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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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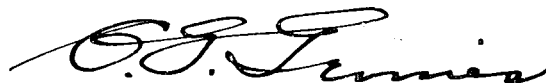
21 November 1945

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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.
Subject: Target Report - Japanese Chemical Warfare.
Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Supplementary Questionnaire "C" of Fascicle M-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Comdr. F.B. Ayres, (MC) USNR, assisted by Lt.(jg) F.J. Gilbert, USNR, and Lieut. R.C. Baldrige, AUS.



C. G. GRIMES
Captain, USN

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RESTRICTED

M-C

JAPANESE CHEMICAL WARFARE

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945
FASCICLE M-1, SUPPLEMENTARY QUESTIONNAIRE "C"

NOVEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MEDICAL TARGETS

JAPANESE CHEMICAL WARFARE

The exploitation of the main target, SAGAMI Navy Yard, where naval chemical warfare research and poison gas production was carried on, yielded information of as complete a nature as could be desired on the following:

1. War gases manufactured.
2. Decontaminating agents.
3. Location of storage dumps.
4. Training of Japanese naval personnel in anti-gas measures.
5. Researches and new compounds produced. (In addition to gas formulae developed, a fair substitute for ship-bottom paint was found).

The source of information was the former director of the Gas Research Laboratory, and it is felt his knowledge was exact. Repeated interrogations of all contacted medical personnel from the Bureau in TOKYO to the field medical officers has revealed a lack of familiarity with the subject, so that the knowledge gained has been very meager.

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REFERENCES

A. Location of Target:

SAGAMI Chemical Works, SAGAMI Navy Yard, located on the west coast of the MIURA Peninsula, north of ZUSHI, at CHIGASAKI, JAPAN.

B. Japanese Personnel Who Assisted in Gathering Equipment and/or Locating Documents:

Captain K. HIRATSUKA, IJN, research chemist, and director of the SAGAMI Chemical Research Laboratory. Graduate of TOKYO Imperial University.

C. Japanese Personnel Interrogated:

The same personnel named in Reference "B".

Comdr. YOSHIDA, IJN, SAGAMI Navy Yard.

All medical officers as in Reference "B" of NavTechJap Report - "Data Relative to Life in the Jungle" - Index No. M-01.

D. Cross Reference:

Appendix "A" of NavTechJap Report Index No. M-AA - "Organization, Administration, and Facilities of the IJN Medical Corps".

LIST OF ENCLOSURES

- (A) List of Equipment Forwarded to NMRI, BETHESDA, MD.
- (B) List and Description of Gas Protective Devices seized and/or Developed by the Japanese Navy.
- (C) Formulae of Gas Compounds Developed by the Japanese.

