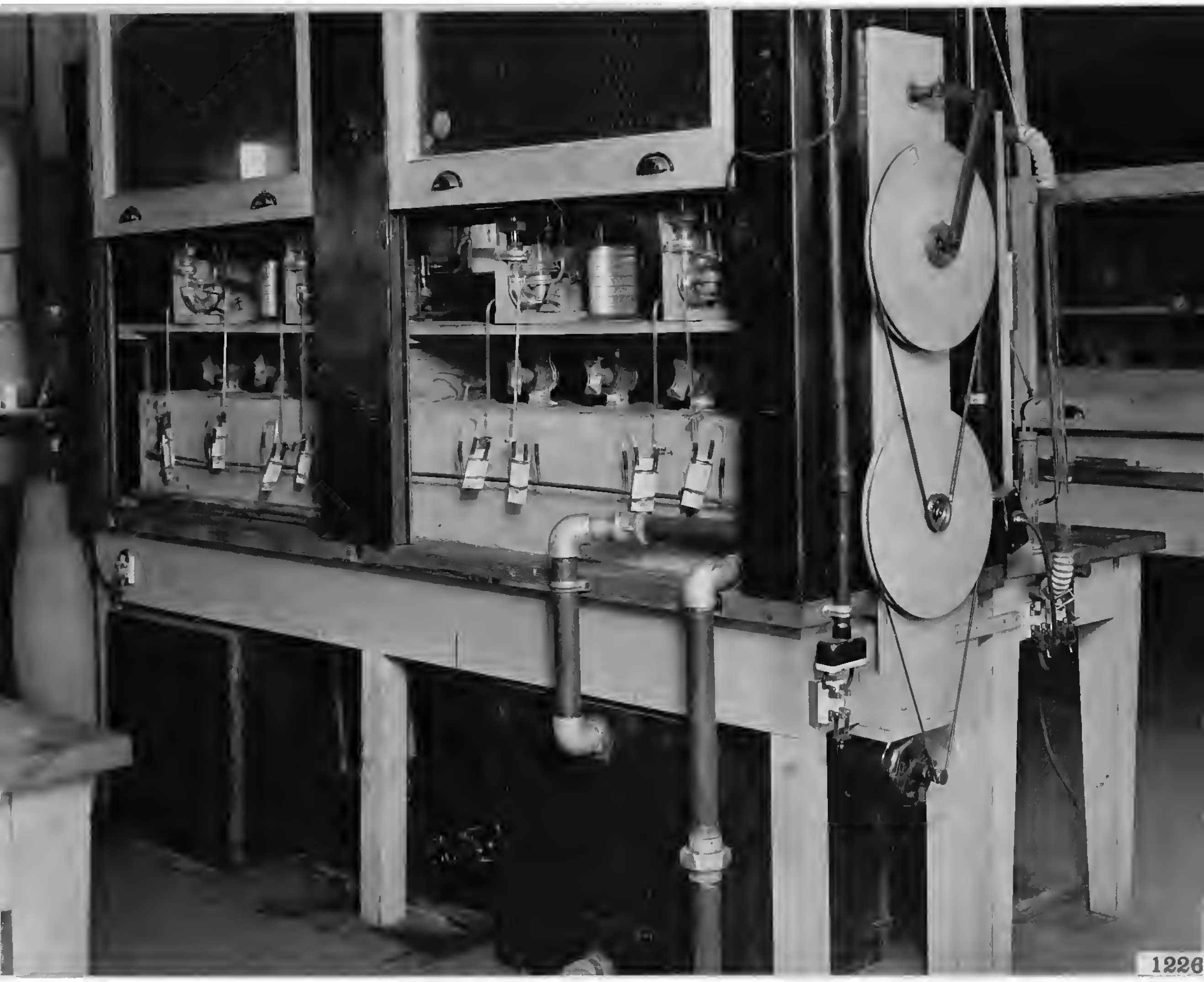
All intermittent tests were run at 20 inhalations per minute.



A NEW MULTIPLE MACHINE FOR TESTING CANISTERS

WITH INTERMITTENT FLOW

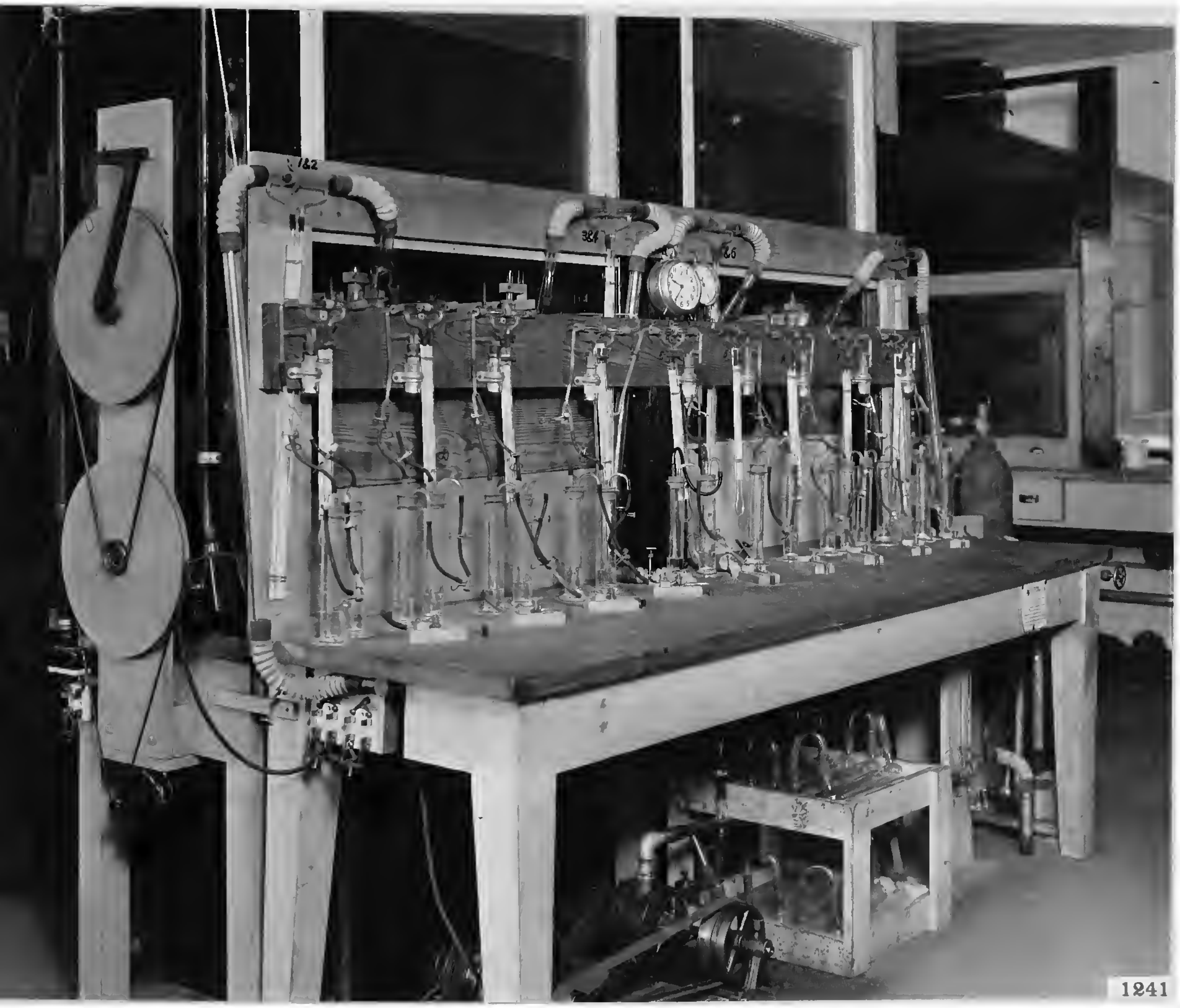
(Front View)



A NEW MULTIPLE MACHINE FOR TESTING CANISTERS

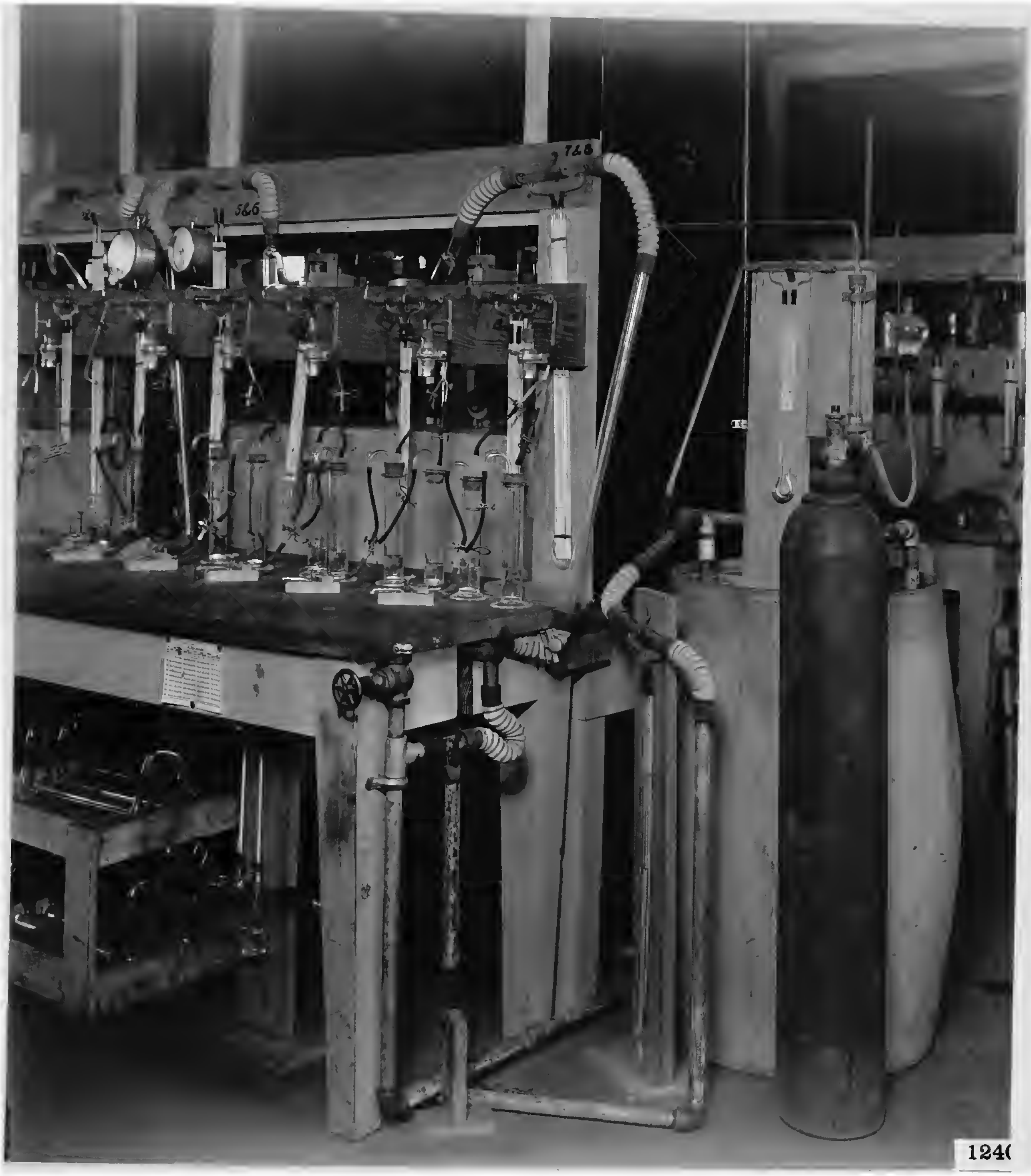
WITH INTERMITTENT FLOW

(Rear View)

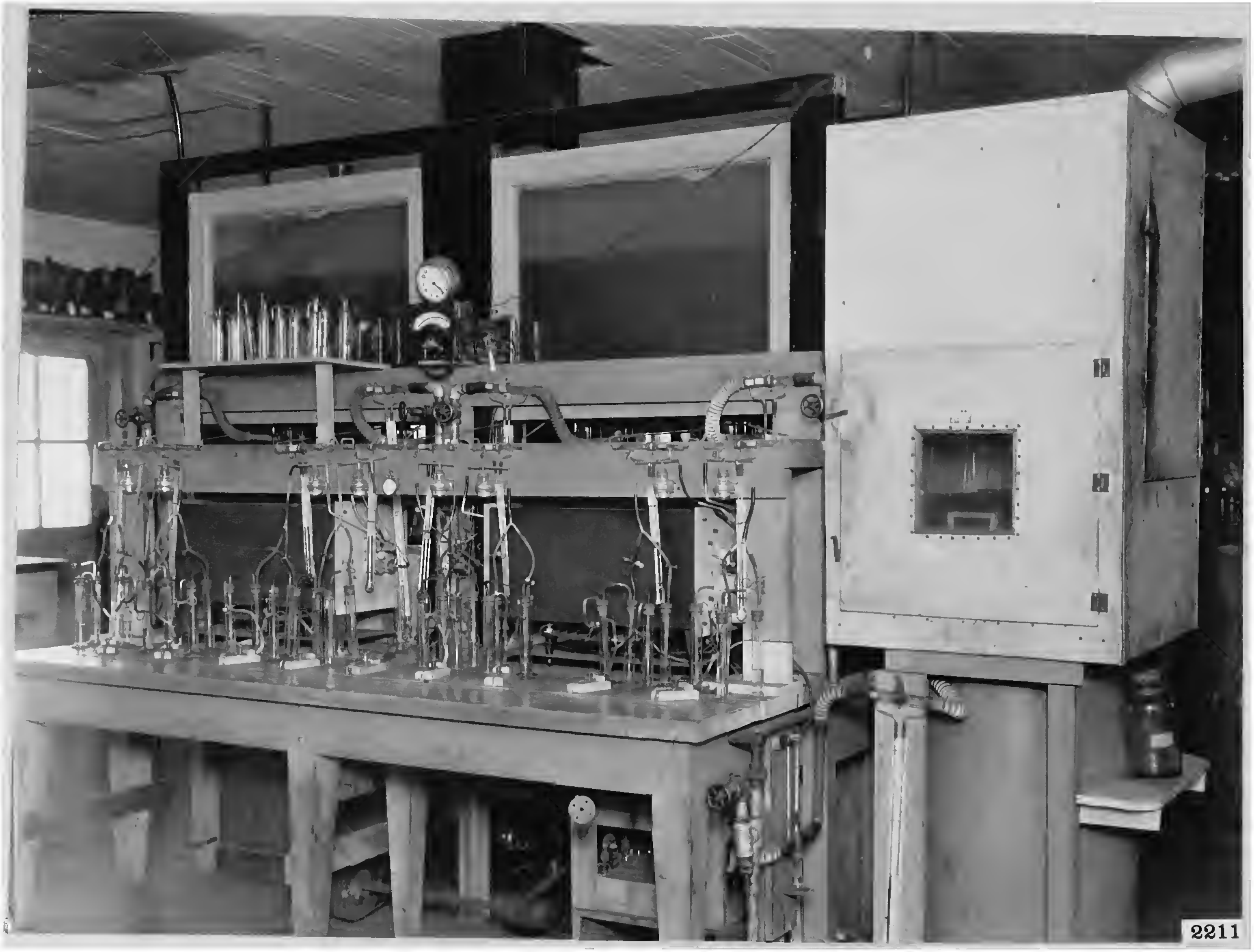


CHLORINE INTERMITTENT CANISTER TESTING MACHINE

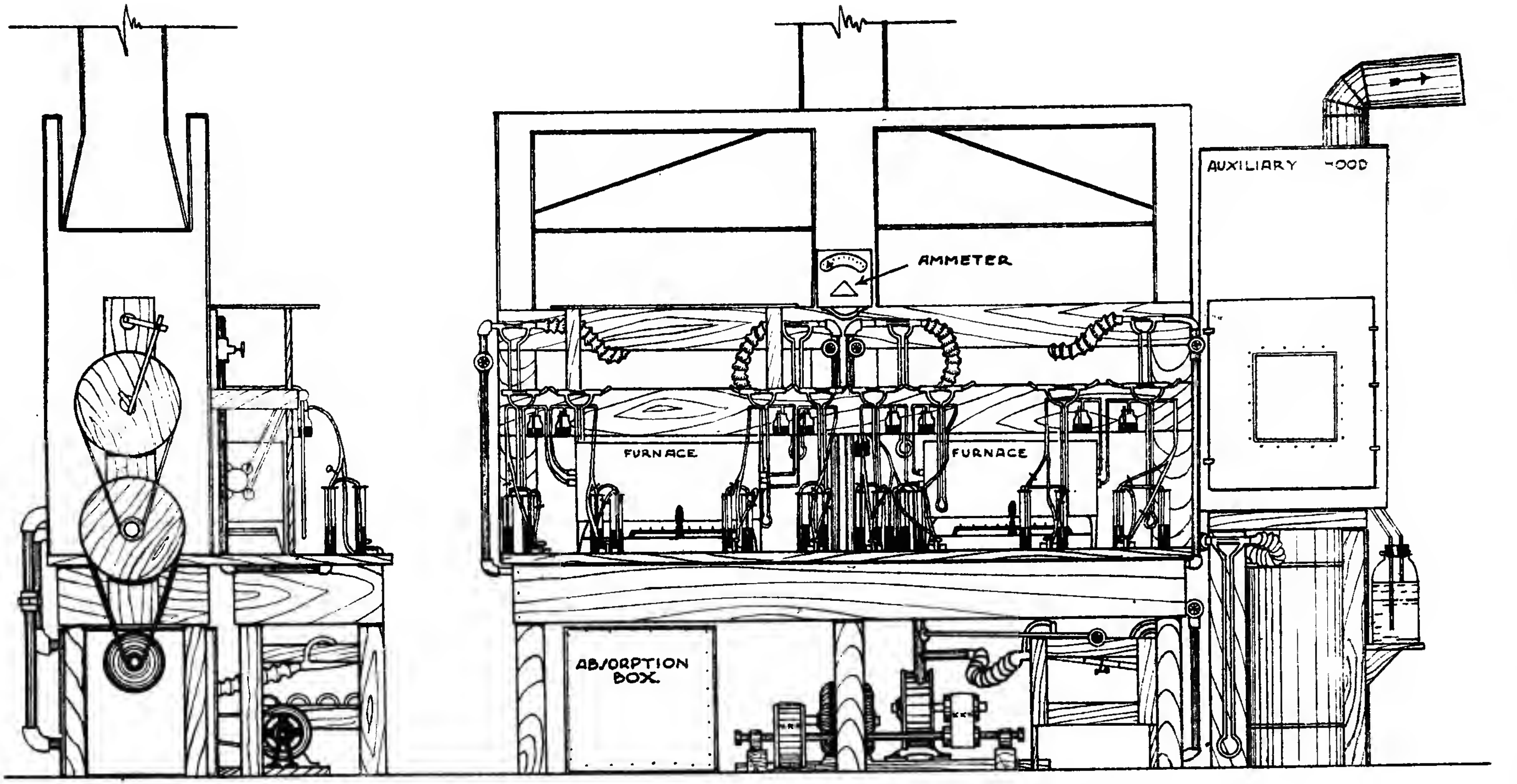
(Front View)



CHLORINE INTERMITTENT CANISTER TESTING MACHINE



A MULTIPLE MACHINE FOR TESTING CANISTERS AGAINST CHLORPICRIN.



LEFT END VIEW. FRONT VIEW.

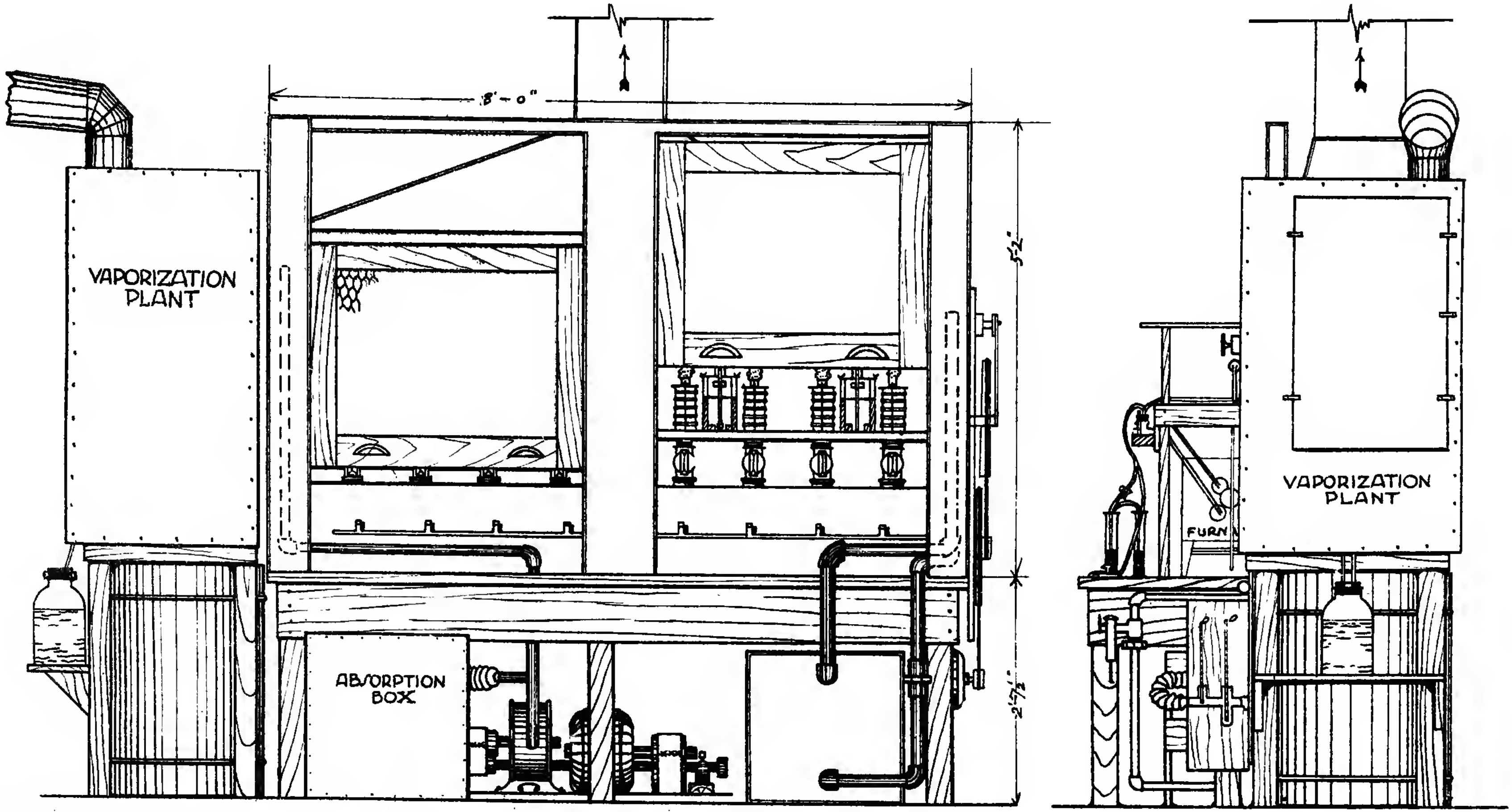
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

A MULTIPLE MACHINE FOR TESTING CANISTERS AGAINST CHLORPICRIN.

SCALE NONE	APPROVED BY [illegible]	NUMBER 1061-I
DRAWN BY PFD		
CHECKED BY C.	COUNTERSIGNED BY M. C. Teague.	
DATE 10-3-18		

PLATE 1



REAR ELEVATION.

RIGHT END VIEW.

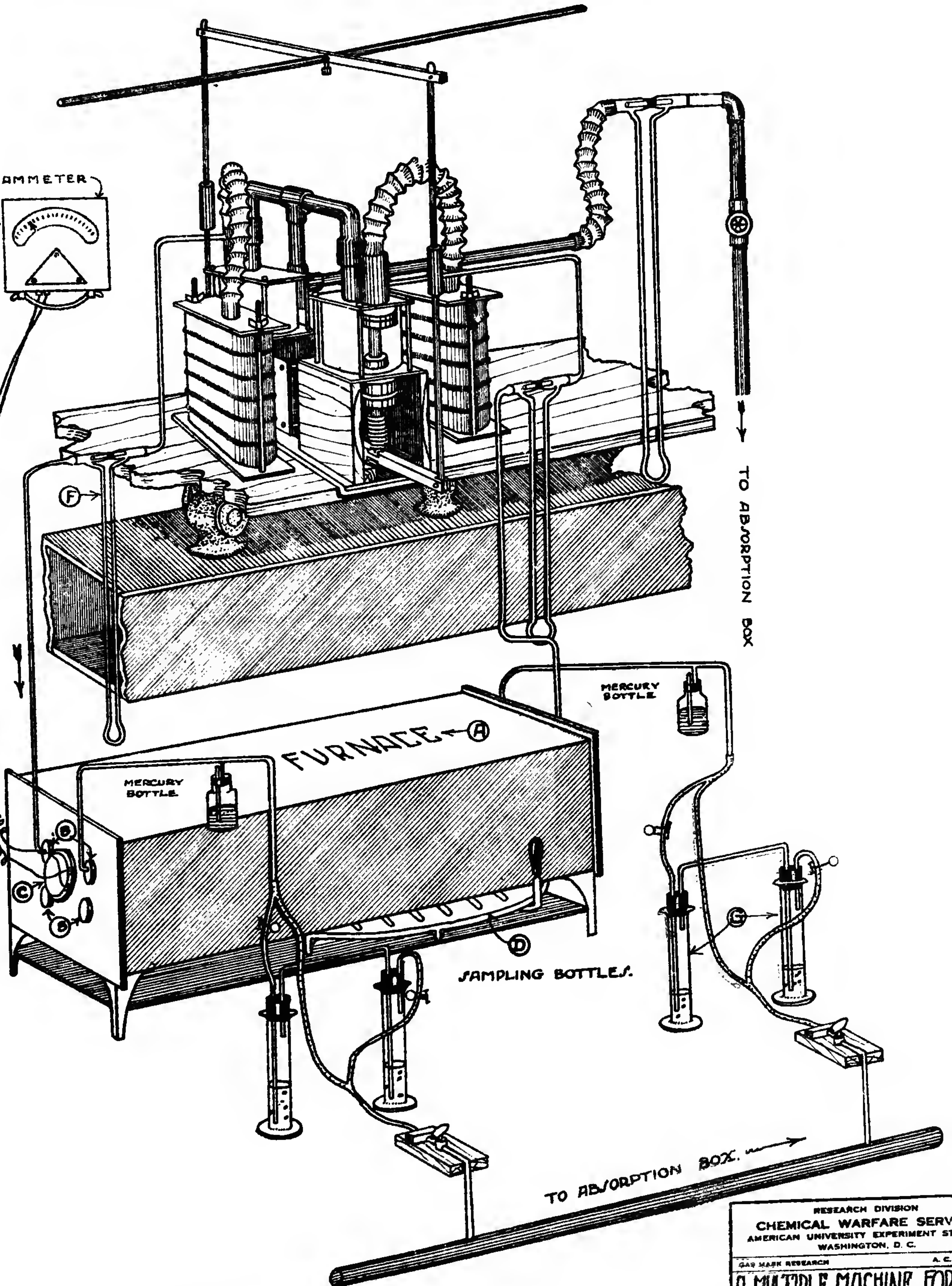
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

A MUTIPLE MACHINE FOR TESTING CANISTERS AGAINST CHLORPICRIN.

SCALE NONE	APPROVED BY W. R. Collette	NUMBER 1061-1
DRAWN BY P.F.D.		
CHECKED BY C.	COUNTERSIGNED BY M. C. Teague	
DATE 10-4-18		

PLATE 2



DETAIL OF ONE UNIT.

NO SCALE

PLATE 3

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

A MULTIPLE MACHINE FOR TESTING CANISTERS AGAINST CHLORPICRIN

SCALE NONE	APPROVED BY W. K. Collette	NUMBER 1061-I
DRAWN BY P.F.D.		
CHECKED BY C	COUNTERSIGNED BY M. C. Teague	
DATE 10-3-18		

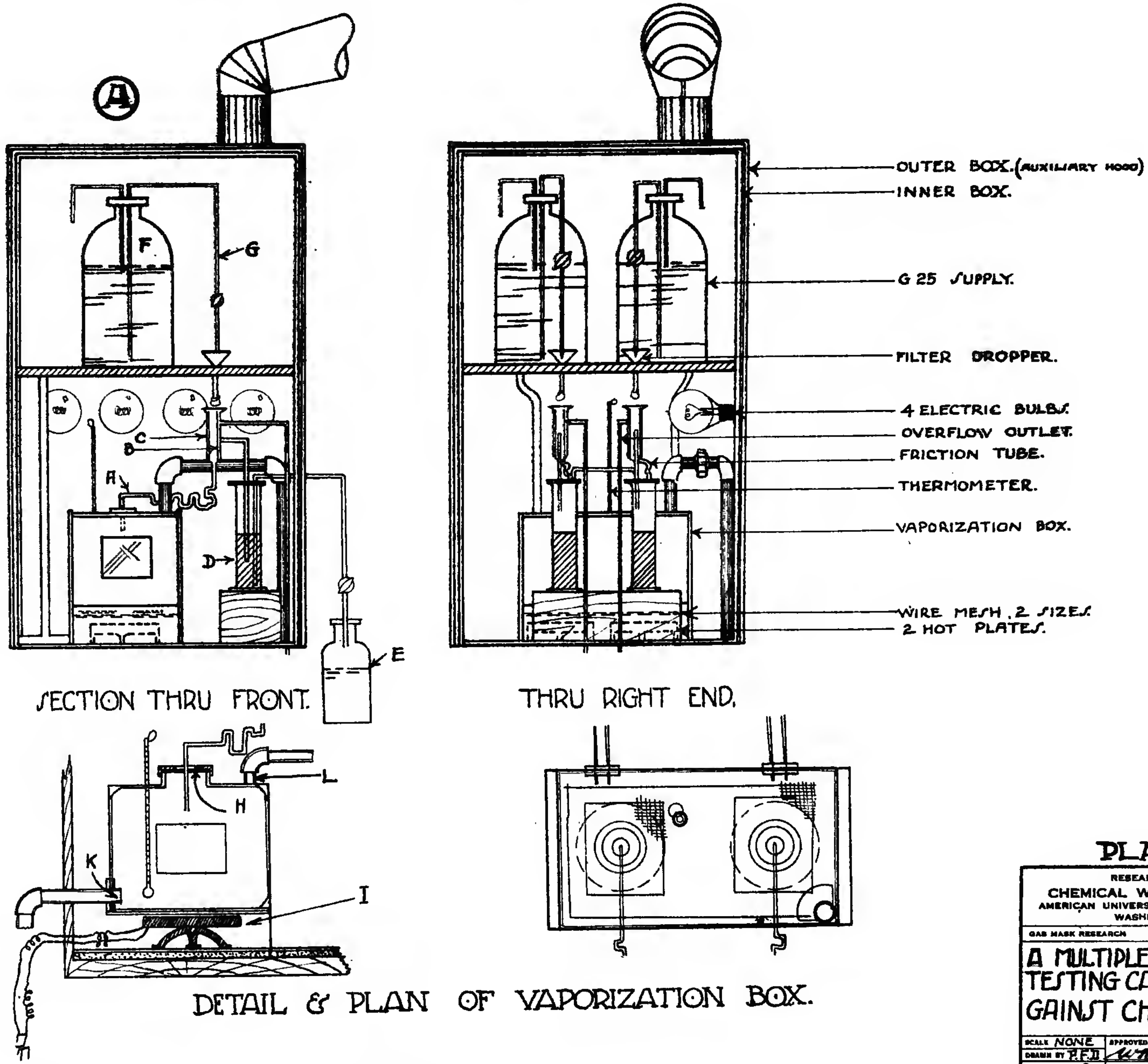


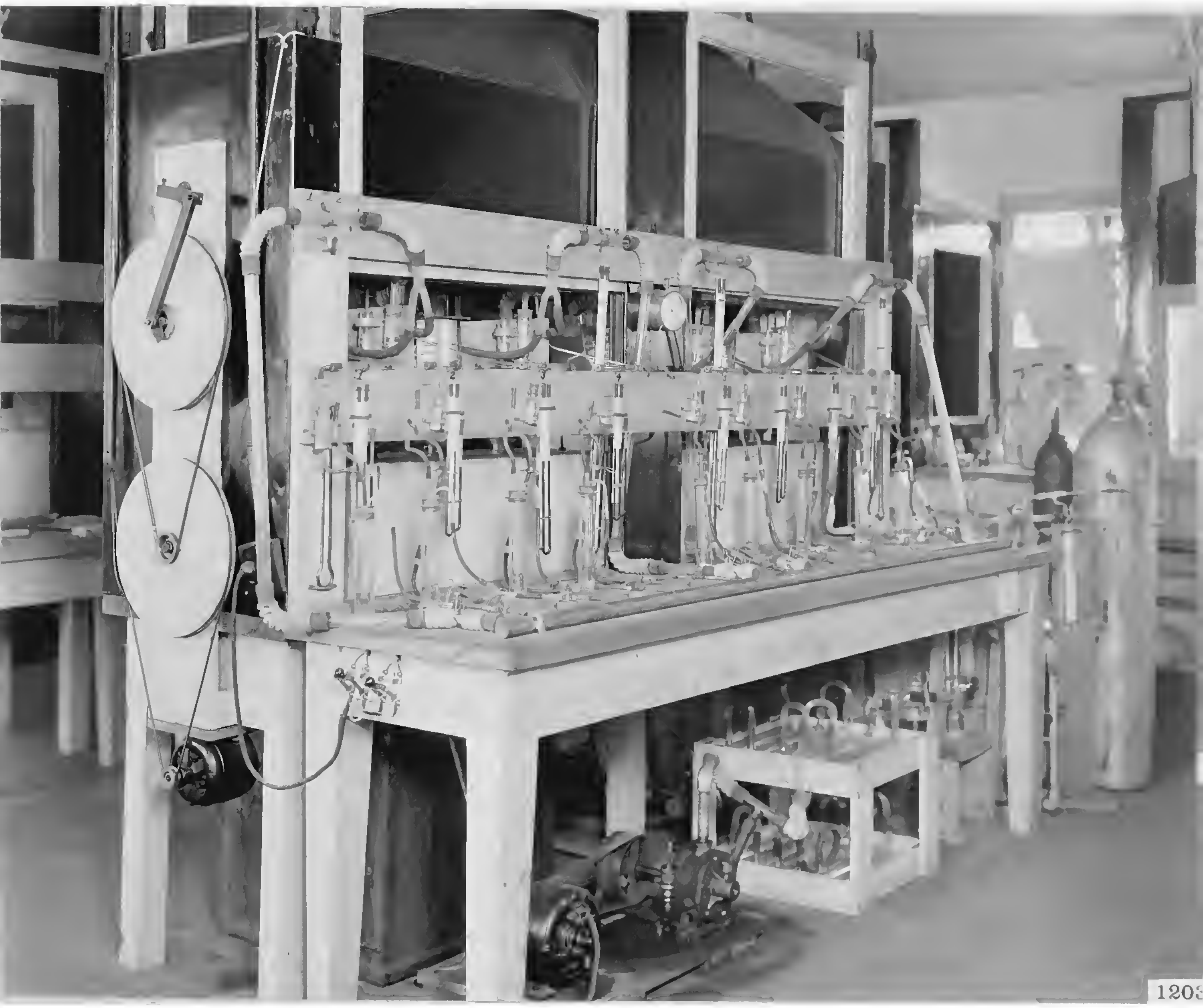
PLATE 4

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

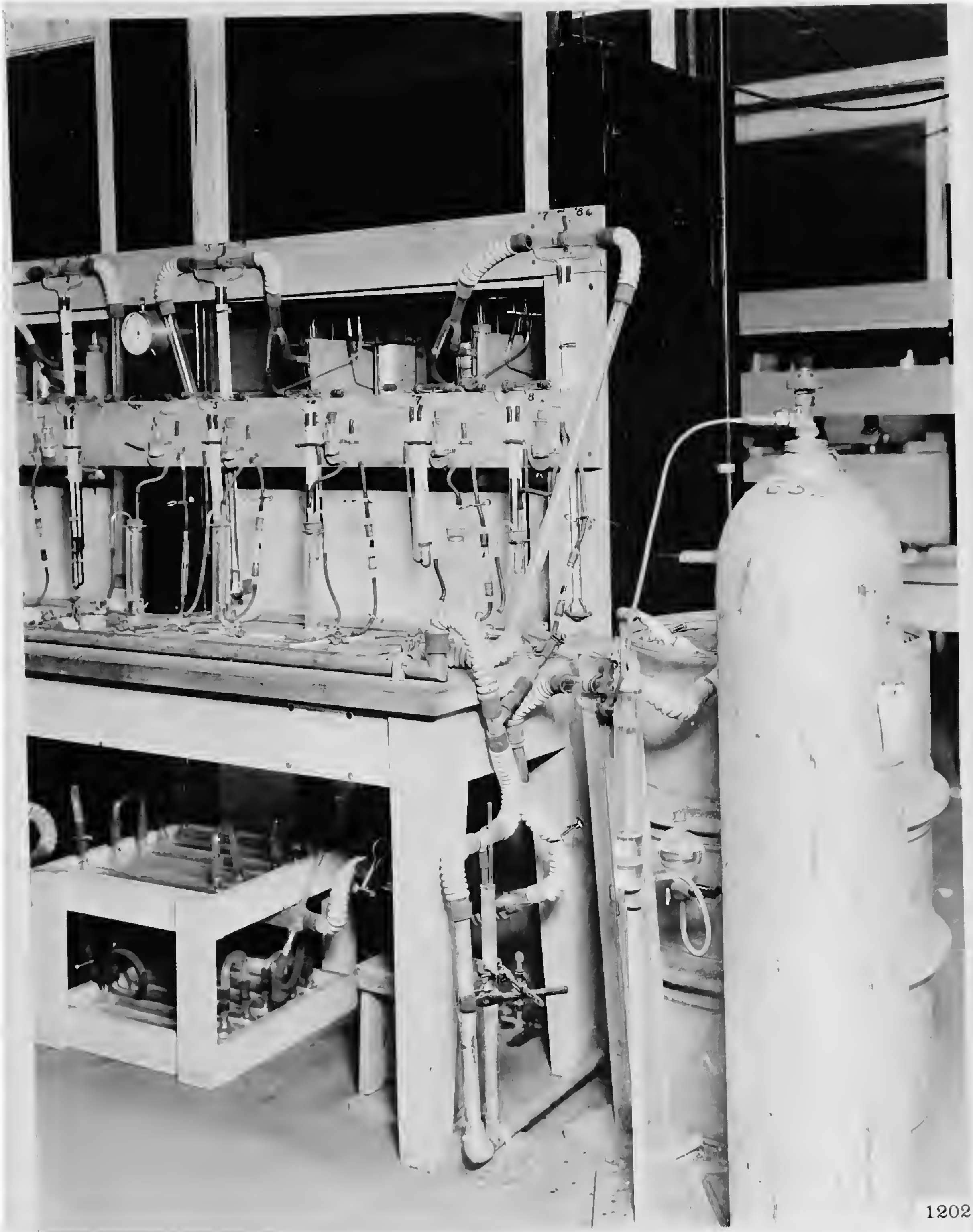
A MULTIPLE MACHINE FOR TESTING CANISTERS AGAINST CHLORPICRIN.

SCALE NONE	APPROVED BY	NUMBER
DRAWN BY P.F.D.		1061-I
CHECKED BY C.	COUNTERSIGNED BY M. C. Teague	
DATE 11-19-18		



G-52 INTERMITTENT CANISTER TESTING MACHINE

(Front View)

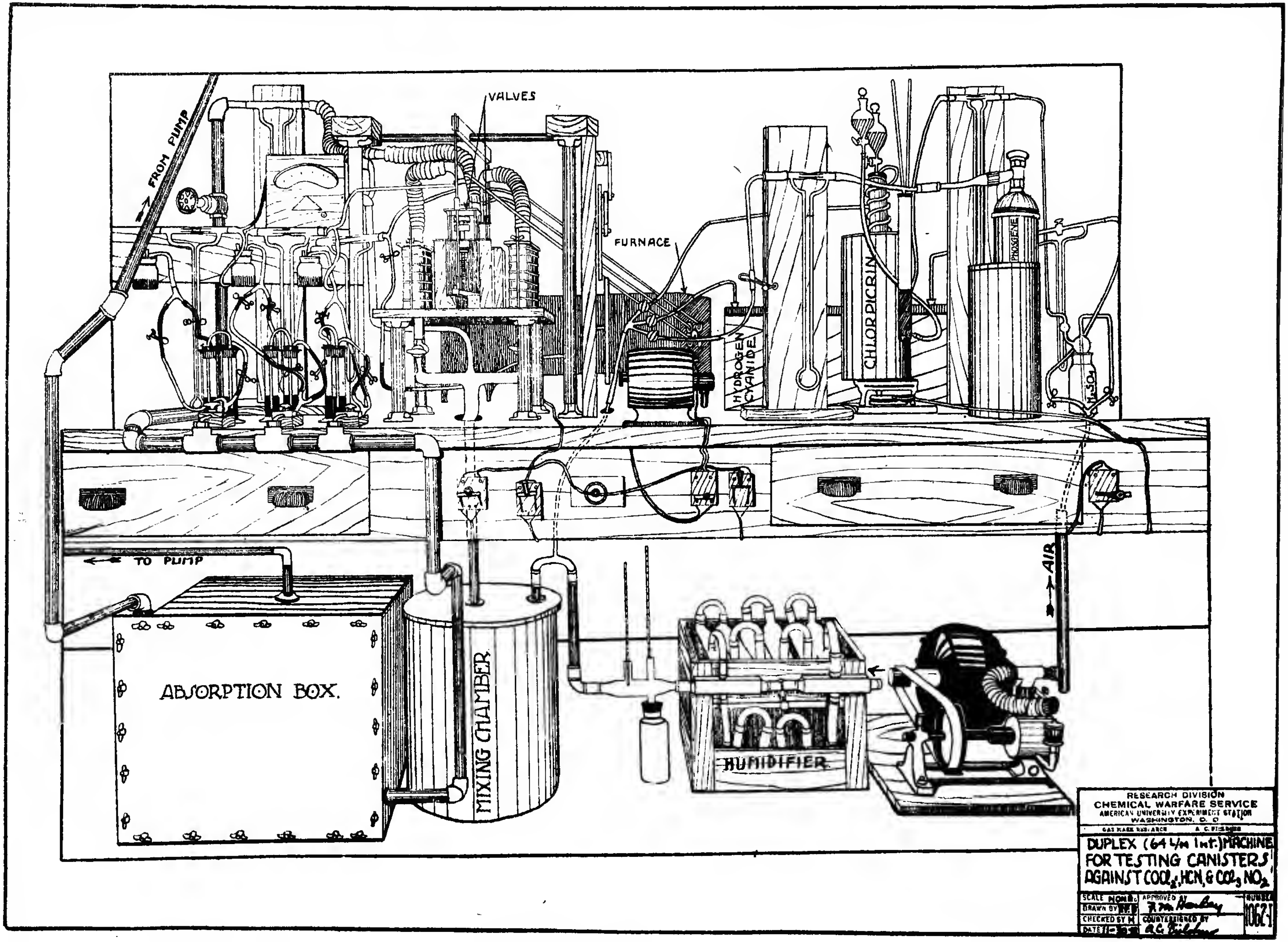


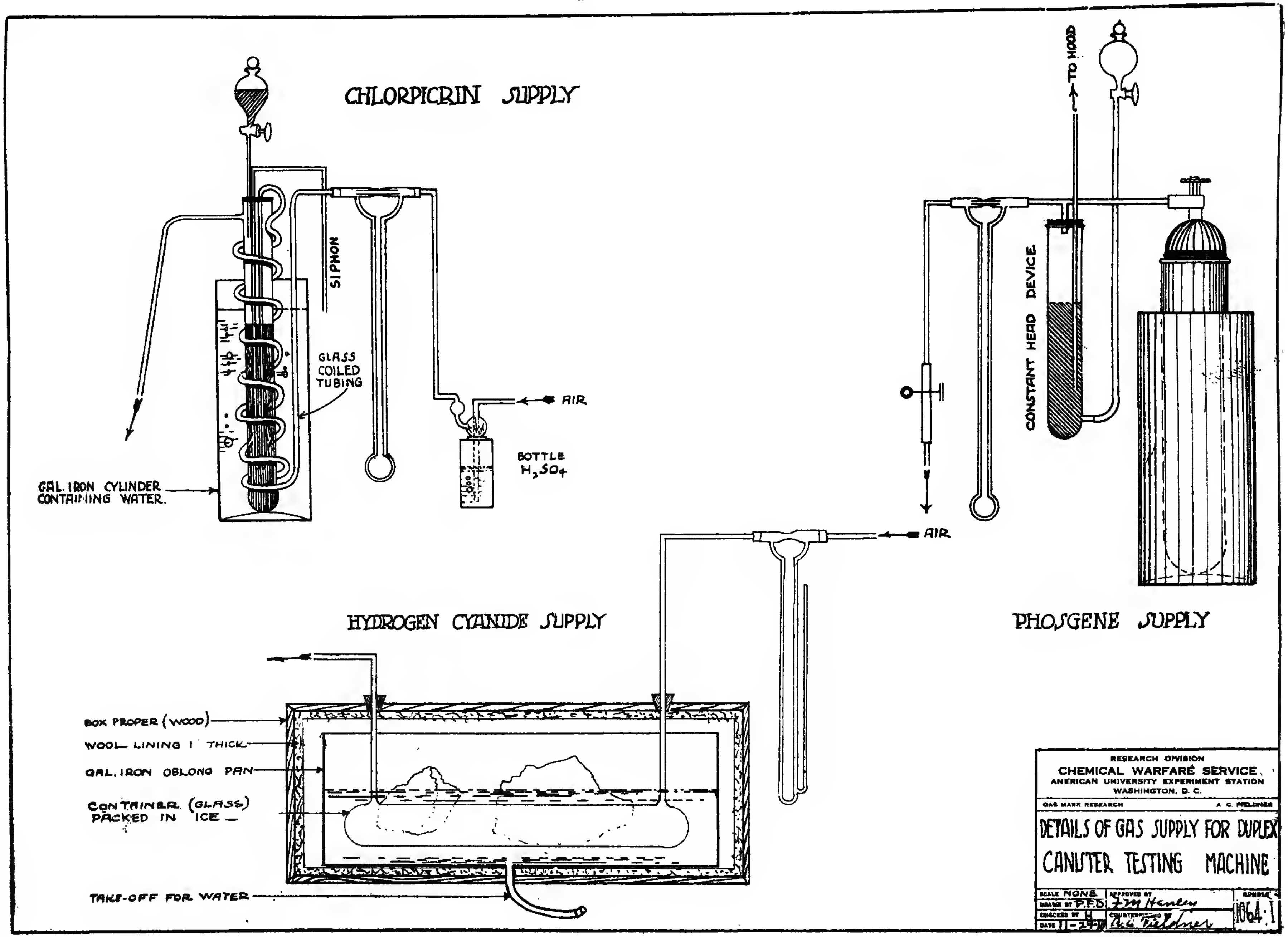
G-52 INTERMITTENT CANISTER TESTING MACHINE

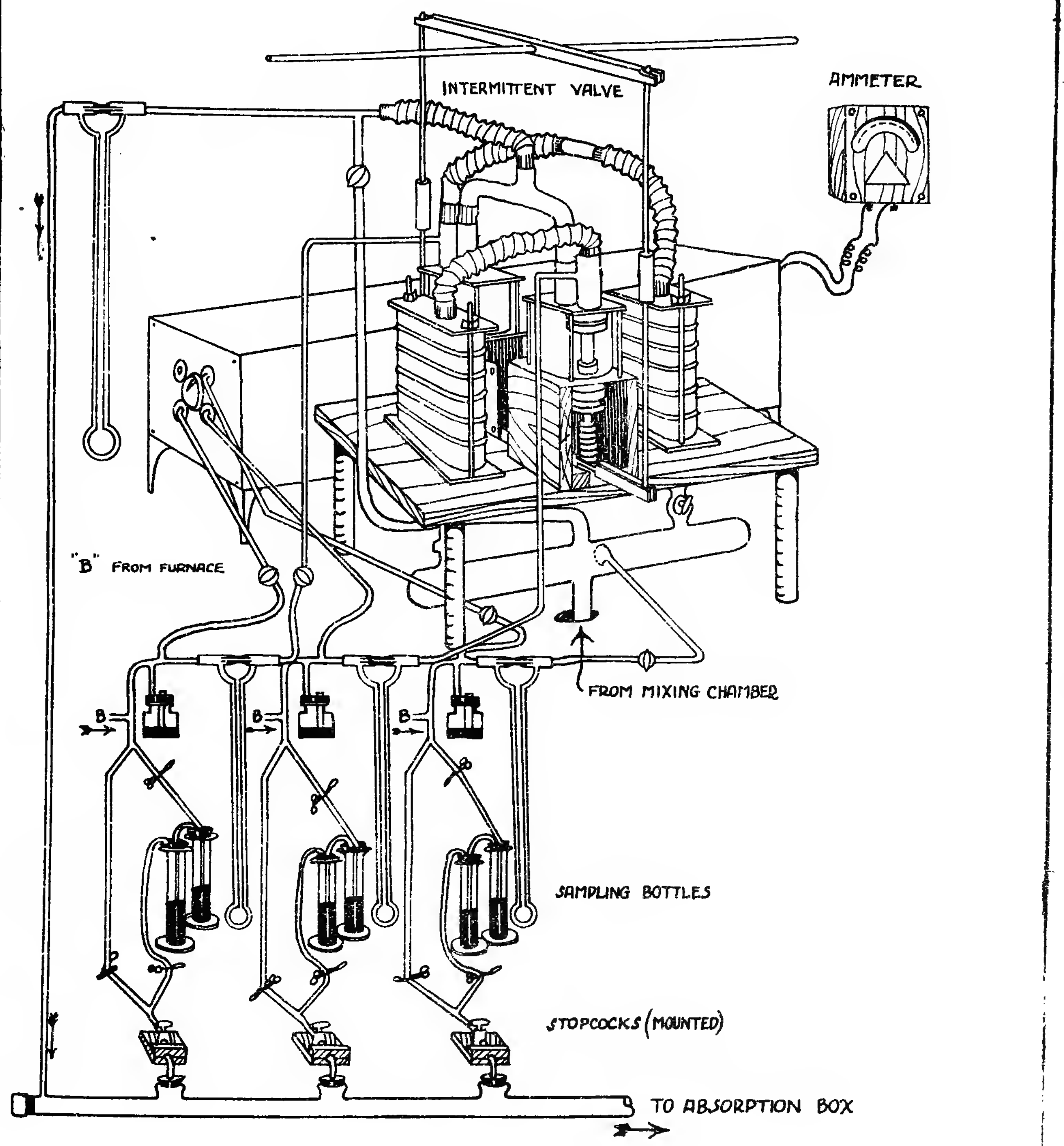
(End View)

G-52 INTERMITTENT CANISTER TESTING MACHINE

(Rear View)


FROM PUMP
VALVES
FURNACE
HYDROGEN CYANIDE
CHLORPICRIN
PHOSGENE
TO PUMP
AIR
ABSORPTION BOX.
MIXING CHAMBER
HUMIDIFIER
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
DUPLEX (64 l/m Int.) MACHINE
FOR TESTING CANISTERS
AGAINST COCl₂, HCN, & CO₂ NO₂
SCALE
DRAWN BY
CHECKED BY
DATE
APPROVED BY
COUNTERSIGNED BY
NUMBER
1062


CHLORPICRIN SUPPLY
SIPHON
GLASS COILED TUBING
AIR
BOTTLE H_2SO_4
GAL. IRON CYLINDER CONTAINING WATER.
TO HOOD
CONSTANT HEAD DEVICE
AIR
PHOSGENE SUPPLY
HYDROGEN CYANIDE SUPPLY
BOX PROPER (WOOD)
WOOL LINING 1" THICK
GAL. IRON OBLONG PAN
CONTAINER (GLASS) PACKED IN ICE
TAKE-OFF FOR WATER
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
DETAILS OF GAS SUPPLY FOR DUPLEX CANISTER TESTING MACHINE
SCALE NONE
DRAWN BY P.F.D.
CHECKED BY H
APPROVED BY
1064.1



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CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

DETAIL OF SAMPLING APPARATUS OF DUPLEX CANISTER TESTING MACHINE.

