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

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

1. Article 2 of the report on Target C-10 (including Target C-28) of Fascicle O-1 of reference (a), covering general aspects of Japanese rocket and gun propellants, is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lt. Comdr. R.A. Cooley, USNR, and Lieut. H.L. Blackwell, USNR.



C. G. GRIMES
Captain, USN

RESTRICTED

O-10-2

**JAPANESE PROPELLANTS - ARTICLE 2
ROCKET AND GUN PROPELLANTS - GENERAL**

**"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945
FASCICLE O-1, TARGET O-10, ARTICLE 2, AND TARGET O-28**

NOVEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

JAPANESE NAVAL PROPELLANTS - ARTICLE 2 ROCKET AND GUN PROPELLANTS - GENERAL

Aside from the excellent Japanese-developed stabilizer, ortho tolyl urethane (see article 1 of this report), there appears to be little that is unique in Japanese naval rocket and gun propellants or in their manufacture.

In the field of liquid propellants, the manufacture of 80% hydrogen peroxide was well started on a commercial scale.

NTJ•L•O-10-2

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REFERENCES

A. Sources of Information:

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Mr. S. MIYAIRI, Research Chemist, Hiratsuka Naval Powder Factory.

B. Request for Information:

BuOrd ltr. (R37g) EF 37/A8-3, dated 13 Sept. 1945.

THE REPORT

1. Historical Background of Japanese Naval Propellant Powder

Prior to 1896 the Japanese Navy used brown prismatic powder purchased from England, Holland or Belgium. About the year 1896 it became the Japanese Army's responsibility to supply the powder used by the Navy. Since the Army had been using single-base French "Poudre B", this was introduced into Japanese naval use.

In 1907 the Sir William Armstrong Co., of England, erected a smokeless powder factory at HIRATSUKA for the manufacture of double-base British MD cordite to supply the Japanese Navy. Twelve years later, in 1919, the Japanese Navy purchased the Armstrong factory at HIRATSUKA.

About 1912 K. KUSUOSE introduced a new stabilizer, jara jara (beta naphthol methyl ether) and a new smokeless powder known as composition C₂ was developed using this stabilizer. This powder represents the first powder manufactured purely as the result of independent Japanese research and development. The chemical composition of C₂, which is a nitroglycerine gun cotton powder using acetone as a solvent, is shown in Table I.

In 1920, centralite, as a gelatinizer, was introduced from Germany. By 1924 solventless DC (Deutsche Cordite) powder was adopted as the service powder of the Japanese Navy.

About 1933 ortho tolyl urethane was introduced into powder, and was said to give a composition which could be handled with greater ease and safety during kneading and rolling. These advantages were attributed to the low melting temperature of ortho tolyl urethane.

Fairly satisfactory flashless powder (FD), containing potassium sulfate and hydrocellulose, was developed about 1938.

2. Chemical Compositions and Properties of Japanese Naval Propellants

Table I summarizes the chemical compositions as well as the calorific values, force values and stability values of powders used by the Japanese Navy.

The composition of Japanese Army propellants are shown for comparison in the "C" and "G" smokeless powder charts at the end of this report.

3. Nitrocellulose Used in Naval Propellants

The Japanese Navy has used the following kinds of nitrocellulose:

NC₁ or guncotton, $13.15 \pm 0.15\%$ N

NC₂ or collodion cotton, $10.90 \pm 0.20\%$ N

NC₃ or pyrocollodion, $12.50 \pm 0.20\%$ N

NC₁ and NC₂ are blended to make a mixed cotton MC₁ ($11.85 \pm .05\%$ N) which is used in such solventless powders as DC₁, DC₂, DC₃ and FDT₆. Blending is necessary to obtain a nitrocellulose which is sufficiently soluble in nitroglycerin to mix without solvent. NC₁ is relatively insoluble in nitroglycerin, but NC₂ is relatively soluble, so that a satisfactory mixture is obtained. NC₁ and NC₃ are blended to make another mixed cotton MC₂ ($13.00 \pm .05\%$ N) which is used in single base powder. NC₃ is the highest nitrogen content nitrocellulose of sufficient solubility in ethereal alcohol.

