USSR 0400 Weapons

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SID NO.	CONFIDENTIAL SECURITY INFORMATION	COUNTRY USSR
REPORT NO. ORD OTH 4080	WDC INTELLIGENCE REPORT	I. D. NO. 872660 D

SUBJECT: [illegible] of Unfired 122mm SR. [illegible] Round of Soviet Gun Ammo. Shell Mod. of 471H & [illegible] 2229K Respectively

FROM: [illegible] REFERENCE: PICATINNY ARS Report, 19 Nov 51

EVALUATION: A-1 DATE OF INFORMATION: Feb 51 DATE OF REPORT: 19 Nov 51

INCL. [illegible] PREPAID BY: Ord Corps. Dept/Army SOURCE: Actual Specimen

SUMMARY OR SID REPORT:

This is a technical examination with dimension sketches, a complete round drawing, chemical analysis of explosives, and metallurgical analysis of the subject projectile and cartridge case.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.
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1 Tech Intel Dr

7841

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FILE UNDER: 0400 USSR

INDEX SHEET

DATE: 7 Sep 51

FROM: G-2 TO: CofS

SUBJECT: Soviet 132 mm Rockets

DOCUMENT FILED UNDER: 319 Circ Queries (#1)

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HEADQUARTERS
ORDNANCE TECHNICAL INTELLIGENCE DETACHMENT
8087TH ARMY UNIT

24 February 1951

ORDNANCE TECHNICAL INTELLIGENCE REPORT No. 63
(122mm SEMI-FIXED, AP, BALLISTIC CAPPED ROUND FOR SOVIET M1931/37 122mm GUN)

1. This unit examined a semi-fixed complete round for the Soviet Model 1931/37 122mm Gun. The round was in the Taegu, Korea, Ammunition Supply Point. The round was not disassembled, so all data and measurements included in this report are those visible externally. This round appeared to be fitted with an aluminum ballistic cap, which was roll crimped to the main projectile. The round had a tracer element screwed into the base of the projectile, which was evidently base loaded with high explosive, and base fused.

2. The round was packed in a yellowish-green painted wooden box, and was adequately shored. The original marking on the exterior of the box was obliterated and the box had the following outside dimensions:

a. Height: 2½ in.

b. Length: 33½ in.

c. Width: 15 in.

3. The exterior dimensions and contour of the projectile and its base are as shown in a diagram included in this report. The shell was painted dark olive-drab with the exception of the one (1) rotating band and the two (2) bourrelets. The rotating band and bourrelets were well covered with thick grease, with a layer of paper over the grease.

Stenciled upon the projectile, in black paint, were the following data:

Front:	Reverse:
A-IX-2	114
M A -5	7-49
БР-471 Б	122

Stamped into the rotating band was "26- VA ", and stamped into the projectile above the lower bourrelet is "139 ".
"1945. ".

4. The brass, rimmed, tapered, drawn cartridge case appeared to be of one (1) piece construction. The propellant was protected by a heavily greased, removable, cardboard plug. The dimensions and contour of the case are as shown in a diagram which follows. Stamped into the base of the cartridge case are the following data:

7
48 2

3.257
CH

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Stenciled in black paint upon the outside of the cartridge case are the following data:

ПОЛ БРОНЕБ
Ж-471
122-31
22/1 ТРСБ 9/49 Т
22/1 ТРСБ 10/49Т
902-49- 29

5. The primer is of the standard Soviet threaded type, and is of blackened steel. It has stamped into its surface the following data:

$\frac{1}{4\ 8}$ 603 БР

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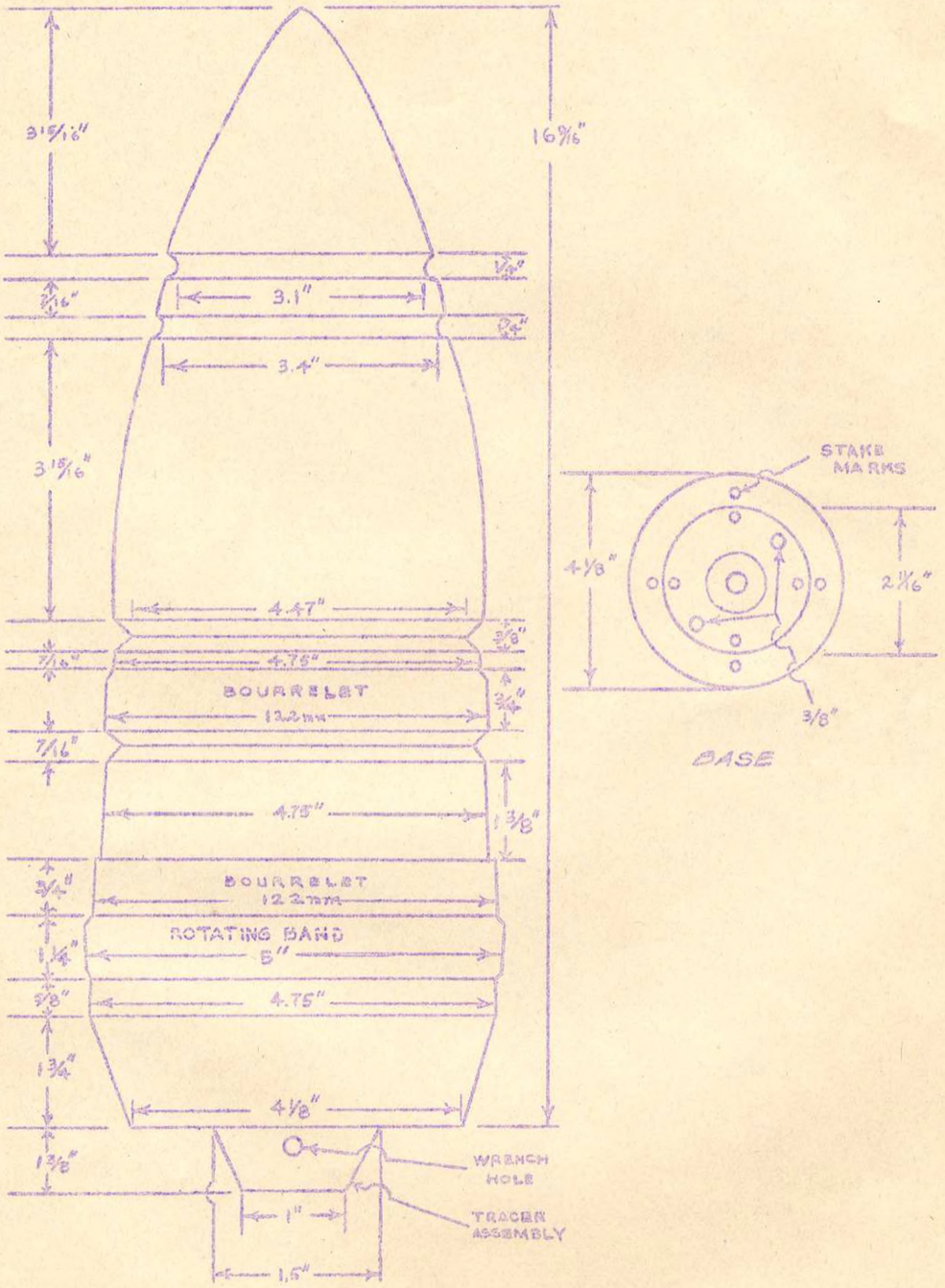

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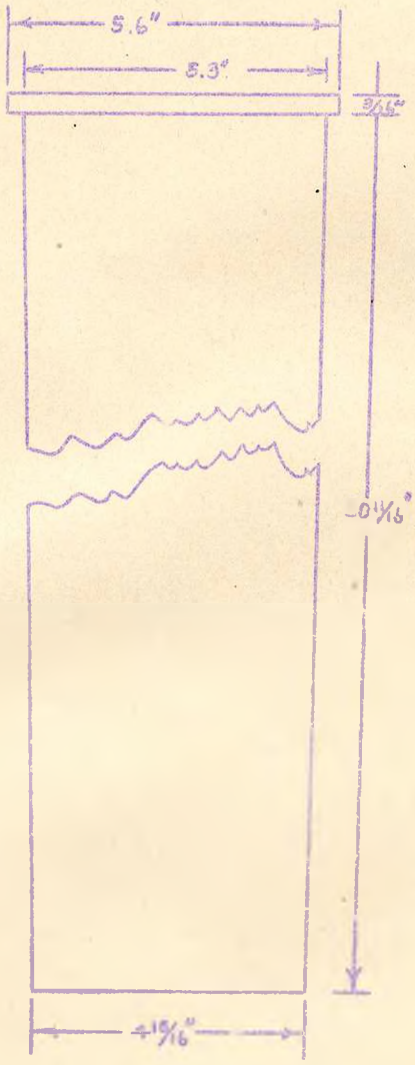

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FILE UNDER: ~~HT~~ 0400 USSR

INDEX SHEET

DATE: 20 Apr 51

FROM: TTB TO:

SUBJECT: Study of Soviet Artillery

DOCUMENT FILED UNDER:

HT15 Doc. 31995

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TB-363-51

FOR: T/Intel

0500 USSR

5813

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TB-363-51

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Subject Motor Vehicles B. I. D. No. _____
(Communications, etc.)

Name Truck
(Telephone, etc.)

Type 4 x 2, Cargo
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-150

Year _____

Photographed Feb 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Close-up of right side, showing nameplate and it's location.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ (Number) In _____ (Office)

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(Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 851506

Subject Motor Vehicle B.I.D. No. _____
(Communications, etc.)

Name Truck
(Telephone, etc.)

Type 4 x 2, Cargo
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-150

Year _____

Photographed Feb 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Close-up of right side, showing nameplate and it's location.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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RESTRICTED

Subject Motor Vehicles (Communications, etc.) B.I.D. No. _____

Name Truck (Telephone, etc.)

Type 4 x 2, Cargo (Field, etc.)

Made by USSR (Manufacturing nation)

Model ZIS-150

Year _____

Photographed Feb 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Left side view.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

RESTRICTED (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Motor Vehicles (Communications, etc.) B.I.D. No. _____

Name Truck (Telephone, etc.)

Type 4 x 2, Cargo (Field, etc.)

Made by USSR (Manufacturing nation)

Model ZIS-150

Year _____

Photographed Feb 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Left side view.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

RESTRICTED (Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 851506

HEADQUARTERS
ORDNANCE TECHNICAL INTELLIGENCE DETACHMENT

19 February 1951

ORDNANCE TECHNICAL INTELLIGENCE REPORT No. 60
(76mm HE Round, Unfuzed Russian)

1. Twenty-eight (28) rounds of 76mm HE ammunition, unfuzed, were examined at the 335th Ordnance Ammunition Battalion near Pusan, Korea, on 11 January 1951. These rounds had longer shell cases than any previously examined by this unit. Their place of capture is unknown.

2. These rounds were packed four (4) to a box. The cleated boxes are painted a brick red and have the following outside dimensions:

a. Height: 6 in.

b. Length: 37 in.

c. Width: 21 in.

3. Data was stenciled upon the top, front, and back of the boxes in black paint. The stenciling on the top, front, and back of each box was identical, but varied in the numbers painted on each. The stenciling appears as follows:

Box No. 1: П. УНИТ Н д ЗИ д УЗИСИ
1 шт 'Н' 1026 НЕС ОРУТТО 62 К Г.

Box No. 2: 'Н' 1052
" " 3: 'Н' 1002
" " 4: 'Н' 1075
" " 5: 'Н' 992
" " 6: 'Н' 1042
" " 7: 'Н' 1031

4. An Inspector's label is pasted on the inside of the top of each case. All labels are identical, and a sample photostat from Box No. 1 is attached as Inclosure No. 1 to this report. It is believed that this ammunition was packed on 11 March 1950.

5. The round consists of an unfuzed, loaded projectile, crimped with one (1) cannelure to a brass shell case, which is fitted with a threaded steel primer. Theprojectile's explosive filling and its fuze threads are protected with a black plastic closing plug. The dimensions and general appearance of the round are shown in a diagram included in this report.

6. The projectile is of steel and is unpainted and unfuzed. The whole projectile was well covered with cosmoline type grease and when this grease was removed, the metal of the projectile and the rotating bands were revealed to be in excellent condition. The metal of the projectile was ground finished, with a straight cylinder for three (3) inches in front of the rotating band up to the ogive, which was rough machine finished. The stenciling, in black, upon the ogive of the projectile was largely illegible, but upon a few of the rounds the following was legible:

Front:	Reverse:
Т	15
О-361	307-41
	76
	Н

0400 USSR.

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7. The crown rimmed single piece brass shell cases were unstenciled and appeared to have been reworked. Stamped into the base of these cases, about the primer, were the following data:

ROUNDS:	DATA:	
1	77 38 ⌐	3.176 ϕA
1	115 38 ⌐	3.176 ϕA
1	124 38 ⌐	3.176 ϕA
1	132 38 ⌐	3.176 ϕA
1	185 38 ⌐	3.176 ϕA
1	183 39 ⌐	3.176 HO
1	186 39 ⌐	3.176 HO
1	3 40 ⌐	3.176 HO
1	19 40 ⌐	3.176 C ⊓
1	83 40 ⌐	3.176 HO
1	86 40 ⌐	3.176 HO
2	92 40 ⌐	3.176 C ⊓
2	101 40 ⌐	3.176 C ⊓
1	107 40 ⌐	3.176 C ⊓
1	143 40 ⌐	3.176 C ⊓
1	215 40 ⌐	H. ⊓ .
1	224 40 ⌐	3.176 H ⊓
1	322 40 ⌐	3.176 H ⊓
1	51 41 ⌐	3.176 H ⊓

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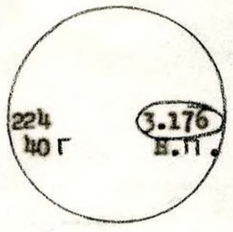
ROUNDS:	DATA:	
1	129 41 Г	3.176 НВ
1	151 41 Г	3.176 НВ
1	230 41 Г	3.176 НВ
1	240 41Г	3.176 НВ
3	Illegible	

Shell Case base stamping:



8. The steel primers were of the standard Russian threaded type with stamped in data as illustrated below:

ROUNDS:	DATA:
10	КК 15/42 Г Б А
18	ЗИЗ 9/42 Г Б А



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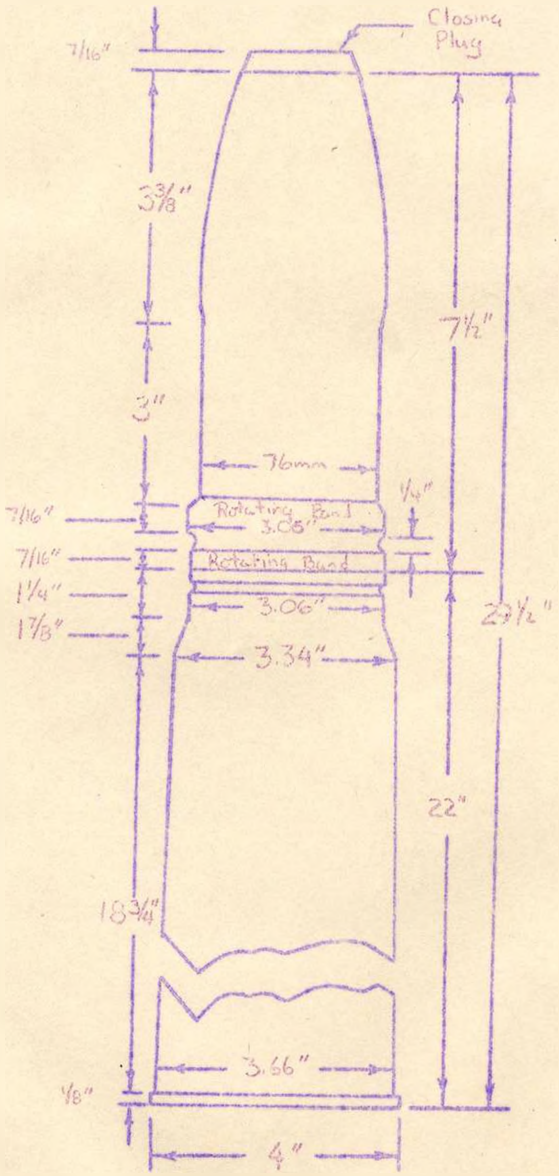

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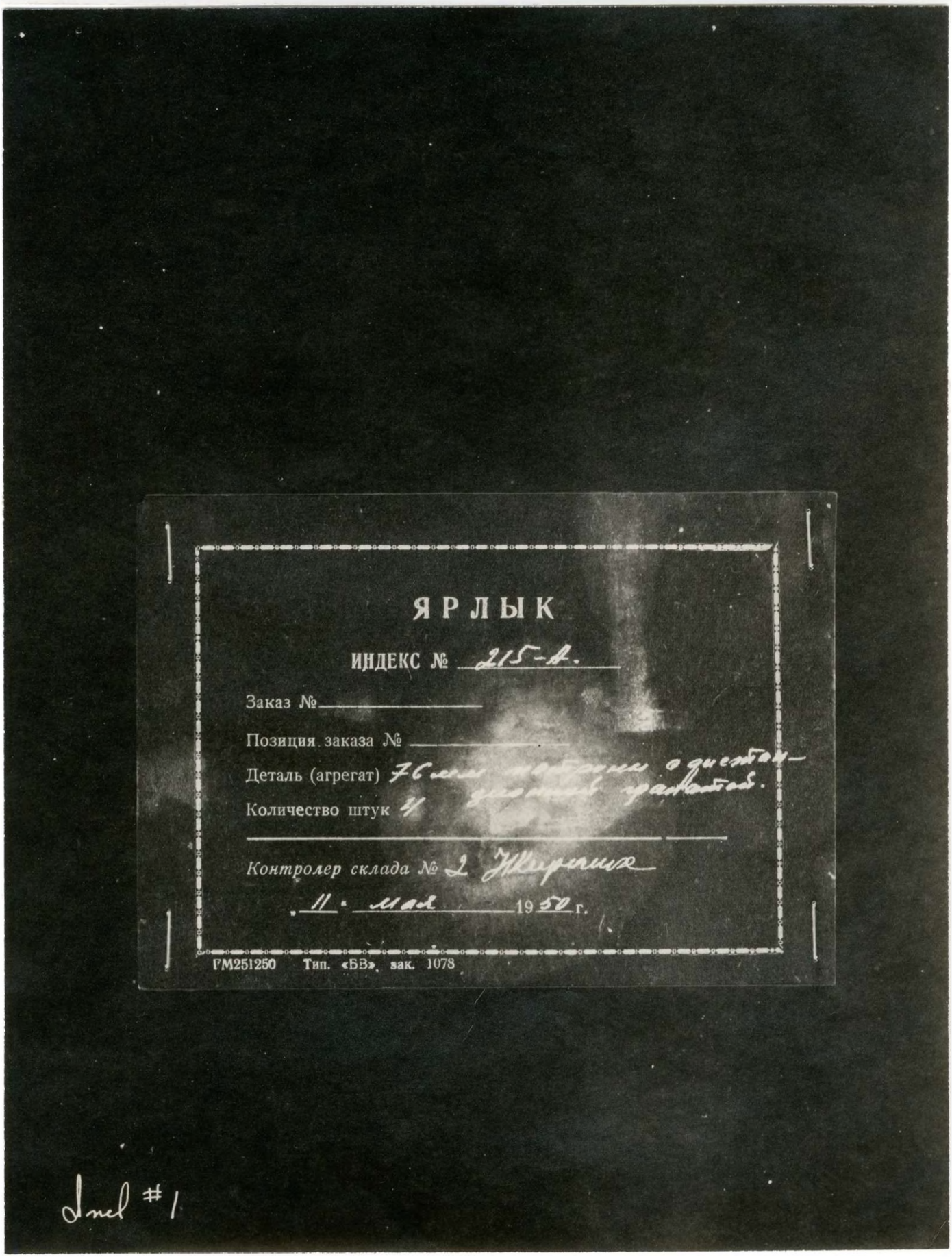

ЯРЛЫК

ИНДЕКС № 215-А.

Заказ № _____

Позиция заказа № _____

Деталь (агрегат) 76 мм [illegible] с дистанционной гранатой.

Количество штук 4

Контролер склада № 2 [illegible]

«11» мая 1950 г.

ГМ251250 Тип. «БВ». зак. 1078

Incl #1

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CONFIDENTIA

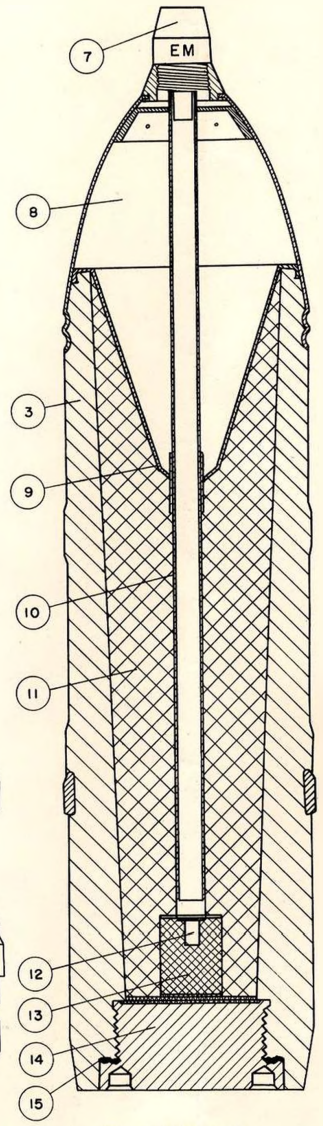
76 MM ARMOR – PIERCING

ARMOR – PIERCING HIGH EXPLOSIVE SHELL
FOR 76MM REGIMENT AND DIVISION GUNS

MADE OF STEEL AND PIG-IRON

CROSS – SECTION

FULL VIEW

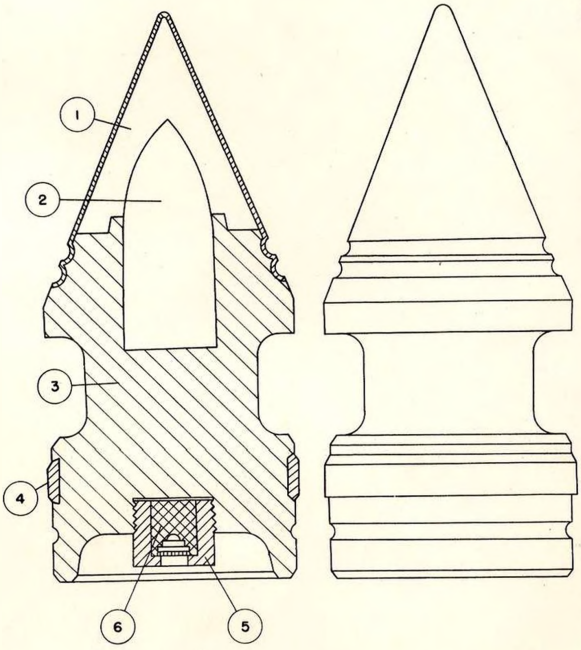


1 – TEMPORARY CAP
2 – CORE OF THE PROJECTILE
3 – SHELL BODY
4 – ROTATING BAND
5 – SCREW RING
6 – TRACER POWDER
7 – FUSE (6M)**
8 – TEMPORARY CAP
9 – CONICAL PART
10 – CENTRAL TUBE
11 – MAIN CHARGE
12 – PRIMER CHARGE
13 – BOOS
14 – BASE
15 – ZINC
16 – MAIN
17 – WAS
18 – FUSE

ARMOR – PIERCING SHELL
FOR 76MM DIVISION AND TANK GUNS
(WITH ARMOR – PIERCING AND TRACER ACTION)

CROSS – SECTION

FULL VIEW



TB-210-07

CONFIDENTIA

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Authority NND 851506

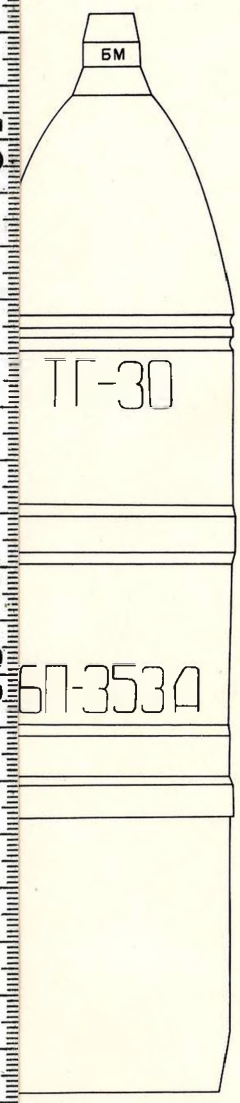
CONFIDENTIAL

R – PIERCING SHELL (SOVIET)

OSIVE SHELL
IVISION GUNS

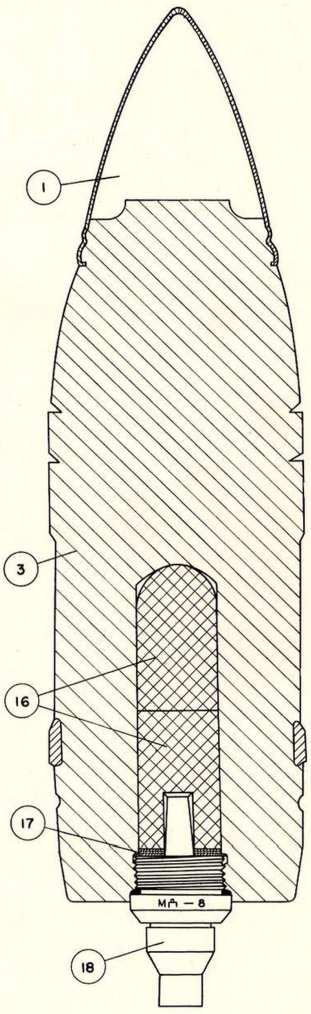
PIG – IRON

FULL VIEW

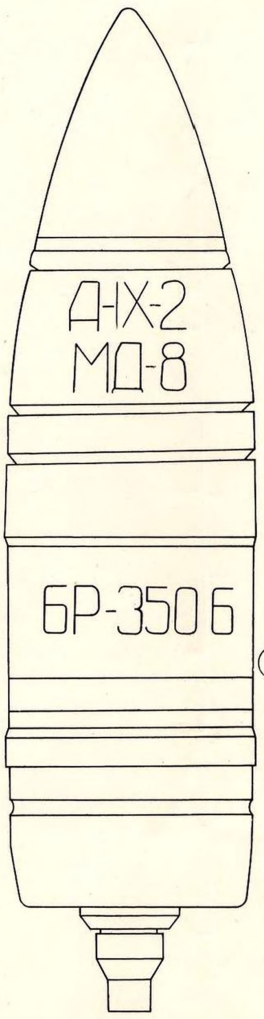


ARMOR – PIERCING AND EXPLOSIVE TRACER SHOT
FOR 76 MM DIVISION AND TANK GUNS

CROSS – SECTION

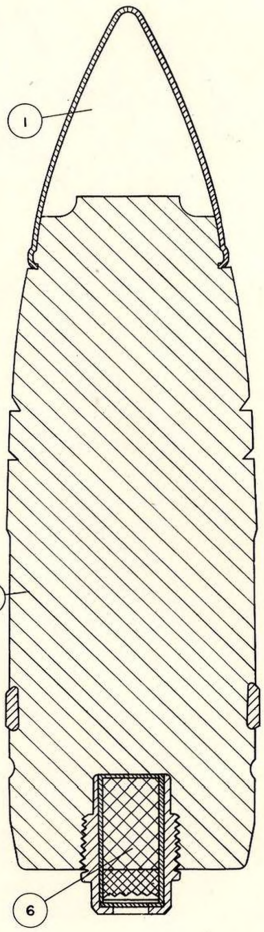


FULL VIEW

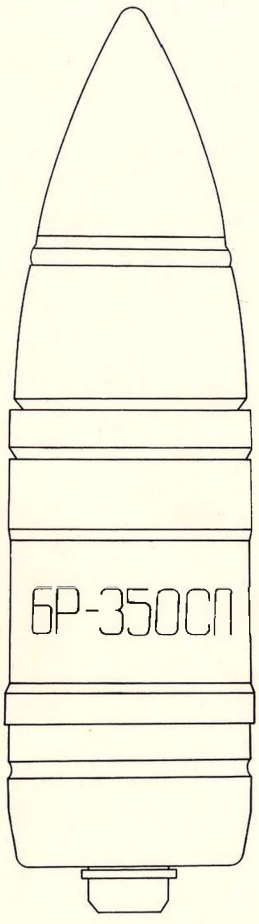


ARMOR – PIERCING TRACER SHOT
FOR 76 MM DIVISION GUNS

CROSS – SECTION



FULL VIEW



FUSE (БМ)**
TEMPORARY CAP
CONICAL PART
CENTRAL TUBE
MAIN CHARGE
PRIMER CHARGE

13 – BOOSTER CHARGE
14 – BASE
15 – ZINC RING
16 – MAIN CHARGE
17 – WASHER
18 – FUSE МД – 8 **

REMARKS: IT IS INCORRECT TO SHOW A RIGHT HAND THREAD SCREW ON THE МД – 8 IN THIS PICTURE. (IT SHOULD BE A LEFT HAND THREAD SCREW.)