SCALE NONE
DRAWN BY P.R.D.
CHECKED BY H
DATE 11-30
APPROVED BY F. M. Hawley
A. C. Fieldner

1063-I

					Time at 100% Efficiency : Rate 1/m										
					8.5				16				32		
Gas	Type Cans	Conc. p.p.m.	Conc. mg/1	Man	Cont	Int	Int/Cont	Int/32Int	Cont	Int	Int/Cont	Int/32Int	Cont	Int	Int./Cont
PŚ	BHP	4000	26.8	249		211		5.02		99		2.35	54	42	1.23
	FHP	4000	26.8	75					34	45	1.32	2.64	13	17	1.3
G28	13$HH	5000			8 1/m Int.	279		6.8					43	41	0.95
G43	172HH	1000	1.1										43	46	1.07
	Navy	100	0.11										13	14	1.07
G49	GHPC 18Y	2000	16.18			448		7.85		253		4.43	52	57	1.09
							8								
CG	GHPC$Y	5000	20.2		266	271	1.14	5.76	104	117	1.12	2.48	42	47	1.11
CG	HHFD 19Y			297		257		5.47						47	
CC	H	500	1.26										51	51	1.

The effect of varying the inhalation is shown by the results given below:

Against PS:

Rate - 85 l/m intermittent Concentration - 4000 p.p.m. Type B Canisters	Oscilla-tions per minute	Minutes at 100%
	20	211
	15	231

Against CG:

Rate - 32 l/m intermittent	36	46
Concentration - 5000 p.p.m.	27	39
Type H Canisters	9	31

Since the intermittent tests indicate that periods of rest between exposure to gas-air have an appreciable effect on the life of the canister, it was thought worth while to determine if a single relatively long rest period between exposures to gas-air, such as a canister would surely experience in field use, would lead to any change in the total life of the canister.

Standard Type H canisters were run for a period equal to 1/3 or 2/3 of the normal life, allowed to stand stoppered for periods of three hours up to 14 days, and then run to 90% efficiency. Tests were made against both PS and CG. The sum of the times of the preliminary period and the time at 100% efficiency on the final run was compared to the life of the control canisters.

Against PS, the rest periods resulted in no appreciable change in life. The tests were made at 32 l/m continuous and 2500 p.p.m. The controls ran 34 minutes at 100% efficiency while the total life of the canisters with 1/3 of normal life before the rest period was 33 to 36 minutes and that of the canisters run 2/3 of normal life prior to rest period was 32 to 34 minutes for all rest periods, the variation being accidental.

Against CG, the tests with 3 hour rest periods showed no change, but indicated that the life was increasing regularly for longer initial exposures and rest periods. The greatest increase was in the canisters run 2/3 of normal life and allowed to stand 14 days. These ran 35% longer than the controls.

The tests were run at 32 l/m continuous and 5000 p.p.m.

TOTAL LIFE--MINUTES

	Rest period	3 hrs.	1day	3days	7days	14 days
Run 1/3 of	Normal life	45	49	49	50	49
" 2/3 of	Normal life	46	53	52	56	60

Controls - 45 minutes life.

These results seem to contradict the intermittent tests especially when the doubled rate of flow in intermittent tests during exposures is taken into consideration. No satisfactory explanation of this apparent discrepancy has been made.

17. STANDARD CANISTER FILLING AND DESIGN:

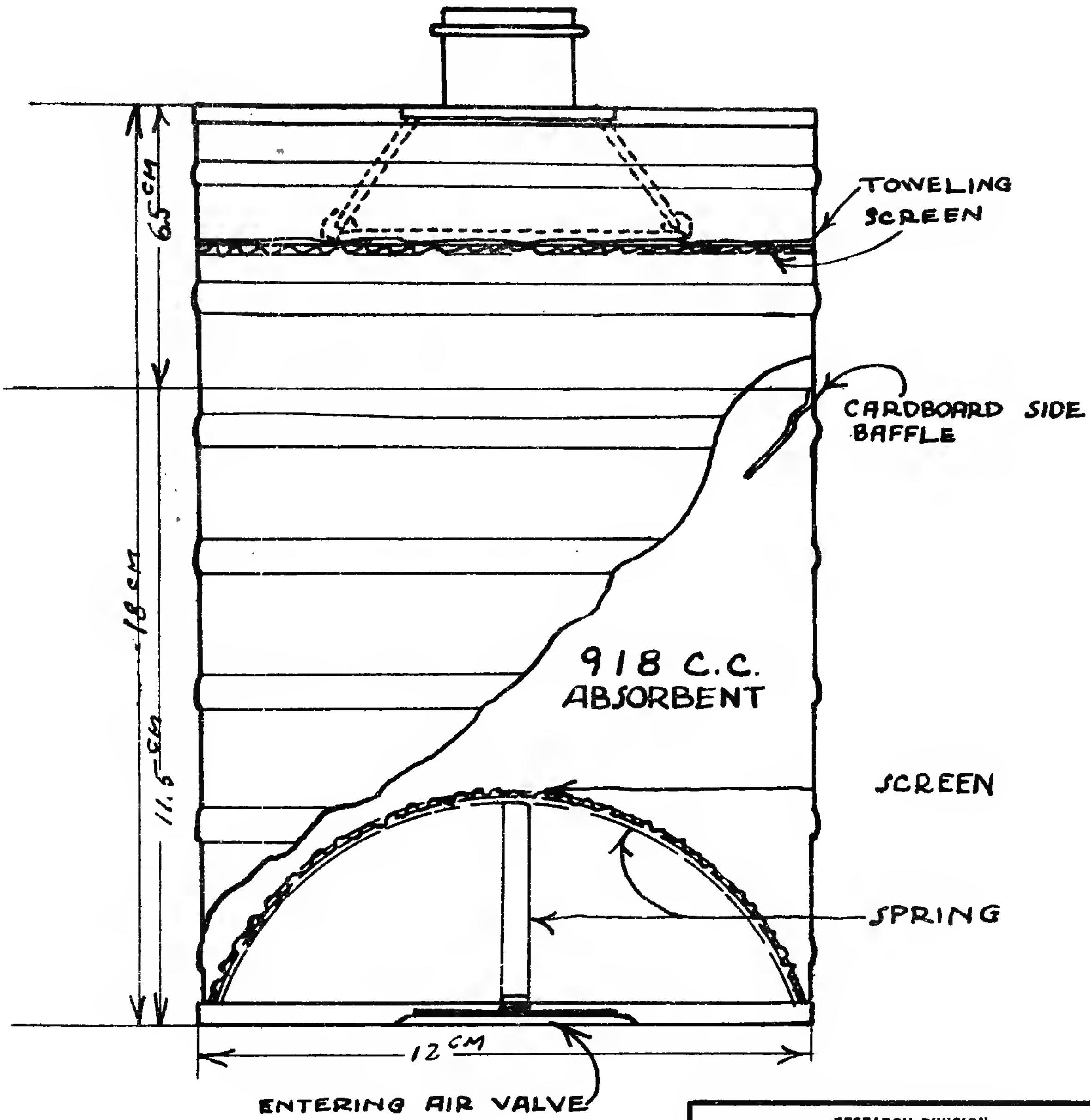
The development of the canister has been along two general lines, viz: decrease in volume as better absorbents were obtained, and reduction of resistance to breathing. A brief description of the various canisters, together with a complete summary of the protection afforded against toxic gases will be found in Table II of the appendix to this report.

The absorbents used in filling the first canisters consisted of wood charcoal and a high caustic green soda lime developed by the Bureau of Mines and the General Chemical Company of Easton, Pa. The first gases to be dealt with were chlorine, phosgene, and hydrocyanic acid. Early experiments showed that with 56 cu. in. of absorbent, 2/5 soda lime was the minimum amount that could be used and still furnish the required protection against the then known war gases. Since charcoal absorbs most gases to a considerable extent it was desired to have as much charcoal in the canister as possible to furnish some protection at least against any surprise gas the enemy might use. Therefore, it was decided to use 2/5 soda lime and 3/5 charcoal by volume, and this proportion has been used in all types of canisters to the present. Tests conducted during the early part of 1918 by the Canister Research Unit confirmed this proportion as giving the best protection, considering all war gases. Tests by the Man Test Unit showed that a 60% soda lime mixture gave a slightly longer life against phosgene, but the advantage was not considered sufficient to recommend a change as it was desirable to have as much charcoal as possible for protection against

chloropicrin and other possible gases. The 60-40 mixture of charcoal and soda lime has, therefore, been adopted as the standard proportion.

The first change in filling canisters was to mix the charcoal and soda lime together instead of separating them in layers. Early experiments by this section proved that the protection afforded by a mixture was equal to that of layers. From a productive standpoint the mixture was easier to handle and was adopted. Later the British confirmed these results and just recently a series of experiments have been conducted by the Canister Filling Unit confirming them. Several combinations of layers of absorbents were tested against the three standard gases, phosgene, hydrocyanic acid and chloropicrin. The following conclusions were drawn: (1) The mixture of charcoal and soda lime is better than any combination of layers of the two for filling canisters which are to be used against all gases. (2) The mixture is far superior to any combination of layers against phosgene and the same protection is afforded whether phosgene enters charcoal first and then soda lime or whether it enters soda lime and then charcoal, (3) The best combination to use against hydrocyanic acid is charcoal in the bottom of the canister and the soda lime on top, (4) The best combination to use against chloropicrin is soda lime in the bottom of the canister and charcoal on top.

In Types B and C canister a side ring paper baffle was placed to prevent channeling of the gases up the sides of the canister. The work which lead to this change was done by Withrow and Young at Ohio State University. The canisters were filled with Easton green soda lime and gassed with chlorine at 120 l/m. continuous flow. The course of the gas was shown by the color change of the soda lime which came in contact with the chlorine. At this rate of flow the gases channeled up the sides. Later, considerable work on channeling was done by the Canister Filling Unit with several types of canisters and at several rates of flow. In these experiments the canisters were filled with pink soda lime and gassed with hydrogen sulphide to obtain the course of the gas through the canister. It was soon proven that at the rates of flow to which the canisters would be subjected, 8 l/m to 32 l/m, the dome in the bottom of the canister was sufficient to direct the gases through the center. So in later fillings the baffles were omitted and still later the dome in the bottom was lowered. A few general conclusions which can be drawn from the channeling or "wave front" experiments are given here:

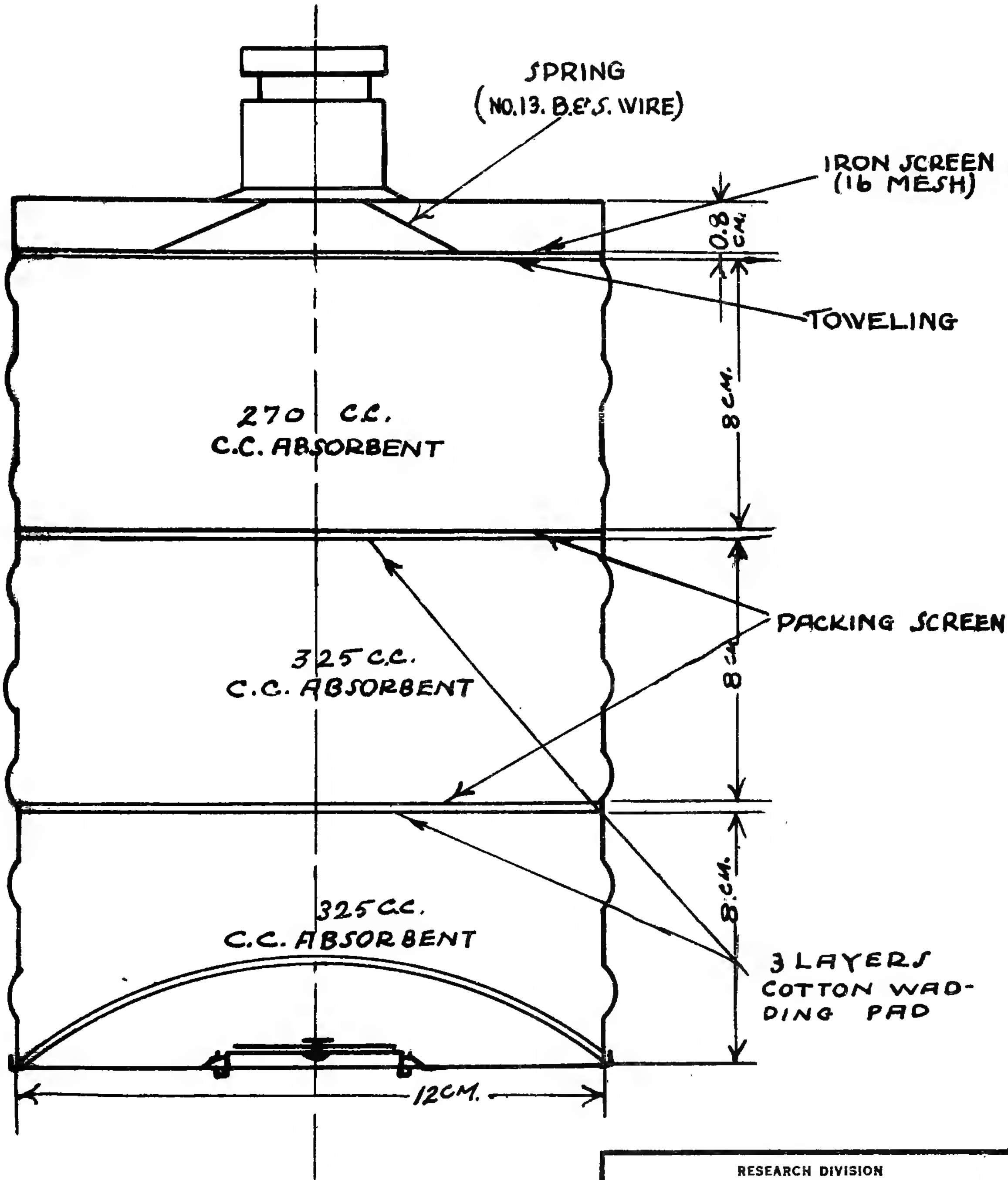


RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

STANDARD TYPE B U. S. ARMY CANISTER.
TYPE C THE SAME.

SCALE 3/4"=1"	APPROVED BY J.H. Yoe	NUMBER 314-A
DRAWN BY D		
CHECKED BY RNP	COUNTERSIGNED BY M.C. Teague	
DATE 11-26-18		



RESEARCH DIVISION

CHEMICAL WARFARE SERVICE

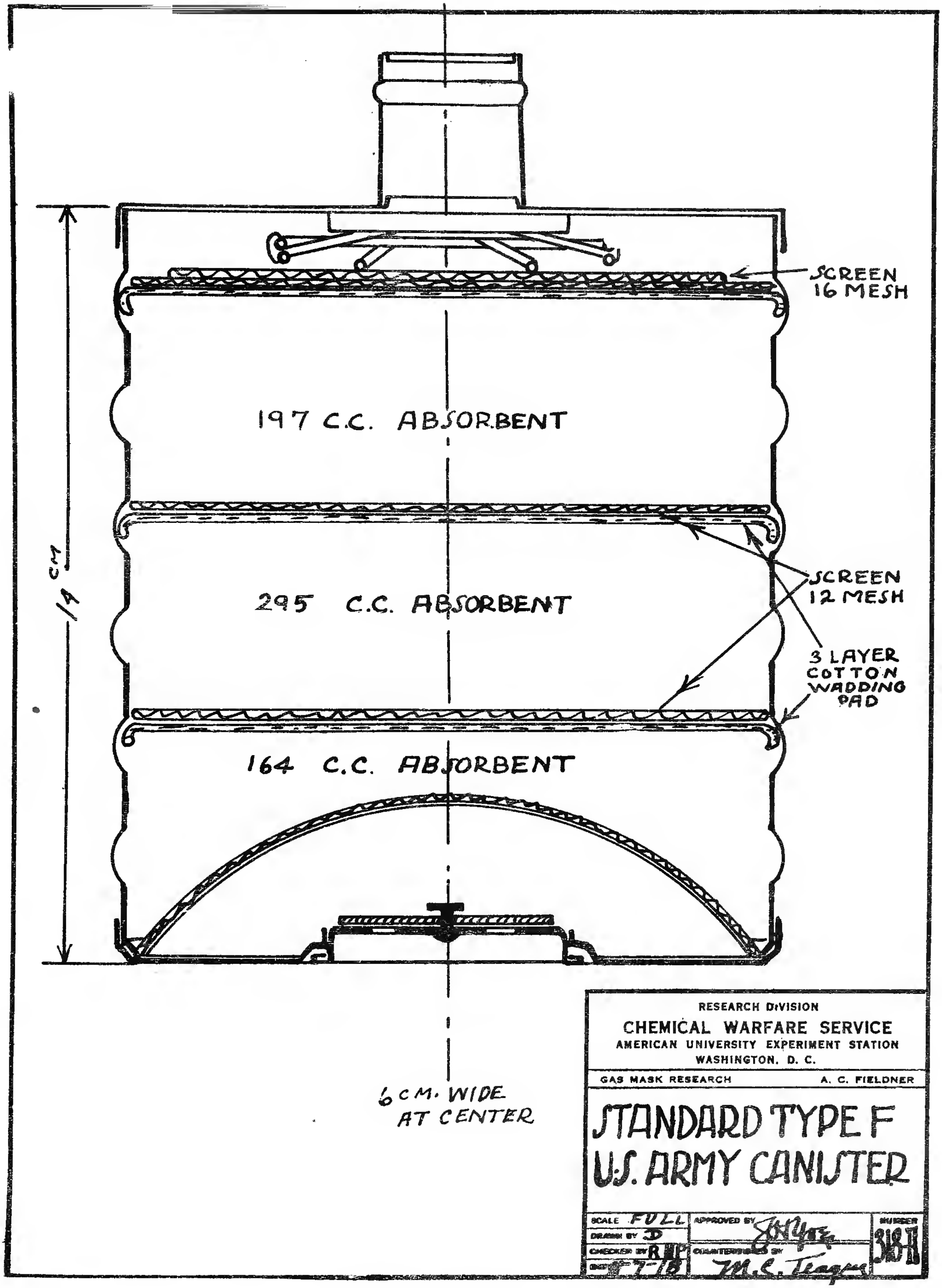
AMERICAN UNIVERSITY EXPERIMENT STATION

WASHINGTON, D. C.

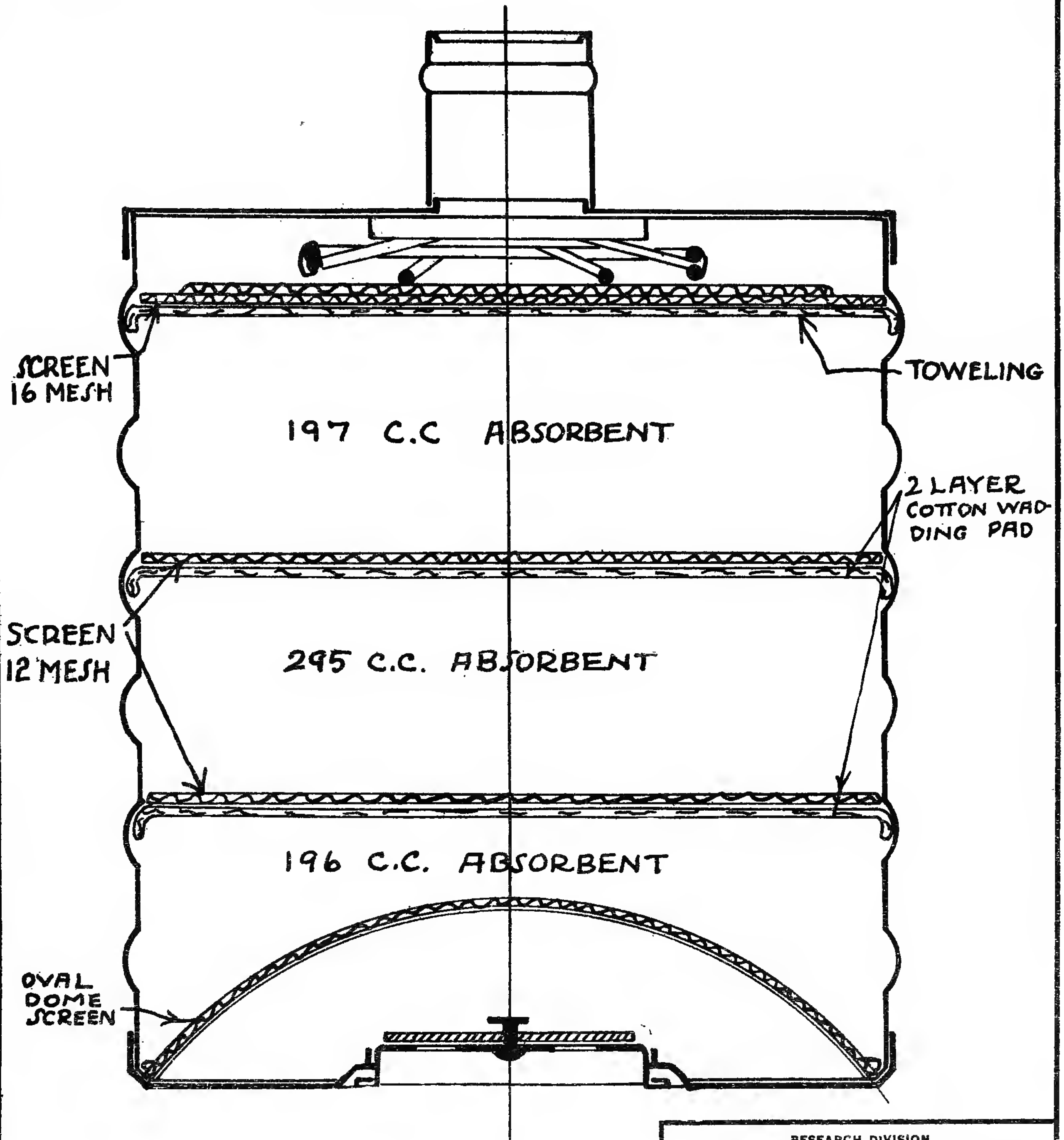
GAS MASK RESEARCH — A. C. FIELDNER

STANDARD TYPE D U.S. ARMY CANISTER

SCALE ½ = 1	APPROVED BY J.H. Yoe	NUMBER 312-A
DRAWN BY P.F.D		
CHECKED BY RNP	COUNTERSIGNED BY M.C. Teague	
DATE 11-9-18		



SCREEN
16 MESH
197 C.C. ABSORBENT
14 CM
SCREEN
12 MESH
295 C.C. ABSORBENT
3 LAYER
COTTON
WADDING
PAD
164 C.C. ABSORBENT
6 CM. WIDE
AT CENTER
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
STANDARD TYPE F
U.S. ARMY CANISTER
SCALE FULL
DRAWN BY
CHECKED BY
APPROVED BY
COUNTERSIGNED BY
M. C. Teague
NUMBER



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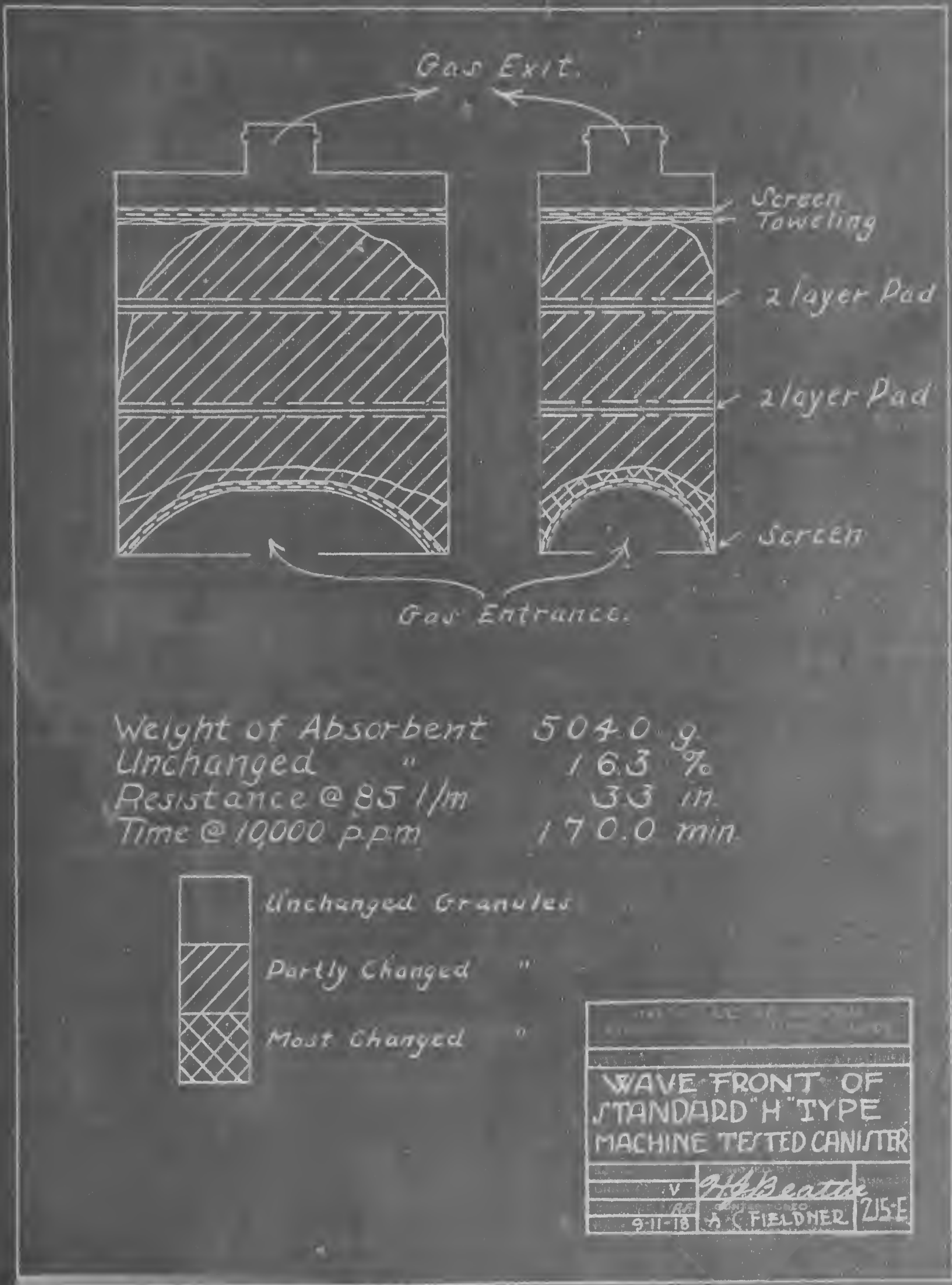
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C

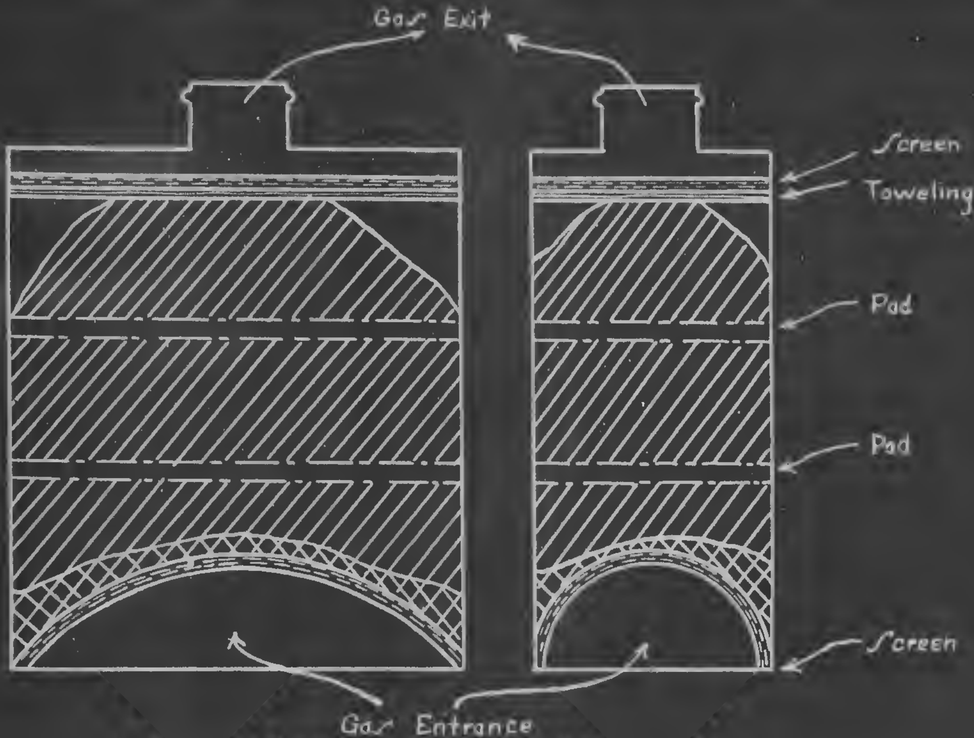
GAS MASK RESEARCH — A. C. FIELDNER

STANDARD TYPE G&H U.S. ARMY CANISTER

SCALE FULL DRAWN BY D CHECKED BY RNP DATE 11-26-18	APPROVED BY [signature] COUNTERSIGNED BY M. C. Teague	NUMBER 316-A

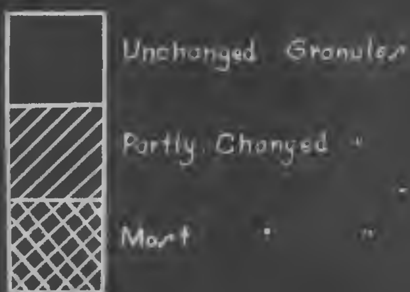


Gas Exit.
Screen
Toweling
2 layer Pad
2 layer Pad
Screen
Gas Entrance.
Weight of Absorbent 504.0 g.
Unchanged " 16.3 %
Resistance @ 85 l/m 3.3 in.
Time @ 10,000 p.p.m. 170.0 min.
Unchanged Granules
Partly Changed "
Most Changed "
WAVE FRONT OF STANDARD "H" TYPE MACHINE TESTED CANISTER
V
RF
9-11-18
A C FIELDNER
215-E



Standard Canister

Weight of Absorbents	517.0	g.
Unchanged "	13.7	%
Resistance @ 85 L/M	4.07	m.
Time @ 10,000 p.p.m.	155.0	min.



BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH A. C. FIELDNER

WAVE FRONT OF STANDARD H TYPE CANISTER-MAN TEST

SCALE 1/2" = 1"
DRAWN BY J.P.
CHECKED BY R.F.
DATE 8-17-18
APPROVED BY [signature]
COUNTERSIGNED A.C. FIELDNER
NUMBER 174-D

1. There is less tendency for a gas to channel up the sides of canisters at lower rates of flow than at higher rates.

2. There is less tendency for a gas to channel up the sides of canisters at intermittent flow than at continuous flow.

3. The manipulation used in packing canisters is an important factor in channeling as it influences the course of the gas materially.

In connection with the work from which the last conclusion above was drawn an improved method of packing was developed. The original method of packing experimental canisters was to pour the absorbents into the canisters and then tamp them down with a wood block. This method packs the center harder than the sides and causes the gas to channel up the sides. The improved method consists in filling the canister with the absorbents, then inserting the top screen and springs. The canister with the spring pressure applied on the absorbents is then jolted on a machine designed to give the canister a 1 inch drop at a rate of 150 drops a minute. This method settles the absorbents evenly and decreases irregular channeling to a great extent. With the latest type of canister, the central breathing tube type, it is absolutely necessary to jolt the canister with the spring pressure applied in order to avoid channeling.

When gas warfare developed from wave or cylinder attacks to shell attacks the gas mask was called upon to furnish protection against smokes such as $SnCl_4$, $SiCl_4$, $TiCl_4$, etc. The charcoal and soda lime in the canister furnished no protection against these smokes and it was found necessary to place two 2 or 3 layer cotton wadding pads in the canister to completely filter out the smokes. Cottom wadding pads were chosen after considerable research by this section in conjunction with the Mechanical Research Section, with several kinds of material. When the first smokes proved effective in gas warfare it was certain that new smokes would follow, which would be more penetrating, so that this stage research on the gas masks divided into two lines, chemical protection and smoke protection. The development of smoke protection is given in another place and only the work done on it that directly affects the chemical protection is given here.

Tests were conducted for the purpose of determining the most desirable positions for the pads in the canister. A series of tests conducted by the Man Test Unit in February 1918, showed that the use of two filter pads located at 1/3 and 2/3 the distance from the bottom of

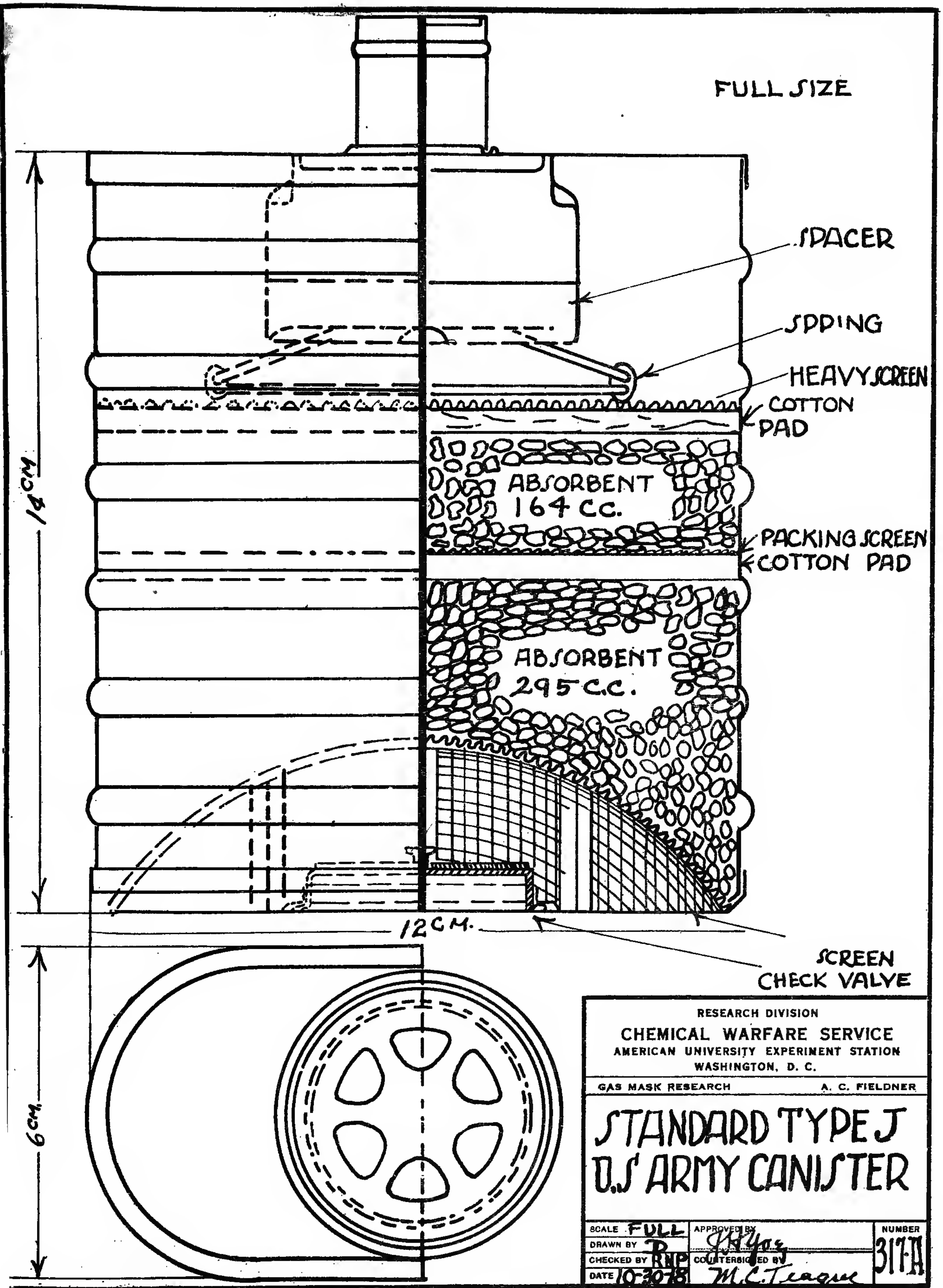
the canister was preferable to the use of one pad located either at the middle or at the top. These conclusions were drawn from the tests against S-22. Test by the Canister Research Unit a little later showed that the position of the pads does not influence the efficiency of the canister against the common gases, CG, G-28, or PS. Man tests showed that with respect to the protection against S-25 the total weight of the filter pads is of very much more importance than the amount of the pad surface or the position of the pads in the canister.

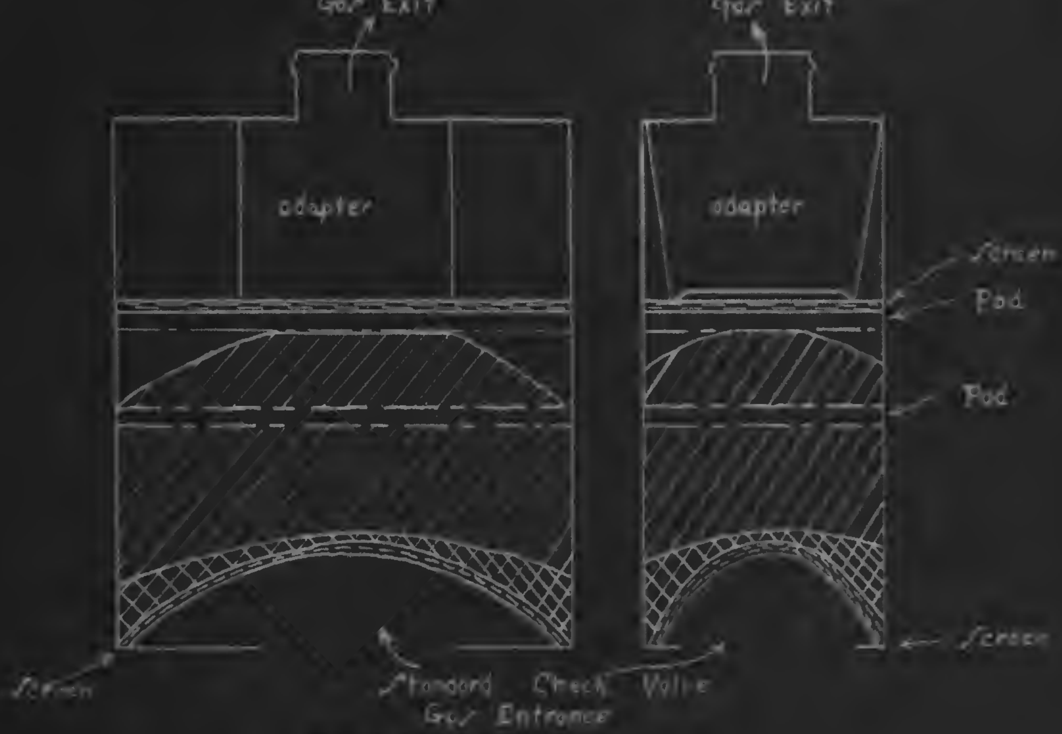
Along with the other research work on absorbents and pads a series of experiments was conducted for the purpose of determining the effect on the life of an absorbent of separating the various meshes and placing them in different layers in the canister. As a result of these tests the following conclusions were drawn:

1. No increase in life is produced by placing the coarse material in the bottom of the canister and the fine in the top.

2. No advantage in efficiency is gained by using fine charcoal and coarse soda lime or fine soda lime and coarse charcoal.