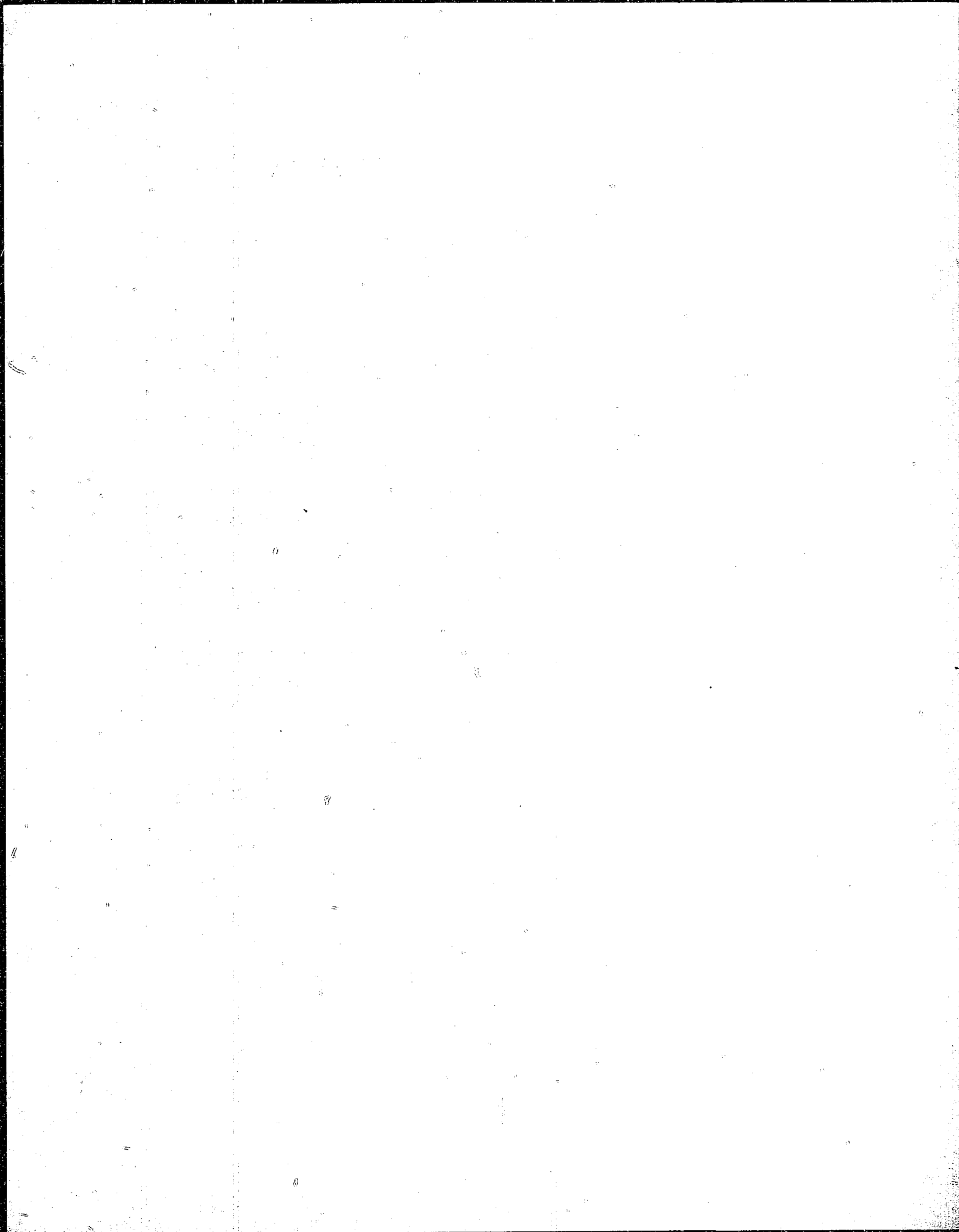
INTRODUCTION

From the time that the tide of JAPAN'S successes in the field began to ebb there has been speculation as to whether she would resort to chemical warfare, especially in a last desperate effort to ward off invasion or to resist to the last on the shores of her homeland.

None of the nations at war could afford to neglect the subject of chemical warfare, and, although not publicized, research and preparation for defense and offense was continually progressing, and stocks of chemical warfare agents were prepared and stored in case of need.

It was felt that JAPAN, no less than her allies and enemies, could not be neglecting this field, and the many reports from CHINA claiming the use of poison gas by the Japanese, although difficult to substantiate after the attack on the UNITED STATES, served to keep the subject open to speculation. In view of the fact that CHINA seems to have been used by the Japanese, to some extent, as a proving ground, and since the use of mustard and lewisite seems fairly well substantiated, the state of JAPAN'S preparedness for chemical warfare has been a matter of curiosity and one which was designated for exploration.

The naval aspect of this question is here presented, with first the information available from the Naval Medical Corps, and then that from the experts. The discrepancies seem to illustrate the secrecy and lack of coordination and cooperation that is found not only between but within the Japanese services.



THE REPORT

1. A course of instruction, consisting chiefly of lectures on chemical warfare, was given in the Japanese Naval Medical School to the class of medical officers concerned (see reference "D"). The various common gases were identified by smell from small samples. The effects of and treatment for each were described and outlined.

Further training consisted in donning the mask and being exposed to tear gas. All ships' crews had gas-mask drill, and were trained in the performance of their duties while wearing their masks. Naval personnel on combat duty were required to carry their masks at all times.

2. New gases, if developed, were unknown to the Naval Medical Corps, Bureau, or individuals. It is believed that no German gases have been adapted. The Japanese personnel concerned insisted that this was the case.

3. The Medical Corps administrative headquarters and the personnel in the various naval districts were unaware of the location of caches of gas. They did not believe they would have been located near POW camps, hence there could be no danger of accidental release of gas.

4. Medical officers lectured their own units or crews on chemical warfare dangers and symptoms, and anti-gas defense.

5. It was "believed" that the trans-Pacific balloon project bore no relationship to plans for bacteriological warfare. The balloon activities of the Japanese Army were made public in the late spring of 1944 through the local newspapers. It was believed this project was intended to boost home morale and to constitute more of a psychological warfare threat against the UNITED STATES than to serve as an actually useful weapon of ordnance. All knowledge of bacteriological warfare plans was denied by the Japanese Navy.

