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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Tracers.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Target O-22 of Fascicle O-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lt. Comdr. L.N. Peabody, USNR. under the direction of Comdr. Dolan, RN, assisted by Lt.(jg) K.L. Lamott, USNR, interpreter and translator.

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JAPANESE TRACERS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE O-1 TARGET O-22

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

JAPANESE TRACERS

The investigations conducted on Japanese tracers established the following:

1. Japanese tracers were of fair quality, although quality levels and functioning requirements seemed much lower than those demanded for U.S. Navy ammunition.

2. The Japanese displayed a certain amount of cleverness in some designs, as for instance in the design of vari-colored tracers for 25mm ammunition.

3. Japanese designs and methods of closure for tracers would not be considered adequate by U.S. standards. Moisture exclusion, dependent on the seal between the cartridge case and projectile, cannot be considered sufficient, since moisture entering through a faulty primer seal could influence the tracer. Moreover, this method creates production problems because immediate assembly of case and projectile is mandatory where the loading is not done in a controlled atmosphere.

4. It is the writer's opinion that Japanese tracers did not compare favorably with those produced by the U.S. at the time the war ended; and also that the ever-increasing pressure placed on their technical staffs prevented the Japanese from making the developments of which they would have been capable if the time element had been more favorable.

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REFERENCES

Japanese Personnel Interviewed:

Technical Commander Shoji TAKAGI.
Entered Navy in 1924, after graduation from Higher Engineering School, HIROSHIMA. In 1925 conducted research on explosives, KURE. In 1942 Inspector of Explosive Ordnance, YOKOHAMA. In 1942, Naval Air Technical Laboratory, YOKOHAMA, Inspector of Machine Gun Cartridges; then Executive Officer (and Second-in-charge) of explosive ordnance dealing with bomb fuzes, incendiary and illuminating projectiles; then to First Naval Technical Research Laboratory.

Mr. Akira SUZUKI.
Graduate of Tokyo University, 1939, major in chemistry (molecular structures), Doctor of Science. Employed at First Naval Air Technical Arsenal, KANAGAWA, six and one half years on research and experimentation in pyrotechnics and bomb fuzes.

LIST OF ENCLOSURES

(A) List of Seized Documents Forwarded Through ATIS to WDC.

(B) Loading Drawing for Model 1, 25mm Vari-colored Tracer.

LIST OF ILLUSTRATIONS

LIST OF ENCLOSURES

(A) List of Seized Documents Forwarded Through ATIS to WDC.

(B) Loading Drawing for Model 1, 25mm Vari-colored Tracer.

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INTRODUCTION

Japanese tracer development and design were examined, and an effort was made to obtain material which could be used for specific answers to the questions promulgated in Target 0-22, Fascicle 0-1, "Intelligence Targets Japan" (DNI) 4 Sept. 1945.

Information was obtained from interrogation of available Japanese military and technical personnel, translations of Japanese military documents, and a survey of documents prepared by other U.S. technical intelligence agencies.

Undoubtedly, study of forwarded documents, after translation, will add materially to the information contained in this report; the fundamental principles of Japanese tracer design and loading techniques, however, are set forth in this report.

THE REPORT

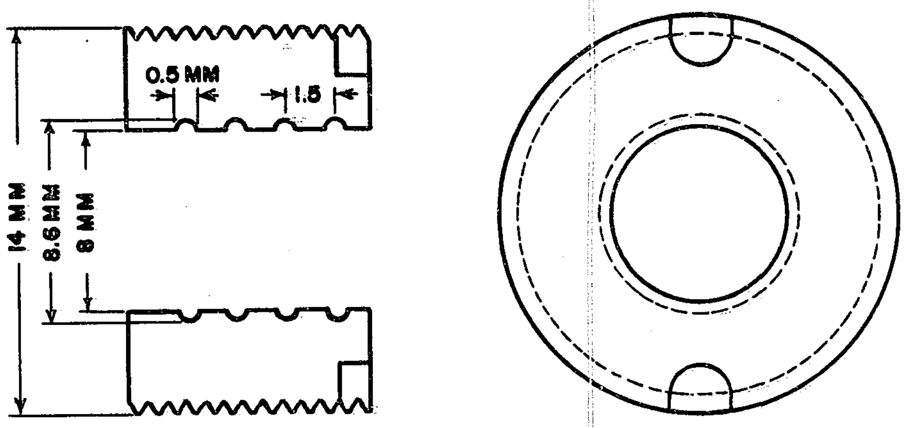
PART I - GENERAL CHARACTERISTICS OF TRACERS