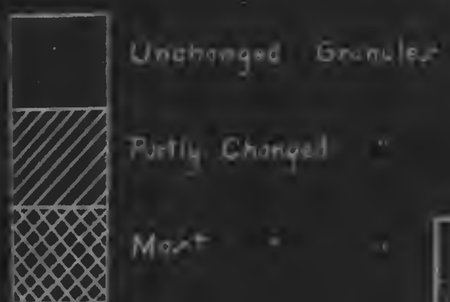
The change from H to J and L type was entirely a change to obtain lower resistance and although a lowering of the resistance of 27% was obtained at a sacrifice of 50% in the protection, it was considered justifiable. At this time all energy was put on developing a canister with a low resistance, less than 2 inches, that would furnish 30 minutes protection against CG, 10,000 p.p.m., and PS 2,000 p.p.m., man tests, and 30 minutes protection against a nominal concentration of 40 p.p.m. of G76 on man test. About the only limits to the shape and size of the canister were that it should fit in the standard haversack. In order to obtain some practical data which would furnish a working basis for designing the most efficient canister possible, a series of experiments were conducted to determine the most efficient grain size and depth for an absorbent in a canister of approximately 500 cc. and resistance less than 1 in. In these tests the volume and resistance were held constant while the mesh and cross sectional area were varied. As a result it was found that the best grain size of absorbent and area of cross section for a canister of approximately 500 cc. volume and from 15 to 25 mm. pressure drop was one of 130 sq. cm. cross sectional area, using 14-20 mesh material. The tests showed that there was a marked decrease in the life when a thinner layer than 38 mm. of absorbents were used. This was caused largely by the


FULL SIZE
SPACER
SPRING
HEAVY SCREEN
COTTON PAD
ABSORBENT 164 C.C.
PACKING SCREEN
COTTON PAD
ABSORBENT 295 C.C.
14 CM
12 CM.
6 CM.
SCREEN
CHECK VALVE
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
STANDARD TYPE J
U.S ARMY CANISTER
SCALE FULL
DRAWN BY
CHECKED BY RHP
DATE 10-30-18
APPROVED BY
COUNTERSIGNED BY M.C. Teague
NUMBER 317-A



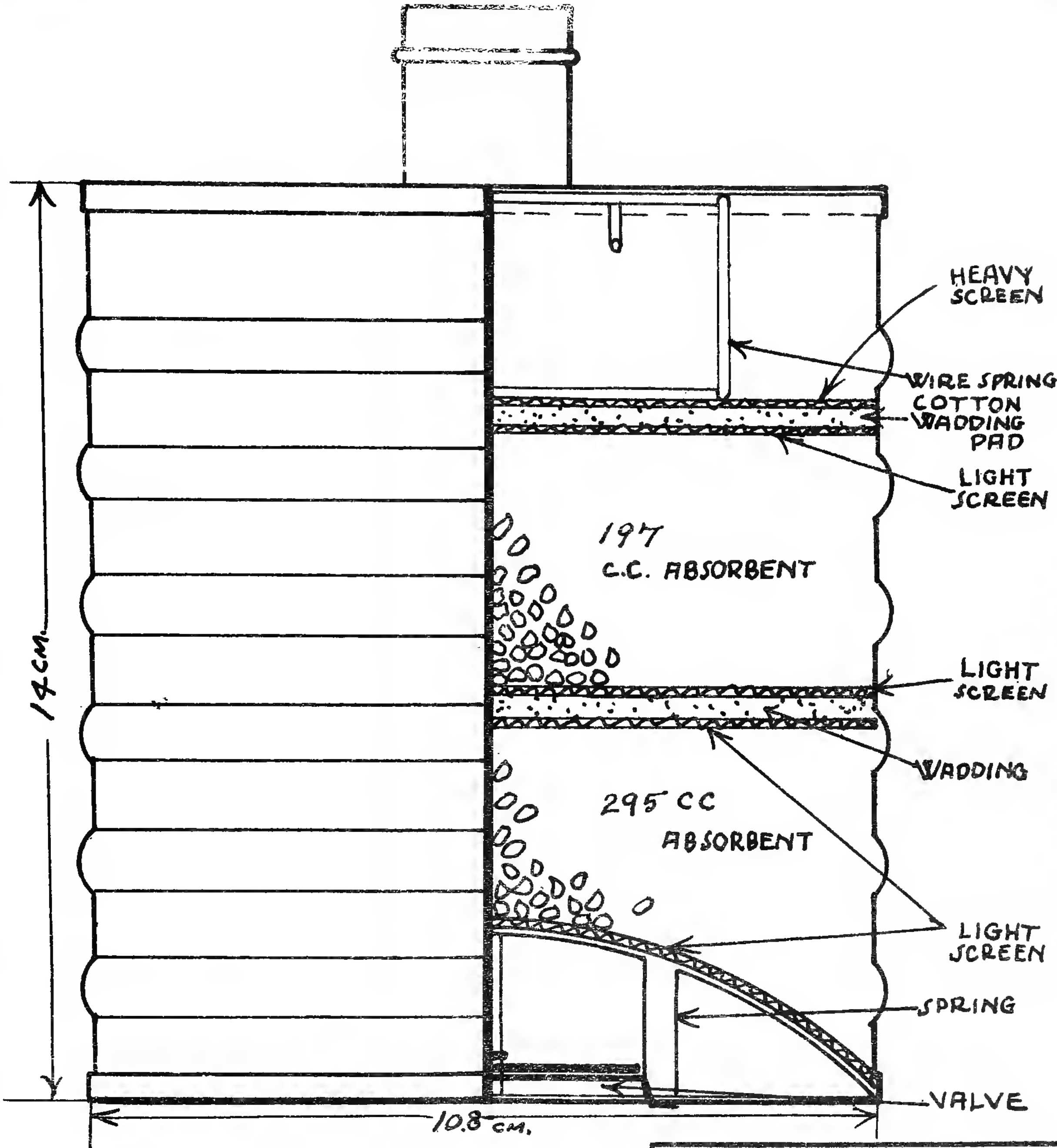
PROBLEM E-2-9

Weight of Absorbent	344.0 g
Unchanged	18.7 %
Resistance @ 85 L/m	3.17 in
Time @ 10000 p.p.m	64.3 min



WAVE FRONT OF TYPE J CANISTERS

J.R.
E.C. FIELDNER
169-D



HEIGHT 14 CM.
WIDTH 6 CM.

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

STANDARD TYPE L U.S. ARMY CANISTER

SCALE FULL	APPROVED BY J.H. Yoe	NUMBER 324-A
DRAWN BY D		
CHECKED BY RNP	COUNTERSIGNED BY M.C. Teague	
DATE 11-17-18		

variations in the depth of absorbent which could not be avoided with the flat type of canisters used. In order to get a fair test of efficiency of thinner layers of absorbent than 38 mm. additional tests were conducted with canisters known as the central breathing tube type. In these canisters the absorbent was held between two concentric cylinders of perforated metal. As in the previous tests the volume and resistance were held constant while the mesh and depth of absorbent were varied. As a result of this series of tests the following conclusions were drawn:

1. The most efficient depth of layer and grain size of absorbent for use in a central breathing tube canister of 500 cc. volume and 15 mm. resistance is one of approximately 20 mm. and 22 to 26 mesh material.

2. The central breathing tube type of canister gives approximately 40% longer life to the same volume of absorbent than a flat type canister or one of the general construction of the U.S.B.R. Type"J".

3. The better type of central breathing tube canister from the standpoint of packing and testing is one in which the central tube does not extend entirely through the absorbent.

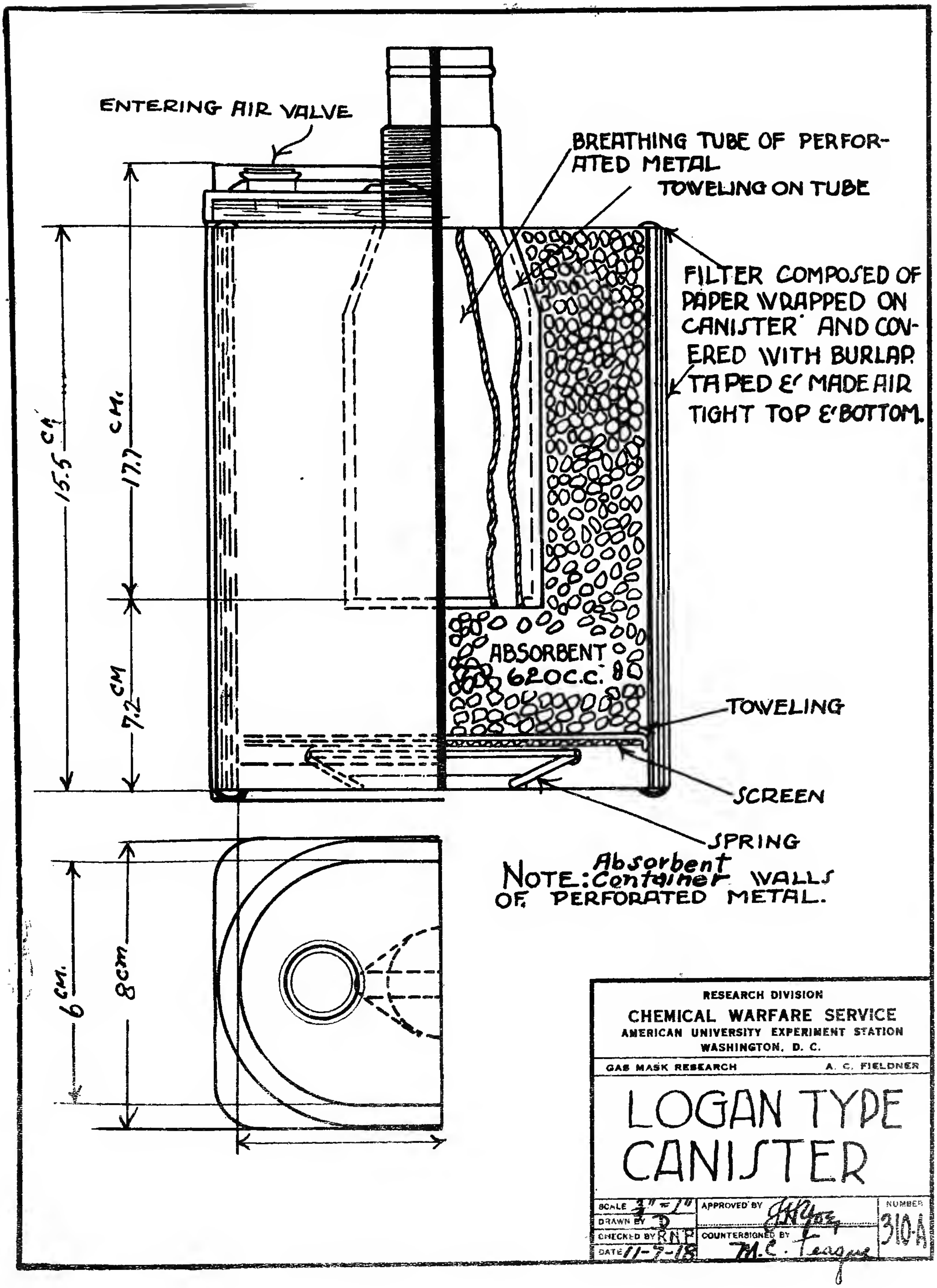
4. Due to the variations in material and packing which cannot be altogether avoided, a 15 mm. resistance packing is found to be much more practical than a 10 mm.

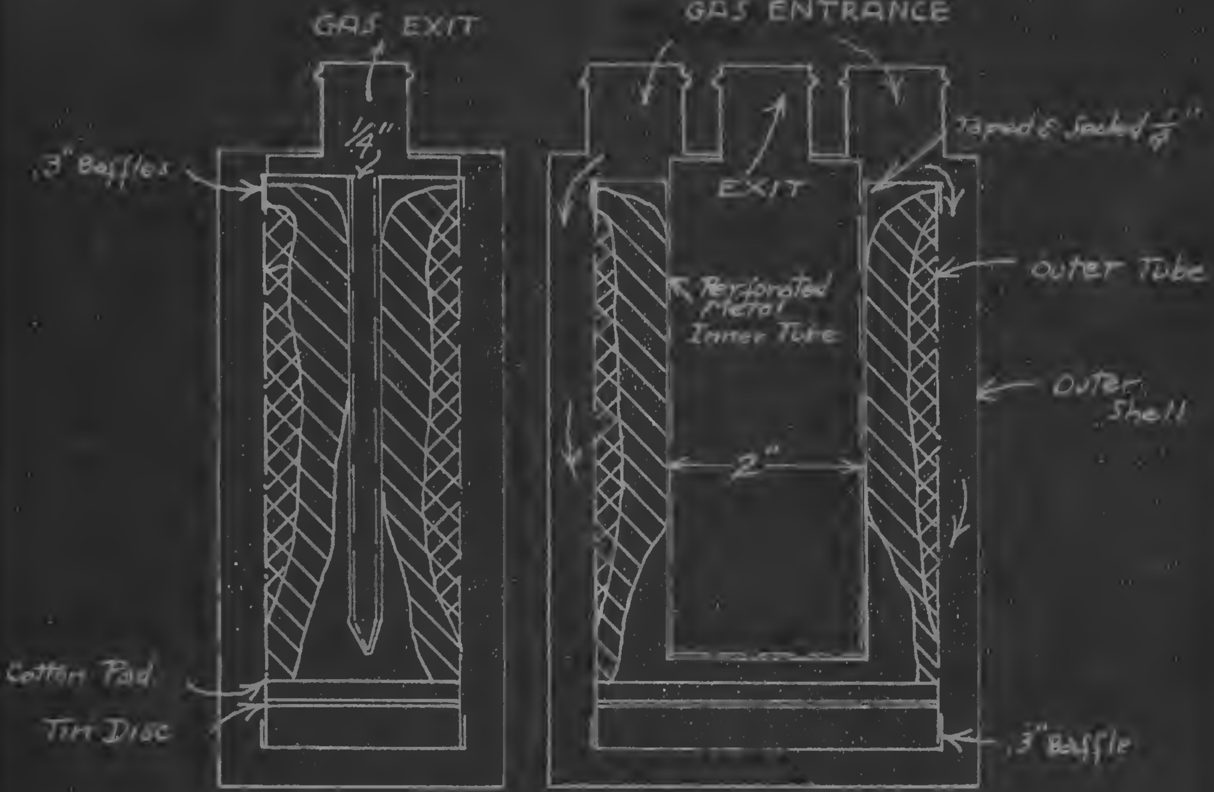
5. In order to control the resistance within fairly close limits it is necessary to remove all dust from the absorbent. The dust was found to clog the pores of the toweling and thereby increase the resistance.

6. Jolting the canisters during packing was found to be absolutely essential to uniformity of resistance and good utilization of the absorbent.

7. With the volume and resistance constant, and a 100% utilization of absorbent realized, the efficiency of an absorbent increased indefinitely with the fineness of the mesh. The poor efficiency obtained in the tests with the fine mesh material were the results of poor utilization, unavoidably caused by channeling.

As a result of these investigations, and with the experience with the British central breathing tube type of canister, the Gas Defense Division designed the Logan canister. Its chief advantages are its low resistance and its adaptability to the best type of smoke filters, giving a compact one-unit canister. Wave-front experiments on the original Logan canister showed that the gas


ENTERING AIR VALVE
BREATHING TUBE OF PERFORATED METAL
TOWELING ON TUBE
FILTER COMPOSED OF PAPER WRAPPED ON CANISTER AND COVERED WITH BURLAP TAPED & MADE AIR TIGHT TOP & BOTTOM.
15.5 CM.
17.7 CM.
7.2 CM
ABSORBENT 620 C.C.
TOWELING
SCREEN
SPRING
NOTE: Absorbent Container WALLS OF PERFORATED METAL.
6 CM.
8 cm
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
LOGAN TYPE CANISTER
SCALE
DRAWN BY
CHECKED BY RNF
DATE 11-7-18
APPROVED BY
COUNTERSIGNED BY M.C. Teague
NUMBER
310-A



PROBLEM E-16

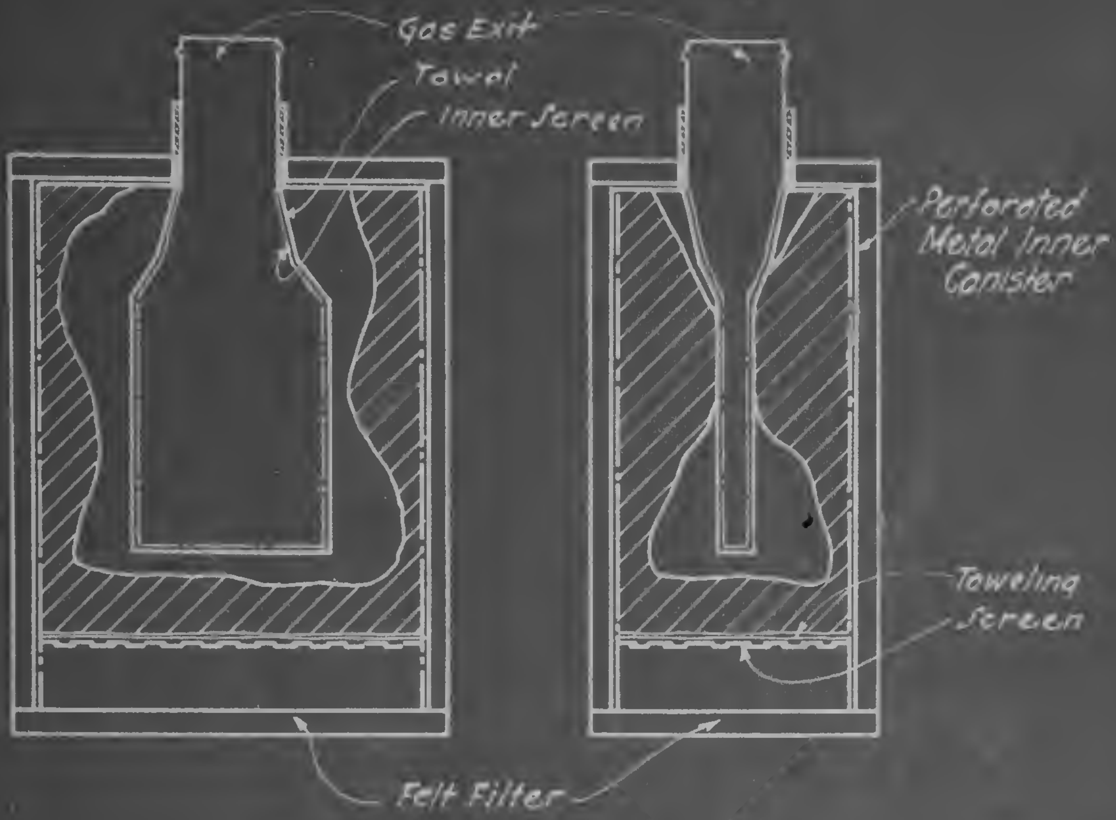
Weight of Absorbent	450 gr.
Unchanged "	26.4 %
Resistance @ 85 L/M	155 m.m.
Time at 5000 P.P.M.	46. min.

Flow, Int. 32 L/M, 22 STROKES / MIN.
Mesh: Equal Parts 12-14, 14-16, 16-18, 18-20, 20-22, 22-24
Layer Depth - 7/8"

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON D. C.

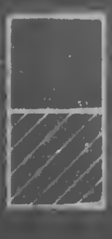
WAVE FRONT OF REVISED LOGAN CANISTER. 34 CUBIC INCHES ABSORBENT

APPROVED BY H. J. Beattie
CHECKED BY R. F.
DATE 11-14-18
COUNTERSIGNED BY A. C. Fieldner
NUMBER 300-E



PROBLEM E-2-18

Weight of Absorbent	483 g
Unchanged "	35.4 %
Resistance @ 85 L/m	52 mm
Flow - Int., 32 L/m, 22 Strokes/Min	
Time @ 5000 P.P.M.	76 Min

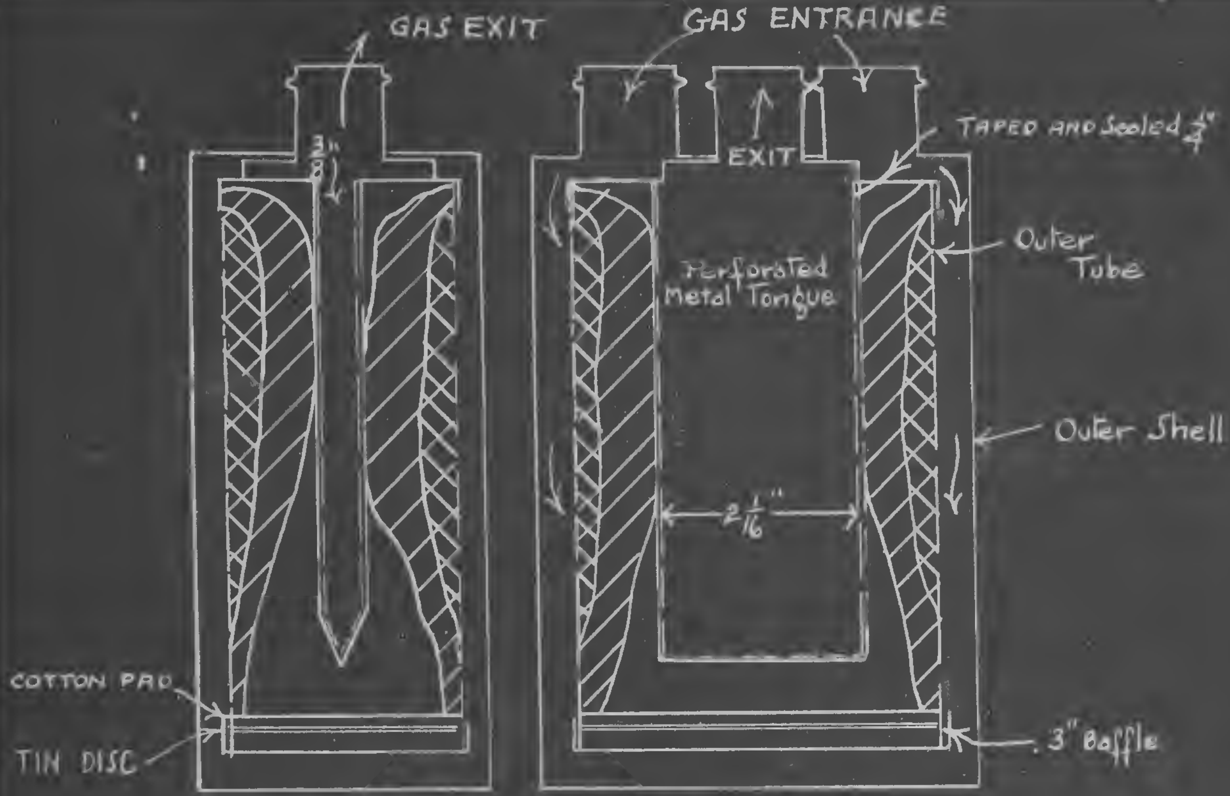


RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D.C.

GAS MASK RESEARCH — A. C. FIELDNER

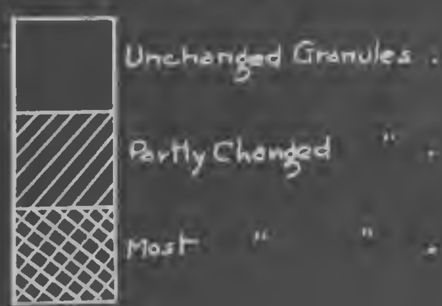
WAVE FRONT OF LOGAN CANISTER
40 CU. IN. OF ABSORBENT

SCALE 1/2" = 1"	APPROVED BY [signature] Beattie	NUMBER 247-E
DRAWN BY H		
CHECKED BY F	COUNTERSIGNED BY A C FIELDNER	
DATE 10-8-18		



PROBLEM E-16

Weight of Absorbent . 540 gr.
Unchanged " " . 27.3 %
Resistance @ 85 L/M 11. m.m.
Time @ 5000 P.P.M 53. min
Flow, Int., 32 L/M, 22 Strokes / Min.
Mesh - Equal parts 12-14, 14-16, 16-18, 18-20, 20-22, 22-24
Layer Depth = 1"

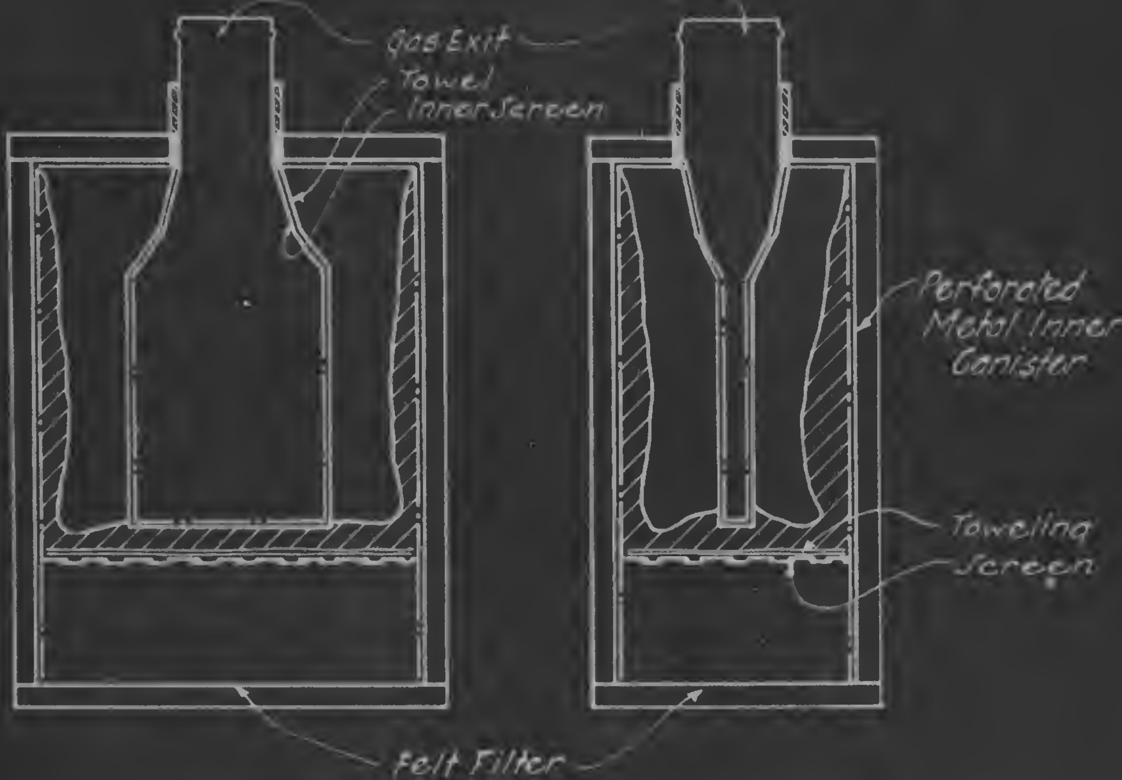


RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH A. C. FIELDNER

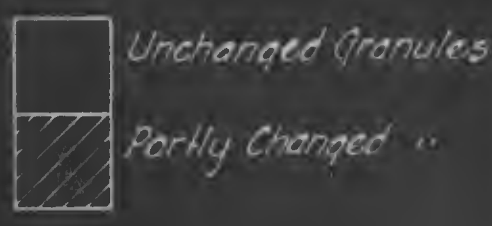
WAVE FRONT OF REVISED LOGAN CANISTER. 40 CU.IN. ABSORBENT

Scale 1/2" = 1" | D | R.F. | 11-14-18 | A. J. Beattie | Countersigned by A C Fieldner | 299 E



PROBLEM E-2-18

Weight of Absorbent	422 g.
Unchanged	60.4 %
Resistance @ 85 L/M	1.2 in.
Flow-Int. 32 L/M. 22 Strokes/Min.	
Time @ 5000 P.P.M.	37 Min.



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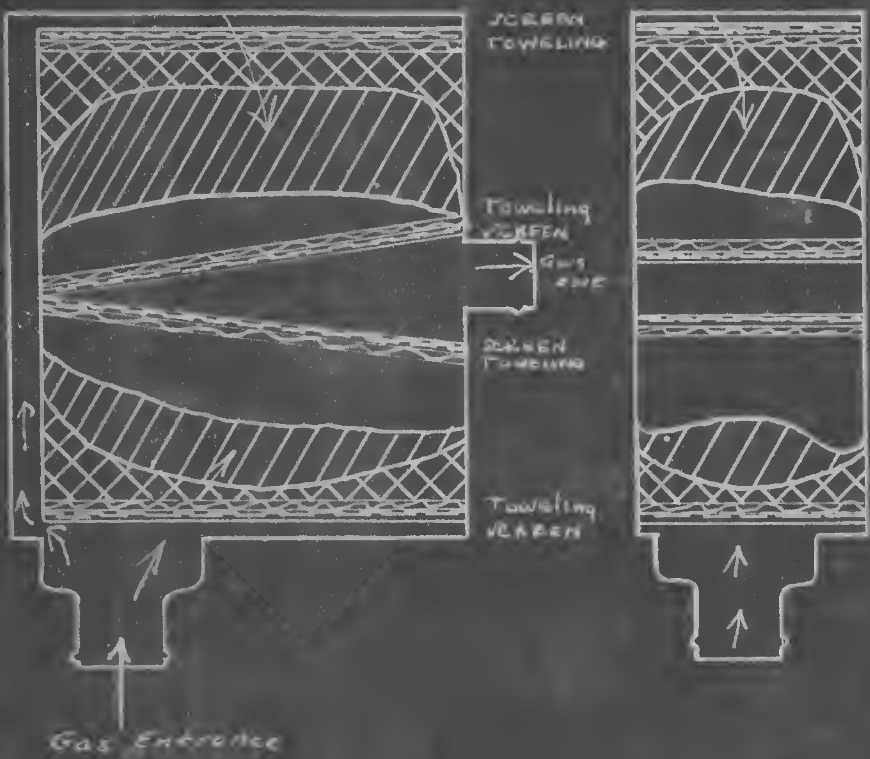
WASHINGTON, D.C.

WAVE FRONT OF LOGAN CANISTER
35 CU. IN. OF ABSORBENT

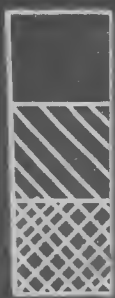
A. C. FIELDNER
15-8-18
748E

No. I



LITTLE CANISTER

Weight of Absorbent	549.0
% Unchanged (upper 29.5, lower 52.4)	Av. 38.9
Resistance @85 l/m.	8.0
Time @10000 p.p.m.	124.0



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AMERICAN UNIVERSITY EXPERIMENT STATION
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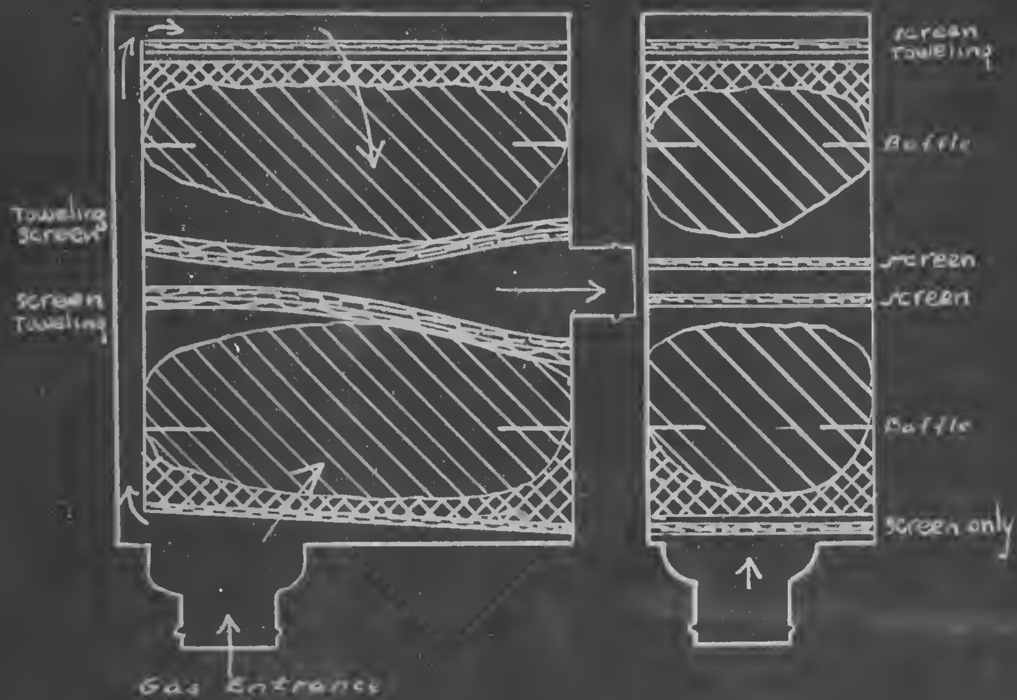
WAVE FRONT
OF
LITTLE SPECIAL CANISTER

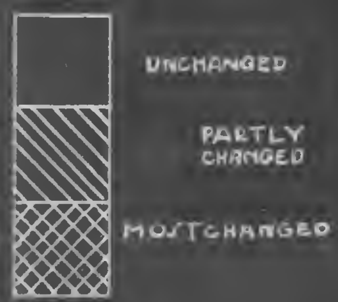
Scale 1" = 1/2"	Approved: H. G. Beattie	Number 120-E
Drawn by V.F.D.		
Checked by R.F.	Countersigned: A·C·FIELDNER	
Date 7-16-18		

No. II



LITTLE CANISTER

Weight of Absorbent		549.0
% Unchanged	upper 21.8 av. / " lower 22.9 "	22.3
Resistance @ 85 l/m.		19.
Time @ 10,000 p.p.m.		115.



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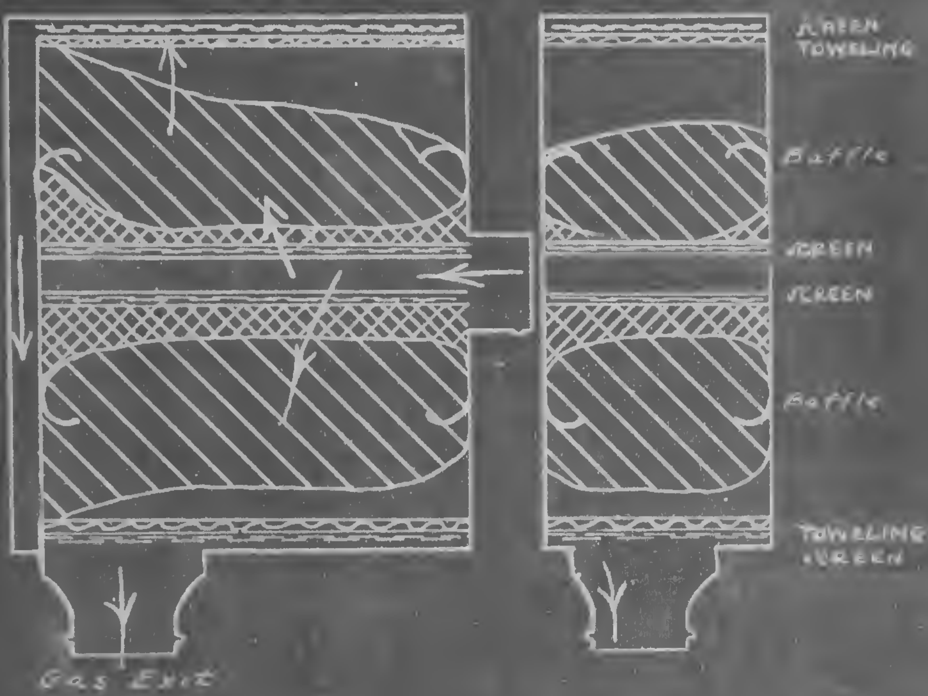
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

Wave Front
of
LITTLE SPECIAL CANISTER

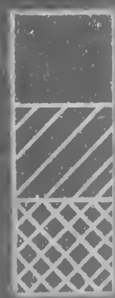
Scale 9" = 1/2"
Drawn by P.F.O.
Checked by R.F.
Date 7-18-18
Approved by H.G. Beattie
Countersigned A. C. FIELDNER
Number 120-E

No. III



LITTLE CANISTER

Weight of Absorbent	549.
% Unchanged — upper 33.8, lower 17.8, Av.	25.8
Resistance @ 85 l./m.	16.
Time @ 18 000 p.p.m.	122.



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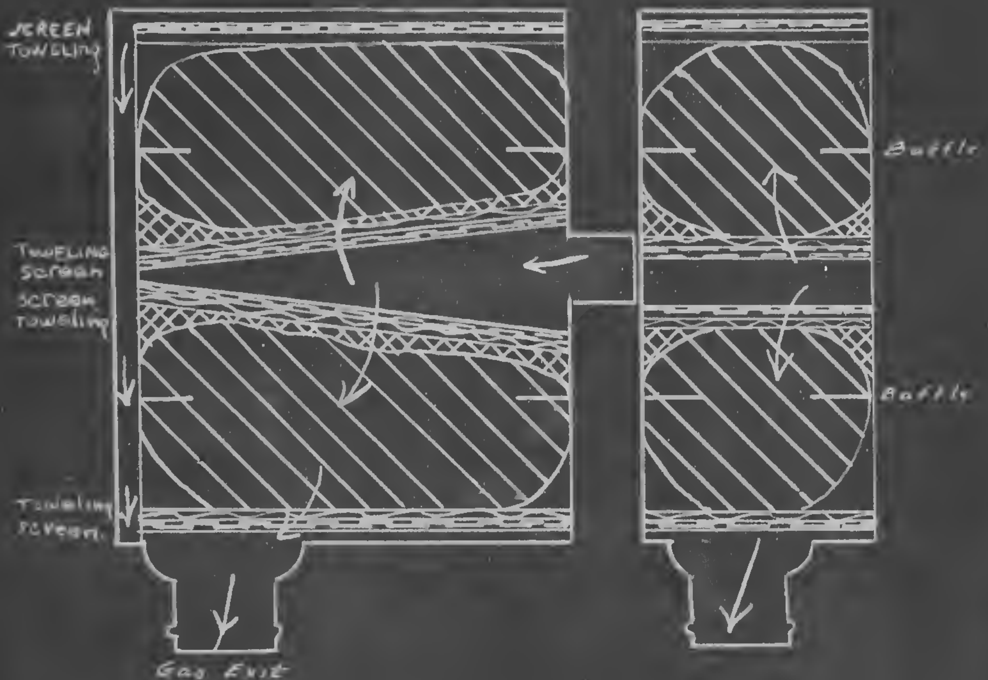
GAS MASK RESEARCH — A. C. FIELDNER

Wave Front
of
LITTLE SPECIAL CANISTER

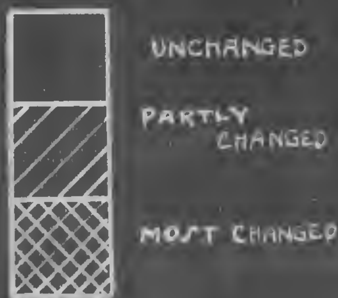
1" = 1/2"	APPROVED BY H. J. Beattie	120-E
DRAWN BY P.F.O.	COUNTERSIGNED A. C. FIELDNER	
DATE 7-19-18		

NO. IV



LITTLE CANISTER

Weight of Absorbent 537.
% Unchanged upper 19.7, lower 20.5, Av 20.1
Resistance @ 85 l/m 12.0
Time @ 10,000 p.p.m. 164.



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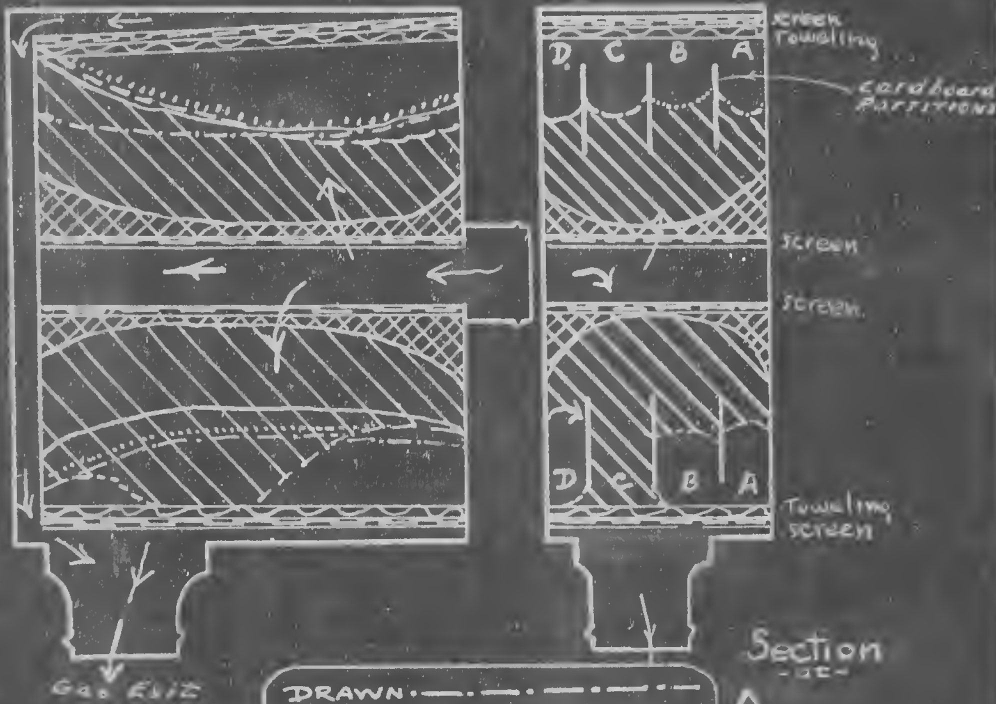
WASHINGTON, D. C.

GAS MASK

Wave Front of LITTLE SPECIAL CANISTER

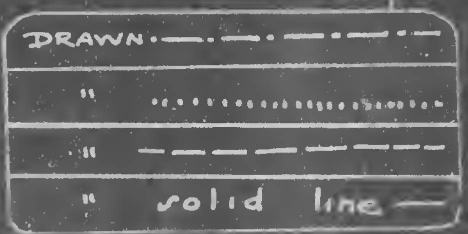
SCALE 1" = 1/2"	APPROVED BY H. G. Beattie	NUMBER 120-E
DRAWN BY P.F.D.	COUNTERSIGNED A. C. FIELDNER	
CHECKED BY R.P.		
DATE 9-19-18		

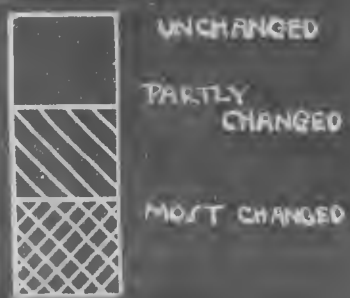
No. V.



LITTLE CANISTER.

Section -at-

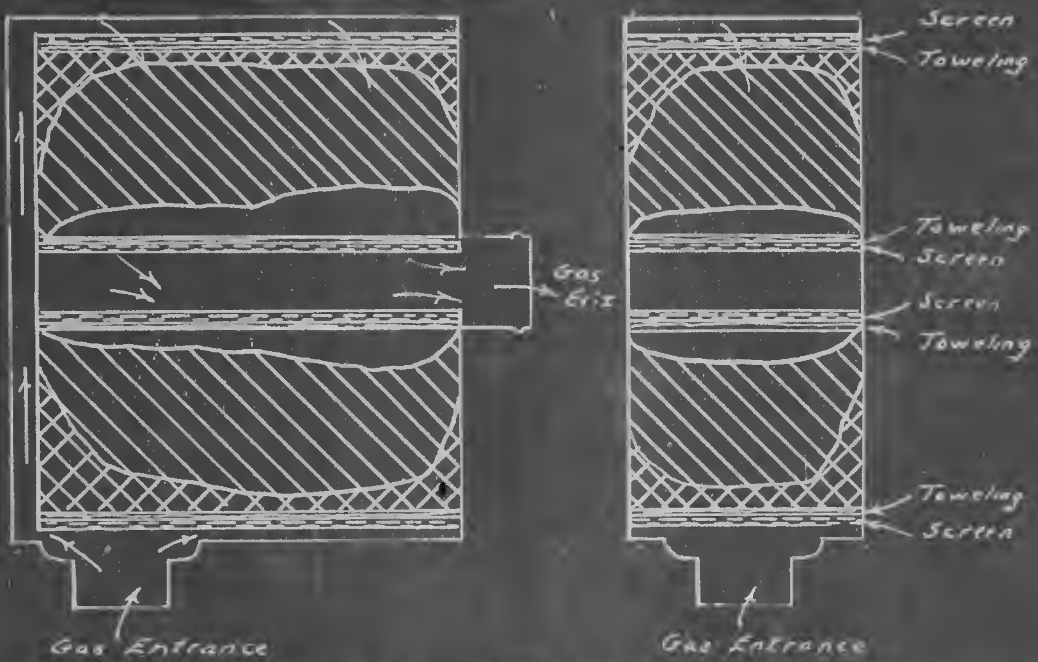




Weight of Absorbent 532.
% Unchanged upper 35.3 / lower 33.1 av. 34.2
Resistance @ 85 l/m 20.
Time @ 10000 p.p.m. 115.

BUREAU OF MINES AMERICAN UNIVERSITY EXPERIMENT STATION WASHINGTON, D.C.	
GAS MASK RESEARCH	A. C. FIELDNER
Wave Front of LITTLE SPECIAL CANISTER	
SC. 1" = 1/2"	APPROVED BY H.G. Beattie
DRAWN BY R.E.D.	NUMBER 120-E
CHECKED BY R.F.	COUNTERSIGNED A.C. FIELDNER
DATE 7-19-18	

NO. VI



LITTLE CANISTER

Weight of Absorbent	5 49.
% Unchanged – upper 28.5, lower 27.1, av.	27.8
Resistance @ 85 l./m.	13.
Time @ 10000 p.p.m.	180.

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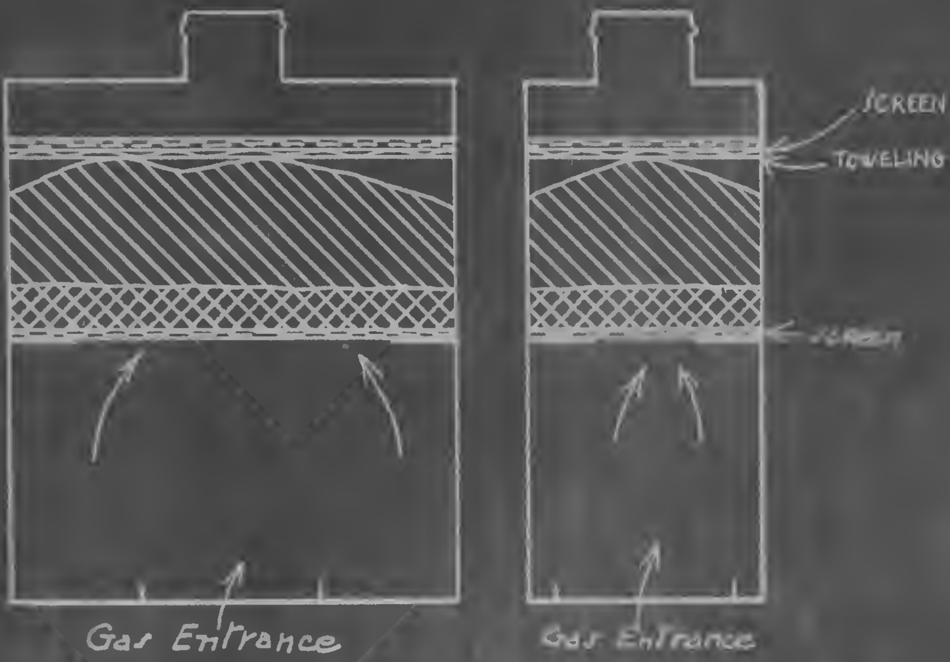
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF LITTLE SPECIAL CANISTER

SCALE [illegible]
APPROVED BY [illegible]
DRAWN BY D
CHECKED BY R.F.
DATE 7-19-18
COUNTERSIGNED A-C-FIELDNER
NUMBER 120-E



Weight of Absorbent	244
% Unchanged	18.0
Resistance @ 85 l/m.	21.4
Time of Run	44.6

Average Wave Front.