Normally the Japanese would prefer to use cotton as the source of cellulose,

but due to shortages it was necessary to use wood pulp during the war. The purification of nitrocellulose is achieved by a total boiling time of about 50 hours with ten decantations. Selwig or Lange nitration methods are used, and blending is achieved by stirring in the presence of excess water.

4. Explosive Oils Used in Propellants

The Japanese had considered the substitution of diethylene glycol dinitrate for nitro-glycerin, since Germany had found the substitution so profitable. Diglycol was rather scarce in Japan however, and aside from experiments, diethylene glycol dinitrate was not used by the Japanese.

Nitroglycerin was manufactured from glycerin obtained from fish and animal fats. Nitration was carried out in a Nathan nitrator at 17.5°C, followed by treatment with a sodium carbonate solution and at least four washings.

5. Stabilizers and Gelatinizers

The Japanese Navy was responsible for the development of one outstanding stabilizer and gelatinizer, namely orthotolyl urethane. Since this stabilizer represents the only point of possible superiority of a Japanese propellant over those of other countries, a special report (Article 1 of this series - "Use and Manufacture of Ortho Tollyl Urethane for Stabilizing Rocket and Gun Propellants" - Index No. O-10-1) has been prepared on the subject.

Other stabilizers used by the Japanese Navy were: beta naphthal methyl ether, symmetrical diethyldiphenylurea, diphenylamine, mononitronaphthalene, and dimethyl phenyl ortho tolylurea. The last stabilizer, though not yet tested by time, was considered to be a very promising stabilizer, because it is a liquid at room temperature and makes a powder easy to manufacture.

6. Flash Reduction

Flash was said to be fairly reliably eliminated in guns up to 14 cm (5.6 inches), but not in larger guns. The elimination or suppression of flash was attained by use of 8 or 4 per cent of potassium sulfate as shown in Encl. (A) for composition FD and FD₁.

7. Manufacture of Propellant Powder

The manufacture of Japanese solventless powder consists of three steps: mixing, rolling and extrusion. The last two steps are at elevated temperatures. The stabilizer is first added to the nitroglycerin, which is then added to wet nitrocellulose; the resulting paste is agitated mechanically. The water content of the paste is then reduced to 45% by centrifuging. The paste is next rolled at 82°C. for about 6 minutes. The resulting sheets are then carpet-rolled and extruded from a press at 80°C.

8. Liquid Propellants for Rockets

The Japanese had received information on the German hydrogen peroxide-hydrazine hydrate liquid propellant, and were producing 80% hydrogen peroxide on an industrial scale (See NavTechJap Report - "Japanese Fuels and Lubricants, Article 5 - Research on Rocket Fuels of the Hydrogen Peroxide - Hydrazine Type", Index No. X-38(N)-5.). None of the devices using liquid propellant had reached the operational stage, however, and no new ideas could be found in anticipated developments. The well-known nitric acid-alcohol combination had been experimented with, but the hydrogen peroxide-hydrazine system was thought more promising.