A. Sealing of Tracers

1. The most commonly used tracer shell was obtained by placing a brass disc 1mm thick at approximately the diameter of the bore, directly on top of the starter composition. The outer edge of the exposed face of the disc was slightly coated with shellac, and a thin crimping fillet at the top of the tracer cavity of the projectile was then crimped over the shellacked surface of the disc by the direct mechanical pressure.

2. A paper disc was placed directly on top of the starter composition, and a steel or brass washer 1mm thick with a hole varying from 3mm to 8mm in diameter (size depending on the round caliber) was then crimped in on top of the paper disc. No sealing compound was used. Seal against moisture was dependent on a nitrocellulose lacquer seal used between the projectile and the cartridge case. This method required immediate assembly with the cartridge case after tracer loading.

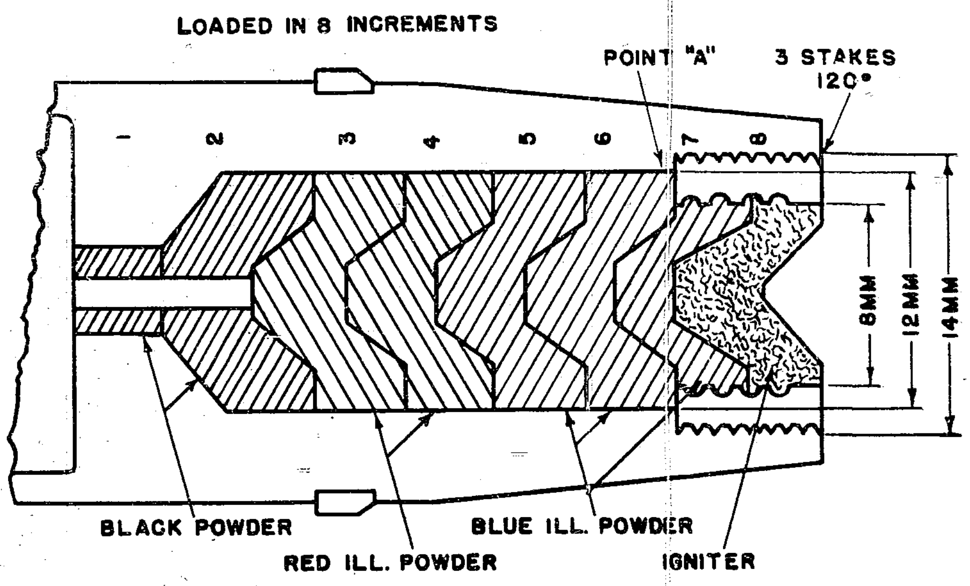
3. The Model I Tracer for 25mm Machine Gun Ammunition was closed by employing a steel screwed in bushing as shown in Figure 1.



STEEL CLOSING BUSHING
25 MM TRACER
MODEL I VARI-COLORED

FIG. I

Use of the steel bushing required the tracer loading to be accomplished in two stages. In the first stage, six increments of the tracer load were pressed in; the face of this column was flush with the shoulder at point A, as shown in Figure 2.



LOADING METHOD FOR
25 MM TRACER
MODEL I VARI-COLORED

FIG. 2

The bushing was then screwed in and positioned so that its lower face was in contact with the top increment of the initial charges. Three stabs, 120° apart, were used to secure the bushing against black-out. Increments 7 and 8 were then pressed into the bushing. No sealing against moisture was incorporated in this closure, moisture exclusion being entirely dependant on the seal between the projectile and cartridge case as described in second method above.