It has been established that the army units under whose cognizance the trans-Pacific balloon operations came had no knowledge of the extensive research and plans undertaken by the Army bacteriological warfare section, and hence there could have been no relationship between the two.

6. The following are replies by Capt. HIRATSUKA to a general gas questionnaire:

a. Question: What war gases were manufactured?

Answer:

<u>Gas</u>	<u>Formula</u>	<u>Quantity Manufactured at SAGAMI (tons)</u>
Mustard	$\text{Cl-CH}_2\text{CH}_2\text{-S-CH}_2\text{CH}_2\text{Cl}$	500
Lewisite	$\begin{array}{c} \text{H H} \\ \text{ClC=C-AsCl}_2 \end{array}$	20
Diphenyl Cyanarsine	$\begin{array}{c} \text{CN} \\ \\ \text{As} \\ / \quad \backslash \\ \text{C}_6\text{H}_5 \quad \text{C}_6\text{H}_5 \end{array}$	120
Adamsite	$(\text{C}_6\text{H}_4)_2\text{NHAsCl}$	2
Chloracetophenone	$\begin{array}{c} \text{O} \\ \\ \text{C-CH}_2\text{Cl} \\ \\ \text{C}_6\text{H}_5 \end{array}$	120

b. Question: What articles of protective equipment, clothing etc. were used by the Japanese Navy?

Answer:

(1) Gas Masks	No. Manufactured
Type 93 Mk II	147,000
Type 93 Mk III	590,000
Type 93 Mk IV	110,000
Type 97	18,000
Type 3	6,000
(2) Other - Oxygen Mask	4,200
(3) Protective Clothing	
Type 98 protective clothing	2,970
Light protective clothing	102,500
Light protective cape	220,000
(4) Mod. 1 oxygen breathing apparatus for aeroplane	2,000

c. Question: What decontamination agents were used? What are the chemical compositions, methods of use and directions to troops?

Answer:

(1) No.1 is composed of potassium permanganate ($KMnO_4$). It is packed in tin-plated cans containing 150 gms. of the substance. This agent is used in solution to decontaminate sneezing and tear gases (as a spray).

(2) No.2 is composed of Caustic Soda ($NaOH$). It is packed in cans containing 1 kilogram of the substance. This agent is also used in solution as a spray to decontaminate tear and sneezing gas.

(3) No.3 replaced both No.1 and No.2 in 1943. It is composed of bleaching powder, ($Ca(OCl)_2$) or ($CaOCl_2$), and is packed in 8 kg. tin-plated cans. It is prepared in a water suspension and used for decontamination of mustard and lewisite (also tear and sneezing gases). This substance was the most widely distributed.

(4) No.4 is a solution of 10 gms. of Chlorine (Cl_2) in 40 gms. of carbon tetrachloride (CCl_4). It is contained in a spherical glass bottle and thrown against a wall or other hard surface. The (Cl_2) escapes and decontaminates gases, vesicants and sneezing gases.

(5) No.5 is a mixture of 16 parts Chloramine T ($CH_3C_6H_4SO_2NNaCl \cdot 3H_2O$) 81 parts "Bentonite" ($3Al_2O_3 \cdot H_2O \cdot (SiO_2)_n$) and 3 parts "Excelsine" ($C_{12}H_{25}OSO_3Na$).

It is used in an aqueous solution as a decontaminant for clothing and surface of the body.

(6) No.6 is used to detect and decontaminate arsenic contaminated water. This kit was described in Weekly Intelligence P.O.A.

d. Question: What are the tables of equipment for gas decontamination equipment in the Japanese Navy?

Answer: The decontamination equipment for ships consisted of only sprinklers. These each contained 20 liters of a solution of No.3 decontaminating agent (bleaching powder). Battleships were equipped with approximately 10, cruisers with approximately five, and destroyers one or two. A portable ventilating fan with an 11 horse power motor was also provided for each ship. On land bases it was planned to equip critical buildings with sprinklers mentioned above and with 10 kilogram packages of bleaching powder. This, however, was reportedly not carried out.

e. Question: What German gases were adopted?

Answer: The Japs had heard of Nitrogen Mustard ($\text{ClCH}_2\text{CH}_2\text{N} \begin{matrix} \text{CH}_2\text{CH}_2\text{Cl} \\ \text{CH}_2\text{CH}_2\text{Cl} \end{matrix}$). Fifty kilograms were manufactured for experimental purposes only. No German gases were adopted.

f. Question: Where are the large storage dumps of war gases in JAPAN?