CHART PREPARED BY ATIS, GHQ, FEC FROM NORTH KOREAN DOCUMENT CAPTURED DURING KOREAN OPERATIONS.

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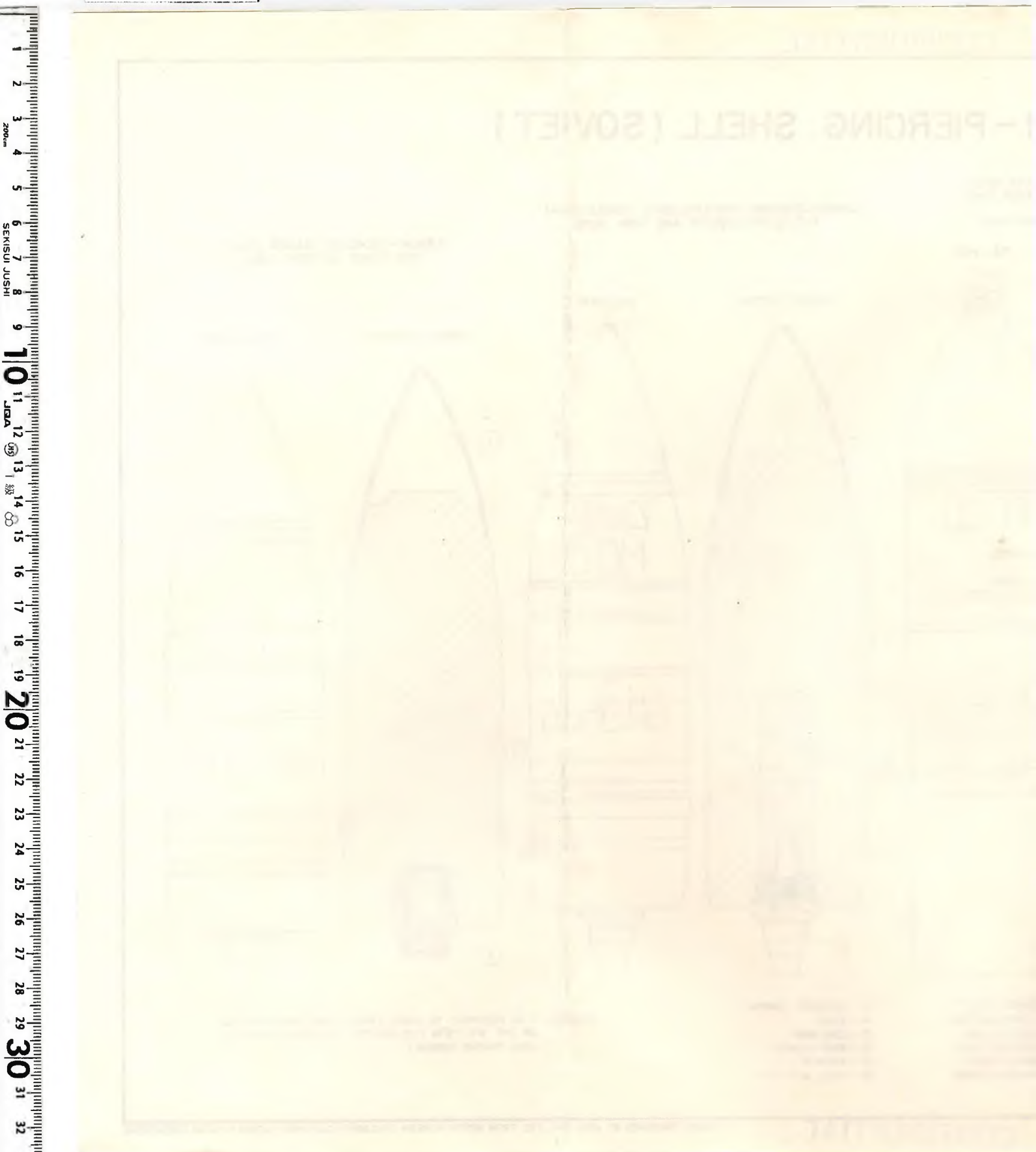

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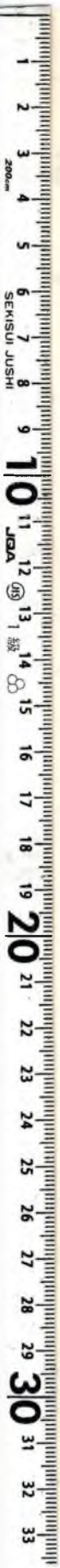

T13-210-51

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Korea

TB-198-51
Serial Numbers on Soviet Artillery (509th OTID Rpt No. 30)
T/I, G-2, GHQ, FEC D/A Control No. ID 47/1
Jan 51 3 Feb 51
one MISD, G-2, GHQ, FEC 509th OTID

Forwarded herewith one (1) copy 509th Ordnance Technical Intelligence Detachment Report No. 509-30, "Serial Numbers on Soviet Artillery," dated 22 January 1951, concerning markings found on Soviet artillery pieces in a collecting point at UISONG, KOREA. This report pertains to the following weapons: (a) 122mm Howitzer, M1938; (b) 57mm, M1943, AT gun; 76mm, M1942 gun.

For the Assistant Chief of Staff, G-2:

WILLIAM F. NORTHAM
Lt Col, GSC
Executive

1 Inclosure (1 cy)
509th OTID Report No. 30

SECRET

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26 January 1951

Markings Report No. 4

The following markongs on Soviet artillery pieces captured in Korea were obtained by Major Ronningen, D/A G-2 representative during period 3-15 January 1951:

1. 14 Howitzers, 122mm M1938 bore the following nomenclature and trademark on top side of breech ring:

122 мм ГАУБИЦА ОБР 1938 г



The following additional data was obtained from the breech ring:

Year of Manufacture	Serial Number	Year of Manufacture	Serial Number
1949	No. 19967	1943	M12523
1949	M19962	1945	M17647
1949	M19979	1945	M17248
1949	No. 19975	1943	M12690
1949	No. 19999	1944	M13198
1949	No. 19967	1944	M16441
1949	No. 19990		
1949	No. 19989		

2. 20 Howitzers, 122mm, M1938 bore the following nomenclature and trademark on top side of breech ring:

122 мм ГАУБИЦА ОБР 1938 г



The following additional data was obtained from the breech ring:

Year of Manufacture	Serial Number	Year of Manufacture	Serial Number
1943	M11436	1943	11211
1941	M3673	1942	M4888
1943	M9728	1942	M5207
1943	M9151	1941	M716
1942	M5591	1942	M4835
1943	M10588	1943	M11604
1943	M19253	1943	M8880
1943	19321	1942	M6310
1942	M8076	1943	M9065
1943	M10580	1941	M3400

3. 4 AT guns, 45mm, M1942, were marked as follows on top side of breech ring:

No. 2192  1945 г

No. 674  1945 г

No. 2039  1945 г

No. 2305  1945 г

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4. 18 Guns, 76mm, M1942, were marked as follows on right side of breech ring:

No. 14498		1943
N 17879	—	1945
N A 3711		1945
N662754		1944
N7866		1944
NA 6362		1945
N 17756		1945
N 17909		1945
N A 4358		19 (Remainder of year of manufacture obliterated).
N 18615		1945
N768584		1944
N A 4788		1945
N 15813		(year of manufacture obliterated)
N A 4462		1945
N 15095		(year of manufacture obliterated)
N 19562		1945
N 15984		1945
No. A 6833		1945

5. Three Howitzers, 76mm, M1927, were marked as follows on barrel 15 inches above breech ring and on nameplate on carriage:

Trademark	Serial Number	Date	Nameplate Markings
	No. 1816	1933	ЛАФЕТ No. 1825 1933 г.
	No. 4448	1939	ЛАФЕТ No. 4268 1939 г.
	No. 4299	1938	ЛАФЕТ No. 4111 1938 г.

6. Twelve Howitzers, 76mm, M1927, bore the following trademark: ◇ These pieces were marked as follows on barrel and carriage nameplate:

Serial Number	Date	Nameplate Markings	
N 15424	1943	15294	1943
N 8561	1942	None	
N 8789	1942	None	
N 14664	1943	◇	14308
N 11390	1942	◇ ЛАФЕТ	No. 11143 1942

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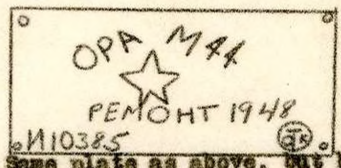
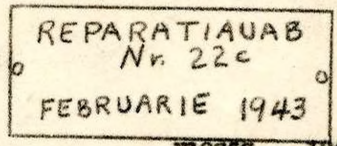
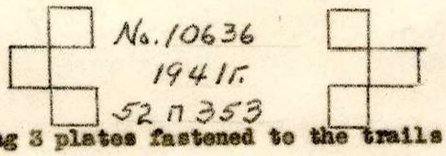
Serial Number	Date	Nameplate Markings
M10702	1942	10510 1942
M15160	1943	M15160 - 1945г.
M15371	1943	ЛАФЕТ 15329 1943г.
M13713	1942	None
M10385	1942	
M14722	1943	Same plate as above, but bearing number as follows: И 14722
M10437	1942	None

7. Three (3) Howitzers, 76mm, M1927, had same trademark as twelve howitzers above, but had a different type of barrel. The best of these three pieces, barrel No. 29A, has been packed for shipment to Aberdeen Proving Ground, Md.

Serial Number	Date	Nameplate Markings
N5A	1943	14982
N29A	1943	
N6850	1943	ЛАФЕТ M10363 1942г.

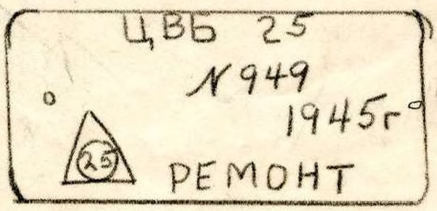
8. One (1) Howitzer, 76mm, M1927, had the following marking on the barrel 15 inches above the breech ring:



This piece had the following 3 plates fastened to the trails in the order shown:







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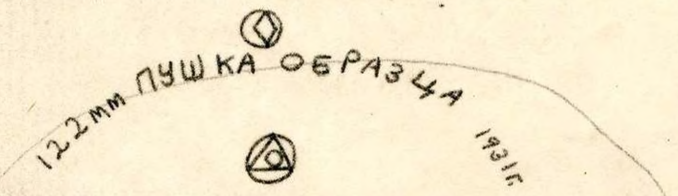
9. One (1) howitzer, 122mm, M1931, had the following marking stamped on the barrel above the breech ring:

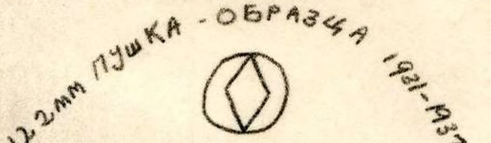
РЕМОНТЫЙ - 1947 г.



N 430 1939 г.

A second howitzer, 122mm, M1931, had an identical marking as that above except that the serial number has M589 and the word "РЕМОНТНЫЙ" had been partially obliterated by a sharp instrument.

One (1) howitzer, 122mm, M1931/37, had the following marking stamped on the barrel above the breech ring:



N 3944 1944 г.

Two howitzers bore the same marking as above except that serial numbers were M3888 and M3898.

Three howitzers bore different serial numbers and years of manufacture than three pieces listed above and had indicated markings above the nomenclature in the same manner indicated in sketch under item No. 8.

Serial Number	Date	Additional Marking
M759	1942	РЕМОНТНЫЙ - 1947 г.
		Note: Marking "РЕМОНТНЫЙ" partially obliterated
M1187	1943	РЕМОНТНЫЙ - 1946 г.
M5418	1947	РЕМОНТНЫЙ - 1947 г.

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524TH TECHNICAL INTELLIGENCE
COORDINATOR DETACHMENT

14 January 1951

SUBJECT: Markings and Serial Numbers on Russian Vehicles in Korea

1. The following are markings and serial numbers obtained from Russian vehicles in Taegu, Korea, by Major Ronningen (DA), 2nd Lt Hills of this organization, and 2nd Lt. Dong Hoon Kim, Office of Charge of Ordnance, Korean Army:

GAZ-67 (5 ?)

Motor No.	Location
776525	Stamped in raised portion of engine block. Nameplate missing.

GAZ-67 Data from plate under hood on right side.
Motor No. 746745
Chassis No. 123083
CO PAHO 19-04
Date of Mfg. 50

ZIS-150 Stamped on nameplate on right side of frame, forward of the rear wheel.

Motor No.	Chassis No.
219891	164028
232588	174126
232491	174728
75050	105361
65528	150410

GAZ-51 Information obtained from nameplate located on right side under hood.

Motor No.	Chassis No.	Date Mfg.
112030	41101	1948
51 200631*	M162517*	1950

*Obtained from engine block and stencilled number on frame.

GAZ-51

Motor No. (Stamped on left side engine block)	Chassis No. (Painted right side toward rear wheel)
51 260090	M18240
51 262630	M185953
51 261529	M183316
51 264169	M-185562

ZIS-151 Stamped on nameplate on right side of frame between rear wheels and gasoline tank.

Motor No. 241839
Chassis No. 10116

Motor had been removed from vehicle and another ZIS-151 motor substituted. Number stamped on engine block of the new motor was as follows: 252189

GAZ-63
Both the chassis number and the motor number had been so defaced on the nameplate and on both sides of the chassis and motor proper it was impossible to read. The year of mfg was legible and read 1947.

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SECRET Korea

TB-146-51

Serial Numbers on Soviet Artillery (509th OTID Rpt No. 509-28)

T/I, G-2, GHQ, FEC Control No. ID 47/1

Jan 51 27 Jan 51

O MISD, G-2, GHQ, FEC 509th OTID

This 509th Ordnance Technical Intelligence Detachment report No. 28, "Serial Numbers on Soviet Artillery", dtd 16 Jan 1951, concerns markings, which were taken from artillery pieces recovered north of TANGU, KOREA. Weapons found in this collection point were: 45mm AT gun, M1942, 28 each; 122mm HOW, M1938, 11 each; 76mm HOW, M1927, 11 each; 76mm gun, M1942, 13 each.

For the Assistant Chief of Staff, G-2:

WILLIAM F. NORTHAM
Lt Col GSC
Executive

DISTRIBUTION:
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1 - T/I, TB
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122 MM HOW, M1938, SERIAL NOS's

Below is the 1st row of markings found on all guns.

122ММ ГАУБИЦА ОБР 1938Г.