4. In the 40mm tracer round, closure and seal was effected by swaging in a lead disc similar to the closure used in the U.S. Navy 40mm Mark 10 Tracer, and the British 2 Pdr. Round.

B. Color of Tracers

It was found that the Japanese used four colors for the illumination of their tracer ammunition: red (carmine), blue, orange and yellow.

C. Composition of These Pyrotechnics

1. Brief History of Japanese Tracer Development

In the early days, prior to World War II, Oerlikon tracer designs and a few samples were obtained from Switzerland. The tracer composition was that described below as red (carmine). After considerable investigation, it was decided to use this compositon for the mass production of 20mm ammunition. This decision was made despite two objections: first, the expense involved in the use of mercury chloride; second, and more serious, the possibility of a shortage of strontium nitrate, in the event of war.

This composition was also used for the 30mm and in most cases, for 40mm tracers. The Japanese developed the yellow tracer and used it in the 7.7mm and 13mm rounds. Later, research was undertaken to discover an alternative to the red composition to prepare for the time when the supply of strontium nitrate might become critical. From this research the orange tracer was developed. It was decided that this mixture would be satisfactory, although it gave approximately 20% failure at gun trials after twelve months storage. Mass production was begun, but it is doubtful that any tracers loaded with this composition were actually used in service.

(Note: The Japanese did not trace any rounds above 40mm caliber. However, toward the end of the war the Navy asked for tracers for larger caliber rounds. Work was probably begun on this project, but nothing of record was brought to light. It is further noted that about 1937 an attempt was made to trace larger calibers, but was shortly abandoned. No reason for stopping was advanced.)

2. <u>Formulas Used to Obtain Colors for Illuminating Composition</u>

<u>Red (carmine)</u>

Strontium nitrate	70%
Magnesium	20%
Mercury chloride	7%
Shellac	3%

<u>Blue</u>

Magnesium	28%
Barium nitrate	62%
Barium chloride	6%
Beeswax	4%

<u>Orange</u>

Calcium peroxide	50%
Magnesium	30%
Sodium chloride	12%
Shellac	8%

<u>Yellow</u>

Barium nitrate	70%
Magnesium	20%
Sodium oxalate	7%
Paraffin wax	3%

<u>Red (Model 1 Tracer for 25mm)</u>

Strontium nitrate	60%
Magnesium (3% shellac coated)	30%
Strontium carbonate	5%
Beeswax	5%

3. Starting Compositions Used for Above Tracers

Red (carmine), orange and yellow

Barium peroxide.........75%
Magnesium............. 20%
Shellac................. 5%

Red (Model 1, 25mm Tracer) and blue

Barium peroxide........ 83%
Magnesium............. 11%
Shellac................. 6%

Special red igniter (used experimentally in Model 1, 25mm Vari-colored Tracer)

Barium peroxide........ 65%
Strontium peroxide..... 18%
Magnesium............. 12%
Shellac................. 5%

4. Burning Times and Colors Used in Tracer Rounds for Japanese MG

Round (Caliber)	Time (Seconds)	Color
7.7mm	5-6	Yellow
13mm	3-4	Yellow (Inert pellet filler)
20mm	3-4	Red (Inert pellet filler)
25mm	14-15	Red; red and blue
30mm	3-4	Red (Inert pellet filler)
40mm	4-5	Red (Inert pellet filler)

(Note: A straight lead oxide pellet was used to shorten the tracer cavity. The original trace time for the 20mm round was 11-12 seconds.)