Answer: Most of the Navy's poison gas was stored at the SAGAMI Arsenal. Besides the 60 kg. mustard gas bombs at SAGAMI, bombs were stored at other localities as listed below.

Name of Station	City	Prefecture	No. of 60 kg. Mustard bombs
2nd Naval Aeronautical Arsenal	SEYA	KANAGAWA	8,852
11th Naval Aeronautical Arsenal	KURE	HIROSHIMA	11,344
12th Naval Aeronautical Arsenal	OITA	OITA	2,351
21st Naval Aeronautical Arsenal	HAKATA	FUKUOKA	74
41st Naval Aeronautical Arsenal	CHITOSE	HOKKAIDO	217

g. Question: Were gas storehouses located near prisoner-of-war camps?

Answer: No.

h. Question: What training in defense against chemical warfare was given to naval units?

Answer: Details of training, i.e. hours spent on each subject etc., are available at the Japanese Navy Ministry in the Bureau of Military Affairs. Originally, defense against chemical warfare was incorporated and taught only aboard ships as a part of damage control. However, this training was not greatly stressed. At the first of the year in 1944 training was instituted at the TATEYAMA Gunnery School to train instructors. Up to the end of the war about 250 officers and 450 men were trained there. One trained officer and two enlisted men were assigned to each major naval unit and base. These teams lectured to several groups and conducted training within the various organizations.

Individual training consisted mainly of wearing gas masks on maneuvers and problems, etc.

Decontamination training was performed on a small scale. Practice was held to treat decontaminated areas of several men to train in personal decontamination.

i. Question: What new gases were under experiment or production? What was the status of new researches?

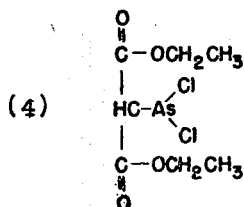
Answer: The following is a discussion of the researches made at the SAGAMI Chemical Research Laboratory under the supervision of Captain K. HIRATSUKA, IJN, a graduate of Tokyo Imperial University. Capt. HIRATSUKA worked mainly with common agents such as Lewisite, Mustard, Chloroacetophenone, Diphenylcyanoarsine, etc. in an attempt to find more effective gases by modifying these agents. He concluded that his researches uncovered no more effective gases than those mentioned above. A summary of HIRATSUKA'S work extracted from his report is given below:

(1) Nitro brom-benzyl cyanides were made and tested. The presence of the nitro group did not appreciably increase the lachrymatory power, but produced more skin irritation. The normal effect of decomposition when in contact with metals was noted.

(2) Various derivatives of HCN were prepared but none proved more efficacious than HCN itself.

Bromo and other halo-cyanides were prepared. Iodine derivatives were not made due to the scarcity of Iodine in JAPAN.

(3) A search was made for bromo and iodo-acetic acid esters but nothing new was found.



and similar compounds were formed but no better arsenicals were found.

(5) The mono-nitro derivatives of benzyl chloride were prepared in hopes of finding a better lachrymator. The ortho derivative caused some skin irritation, the m & p did not. However, the o-derivative decomposes in the presence of metal.

These compounds proved to have no greater lachrymatory powers and were quickly decomposed by powder flash.

(6) The chloro derivative of the diphenyl arseno compounds was found to be more efficient than the bromo, iodo, or fluoro.

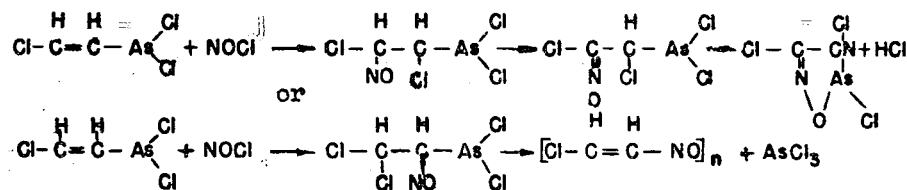
(7) Tetrachloro-dinitroethane, $\text{NO}_2-\overset{\text{Cl}}{\underset{\text{Cl}}{\text{C}}}-\overset{\text{Cl}}{\underset{\text{Cl}}{\text{C}}}-\text{NO}_2$, proved more effective than chloropicrin but is easily decomposed by powder flash.

It was observed that an increase in halogen content increases the lachrymatory effect and that an increase in nitro groups increases the acidity of the compound.