PROBLEM E-6

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AMERICAN UNIVERSITY EXPERIMENT STATION
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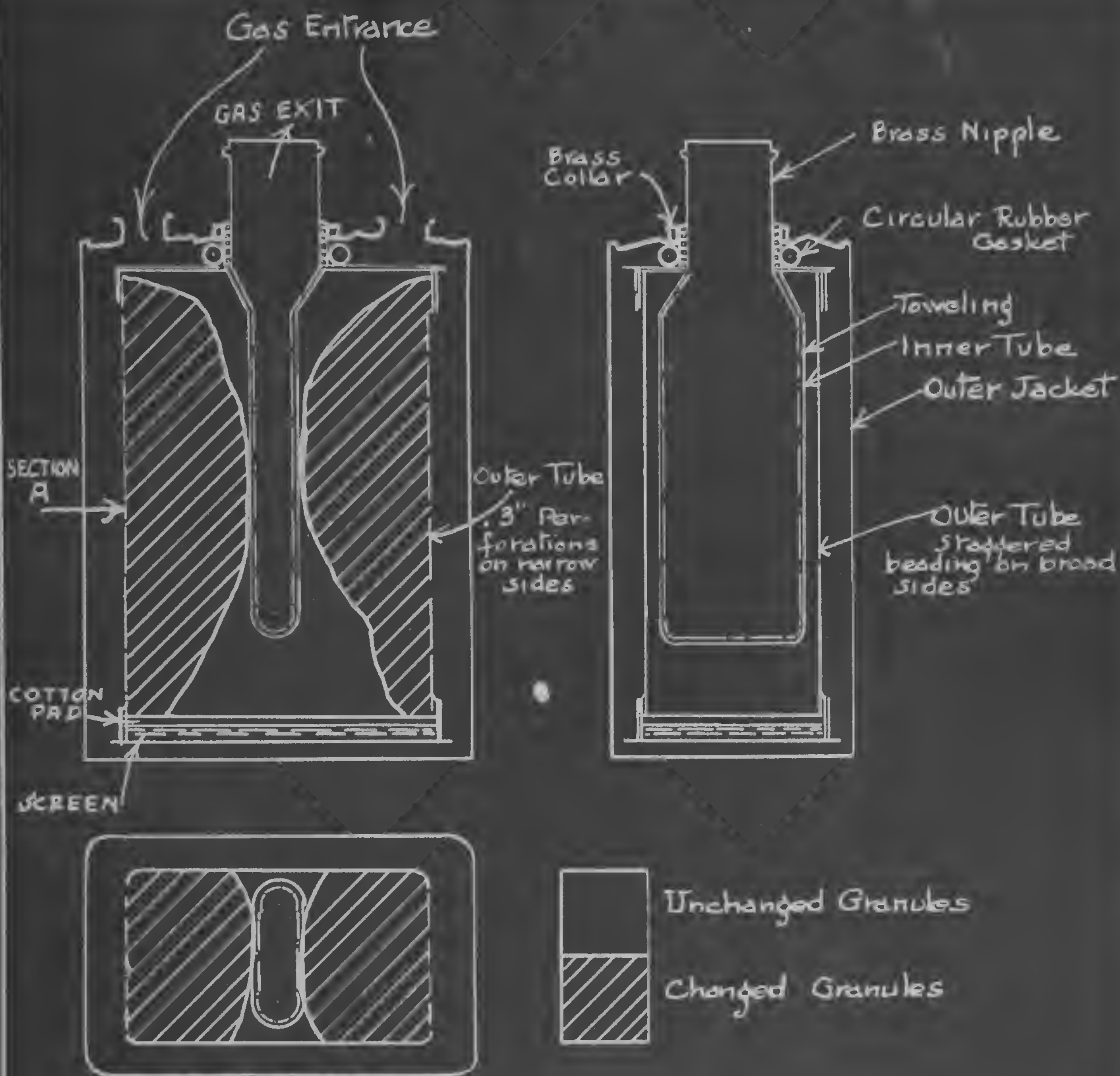
GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF LOW RESISTANCE CANISTER

SCALE 1" = 1"	APPROVED BY H. G. Beattie	NUMBER 179-D
DRAWN BY D		
CHECKED BY R.F.	COUNTERSIGNED A.C. FIELDNER	
DATE 8-21-18		



SECTION AT A.

PROBLEM E 2-20

Weight of Absorbent 457. g
% Unchanged " 32.2 %.
Resistance @ 85 L/M 15 MM.
Time @ 5000 P.P.M. 31 MIN.
Flow Intermittent @ 32 L/M 22 Strokes Min
Mesh of Absorbent 8-14.

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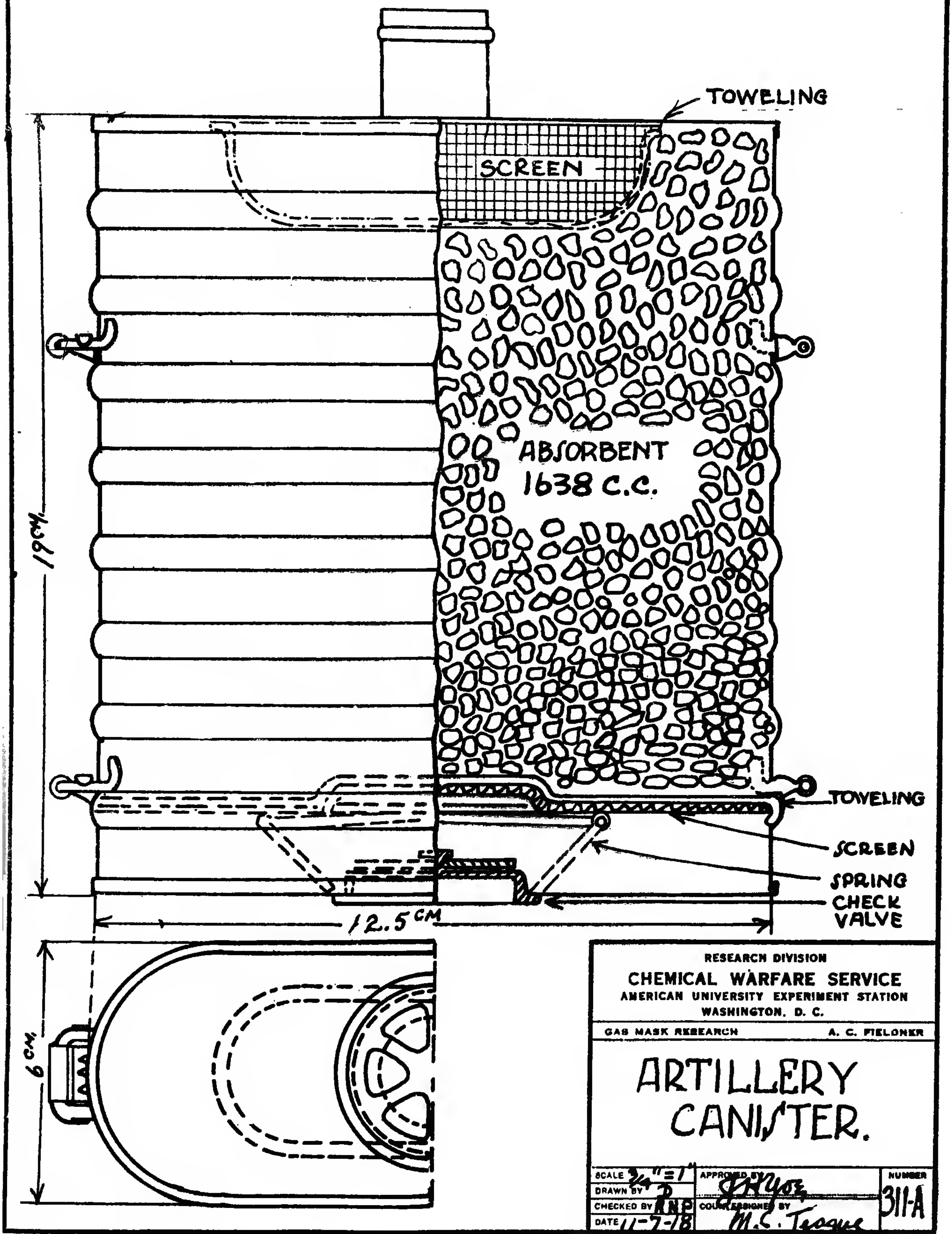
GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF TYPE U BRITISH CANISTER.

SCALE 1/2" = 1"
DRAWN BY P.F.D
CHECKED BY R.F.
DATE 11-26-18
APPROVED BY
COUNTERSIGNED BY
NUMBER 372-E



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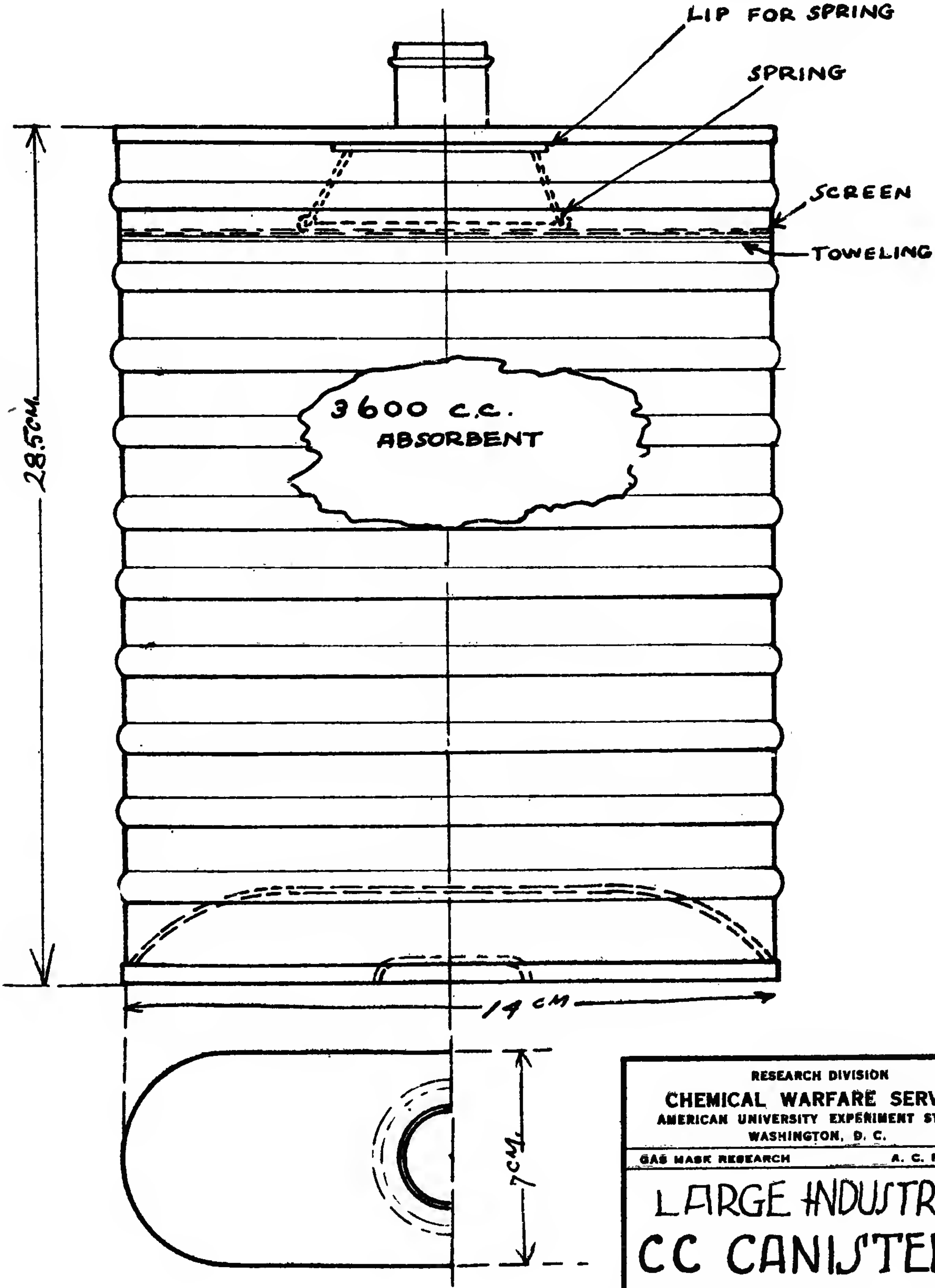
GAS MASK RESEARCH — A. C. FIELDNER

ARTILLERY CANISTER.

SCALE 3/4"=1"
DRAWN BY
CHECKED BY
DATE 11-7-18
APPROVED BY
COUNTERSIGNED BY M. C. Teague
NUMBER 311-A



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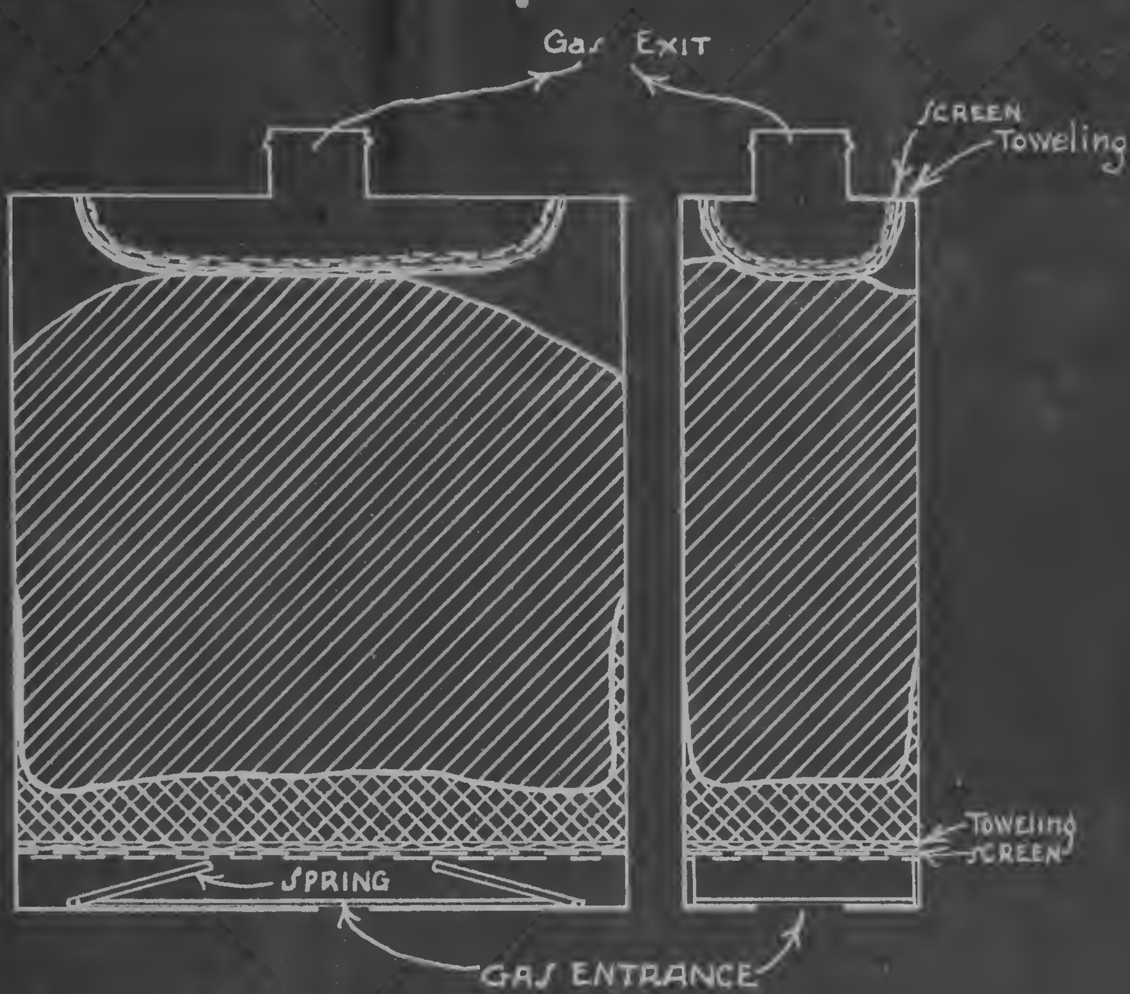
GAS MASK RESEARCH — A. C. FIELDNER

LARGE INDUSTRIAL CC CANISTER.

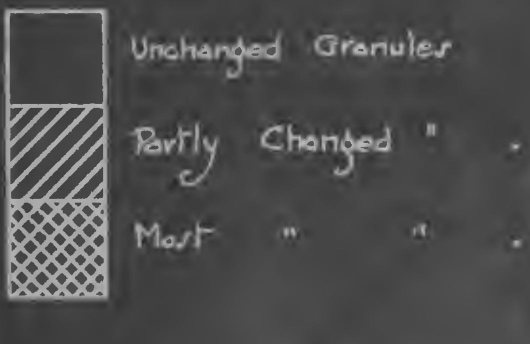
SCALE 1/2 = 1	APPROVED BY [illegible]	NUMBER 313-A
DRAWN BY PFD		
CHECKED BY RAB	COUNTERSIGNED BY M. C. Teague	
DATE 11-26-18		



Problem E - 14

Weight of Absorbent	1276. g.
Unchanged "	12.1 %
Resistance @ 85 l/m	1.75 in.
Time @ 10,000 ppm.	108. min.

Flow Intermittent, 32 L/m, 22 STROKES.



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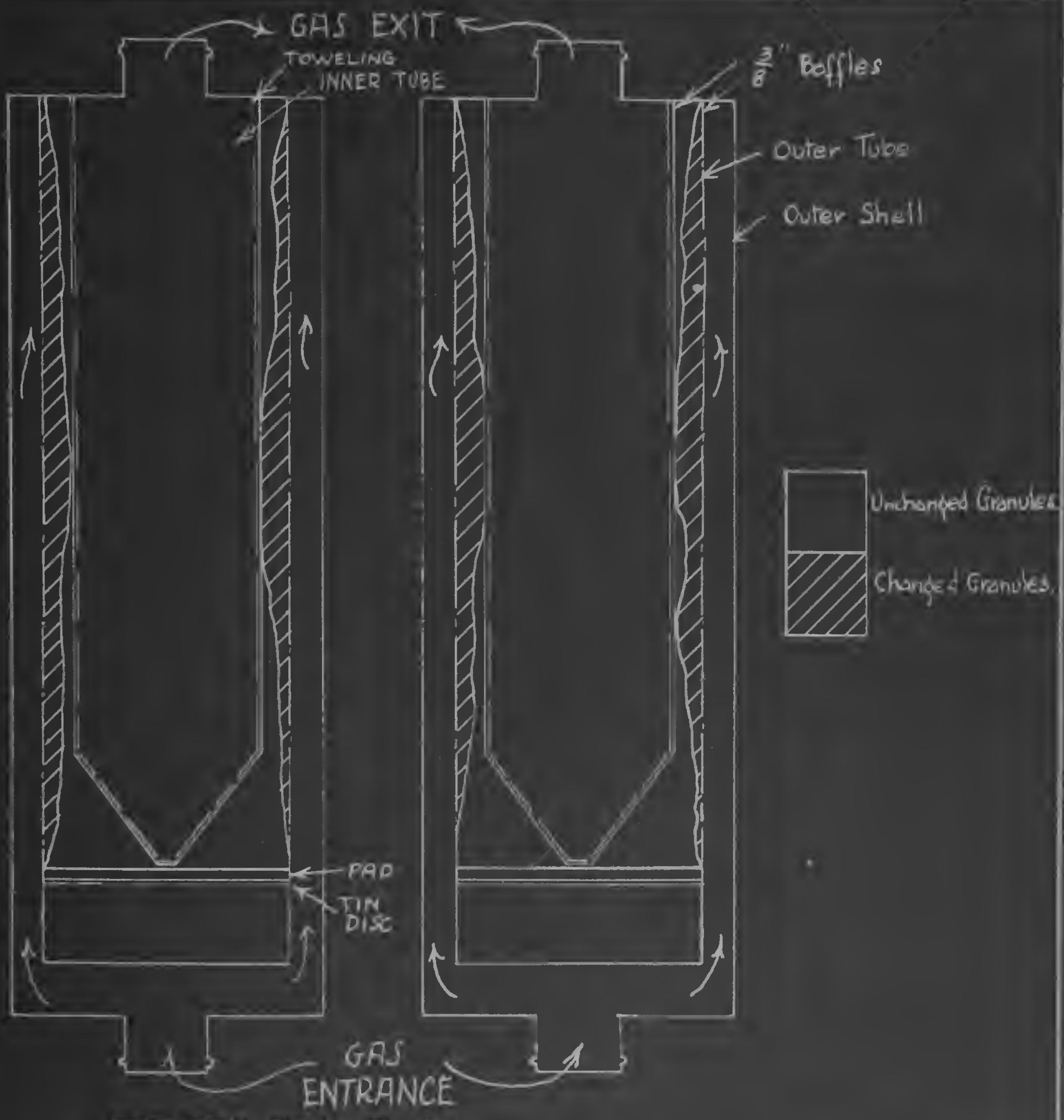
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF 110 CU. IN CANISTER AT 32 LM FLOW.

SCALE ½" = 1"	APPROVED BY H. J. Beattie, sc	NUMBER 229-E
DRAWN BY JJ		
CHECKED BY R.F.	COUNTERSIGNED BY A. C. FIELDNER	
DATE 9-17-18		



PROBLEM E-11

Weight of Absorbent	430 gr.
Mesh of " ..	50% (40-48) 50% (48-65)
Resistance @ 85 L/M	15 MM.
Time @ 5000 P.P.M.	43 MIN.
Flow Int. 32 L/M	22 STROKES/MIN.
Unchanged Absorbent about	60%

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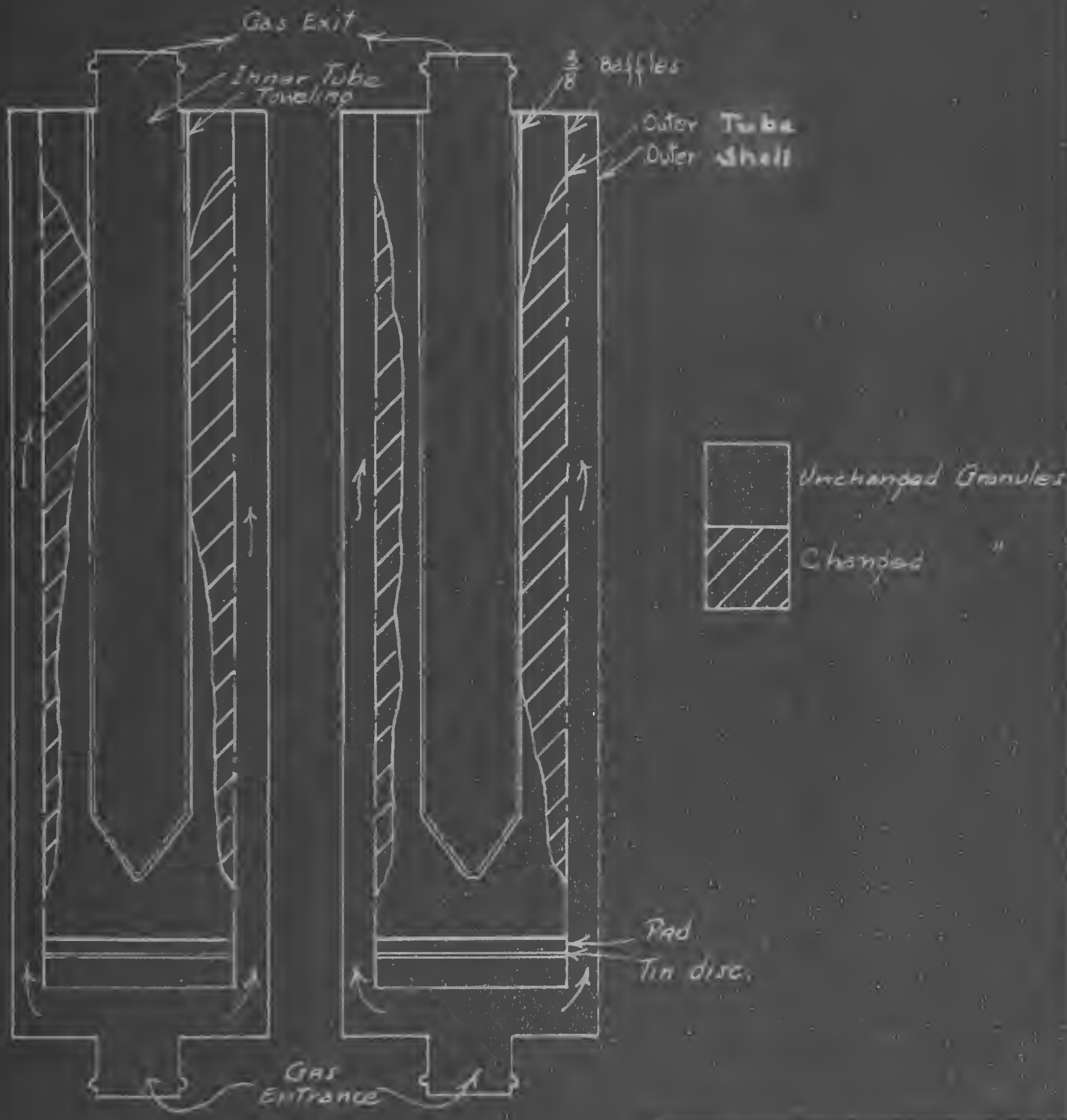
GAS MASK RESEARCH — B. C. FLETCHER

WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CAN. ABS. DTH = 10MM.

SCALE
DRAWN BY D
CHECKED BY R.F.
DATE 11-12-18
APPROVED BY H. J. Beattie
COUNTERSIGNED BY B. C. Fletcher
298 E



PROBLEM E-11

Weight of Absorbent 440 gr.
Mesh " " (30-35)
Resistance @ 85 L/M 14.5 m.m.
Time @ 5000 P.P.M. 36.5 min.
Flow, Inh. 32 L/M, 22 strokes/Min.
" " about 50 %

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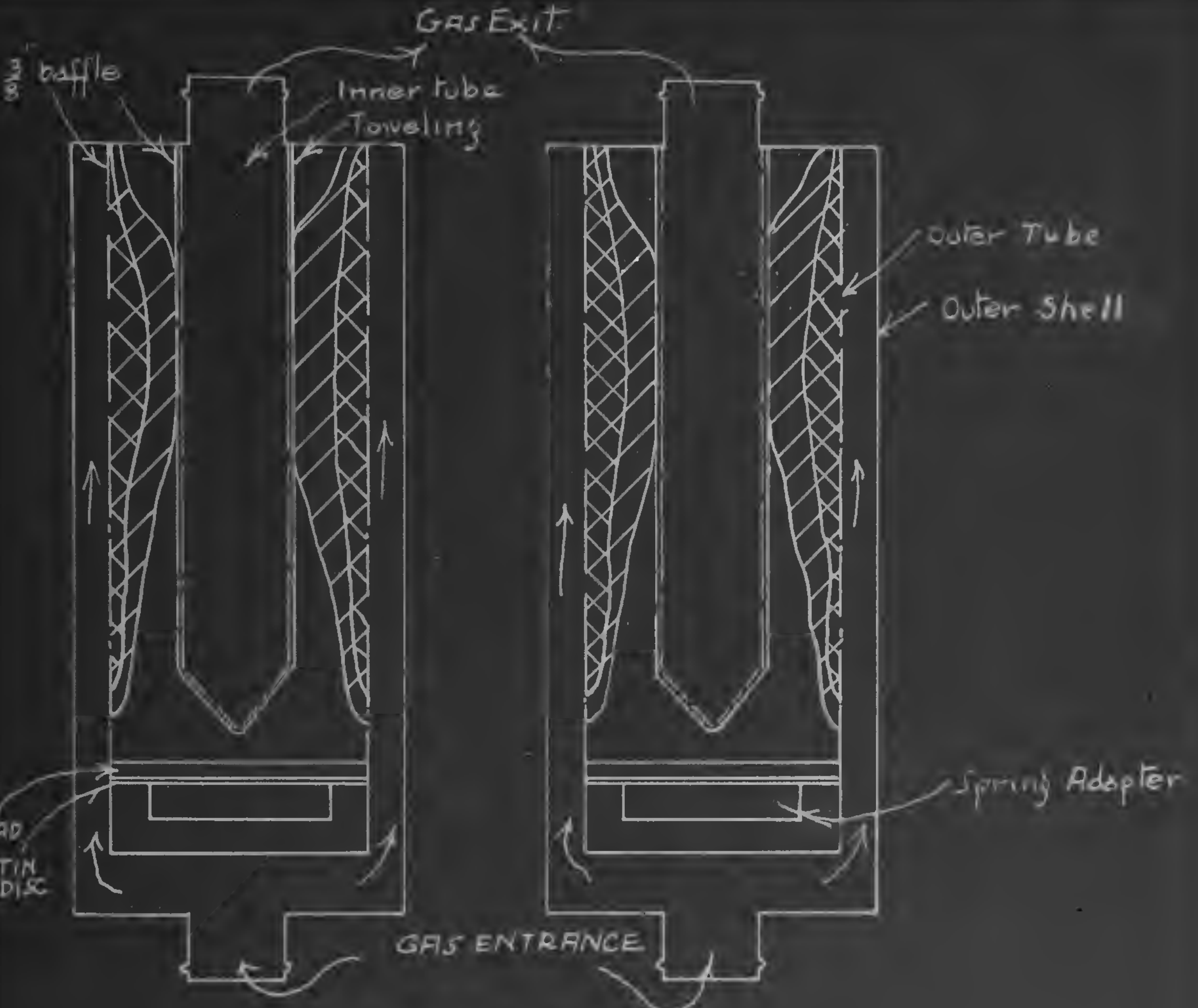
WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CAN. ABS. DEPTH = 15 MM

2
R.F.
11-9-18
APPROVED BY H.H. Beattie
COUNTERSIGNED BY
NUMBER 295-E



PROBLEM E-11

Weight of Absorbent	440 gr.
Unchanged "	34.3 %
Resistance @ 85 L/M	14. M.M.
Time at 5000 P.P.M.	38 MIN.
Flow. Int. 32 L/M	22 STROKES/ MIN
Mesh of Absorbent	22 - 24

Unchanged Granules.

Partly Changed ".

Most " ".

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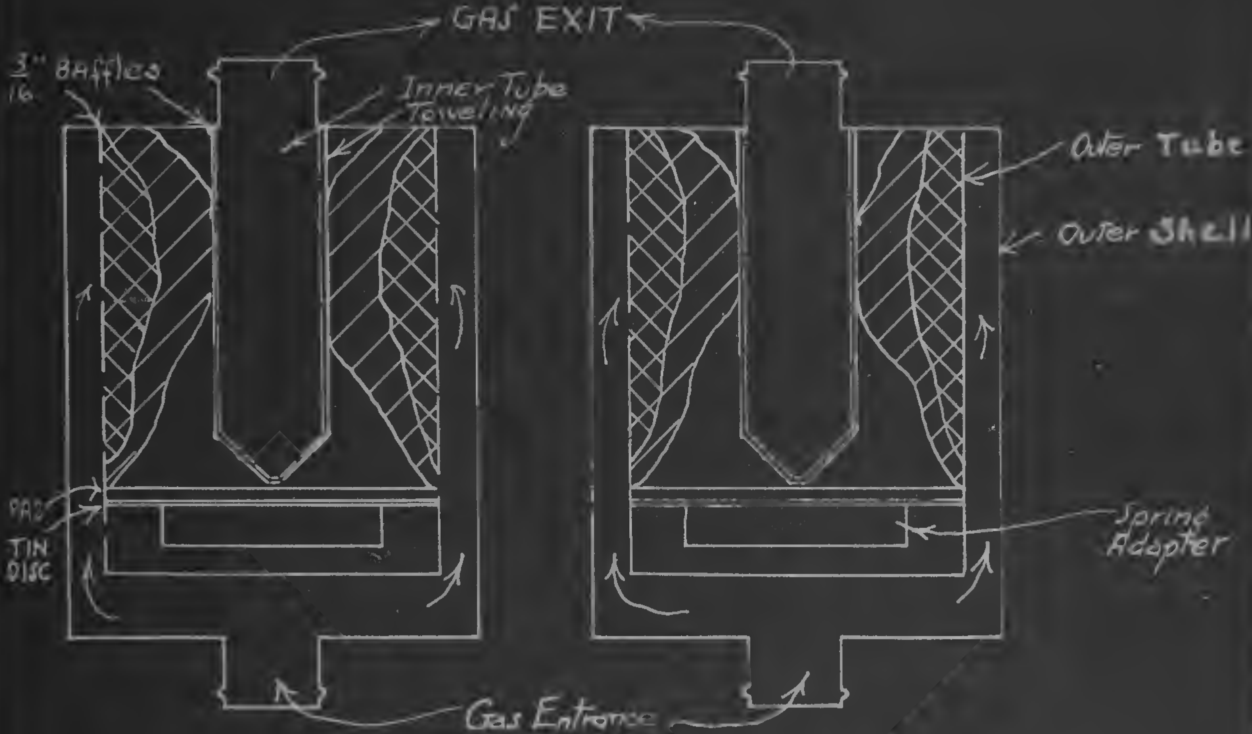
GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CAN. ABS. DEPTH=20MM.

NOTES	APPROVED BY	NUMBER
DRAWN BY D		297-E
CHECKED BY R.F.	COUNTERSIGNED BY	
DATE 11-9-18		



PROBLEM E-11

Weight of Absorbent	450	gr.
Unchanged "	26.4	%
Resistance @ 85 L/M	15.	m.m.
Time @ 5,000 P.P.M.	45	min.
Flow Int., 32 L/M, 22 strokes/Min.		
Mesh of Absorbent	14-16	

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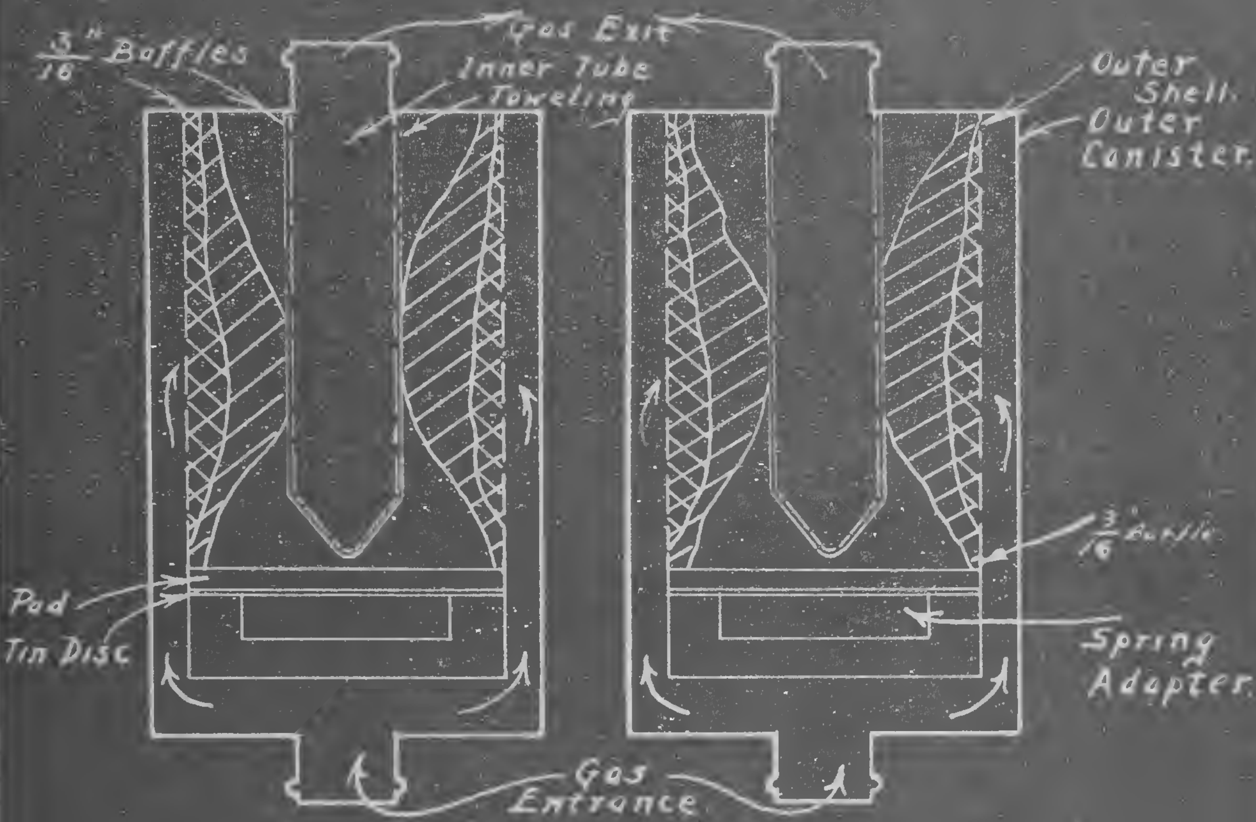
GAS MASK RESEARCH

WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CANISTER. ABS. DEPTH = 30 M.M.

DRAWN BY D
DATE 11-9-18
APPROVED BY
COUNTERSIGNED BY
296 E



PROBLEM E-11.

Weight of Absorbent	450.	gr
Unchanged "	32.3	%
Resistance @ 85 L/M	15.5	m.m.
Time @ 5000 P.P.M.	49.	min.

Flow Int., 32 L/M, 22 strokes/min.

Mesh of Absorbent 18-20

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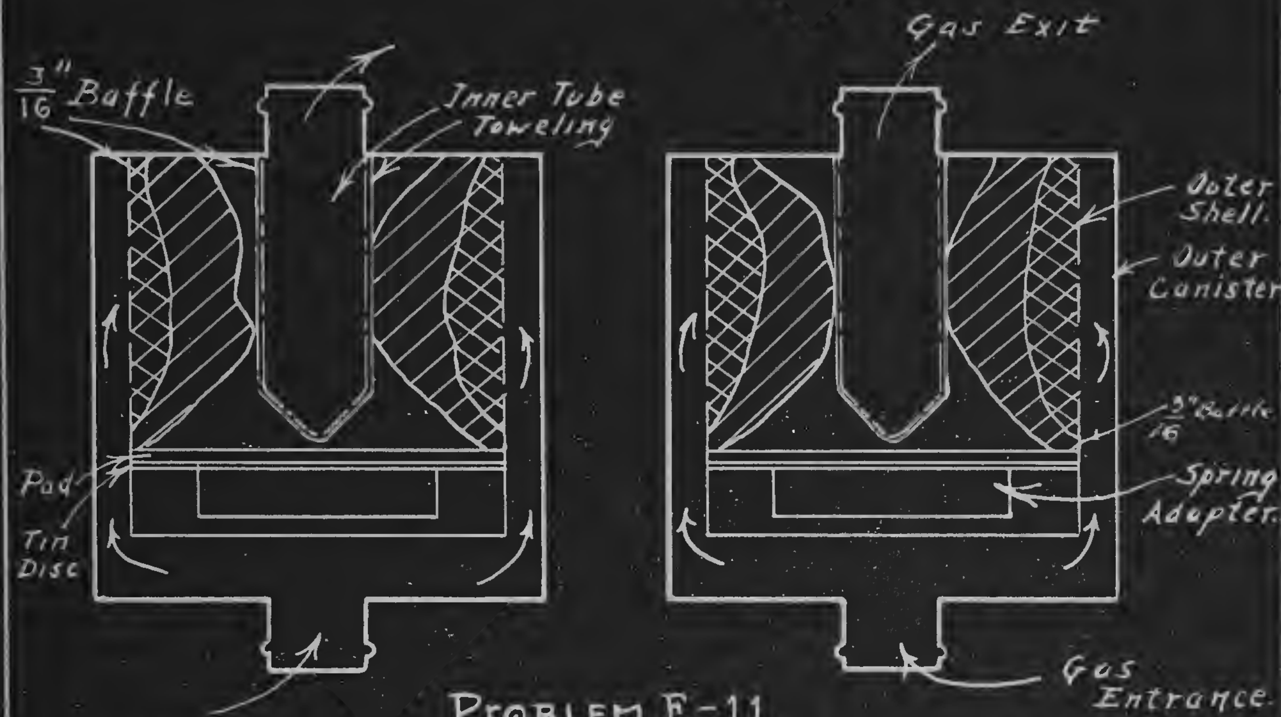
WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CANISTER ABS. DEPTH 25 M.M.

SCALE ½" = 1
DRAWN BY V
CHECKED BY R.F.
DATE 11/7/18

NUMBER 293-E

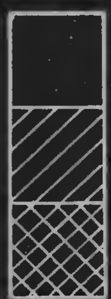


PROBLEM E-11.

Weight of Absorbent	460.	gr.
Unchanged "	16.0	%
Resistance @ 85L/M.	14.0	m.m.
Time @ 5000 P.P.M.	40.0	min.

Flow, Int., 32L/M, 22 Strokes/Min.

Mesh of Absorbent (12-14)



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GAS MASK RESEARCH — A. C. FIELDNER

WAVE FRONT OF OPTIMUM GRANULES IN CENTRAL BREATHING TUBE CANISTER ABS. DEPTH=35 m.m.

Scale 1/2" = 1" — Checked — Date 11/7/18 — Countersigned by — 294E

penetrated first from the bottom, and that a better design was obtained by closing off the bottom with solid tin and having the inner breathing tube extend nearly to the bottom. This so-called Revised Logan canister has a resistance (including filter) of less than 2 inches and the protection afforded per unit volume of absorbent is much greater than in any other type so far designed.

18. METHODS OF TESTING GAS MASK FABRICS AND PROTECTIVE CLOTHING:

Methods have been devised and standardized for testing the permeability of gas mask fabrics and protective clothing for the following gases: chloropicrin, phosgene, acrolein, dimethyl chloroarsine, mustard gas, superpalite. Lewisite, ethyl iodoacetate, chloracetophenone, and xylyl bromide. Both chemical and physiological tests have been employed. These methods have been adopted by the Gas Defense Division.

19. ROUTINE PERMEABILITY TESTS OF MASK FABRICS AND PROTECTIVE CLOTHING:

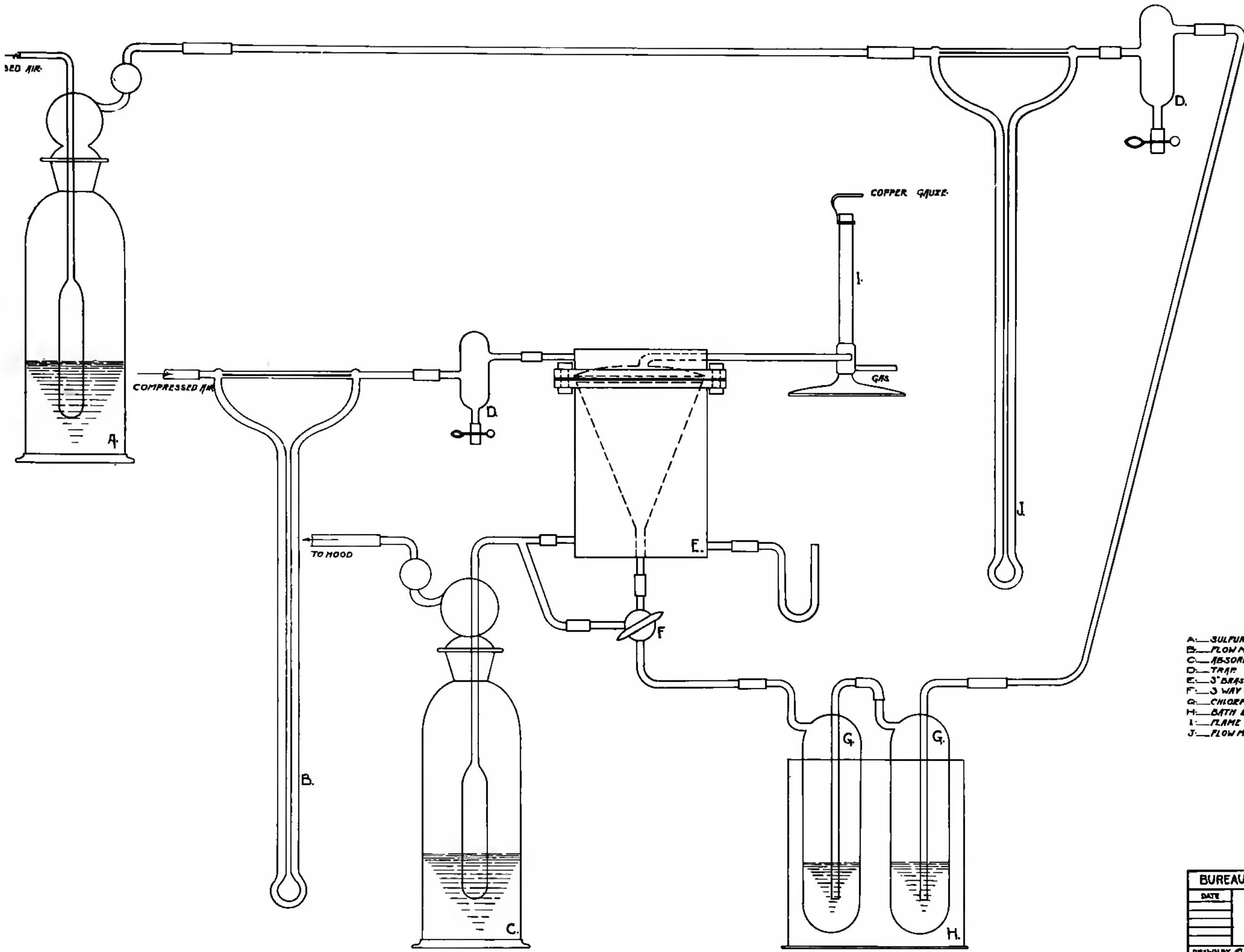
The Fabric Testing Unit has examined about 625 different fabrics, making in all some 2500 separate permeability tests. Fabrics intended for gas mask use were generally tested against PS only, while those considered as possible material for protective clothing were tested against both PS and HS. The times of penetration for HS are merely relative values, and do not show the actual time required for HS to penetrate, because of the lesser sensitivity of the indicator used as compared with a physiological test.

The results of permeability tests on about 85 representative fabrics will be found in the Appendix to this report, Table IV.

It will be seen that fabrics fall into four general classes, according as the gas-proofing material is (1) rubber, (2) pyroxylin (cellulose acetate, nitrate, etc), (3) oxidized oil (e.g. linseed, chinawood, etc), or (4) gelatin(glue-glycerine, gelatine-formaldehyde, etc.). In general these groups show resistance to penetration by the common war gases of organic nature, in the order listed, the gelatin fabrics being extremely resistant.

20. DEVELOPMENT OF PROTECTIVE COATINGS FOR FABRICS:

(a) Impervious fabrics: Fabric coated with "Viscamite" a starch plumbate, proved extremely resistant to



A.—SULFURIC ACID DRYING BOTTLE.
B.—FLOW METER.
C.—ABSORBENT BOTTLE.
D.—TRAP.
E.—3" BRASS DIFFUSION APPARATUS.
F.—3 WAY STOP.
G.—CHLORPICRIN SATURATING BOTTLES.
H.—BATH AT 20° C.
I.—FLAME TEST.
J.—FLOW METER.

BUREAU OF MINES PITTSBURGH, PA.