5. Tracer Loading

Consolidating punches in general use for tracer loading were of the flat cone, pointed cone, and serrated or waffle types. Consolidating pressures varied from 1000kg per sq cm (14,200lbs per sq in) to 4000kg per sq cm (56,000lbs per sq in) depending on the type of composition used. Dwell times used were from 1 to 60 seconds. No reliable density data could be obtained. Standard tracers were usually loaded in four increments with three equal increments of tracer mix and one increment of starter. In most cases a serrated punch was used to consolidate the starter, leaving a "waffled" surface for ignition. In a few instances, the pointed cone type punch was used for starter consolidation. All charges were "scooped in" loose. Inert fillers were pelleted. A pressure of 1000kg per sq cm (14,200lbs per sq in) was used for the consolidation of all increments in standard tracer rounds. Tracer mixtures were mixed dry in a mechanical mixer, consisting of a bowl-shaped vessel having two rotating arms. Mixing time for the standard tracing composition was 30 minutes. The starter mixtures were mixed by hand. After mixing, tracer compositions were stored in heated cabinets until immediately before use. There was no atmosphere or humidity control of air in the room where tracer loading was done, although this control was known to be desirable. The walls of the tracer cavity in all rounds were coated with a thin film of shellac.

D. Dark Ignition Tracers

Late in the war the research laboratories were requested to develop a dark ignition tracer. Initial attempts were made to reduce the "dazzle" effect of the tracer by increasing the amount of starter charge, and reducing its illuminating power. No constructive progress, however, had been made up to the time the war ended.

E. Tracer Burn-Out Self-Destroying Feature

The Japanese used the tracer burn-out self-destroying feature in their 20mm, 25mm and 40mm rounds. In the 20mm and 25mm rounds the septum had a single perforation which was loaded with a black powder delay and connected with three black powder pellets leading through the high explosive charge to a hole in the gaine. The 40mm round was loaded with a disc between the high explosive and the tracer charge. The disc carried a primer which was initiated by heat from the tracer and fired a detonator loaded into the base of the burster charge.

F. Resistance to High Temperature and Humidity Storage Conditions

Storage trials as follows were conducted with loaded tracers. Loaded tracers were stored in an artificial atmosphere having a temperature of 45°C and a relative humidity of 90% for a period of eighteen months. Periodically during the test, ten samples were chosen at random and fired for tracer functioning. Samples were taken at intervals of one, three, six, twelve and eighteen months. Strontium nitrate and sodium oxalate mixtures gave good results, but the calcium peroxide mixtures gave about 20% failures after twelve months storage. It was considered that the failures were due to moisture penetration permitted by a faulty or inadequate seal. There was no surveillance test conducted on the loose powders.

G. Composition of Pyrotechnic Delays

Pyrotechnic delays in general use were made of black powder, or a mixture of black powder and shellac. This delay gave erratic performance in the low pressures encountered at high altitudes.

Research was undertaken to produce a mixture which would give less gas at combustion, and therefore more uniform burning, because its rate of burn would not be influenced by variations in back pressures due to altitude differences. The following formula was tried, but was found to be too hygroscopic:

Barium peroxide...........95%
Sulphur...................5%

The defect was attributed to variations in the quality of the barium peroxide which could be produced.

Another mixture tried was:

Barium peroxide...........85%
Selenium..................15%

This composition was found to suffer from deterioration in storage also.

The most successful delay powder produced was the following:

Red lead (Pb_3O_4)..................16%
Ferro-silicon (Fe-Si).............38%
Lead chromate ($PbCrO_4$)...........46%

The above mixture did not produce gas during combustion, was non-hygroscopic and burned at a steady rate of 4.5mm (0.5mm) per second in atmospheric pressures varying from 760mm to 10mm as measured by a mercury barometer. The starting mixture used with this delay powder was of the following composition:

Red lead (Pb_3O_4)..................80%
Ferro-Silicon (Fe-Si).............20%

(Note: With this powder it was possible to obtain a delay of 30 seconds in a total length of less than six inches. This delay was being used in AA time fuses and in anti-submarine 5 second delay fuses. It was scheduled to come into general use about the time the war ended.)