(8) Hexachloro-dimethyl oxalate, $(\text{CO}_2\text{CCl}_3)_2 + \text{O} \rightarrow 3\text{COCl}_2 + \text{CO}$, was chosen as a phosgene producing agent.

(9) Lewisite was reacted with (NOCl) in a cool-place and an arsenic-free precipitate formed. The liquor proved to be twice as effective as Lewisite but decomposed over a period of weeks. This liquid, however, is easily hydrolyzed.

The following reaction stages were proposed:



The vapor is very irritating to mucous membranes, but has a slight delay action.

(10) Brom and fluor Lewisite were prepared. The former proved less effective and the latter more toxic and less easily hydrolyzed.

(11) Aryl dichlor arsines and cyanides were prepared, including methyl and ethyl derivatives which were less easily hydrolyzed and had more satisfactory vapor pressures than Lewisite, but none proved more toxic than the phenyl derivatives.

(12) Other halo derivatives of Mustard were prepared but none proved more efficacious than Mustard.

- a. Dichloro-dipropyl sulfide was found to be effective in lowering the freezing point of Mustard, however.
- b. Selenium derivatives of Mustard homologues were tried but proved less effective than the mother compound.
- c. Dichloro diethyl sulfone and its derivatives were found to be less active than Mustard.

(13) Trichlorotriethylamine and its salts with (HCl), (HBr) and (AsCl), were found to be very effective and in addition are difficult to decontaminate and resist hydrolysis and decomposition due to gun flash to a greater degree than Lewisite. However, compounds were less toxic than Mustard and there was a greater time delay in its action.

(14) Phosgenox was found to be unstable toward water and heat.

(15) M - nitro chloracetophenone and perchloracetophenone were prepared but proved less satisfactory than chloracetophenone itself.

(16) While in the process of researching for war gases, some of the organic arsenicals were prepared for ship-bottom paint due to the scarcity of copper $\text{Cl}-\text{C}=\text{C}-\text{As}$ and phenylarsenious oxides proved fair substitutes. Organic phosphorous compounds were tried but proved ineffective.

ENCLOSURE (A)

A LIST OF EQUIPMENT FORWARDED TO NMRI, BETHESDA, MD.

Equipment	NavTechJap Equipment Number
(a) Model 1 Oxygen Breather Apparatus	JE 21-7506
(b) Type 97 Gas Mask	JE 21-7506
(c) Type 98 Gas Protective Suit	JE 21-7506
(d) Light Protective Suit (pants and gloves)	JE 21-7506
(e) Type 93 MK.3 - Gas Masks	JE 21-7506
(f) Type 3 Gas Mask	JE 21-7506
(g) Gas Testing Set	JE 21-7506
(h) Light Protective Suit (Rubber) (shoes, gloves and pants)	JE 21-7505 JE 21-7519
(i) Chemical Field Testing Set	JE 21-7519
(j) Yprite Gas Decontamination Set	JE 21-7519
(k) Bulbs, MK 4, Gas Decontaminant	JE 10-7503
(l) Oxygen Gas Mask	JE 10-7502
(m) Oxygen Breather	JE 10-7501
(n) Gas Decontaminant Bulbs Mark 4	JE 10-7503
(o) Chemical Field Testing Kit, Anti-Sneeze Nose Drops, Yprite-Gas Decontamination Set, Gas-Testing Set	JE 10-7503 JE 10-7505
(p) Oxygen Breather Apparatus Model 1	JE 10-7506
(q) Oxygen Breathing Apparatus Type 3	JE 10-7509

ENCLOSURE (B)

LIST AND DESCRIPTION OF GAS PROTECTIVE DEVICES SEIZED,
AND/OR DEVELOPED BY THE JAPANESE NAVY

Equipment Submitted Under Separate Shipment, NavTechJap Equipment No. JE-21-7506:

(a) Type 93 Mark IV Gas Mask: has 3-way mask valve, 2-section cannister. Upper part contains $(\text{MnO}_2(70))$ and $(\text{CuO}(30))$; also activated charcoal and soda lime fixed with Fuller's earth. Detachable lower part contains 7 thicknesses of accordion-folded paper made of silkworm cocoon cotton and moxa mixture. For shipboard use.

(b) Type 93 Mark III: with cannister same as above. Has interchangeable cannister for protection against CO. For use ashore.

(c) Type 93 Mark II: older type than above. Has larger cannister, no 3-way valve, no drying agent.