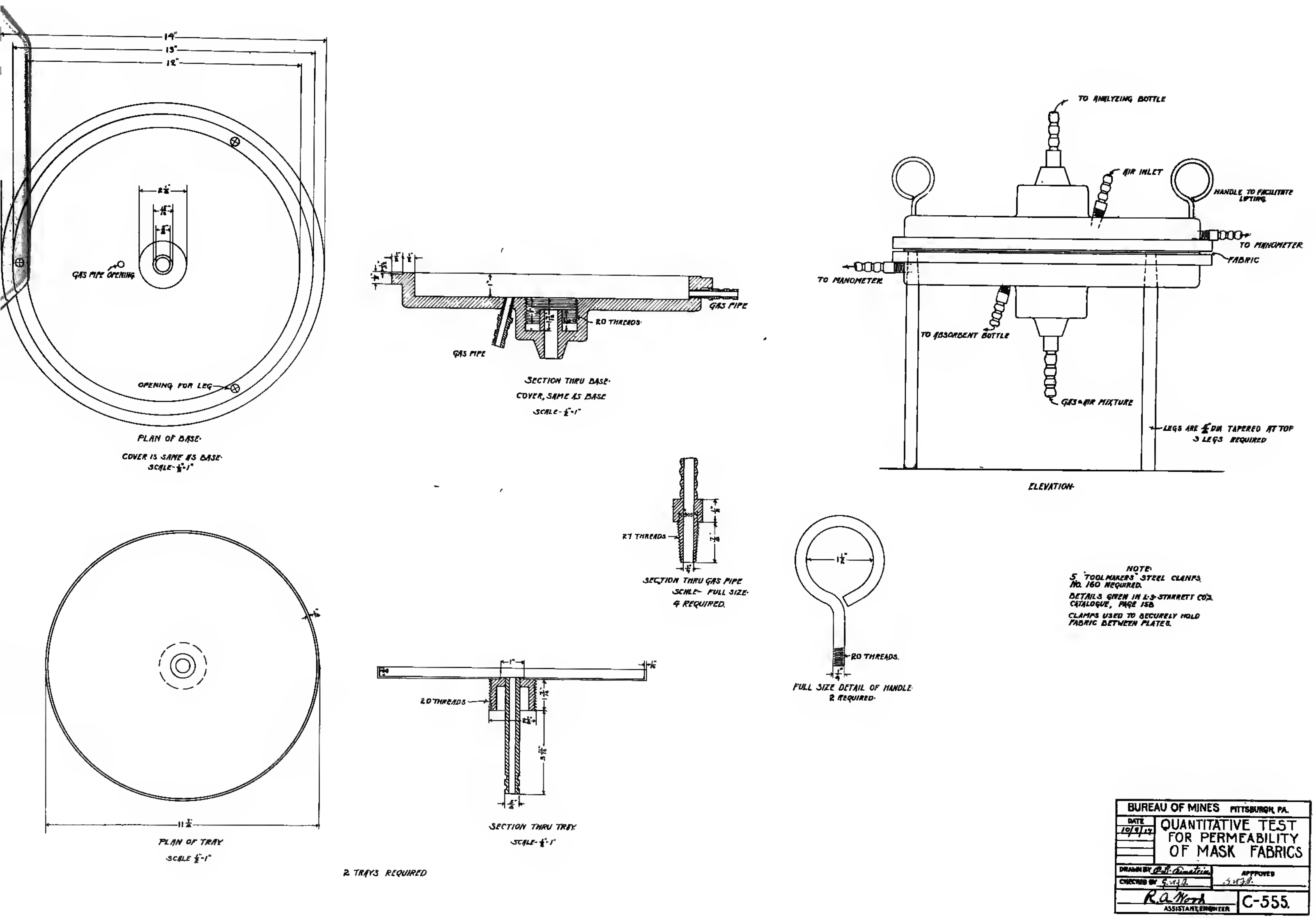
DATE

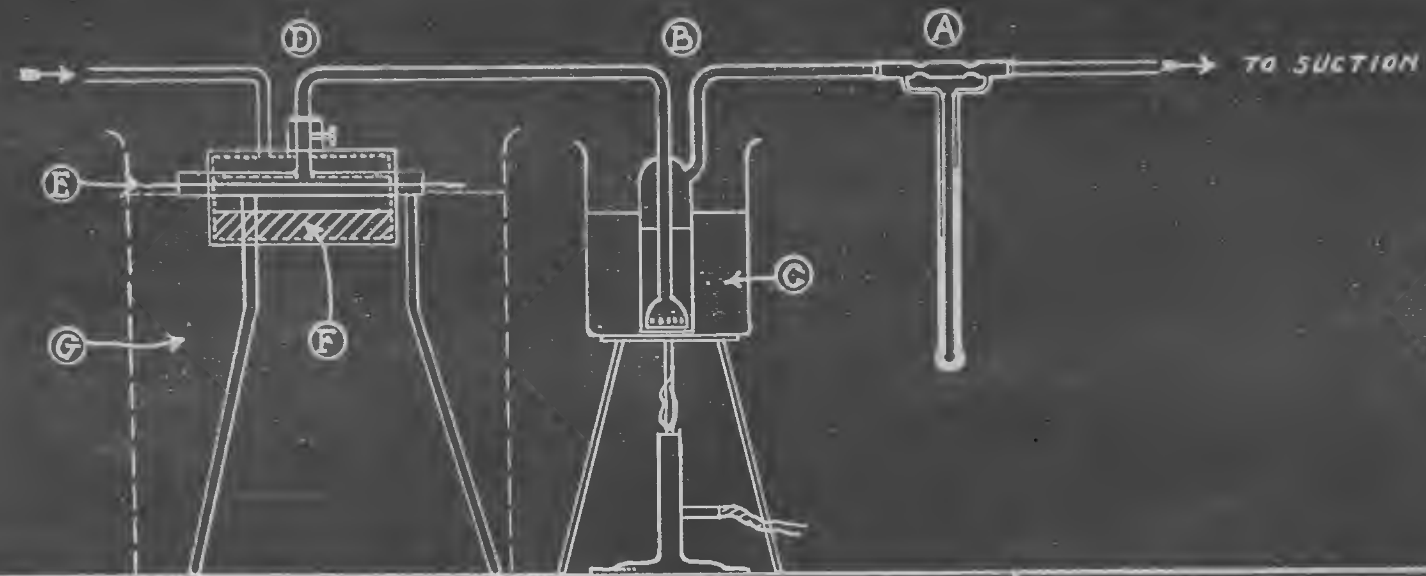
FLAME TEST FOR PERMEABILITY OF MASKE FABRICS.

DRAWN BY C. B. Sinestein
CHECKED BY G. W. J. P.
APPROVED G. A. J. B.

R. A. Wood.
ASSISTANT ENGINEER

C·533.


14"
13"
12"
GAS PIPE OPENING
OPENING FOR LEG
PLAN OF BASE.
COVER IS SAME AS BASE.
SCALE-⅛"-1"
GAS PIPE
RO THREADS
SECTION THRU BASE.
COVER, SAME AS BASE
SCALE-½"-1"
TO ANALYZING BOTTLE
AIR INLET
HANDLE TO FACILITATE LIFTING
TO MANOMETER
FABRIC
TO MANOMETER
TO ABSORBENT BOTTLE
GAS & AIR MIXTURE
LEGS ARE ⅝" DIA TAPERED AT TOP
3 LEGS REQUIRED
ELEVATION.
RT THREADS
SECTION THRU GAS PIPE
SCALE- FULL SIZE.
4 REQUIRED.
1½"
RO THREADS.
FULL SIZE DETAIL OF HANDLE.
2 REQUIRED.
NOTE:
5 "TOOLMAKERS" STEEL CLAMPS
No. 160 REQUIRED.
DETAILS GIVEN IN L.S. STARRETT CO'S CATALOGUE, PAGE 158.
CLAMPS USED TO SECURELY HOLD FABRIC BETWEEN PLATES.
11½"
PLAN OF TRAY
SCALE ½"-1"
RO THREADS
SECTION THRU TRAY.
SCALE-½"-1"
2 TRAYS REQUIRED
BUREAU OF MINES PITTSBURGH, PA.
DATE 10/9/17
QUANTITATIVE TEST FOR PERMEABILITY OF MASK FABRICS
DRAWN BY
CHECKED BY
APPROVED
R.A. Work
ASSISTANT ENGINEER
C-555.



Ⓐ — FLOWMETER

Ⓑ — ABSORPTION TUBE

Ⓒ — WATER BATH AT 85°C

Ⓓ — PERMEABILITY APPARATUS

Ⓔ — FABRIC

Ⓕ — COTTON WADDING SATURATED WITH DICHLORETHYLSULPHIDE

Ⓖ — WATER BATH AT 20°C

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

PERMEABILITY TEST APPARATUS.

SCALE	APPROVED BY G. St. J. Perrott	NUMBER 463-D
DRAWN BY V		
CHECKED BY	COUNTERSIGNED BY	
DATE 1-29-19		

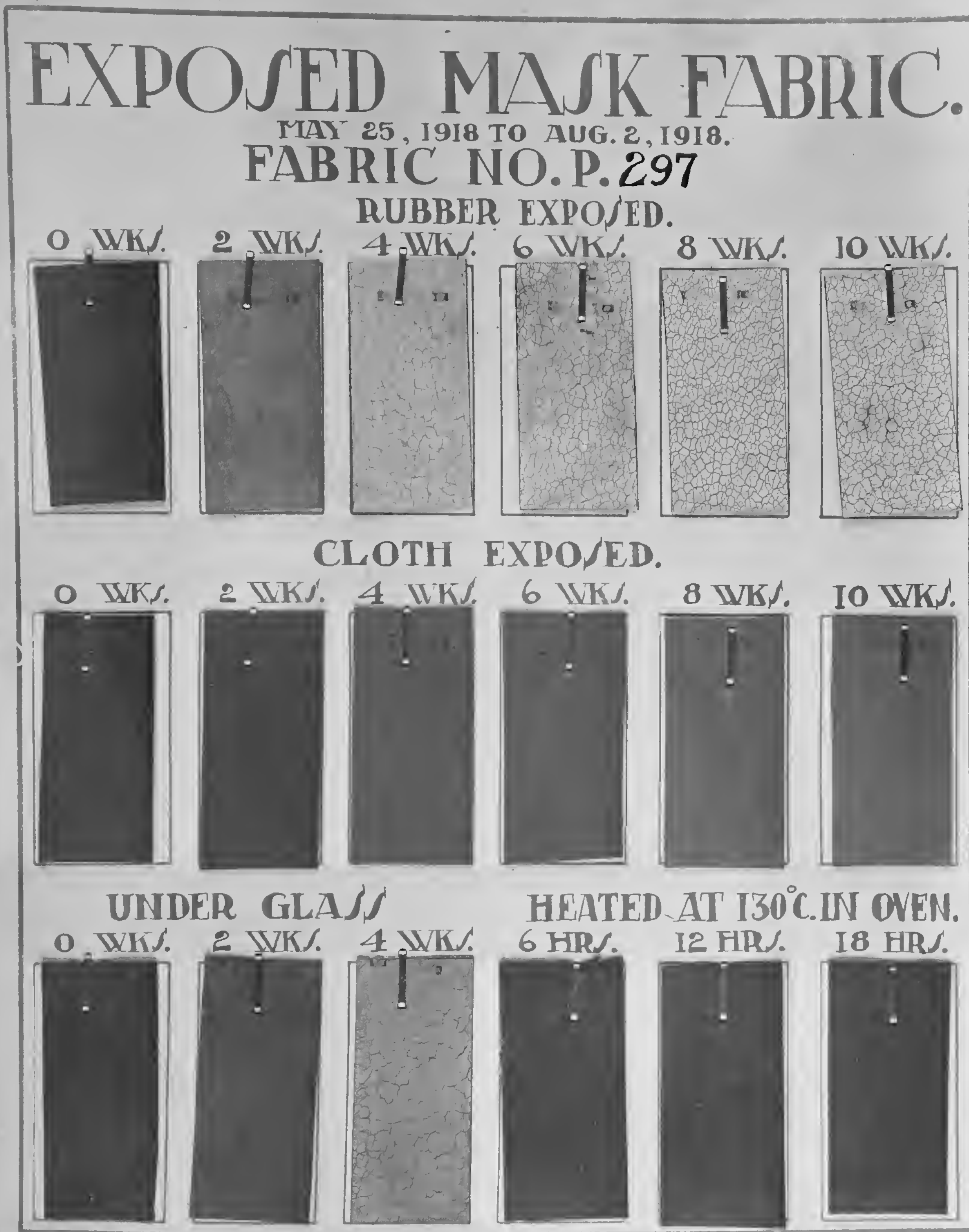
HS, giving a time to penetration of 24 hours. The material had the disadvantage of not being entirely waterproof, although its other mechanical qualities were excellent. When mixed with 25% of pyroxylin varnish, the material was waterproof, but offered no great resistance to HS. Fabrics coated with viscose have been found to be extremely resistant to HS (48 hours) and to aerate very rapidly, but it has not been possible to make a coating with sufficient elasticity. Chlorinated gelatine resists HS for long periods. When mixed with oil this material is flexible, but not completely waterproof.

(b) Air- and Water-permeable fabrics: Considerable work has been done in an attempt to produce a fabric which would permit transpiration of water vapor and preferably air as well, but resist the passage of HS. A variety of oil impregnating media were investigated. It was found advantageous to substitute cheaper and more readily available material, i.e. rosin and cylinder oils, for the lanolin in the lanolin-zinc soap emulsion for impregnating fabrics (developed by Dr. Hill of the Defense Chemical Research Section). An improvement was made in protective underwear by using a soluble soap mixture in oil instead of the insoluble soap, since in washing a high percentage of the insoluble soap was lost, and it seemed better to use a soluble soap which could be completely removed by washing. The sodium soap-cylinder oil mixture, when impregnated on thin sheeting to about 50% of the weight of the sheeting, gave protection against saturated HS vapor for 20 minutes, as shown by physiological test.

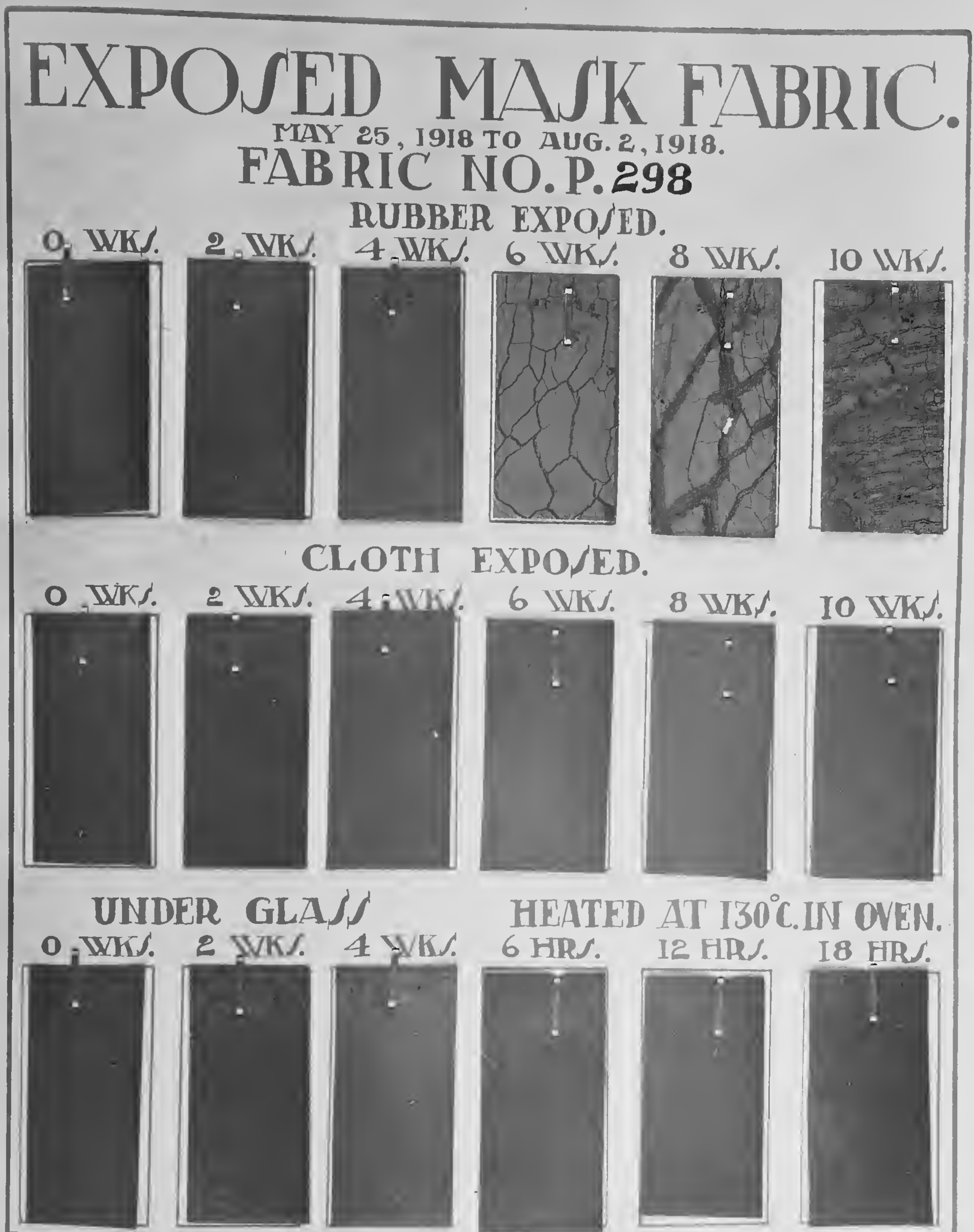
All these impregnating media serve merely to dissolve HS and have no destructive action. Mixtures of chlorazene with soluble soaps and glycerine were, however, found to afford considerably better protection than the soaps alone, and gave only a very slight residual burn after being broken down by HS.

21. RENOVATION OF FABRICS CONTAMINATED WITH HS:

A large number of solutions have been investigated with a view to the destruction of HS on fabrics. Small scale tests were made first, using pieces of diaper cloth, after which large scale test using O.D. woolen uniforms were carried on. The solutions showing the greatest hydrolyzing effect in the first tests were used for renovating the uniforms. From the results of the preliminary tests, the following solutions seemed to be the most efficient.


EXPOSED MASK FABRIC.
MAY 25, 1918 TO AUG. 2, 1918.
FABRIC NO. P. 297
RUBBER EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
CLOTH EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
UNDER GLASS
0 WKS. 2 WKS. 4 WKS.
HEATED AT 130°C. IN OVEN.
6 HRS. 12 HRS. 18 HRS.

2363


EXPOSED MASK FABRIC.
MAY 25, 1918 TO AUG. 2, 1918.
FABRIC NO. P. 298
RUBBER EXPOSED.
0 WKS.
2 WKS.
4 WKS.
6 WKS.
8 WKS.
10 WKS.
CLOTH EXPOSED.
0 WKS.
2 WKS.
4 WKS.
6 WKS.
8 WKS.
10 WKS.
UNDER GLASS
0 WKS.
2 WKS.
4 WKS.
HEATED AT 130°C. IN OVEN.
6 HRS.
12 HRS.
18 HRS.


EXPOSED MASK FABRIC.
MAY 25, 1918 TO AUG. 2, 1918.
FABRIC NO. P. 299
RUBBER EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
CLOTH EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
UNDER GLASS
0 WKS. 2 WKS. 4 WKS.
HEATED AT 130°C. IN OVEN.
6 HRS. 12 HRS. 18 HRS.


EXPOSED MASK FABRIC.
MAY 25, 1918 TO AUG. 2, 1918.
FABRIC NO. P. 366
RUBBER EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
CLOTH EXPOSED.
0 WKS. 2 WKS. 4 WKS. 6 WKS. 8 WKS. 10 WKS.
UNDER GLASS
0 WKS. 2 WKS. 4 WKS.
HEATED AT 130°C. IN OVEN.
6 HRS. 12 HRS. 18 HRS.

2362

of all fabrics decreased about 15% as a result of the exposure. Exposure to high concentrations of CG for 15 hours rotted both the fabric and the rubber. Chemical analysis of the fabrics indicated that more than 10% bitumen is undesirable and that as high as 20% of carbon tends to preserve the fabric, especially when exposed to sunlight. Fabrics with a high percentage of gum were found, in general, to be more resistant to the effects of weather than those containing a large amount of filler. On the whole the results showed that any of the fabrics tested, with the exception of the Kenyon Company samples, were satisfactory from the standpoint of resistance to weather.

A number of other aging tests were made on various fabrics. Materials submitted by the DuPont Fabrikoid Company for use in overall garments for protection against HS were exposed to sun and rain for two weeks, after which the fabrics were swollen and brittle and quite useless. A considerable number of permeability tests were also made to determine the effect of aging on a variety of fabrics submitted by the Gas Defanse Division.

23. MECHANISM OF FABRIC PENETRATION:

The mechanism of the passage of gas through rubber is undoubtedly one of solution; all the evidence is in harmony with this point and some results cannot be explained on any other basis. Thus the relative rates of diffusion of some gases are as follows: nitrogen 1, oxygen 2.5, hydrogen 5.5, carbon dioxide 13.6; results which could not be accounted for on the basis of a diffusion through the pores. Again the very large effect of temperature is far beyond what it could possibly be if the passage were through actual pores.

The war gases, especially those which are easily condensible vapors penetrate rubber fabric very readily. A rubber sheeting 0.10 inch thick is penetrated by the saturated vapor of chloropicrin in about 15 minutes. Phosgene under the same conditions (1,000,000 p.p.m.) penetrates in about 5 minutes, acrolein in 4 minutes, superpalite in 15 minutes, xylyl bromide in 30 minutes, monomethyldichlorarsine (liquid) in 8 minutes, chlorcyanogen (1,000,000 p.p.m.) in 8 minutes, mustard gas liquid in 10 minutes, mustard gas saturated vapor in 45 minutes. All figures are for 20°C.

Aeration is very important. A fabric initially permeated by the gas will continue to give off this gas for some time thereafter and is consequently useless until this evolution of gas has ceased. The importance of the rapidity

These results show that small quantities of water in the capillaries of the fabric actually hasten the rate of penetration by mustard gas.

24. DUGOUT PROTECTION:

In protecting dugouts from gas, blanket curtains which roll down over a wooden door frame have been found most satisfactory. Usually two of these blankets are employed with an air lock between. When in use, the blankets were kept saturated by spraying with the Vermorel spray solution (sodium carbonate and sodium thiosulphate). The function of this solution was not that of filtering air which passed through the fabric but was to render the fabric impermeable. Dugouts are apparently not closed for long enough continuous periods to require ventilation. This apparently very imperfect means of protection had the advantages of simplicity and durability, which enabled it to survive other schemes such as gas-tight doors and the like.

The drawbacks of the method were principally in the solution used for saturating the blankets. Blankets sprayed with the Vermorel solution dried out quickly and had to be resprayed very frequently. Calcium chloride and glycerine solutions were found to be unsatisfactory due to their tendency to sweat and collect moisture on the floor. The ideal impregnating medium should keep the blanket at the proper degree of dampness without draining. Mixtures of mineral oil and lanoline and vaseline proved more impermeable than any impregnating media before tried and had the advantage that they did not drain out at temperatures as high as 60°F. It is not known that these oil-impregnated blankets were ever used by the British in the field.

In response to a cabled request from General Pershing an intensive study of the available oils in this country suitable for impregnating blankets was made. At the same time a search was made for a substitute for the army blanket which should be cheaper, stronger and more efficient. Investigation of the possibility of using a pyroxylin or linseed oil coated fabric for the purpose was also undertaken.

As a result of several months of work in which tests of blankets impregnated with a great variety of impregnating materials were made in a model dugout test chamber, it was decided that the best oil impregnating medium from the point of view of efficiency and availability was a mixture consisting of 85% of a steam refined cylinder

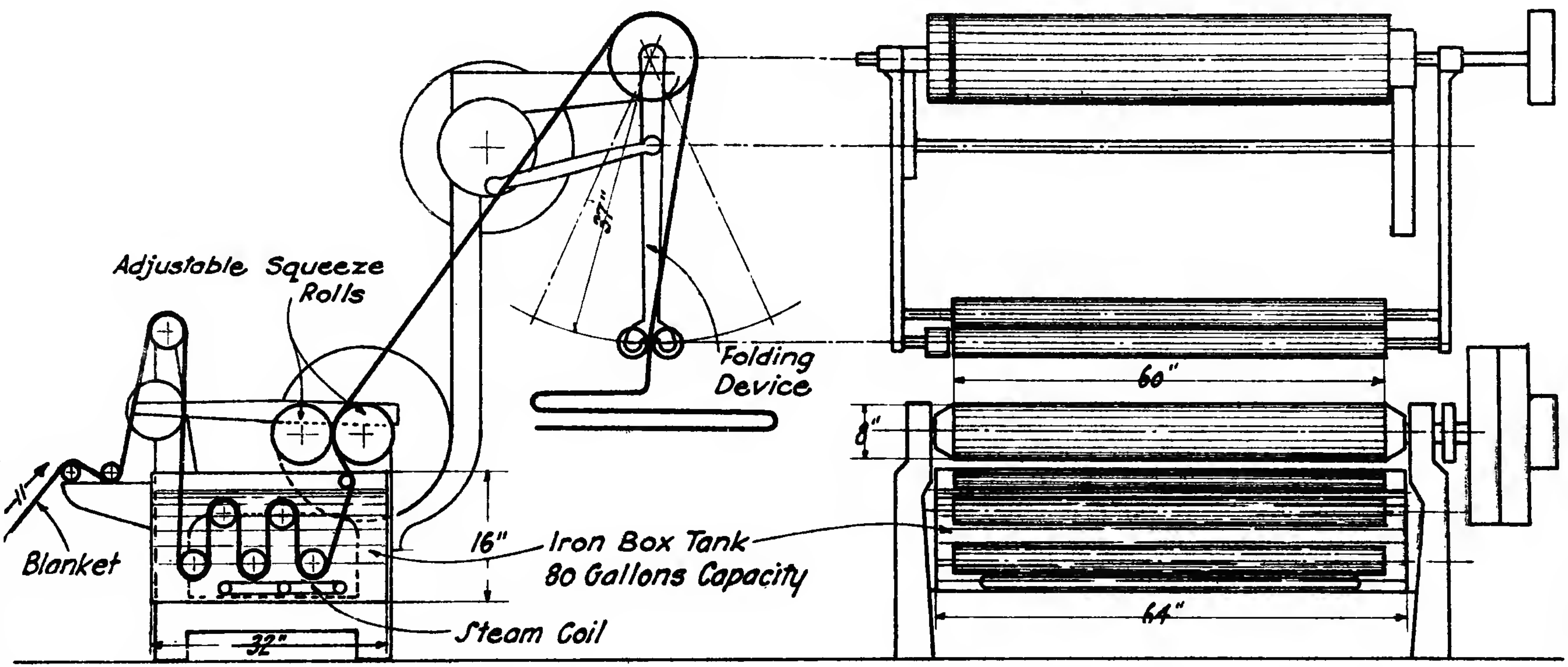
stock or topped crude oil with a viscosity over 200 seconds Saybolt and 15% boiled linseed oil. The linseed oil was added to give a curtain with a less sticky surface and to prevent draining. Such a curtain would resist field concentrations of gas for an almost indefinite period of time, would not drain appreciably even in summer weather and would retain its flexibility to a large degree even at temperatures as low as 0°F.

As a result of conferences with several blanket manufacturers, a number of experimental fabrics were made up for testing. The blanket finally selected was an all-cotton blanket made on the American cotton system, weighing about 3.5 lbs. (4 ft. x 7 ft.) costing about $3.50. It had a very tight weave which showed a tendency to slide on the warp, it absorbed the oil well leaving a semi-dry surface, and had a tensile strength over 60 lbs. in each direction. This blanket was much superior in every way to the army blanket for the purpose and cost about 25% less.

Due to difficulties in shipping the impregnated blankets, impregnation was to be carried out in France. For this purpose two types of machine were recommended: (1) a power driven machine designed by the H.W. Butterworth Company of Philadelphia which would be capable of handling the entire needs of our army. Blankets sewed end to end with a coarse chain stitch are sent through the machine in an endless chain. A folding device deposits the impregnated material in wooden cars from which the blankets are hung on racks and dried for several days. Blankets are shipped to the front in 50 yd. rolls, each roll in a wooden box to prevent squeezing out of the oil by pressure on the roll from above. (2) a field impregnating apparatus to supplement the power machine. This machine was to be used for reimpregnation and for initial impregnation if for any reason the supply of impregnated blankets should run out. In both apparatus the oil was kept at a temperature of about 70°C.

The finished blanket weighed about 15 pounds. Two Butterworth machines and 40 of the field impregnating apparatus were constructed.

Blankets were being manufactured by five concerns at the rate of about 40,000 per month beginning August 1, 1918. The number of blankets required was figured on the basis of 2500 blankets per 25,000 men sent to France. About 72,000 blankets had been shipped to the terminals in New York and Boston by October 5, 1918. Oil was shipped overseas in steel drums, 2620 gallons of mineral oil and 380 gallons linseed oil per thousand blankets



SECTION THRU SIDE

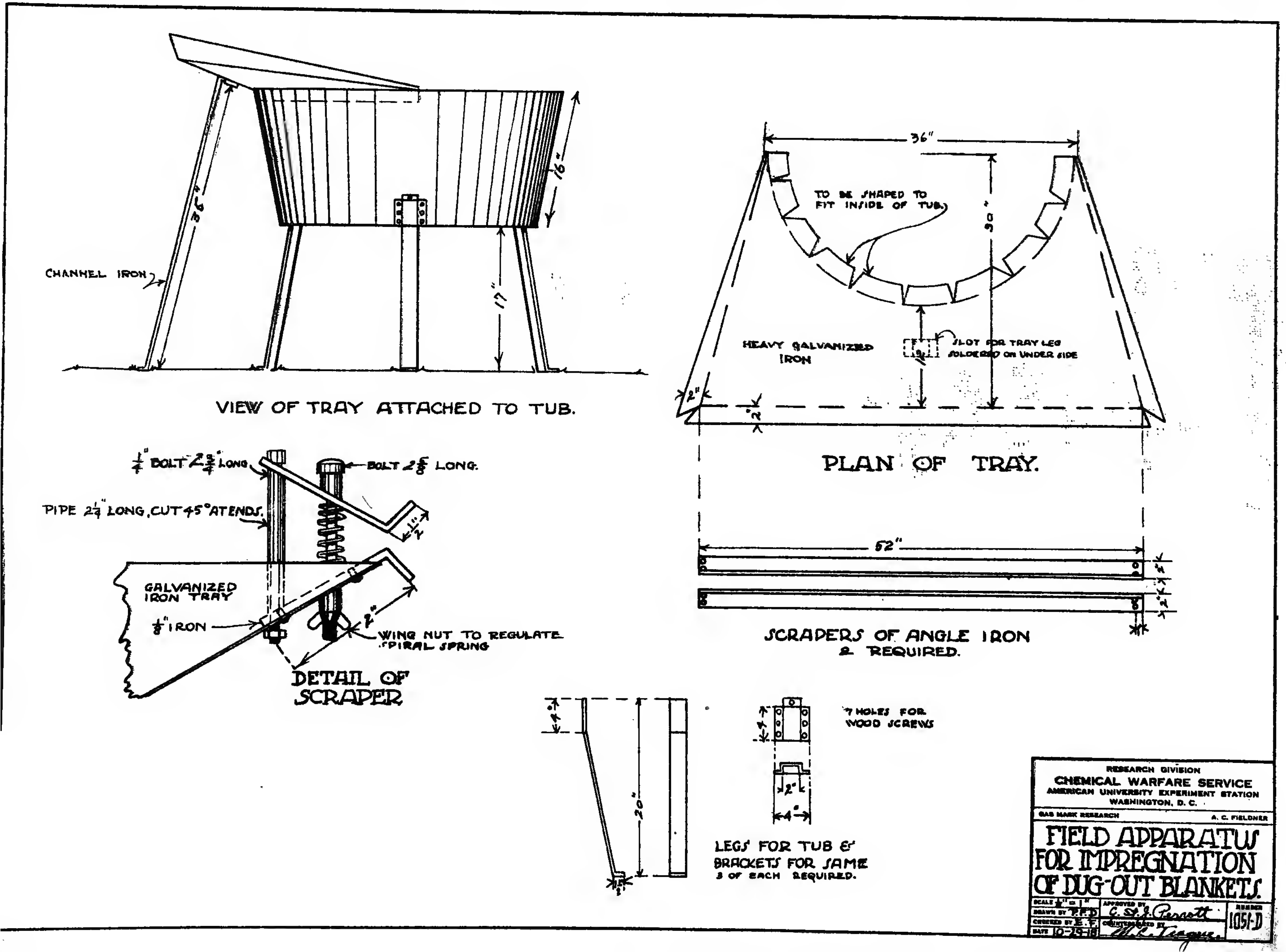
SECTION THRU FRONT

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

MACHINE FOR SATURATING BLANKETS
DESIGNED BY
H.W. BUTTERWORTH & SONS CO.

SCALE 1" = 2'-0"	APPROVED BY G. St. J. Perrott	NUMBER
DRAWN BY H		234-D
CHECKED BY P	COUNTERSIGNED BY	
DATE 9-23-18	A. C. Fieldner	


CHANNEL IRON
36"
16"
17"
VIEW OF TRAY ATTACHED TO TUB.
36"
TO BE SHAPED TO FIT INSIDE OF TUB.
30"
HEAVY GALVANIZED IRON
SLOT FOR TRAY LEG SOLDERED ON UNDER SIDE
2"
PLAN OF TRAY.
1/4" BOLT 2 3/4" LONG
BOLT 2 5/8 LONG.
PIPE 2 1/4" LONG, CUT 45° AT ENDS.
GALVANIZED IRON TRAY
1/8" IRON
WING NUT TO REGULATE SPIRAL SPRING
DETAIL OF SCRAPER
52"
SCRAPERS OF ANGLE IRON 2 REQUIRED.
4"
20"
2"
7 HOLES FOR WOOD SCREWS
LEGS FOR TUB & BRACKETS FOR SAME 3 OF EACH REQUIRED.
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
FIELD APPARATUS FOR IMPREGNATION OF DUG-OUT BLANKETS.
SCALE 1/4" = 1"
DRAWN BY P.F.D.
CHECKED BY E. F.
DATE 10-29-18
APPROVED BY C. St. J. Perrott
COUNTERSIGNED BY M. C. Teague
NUMBER 1051-D

produced were provided. This provided sufficient oil for saturating the cloth covered supports and for one reimpregnation.

A pyroxylin coated fabric made by the DuPont Company showed some promise. The fabric consisted of a napped moleskin cemented to a cotton sheeting coated with a pyroxylin composition. The back of this fabric was to be saturated with oil where it fitted against the supports in order to secure a gas-tight fit. About 100 of these blankets were made up and were to be sent to France for trial. They had the advantage of being light, clean, cheap and requiring no impregnation in France. It was a question whether the coating would stand the rough handling of field use, especially in cold weather.

25. COMFORT FIT AND GENERAL WEARING PROPERTIES OF MASKS:

The earlier experiments along these lines were largely confined to tests of fit and protection of various types of face-pieces. A number of tests were made to determine the effect of punctures on the protection afforded by Tissot type masks. A comparison of U.S. and foriegn masks showed that the French type was by far the most comfortable; the German type was more comfortable than the British or U.S. and was comparatively free from the dimming of the eye-pieces, observed in the case of the two latter. A number of types of modified Tissot masks were worn 15-30 minutes in the gas chamber, in nearly all cases with comfort and perfect protection to the wearer. The absence of dimming in this type of mask was very satisfactory.

The question of the physiological effect of breathing against resistance was studied and although no quantitative results were obtained because of the large number of variables involved, it was nevertheless firmly established that, qualitatively increased resistance reduces a man's working capacity and endurance.

Later a new unit was formed to investigate systematically the whole question of fit and wearing qualities of masks. Three standard tests have been devised for comparing different types of masks. Test No. 1, is a five-hour continuous-wearing test for comfort. During this time various activities are engaged in, and at the beginning and end of the period each subject fills out a questionnaire covering every detail of the protection, vision and especially the comfort afforded by his mask. There are 25 question each so worded that an answer of "yes" is at once indicative of dissatisfaction with that particular feature of the

WAR DEPARTMENT
AMERICAN UNIVERSITY EXPERIMENT STATION
Chemical Warfare Service, U.S.A.
Research Division
Washington, D. C.

STANDARD FIELD TEST # 1
Gas Mask Research Section
Problem No. . . . .
Date. . . . .

FIELD TEST No. NAME
INDIVIDUAL TEST No. TIME

Answer "YES" or "NO" by "X"		BEFORE Yes	BEFORE No	REMARKS	AFTER Yes	AFTER No	REMARKS
PROTECTION							
1. In gas-chamber, does the mask leak?	1						
2 Does mask need adjustment to keep out gas?	2						
VISION							
3 Would you prefer eyepieces higher?	3						
4 Would you prefer eyepieces lower?	4						
5 Is your angle of vision impaired laterally?	5						
6 Is your angle of vision impaired vertically?	6						
7 Do you get any dimming?	7						
8 Did you use anti-dim?	8						
COMFORT							
9 Is the head-harness uncomfortable?	9						
10 Are tapes crossing the ears uncomfortable?	10						
11 Is the forehead band uncomfortable?	11						
12 Does air blow into your eyes?	12						
13 Does the resistance seem high?	13						
14 Is the nose-clip uncomfortable?	14						
15 Does the mask touch your face?	15						
16 Does the mask touch your nose?	16						
17 Do air-tubes or deflectors touch your face	17						
18 Do air-tubes or deflectors touch your nose	18						
19 Is the chin-rest uncomfortable?	19						
20 Does the mask draw up on the chin?	20						
21 Does the mask hurt Adam's apple?	21						
22 Is the mask too full under chin?	22						
23 Does flutter-valve guard interfere?	23						
24 Is ability to talk hindered by mask?	24						
25 Does perspiration accumulate in mask?	25						
Totals							

Wearer's Facial Characteristics: Forehead. . . . . .inches.
Binders. . . . . .inches: Cranial. . . . . .inches.
Nose. . . . . .inches.
Size of mask indicated. . . . .

Rate your mask by checking one of these:

1	Absolutely unbearable	
2	Almost unbearable	
3	Highly uncomfortable	
4	Fairly comfortable	
5	Entirely comfortable	

Accurate description of mask:
Have you worn mask before?. . . . . How many total hours?. . . . .
When worn?. . . . . .Types of masks?. . . . .
Uncomfortable features--Order of importance:

Remarks:

Signed. . . . .
Major C.W.S. in Charge Gas Mask Research

By. . . . .

mask being tested. The percentage of affirmative answers received is, therefore, a measure of the general desirability, the best mask making the lowest percentage. Results follow:

Type of Mask	No. Tested	% answers indicating dissatisfaction Start of Test	End of Test
K.M. Tissot	15	11.0	11.2
Akron "	7	10.3	26.3
Kops "	3	18.7	20.0
Miller "	5	22.4	24.0
R.F.K. (U.S.)	1	16.0	28.0
German	14	35.1	30.4

The ratings given to the masks by their wearers at the end of five hours are given below:

Type of Mask	No. Tested	Entirely comfortable	Fairly comfortable	Highly comfortable	Almost unbearable	Absolutely unbearable
K.M.Tissot	15	93.3	6.7	0.0	0.0	0.0
Akron "	7	14.3	71.4	14.3	0.0	0.0
Kops "	3	0.0	100.0	0.0	0.0	0.0
Miller "	5	0.0	100.0	0.0	0.0	0.0
R.F.K.(U.S.)	1	0.0	100.0	0.0	0.0	0.0
German	14	0.0	42.9	28.6	28.6	
Miller (Rubber Dam)	12	16.7	75.0	8.3	0.0	0.0

It will be seen that the German mask was found to be much less comfortable than any of the Tissot types tested. The K.M. Tissot proved to be by far the most comfortable.

Test NO. 2, is for the protection afforded by the masks under conditions of increasingly severe activity. Visits to the gas chamber after each period of activity show whether the masks have been disarranged enough to cease protecting the wearer. A speed trial for adjustment is included in the test.

Type of Mask	No. Tested	% of masks failing to give protection: Start of Test	15 min. hike	15 mins. calisthenics	15 mins. games	Speed Test	Average time for adjustment (seconds)
K.M. Tissot	15	0	0	0	0	14.3	5.7
Kops "	5	0	0	20.0	0	60.0	5.2
Akron "	15	13.3	6.7	0	0	33.3	6.0
German "	14	35.7	21.4	14.3	0	7.1	2.5
R.F.K.(U.S.)	Not necessary to test--no possibility of danerous leakage.						

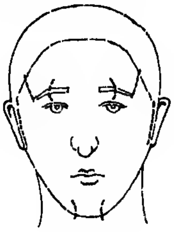
Test No. 3 is for vision. A special hemispherical chart, marked off in degrees, has been designed, so that measurements of the scope of vision may be taken in all directions. The test also includes a speed trial over a course filled with obstacles calculated to test especially downward and lateral vision. The percentage increase in a man's time when wearing a mask gives a measure of the value of that mask from the standpoint of vision.

Type of Mask	No. Tested	Percent of field included by observer without mask: total field	Above horizontal	Below horizontal	Binocular vision	Percent increase in time in obstacle race
No mask worn		100	100	100	100	----
K.M. Tissot	15	32.5	30.5	33.6	7.5	2.80
Akron "	14	35.7	37.6	34.7	8.0	8.57
Kops "	14	27.1	22.1	29.9	15.9	4.29
Miller "	--	37.4	22.9	45.4	10.9	----
R.F.K.(U.S.)	23	---	---	---	---	3.17
German	14	28.6	23.2	37.8	5.0	8.59

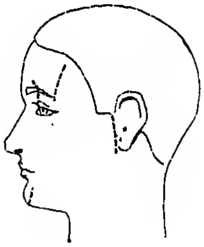
A simple guage has been developed whereby the tension on any particular tape of the head-harness of a mask may be read directly. Another apparatus has been constructed to measure the leakage around the edges of the

FIELD TEST REPORT

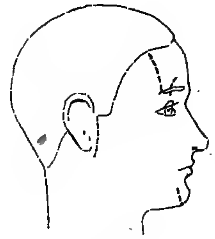
POSITION OF MASK BEFORE TEST



FRONT



LEFT



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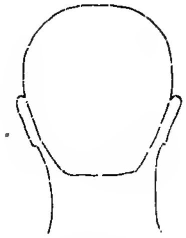
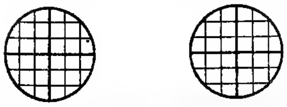
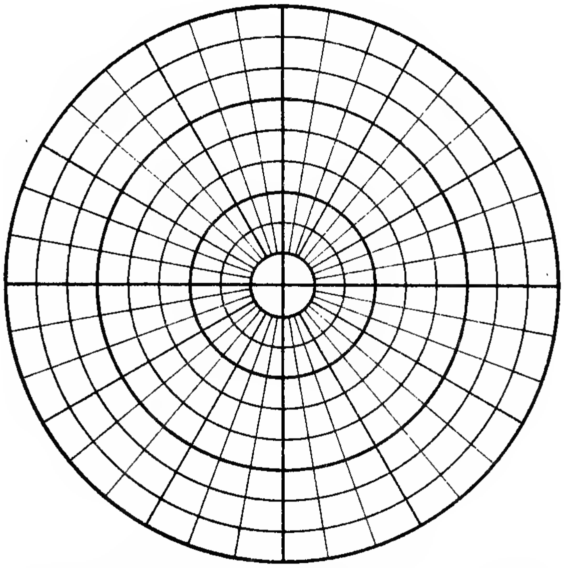


BACK

DOTTED LINES DENOTE NERVE COURSES



RIGHT LEFT
LOCATION OF PUPIL CENTER



SCOPE OF VISION

PROJECTION POINTS OF LENS CENTER INDICATED BY (X)

FIELD TEST NO. ______ NAME ______

STANDARD TEST NO. ______ DATE ______

INDIVIDUAL TEST NO. ______ TIME ______

ACCURATE DESCRIPTION OF MASK ______

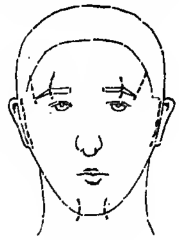
______

______

______

OBSERVED BY ______ CHECKED BY ______

POSITION OF MASK AFTER TEST



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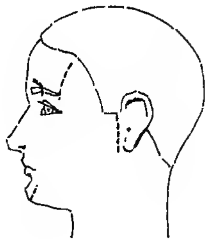

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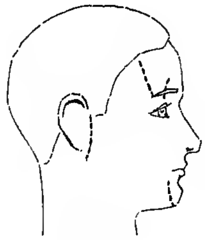
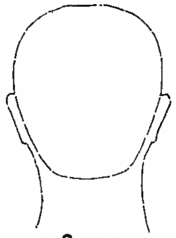
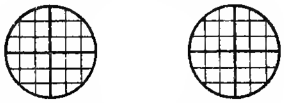


RIGHT

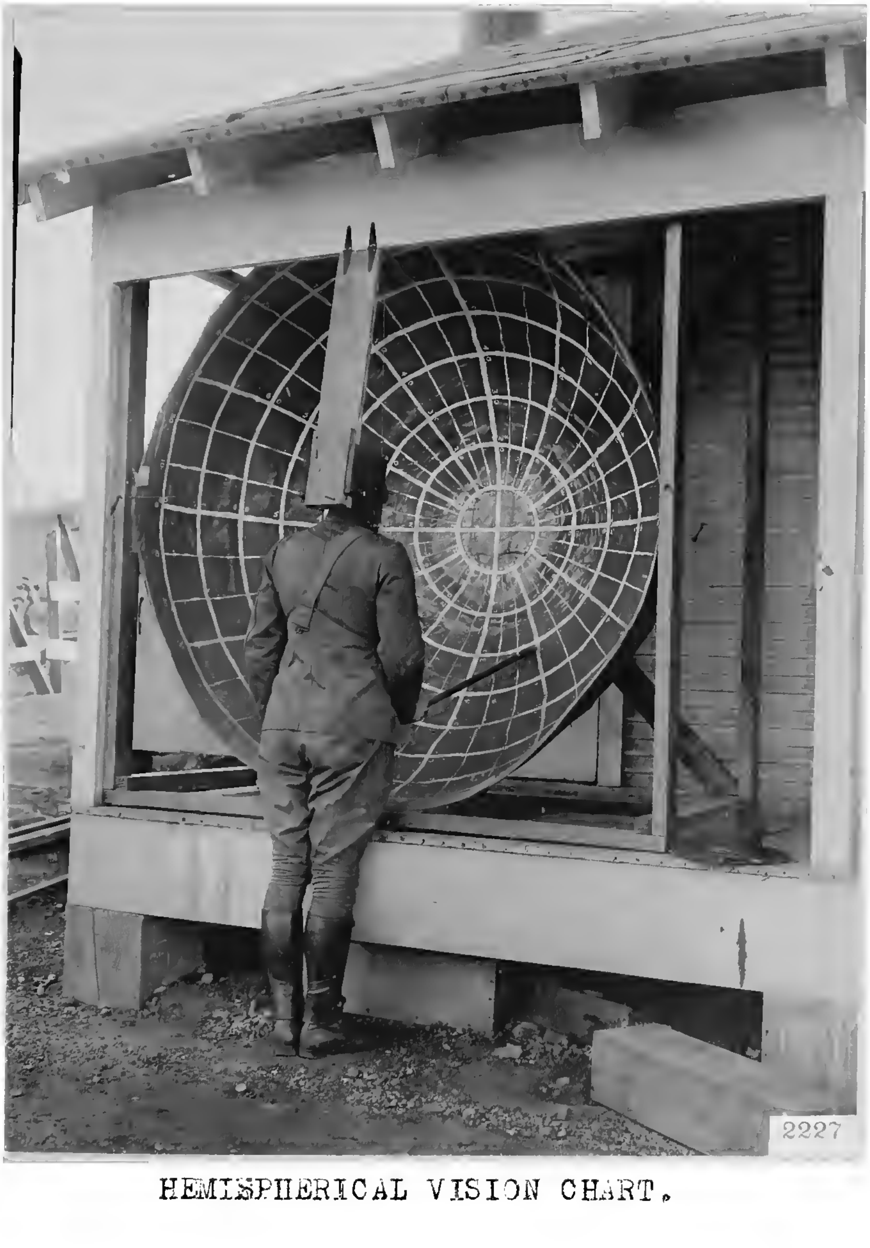


BACK

DOTTED LINES DENOTE NERVE COURSES



RIGHT LEFT
LOCATION OF PUPIL CENTER



HEMISPHERICAL VISION CHART.