1772

	Plate No.	Factory Symbol	Year of Manufacture	
1	USSR 0100		1942	
2	N5618		1942	
3	N4491		1942	
4	N10731		1943	
5	N6414		1942	
6	N20006		1949	(Note mar)

SECRET

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SECRET Korea

TB-146-51
Serial Numbers on Soviet Artillery (509th OTID Rpt No. 509-28)
T/I, G-2, GHQ, FEC Control No. ID 47/1
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For the Assistant Chief of Staff, G-2:

WILLIAM F. NORTHAM
Lt Col GSC
Executive

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DISTRIBUTION:

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1772

USSR 0400

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16 January 1951

Serial Numbers on Soviet Artillery

45MM AT GUN, M1942 - Breech Stampings

1	No. 4463	1943	13	No. 110	1945
2	No. 8357	1944	14	No. 8472	1944
3	No. 461	1945	15	No. 8671	1944
4	No. 4500	1943	16	No. 8614	1944
5	No. 8387	1944	17	No. 156	1944
6	No. 1302	1945	18	No. 8353	1944
7	No. 8662	1945	19	No. 1407	1943
8	No. 1187	1945	20	No. 1181	1945
9	No. 4479	1943	21	No. 1325	1945
10	No. 251	1945	22	No. 2237	1943
11	No. 8016	1944	23	No. 5336	1944
12	No. 934	1945	24	No. 8512	1944
			25	No. 184	1944
			26	No. 8583	1944
			27	No. 935	1945
			28	No. 1244	1945

122 MM HOW, M1938, BREECH MKG's

Below is the 1st row of markings found on all guns.

122 ММ ГАУБИЦА ОБР 1938г.

	Piece No.	Factory Symbol	Year of Manufacture	
1	M7893		1942	
2	M5618		1942	
3	M4491		1942	
4	M10731		1943	
5	M6414		1942	
6	M20006		1949	(Note yar)

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7	N10617		1943
8	N5425		1942
9	N10701		1943
10	N12073		1943
11	N10399		1943

76 MM How, M1927, Tube MKG's

1.



N 1077 1931 Г

ВЕС ВЕС
СЗАМКОМ ВЕЗ ЗАМКА
229,5 кг. 217,4 кг.

2.



N 15377 1943 Г.

52. П .353

ВЕС ВЕС
СЗАМКОМ ВЕЗ ЗАМКА
229,5 кг. 217,4 г.

These markings are the same on remaining 76 mm Howitzer M1927

3	N7325		1942
4	N15722		1943
5	N10773		1942
6	N12888		1942
7	N15161		1943
8	N47.А.		1943 (note different type serial number)
9	N10538		1942
10	N12458		1942
11	N15317		1943

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The first line of markings on all weapons are stamped as follows: 3 NC -3

1 N750034  1944

2 N7845  1944

3 N5543  1942

4 N  12584 1944

5 N767574  1944

Trail Repair Tag



6 N289373 1943

Trail Repair Tag



7 N-A9486  1945

8 N350513  1943

9 N756944  1944

10 NA3458  1945

11  16923 1945

12 N746864  1944

13 N752264  1944

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BID NO.	RESTRICTED CLASSIFICATION	COUNTRY USSR
MIG NO.		
REPORT NO. ORD OIN 3490	WDGS—INTELLIGENCE REPORT	I. D. NO. 856863

SUBJECT: Exam. of Unfired 57MM HE Comp. Rd of Soviet Ammunition MOD UO271 (FMAM-2227)

FROM: OCofORD REFERENCES: Pic Report (ORD OIN 3490)

EVALUATION: A-1 DATE OF INFORMATION: Feb 51 DATE OF REPORT: 12 Sep 51

INCL. 12 PREPARED BY: Ord Corps, Dept/Army SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

This report concerns one loaded and fuzed complete round of Soviet 57mm HE Ammunition, MOD UO-271 which was examined. The complete round consists of a point-fuzed HE shell, force fitted into a primed brass cartridge case. The shell is loaded with a cast TNT bursting charge, cavitated for the booster which is assembled in the base of the fuze. The brass cartridge case, of conventional design, contains a multi-perforated grain nitrocellulose propellent charge, a bagged black powder igniter charge and has a percussion type primer of relatively short length in its base. Photos and diagrams of subject ammo. are inclosed.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.
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Tecom Ltr

(Classification Stamp)

GS ID USA TRANSLATION

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REQUESTED BY	REGISTRY NUMBER	I. D. NUMBER
W and E Sec. Tech Br. ID G-2	F-6467	758514
TRANSLATION OF OR FROM		INITIALS OF TRANSLATOR
Russian		H.H.

REFERENCES Tablissi Strelby 85 mm Samokhodnykh Pushek, 85 mm Tankovoi Pushki 1943 i 1944 Firing Tables for the 85 mm Self propelled Guns, 85 mm Tank Guns, Models 43. 44

SUBJECT

Firing Tables

86640

FIRING TABLES

For 85 mm Self Propelled Guns, Models D5-C85 and the D5-C85A,

the 85 mm Tank Gun, Model 1943, D5-T85,

the 85 mm Tank Gun, Model 1944, ZIS-C53

Firing Tables
Office of the Chief of Artillery NO. 240

Second Edition, Supplement

Military Publication of the National Commissariat of Defense

Moscow, 1944

Armor Piercing-Tracer Shells, Fragmentation Shell with KTM-1 fuze, Fragmentation time Shell with T-5 vuze, Subcaliber Armor Penetrating-Tracer Shell.

This copy of the Second Pulbication is supplemented with instructions for firing subcaliber armor piercing-tracer Shells of the BR-365P type.

Artillery Systems

The 85 mm SU guns, models D5-G85 and the D5-S85A, the 85 mm tank gun, model 1943 D5-T85 and the 85 mm tank gun, model 1944 ZIS-S53, — all of these have the same barrel as used by the 85 mm antiaircraft gun, model 1939, without the muzzle brake. The ballistics of all these guns is the same.

The 85 mm tank gun, model 1944 ZIS-S53 is installed in a tank containing a standard slide (?), as well as in tanks with slides extended to 1,600 mm.

The angles of jump of these guns are varied:

— in the 85 mm SU gun (self propelled gun) D5-S85 — it is minus 4

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minutes;

— in the 85 mm SU gun, D5-S85A it is plus 7 minutes;

— in the 85 mm tank gun, model 1943, D5-T85 it is minus 1 minute;

— in the 85 mm tank gun, model 1944 ZIS S53 on tanks with standard (slides ?) it is minus 4 minutes, and in tanks with extended slides it 's minus 9 minutes (the Russian term pogon refers to a gun part which slides over another);

D5-S85 self propelled guns differ from D5-S85A self propelled guns (85 mm) in accordance with the following:

D5-S85	D5-S85A
1) The breech and recoil lug constitute a unit whole	1) The recoil lug is screwed to the breech
2) The inscription "D5-S85" is engraved on the breech	2) The inscription "D5-S85A" is engraved on the breech
3) The gun is equipped with the sight used by the model 1938,122mm Howitzer and contains indicators.	30 The gun is equipped with a sighting device (without indicators) taken from the 76 mm gun, model 1942 (ZIS-3).

Sighting Devices

1. The 85 mm self propelled gun, D5-S85 can use the following types of aiming devices:

— the 10T-15 telescopic sight, or the TSh-15 telescopic hinged sight for direct fire;

— the panoramic sight taken from the 122 mm howitzer, model 1938 for fire by indirect laying.

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The self propelled gun, D5-S85A, has the following types of sighting devices:

— the TO T -15 telescopic sight, or the TSh-15 telescopic hinged sight;

— the panoramic sight used in the 76 mm gun, model 1942 (ZIS-3) without indicators.

The 85 mm tank gun, model 1943, D5-T85, has the following type sights;

— the 1OT-15 telescopic sight, or the TSh-15 telescopic hinged sight;

— the PT4-15, or the PT9-15 periscopic sights;

— and a level for fire by indirect laying.

The 85 mm tank gun, model 1944 employs the following type sights:

— the TSh-15 telescopic hinged sight, or the 1OT-15 telescopic si ht;

— and a level for fire by indirect laying.

2. The TSh-15 aiming device is a hinged telescopic sight. The eyepiece assembly is reigidly secured to the turret, while the objective piece assembly is connected with the tipping parts of the piece.

The following range scales are contained in the field of vision of the sight:

— the "BROM" scale for firng armor piercing tracer ammunition and fragmentation shells with KTM-1 fuzes in ranges up to 5,200 meters; the scale graduations equal 200 meters of range, and are numbered in hundreds of meters;

— the "DT" scale for firing light projectiles from the DT machine gun, coaxially mounted on the artillery piece.

Use is made of the indicators and marks underneath the scale when training on a target. The line of sighting at zero settings corresponds to the central indicator, while the lateral indicators amd marks are employed for entering deflection corrections.

The horizontal cross hair, which is not moved in fire, serves as the scale indicator.

The scale, together with the indicators which are contained on one of the plates, may be moved with respect to the scale indicator, by means of the eleva-

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tion knob affixed to the aiming device.

In adjusting the sight, the plates with the scales can be moved horizontally by means of the adjustment screw on the left, while the scale indicator (cross-hair) may be moved vertically by means of the screw located below the instrument.

The following inscription is contained on the sighting d vice: TSh-15 for the 85 mm in the KV".

3. The 1OT-15 aiming device is a telescopic sight. The following range scales are contained in the field of vision:

-- the "BROO" scale with the same type graduations as contained in the TSh-1 sight in ranges up to 6,000 meters;

-- the "DT" scale.

In addition to the range scales, the field of vision of the sight contains the scale of deflection corrections in mils (1 milx = 3.6 minutes). The value of one graduation is equal to 4 mils.

The scales in the aiming device are rigidly secured.

The horizontal and vertical crosshairs, which can be shifted by means of two knobs contained on the aiming device,act as the indicators.

The sight is set by shifting the horizontal crosshair relative to the range scales, while the deflection markingx corrections are entered by shifting the vertical crosshair with respect to the scale of lateral corrections.

The sight is trained on the target according to the intersect d crosshairs. The line of sightingx at zero settings corresponds to the position of the scale indicators when they are on the zero settings. In making adjustments, the entire sight is trans-ferred or shifted with the aid of a device located on the sight bracket.

The following inscription is contained on the aiming device: "1OT-15 for the 85 mm in the KV".

4. The PT4-15 aiming device is a periscopic sight. The scale markings in this sight are similar to those of the 1OT-15 sight scales. RESTRICTED

The following inscription is contained on the aiming device: "PT4-15 for the

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KV".

5. The P-9-15 aiming device is not capable of all around field of view, and thus differs from the PT4-15 sight which does have this capacity.

6. The aiming device with the panoramic telescope taken from the 122 mm howitzer, model 1938, contains the following:

-- a mils scale (1 mil equal 3.6 minutes);

-- range scale "BROG KTM-1" for firing armor piercing tracer shells and fragmentation shells with KTMO1 fuzes.

7. The aiming device with the panoramic telescope taken from the 76 mm gun, model 1942, (ZIS-3) may have the following:

-- on the pieces of the first manufactured series -- on the mil scale only (1 mil equals 3.6 minutes);

-- on the pieces of later manufacture -- the mil scale and the "BROG KTM-1" scales.

8. There is a coarse scale on the arc of the gunners quadrant with a fine scale on the drum. The coarse scale contains graduations with the following numbers inscribed: -1,), /1, / 2, / 3, /4, and / 5. The precision setting scale on the drum contains 100 graduations (mils, 1 mil equals 3.6 minutes); one rotation of the drum moves the indicator on the coarse scale one mark or graduation. On some levels, the coarse scale may be numbered as follows: 29, 30, 31, 32, 33, 34, and 35. In this case, the 30 setting on the coarse scale and the 0 setting on the drum (30-00) will correspond to the horizontal position of the gun barrel.

ADJUSTMENT OF SIGHTS

1. The range scales of the above-mentioned sights are made in accordance with the ballistic properties of the 85 mm SU gun D5-S85, with an angle of jump equal to minus 4 minutes.

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2. The 85 mm SU gun, D5-S85 and the 85 mm tank gun, model 1944 ZIS-S53 in tanks with standard (slide, race, traverse?), have an angle of jump equal to minus 4 minutes, i.e., the same angle as that used in marking the sights. Sights mounted in the given gun pieces should be adjusted at distant targets observing the following rules:

a) The TSh-15 sight. Attach reticle to marks contained on face of barrel muzzle and remove firing mechanism from breech.

Sighting through firing pin aperature, train cross hairs at point of aim, not less than 500 meters from gun.

Cause zero of scale to coincide with scale indicator (cross hair); in so doing, the point of the central indicator mark should coincide with the point of aim at which the barrel is trained.

If this does not result, it is then necessary to move the plate containing the scales by means of the angle of elevation handle and adjustment screw on the left, and cause the point of the central marker to coincide with the point of aim at which the gun is trained. Following this, the indicator should be caused to coindide with the zero markers of the scale by means of the adjustement screw located below.

b) The 10T-15, PT4-15, and the PT9-15 sights. Train barrel in accordance with reticle on muzzle at a point not less than 500 meters from the gun.

Set the horizontal cross hair on zero of range scale, and the vertical cross hair on zero of the deflection correction scale. In this position, the cross hairs in the sight field of vision should coincide with the point at which the barrel is trained.

If this does not result, it is necessary, by means of the sight adjustment mechanism, to cause the cross hairs in the field of vision to coincide with the point of aim.

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c) The sight with the panoramic telescope taken from the 122 mm howitzer, model 1938, is shecked on a distant point so that there by no discrepancies.

3. The 85 mm SU gun, D5-S85A has an angle of jump equal to plus 7 minutes. The difference in the angles of jump for which the sight is made, and that posses-sed by the gun (being 11 minutes) should be taken into consideration when checking the sights; for this type of sighting device, adjustment is made in accordance with the following:

a) The TSh-15 sight. Train barrel in accordance with cross hairs on muzzle at a point not less than 500 meters away from the gun.

Moving the plate with the scale, cause the point of the middle index to coincide with the point of aim at which barrel is trained.

Without disturbing the setting of the barrel and the central index, set the scale indicator (the cross hair) between the zero marker and the "4" marker of the "BROG" scale so that the distance from the cross hair to the zero marker be twice as great as the distance from the cross hair to the "4" marker.

b) The 10T-15 sight. Train the barrel in accordance with the cross hairs on the barrel muzzle at a point not less than 500 meters away from the gun.

Set the horizontal cross hair between the zero marker and the "4" marker so that the distance from the zero marker to the cross hair be twice as great as the distance from the cross hair to the "4" marker; set vertical cross hair on zero of the deflection correction scale. By means of the sight adjustment device cause the sight cross hairs to coincide with the point of aim at which the barrel is trained; the setting of the barrel should not be distrubed.

c) The aiming device with the panoramic telescope taken from the 76 mm gun, model 1942, (ZIS-3) is adjusted on a distant object so that are no discrepancies.