(d) Type 97 Gas Mask: same as Mark IV above, except for diaphragm mouth-piece for speaking.

(e) Type 98 Protective Suit: consists of pants, pullover top, gloves, and boots. Top part only was obtainable.

(f) Light Protective Suit: consists of light rubber pants, overshoes and gloves.

(The following are described only, samples being unobtainable)

(g) Protective cape: a later addition to light protective suit.

(h) Gas Tent: used on ships or ashore for training in gas prevention and decontamination. Construction is rubber sheets and steel framework. Two types with dimensions as follows:

Large: 4 m. wide, 3.5 m. long, 2 m. high, 135 kg. in weight
Small: 3 m. wide, 2.5 m. long, 2 m. high, 85 kg. in weight

(i) Filter Box for Many Persons:

	Type 3	Type 5
Capacity	about 50 persons	About 100 persons
Ventilating Volume	3 m ³ /minute	5 m ³ /minute
Resistance to Ventilation (for 3 m ³ /min)	60 mm. water max	(for 5 m ³ /min) 60 mm. water max
Absorbing capacity (0.5% chlorine)	25 min.	25 min.
Filtering capacity (at 200 mg/m concentration of vomiting gas)	not much irritation in 10 min.	same
Weight	65 kg.	90 kg.

(j) Type 5 Gas Mask:

Inhaling resistance	18-20 mm. water
Exhaling resistance	4-6 mm. water
Filtering capacity	99.85%
Total weight	1.2 kg.

ENCLOSURE (B), continued

Absorbing capacity (0.5% chlorine)	40-45 min.
(0.5% chlorpicrin)	50-55 min.
at battle field con- centration (200 mg/m ³)	60 hours

Face piece is sewn from 1.6 mm. rubber, the absorbent used is activated charcoal (8) and soda lime (2), and the filtering material is the same as that used in the type 93 Mark IV mask described above.

(k) Direct-breathing gas mask (cannister attached directly):

Inhaling resistance	20-23 mm. water
Exhaling resistance	4-6 mm. water
Filtering capacity	99%
Total weight	0.8 kg.
Absorbing capacity (0.5% Cl ₂) (chlorpicrin)	15-20 min.
(hydrocyanic acid)	20-25 min.
at battlefield concentration (200 mg/m ³)	10-15 min.
	25 hrs.

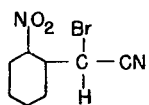
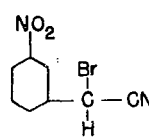
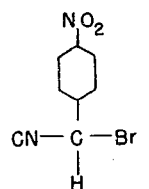
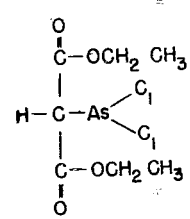
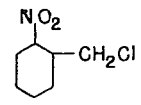
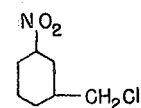
(l) Imitation Mustard Gas for Training (formula for practically harmless gas):

trichlorethylene	50 cc.
glycol	30 cc.
alcohol	32 cc.
sulfur ether	5 cc.
ethyl acetate	10 cc.
hydrochloric acid, 5%	6 cc.

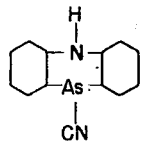
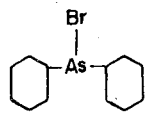
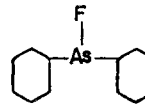
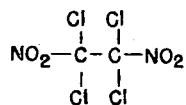
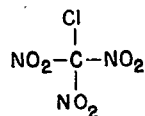
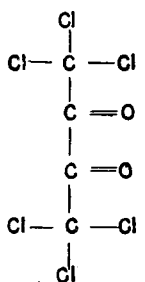
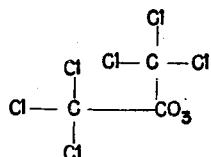
ENCLOSURE (C)

FORMULAE OF GAS COMPOUNDS DEVELOPED AT
THE SAGAMI CHEMICAL RESEARCH LABORATORY.

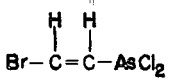

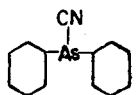
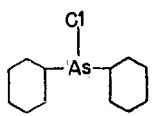
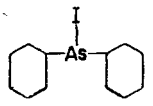
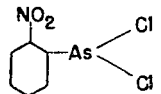
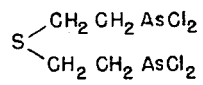
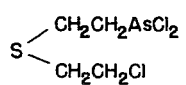
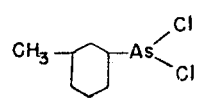
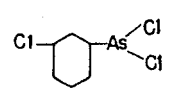
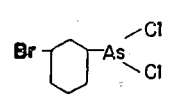
A. Formulae of Gas Compounds.