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ROCKET AND GUN PROPELLANTS USED BY JAPANESE NAVY

Symbol and Name		Composition											Characteristics											
		N/G	G/C	M/C	C/C	C/L	OTU	M/J	J/J	M/N	H/C	GP	M/M	K ₂ SO ₄	Sn	Na/B	Colorific Value (q) (Kcal)	Explosion Temperature (°C)	Specific Volume (cc)	Force of Explosion (kg-dm)	Abel's Heat Test (min)	Silvered Vessel Test (hr)	Volatiles Matter (g)	Color
C	Common Cordite	58	37					5									1212.9	(gas) 3731	881.5	12450	30.0	200	0.3	Light brown
C ₂	Type 2 Cordite	30	65					3	2								1012.7	3250	917.5	11290	20.0	1200	1.65	Light brown
T ₂	Type 2 Tubite	30	65														1012.7	3250	917.5	11290	20.0	1200	1.65	Light brown
DC	Type 13 Cordite	30		64.8		4.5						0.7					931.8	3033	928.7	10660	14.48	800	1.0	Greyish black
DT	Type 13 Tubite	30		64.8		4.5						0.7					931.8	3033	928.7	10660	14.48	800	1.0	Greyish black
DB	Type 13 Lameller	30		64.8		4.5						0.7					931.8	3033	928.7	10660	14.48	800	1.0	Greyish black
O ₃	Type 89 Cordite	26.5	68.5						5								1015.4	3305	898.3	2800	6.0	1800	1.5	Light brown
T ₃	Type 89 Tubite	26.5	68.5						5								1015.4	3305	898.3	2800	6.0	1800	1.5	Light brown
F ₂	Type 90 mk 2 Cordite	15			68		8			8					1	465.8	1680	1071.5	6810	27.4	6006	1.7	Light yellow	
G ₄	Type 92 Cordite	40	55			3	2									1128.4	3590	972.7	11850	20.0	1200	0.3	Light yellow-brown	
T ₄	Type 92 Tubite	40	55			3	2									1128.4	3590	972.7	11850	20.0	1200	0.3	Light yellow-brown	
DC ₁	Type 93 mk 1 Cordite	41		51.8		4.5	2					0.7				964.2	3137	922.5	10950		800	0.6	Greyish black	
DC ₂	Type 93 mk 1 Cordite	27		64.3		5	3					0.7									900	1.0	Greyish black	
DC ₃	Type 3 Cordite	33		60.0		6.5					0.1			0.4							1060	0.89	Greyish black	
DT	Type 93 mk 1 Tubite	41		51.8		4.5	2					0.7									800	0.6	Greyish black	
DT ₂	Type 93 mk 2 Tubite	27		64.3		5	3					0.7	3			789.0	2640	978.1	9770		900	1.0	Greyish black	
T ₂	Toku	27		64.3		5	3					0.7									1135	3.1	Greyish black	
FD	Toku	26.4		53.4		7.24#				6.0	0.09					984.2	3137	922.5	10950		3642	1.0	Greyish black	
FD ₁	Toku	27.5		55.6		7.64#															3529	1.0	Greyish black	
T ₆	Toku	30		60		3.0										652.9	2260	938.8	8286		963	2.88	Yellow-brown	
FD ₆	Toku	27		60		3.0*						7.0									863	2.39	Yellow-brown	
FD	Type 2 mk 1	30		61.3		5	3			8		0.7	8											Flameless
FD ₁	Type 2 mk 2	30		65.3		5	3			8		0.7	4											Flameless

* Used in rockets.
This value denotes total per cent of C/L and OTU combined.
Editor's note: Information in the lower right quarter of above table is possibly in error due to misalignment of original.

N/G Nitroglycerin
G/C Gun Cotton
M/C Mixed Nitrocellulose
C/C Colloidion cotton

C/L Centralite
OTU Orthotolylurethane
M/J Mineral Jelly
J/J JalaJala or Jara Jara

M/N Mononitronaphthalene
H/C Hydrocellulose
M/M Mineral Matter
Na/B Sodium Bromide

[illegible]