4. The 85 mm tank gun, model 1943, D5-T85, has an angle of jump equal to

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minus one minute. The difference in the angles of jump of the sight and the gun is equal to 3 minutes; it should be taken into consideration in checking the sights and is done in the following manner:

a) The TSh-15 sight. Train the barrel in accordance with the cross hairs on the muzzle, at a point which is not less than 500 meters away from the gun. Shifting the plate with scales, cause the peak of the central index to coincide with the point at which the barrel is trained.

Without distrubing the settin, of the barrel and the central index, set the scale indicator (cross hair) between the zero marker and the "4" markers of the "BROG" scale a distance three times the thickness of the hair from the zero marker.

b) The PT4-15 and the PT9-15 sights. Train the barrel in accordance with the cross hairs on the muzzle at a point not less than 500 meters away.

Set the horizontal cross hair in the field of vision of the sight between the zero marker and the "4" marker of the "BROG" scale a distance which is three times the thickness of the hair away from the zero marker. Set the vertical cross-hair on zero of the deflection correction scale.

With the aid of the adjustment equipment of the sight, cause the sight cross hairs to coincide with the point of aim at which the barrel is trained; the setting of the barrel should not be disturbed.

5. The 85 mm tank gun, model 1944, in tanks with extended (traverse, race ?) has an angle of jump equal to minus 9 minutes.

The difference in the angles of jump for the sight and the gun is equal to 5 minutes. It should be taken into account in checking the sight. In the case of the sight under consideration this is carried out in the following manner:

a) The TSh-15 sight. Train the barrel in accordance with the cross hairs on the muzzle of the barrel at the point of aim which is not less than 500 meters away from the gun.

Moving the plate containing the scale, cause the central index to be coincide with the point at which the barrel is trained; cause the scale indicator to be

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to coincide with the zero marker of the scales with the aid of the adjustment screw.

By rotating the handle of the angle of elevation settings, set the plate with scales in such a manner that the scale index be one-third the distance between the zero marker and the "4" marker of the "BROG" scale. The peak of the central index will move below th point of aim.

With scales in this position, again set the indicator of scales with the aid of the adjustment screw on zero of the scales.

b) The 10T-15 sight. Train the barrel in accordance with cross hairs on the muzzle at point of aim not less than 500 meters away from the gun.

Set horizontal cross hair on zero of range scale, and vertical cross hair on zero of deflection correction scale. By means of adjustment device located on the sight bracket, cause sight cross hairs to coincide with the point at which the barrel is trained; the barrel setting should not be disturbed in the process.

After this, set the horizontal cross hair, by means of the sight thumbscrew, one-third of the distance from the zero marker and the "4" marker of the "BROG" x scale.

By means of the elevating mechanism of the gun, train the sight cross hairs at the same point of aim used by the gun barrel; in the process, the cross hairs of the barrel will move above the point of aim.

Without distrubing the position of the barrel, again set the horizontal cross hair on zero of the range scale, and, using adjustment mechanism contained on the sight bracket, superimpose the sight cross hairs on the point of aim.

By following these procedures the sight will be properly adjusted in five minutes.

Sights should be adjusted with care and in accordance with instructions as set forth herein.

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AMMUNITION

The 85 mm SU guns, D5-S85 and D5-S85A, 85 mm tank guns, model 1943 D5-T85 and 1944 ZIS S-53 use ammunition provided for the 85 mm antiaircraft gun, model 1939 including the following:

a) AP tracer projectiles, BR-365 and BR-365K;

b) Subcaliber AP tracer projectiles, BR-365P;

c) Fragmentation steel shell, O-365K with special (perekhodnaya golovka) head and KTM-1 fuze.

The above-named serve as the basic type ammunition for the pieces mentioned. In the absence of the foregoing type of ammunition, use may be made of the O-365 fragmentation shell with the T-5 fuze; the latter should be used exclusively in time fire (fire for aerial bursts).

The T-5 time fuze is not activated by persussion action, and is not activate by striking against any type of obstacle.

Table of Armor penetration by the BR-365 AP Tracer projectile

Range in Meters	Thickness of armor penetrated in mm		Remarks
	At 90° angle of impact	At 60° angle of impact	
100	119	97	Armor penetration is calculated in accordance with the formula of Jacob DeMar for cement steel with the coefficient K equal to 2,400
250	114	94	
500	111	91	
750	107	87	
1000	102	83	
1500	93	76	
2000	85	69	
2500	77	63	
3000	70	57	

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INSTRUCTIONS FOR FIRE

1. Sights containing scales made in accordance with the ballistic properties of the 85 mm SU D5-S85 should be checked in strict accordance with the rules set forth in the portion entitles "Sights".

All artillery pieces, mentioned in the foregoing, with sights adjusted according to the ins ructions set forth in this handbook should be fired from a single table for AP tracer projectiles and fragmentation shells with KTM-1 and T-5 fuzes.

2. Direct fire with the above-mentioned ammunition should be conducted utilizing the "BROG" scale of the TSh-15, the PT4-15, the 10T-15, and the PT9-15 sights. The sight settings should be taken from the column of the firing tables labeled "BROG" scale. The value of each graduation of the scale is 100 meters.

Fire by indirect laying should be conducted:

a) from the SU D5-S85 gun using the sight provided with the panoramic telescope and making use of the "BROG KTM -1" scale; the sight settings should be made taking data from the firing table column labeled "BROG KTM -1 SCALE". The value of one graduation of the scale is 50 meters. Use may also be made of the "mils" scale; the sight settings in that case are taken from the column labeled: "mils scale".

b) from tank guns using the longitudinal level; in the case of levels for which the horizontal position of the barrel is equal to a setting of 0-00, the sight settings should be taken from the column in the firing table labeled "Mils Scale".

For levels in which the horizontal position of the barrel corresponds to a 30-00 setting, it is necessary to add 30-00 to the setting taken from the tables.

3. In time fire of fragmentation shells with T-5 fuzes, the fuze settings should be taken from the given table of fire. The fuze setting is calculated for bursts on the horizon of the gun with the interval of burst at 0 meters.

INSTRUCTIONS FOR FIRING 85mm SUBCALIBER AP TRACER PROJECTILES BR-365P

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1. UBR-365P ammunition with the 85 mm subcaliber AP Tracer projectile, BR-365P should be fired from 85 mm SU guns, D5-S85 and D5-S85A, and from 85 mm D5-T85 tank guns, model 1943/and model 1944 ZIS-S53.

2. The 85 mm subcaliber projectile BR-365P should be used exclusively in fire at heavy tanks and self propelled guns in direct fire at ranges up to 1,000 meters.

Fire in ranges in excess of 1,000 meters is not very effective.

Fire at heavy tanks at ranges in excess of 1,000 meters, and at medium and light tanks at all ranges should be conducted utilizing conventional AP Tracer projectiles BR-365 and BR-365K.

It is not permissible to expend subcaliber shells in fire at medium and light tanks when conventional armor piercing projectiles are available.

3. Direct laying fire should be employed in firing the 85 mm subcaliber BR-365r projectile from D5-S85 and D5-S85A self propelled guns, and from tank guns, model 1943 and, D5-T85 and model 1944 ZIS-S53; the following settings should be used for the TSh-15, LOT-15, PT4-15 and the PT9-15 optical sights:

— in ranges up to 500 meters — "3" on the "BROG" scale,

— in ranges between 500 and 1000 meters — "6" on the "BROG" scale.

4. The 85 mm subcaliber projectile has the following armor piercing characteristics:

Initial velocity - 1030 m/sec
Coefficient K equals 2400

Range in meters	Thickness of Armor in mm (penetration)	
	90° angle of impact	60° angle of impact
100	175	143
300	156	127
500	138	113
700	122	100
1000	100	81

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5. In contrast to conventional armor piercing projectiles, the subcaliber projectile, BR-365P, has a sharper head portion and a cylindrical outline of body. Fixed ammunition containing this type projectile is shorter than that containing the conventional armor piercing projectile.

The following inscription is contained on shells with subcaliber projectiles:

UBR-365P
85 mm 1939

The following inscription is contained on the front of the case:

85 mm 39 Armor Piercing Tracer
Subcaliber

The following notation is entered on the cover of the case:

"To be fired as indicated in handbook contained in the case".

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Firing Table

For the Fragmentation Steel Shell O-365K with Convertible Head Containing KTM-1 Fuze

The following ammunition will be fired in accordance with this table:

Armor piercing tracer projectiles, BR-365, and BR-365K, as well as the fragmentation timed steel shell O-365 with the T-5 fuze.

Scales: "BROG KTM-1" and "Mil" for sights with panoramic telescope.

"BROG" scale for the 1OT15, TSh-15, PT4-15 and PT9-15 optical sights.

Initial velocities:
a) O-365K shell – 785 m/sec;
b) BR-365 armor piercing trace shell and AP tracer BR-365K is 792 m/sec;
c) Time shell, O-365 is 792 m/sec.

Range	Settings, graduations: Sights with panoramic telescope "BROG KTM-1" Scale	Settings, graduations: Sights with panoramic telescope "Mil" Scale	Settings, graduations: Optical sights "BROG" Scale	Fuze Settings T-5 in graduations	Height of Trajectory in meters	Time of Flight
400	8	4	4	6	0.9	0.5
600	12	6	6	9	1.5	0.8
800	16	8	8	12	2.1	1.1
1000	20	10	10	15	2.9	1.4
200	24	12	12	18	3.8	1.7
400	28	14	14	21	5.0	2.0
600	32	16	16	24	6.4	2.3
800	36	18	18	27	8.1	2.6
2000	40	20	20	30	10	2.9
200	44	22	22	33	12	3.2
400	48	24	24	36	15	3.5
600	52	26	26	39	18	3.8
800	56	29	28	42	21	4.2
3000	60	31	30	45	25	4.6
200	64	34	32	49	29	5.0
400	68	36	34	52	34	5.4
600	72	39	36	55	40	5.8
800	76	42	38	59	46	6.2

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Firing Tables (continued)

Range	Settings, graduations: Sights with panoramic telescope: "BROG KTM-1" Scale	Settings, graduations: Sights with panoramic telescope: "Mil" Scale	Settings, graduations: Optical sights: "BROG" Scale	T-5 Ruze settings in graduations	Height of Trajectory in meters	Time of Flight
4000	80	46	40	62	58	6.6
200	84	49	42	65	61	7.0
400	88	52	44	69	70	7.5
600	92	56	46	72	80	7.9
800	96	60	48	76	90	8.4
5000	100	64	50	80	100	8.9
200	104	68	52	84	113	9.4
400	108	72	54	88	125	10.0
600	112	76	56	92	140	10.5
800	116	81	58	96	155	11.1
6000	120	85	60	100	172	11.6
200	124	90	62	104	191	12.2
400	128	95	64	108	210	12.8
600	132	100	66	112	231	13.4
800	136	105	68	116	253	14.0
7000	140	111	70	120	276	14.6
200	144	117	72	125	301	15.2
400	148	123	74	129	328	15.9
600	152	130	76	134	357	16.5
800	156	136	78	138	387	17.2
8000	160	143	80	142	418	17.9
200	164	150		147	454	18.6
400	168	158		151	492	19.3
600	172	165		155	529	20.0
800	176	173		160	567	20.7
9000	180	181		164	605	21.5
200	184	189			648	22.2
400	188	198			695	23.0
600	192	206			743	23.7
800	196	215			793	24.5

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Firing Tables (continued)

Range	Settings, graduations: Sights with Panoramic telescope "EROG KTM-1" Scale	Settings, graduations: Sights with Panoramic telescope "Mils" Scale	Settings, graduations: Optical Sights "EROG" Scale	T-5 Fuze settings in graduations	Height of Trajectory in Meters	Time of Flight
10000	200	224			845	25.3
200	204	233			902	26.1
400	208	242			955	26.9
600	212	252			1010	27.8
800	216	262			1080	28.6
11 000	220	272			1150	29.5
200	224	282			1220	30.3
400	228	293			1290	31.2
600	232	303			1370	32.1
800	236	315			1450	33.0
12 000	240	327			1540	33.9
200	244	339			1630	34.9
400	248	352			1730	35.8
600	252	365			1830	36.8
800	256	379			1940	37.8
13 000	260	393			2050	38.9
200	264	408			2180	40.0
400	268	424			2320	41.2
600	272	441			2470	42.4
800	276	458			2580	43.6
14 000	280	476			2730	44.9

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TABLES OF HEIGHTS OF TRAJECTORIES

In meters above the horizon of the cannon bore axis, and the maximum ordinates of armor piercing tracer BR-365 and BR-365K projectiles

Range in meters	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	Maximum Ordinate
200	0	-0.70										0.2
400	.35	0	-1									0.5
600	.7	.7	0	-1.4								0.9
800	1.1	1.4	1	0	-1.7							1.5
1000	1.4	2.1	2.1	1.4	0	-2.1						2.3
1200	1.7	2.8	3.1	2.8	1.7	0	-2.4					3.3
1400	2.1	3.5	4.2	4.2	3.5	2.1	0	-3.2				4.6
1600	2.5	4.3	5.4	5.8	5.5	4.5	2.8	0	-3.7			6.2
1800	2.9	5.1	6.6	7.4	7.6	7.0	5.7	3.3	0	-4.1		8.0
2000	3.3	5.9	7.9	9.1	9.6	9.4	8.5	6.5	3.7	0	-5.1	10
2200	3.8	6.9	9.3	11	12	12	12	10	7.9	4.7	0	12

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MEAN DEVIATIONS

(in meters)

Range in Meters	Range Probable Error	Vertical Probable Error	Deflection Probable Error
XXXX	XXX	XXX	XXX
500	34	0.1	0.1
1000	32	0.3	0.3
1500	30	0.4	0.4
2000	29	0.6	0.6
2500	27	0.8	0.8
3000	25	0.9	0.9
	0-365K Fragmentation Shell with KTM-1 Fuze		
1000	24	0.2	0.4
2000	24	0.5	0.7
3000	25	1.0	1.0
4000	27	1.8	1.3
5000	29	3.0	1.6
6000	32	4.7	1.9
7000	36	7.0	2.2
8000	41	11	2.6
9000	47	16	3.1
10000	53	23	3.8
11000	59	33	4.6
12000	66	45	5.6
13000	72	60	6.8
14000	79	81	8.4

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MEAN DEVIATIONS

Range in Meters	In Percussion Fire			In Timed Fire	
	Range Probable error	Vertical Probable Error	Deflection Probable Error	Height of Burst Probable error	Range Probable Error (time fire)
1000	32	0.3	0.3	0.6	24
2000	29	0.6	0.6	1.3	22
3000	26	1.0	0.9	2.0	21
4000	24	1.6	1.2	2.7	21
5000	23	2.4	1.5	3.6	21
6000	24	3.7	1.8	4.7	23
7000	26	5.5	2.2	7.0	25
8000	28	7.9	2.6	11	28
9000	30	11	3.1	16	31

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Instructions for firing 85 mm subcaliber armor piercing tracer shells, BR 365P (In ground fire)	14
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GENERAL HEADQUARTERS
FAR EAST COMMAND
TRANSLATOR AND INTERPRETER SERVICE
8238TH ARMY UNIT
Central Interrogation Center

APO 500
18 October 1951

SUMMARY OF INFORMATION:

SUBJECT: Rocket Launchers

EXTRACT FIELD RPT 3D DIV NO 418 DTD 7 OCT 51

7. ROCKETS:

On 27 Sep 51, both PsW observed four (4) camouflaged trucks laden with rocket launching equipment at Changdong-ni (CT 303442). The vehicles were moving Northward.