The shortest delay in use was in the Type 97 Bomb Fuse which had a delay of 0.05 seconds. It consisted of a 0.5gr black powder pellet pressed at 1000kg per sq cm (14,200lbs per sq in) with an effective burning distance of 1mm between an initiating first capsule of 0.5gr of mercury fulminate and a second capsule of lead oxide. The accuracy of this delay was 20%.

Another type of black powder delay still in the experimental stage, involved the use of two layers of black powder in the pellet, one of pulverized and the other of very fine grain black powder. Control of delay time was accomplished by varying the thickness of the two black powder layers. The times were 0.01 seconds to 0.1 seconds.

PART II
DESCRIPTION OF MODEL 1 VARI-COLORED TRACER FOR 25mm MG AMMUNITION

Prior to 1940 the Japanese Navy attempted to produce a tracer for 25mm ammunition which would indicate visually the distance of the projectile from the gun, as well as its path of flight. The indicators used were Blue Tracer, Red Tracer, Dark Tracer and Black Smoke. These elements were loaded in the following order (desired tracing times and distances are also noted):

Muzzle to 1500m(1640yds)..................3sec.................Blue tracer
1500m to 2250m(2733yds).................5.7sec..................Red tracer
2500m to 3500m(3827yds)..................10sec.................Dark tracer
3500m Black smoke, obtained by detonation of fine grain black powder charge

An accuracy of 0.5 seconds at color change-over was desired.

Composition of mixtures used for this tracer are given in Table I shown on page 12. Those for the Dark Tracer and Black Smoke are given below.

Dark tracer composition

Sodium Perchlorate.............85.5%
Lamp Black.....................19.5%

Consolidating pressure 1000kg per sq cm(14,200lbs per sq in).
Dwell time, 1 second.

Smoke producer

Black powder (fine grain).
Consolidating pressure 1000kg per sq cm (14,200lbs per sq in).
Dwell time, 1 second.

Commander TAKAGI and Mr. SUZUKI, who worked on this project, both stated that results were unsatisfactory due mostly to erratic burning times and a high percentage of blinds. They asserted that color and visibility of the tracer were very good.

Because of the unsatisfactory performance of the round, it was decided to conduct further experiments with the vari-colored tracer, but to eliminate the dark trace feature. The new experiments involved trials with various consolidating pressures and dwell times. It was stated no change was made in the tracer mixtures which are shown in Table I below.

TABLE I

Material	Igniter	Blue Illum. Powder	Red Igniter	Red Illum. Powder
Magnesium	11	28	12	--
Magnesium coated 3% shellac	--	--	--	30
Barium peroxide	83	--	65	--
Strontium peroxide	--	--	18	--
Barium nitrate	--	62	--	--
Strontium nitrate	--	--	--	60
Strontium carbonate			--	5
Shellac	6		5	
Beeswax	--	4	--	5
Barium chloride	--	6	--	--

Consolidating pressure: 4000 kg per sq cm (56,800 lbs per sq in).
Dwell time: 60 seconds.
Order and method of loading tracer are detailed in Enclosure (B).
Functioning performance required: 90% light-up; 10% blinds acceptable; 0.5 seconds change-over time.
Desired tracing times: Blue Trace-3.0 seconds 1/500 meters (1/640 yards); Red Trace-5.7 seconds 2/500 meters (2/734 yards).

Results of gun trials are tabulated in Table II below.

TABLE II

No. of rounds Tested-148	Muzzle to color change: Max	Min	Avg	Avg error	Muzzle to dark (seconds): Max	Min	Avg	Avg error
No. of rounds Timed-95	3.6	2.8	3.0	±0.09	6.75	5.0	5.8	±0.34

Light up 99.3% for 148 rounds fired. Visibility very good for both colors.

An interview with Capt. Kichiro KURODA, Gunnery Officer of ISE and later of YAMATO, revealed that this tracer was used in service ammunition, but he doubted its value to the gunner. He stated the visibility for both colors was very good.