CLASSIFICATION NAMES	FORM	STANDARD INGREDIENT				DEGREE OF NITRATION OF NITROCELLULOSE C.C.	THICKNESS OF THE POWDER M.M.	VOLATILE MATTER %	REMAINING VOLATILE MATTER %	APPARENT DENSITY GM./LITER	CHARACTERISTICS OF POWDER				MAIN USE	GENERAL
		PRINCIPAL INGREDIENT NITROCELLULOSE	STABILIZER (D)	VOLATILE MATTER	THE OTHERS						RIFLE OF TEST GUN	WEIGHT OF CHARGE	MUZZLE VELOCITY	PRESSURE BORE		
SMOKELESS RIFLE POWDER	Square	96.2	1.5	2.3	—	206	0.27±.05	2.30±.25	1.2		38 TYPE INFANTRY RIFLE	2.15±.05 GM.	762±8	3,400±400	VARIOUS KINDS OF 65 MM. RIFLE & MACHINE GUN	38 NEW TYPE RIFLE, 38 TYPE 37 TYPE LAMP M.C. LOADED ON GUN (1,5,20), 14 NEW TYPE TYPE PULVE (20), SMITH-WATSON
X-SMOKELESS RIFLE POWDER B	Square						0.30									NONE
No. 4 RIFLE POWDER	Square	97.5	1.5	1.0	SURFACE GELATINIZER 5%	206	0.40	1.00±.35	0.5		99 TYPE RIFLE	2.75±.10 GM.	740±8	2,800±150	VARIOUS KINDS OF 99 TYPE RIFLE & MACHINE GUN	99 TYPE RIFLE &
POWDER TYPE "RA" FOR MACH. GUN	Square	97.5	1.5	1.0	SURFACE GELATINIZER (CAMPHOR) 3.5%	208	0.35	1.00±.35	0.5		"RA" TYPE REVOLVING MACH. GUN & PRESSURE TEST GUN	2.70-2.80 GM.	IN COMPRESS WITH THE STANDARD POWDER ±8	IN COMPRESS WITH THE STANDARD POWDER ±200	RHEIN METAL TYPE MACHINE GUN	7.92 MM. MACH. GUN (E)
0.5 MM. SQUARE POWDER	Square	96.5	1.5	2.0		206	0.07±.03	2.00±.25	1.0		92 TYPE INFANTRY CANNON	43 GM.	184±2.5	1,320±120	GRENADE DISCHARGER TYPE	89 TYPE HEAVY GRENADE 10 NEW TYPE GRENADE
0.6 MM. SQUARE POWDER	Square	96.5	1.5	2.0	—	206	0.13±.03	2.00±.25	1.0		92 TYPE INFANTRY CANNON	50 GM.	197±2.5	1,200±120	92 TYPE INFANTRY GUN, 11-NEW TYPE INFANTRY MORTAR	92 TYPE INFANTRY GUN (C)
5 MM. SQUARE POWDER	Square	96.1 97.2	1.5 1.5	2.4 1.3	SURFACE GELATINIZER 5%	206	0.33±.05 1.30±0.35	2.40±0.35 1.30±0.35	0.1		11 TYPE INFANTRY GUN	50±1 GM.	450±45	1,530±170	SMALL CALIBRE CANNON 41 TYPE MT. GUN	11 NEW TYPE INFANTRY GUN
No. 1 SQUARE POWDER	Square	96.0	1.5	2.5	—	204	0.41±.04	2.50±.25	1.5		41 MT. GUN	245 GM.	385±35	1,770±140	VARIOUS KINDS OF MED. OR SMALL CALIBRE HOWITZER	54 TYPE 39mm. A-E, SMITH-WATSON, 11 YEAR 70mm. CANNON (LIGHTNING), 57mm. MADE 60mm. HOWITZER, 10 150mm. HOWITZER (E.D.), STEEL MADE HOWITZER & MACH. "TOS-10" 100mm.
No. 2 SQUARE POWDER	Square	95.7	1.5	2.8	—	204	0.66±.06	2.85±.35	1.7		38 FIELD GUN	600 GM.	494±5	MAX. 2200 STD. 2150 MIN. 2000	VARIOUS KINDS OF LARGE OR MEDIUM CALIBRE HOWITZER	30 TYPE 10 cm. HOWITZER, 20mm. 45 TYPE 24 cm. HOWITZER (E. CANNON) HOWITZER LONG SHOOT (2000)