PsW described the equipment as similar to the M-13 132mm rocket launcher, except these launchers had 12 rails, rather than eight. Hearsay was that the rockets for the launchers weigh 80 lbs and that the range was 8km; furthermore the launchers had not yet been used in Korea.

PsW gave the following fragmentary organization for a division employing launchers and rockets as its principle weapon:

a. Division .....3 Regts

b. Regiments .....3 Bns

c. Battalions.....3 Cos

d. Company .....3 Pltns

e. Platoon .....3 Sqds

A division of this sort was reputed to be in Korea. PsW heard that its present equipment included only four launchers.

C.J.W.

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DID NO. _____ RESTRICTED CLASSIFICATION COUNTRY USSR
IHG NO. _____
REPORT NO. ORD OIN 3708 WDGS—INTELLIGENCE REPORT I. D. NO. 856857
SUBJECT: SHORT FIRING TABLES for SOVIET GUN, 85mm Antiaircraft, Model 1939
FROM: OCoFORD REFERENCES: APG FT-F-85-1
EVALUATION: A-1 DATE OF INFORMATION: October 1951 DATE OF REPORT: October 1951
INCL 12 PREPARED BY: Ord. Intel, Ord Corps, Dept/Army SOURCE: Original Document

SUMMARY OR SID REPORT:

SHORT FIRING TABLES for SOVIET GUN, 85mm Antiaircraft, Model 1939. For use in the ground firing of Armor-piercing, Tracer Shell -365 with -5 Fuze; Fragmentation Long Range Shell O-365M, with -2 Fuze; Fragmentation Long Range Shell O-365, with T-5 Fuze.

These tables are a translation of the original Soviet firing tables, however the data has not been check by U.S. Army Ordnance Corps firing tests.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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BID NO.
MIG NO.
RESTRICTED CLASSIFICATION
COUNTRY USSR
REPORT NO. ORD OIN 3478
WDGS--INTELLIGENCE REPORT
I.D. NO. 856862
SUBJECT: Exam. of Unfired 85mm APHE-T Comp Rd of Soviet Ammo. MOD UBR 365K
FROM: OCofORD
REFERENCES: Pic Report (ORD OIN 3478)
EVALUATION: A-1
DATE OF INFORMATION: Feb 51
DATE OF REPORT: 18 Oct 51
INCL. 12
PREPARED BY: Ord Corps, Dept/Army
SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

This report concerns one loaded and fuzed complete round of Soviet 85mm, APHE-T, Ammunition/Mach Subjected to technical examination. The complete round consists of a base-fuzed, uncapped, armor-piercing projectile, with tracer, assembled in a primed brass cartridge case. The projectile is loaded with a high explosive bursting charge. The cartridge case contains a coil of soft lead wire, two closing cups, a cylindrical distance wad, a short percussion primer, and propellent powder packed loosely in a bag. The bag has a quilted section on the bottom containing a loose black powder igniter charge.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C. 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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BID NO.
MIG NO.
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COUNTRY USSR
REPORT NO. ORD OIN 3477
WDGS--INTELLIGENCE REPORT
I. D. NO. 856859
SUBJECT Unfired Round without Fuze, 76mm, HE, Soviet) Mod UO-361D, FMAM-2270
FROM: OCofORD
REFERENCES: Pic Report (ORD OIN 3477)
EVALUATION: A-1
DATE OF INFORMATION: 17 Oct 51
DATE OF REPORT: 17 Oct 51
INCL 12
PREPARED BY: Ord Corps, Dept/Army
SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

This report concerns the examination of subject ammunition which was captured in Korea. A Photo and a Drawing of subject ammo. are included.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.
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BID NO.
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REPORT NO. ORD OIN 3503

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COUNTRY USSR

WDGS—INTELLIGENCE REPORT

I. D. NO. 856861

SUBJECT: Exam. of Unfired 45mm APHE-T Comp Rd of Soviet Ammo. MOD.UBR 243Z (FMAM-1121)

FROM: OCofOR) REFERENCES: Pic Report (ORD OIN 3503)

EVALUATION: A-1 DATE OF INFORMATION: Feb 51 DATE OF REPORT: 28 Sep 51

INCL. 12 PREPARED BY: Ord Corps, Dept/Army SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

This report concerns one loaded complete round of Soviet 45 mm APHE-T Ammunition Mod UBR 243Z which was examined. The Complete round consists of a base fuzed, capped, armorpiercing projectile, assembled in a primed brass cartridge case. Photographs and drawings are included in the Report.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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COUNTRY USSR
WDGS—INTELLIGENCE REPORT
I. D. NO. 856858

SUBJECT: SOVIET ARTILLERY AMMUNITION MARKINGS
FROM: OCofOrd REFERENCES: APC ST-F-9-1900-1
EVALUATION: A-1 DATE OF INFORMATION: September 1951 DATE OF REPORT: Sep 1951
INCL. 12 PREPARED BY: Ord Intel, Ord Corps, Dept/Army SOURCE:

SUMMARY OR SID REPORT:

This Pamphlet contains a brief description of the system used within the Soviet Army to mark artillery ammunition for identification purposes.

NOTE. This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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25 June 1951 1951

SUBJECT: Soviet Armament in Korea

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SUMMARY OF INFORMATION

DATE 3511 4

PREPARING OFFICE JT/ky 12 June 51

SUBJECT Seventh District

SOVIET ARMAMENT IN KOREA

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OF SOURCE:		OF INFORMATION:	
COMPLETELY RELIABLE	A	CONFIRMED BY OTHER SOURCES	1
USUALLY RELIABLE	B	PROBABLY TRUE	2
FAIRLY RELIABLE	C	POSSIBLY TRUE	3
NOT USUALLY RELIABLE	D	DOUBTFULLY TRUE	4
UNRELIABLE	E	IMPROBABLE	5
RELIABILITY UNKNOWN	F	TRUTH CANNOT BE JUDGED	6

SUMMARY OF INFORMATION

On 30 May 51, a conference was held at the home of Ito, Yuji (1). Those present at this conference were Jin, Akira (2), Shimodaira, Nagao (3), and Yoshino, Matsuo (4). The gist of a statement made by Yoshino during the conference follows:

He was well acquainted with a Russian from the Soviet Embassy, and had frequent visits with this Russian. During his meetings with this Russian, Yoshino is usually asked about US planes in Japan. He did not state exactly that specific information was asked for by the Russian.

Yoshino further stated that he was told by the Russian that the American F-86 and the MIG were almost the same in performance, but that the Russians had a far superior plane than the MIG. This plane will be used at a later date in Korea when the Russians have produced a still better plane. The Russian further stated that the Russians had tested a guided missile in Korea and had succeeded in downing a US plane at an altitude of 12,000 ft.

(B-6)

SOURCE:
Confidential Informant A-997

LEGEND: (1) Ito, Yuji (伊藤勇治)(Japanese)(U), 3-1, Nishi Shibaura, Minato-ku, Tokyo-to.

(2) Jin, Akira (神 彰)(Japanese)(U), former newspaperman in Manchuria, and presently employed at the Pao San Hon Co., Tokyo office.

(3) Shimodaira, Nagao (下平永男)(Japanese)(U), former newspaperman in Manchuria, presently working for the Soviet Press located on the 4th floor of the Shinbashi Building.

(4) Yoshino, Matsuo (吉野松夫)(Japanese)(S-CP), formerly with the Japanese Tokumu Kikan in Sanga, Manchuria; presently employed by the Soviet Press.

JUN 18 1951

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MIG NO.

COUNTRY USSR

REPORT NO. ORD OIN 2471 WDGS — INTELLIGENCE REPORT I. D. NO. 804756

SUBJECT: Soviet Gun, Submachine, 7.62-MM, Model 1941 PPSh 31363

FROM: OCofORD REFERENCES: APG Report (ORD OIN 2471)

EVALUATION: A-1 DATE OF INFORMATION: ----- DATE OF REPORT: Undtd

INCL. 12 PREPARED BY: Ordnance Corps, Dept/Army SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

The report consists of a brief description, diagram of parts of the subject gun. Report also contains diagram of firing positions, gun in cocked position, & partial breakdown of magazine for purposes of filling with ammunition.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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OIN - 2471 804756

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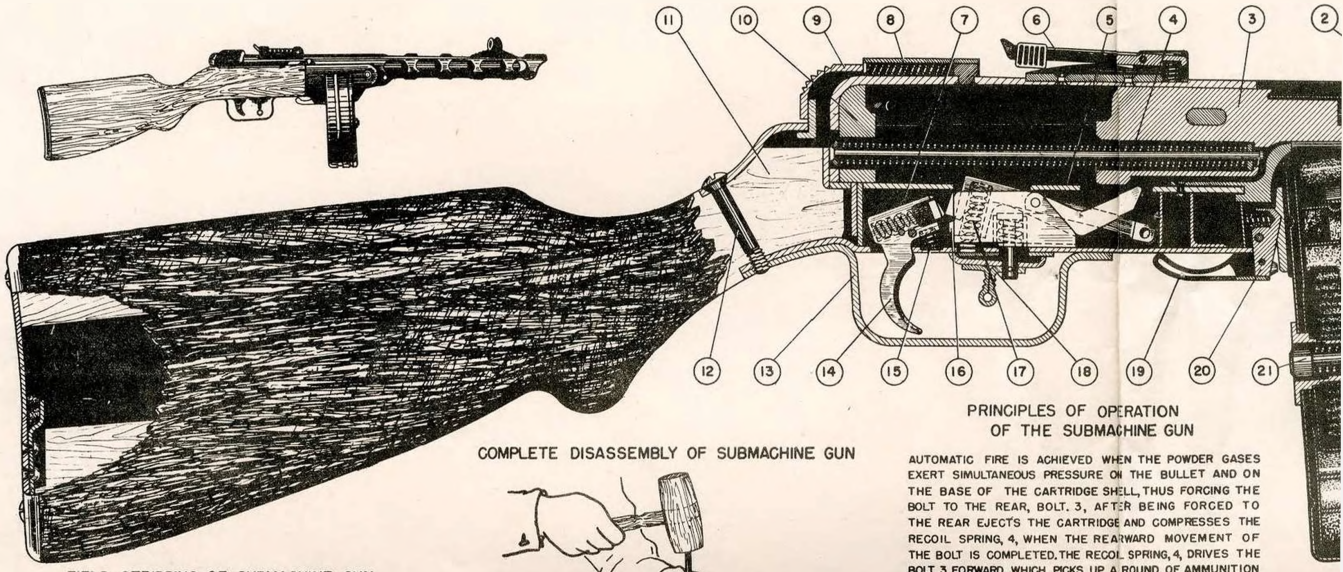
GUN, SUBMACHINE, 7.62-MM, MOD

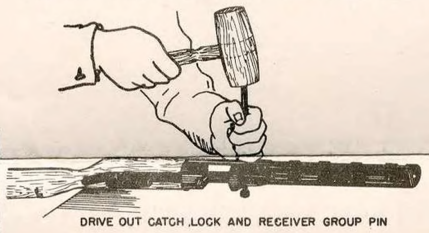


PRINCIPLES OF OPERATION OF THE SUBMACHINE GUN

AUTOMATIC FIRE IS ACHIEVED WHEN THE POWDER GASES EXERT SIMULTANEOUS PRESSURE ON THE BULLET AND ON THE BASE OF THE CARTRIDGE SHELL, THUS FORCING THE BOLT TO THE REAR, BOLT. 3, AFTER BEING FORCED TO THE REAR EJECTS THE CARTRIDGE AND COMPRESSES THE RECOIL SPRING, 4, WHEN THE REARWARD MOVEMENT OF THE BOLT IS COMPLETED, THE RECOIL SPRING, 4, DRIVES THE BOLT 3 FORWARD WHICH PICKS UP A ROUND OF AMMUNITION FROM THE MAGAZINE 22, SEATS IT IN THE CHAMBER AND FIRES.

THIS IS THE PRINCIPLE OF THE OPERATION OF THE SUBMACHINE GUN. THE CHANGE LEVER (18) IS PULLED TO THE REAR FOR SEMIAUTOMATIC FIRE. DURING AUTOMATIC FIRE IT IS MOVED FORWARD.