Tissot type masks. Together these tests form a means of determining the relation between tightness of head-harness and mask leakage. These tests are not yet complete, but it has been found that for any given amount of face-piece leakage , the tension of the head tape must be greatest for the Kops Tissot, less for the Akron Tissot, and least for the K.M. Tissot. A secondary result of these tests was that face piece leakage is less at high breathing rates than at low ones.

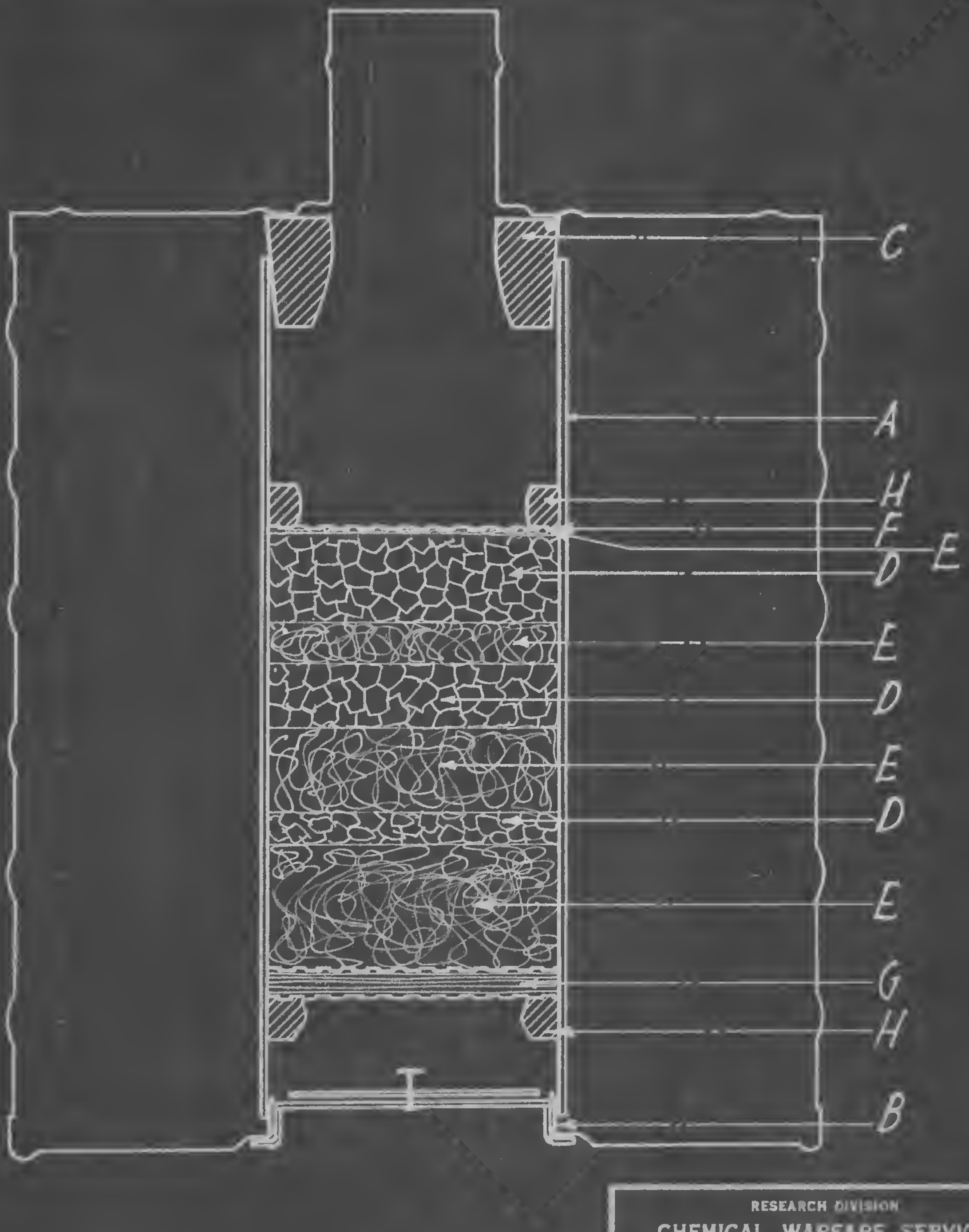
Taken together, these tests indicate a very marked superiority of the K.M. Tissot mask, in respect to fit, scope of vision, comfort, etc., over all other types tested. Other modifications of Tissot type masks were, in turn, superior to the German mask in these respects.

26. SMOKE TESTING:

Until early in 1918, the chief smokes encountered in gas warfare were stannic chloride, silicon tetrachloride, arsenic trichloride and titanium tetrachloride. In each case the dense white smoke was due to the hydrolysis of the original substance. The particles were comparatively large, moist and would rapidly clog filters. In testing canisters against such smokes it was therefore important to determine not only the efficiency-time curve but also the resistance-time relation.

The Gas Mask Research in connection with the Mechanical Research Section conducted an extensive investigation to determine the best material as well as its weight and position in the canister to offer adequate protection against these smokes. The chief materials tried were the following: lintene pads, absorbent cotton, cotton wadding, canton flannel, outing flannel, wool flannel, glass wool and steel wool. The work included both the army and navy canisters. Two 2-layer pads of cotton batting were recommended 1/3 and 2/3 distance in the navy canister while two 3-layer pads were similarly placed in the army canister. (Each pad used in the army canister weighed from 3.5 to 3.8 grams). The addition of the pads gave (1) perfect protection against these so-called heavy smokes except perhaps S-22. (2) increased protection against other war gases by the prevention of channeling. (3) smaller variation in resistance, (4) greater uniformity in life but (5) a material increase in the resistance of the canister (2 inches for the army canister).

The problem of protection against S-22 without an excessive increase of resistance was slightly more



RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

CANISTER FOR DETERMINING BREATHING RATES

SCALE FULL	APPROVED BY	NUMBER 349-H
DRAWN BY VV		
CHECKED BY J	COUNTERSIGNED BY	
DATE 12-12-18		

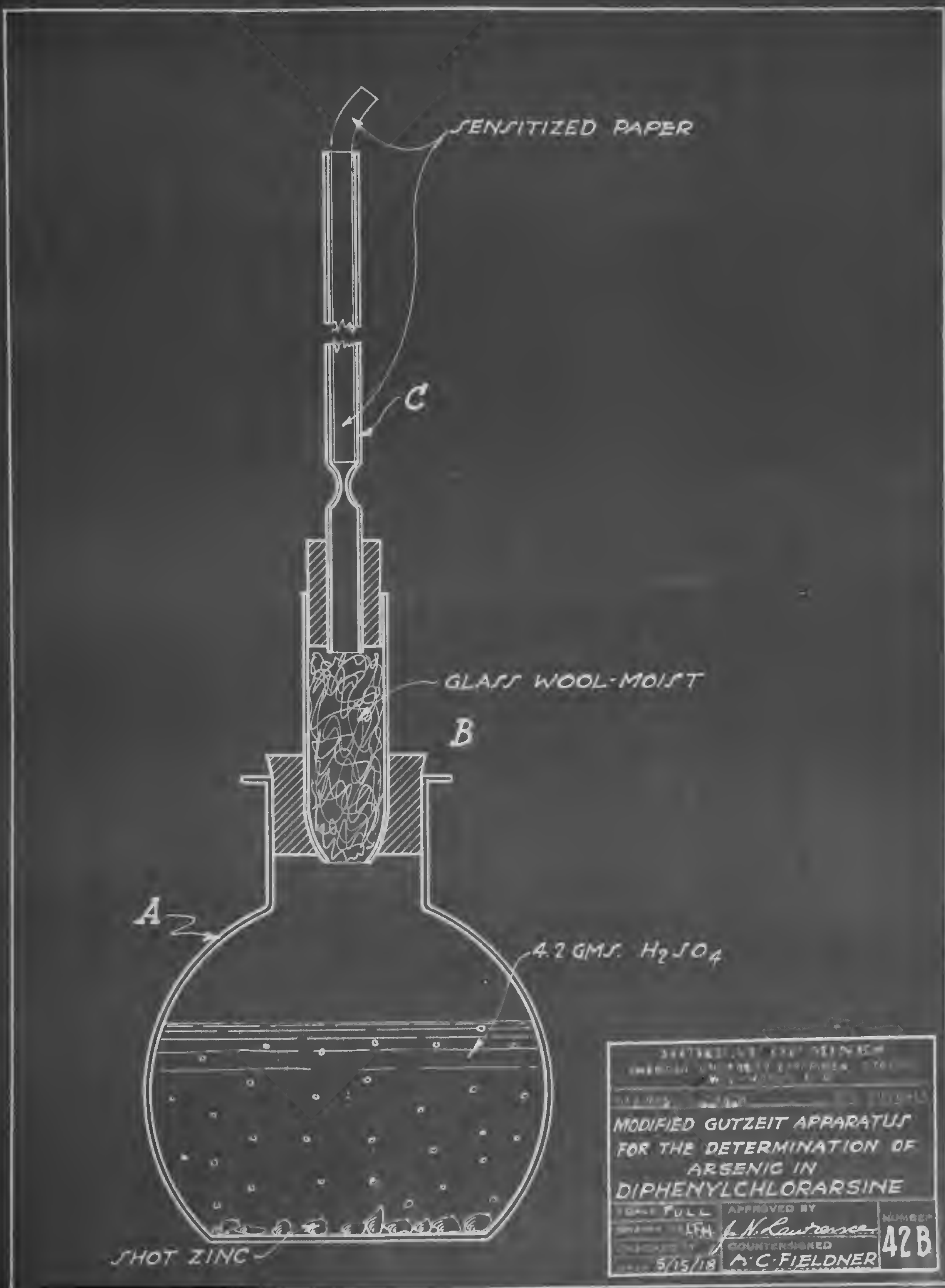
difficult. It was in this connection that the Gas Mask Research Section first suggested the use of paper as a filtering medium. (The British had previously employed a cellulose pad inside the canister). In order to avoid its great resistance the canister itself was placed inside a bag of closely woven paper. Other materials investigated for use as bag filters were: brown wool, white wool felt, loosely woven felt, shoddy felt, gray wool shoddy, analytical filter paper and cellulose surgical paper. It was at this time that DA was first introduced by the Germans, which made necessary an infinitely greater smoke protection. To obtain this, the British as well as the Americans have since adopted the above paper bag filter idea.

In order to develop a filter which would give adequate protection against DA it was essential that an accurate and rapid method of testing the proposed filters be established. This introduced many difficulties. The Gas Mask Research Section, therefore, confined itself largely to this phase of the problem, the further development of the filter itself being carried on by other sections.

Due (1) to varying amounts of impurities in the samples of G-76 with which the work had to be carried out, (2) to the widely different degrees of sensitivity of men to G-76 and (3) to the small concentrations then obtainable, the problem was not found to be an easy one. Considerable experience had first to be gained in purifying the material, after which a large so-called standard sample was prepared.

Three methods of analysis were developed (1) determination of the arsenic as arsenious acid by titration with iodine, (2) the so-called "iodine method" viz; absorption of the smoke in glacial acetic acid and titration with iodine, and (3) a modification of the Gutzeit method, in which arsine, formed from the DA is estimated colorimetrically by means of mercuric chloride paper. The first two methods are specially adapted to determining the purity of the solid material itself.

To determine the protection afforded by the standard canisters an apparatus similar to that used for chlorpicrin was first employed. They were found to give excellent protection against the saturated vapor air mixtures, due to the charcoal in the canisters. Protection was not afforded, however, against the "smoke-air" mixtures in which form DA was being used. The apparatus was then modified to accommodate the bag type of filter canister. The DA air-mixture was introduced into a shell jar in which the


SENSITIZED PAPER
C
GLASS WOOL-MOIST
B
A
4.2 GMS. H2SO4
SHOT ZINC
MODIFIED GUTZEIT APPARATUS FOR THE DETERMINATION OF ARSENIC IN DIPHENYLCHLORARSINE
FULL
LFH
5/15/18
APPROVED BY
J. N. Lawrence
COUNTERSIGNED
A. C. FIELDNER
NUMBER
42B

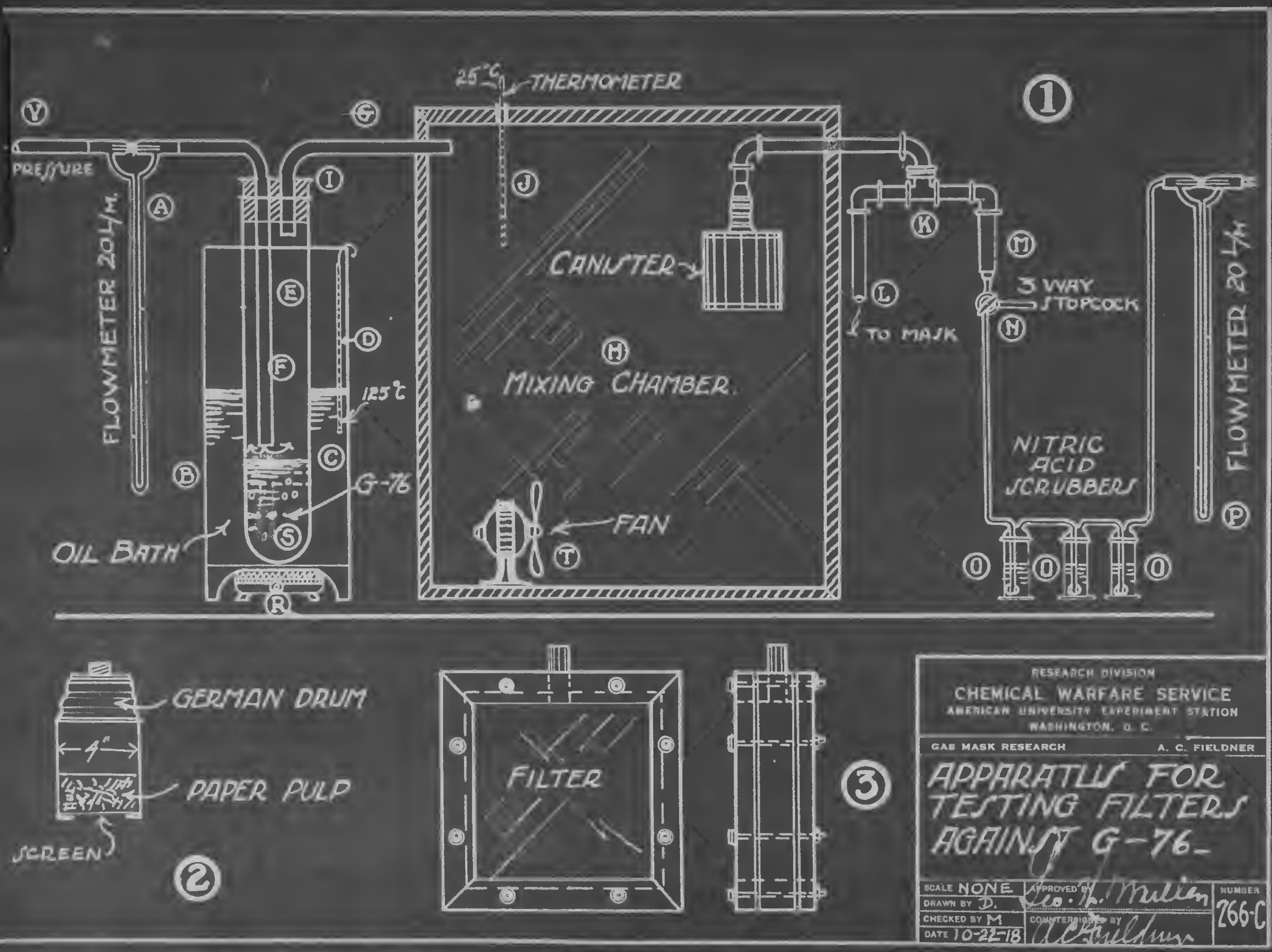
canister was tested, this insuring the use of the entire filtering surface against the smoke-air mixture.

The method to be used in putting up concentrations of DA in the gas chamber was investigated quite thoroughly. (1) The DA was dissolved in ethyl alcohol and this solution sprayed into the chamber by means of small atomizers. (2) Either the liquid or solid material together with #6 electric detonators was placed in gelatine capsules; the capsules were suspended within iron guard shells (open at top and bottom) in the chamber, and detonation then effected. (3) A rapid stream of air was passed through heated DA and then into the chamber. The effect of size of detonator, amount of detonator per capsule, frequency of detonation, concentration of DA in the alcohol, temperature of bath and temperature and humidity in the gas chamber were carefully studied. After considering the effect of these various factors, the convenience of operation of the methods and the constancy of concentrations maintained by them, a carefully controlled detonation test was selected (using a "Standard" sample of DA). This method was later adopted by the Coordinating Committee on Analytical and Research Methods as the Standard DA Man Test to be used in all control laboratories.

There has been considerable dispute as to the reality of the so-called break point of the filter. Much work has been carried out in this connection with the result that the break point is now believed to be unreal. DA, it is thought, comes through the filter from the start of the test, but in amounts too minute for detection; the concentration is being increased as the test progresses until finally the effluent concentration is sufficient to be detected physiologically.

Due to the lack of sufficient data to furnish statistical averages and due to the use of impure samples, no apparent relation was observed between the man and machine DA tests. In view of the difficulties encountered in developing a convenient chemical qualitative test and to the fact that the man test most nearly resembled actual field conditions, the machine method of development testing was discontinued.

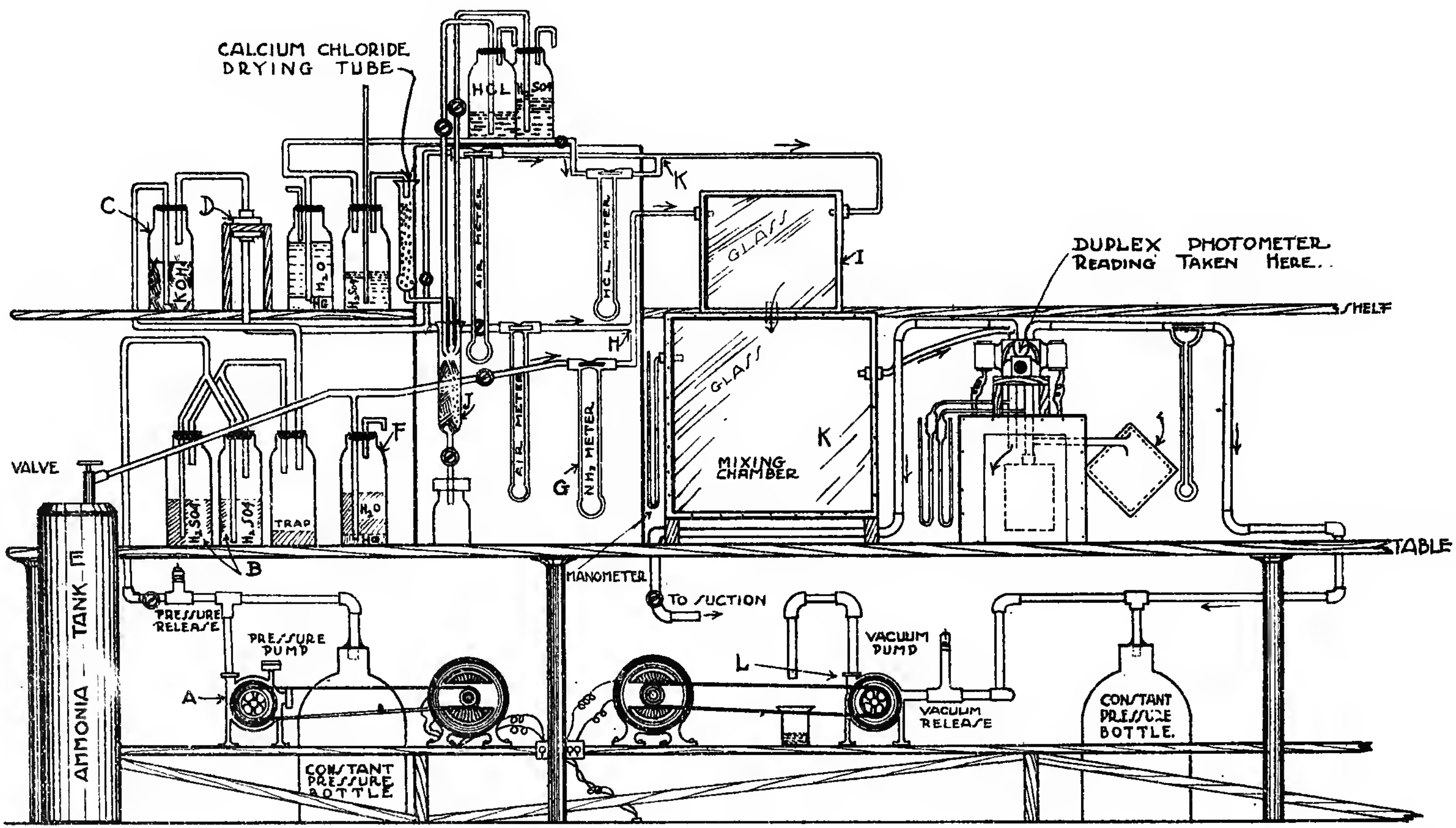
Considerable effort was next exerted in developing other and more convenient methods of grading filters and establishing their relation to the standardized DA Man Test. This effort has met with gratifying results. There have been two methods (ammonium chloride and tobacco smokes) developed and these together with a third (sulfuric acid smoke) studied in detail by this section.


1
PRESSURE
FLOWMETER 20 L/M.
25°C
THERMOMETER
CANISTER
MIXING CHAMBER.
FAN
OIL BATH
125°C
G-76
TO MASK
3 WAY STOPCOCK
NITRIC ACID SCRUBBERS
FLOWMETER 20 L/M
2
GERMAN DRUM
4"
PAPER PULP
SCREEN
FILTER
3
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
APPARATUS FOR TESTING FILTERS AGAINST G-76.
SCALE NONE
DRAWN BY D.
CHECKED BY M
DATE 10-22-18
APPROVED BY
COUNTERSIGNED BY
NUMBER 266-C

The ammonium chloride method consists in allowing a stream of hydrochloric acid-air-mixtures to meet a similar stream of ammonia in a reaction chamber, thus producing the ammonium chloride smoke. The quantitative determination of the filtering efficiency was made photometrically by measuring the relative intensity of the two Tyndall beams produced by the entering and effluent streams. Several standard forms of photometer were used, but owing to the difficulty in obtaining them, a new form, made of easily obtainable parts, was designed, and this has proved highly satisfactory for filter testing. The correlation between this method of testing canisters and the DA man test was found to be excellent. An ammonium chloride machine was installed at the Bureau of Standards for flange testing, and a thorough study made of the effect on the filtering efficiency of paper against ammonium chloride smoke of various factors, such as the rate of flow, concentration, humidity, and area of flange.

The tobacco smoke method of testing canisters and filtering materials was the product of considerable investigation of possible materials for testing purposes. Tobacco powder molded into sticks with potassium nitrate and rosin was finally chosen. These sticks burn slowly and uniformly to a clean ash, giving a dense homogeneous smoke. Filtering efficiencies were determined photometricall in much the same way as with ammonium chloride. Canisters tested by this method gave results in very satisfactory agreement with the efficiencies as determined by the standard DA man test. Tobacco smoke machines for testing various filtering materials were installed, along with the necessary operators, in the Bureau of Standards, A.D.Little, Inc. at Cambridge, Mass., and at the Forest Products Laboratory at Madison, Wis. This method of test proved entirely adequate as a guide in the development of canisters and papers for protection against toxic smokes. A thorough study was made of the variables involved in the test, and standard specifications drawn up for source of smoke, concentration, rate of flow and humidity.

The Manufacturing Development Section has studied sulphuric acid smoke for testing purposes, and this work was continued by this Section. This method has the advantage over the other two in that it is possible to determine the exact concentration of smoke which will penetrate a canister, whereas only relative percentage filtering efficiencies are determined by the other methods. The correlation between the sulfuric acid method and the DA man test was also very satisfactory. The method at first did



FRONT VIEW OF MACHINE.

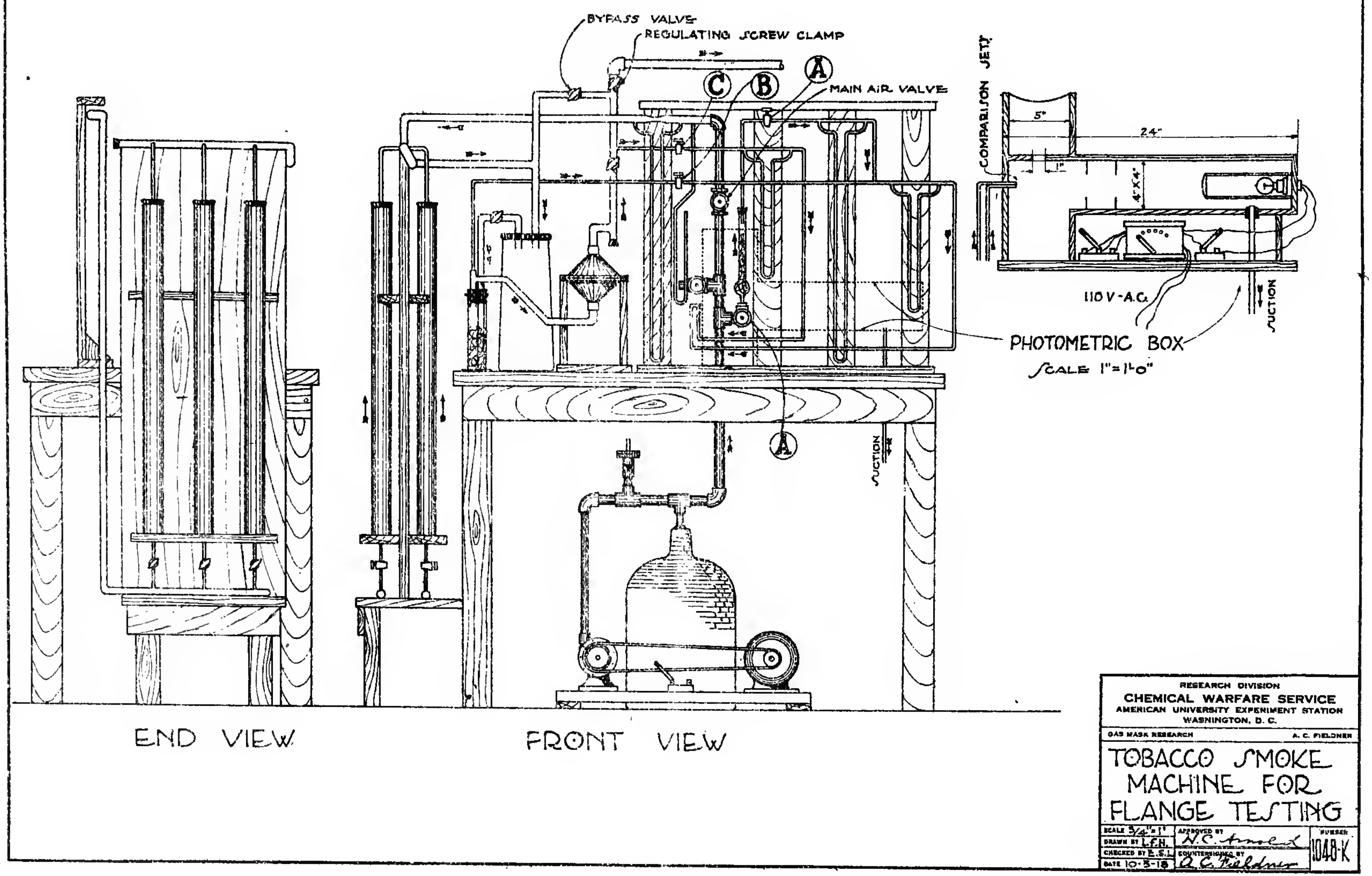
BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

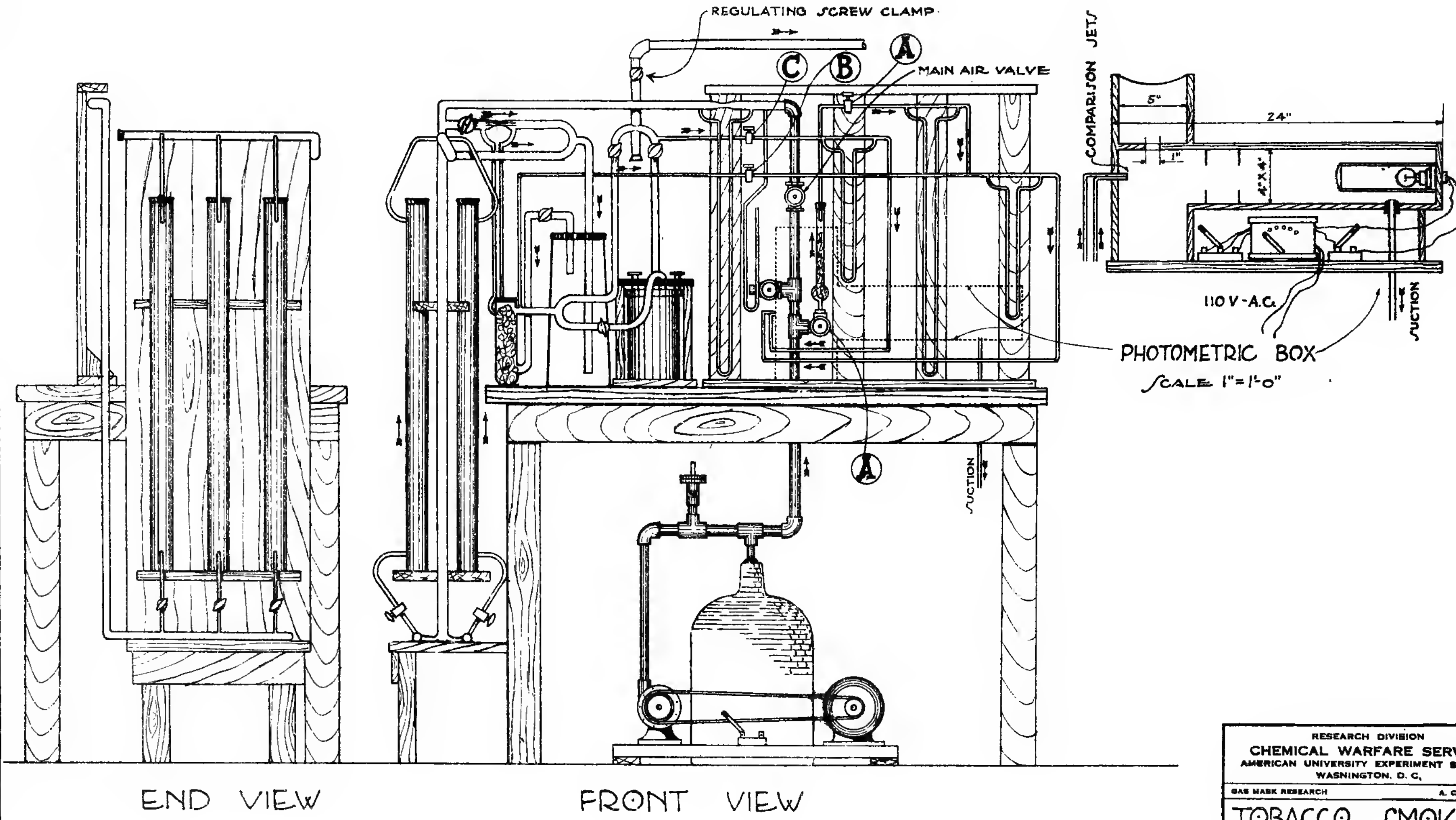
GAS MASK RESEARCH — A. C. FIELDNER

AMMONIUM CHLORIDE SMOKE MACHINE

SCALE NONE — DRAWN BY R.E.D. — NUMBER 1034-A

Fig. 1.


BYPASS VALVE
REGULATING SCREW CLAMP
C
B
A
MAIN AIR VALVE
A
SUCTION
COMPARISON JET
5"
24"
1"
4"X4"
110 V-A.C.
PHOTOMETRIC BOX
SCALE 1"=1'-0"
SUCTION
END VIEW
FRONT VIEW
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.
GAS MASK RESEARCH
A. C. FIELDNER
TOBACCO SMOKE MACHINE FOR FLANGE TESTING
SCALE 3/4"=1'
DRAWN BY L.F.H.
CHECKED BY E.S.L.
DATE 10-5-18
APPROVED BY
COUNTERSIGNED BY
NUMBER
1048-K



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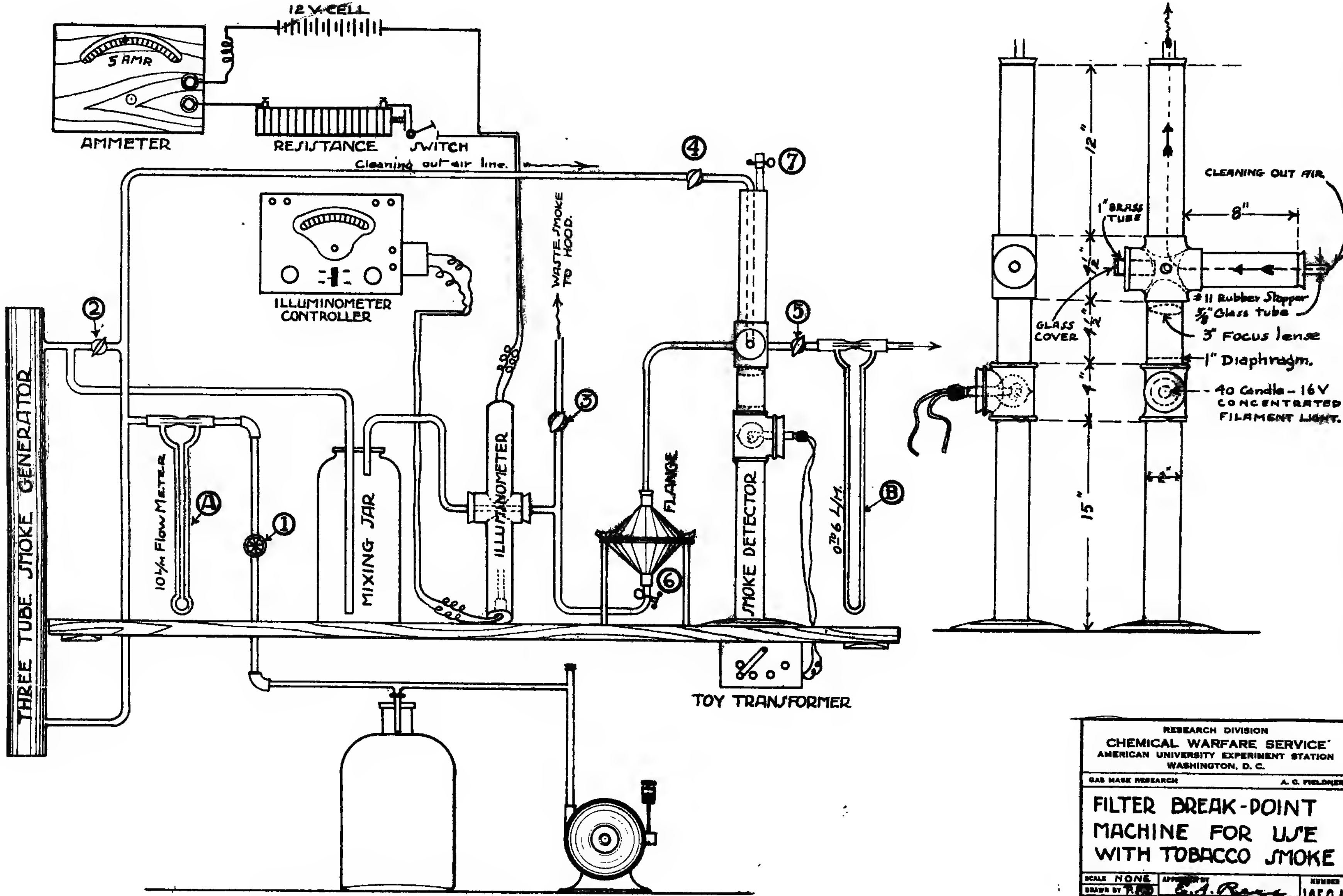
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

TOBACCO SMOKE MACHINE FOR CANISTER TESTING

SCALE 3/4"=1'	APPROVED BY N. C. Arnold	NUMBER 1048-K
DRAWN BY I. F. H.		
CHECKED BY E. S. L.	COUNTERSIGNED BY A. C. Fieldner	
DATE 10-5-18		



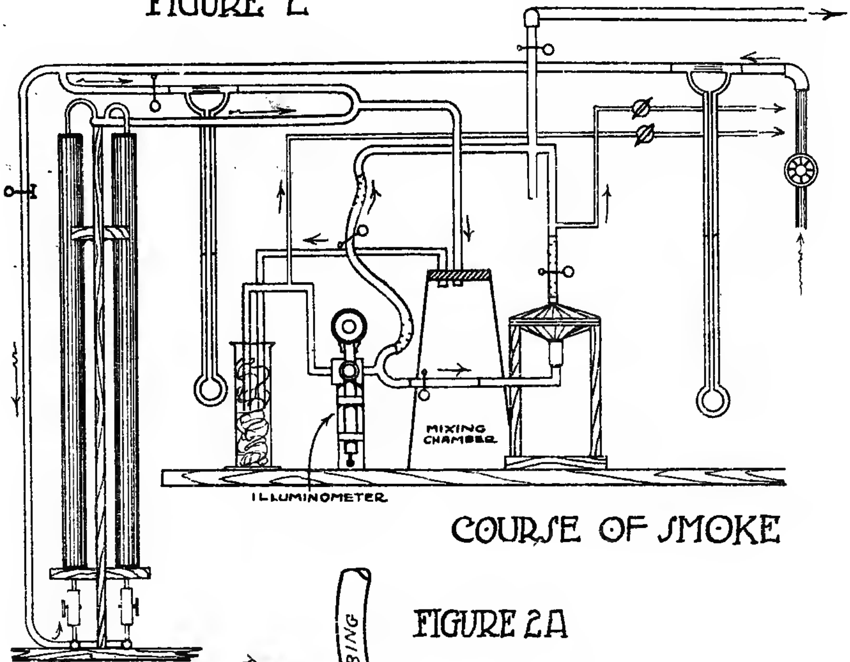
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

FILTER BREAK-POINT MACHINE FOR USE WITH TOBACCO SMOKE

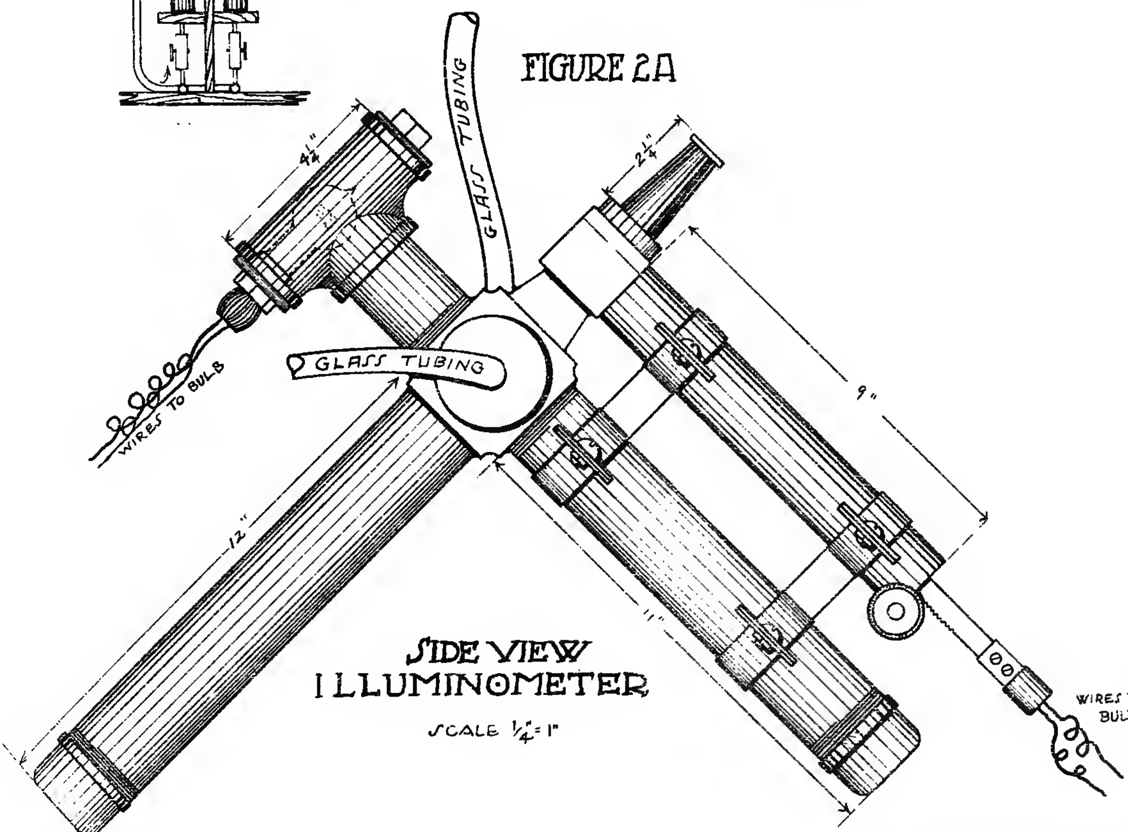
SCALE NONE	APPROVED BY E. A. Rees	NUMBER 1058-K
DRAWN BY P. RO		
CHECKED BY	COUNTERSIGNED BY A. C. Fieldner	
DATE 11-19-18		

FIGURE 2



COURSE OF SMOKE

FIGURE 2A



SIDE VIEW
ILLUMINOMETER

SCALE ¼" = 1"

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CHEMICAL WARFARE SERVICE
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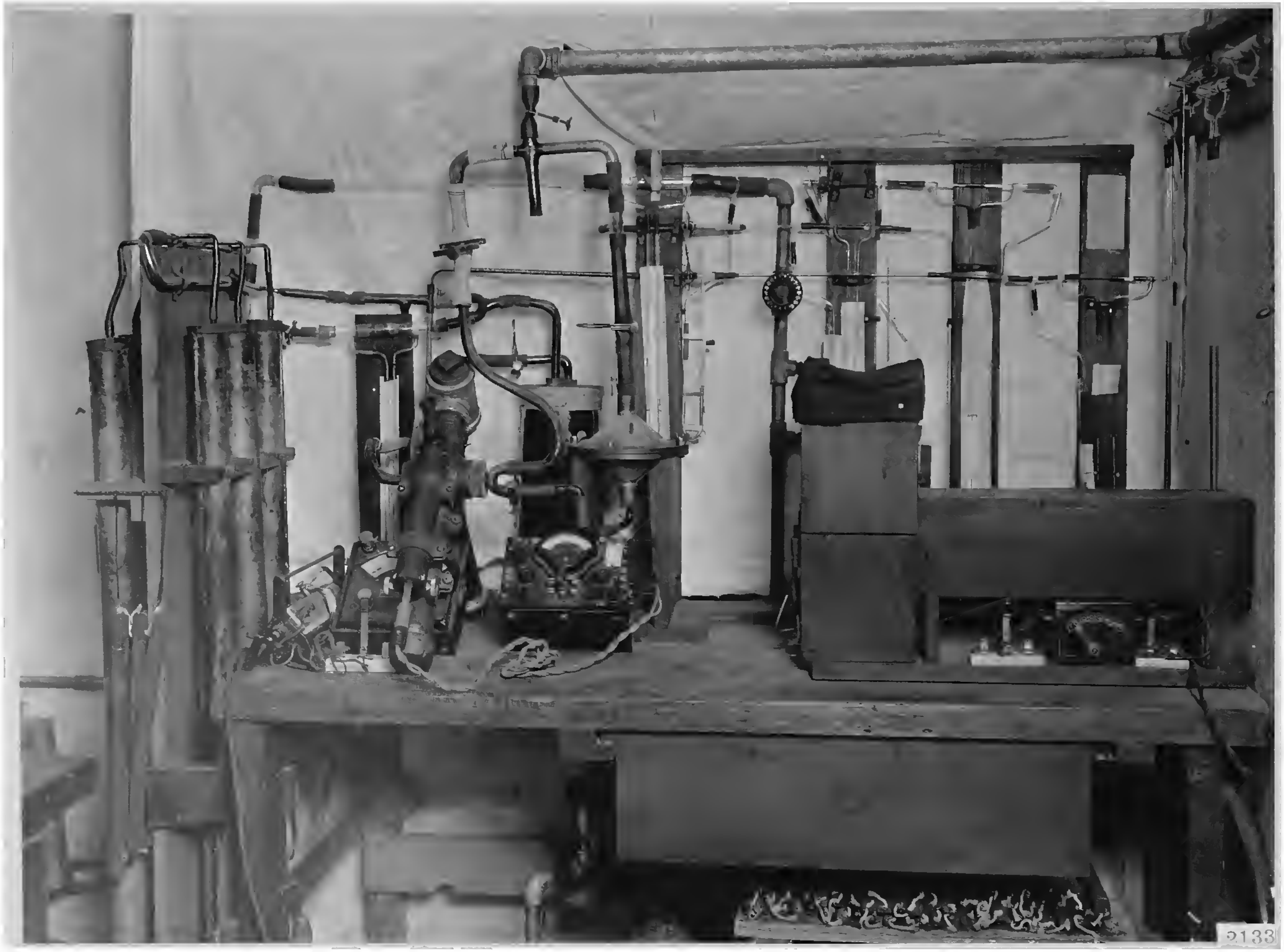
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