No. 3 TUBULAR POWDER	TUBULAR	97.5	1.5	1.0	SURFACE GELATINIZER 5%	206	0.26±.05	1.00±0.35	0.5		FOR VELOCITY MEASUREMENT 92 TYPE 15 cm. M.G. FOR PRESS. TESTING 7.7mm. PULVE TEST GUN	2.85±0.1 GM.	740±8	3150±250		99 LIGHT MACHINE GUN, "C" 97 AUTOMATIC CANNON (E) 33 SHARPshoot GUN, 94 REAR MACHINE GUN on "BAMPING" 27mm.
No. 4 TUBULAR POWDER	TUBULAR															
No. 5 TUBULAR POWDER	TUBULAR	97.5	1.5	1.0	SURFACE GELATINIZER 5%	206	0.52±.05	1.00±.35	0.5		92 TYPE 13mm. M.G. LOADED ON VEHICLE	14.50 GM.	800±8	FIGURE TO BE OBTAINED IN FUTURE TESTS		97 AUTOMATIC GUN, 92 LAMP TEST 20mm. REVOLVING (BLANK CARTRIDGE OF 98)
No. 6 TUBULAR POWDER	TUBULAR															
No. 7 TUBULAR POWDER	TUBULAR	97.5	1.5	1.0	SURFACE GELATINIZER 2% FLAME EXTINGUISHER 0.5%	206	0.70±.05	1.00±.35	0.5		TYPE 93 A-A MACHINE GUN	FIGURE TO BE OBTAINED IN FUTURE TESTS	950±8	STANDARD 2,800±150		98 TYPE A-A MACHINE TEST "KERI", "HOKI"
No. 1 BELT-TYPED POWDER	STRIP LIKE FORM	95.7	1.5	2.8	—	204	0.58±.06	2.85±.35	2.4		38 TYPE FIELD CANNON	600 GM.	500±5	2,150±150	7.5 cm. CLASS CANNON	38 FIELD, 41 CALIBRE, REAR RAPID FIELD, 11 YEAR 75cm. A-E 11 YEAR 75cm. CANNON (E) REAR STEEL MADE 12 cm. RAPID- CANNON (E) REAR, THE FOLLOWING, "TOS"
X BELT-TYPED POWDER B	STRIP LIKE FORM						0.75									NO US
No. 2 BELT-TYPED POWDER	STRIP LIKE FORM	95.1	1.5	3.4	—	204	0.86±.06	3.40±.40	2.6		"KOKU" - TYPE AND 38 TYPE 10 cm. CANNON	1.74 Kg.	535±5	2,460±200	CANNON (MEDIUM OR SMALL CALIBRE)	38 FIELD, 38 FIELD, 87 STEEL- (SPECIAL 30 CALIBRE), 7.7 cm. FIELD 12 cm. RAPID Firing Cannon, 26 GUN on Rail (SMITH-TYPED)
No. 3 BELT-TYPED POWDER	STRIP LIKE FORM	94.9	1.5	3.6	—	204	1.17±.06	3.60±.50	2.8		"KOKU" - TYPE AND 38 TYPE 10 cm. CANNON	2 Kg.	529±5	1,940±150	MEDIUM CALIBRE CANNON, LARGE CALIBRE HOWITZER	85 TYPE 7cm. A-A (E) REAR, 10 75cm. RAPID Firing Cannon, 75cm. 10mm. Cannon, "TOS" 30 CALIBRE 25 CALIBRE 24 cm. CANNON.
No. 4 BELT-TYPED POWDER	STRIP LIKE FORM	94.6	1.5	3.9	—	204	1.44±.09	3.90±.50	3.0		"KOKU" - TYPE 35 CAL. 15 cm CANNON	9 Kg.	612±7	2,130±120	MEDIUM CALIBRE CANNON, LARGE CALIBRE HOWITZER	30 CALIBRE, 30 CALIBRE, "TOS" TYPE "TOS" TYPE, "TOS" TYPE, "TOS" TYPE "TOS" TYPE, "TOS" TYPE, "TOS" TYPE "TOS" TYPE, "TOS" TYPE, "TOS" TYPE "TOS" TYPE, "TOS" TYPE, "TOS" TYPE
No. 5 BELT-TYPED POWDER	STRIP LIKE FORM	94.2	1.5	4.3	—	204	2.30±.15	4.30±.50	3.4		"KOKU" TYPE 30 CALIBRE 24 cm. CANNON	30 Kg.	452±5	1,670±140	MEDIUM CALIBRE CANNON, LARGE CALIBRE HOWITZER	7 NEW TYPE 30cm. HOWITZER SPECIAL 24 cm. HOWITZER (C)