COMPLETE DISASSEMBLY OF SUBMACHINE GUN



DRIVE OUT CATCH ,LOCK AND RECEIVER GROUP PIN

FIELD STRIPPING OF SUBMACHINE GUN



REMOVE MAGAZINE



DISENGAGE RECEIVER GROUP AND BARREL ASSEMBLY



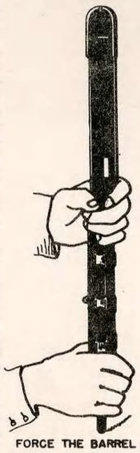
SEPARATION OF RECEIVER GROUP AND BARREL



REMOVE REAR GUARD SCREW



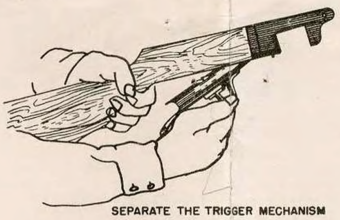
TILT RECEIVER GROUP



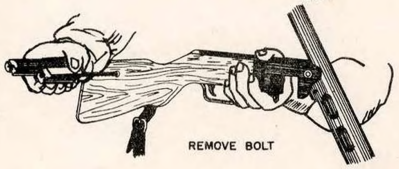
FORCE THE BARREL OUT



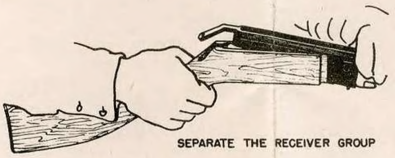
SEPARATION OF BARREL FROM RECEIVER GROUP



SEPARATE THE TRIGGER MECHANISM



REMOVE BOLT

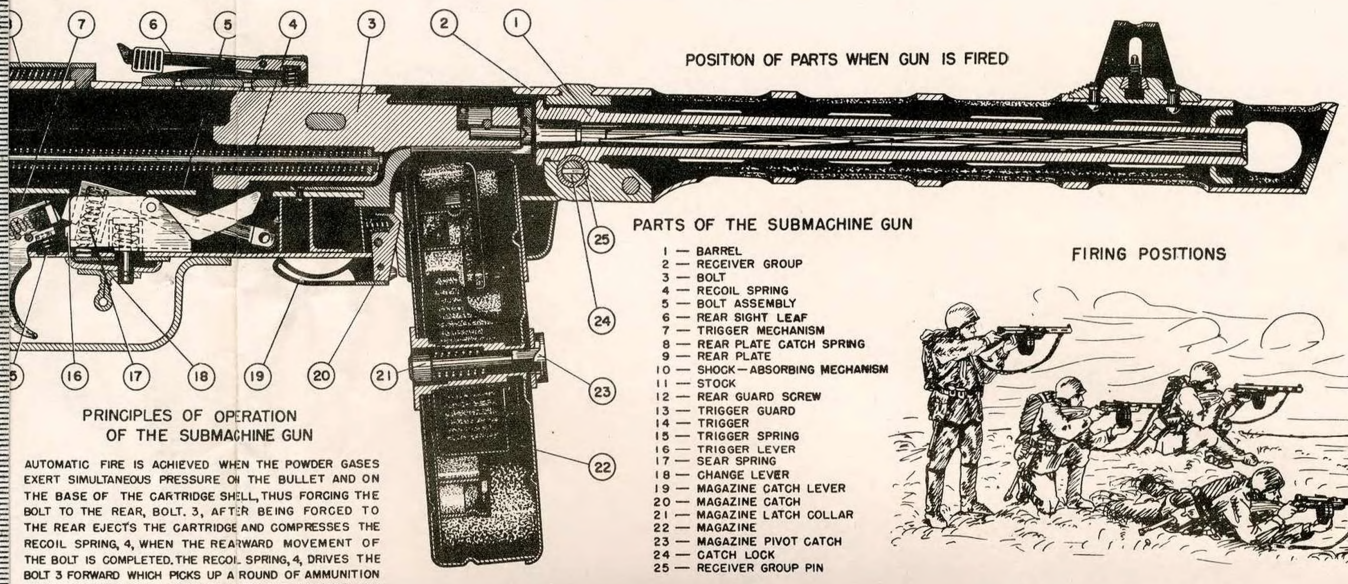


SEPARATE THE RECEIVER GROUP

DECLASSIFIED
Authority NND 851506

4756 RESTRICTED

SOVIET
CHINE, 7.62-MM, MODEL 1941 PPSh



POSITION OF PARTS WHEN GUN IS FIRED

PARTS OF THE SUBMACHINE GUN

1 — BARREL
2 — RECEIVER GROUP
3 — BOLT
4 — RECOIL SPRING
5 — BOLT ASSEMBLY
6 — REAR SIGHT LEAF
7 — TRIGGER MECHANISM
8 — REAR PLATE CATCH SPRING
9 — REAR PLATE
10 — SHOCK—ABSORBING MECHANISM
11 — STOCK
12 — REAR GUARD SCREW
13 — TRIGGER GUARD
14 — TRIGGER
15 — TRIGGER SPRING
16 — TRIGGER LEVER
17 — SEAR SPRING
18 — CHANGE LEVER
19 — MAGAZINE CATCH LEVER
20 — MAGAZINE CATCH
21 — MAGAZINE LATCH COLLAR
22 — MAGAZINE
23 — MAGAZINE PIVOT CATCH
24 — CATCH LOCK
25 — RECEIVER GROUP PIN

FIRING POSITIONS

PRINCIPLES OF OPERATION OF THE SUBMACHINE GUN

AUTOMATIC FIRE IS ACHIEVED WHEN THE POWDER GASES EXERT SIMULTANEOUS PRESSURE ON THE BULLET AND ON THE BASE OF THE CARTRIDGE SHELL, THUS FORCING THE BOLT TO THE REAR, BOLT. 3, AFTER BEING FORCED TO THE REAR EJECTS THE CARTRIDGE AND COMPRESSES THE RECOIL SPRING, 4, WHEN THE REARWARD MOVEMENT OF THE BOLT IS COMPLETED. THE RECOIL SPRING, 4, DRIVES THE BOLT 3 FORWARD WHICH PICKS UP A ROUND OF AMMUNITION FROM THE MAGAZINE 22, SEATS IT IN THE CHAMBER AND FIRES.

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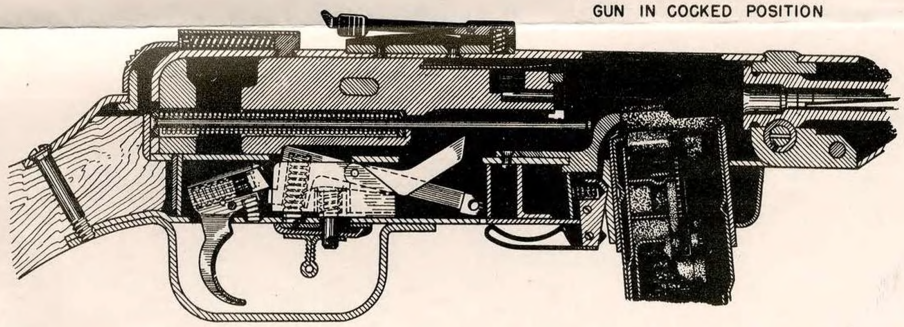
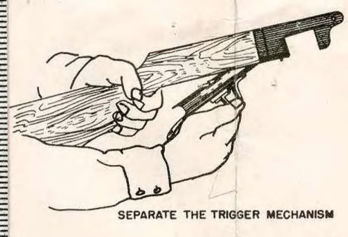
GUN IN COCKED POSITION

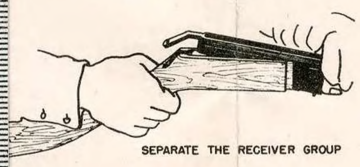




REMOVE REAR GUARD SCREW

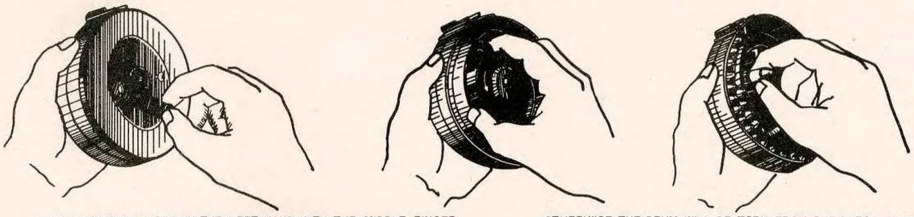


SEPARATE THE TRIGGER MECHANISM



SEPARATE THE RECEIVER GROUP

PARTIAL BREAKDOWN OF MAGAZINE FOR PURPOSES OF FILLING WITH AMMUNITION.



1. HOLD THE MAGAZINE IN THE LEFT HAND, WITH THE MIDDLE FINGER PRESS THE LATCH OF THE DRUM UP AS FAR AS POSSIBLE, WITH THE THUMB OF THE RIGHT HAND TURN THE LATCH OF THE COVER APPROXIMATELY AT AN ANGLE OF 90°.
2. REMOVE THE COVER
3. WIND THE MAGAZINE SPRING. HOLD THE MAGAZINE IN THE LEFT HAND AND WITH THE FINGERS OF THE RIGHT HAND GRASP THE RIDGES OF THE DRUM TURNING IT COUNTER CLOCKWISE. THE MAGAZINE DRUM MUST BE TURNED TWICE, THERE SHOULD BE EIGHT CLICKS. WATCH THAT ON THE FIRST TURN OF THE DRUM THE FEEDER SLIDES ALONG THE INNER GROOVE OF SPIRAL. BE CAREFUL! DO NOT RELEASE THE DRUM UNTIL THERE IS A CLICK DO NOT PRESS DOWN ON THE LATCH OF THE DRUM. OTHERWISE THE DRUM WILL BE TORN FROM THE LATCH, UNWIND WITH FORCE, INJURE THE FINGERS OF THE RIGHT HAND AND CAUSE DAMAGE TO THE MAGAZINE.
4. PLACE 71 TO 72 ROUNDS OF AMMUNITION IN THE MAGAZINE. THE ROUNDS ARE PLACED VERTICALLY (BULLETS FACING THE COVER) IN BOTH GROOVES OF THE SPIRAL.
5. AFTER FULLY LOADING THE MAGAZINE WITH AMMO, TURN THE DRUM COUNTER CLOCKWISE WITH RIGHT HAND AND, PRESSING ON THE LATCH OF THE DRUM WITH THE MIDDLE FINGER OF THE LEFT HAND, RELEASE THE DRUM.
6. SLIP ON THE MAGAZINE COVER, PRESS THE DRUM LATCH UP AS FAR AS POSSIBLE AND CLOSE IT WITH THE LOCK

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51660 T/1 FEC-2

DID NO.
MG NO.

SECRET

COUNTRY USSR-Czechoslovakia

REPORT NO. SR-208-51 WDGS — INTELLIGENCE REPORT I. D. NO. 822130

SUBJECT: Soviet Antitank Mine Patterns

FROM: SS Team Paris REFERENCES: NIS VII 70; VIII 81 J 1; SR-155-51

EVALUATION: B-3 DATE OF INFORMATION: 1950-1951 DATE OF REPORT: 5 July 51

INCL. 3 PREPARED BY: Captain Jack D. Reid, GSC SOURCE: Colonel Pejsa

SUMMARY OR SID REPORT:

Inclosures One, Two and Three to this report are purported to be sketches of present Antitank Mine laying technique employed at the present time in the USSR and the CSR by Soviet and Czech engineer troops. The information was obtained through Colonel PEJSA, a source of this office (See SR-155-51).

Colonel Pejsa received the sketches from Lieutenant KYSEL, a Czechoslovakian engineer officer who recently defected from the CSR. Kysel is reported to have been in charge of an antitank mine laying company in Bohemia prior to his defection. According to Kysel the mine laying patterns depicted in the inclosures have been employed since 1950 by the Soviet and Czech armies. It would, consequently, be interesting to learn if anything resembling these techniques are employed against UN troops in Korea.

Distribution by originator: NA-Paris AirA-Paris EUCOM USFA ArmA-Praha ArmA-Moscow

3 Incls:
a/s

APPROVED:

J. J. O'HARE
Brigadier General, GSC
Army Attache

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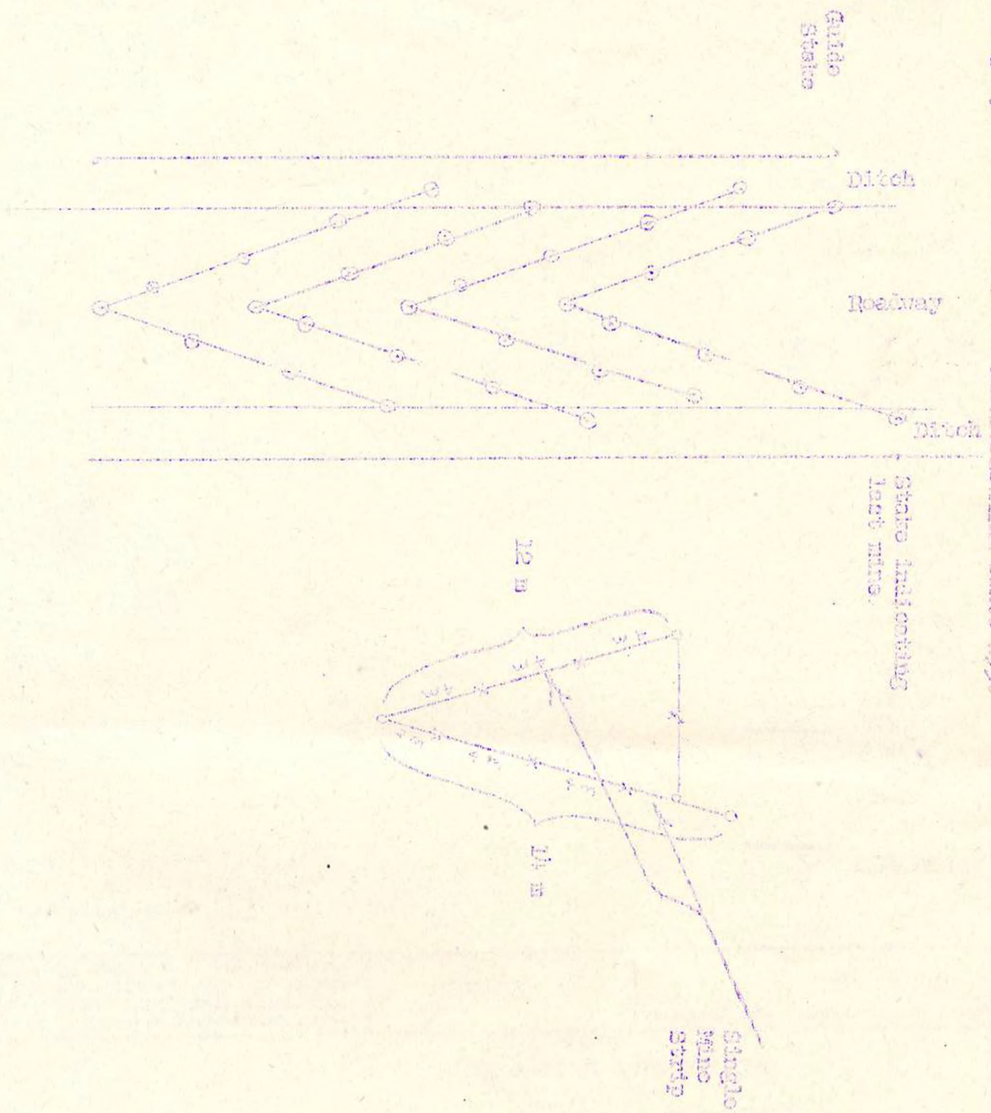
TYPICAL ANTITANK MINE PATTERN FOR A ROAD OR HIGHWAY