1.  o-nitro brombenzyl cyanide
2.  m-nitro brombenzyl cyanide
3.  p-nitro brombenzyl cyanide
4.
$$\text{CN}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OCH}_2\text{CH}_3$$
 ethyl-l-cyano acelale
5.
$$\text{CN}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$$
 acetyl nitrite
6.
$$\text{I}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OCH}_2\text{CH}_3$$
 ethyl iodo formate
7.  diethyl malonyl dichloroarsine
8.  o-nitro benzyl chloride
9.  m-nitro benzyl chloride

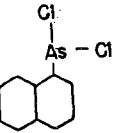
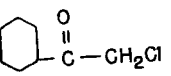
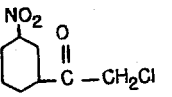
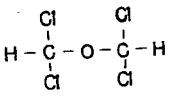
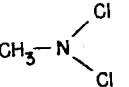
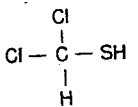
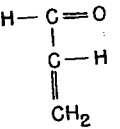
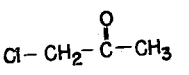
ENCLOSURE (C), continued

10. BrCN bromocyanide
11.  diphenyl amine cyano arsine
12. $\text{H}_4\text{Fe}(\text{CN})_6$ ferrocyanic acid
13.  diphenyl bromo arsine
14.  diphenyl fluoro arsine
15.  tetra chloro dinitro ethane
16.  chloropicrin
17.  hexa chloro dimethyl oxalate
18. diphosgene
19.  hexa chlorodimethyl carbonate
20. $\text{Cl}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{C}-\text{AsCl}_2+\text{NOCl}$ Lewisite and nitrous chloride
(product unknown)

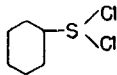
ENCLOSURE (C), continued

21.  bromo-lewisite
22. fluoro lewisite
23.  tri fluoro arsine
24.  diphenyl cyano arsine
25.  diphenyl chloro arsine
26.  diphenyl iodo arsine
27.  o-nitro phenyl dichloro arsine
28.  B' dichloro arseno-di ethyl sulfide
29.  dichloro arseno,
B' chloro diethyl sulphide
30.  m-tolyl dichloro arsine
also
o-tolyl dichloro arsine
p-tolyl dichloro arsine
31.  m-chloro phenyl dichloro arsine
also
o-chloro phenyl dichloro arsine
p-chloro phenyl dichloro arsine
32.  m-bromo phenyl dichloro arsine
also
o-bromo phenyl dichloro arsine
p-bromo phenyl dichloro arsine

ENCLOSURE (C), continued

33.  α -naphthyl dichloro arsine
also
 θ -naphthyl dichloro arsine
34. $\text{Cl}-\text{CH}_2\text{CH}_2-\text{S}-\text{CH}_2\text{CH}_2\text{Cl}$ β B' dichlorodiethyl sulfide (mustard)
also
Br, F, I mustards
35.  chloracetophenone
36.  m-nitro chloracetophenone
also
o-nitro chloracetophenone
p-nitro chloracetophenone
37.  dichloro dimethyl ether
also
dibromo dimethyl ether
di iodo dimethyl ether
38.  dichloro methyl amine
39.  dichloromethyl mercaptan
40.  acrolein
41. $\text{C}_6\text{H}_5\text{NCCl}_2$ phenyl carbylamine chloride
42. CH_3AsCl_2 methyl chlorarsine
also
ethyl, propyl, butyl, amyl
43. $\text{NH}_2-\text{NH}_2 \cdot \text{H}_2\text{O}$ hydrazine hydrate
44.  chloracetone
also
bromacetone