No. 6 BELT-TYPED POWDER	STRIP LIKE FORM		2.0		FIGURE TO BE OBTAINED IN FUTURE TESTS	204	FIGURE TO BE OBTAINED IN FUTURE TESTS	FIGURE TO BE OBTAINED IN FUTURE TESTS	FIGURE TO BE OBTAINED IN FUTURE TESTS		"KOKU" - TYPE 20 CALIBRE 24 cm. CANNON	36 Kg.	520±5	MAXIMUM 1,800 STANDARD TO BE DETERMINED LATER		"KOKU" "TOS" "SHIR" 40 (AS A SUBSTITUTION OF II (CHARGE A)
SMOKELESS POWDER FOR PISTOL	GRAINY (EMPTY)		1.5	—		208	0.40	2.00±.50	—		14-NEW TYPE PISTOL	0.3±.02 GM.	334±15	1,700	VARIOUS KINDS OF PISTOLS	14 NEW TYPE PISTOL, 6 NEW 89 TYPE HEAVY GRENADE (E) (FOR FIRM TAPPING) JAPANESE
SMOKELESS PRIMING POWDER	GRAINY	94.0	3.0	1.8	NITRO BICARBONATE 3% OF SODA CHARCOAL, FEW	210	1.10±.20	1.80±.50	0.5		LESS THAN 12 SECONDS WITH A COMBUSTION EXAMINER	/	/	/	IGNITION CHARGE OF VARIOUS POWDER CHARGES	
SMOKELESS DUMMY CANNON POWDER	GRAINY (EMPTY)		0.5	2.0				2.00±.100	—			20 GM.	IF IS HELD FOR RAPID COMBUSTION IN PROPER CONDITIONS		VARIOUS DUMMY GUNS	
No. 1 BLANK CARTRIDGE POWDER	SAME AS POWDER FOR PISTOL	97.5	0.5	2.0		7201	/	2.00±.50	/		38 TYPE INFANTRY RIFLE PRESSURE TEST GUN	0.7 GM.	MAXIMUM 2,000 MINIMUM 1,000 TO BE DETERMINED LATER		VARIOUS RIFLES & SMALL CALIBRE BLANK CARTRIDGES	38 TYPE RIFLE, 30 NEW TYPE 34 TYPE 37mm. Cannon, 94 TYPE 94 CANNON GUN, CARTRIDGE
No. 2 BLANK CARTRIDGE POWDER	SAME AS THE 0.6 MM. SQUARE POWDER	96.5	1.5	2.0		7206	/	2.00±.40	/		92 TYPE HEAVY MACHINE GUN & BLANK BARREL	2.85 GM.	WOODEN SHELL BREAKS WITHIN 10m. FROM MUZZLE		VARIOUS BLANK CARTRIDGES FOR MACHINE GUNS	38 TYPE RIFLE, 3 NEW TYPE A LIGHT MACHINE GUN LOADED LOADED ON VEHICLE, "C" TYPE LOADED ON VEHICLE, "NO" TYPE
No. 3 BLANK CARTRIDGE POWDER	OBLONG (EMPTY)	97.2	0.5	2.3		7201	/	2.30±.50	/		41 TYPE MOUNTAIN GUN	100 GM.	COMPRESSED SHELL BREAKS WITHIN 50 m. FROM MUZZLE	1,300 MINIMUM TO BE DETERMINED LATER	VARIOUS BLANK CARTRIDGES FOR MEDIUM CALIBRE HOWITZERS	11 NEW TYPE INFANTRY GUN 91 TYPE 8 cm. HOWITZER, 4 cm. HOWITZER, 96 TYPE 15 cm. HOWITZER
No. 4 BLANK CARTRIDGE POWDER	OBLONG (EMPTY)	97.2	0.5	2.3		7201	/	2.30±.50	/		41 TYPE MOUNTAIN GUN	120 GM.	COMPRESSED SHELL BREAKS WITHIN 50m. FROM MUZZLE	700 MINIMUM TO BE DETERMINED LATER	FIELD GUN CLASS & 10 cm. CANNON CLASS BLANK CARTRIDGES	38 TYPE FIELD, 41 TYPE CAVALRY 31 TYPE 110 mm. MT, 41 MT, 80 11 YEAR 75 cm. EMPLOYMENT 38 TYPE 10 cm. Cannon, 92 TYPE

[illegible]