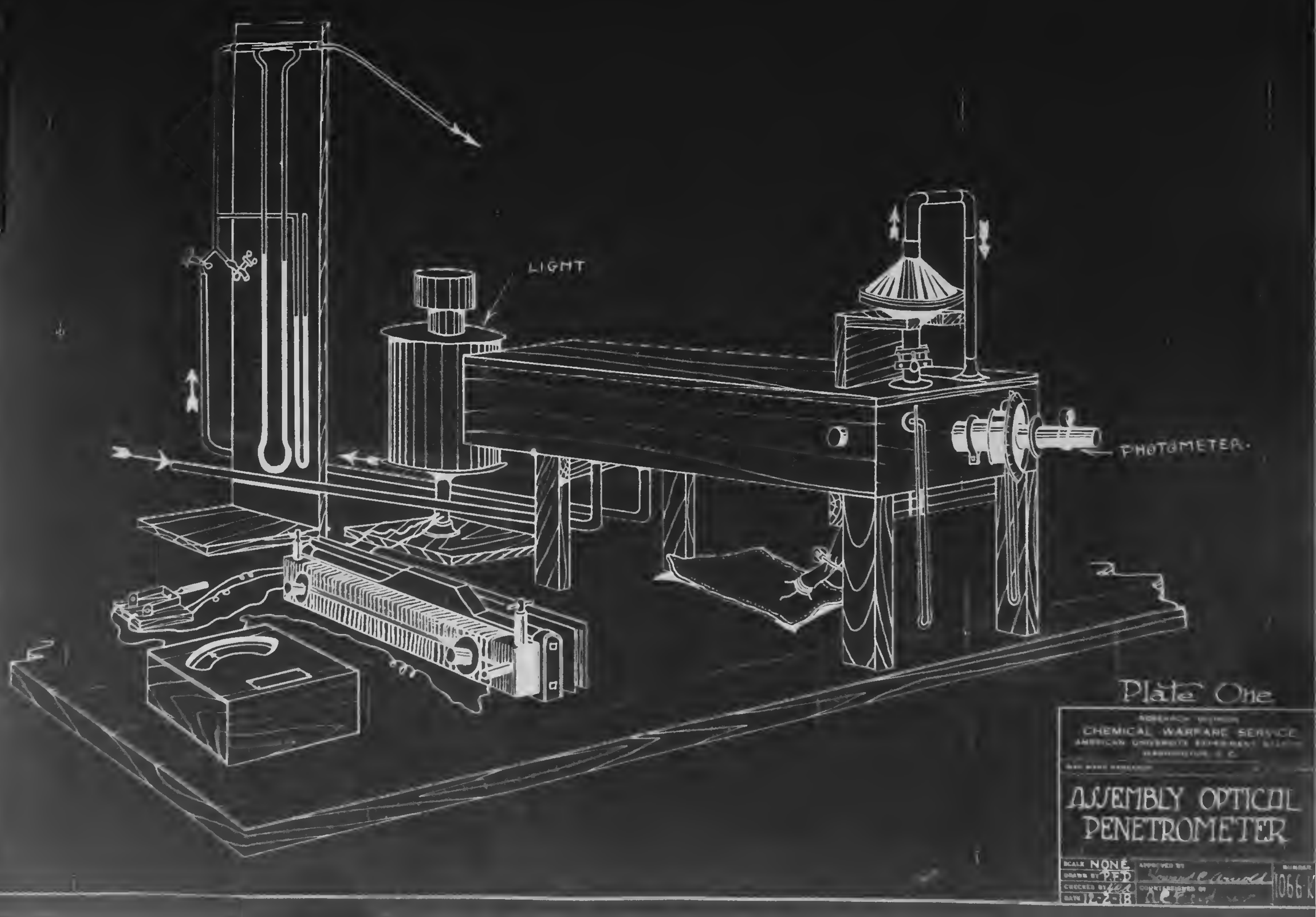
TOBACCO SMOKE MACHINE FOR FLANGE TESTING, WITH ILLUMINOMETER ATTACHMENT

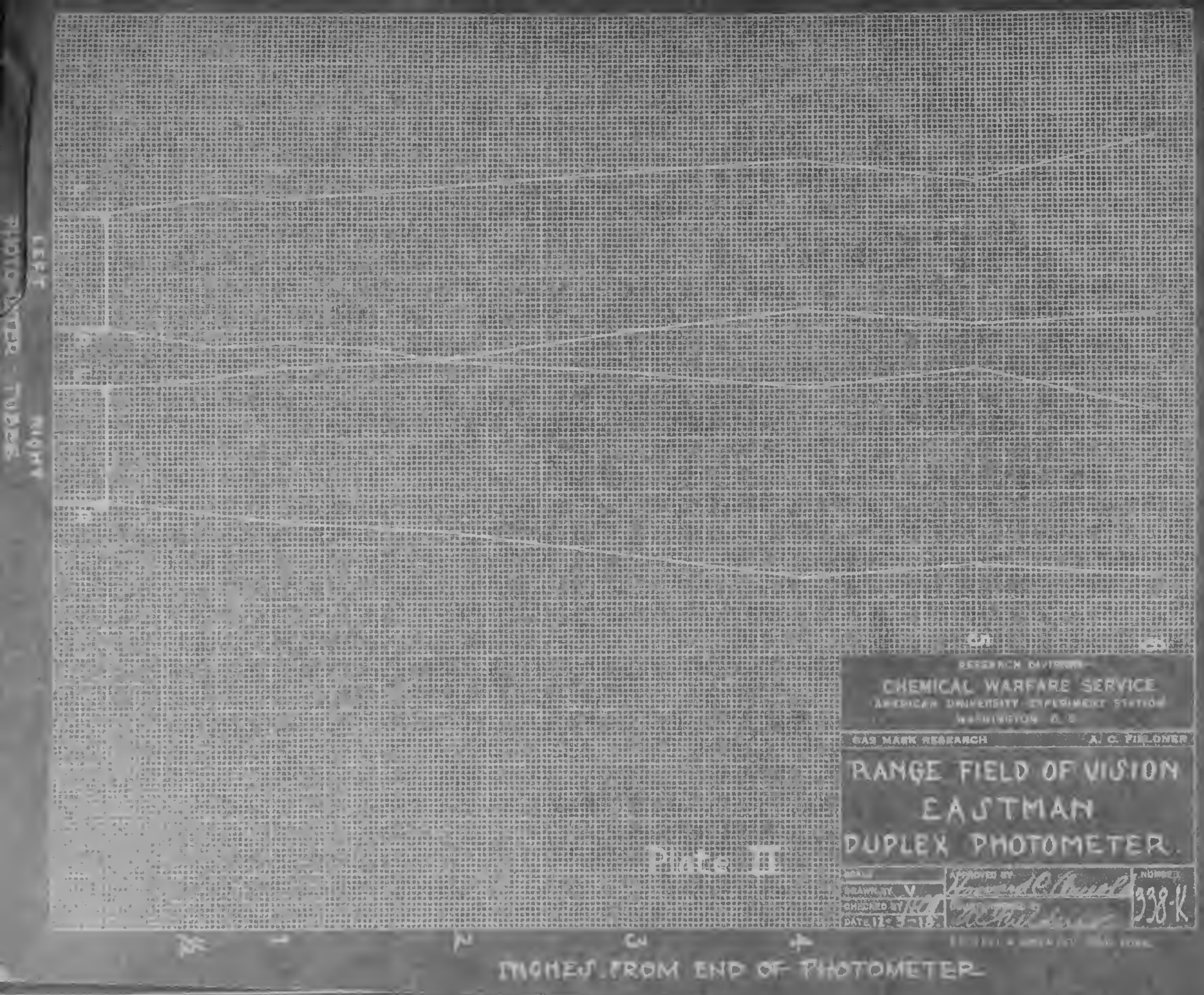
SCALE NO	APPROVED BY E. A. Rees	NUMBER 1052-K
DRAWN BY P.F.D		
CHECKED BY L	COUNTERSIGNED BY A. C. Fieldner	
DATE 11-7-18		



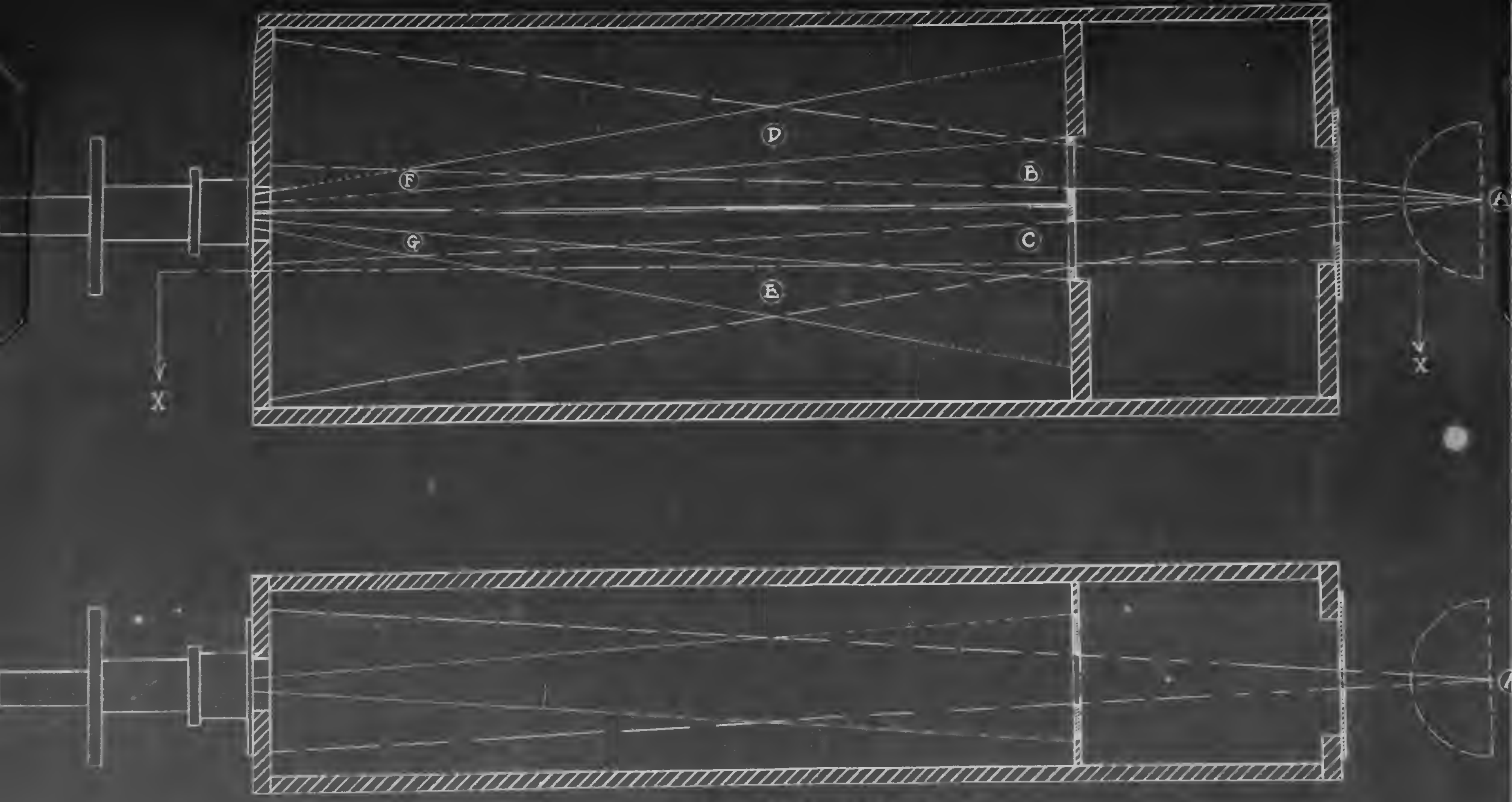
TOBACCO SMOKE MACHINE FOR FLANGE TESTING OF FILTERS

ILLUMINOMETER SET-UP ATTACHED


LIGHT
PHOTOMETER.
Plate One
CHEMICAL WARFARE SERVICE
ASSEMBLY OPTICAL
PENETROMETER
NONE.
P.F.D
12-2-18
1066-K



LEFT
RIGHT
PHOTOMETER TUBES
½
1
2
3
4
5
6
INCHES FROM END OF PHOTOMETER
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D.C.
GAS MASK RESEARCH
A. C. FIELDNER
RANGE FIELD OF VISION
EASTMAN
DUPLEX PHOTOMETER
Plate II
APPROVED BY
DRAWN BY
CHECKED BY
NUMBER
338-K



SECTION AT X-X

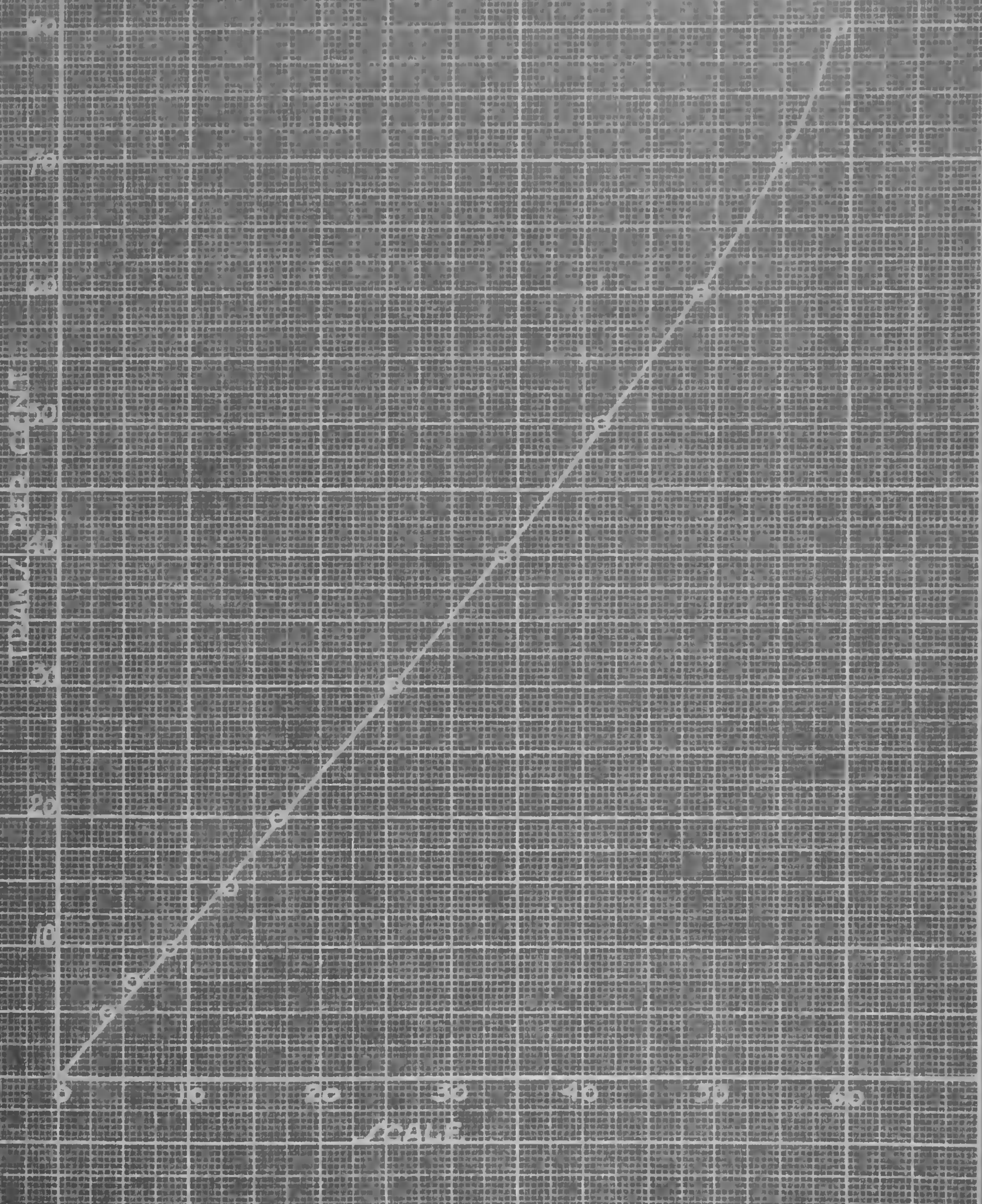
RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATIO[N]
WASHINGTON, D. C.

GAS MASK RESEARCH A. C. FIEL[D]

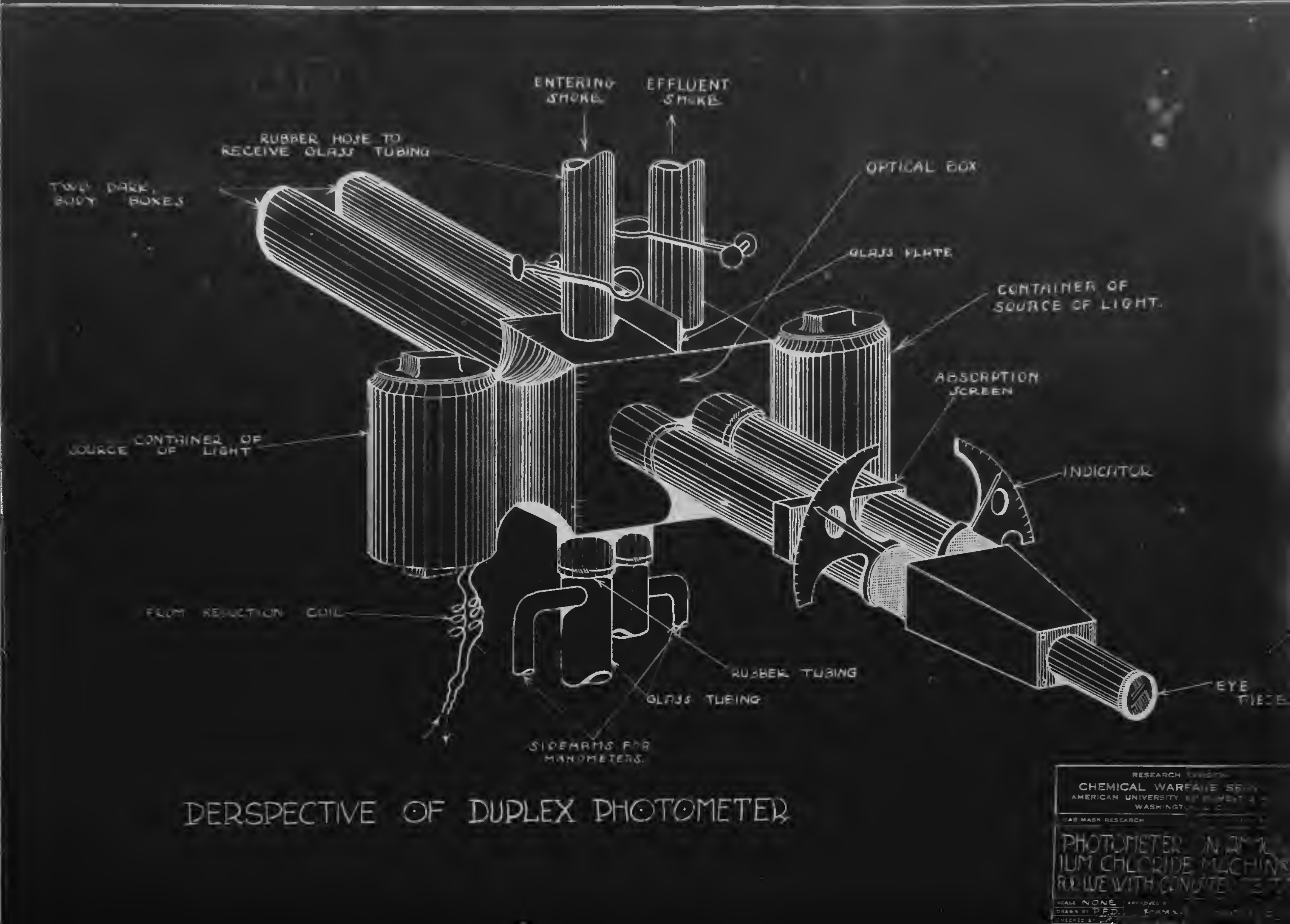
RAY INTERSECTIO[N]

SCALE 1/4" = 1"	APPROVED BY Howard E. Arnold	106
DRAWN BY P.F.R.		
CHECKED BY H.E.A.	COUNTERSIGNED BY	
DATE 12-3-18	[illegible]	

Assembly of Optical Penetrometer.



CALIBRATION CURVE FOR
EASTMAN PHOTOMETER


ENTERING SMOKE
EFFLUENT SMOKE
RUBBER HOSE TO RECEIVE GLASS TUBING
TWO DARK BODY BOXES
OPTICAL BOX
GLASS PLATE
CONTAINER OF SOURCE OF LIGHT.
ABSORPTION SCREEN
CONTAINER OF SOURCE OF LIGHT
INDICATOR
FROM REDUCTION COIL
RUBBER TUBING
GLASS TUBING
EYE PIECE
SIDEARMS FOR MANOMETERS.
PERSPECTIVE OF DUPLEX PHOTOMETER
RESEARCH
CHEMICAL WARFARE
AMERICAN UNIVERSITY
WASHINGTON
GAS MASK RESEARCH
PHOTOMETER
IUM CHLORIDE
SCALE NONE
DRAWN BY P.F.D.

not give reproducible results and was difficult to manipulate, but after considerable investigation, these difficulties were removed, and very satisfactory checks obtained between the results of this Section and those of the Long Island laboratory.

The following tabulation shows the approximate number of different smoke tests made by this section. In all about 22,000 tests were made;

	NUMBER OF TESTS		
Smoke	Man Tests	Canister Machine Tests	Flange Machine Tests
Stannic chloride	500	100	---
Arsenic trichloride	25	50	---
Titanium tetrachloride	75	--	---
Silicon tetrachloride	125	--	---
DA	3100	500	---
Ammonium chloride		3700	1000
Tobacco		4600	5500
Sulphuric acid		2000	1000
TOTAL	3825	10950	7500

27. FIELD PENETRATION TESTS:

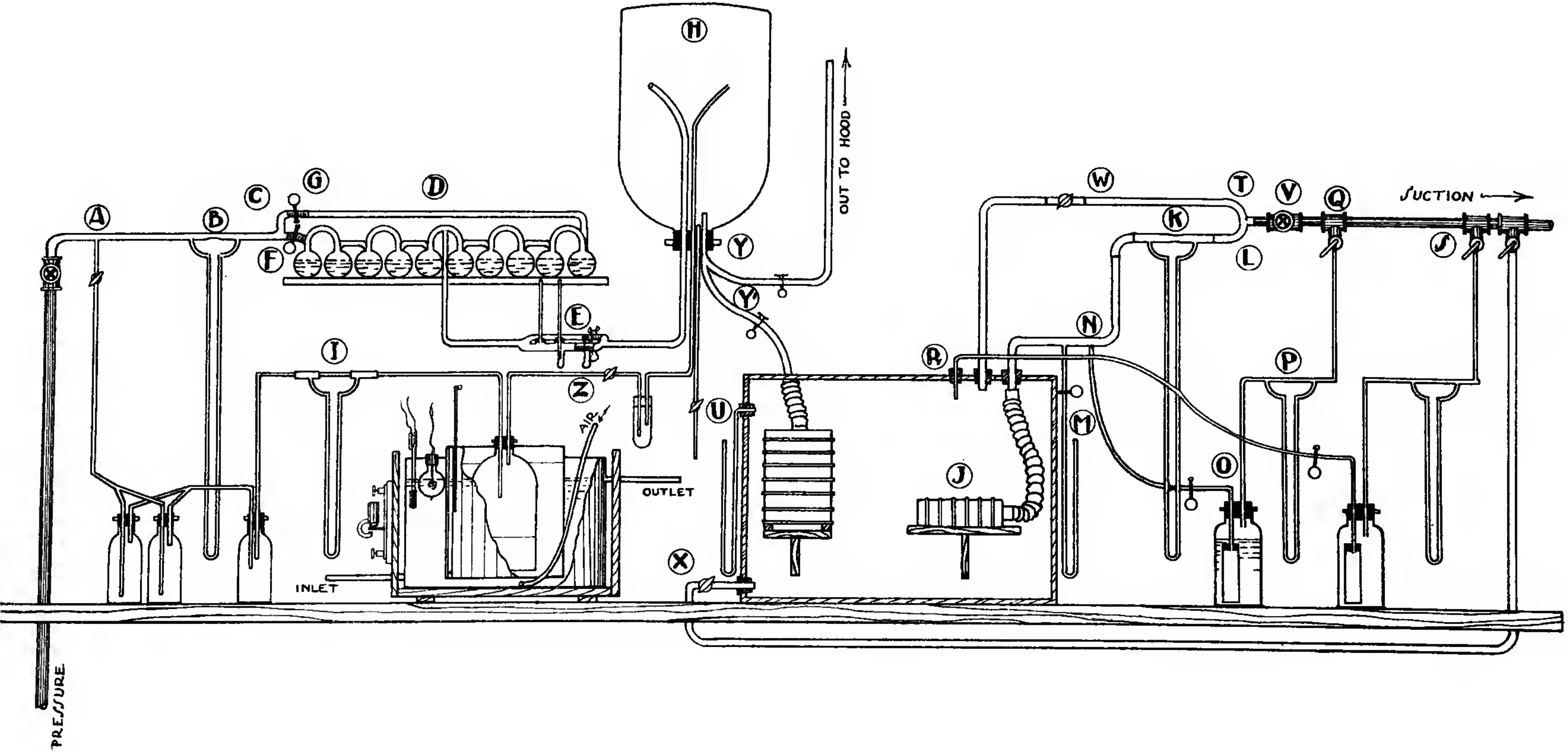
Various canisters have been tested against smokes, gases and smoke-gas mixtures under as nearly as possible actual field conditions.

The tests can be classified as follows:

1. Field tests with smoke candles.
2. Bomb pit tests with smoke shell.
3. Field tests with smoke shell and smoke-gas mixtures.
4. Field tests with gases.
5. Bomb pit tests on NC dugout grenades.

Smoke Candles - A field test was conducted October 5,1918, at Burrell Field, to determine the protection afforded by various canisters against DA candles designed by the Pyrotechnic Section. The conditions were unfavorable for a fair estimation of the penetrating power of the smokes.

In this test all Cover Cartridge, flat felt, and rectangular accordion filters afforded complete protection at all distances from the source of cloud. One German drum



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WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

CANISTER TESTING MACHINE FOR F-10 SMOKE.

SCALE NONE	APPROVED BY H. C. Arnold	NUMBER 1049-K
DRAWN BY D		
CHECKED BY	COUNTERSIGNED BY A. C. Fieldner	
DATE 10-1-18		

was penetrated unbearably in 6 minutes, 50 yds. from the candles while the U.S.B.R. in the same group was penetrated unbearably in 10 minutes. Two hundred yards from the candles the two observers with German canisters reported slight penetration. No observers at 500 yds. stations reported penetrations, but observers with German masks instructed to vary their positions to determine the effective area of the cloud reported penetrations at distances of 700 and 800 yards from candles. A Logen canister from the first shipment of these canisters to this station was strongly penetrated at 50 yds. in 8 minutes, but did not become unbearable.

A field test carried out in cooperation with the Dispersoid Section at Bradley Field, October 23,1918, had for its object the determination of the protection afforded by various canisters against pure and impure DM smoke from DM candles, and resulted unsatisfactorily because the test was not made on a large enough scale. The impure DM candles produced a smoke which was much more penetrating 50 yds. from the candles than that produced by the pure DM as evidenced by the complete breakdown of even the flat felt filters and Cover Cartridges, but was much less penetrating at a distance of 150 yards where not even the German canister was penetrated. The pure DM smoke broke both the German and U.S.B.R. canisters at 150 yards. The conditions were slightly more favorable for the impure candles test and the subjects in this test were in a dense cloud, but the particles in this cloud appear either to have coagulated between 50 yards and 150 yards to a size that would not penetrate the filters or to have lost their effectiveness in some other manner. The German and U.S.B.R., "J" Type canisters gave about equal protection in both tests. The Cover Cartridge and flat felt filters gave perfect protection against the pure DM, but both were broken by the smoke from the impure candles.

A test was conducted at Berlin, Md., November 2nd, 1918, to determine (1) the protection afforded by various canisters against 300 DM candles and (2) the effective area of the resultant cloud from these candles which were made by the Dispersoid Section.

The German drum with paper extension and the Standard Box Respirator gave little or no protection in any part of the cloud. The Cover Cartridges which were placed on J canisters packed without filtering pads, failed to protect in the higher concentrations, but gave perfect protection in less dense portions of the cloud. The

2002

TROOPS RECEIVING FINAL INSTRUCTIONS BEFORE TEST.

Fogler flat felt filters gave complete protection except in the 100 and 300 yards groups where they were slightly penetrated. The principal achievement of these tests was that they showed the possibility of building up a concentration of DM in the field that will easily penetrate both the Standard B.R. and the German canisters at distances of at least a mile.

A test very similar to the Berlin test was conducted at Lakehurst Proving Grounds, December 12, using 500 DM candles. Virtually all German and U.S.B.R. canisters were penetrated unbearably to a distance of 1800 yards. The Fogler flat felt filter gave complete protection at all points in the cloud, while the Logan felts were slightly penetrated in almost every instance to a distance of 1000 yards. One Logan canister with sucked-on pulp filter was unbearably penetrated at 400 yards, but others of this type gave complete protection beyond that point. The Cover Cartridges performed exactly as the Logan canister with sucked-on pulp filters. Of the three English canisters used in this test, one was found unbearable at 400 yards, one was slightly penetrated at 900 yards, and the other gave complete protection at 1000 yards.

A field test in which 30 DA candles designed by the Pyrotechnic Section were burned to determine the protection afforded by various canisters was conducted October 5, 1918, at Conduit Road Field. One German canister and one U.S.B.R. "J" Type, were unbearably penetrated at 50 yards, but beyond that point only two German canisters were slightly penetrated, both 200 yards from the candles. One Logan canister from this first shipment of this type to this section was strongly penetrated at 50 yards. The other types of protection viz: Cover Cartridge, flat felt and accordion filters afforded complete protection throughout.

A comparative field test with D4 candles designed by the Dispersoid Section and candles designed by the Pyrotechnic Section was conducted at the Montgomery County Country Club, Md., October 30, 1918. Conditions were ideal for the favorable performance of smoke clouds and remained the same throughout both tests. The smoke from the Pyrotechnic candles was more dense than that from the Dispersoid candles due to the presence of zinc chloride in the former. The penetrability of DA set up by the Dispersoid candles was greater than that set up by the Pyrotechnic candles up to distances of 600 yards, but from 600 to 1100 yards there was not much difference.

2004

VIEW FROM 100 FEET BACK OF ORIGIN AFTER
CLOUD HAD OBTAINED ITS MAX-
IMUM DENSITY.

VIEW FROM BEHIND ORIGIN AFTER IGNITION OF

THIRD ROW OF CANDLES.

The German drum again gave the least protection of all types represented and the U.S.B.R. gave only slightly better protection. The Cover Cartridges were slightly penetrated up to distances of 300 yards by the cloud from the Pyrotechnic candles, but beyond that point afforded complete protection. The Dispersoid candles penetrated one Cover Cartridge unbearably at 100 yards and slightly at a distance of 600 yards. Only one flat felt filter was penetrated but that was unbearable at 100 yards in the clouds from the Dispersoid candles. A final DA candle test using 500 DA candles made by the Dispersoid Section was made at Lakehurst Proving Grounds, but owing to the unsuitability of the location to gather information of the nature desired, the results were not satisfactory.

<u>75 mm. Gas Shell in Bomb Pit:</u> October 4, 1918, a 75 mm. gas shell containing 375 cc. of crude DA with a booster charge of 75.5 gms. T.N.T. and 10 gms. tetryl was exploded and men equipped with various protections were sent into the pit to remain 15 minutes if possible. The men equipped with German masks and those with U.S.B.R. Type J canisters were forced out while descending the stairs leading into the pit, having received practically no protection from their filters. The average time in pit for each type of protection represented was as follows:

5 German canisters ----------------	no protection
5 U.S.B.R. "----------------------	24 seconds
2 Flat Felt Filters ---------------	5 min.48 sec.
4 Rectangular Accordion filters ----	10 " 18 "
5 Cover Cartridges------------------	13 " 24 "

Another similar test was made October 10, 1918, this time firing a 75 mm. gas shell containing 43 cc. of crude DA and 392 cc. of CG. with a booster charge of 27 gms. T.N.T. and 9.5 gms. tetryl. The purpose of this test was to determine the possibilities of particles of DA carrying enough CG through the canisters with them to cause casualties. The German mask offered no protection against DA. In contrast to this the Type U.S.B.R. canister gave good protection, two of the five giving complete protection. The Cover Cartridges and flat felt filters gave complete protection. The 10% DA and 90% CG mixture was not nearly as penetrating as the DA alone, and whenever a canister attached to RFK face pieces was penetrated DA was the only gas reported coming through. Some observers with Tissot face pieces reported both DA and CG, but the

indications were that the CG came through badly fitting face pieces.

Field Tests with Smoke Shells: One of the first field tests made with shell was made October 19, 1918, with 75 mm. gas shell containing the following:

Type 1	Type 2
10% Crude DA	25% Crude DA
90% CG	75% CG

The shells with type 2 filling exhibited greater penetrability than type 1, for it strongly penetrated one Cover Cartridge and one standard B.R. while the first only penetrated 2 U.S.B.R's slightly. The German masks were all penetrated by DA. All Cover Cartridges except the one noted above and all flat felt filters gave perfect protection as did nine U.S.B.R's; two U.S.B.R's were slightly penetrated by type 1, and one strongly by type 2. The German masks were all penetrated, 60% of them unbearably. The indications were that if such a cloud could be maintained along a considerable front for about 30 minutes none of these canisters would afford complete protection within 50 yards of the center of impact.

A field test conducted in cooperation with the Dispersoid Section at Bradley Field, October 16, 1918, had for its purpose the determination of the most effective type of DA shell and the establishing of the relative protection afforded by various canisters against the various types of DA shell. Eight shells were fired simultaneously in each test. Cover Cartridges and flat felt filters gave absolute protection against the resulting clouds from all six types of DA shell. The German masks were penetrated by the resulting clouds from 5 of the 6 types of shell, while the U.S.B.R. gave ample protection against 4 of the 6 types, but was wholly inadequate for the type L 1-7/16" and type M 70/30 shells.

In another test carried out at Lakehurst Proving Grounds, November 20-22, the type L and type M DA shells were fired by artillery. In one test 100 of the type M shells were fired by six 75 mm. guns, consuming a period of 7 minutes. After the firing ceased subjects entered the cloud and followed it down the range as far as possible. Owing to unfavorable conditions, the men were unable to get into the main part of the cloud and only one of the

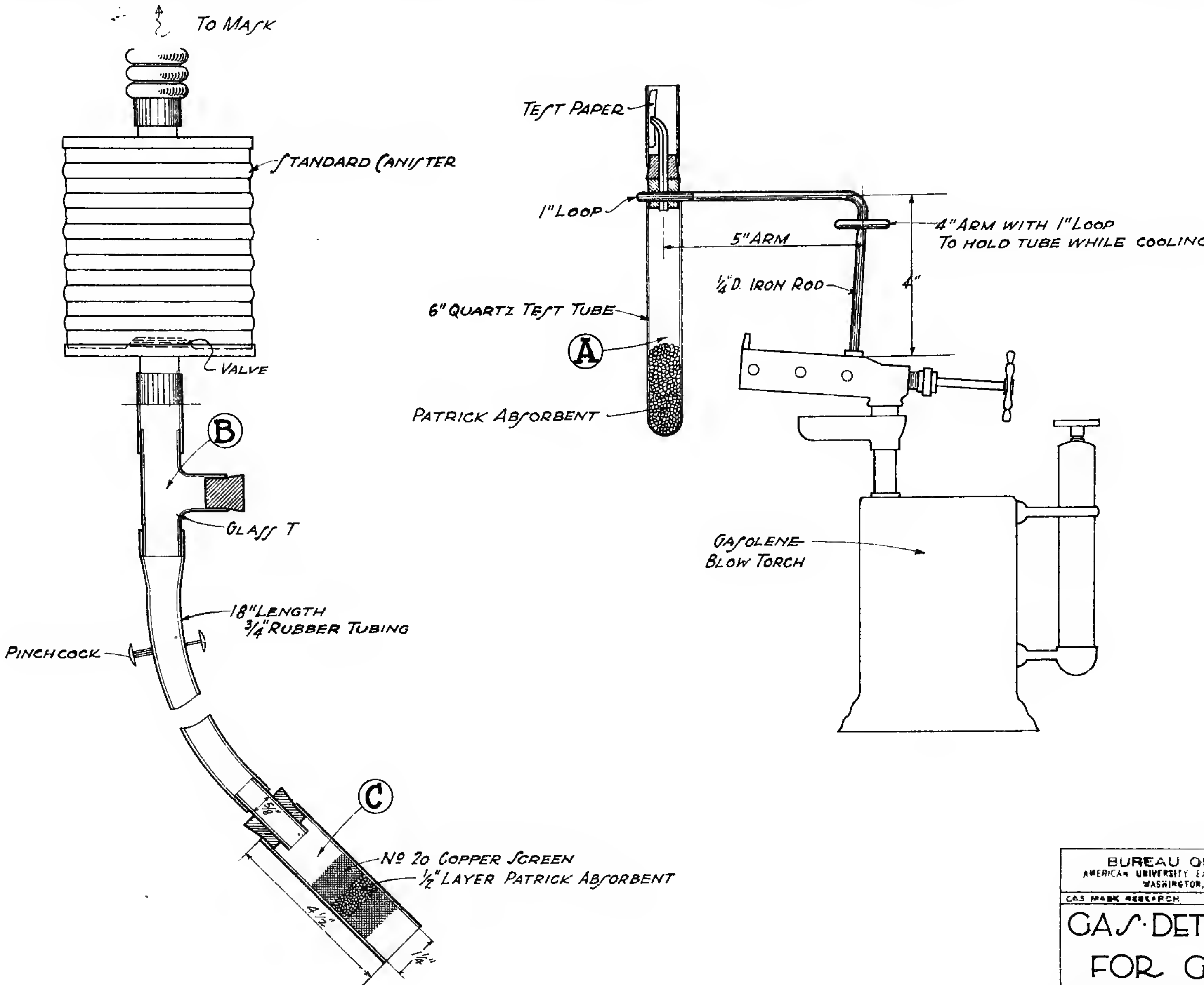
1758 3

FIELD DETECTOR FOR G-34

FIELD DETECTOR FOR G-34 IN USE

MUSTARD GAS DETECTOR

LANTERN TYPE

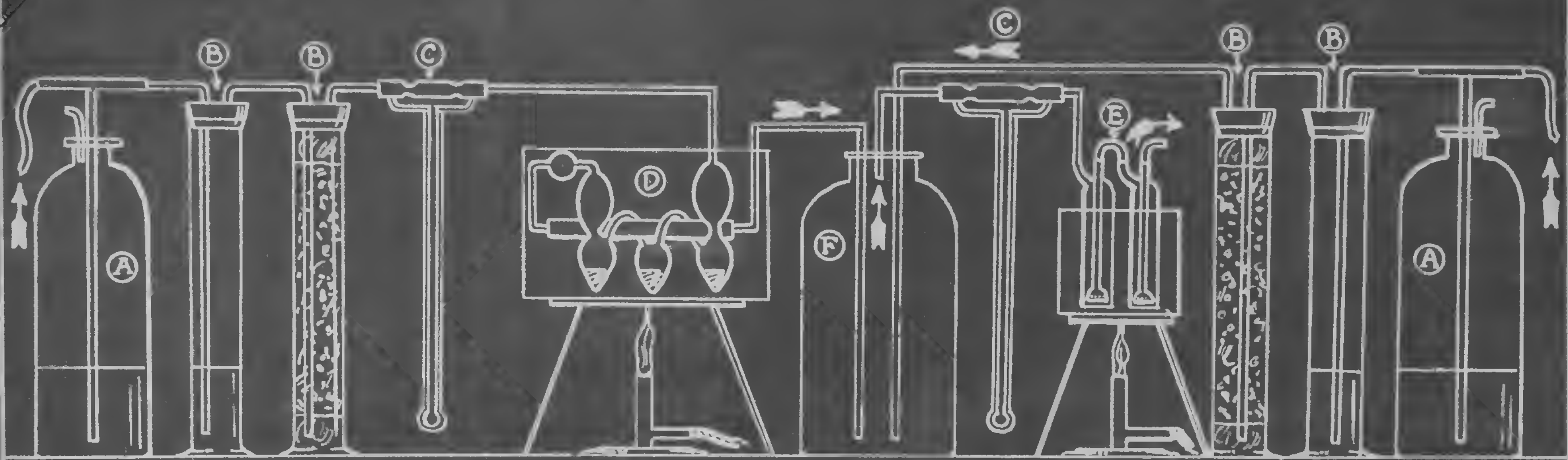


BUREAU OF MINES
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH		A. C. FIELDNER

GAS DETECTOR FOR G-34

SCALE 1/4" = 1"	APPROVED BY G. G. Oberfell	NUMBER 1026-C
DRAWN BY L.F.H.		
CHECKED BY C.H.B.		
DATE 7-11-18	A. C. Fieldner	



Ⓐ Constant Pressure Bottle.
Ⓑ Air Purifying Bottle.
Ⓒ Flowmeter.
Ⓓ HS Bubbler in bath at 25°C.
Ⓔ Selenious acid bubblers in bath at 85°C.
Ⓕ Mixing Jar

RESEARCH DIVISION
CHEMICAL WARFARE SERVICE
AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

GAS MASK RESEARCH — A. C. FIELDNER

APPARATUS USED IN STANDARDIZING SELENIOUS ACID METHOD.

SCALE	APPROVED BY G. St. J. Perrott	NUMBER 438-D
DRAWN BY V		
CHECKED BY	COUNTERSIGNED BY A C Fieldner	
DATE 19-12-'18		

A second method consisted in absorbing the traces of G-34 in Patrick absorbent (silica gel), and subsequently breaking up the gas with heat and testing for the resulting H_2S with lead acetate paper. A suitable field apparatus was designed. This test is apparently specific, and sensitive to 0.5 - 1 p.p.m.

A solution of selenious acid in 1:1 sulphuric acid was found capable of detecting 0.1 p.p.m. of G-34. This principle has been embodied in a compact field apparatus. Heating is unnecessary. A negative test is given by the common war gases with the exception of arsenic compounds and mercaptans. The selenious acid reagent has been found capable of quantitative application to the estimation of traces of G-34 in air, and the details of a nephelometric method have been described. Pumice stone impregnated with selenious acid reagent has been found to indicate the presence of G-34 in contaminated soil in concentrations as low as 1 p.p.m.

31. DETECTION OF HYDROGEN IN SUBMARINE ATMOSPHERES:

The Burrell methane detector has been modified and rendered more sensitive so as to detect the presence of hydrogen in air.. Several of these hydrogen detectors have been made up for the Navy Department, who have found them satisfactory.

32. ESTIMATION OF ARSINE IN AIR:

Paper dipped in a saturated solution of mercuric bromide in alcohol, and dried, has been found to give marked changes of color when exposed to a few parts of arsine in 100,000,000 parts of air, Specifications for test paper and standard color charts have been prepared and submitted to the Navy Department, for the estimation of arsine in submarine atmospheres.

33. PORTABLE ORSAT GAS ANALYSIS APPARATUS:

A portable Orsat gas analysis apparatus has been designed for determining oxygen and carbon dioxide in submar ine atmospheres. Working drawing and specifications have been submitted.

SPECIFICATIONS.

BURETTE: Burette (A) to have a total capacity of 100 c.c., the bulb having a capacity of 75 cc, the stem a capacity of 25 cc. The stem is graduated in tenths of a cc from 75 cc to 100 cc. The zero point of the burette to be on the capillary tubing attached to the burette, the capillary tubing being 2 to 3 mm. The capillary train (G) to be 2 mm bore.

WATER JACKET: A water jacket (B), 2½ inches in diameter surrounds the burette. The water jacket is securely held in place by supports at top and bottom, the water jacket and supports being protected by strips of felt. Arrangements to be made for easy removal of burette and water jacket. The front and back of water jacket to be free from obstructions, which would render it difficult to make readings on the burette.

LEVELLING BOTTLE: The levelling bottle (C) to be 200 cc capacity and attached to the burette by 36 inches of ³⁄₁₆ inch pure gum heavy walled tubing. The bottle is to be securely clamped in position by clamps of wood with felt protection. A rubber stopper is placed in the bottle when not in use to prevent the spilling of the liquid.

PIPETTES: The pipettes (D) to be made of strong glass tubing. The pipettes, supports and clamps to be of uniform measurements so as to permit the exchange of these various parts. Clamps and supports at top and bottom to be of wood and have protecting strips of felt. The glass tubing in the pipettes to be 4 to 5 mm inside diameter thin walled tubing, so arranged that there will be very little free air space at the top of the tubing (less than 5 cc). The pipettes should be able to hold 100 cc. of gas as delivered by the burette. The pipettes are fitted with rubber bags (E). See Eimer and Amend Catalogue No 1282. Rubber stoppers to be supplied for pipettes when apparatus is not in use.

PINCH CLAMPS: Pinch clamps to be of the S M Co type catalogue No 1546 medium.