ENCLOSURE (C), continued

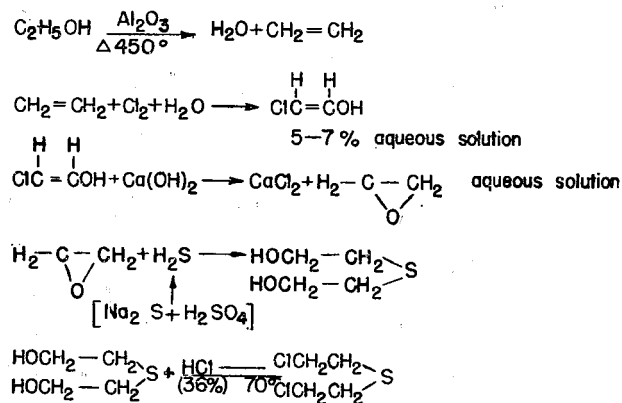
45. $\text{ClCH}_2\text{CH}_2\text{SH}$ chlorethyl mercaptan
46. dichloropropyl sulfide
47. $\begin{array}{l} \text{ClCH}_2\text{CH}_2 \\ \text{ClCH}_2\text{CH}_2 \end{array} \text{Se}$ dichloro diethyl selenide
48. $\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3\text{CH}_2\text{-O-S-Cl} \\ \parallel \\ \text{O} \end{array}$ ethyl chlorsulfate,
also
methyl chlorsulfate
49. $\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{Cl-C=C-AsS} \end{array}$ chlorvinyl arseno sulfide
50. $\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{Cl-C=C-AsO} \end{array}$ chlorvinyl arsenous oxide
51. $\begin{array}{c} \text{C}_6\text{H}_5 \\ \text{C}_6\text{H}_5 \\ \text{C}_6\text{H}_5 \\ \text{C}_6\text{H}_5 \end{array} \begin{array}{l} \text{As} \\ \text{As} \end{array} \text{Fe(CN)}$ diphenyl arsine ferrocyanide
52.  phenyl dichloro sulfide
53. $\text{Cl-CH}_2\text{-CH}_2\text{-S(=O)(=O)-CH}_2\text{CH}_2\text{Cl}$ dichloro diethyl sulfone
and derivatives thereof
54. $\begin{array}{c} \text{CH}_2\text{CH}_2\text{-Cl} \\ | \\ \text{N-CH}_2\text{CH}_2\text{-Cl} \\ | \\ \text{CH}_2\text{CH}_2\text{-Cl} \end{array}$ tri chloro triethyl amine
and its derivatives
55. $\begin{array}{c} \text{Br} \\ | \\ \text{NO}_2\text{-C-NO}_2 \\ | \\ \text{NO}_2 \end{array}$ brompicrin
56. chloral compounds

ENCLOSURE (C), continued

57.
$$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{Cl}-\text{C}=\text{C} \\ | \quad | \\ \text{Cl}-\text{C}=\text{C} \\ | \quad | \\ \text{H} \quad \text{H} \end{array} \begin{array}{l} \diagup \\ \diagdown \end{array} \text{As}-\text{Cl}$$
 dichloro divinyl chloro arsine
58.
$$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{Cl}-\text{C}=\text{C} \\ | \quad | \\ \text{Cl}-\text{C}=\text{C} \\ | \quad | \\ \text{H} \quad \text{H} \end{array} \begin{array}{l} \diagup \\ \diagdown \end{array} \text{As}-\text{CN}$$
 dichloro divinyl cyanoarsine
59.
$$\begin{array}{c} \text{Cl} \\ | \\ \text{H}-\text{C}-\text{OH} \\ | \\ \text{Cl} \end{array}$$
 dichloro methanol
60. hydroxylamine

B. METHODS OF MANUFACTURE

1. Mustard



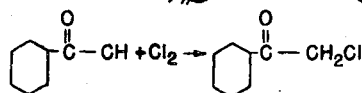
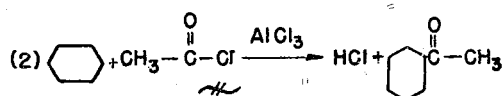
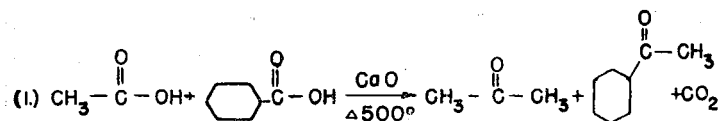
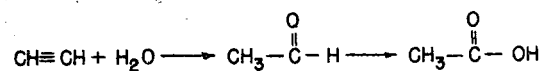
2. Alcohol from fermenting potatoes and grain mash.

Cl_2 from electrolysis of NaCl

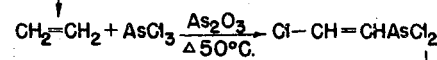
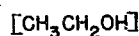
Na_2S from ore

ENCLOSURE (C), continued

3. Chlor aceto phenone



4. Lewisite



(in 20% HCl containing
20 to 30% Cu_2Cl_2)

5. Diphenyl cyano arsine