The conclusion of the Japanese technicians in charge of these experiments was as follows: "This tracer, from the point of view of light-up, accuracy of time and visibility, is good. But due to the long dwell time required in consolidating the tracer charges (60 seconds), the round did not lend itself to rapid production. It was recommended that further experiments be conducted with special reference to consolidating pressures and dwell times." Reference is also made to the breakup of the dummy fuze or nose piece at the gun muzzle.

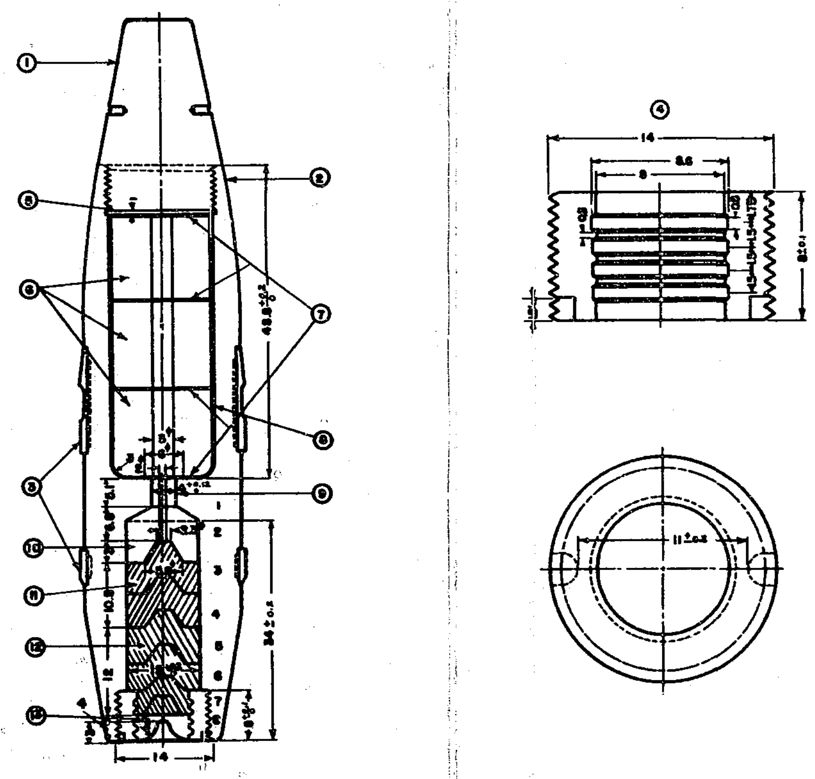
ENCLOSURE (A)

LIST OF SEIZED DOCUMENTS FORWARDED THROUGH ATIS TO WDC

NavTechJap Document No.	ATIS No.	Title
ND50-3525	3919	Filling of 25mm automatic cannon tracer high-explosive shell.
ND50-3526	3920	Experimental type 99 self-destroying tracer high-explosive shell.
ND50-3527	3921	Experimental report on types of anti-aircraft self-destroying tracers.
ND50-3528	3922	Barium peroxide plus igniting compounds for machine gun ammunition.
ND50-3529	3923	Mechanical mixing method for powders.
ND50-3530	3924	Carbon powder trains.
ND50-3531	3925	Tracer powder stability.
ND50-3532	3926	Pressed black powder burning characteristics.
ND50-3533	3927	Experiments on 8cm anti-aircraft tracer shot.
ND50-3534	3928	Storage stability of 25mm machine-gun tracer bullet powder, 1942.
ND50-3535	3929	Report on Model 1 tracer (25mm) machine-gun ammunition, 1940.
ND50-3217	3917	Investigation of tracer bullet visibility.
ND50-3220	3918	Investigation of tracer ammunition.