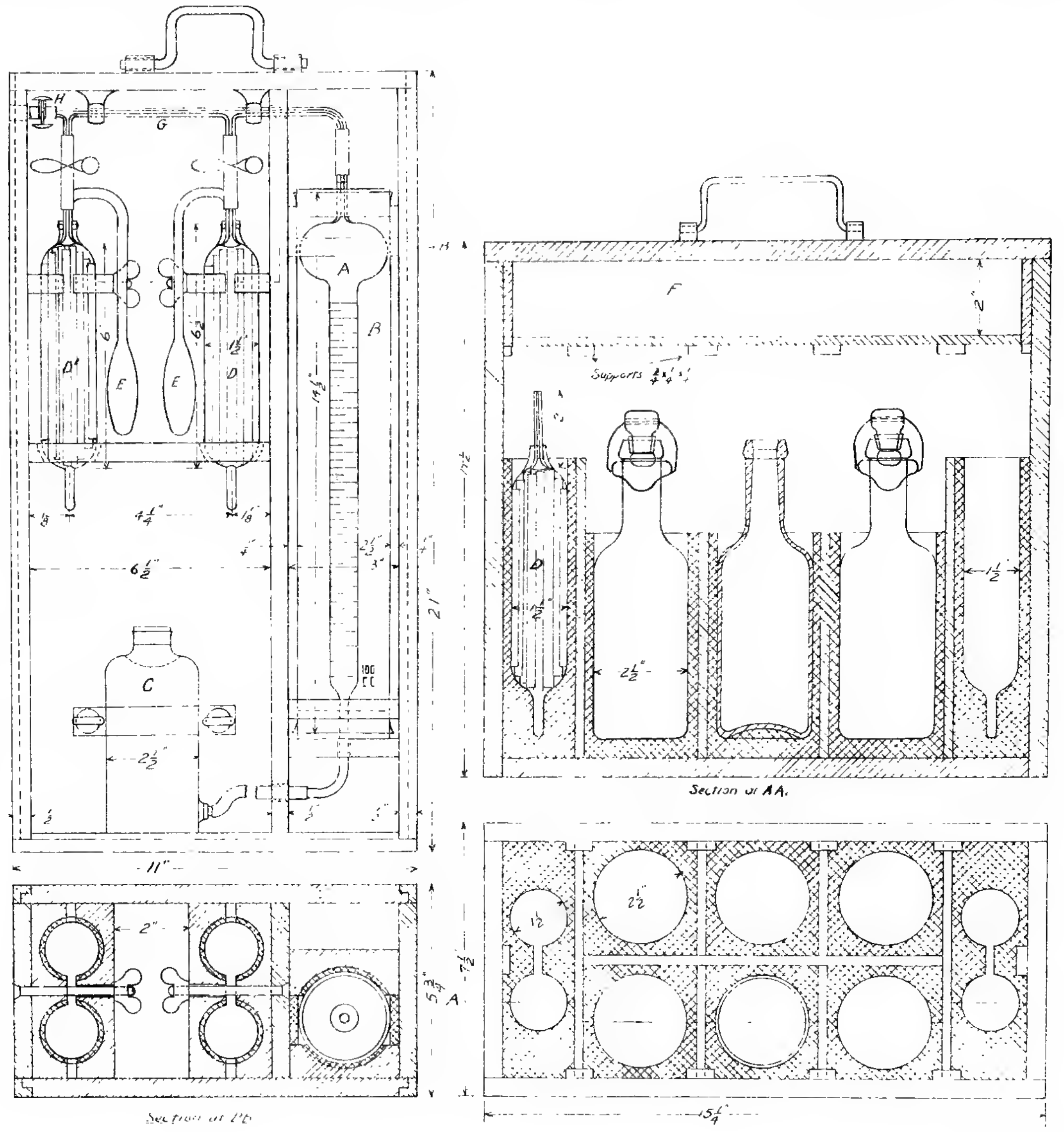
CONNECTION TUBING: The connection tubing to be ³⁄₁₆ inch pure gum medium walled.

PROTECTING FELT: The protecting strips of felt to be not less than ¼ inch thickness.

CARRYING CASE: Carrying case to be made of wood. Sliding doors to be placed at front and back. These doors to be smooth fitting so as to afford easy removal of same when apparatus is to be used.

ACCESSORIES AND CASE: The accessories to be carried in a separate case made of light wood. It is to hold six magnesium citrate bottles and two extra pipettes. A substantial frame work with felt packing is to be preferred to receptacles made from solid wood protected by strips of felt, since the weight of case is thereby reduced. A small compartment box (F) is placed in the case to hold the following accessories:

- 1 spool of copper wire No 20
- 1 pair of small pliers, 4 inch S.M Co Catalogue No 4556
- 10 feet of pure gum rubber tubing ⅛ inch internal diameter medium walled
- 4 medium sized pinch-clamps, S M Co Catalogue No 1546.
- 4 medium sized screw-clamps, SM Co Catalogue No 1552
- 2 Triangular files 6 inch



ARMY AND NAVY
WAR GAS INVESTIGATION
AMERICAN UNIVERSITY
EXPERIMENT STATION
Bureau of Mines Washington D.C.
May 2 1918 Scale 1"=2"
PORTABLE ORSAT GAS ANALYSIS APPARATUS
Drawn by H.G. Dulcault
Checked by
Approved by
1009-C

APPENDIX

Table I

Absorption Values of Various Absorbents

(a) Charcoals:

Period	Kind of Charcoal	Mesh	PS TESTS: Accelerated: 10 cm. layer: No. of Sample	Time in Minutes	Standard: 5 cm. layer: No. of Samples	Time in Minutes	Standard: 10 cm. layer: No. of Sample	Time Mins.
1917	Astoria							
Sept.29-Nov.18	CODC	10-14	45	15.11	46	55.8		
Nov.19-3/8/18	"	8-10	167	15.00	96	53.0	9	190
1918								
May 9-June 12	"	8-14	29	15.25				
June 13-Aug.23	Air activated mixed shell	8-14	70	14.28				
Aug.24-Nov.22	Steam activated mixed shell	8-14	89	24.59				
Large drum Astoria	CODC	10-14	4	19.2	4	88		
	"	8-10	7	19.7	3	65	1	147
	"	8-14	3	16.3				
	Air activated mixed shell	8-14	11	19.7				
	Steam activated mixed shell	8-14	10	24.2				
	CIHT	10-20	1		1	48		
	"	8-14	2	7.3				
	Whetlerite A	as recd	11	27.1				
	" B	8-14	3	30.1				
	Batchite	8-14	8	19.2			1	197
	Hudson cocoanut	8-10	2	32.3				
	"	8-14	1	15.4				

Period	Kind of Charcoal	Mesh	PS TESTS					
					Standard			
			Accelerated		5 cm. layer		10 cm. layer	
			No. of Samples	Time in Minutes	No. of Sample	Time in Minutes	No. of Sample	Time in Minutes
	Natl. Car.							
	Company	10-14	1	57.0	1	212		
	Rodman							
	activated	8-20	1	13.3				
	"	10-14	1	8.6				
	Natl. Lmp.							
	Co.	8-10	2	24.7	1	89		
	"	10-14	4	28.2	4	101		
	Dorsey	8-10	1	11.6	1	45		
	"	10-14	1	17.9	1	66		
	"	14-20	1	19.4	1	94		
	Dorsite	8-14	1	63.6				
	Palmetto	8-14	1	0				
	German							
	1916							
	Abs. #1				2	0		
	" #2				2	7.5		
	" #3				2	0		
	Germ. 1918		1	35.0				
	Eng. 1917				1	6		
	Eng. 1918		1	16.9				
	Eng. smpl							
	A	8-10			1	70		
	B	8-10			1	91		
	C	8-10			1	33		
	D	8-10			1	33		
	E	8-10			1	15		
	F	8-10			1	26		
	French							
	1917				1	1		
	1918	8-14	1	2.5				
Other absorbents:								
	Silica	8-10	3	24.2	3	45	2	144
	Gel.	as						
	"	recd.	3	27.6				
	Calif.	8-14	1	2.5			1	11
	white							
	clay							

Period	Kind of Charcoal	Mesh	STANDARD CG: 1000 ppm. .5 cm. layer: No. samples	1000 ppm. .5 cm. layer: Time Mins.	1000 ppm. 10 cm. layer: No. samples	1000 ppm. 10 cm. layer: Time Mins.	5000 ppm. 10cm. layer: No. samples	5000 ppm. 10cm. layer: Time Mins.	10000 ppm. 10cm. layer: No. samples	10000 ppm. 10cm. layer: Time Mins.
9/19/17-11/18/17	CODC	10-14	46	57						
11/19/17-5/8/18	"	8-10	114	48	2	235	6	25.4		
5/9/18-6/12/18	"	8-14							2	15.8
6/13-8/23/18	Air activated mixed shell	8-14					10	25.4		
8/24-11/22/18	Steam activated mixed shell	8-14					10	27.3	2	13.5
Large drum Astoria	CODC	10-14	4	67						
"	"	8-10	7	53			2	25.0		
"	Steam activated mixed shell	8-14							3	16.0
	CIHT	8-14					1	12		
	whet. A	as recd			1	30				
	B	8-14							3	57
	B	8-10							1	38
	B	10-14			1	36			1	
	Batchite	8-14	1	52						
	Natl. Car. Co.	10-14	1	65						
	Rodman Activated	8-20			1	268				
	"	10-14			1	267				
	Natl. Lamp Co.	8-10	1	49						
		10-14	3	72						
	Dorsey	8-10	1	59						
	"	10-14	1	82						
	"	14-20	1	124						
	Ger. 1916: Abs. #1		2	30						
	" #2		2	142						
	" #3		2	5						
	Ger. 1918	8-14							1	6.5
	Eng. 1917		1	10						
	" 1918	8-14	1	14					1	13.0

			STANDARD CG							
			1000 ppm. 5 cm. layer		1000 ppm. 10cm. layer		5000 ppm. 10cm. layer		10000 ppm. 10cm. layer	
Period	Kind of Charcoal	Mesh	No. samples	Time Mins.	No. samples	Time Mins.	No. Samples	Time Mins.	No. samples	Time Mins.
	English Sample									
	A	10-14	1	8						
	B	8-10	1	36						
	C	8-10	1	16						
	D	8-10	1	14						
	E	8-10	1	10						
	French									
	1917		1	29						
	1918	8-14							1	4.5
Other absorbents:										
	Silica gel	8-10	1	3	1	5				
	Calif. white Clay	8-14							1	0

Period	Kind of Charcoal	Mesh	Std. G-43 No. samples	Std. G-43 Time Mins.	Std. G-7 No. samples	Std. G-7 Time Mins.	Std. SF No. samples	Std. SF Time Mins.	Std. G-178 No. samples	Std. G-178 Time Mins.
9/19/18-11/18/18	Astoria CODC	10-14	4	27						
11/19-5/8/18	"	8-10	25	29	18	22				
5/9/18-6/12/18	"	8-14	6	19	6	17				
6/13 to 8/23	Air activated Astoria mixed shell	8-14	20	22	4	19	16	61	29	51
8/24 to 11/22	Steam activated mixed shell Astoria	8-14	17	19	14	37	9	75	78	95
Large drums Astoria	CODC	10-14	4	31	4	33				
"	"	8-10	7	34	7	29				
"	"	8-14	3	22	3	24				
"	Air activated mixed shell	8-14	9	20	7	21	9	89	8	67
	Steam activated mixed shell	8-14	4	34	8	24	9	77	8	99
	CIHT	8-14	1	4	1	5			2	26
	Whet. A	as recd			1	113				
	B	8-14	2	62	1	260	1	116	5	64
	Bacnite	8-14	1	22	1	39			2	39
	Rodman Activated	8-20	1	30	1	43				
	"	8-14	1	19	1	12				
	Nat.Lamp	8-10	1	18						
	" "	10-14	1	33						
	Dorsite	8-14	2	13						
	Palmetto								1	0
	Hopcalite	8-20							1	66
	Ross #1	as recd							1	95

Period	Kind of Charcoal	Mesh	Std. G-43 10cm. layer No. samples	Std. G-43 10cm. layer Time Mins.	Std. G-7 10cm. layer No. samples	Std. G-7 10cm. layer Time Mins.	Std. SF 10cm. layer No. samples	Std. SF 10cm. layer Time Mins.	Std. G-178 10cm. layer No. samples	Std. G-178 10cm. layer Time Mins.
	German 1916									
	Abs. #1		2	3	2	0	(5 cm. layer)			
	" #2		2	19	2	0				
	" #3		2	0	2	0				
	Ger. 1918	8-14	1	19	1	35	1	26	1	25
	Eng. 1917		1	8	1	0				
	" 1918	8-14	1	39	1	36	1	70	1	67
	English Sample									
	A	10-14	1	6						
	B	8-14			1	4				
	B	8-10	1	4						
	B	10-14			1	3				
	C	10-14	1	18	1	4				
	D	8-10	1	6						
	D	10-14			1	6				
	E	8-10	1	5						
	E	10-14			1	6				
	F	8-10	1	5						
	F	10-14			1	6				
	French 1917		1	8	1	4				
	1918	8-14	1	20	1	0	1	47	1	19
Other absorbents:										
	Silica gel	8-10	2	10	2	5				
	"	as recd.							1	15.5
	Salvas	8-14	1	52	(5 cm. layer)					
	Calif. white clay	8-14							1	0

(b) Soda-lime:

Period	Kind of Soda-lime	Mesh	Standard CG 1000 p.p.m. 10cm. layer No. of Sample	Time Mins.	Standard CG 10000 p.p.m. 10cm. layer No. of Sample	Time Mins.	Std. SF 1000 p.p.m. 10cm. layer No. of Sample	Time Mins.
Feb.25-Mar.25	Astoria	8-10	7	164	20	16.6		
Mar.26-Nov.13	"	8-14			161	24.7	104	130
	" drums	6-20			1	5.0	1	18
	" "	8-14			19	25.1	13	12
	" "	8-10	7	103	2	9.0		
	" white	8-14			3	23.8	3	190
Genl.Chem.Co.	Green	8-10	1	122				
	"	8-14			2	2.5		
	Wilson	8-10	1	35				
	"	8-14	4	160				
	McNeil	6-18	1	14				
	"	8-10	3	15				
	"	10-14	1	50				
	"	6-14	1	3				

Period	Kind of Soda-lime	Mesh	Standard G-43 1000 p.p.m 5 cm. layer No. samples	Time Mins.	Standard G-43 1000 ppm. 10cm. layer No. samples	Time Mins.	Standard G-7 1000 ppm. 15cm. layer No. samples	Time Mins.	Standard G-7 1000 ppm. 10cm layer No. samples	Time Mins.
Feb.25-Mar.25	Astoria	8-10	19	34			22	11.8	19	5.6
Mar.26-Nov.13	"	8-14			20	141			139	8.0
	" drums	6-20			1	106			1	3.5
	" "	8-14			11	103	3	12.5	16	6.7
	" "	8-10	8	29			8	7.8	7	3.4
	Green	8-10	1	258						
	"	8-14	1	112	1	398				
	Wilson	8-10							2	4.0
	"	8-14					4	8.1	4	6.3
	" white	8-14			4	156				
	McNeil	6-8	1	13					1	0
	"	8-10	3	19					3	2.3
	"	10-14	1	25					1	0
	"	8-14	1	13					1	0

Period	Sample of	Mesh	Std. CG 1000 p.p.m. 5 cm. layer		Std. G-43 1000 p.p.m. 5 cm. layer		Std. G-7 1000 p.p.m. 10 cm. layer	
			No. of samples	Time Mins.	No. of samples	Time Mins.	No. of samples	Time Mins.
	English soda lime 1917		1	10	1	8	1	0
	English permanganate granules of 30/10/17.	8-10	1	2	1	25	1	1.7
	English caustic soda of 30/10/17	8-10	1	12	1	37	1	.1
	English chemical absorbent	8-10	1	61	1	8	1	.6
	French chem. absorbent		1	300 G28	1	950	1	1
	Standard G-28 10,000 p.p.m. 10 cm. layer.							
	White soda lime	as recd.	16	42.0				

(c) Charcoal-soda lime mixtures:

Period 1918	Mesh	CG 10,000 ppm. 10 cm. layer No. of samples	Service time in minutes
3/30 to 6/2	8-14	31	26.5
6/3 to 7/17	"	28	26.1
7/18 to 8/5	"	10	25.0
8/6 to 8/29	"	21	24.7
8/30 to 9/21	"	17	30.8

TABLE II

PROTECTION AFFORDED BY VARIOUS CANISTERS AGAINST TOXIC GASES.

Description of Canisters:

With the exception of the Logan canister and the Navy drum, all the canisters mentioned below are of the same general form. The canister is of corrugated tin plate with a flattened oval cross section and straight sides. There is an oval dome screen in the bottom of the canister. Inspired air enters through a circular valve at the bottom of the canister, passes up through the absorbent, and is drawn out through a tube at the top of the canister.

Logan Canister: The absorbent mixture is contained in a perforated metal cylinder of proportions similar to those of the standard type H canister, but of smaller dimensions. The cylinder is surrounded by a felt bag filter and the whole enclosed in a rather closely fitting metal container having two inlets at the top of either side of the outlet tube. The outlet tube connects with a flattened tube of perforated metal which runs down into the absorbent. This extension is covered by a piece of towelling.

Volume of absorbent	620	c.c.
Weight of absorbent	400	gms.
Area of absorbent exposed to entering air	330	sq.cm.
Approximate thickness of absorbent layer	3-4	cm.
Surface area of outlet tube extension	84	sq.cm.
Press.drop @85 l/m. mm. H_2O	44	
Press.drop at 85 l/m. mm. H_2O without felt filter	15	

Navy Drum Type D ("Navy"): The Navy drum is somewhat like the German in shape. The container is a slightly tapered metal cylinder, 9 cm. in diameter at the bottom. The optimum filling for this drum is designated as "Type D". It consists of two layers, 98 c.c. of each, of a standard mixture of 60% A-4 and 40% A-25B, 6-20 mesh, separated by a cotton-wadding pad and a ring baffle;

Volume of absorbent ------------------200 c.c.
Average cross sectional area---------- 62 sq.cm.
Height of absorbent layer-------------4.5 cm.
Press. drop @85 l/m. mm. H_2O ---------38.

Dimensions and Resistance of Canisters:

Below are given the dimensions and resistance of the various types of canisters.

The height of absorbent layer above the dome has been estimated and is given as being the approximate effective thickness of absorbent layer in the canister.

Under "Cross Sectional Area" is given the cross section of the canister normal to the direction of flow, except in the Logan canister for which is given the total area of absorbent exposed to the entering gas.

TYPE	Press. Drop @85 l/m: mm. H_2O	ABSORBENT Volume c.c.	ABSORBENT Weight gms.	ABSORBENT Height abs. Layer (above dome) cm.	Cross sectional area sq.cm.
Standard U.S. "B"	51	920	660	13.5	65
"C"	51	920	660	13.5	65
"D"	102	900	645	12.5	65
"F"	99	655	425	8.5	65
"G"	108	690	450	8.5	65
"H"	90	690	450	8.5	65
"J"	76	460	300	5.5	65
"L"	72	500	325	5.5	65
Artillery ("Art")	52	1639	(1065)	18.0	85
Spec.C.C.Industrial "Sp.C.C."	33	3600	(2340)	25.0	140
Navy -- CMA-1	92				65
Navy -- CMA-2	45				90
Navy -- CMA-3	69	750		15.0	45
Navy drum Type D ("Navy")	38	200		4.5	62
Logan Can ("Logan")	44	620	400	(3-4)	(330)
Ammonia Can #1	75	492		4.8	90

RESULTS:

Protection against Toxic Gases: Under "Date of Filling, or Absorbent", if the date of filling is given, it is understood that standard U.S. Army canisters, containing

the standard 60% A-4 and 40% A-25B mixture were used . The A-25 is the green granule type in Types B, C and D canisters, and the pink granule type in all others. A-25B designates the pink granules, and the word "green" will be written in to show the green type.

When the canister is specially packed, the efficiency of the absorbent used in given in parentheses after the description of the absorbent. This time (in minutes) is the result for A-4, of the standard accelerated PS tube tests, and for A-25 of the Standard CG tube test.

Under "Intermittent" will be given either the number of inhalations per minute or the abbreviation "Cont". signifying continuous flow, or "Man Test" indicating that tests were run with a man breathing at rest (approx. 8 l/m) through the canister.

Gas	Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Concentration: mg/lit	Rate l/m	Intermittent in. gal/min	Life Minutes
G-4	B	BHPK15XA	1	500	1.15	32	Cont.	Over 340
		K26X	2	5000	11.46	"	"	53
		100-A4						
		(26.5 minutes)	2	"	"	"	"	101
		100-A25 (green)						
		(7 minutes)	2	"	"	"	"	0
G-7	H	HHPD 12Y	3	100	0.32	32	Cont.	113
		"	3	500	1.60	"	"	21
		"	3	1000	3.19	"	"	8
		"	3	5000	16.95	"	"	3
		100-A-4						
		(16 minutes)	2	1000	3.19	"	"	22
		100-A-25B						
		(9 minutes)	2	"	"	"	"	10
		100-Whetlerite"B"	2	"	"	"	"	686
		100- " "A"&"B"						
		(mixed sample)	1	2500	8.48	"	"	Over 90
		100-Rankinite	1	1000	3.19	"	"	606
		100-Larsenite	1	"	"	"	"	665
	"Navy"	60-A4;40-A25B	4	225	0.72	"	"	0.5
		"	3	100	0.32	"	"	1.0
G-10	B	BHPK1-L11X	1	500	3.71	32	Cont.	119
		"	28	2000	14.83	"	"	64
G-16	B	---------	--	(250)	Similar to G-172 (470)			
G-22	B	BHPK1-L11X	1	2000	7.57	32	Cont.	226
		"	5	8000	30.27	"	"	41
PS	B	BHPK1-L11X	90	4000	26.89	32	Cont.	33
		BHPK10-14A	5	"	"	8.5	15	231
		"	5	"	"	"	20	211
		"	5	"	"	16	20	99
		"	5	"	"	32	20	42
		"	4	"	"	Man Test		227
		K3-30X	5	2000	13.45	"	"	Over 360
		60-A4	5	2000	"	32	Cont.	57
		40-A25B						
		40-A4	5	"	"	"	"	43
		60-A25B						

Gas	Canisters: Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Concentration: Mg/lit	Rate: l/m	Inter-mittent in-hal/min	Life Minutes
PS	C	CHPL11X-A1Y	10	4000	26.89	32	Cont.	44
	D	DHPA1-5Y	1	"	"	"	"	36
		100-A4 (Hudson)	4	1500	10.09		Man Test	58
		" (Astoria)	4	1000	6.72		" "	100
		" (Bachelor)	5	3000	20.17		" "	260
	F	FHPA8-25Y	51	4000	26.89	32	Cont.	21
		FHPA23-25Y	5	"	"		Man Test	75
	G	GHPC4Y	2	500	3.36	32	Cont.	263
		"	5	4000	26.89	"	"	30
		"	3	10000	67.23	"	"	12
		"	2	17500	117.6	"	"	7
	H	199-207 HH	10	2500	16.8	32	Cont.	35
		175-275 HH	86	"	"	"	22	41
		143-162 HH	5	500	3.36		Man Test	Over 60
		60-A4(15 minutes) 40-A25B(20 ")	3	500	3.36	32	Cont.	195
		"	3	2500	16.80	"	"	29
		"	3	5000	33.62	"	"	15
		"	5	15000	100.9	"	"	5.5
		"	4	2000	13.45	8	"	264
		"	4	"	"	16	"	85
		"	4	"	"	32	"	33
		100-Whetlerite"B"	2	4000	26.89	32	"	112
		100-Rankinite	2	"	"	"	"	111
		100-Larsenite	2	"	"	"	"	115
	J	211-215 HJ	8	2500	16.80	32	Cont.	14
		175-275 HJ	82	"	"	"	22	16
		------ HJ	10	2000	13.45		Man Test	109
		60-A4(15 minutes) 40-A25B(20 ")	3	500	3.36	32	Cont.	79
		"	3	2500	16.80	"	"	13
		"	3	5000	33.62	"	"	7
		"	3	15000	100.9	"	"	2.5
		"	4	2000	13.45	8	"	128
		"	4	"	"	16	"	44
		"	3	"	"	32	"	19
	L	264-275 HL	15	1000	6.72	32	22	59
	CMA-3	60-A4(16.5 minutes) 40-A25B(31 ")	4	2500	16.80	32	22	49
	Navy	Stand.60-40mixture	5	4000	26.89	32	Cont.	3
		"	4	1000	6.72	"	"	9
	Logan	Stand.60-40 "	7	1000	6.72	"	22	57

Gas	Canisters: Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Concentration: Mg/lit	Rate l/m	Inter-mittent in. hal/min	Life Minutes
G-28	B	BHPK1-L11XA	4	10000	29.0	32	Cont.	33
	C	CHPL11-31X	2	"	"	"	"	42
	D	DHPA1-5Y	5	"	"	"	"	33
		40-A4						
		60-A25 (green)	5	26750	77.6		Man Test	43
	F	Stand. 60-40 mixture		500	1.45	32	Cont.	227
		"		5000	14.50	"	"	21
		"		10000	29.0	"	"	13
		"		17500	50.8	"	"	6
	G	GHPA25-D1Y	83	5000	14.50	32	Cont.	41
	H	HHP-------	23	"	"	"	"	47
		"	128	10000	29.0		Man Test	125
		100-Whetlerite"B"	1	5000	14.50	32	Cont.	59
		100-Rankinite	1	"	"	"	"	65
		100-Larsenite	1	"	"	"	"	82
G-31	CMA-1	300 cc. HL	--	10000	----	"	"	35(90%pt)
	CMA-2	440 cc. HL	--	"	----	"	"	45 "
	CMA-3	260 cc. HL	--	"	----	"	"	21 "
	CMA-3	250 cc. HC #200	2	"	----	"	"	190 "
		"	1	"	----		Man Test	600 "
HS	H	HHPL5Y	2	100	0.651	32	Cont.	1980
		100-A25B	1	"	"	"	"	0 slight leak
G-37	C	CHPL14X	1	700	3.61	"	"	Over 386
	F	FHPA21Y	3	700	"	"	"	262
G-43	B	BHPK1-L11X	78	5000	5.52	"	"	25
	C	CHPL11X-A2Y	8	"	"	"	"	20
	D	DHPA1-5Y	4	"	"	"	"	23
	F	FHPA-8-25Y	40	"	"	"	"	11
	G	GHPA25-D1Y	137	2000	2.21	"	"	29
	H	198-207 HH	10	2500	2.76	"	"	23
		175-275 HH	162	1000	1.10	"	22	43
		164 HH	8	250	0.276	"	26	217
		"	8	1000	1.10	"	"	64
		"	24	2500	2.76	"	"	30
		"	8	5000	5.52	"	"	17
		100-A25B (25 minutes)	8	"	"	"	22	31
		100-A25 (green)	8	"	"	"	"	67

Gas	Canisters: Type	Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Mg/lit	Rate 1/m	Intermittent inhal/min	Life Minutes
G-43	H	100-Whetlerite"A"	1	2000	2.21	32	Cont.	66
		100- " "B"	2	"	"	"	"	40
		100-Rankinite	2	"	"	"	"	30
		Larsenite	2	"	"	"	"	16
	J	211-215 HJ	8	2500	2.76	"	"	12
		240-278 HJ	160	1000	1.10	"	22	20
	L	266-277 HL	18	500	0.552	"	"	36
	CMA-3	60-A4(16.5 minutes)						
		40-A25(31 ")	4	1000	1.10	"	"	57
	Navy	Standard 60-40	5	2000	2.21	"	Cont.	4
		mixture						
		"	5	1000	1.10	"	"	6
	Logan	Standard 60-40						
		mixture	8	500	0.552	"	22	48
SF	G	CHPC18Y	5	2000	16.18	32	Cont.	52
		"	5	"	"	8.5	15	448
		"	4	"	"	16	20	253
		"	5	"	"	32	20	57
	H	HHPD1Y	5	"	"	32	Cont.	56
		"	5	3000	24.28	"	"	39
		100-Whetlerite"A"	1	3000	"	"	"	57
		100- " "B"	2	2000	16.18	"	"	46
		100-Rankinite	2	"	"	"	"	42
		100-Larsenite	2	"	"	"	"	33
	Navy	Standard 60-40						
		mixture	4	2000	"	"	"	10
		"	4	1000	8.09	"	"	23
CG	B	BHPK1-L11X	65	5000	20.23	32	Cont.	31
	C	CHPL11-31X	6	"	"	"	"	29
	D	DHPA1-5Y	11	"	"	"	"	36
	F	FHPA8-25Y	81	"	"	"	"	46
	G	GHPC5Y	4	"	"	8	"	236
		"	5	"	"	16	"	104
		"	6	"	"	32	"	42
		"	6	"	"	8	20	271
		"	6	"	"	16	20	117
		"	6	"	"	32	20	47
		100-A4	8	"	"	"	Cont.	18
		60-A4	4	"	"	"	"	37
		40-A25B						
		40-A4	5	"	"	"	"	47
		60-A25B						
		100-A25B	5	"	"	"	"	39
		100-A25B	6	"	"	"	20	46
		100-A25B	2	"	"	8	"	291

Gas	Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m	Concentration: Mg/lit	Rate 1/m	Intermittent inhal/min	Life Minutes
CG	H	203-207 HH	10	5000	20.23	32	Cont.	41
		175-275 HH	214	"	"	"	22	47
		HHPD18-19Y	10	"	"		Man test	297
		60-A4(14 minutes)	3	"	"	"	Cont.	47
		40-A25B(26 ")						
		"	3	50000	202.3	"	"	6
		"	3	250000	1011.0	"	"	1.5
		"	4	2500	10.11	85	"	23
		"	3	10000	40.45	"	"	7
		"	3	50000	202.3	"	"	1.5
		"	2	1000	4.05	150	"	57
		"	3	5000	20.23	"	"	7
		"	3	10000	40.45	"	"	2
		100-A4	4	5000	20.23		Man Test	160
		"	4	10000	40.45		" "	66
		100-A25B	4	5000	20.23		" "	17
		"	4	10000	40.45		" "	15
		100-A4(18.6 min.)	10	10000	"		" "	78
		60-A4(18.6 ")	10	"	"		" "	178
		40-A25B(23 ")						
		40-A4 (18.6 ")	10	"	"		" "	129
		60-A25B(23 ")						
		100-A25B(23 ")	20	"	"		" "	39
		100-Whetlerite"A"	3	5000	20.23	32	Cont.	51
		(14W18(1))						
		60- "	3	"	"	"	"	60
		40-A25B						
		100-Whetlerite"B"	3	"	"	"	"	65
		(24W25(1))						
		60- "	3	"	"	"	"	66
		40-A25B						
		100-Rankinite"A"	3	"	"	"	"	72
		60- "	3	"	"	"	"	95
		40-A25B						
		100-Rankinite	2	"	"	"	"	37
		100-Larsen ite	2	"	"	"	"	27
	J	211-215 HJ	8	"	"	"	"	21
		175-275 HJ	116	"	"	"	22	23
		---- HJ	20	10000	40.45		Man test	92
		60-A4(14 minutes)	3	5000	22.23	32	Cont.	19
		40-A25B(26 ")						
		"	3	50000	202.3	"	"	2.5

Gas	Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Mg/lit	Rate l/m.	Intermittent inhal/min	Life Minutes
CG	J	40-A25B (26 minutes)	5	100000	404.5	32	Cont.	1.5
		"	3	2500	10.11	85	"	10
		"	2	10000	40.45	"	"	3
		"	3	100000	404.5	"	"	0.5
		"	3	500	2.02	150	"	36
		"	3	2500	10.11	"	"	5
		"	4	5000	20.23	"	"	1
	L	264-275 HL	24	2500	10.11	32	22	41
	CMA-3	60-A4 (16.5 min.) 40-A25B (31 ")	4	5000	20.23	"	"	43
	Navy	Standard 60-40 Mixture	3	5000	"	"	Cont.	9
		"	5	1000	4.05	"	"	57
G-55	H	HHPE-Y	3	1500	11.41	"	"	63
		" (15% rel. humidity)	2	"	"	"	"	38
		100-A4 (20 minutes)	1	"	"	"	"	20
		100-A25B	1	"	"	"	"	3
G-67	F	FHPA17Y	3	5000	21.66	"	"	38
		"	6	100	0.433	"	"	295
	H	HHPD19Y	10	1250	5.43	"	Man test over 60	
G-73	H	147 HH	3	250	1.78	"	Cont.	784
		100-A25B	1	250	"	"	"	6
G-100	H	HHP----	9	5000	23.52	32	"	42
		100-A25B	1	"	"	"	"	0
G-172	C	CHP	3	100	0.699	"	"	470
CC	G	GHPB-Y	3	100	0.251	"	"	144
		"	1	1000	2.51	"	"	22
		"	3	5000	7.54	"	"	4
	H	147-162 HH	5	500	0.754	"	"	21
		164-168 HH	5	1000	2.51		Man test	143
		100-A4 (25 min.)	5	500	1.26	32	Cont.	77
		"	[illegible]	750	1.88	"	"	58
		"	1	5000	7.54	"	"	25
		100-A25B	1	1000	2.51	"	"	0
		100-Whetlerite "A" (14W18(1))	3	500	1.26	"	"	31
		60- " 40-A25B	3	500	"	"	"	7
		100-Whetlerite (14W18:15W19)	3	500	"	32	Cont.	95
		60-- 40-A25B	3	"	"	"	"	23

Gas	Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Concentration: mg/lit	Rate: l/m	Intermittent: in-nal/min	Life Minutes
CC	H	100-Rankinite"A" 60- 40-A25B "	3	500	1.26	32	Cont.	72
			3	"	"	"	"	23
		100-Larsenite	3	"	"	"	"	0
	J	214-215 HJ	4	"	"	"	"	7
	"Art"	100-A4(25 minutes)	1	5000	7.54	"	"	65
	"Sp.CC"	100-A4 (43 ")	3	"	"	"	"	213
G313	H	HHPE-Y	3	2500	16.45	"	"	118
		"	9	5000	32.90	"	"	46
		135-144 HH	10	500	3.29		Man test	Over 310
		100-A4 (20 min.)	1	2500	16.45	32	Cont.	106
		100-A25B	1	2500	"	"	"	94
G-337	H	HHPE-Y	1	28	0.225	"	"	Over 5100
		100-A25B	1	"	"	"	"	0
G-349	H	HHP----	1	31	0.282	"	"	Over 4800
		171-207 HH	10	10	0.091		Man test	16
		100-A4 (20 min.)	1	31	0.282	"	Cont.	Over 1000
		100-A25B	1	"	"	"	"	Over 1500
Chbr-aceto-pnenone	H	HHP---	4	15	0.095	"	"	Over 150
		Y29-140 HH	10	1000 (sprayed)	6.32		Man test	Over 50
	J	HJ	1	15	0.095	32	Cont.	Over 1800
		100-A25B	1	"	"	"	"	0
S-4	H	147 HH	2	10000	6.95	"	"	0
		"	2	5000	3.48	"	"	3
		"	3	2500	1.74	"	"	5
		60HC 40-$CaCl_2$ (in layers)	1	10000	6.95	"	"	8
		100-Whetlerite"B" (24W25(1))	1	"	"	"	"	8
		100-pumice+$NiCl_2 \cdot 6H_2O$	1	20000	13.90	"	"	22
		100-pumice+ $CoCl_2 \cdot 6H_2O$	2	"	"	"	"	84
		" "	1	50000	34.75	"	"	18
		" "	1	"	"		Man test	192
		100-pumice+ $CuSO_4 \cdot 5H_2O$	1	20000	13.90	"	Cont.	46
		" "	1	50000	34.75	"	"	20
		" "	2	"	"	"	Man test	175

Gas	Canisters: Type	Canisters: Absorbent or Date of Filling	No. of Cans	Concentration: p.p.m.	Concentration: mg/lit	Rate l/m	Intermittent inhal/min	Life Minutes
S-4	H	100-Patrick Absorbent	1	20000	13.90	32	Cont.	17
S4	#1	Pumice + H_2SO_4	2	10000	6.95	"	"	42
		" "	4	20000	13.90		Man test	145
		" "	2	25000	17.38		" "	104
		" "	3	40000	27.80		" "	4
C_6H_6	H	162 HH	3	10000	31.9	32	Cont.	14
		162-203 HH	2	40000	127.6	"	"	3.5
		100-A4 (16.6 min.)	1	10000	31.9	"	"	46
		"	1	40000	127.6	"	"	11
		100-A4 (32 min.)	1	10000	31.9	"	"	71
		"	2	50000	159.5	"	"	12
CS_2	H	HHP----	2	10000	31.1	"	"	17
		100-A4 (42 min.)	3	10000	"	"	"	68
		"	3	30000	93.3	"	"	20
		"	3	50000	155.5	"	"	8
Chlor-acetyl chlor-ide.	H	182 HH	1	1000	5.27	"	"	408
		"	5	10000	52.73	"	"	29
		100-A4 (20 min.)	1	10000	52.73	"	"	21
		100-A25B	1	10000	"	"	"	39
H_2S	H	60-A4 (22.5 min.) 40-A25B (16.5 ")	4	10000	13.9	"	22	97
		100-A4 (22.5 ")	4	"	"	"	"	37
		100-A25B (16.5 ")	4	"	"	"	"	170
N_2O_4	G	93-98X6	5	1500	5.64		Man test	Over 70
	H	164-168 HH	4	1500	"		" "	Over 70
SO_2	B	BHP---	1	10000	26.2		" "	0
	H	184 HH	2	2500	6.55	32	Cont.	Slight break 60
		180 HH	5	5000	13.1	"	"	32
		166-182 HH	20	50000	131.0		Man test	29
		100-A4 (20 min.)	1	5000	13.1	"	Cont.	7
		100-A25B	1	5000	"	"	"	54

TABLE III

COMPARISON OF PROTECTION AFFORDED BY FOREIGN & U. S. CANISTERS

Canister	Type	Date of Filling	No. Tested	Method of Test	Conc. p.p.m.	Conc. mg/l	Resistance in mm. H_2O@85 l/m	Life in minutes to 100%	Life in minutes to 90%
				Gas CG					
U.S.	H	June'18	96	32 l/m cont.	5000	20.1	90	45	60
U.S.	J	July'18	8	"	5000	20.1	79	21	29
British			1	"	5000	20.1	101	13	21
French	Lrge Tis.		1	"	5000	20.1	18	402	463
French	Small Tis.		1	"	5000	20.1	9	96	103
German			1	"	5000	20.1		1.2	11
U.S.	H	June'18	80	32 l/m inter. 22 strokes	2500	10.0	96	51	
U.S.	J	July'18	60	"	2500	10.0	76	22	
German		20/11/17	1	"	2500	10.0		25	27
German		14/4/18	1	"	2500	10.0		16	16
U.S.	H	June'18	16	Test on men at rest	10000	40.1	99	160	
U.S.	J	July'18	20	"	10000	40.1	67	92	
British			3	"	10000	40.1		58	
				G-43					
U.S.	H	June'18	10	32 l/m cont.	2500		97	23	38
U.S.	J	July'18	8	"	2500		79	12	19
British			1	"	5000		105	5	10
U.S.	J	July'18	26	32 l/m inter. 22 strokes	500		75	31	58
German		30/11/17	1	"	500			15	18
German		20/11/17	1	"	500			5	5
				PS					
U.S.	H	June'18	10	32 l/m cont.	2500	16.8	94	35	47
U.S.	J	July'18	8	"	2500	16.8	76	14	24
British			1	"	2000		105	10	12
French	Lrge Tis.		1	"	2000		23	90	96
Fench	Small Tis.		1	"	2000		13	14	15

Canister	Type	Date of Filling	No. Tested	Method of Test	Conc. p.p.m.	Conc. mg/l	Resistance in mm. H_2O 85 l/m	Life in minutes 100%	Life in minutes 90%
				Gas PS					
German			1	32 l/m cont.	2000			0	
U.S.	J	July'18	47	32 l/m inter. 22 strokes	1000			45	72
German		14/4/18	1	"	1000			43	76
German		21/12/17	1	"	1000			6	13
U.S.			7	Tests on men at rest	2500			144	
British			3	"	2500			32	
				HS					
U.S.	H	Mar.'18	2	32 l/m cont.	100		105	1800	
German			1	"	100			40	
				G-7					
U.S.	H	June'18	2	32 l/m cont.	250	0.8		27	
U.S.	J	Aug.'18	4	"	250	0.8		9	
French	BM	112	1	"	250	0.8		0	
German		14/4/18	2	"	250	0.8		0	
				CC					
U.S.	G	Feb.'18	1	32 l/m cont.	1500	3.77	107	15	
German			1	"	1500	3.77		0	
U.S.	H	June'18	1	"	100	0.25		55	83
U.S.	J	Aug.'18	2	"	100	0.25		23	48
French	BM	112	1	"	100	0.25		1	3
German		14/4/18	1	"	100	0.25		2	3
German		11/12/17	1	"	100	0.25		3	13
				G-28					
U.S.	G	Feb.'18	6	32 l/m cont.	10000		108	18	27
British			1	"	10000		58	9	14
U.S.	H	Mar.'18	23	"	5000		90	47	64
German			2	"	2000		21	38	
				G-55					
U.S.	H	Jan.'18	3	32 l/m cont.	1500		90	63	130
German	S11 11	B20-10-16	2	"	1500		34	0	4

Canister	Type	Date of Filing	No. Tested	Method of Test	Conc. p.p.m.	Conc. mg/l	Resistance in mm. H_2O @ 85 l/m	Life in minutes to 100%	Life in minutes to 90%
G-73									
U.S.	H	June '18	8	32 l/m cont.	250		99	180	
German	S11-11	B20-20-16	1	"	250		36	0	11
G-76									
U.S.	H	9/11/18	50	Tests on men at rest	3		90	1	
British			6	"				14	
G-100									
U.S.	H	June '18	9	32 l/m cont.	5000			42	59
German		10/20/16	1	"	5000			0	2
G-4									
U.S.	C	Dec. '17	2	32 l/m cont.	5000		51	53	
German			1	"	5000			0	3
G-313									
U.S.	H	May '18	3	32 l/m cont.	2500		84	118	160
German	S11-11	B20-10-16	2	"	2500			9	23
G-337									
U.S.	H	May '18	9	32 l/m cont.	28		96	180	
German	15RHH	119-16	1	"	28		23		186
SO_2									
U.S	H	June'18	5	32 l/m cont.	5000		93	32	43
German	B4	11-16	1	"	5000		33	1	4
2-4D									
U.S.	L	Sept.'18	1	32 l/m cont.	40	393		30 hrs.	
German		Oct. '17	1	"	40	393		30 hrs.	
Chloracetyl chloride									
U.S.	H	July '18	5	32 l/m cont.	10000	46.2		29	40
German		1917	2	"	10000	46.2		0	6
U.S.	H	July'18	1	"	1000	4.62		408	
German		Oct'17	3	"	1000	4.62		41	91
G-349									
U.S.	H	July'18	1	32 l/m cont.	31	0.28		80 hrs.	
German	S-11-11	B12/10/16	1	"	31	0.28		72	126

TABLE IV

PERMEABILITY TESTS ON VARIOUS FABRICS

Manufacturer	Fabric-Description	Lab.No.	Time of penetration in min. PS	HS
Howe Rubber Co.	Mask Fabric	P-382	120	
Ravenna Rubber Co.	Tissot Mask, 70% rubber, gauge 60-100	P-420	175	
U.S.Naugatauk Co.	Mask Fabric, 2 spreader coats, 1 calender coat	P-131	9	
"	Mask Fabric, 2 spreader coats 2 calender coats	P-133	32	
"	Mask Fabric, 2 spreader coats 2 calender coats	P-158	35	
"	Mask Fabric Roll "G" gauge 0.0145"	P-174	25	
Kenyon Rubber Co.	Mask Fabric K.E.104#13(28M)	P-146	21	
"	Mask Fabric " #36(63M)	P-128	17	
"	Mask Fabric " #34(61M)	P-119	25	
"	Mask Fabric " #40(67M)	P-114	23	
"	Cloth for Mouth Piece Washers	P-95	18	
"	Mask Fabric	P-54	19	
Celluloid Co.	Hood Fabric,coated on rubber side	P-188	21	
"	" " " cloth side	P-187	38	
U.S.Rubber Company	Brown Rubberized Fabric, gauge 0.052"	P-381	125	150
"	Mask Fabric, 2 spreader coats 2 calender coats	P-49	28	
Keratol Company	Keratol #2	P-65	42	
Goodrich Rubber Co.	Goodrich Standard Tissot Fabric	P-385	147	157
Good year Rubber Co.	Goodyear Mask Fabric 22 -3E	P-61	43	
A.D.Little Co.	Modified Shellac Fabric	P-480	23	82
Pantasote Co.	Pantasote #1112	P-262	22	21
A.J.Tower Co.	Tower Standard Dipped Suit	P-437		58
L.C.Chase Co.	L.C.Chase #153	P-424	197	
Potter Texile Co.	Fabric "Potter C" Black,rubber coated	P-219	36	151
Standard Oil Cloth Co.	Sample #1,Black coated fabric	P-285	32	64
" " " "	Napped moleskin coated with	P-230	46	300
T.H.Goodlatte Co.	Three ply brown fabric	P-272	62	45
"	Fabric #A-2, oiled fabric	P-91	105	
Quaker City Rubber Co.	Quaker City #2	P-496		96 hrs.
" "	Quaker City #2-B	P-514		133
N.Y.Belting &Packing Co.	Asbestos & Rub.#1,light weight	P-453		67
Nairn Linoleum Co.	Canton Flannel blanket material	P-406	290	292
" " "	Eiderdown blanket material	P-407	150	330
" " "	Nairn Dipped Suit	P-438		35

Manufacturer	Fabric-Description	Lab.No.	Time of penetration in min. PS	HS
Nairn Linoleum Co.	Gas Proof Duck saturated with comp. #36	P-388		123
Dupont Company	Glove Fabric E.S. 539	P-280		71
" "	Fabrikoid D-4, Imitation leather	P-325	2	
" "	Blanket Fabric E.S. 610A	P-423	50	102
" "	Fabric E.S. 623	P-431	26	80
" "	Dupont Factory Run #184	P-602		128
" "	Dupont " " " Misweave	P-603		135
Hodgman Rubber Co.	Hodgman #4	P-253	13	25
Gooden Reed Co.	Gooden Reed #196	P-616		17
British-American Mfg. Co.	B.A.M. #2	P-261	32	
A.C.Lawrence	Black Oiled Glove Leather #2	P-270	21	
Bancroft & Sons	Cotton Fabric coated with red viscose	P-354		205
Victor G.Bloede Co.	Special Fabric #2, gauge 0.022"	P-413	49	13
Western Shade Cloth Co	Western Shade Cloth Co. #B	P-612		76
Brooklyn Rubber Shield Co.	Fabric B.R.S.B	P-85	14	
Metals Coating Co.	Sail cloth coated on both sides with aluminum	P-94	Immediately	
General Bakelite Co.	General Bakelite Co.Exp.Fabric	P-508	25	30
Crown Cork & Seal Co.	Cork Material	P-504	10	
C.R. Allison	Fire Retarding Fabric	P-427		16
Zapon Leather Co.	Black imitation leather #21005	P-326	2	
Boston Indurating Co.	Black glove treated with rosin and petrolatum	P-301		144
Plymouth Rubber Co.	#81-x-2, 2 spreader coats	P-179	54	
	2 calender coats	P-212	25	
Federal Rubber Co.	F.R.C. #1	P-237	19	
Kleinert Rubber Co.	Fabric #24 x 1	P-50	13	
Chicago Rubber Cloth Co.	Sail Cloth with smooth coating. gauge 0.020"	P-241	18	
Littauer Co.	Oiled leather #12	P-244		98
Archec Strausa Co.	A.S. #103	P-210	20	
I.O.C.O. Proofing Co.	Cotton fabric treated with boiled linseed oil	P-191	92	
French American Balloon Co.	Varnished balloon fabric	P-181	51	
	Charcoal paper F 79 Thickness (0.032)	P-542	1	
	Linseed oil #200	P-623		140
	English mask fabric (K3)(53)(80)	P-48	17	
Gossard Co.	Protexwell	P-212	25	