ENCLOSURE (B)

LOADING DRAWING FOR MODEL 1, 25 mm VARI-COLOR TRACER
(ALL DIMENSIONS IN mm)

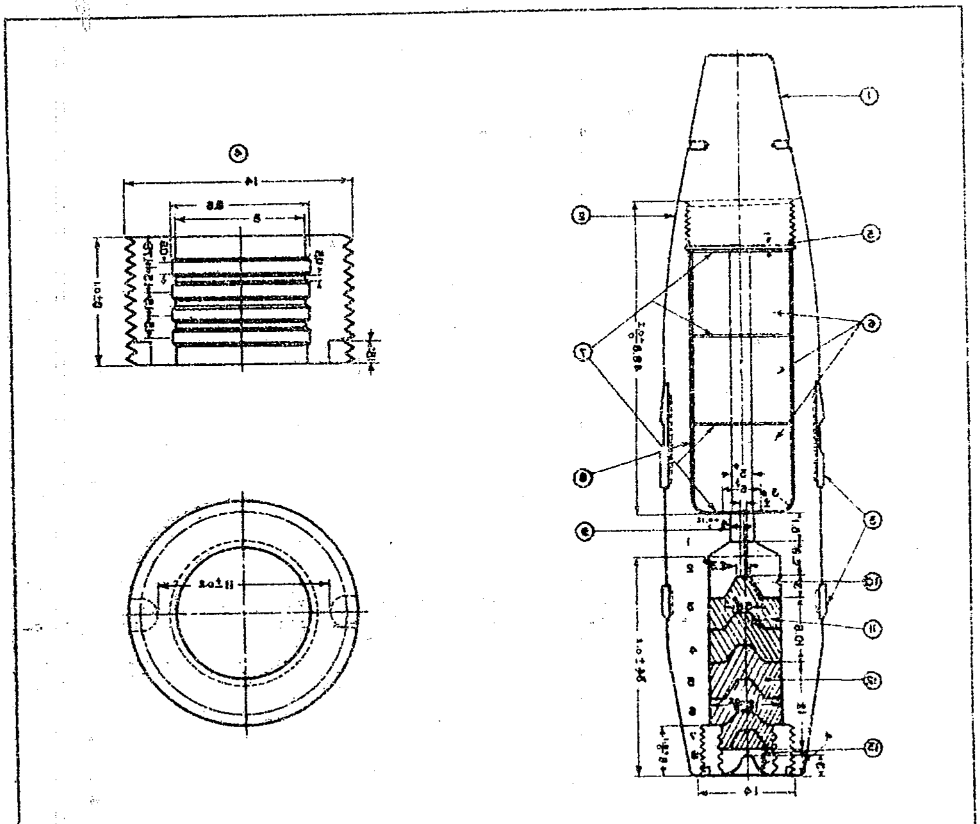


LEGEND

1. HEAD
2. BODY
3. COPPER BAND
4. BASE SCREW
5. PACKING (WASHER)
6. SMOKE POWDER (FINE GRAIN BLACK POWDER)
7. SEPARATOR (PAPER DISC COLLODIAN COATED)
8. PAPER CYLINDER (COLLODION COATED)
9. BLACK POWDER COLUMN (FINE GRAIN)
10. FIRE TRANSFER POWDER (BLACK POWDER FINE GRAIN)
11. RED ILLUMINATING POWDER
12. BLUE ILLUMINATING POWDER
13. IGNITER

ENCLOSURE (B)

LOADING DRAWING FOR MODEL L 25mm VARI-COLOR TRACER
(ALL DIMENSIONS IN mm)



LEGEND

1. HEAD
2. BODY
3. COPPER BAND
4. BASE SCREW
5. PACKING (WASHER)
6. SMOKE POWDER (FINE GRAIN BLACK POWDER)
7. SEPARATOR (PAPER DISC COLLODIAN COATED)
8. PAPER CYLINDER (COLLODION COATED)
9. BLACK POWDER COLUMN (FINE GRAIN)
10. FIRE TRANSFER POWDER (BLACK POWDER FINE GRAIN)
11. RED ILLUMINATING POWDER
12. BLUE ILLUMINATING POWDER
13. IGNITER