Employed in the USSR and CZECHOSLOVAKIA since 1950



INCL 1 TO SR-208-51 SS TEAM PARIS

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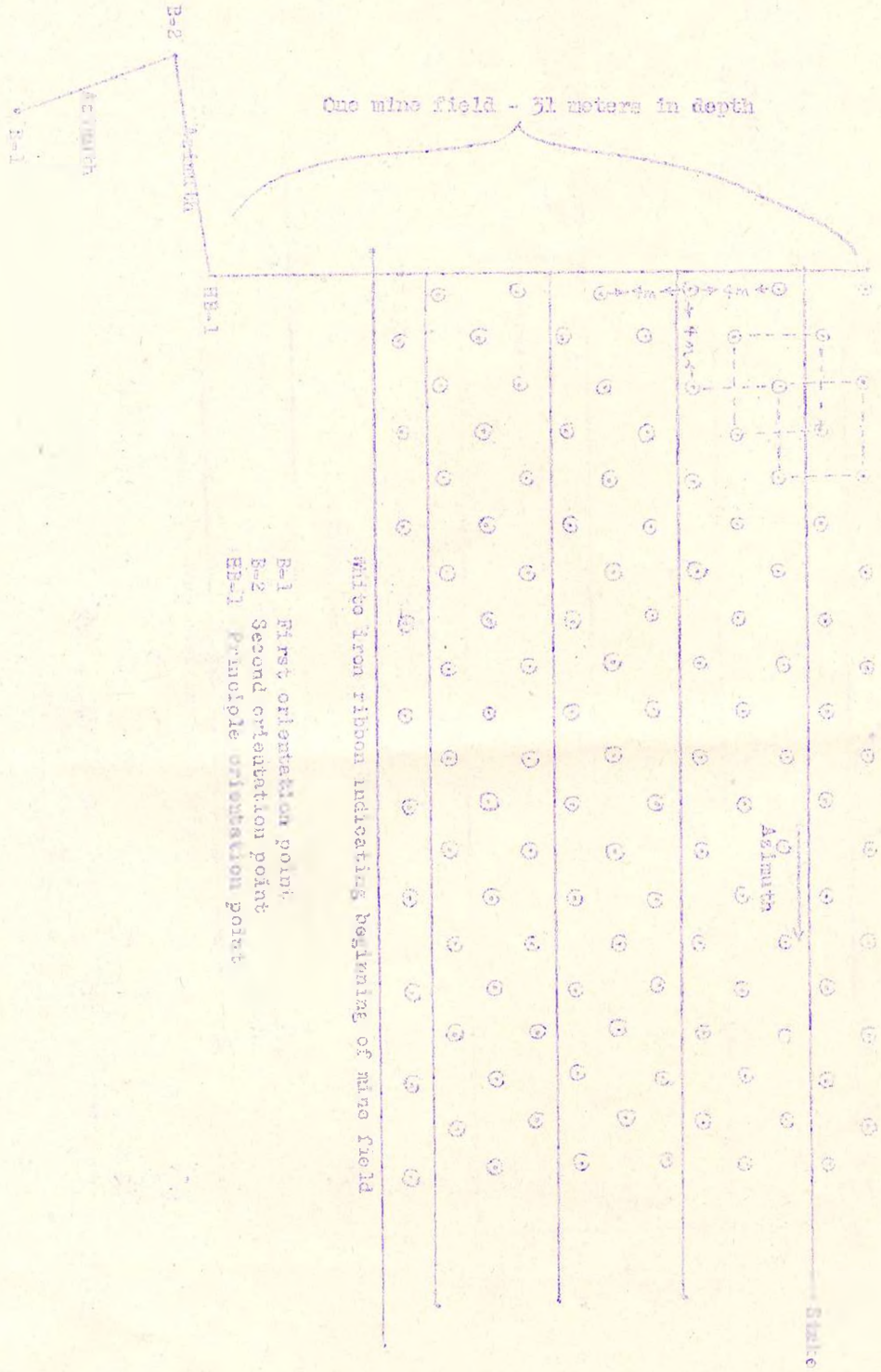
TYPICAL ANTITANK FIELD EMPLOYED IN THE USSR AND (Since 1951) IN CZECHOSLOVAKIA



INCL 2 TO SR-208-51 SS TEAM PARIS

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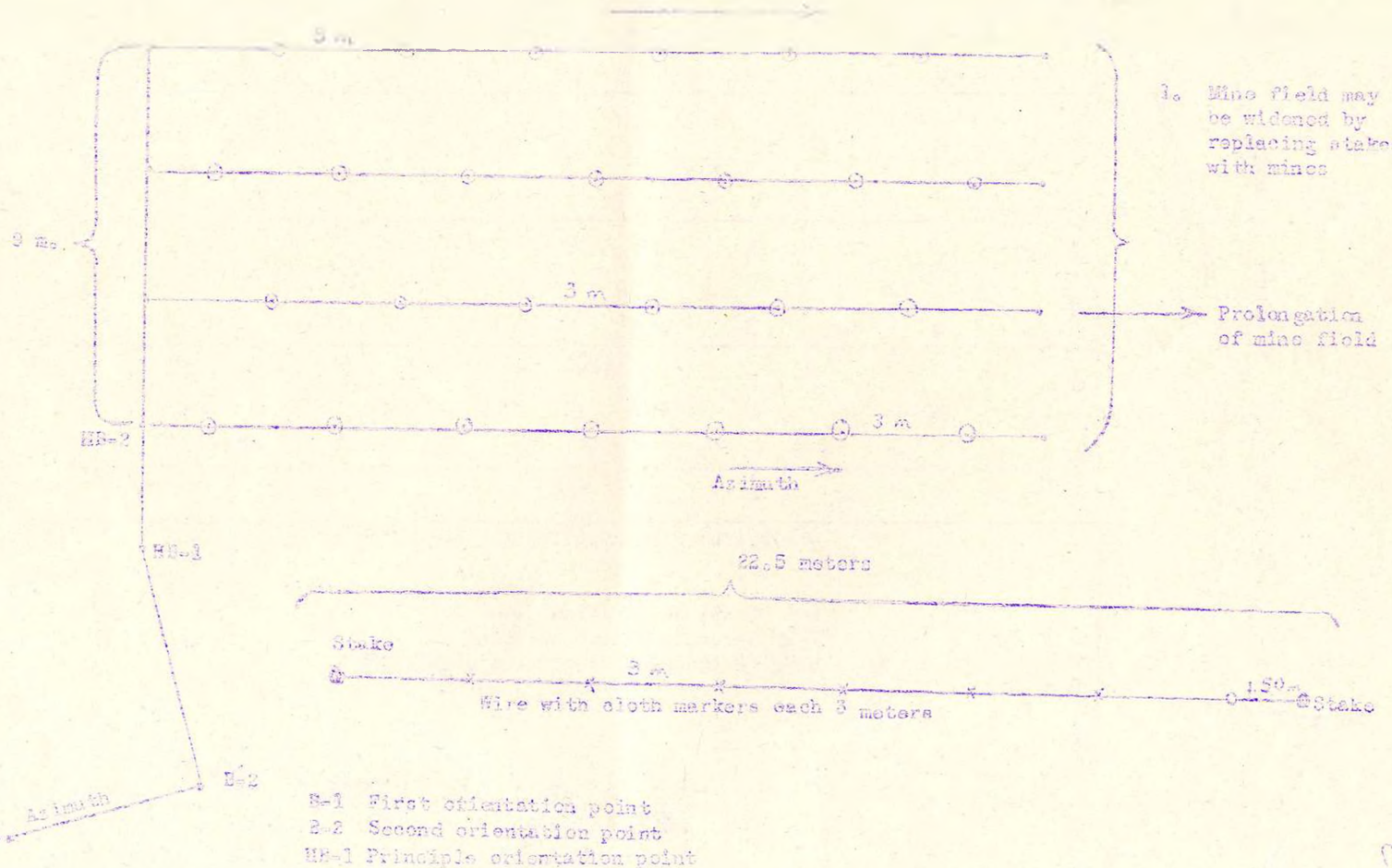
REPORT NO. SR-208-51
PAGE NO. Incl. 3 to report

SECRET

SCHEMATIC DRAWING FOR RAPID ANTITANK MINE LAYING USED IN THE USSR AND CZECHOSLOVAKIA SINCE 1950



INCL 3 TO SR-208-51 SS TEAM PARIS

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Authority NND851506

44885 T1 / FECOM

BID NO.
MIG NO.
REPORT NO. ORD OIN 2842
CONFIDENTIAL
WDGS – INTELLIGENCE REPORT
COUNTRY USSR Including Satellite Countries & Nationalist China
I. D. NO. Nationalist China
SUBJECT: 2nd SUPPLEMENT to May Photo Index Soviet Materiel Including Satellite Items & /
FROM: OCofORD
REFERENCES: APG Report (ORD OIN 2842)
EVALUATION: A-1
DATE OF INFORMATION: 1 July 1951
DATE OF REPORT: 1 July 1951
INCL. 12
PREPARED BY: Ordnance Corps, Dept/Army
SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

817847

2nd SUPPLEMENT to May Photo Index, Soviet Materiel Including Satellite Items and Nationalist China. The index includes: Artillery, & Ammunition.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.
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2nd SUPPLEMENT
to
May Photo Index

SOVIET MATERIEL

817847

Including Satellite Items and Nationalist China

1 July 1951

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ARTILLERY--Code FMAR

620 BAYONET: Rifle, Mosin Nagant, Model 1891 & 1891/30, Soviet
A68841 Full view, new type
A68842 Full view, old type

1414 GUN: A/T, 45mm, Model 1942 w/carriage, Soviet
A68959 3/4 rear view

1433 C BASE PLATE: Mortar, 82mm, Model unidentified, Chinese
A68963 Top & bottom view

1432 B BIPOD: Mortar, 82mm, Model 20, Chinese
A68960 Markings on bipod plate
A68961 Full view

1433 A TUBE: Mortar, 82mm, Chinese (Model unidentified)
A68962 Markings on base cap
A68964 Full view

AMMUNITION--Code FMAM

2262 C/R: 20mm, HE, Type OZT for A/C Cannon, Soviet
A68501 Full view
2262 C/R: 23mm, API, Type BZ for A/C Cannon, Soviet
A68503 Full view
2263 C/R: 23mm, Type OZT for A/C Cannon, HE, Soviet
A68502 Full view
2274 C/R: 45mm, AP-T, Model UBR-243, Soviet
A68603 Full view
2269 C/R: 57mm, HE, Model UO-271CH, Soviet
A68609 Full view
2267 C/R: 76.2mm, AP-T, Model UBR-354B, Soviet
A68607 Full view
2273 C/R: 76.2mm, HE, Model unidentified w/KTM-1 fuze, Soviet
A68602 Full view
2265 C/R: 76.2mm, HE, Model UO-353AM w/KTM-1 Fuze, Soviet
A68604 Full view
2266 C/R: 76.2mm, HE, Model UOF-354M w/KTM-1 Fuze, Soviet
A68605 Full view
2270 C/R: 76.2mm, HE, Model UO-361D w/o Fuze, Soviet
A68610 Full view
2268 C/R: 76.2mm, HEAT, Model UBP-353M, Soviet
A68608 Full view
2175 C/R: 85mm, AP-T, Model UBR-365K, Soviet
A68599 Full view
A68593 Sectionalized projectile
2261 C/R: 85mm, HE, Model UO-365 w/T-s Fuze, Soviet
A68596 Full view
A68594 Sectionalized projectile

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Ammunition con't.

2174 C/R: 85mm, HE, Model UO-365K w/KTM-1 Fuze, Soviet
A68597 Full view
A68592 Sectionalized projectile

2176 C/R: 85mm, HVAP-T, Model UBR-365P, Soviet
A68598 Full view

2276 SHELL: Mortar, 60mm, Model Unidentified, Chinese & U.S. Markings
A68600 Full view

2277 SHELL: Mortar, 82mm, Model Unidentified, Chinese & U.S. Markings
A68601 Full view

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BID NO.	CONFIDENTIAL	COUNTRY USSR Including Satellite Countries & Others
MIG NO.		
REPORT NO. ORD OIN 2475	WDGS — INTELLIGENCE REPORT	L.D. NO. OPS 10658

27592

SUBJECT: INVENTORY - USSR Items - Including Satellite Countries and Others - 1 May 1951
FROM: CC of ORD REFERENCES: APG Report (ORD OIN 2475)
EVALUATION: A-1 DATE OF INFORMATION: 1 May 1951 DATE OF REPORT: 1 May 1951
INCL. 12 PREPARED BY: Ordnance Corps, Dept/Army SOURCE: Captured Materiel

SUMMARY OR SID REPORT:

787842

The inclosed Inventory (11 pgs) consists of the following items:

AMMUNITION	Page 6
ARTILLERY	Page 2
AUTOMOTIVE	Page 3
FIRE CONTROL	Page 4
MISCELLANEOUS	Page 5
OTHER COUNTRIES	Page 11
SATELLITE COUNTRIES	Page 9
SMALL ARMS	Page 1

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INVENTORY

U.S.S.R. ITEMS

Including Satellite Countries

And Others

1 May 1951

787842

AMMUNITION	Page 6
ARTILLERY	Page 2
AUTOMOTIVE	Page 3
FIRE CONTROL	Page 4
MISCELLANEOUS	Page 5
OTHER COUNTRIES	Page 11
SATELLITE COUNTRIES	Page 9
SMALL ARMS	Page 1

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SMALL ARMS and ACCESSORIES--Code FMAR			KOREA		WW II		TOTAL	
			S	U	S	U	S	U
1192	CARBINE:	7.62mm, Model 1910				1		1
616	CARBINE:	7.62mm, Model 1938, Moisin Nagant (See Note K)	1		1		2	
1276	CARBINE:	7.62mm, Model 1944, Moisin Nagant w/folding Bayonet (See Note D)	2		1		3	
1392	GUN:	Machine, A/C, 7.62mm, Degtyarov	1				1	
1421	GUN:	Machine, A/C, Fixed, 7.62mm, SHKAS, electric fired		1				1
227	GUN:	Machine, A/C, Flexible, 7.62mm, SHKAS				2		2
1405	GUN:	Machine, A/C, Fixed, 12.7mm, Model UB	1				1	
7	GUN:	Light Machine, 7.62mm, Model DP, Degtyarov (See D)	8	1	1	1	9	2
621	GUN:	Light Machine, 7.62mm, Model DP w/stock DT, Degtyarov				1		1
1406	GUN:	Light Machine, 7.62mm, Model DPM w/stock DT, Degtyarov	1				1	
1296	GUN:	Heavy Machine, 7.62mm, Model 1910 Maxim, (Bronze)				1		1
749	GUN:	Heavy Machine, 7.62mm, Model 1910 Maxim	2		1		3	
1393	GUN:	Heavy Machine, 7.62mm, Model 1910 Maxim, Modified Water Jacket	6				6	
1060	GUN:	Heavy Machine, 7.62mm, Model 1939			1		1	
1394	GUN:	Heavy Machine, 7.62mm, Model 1943, Goryunov	1				1	
1054	GUN:	Heavy Machine, 12.7mm, Model 1938 DSHK, Degtyarov (See H)	4			1	4	1
407	GUN:	Machine, Tank, Model DT, Degtyarov	1	2	2		3	2
1395	GUN:	Machine, Tank, 7.62mm, Model DTM, Degtyarov	4	2			4	2
1235	GUN:	Sub-Machine, 7.62mm, Model 1934/38			1		1	
1042	GUN:	Sub-Machine, 7.62mm, Model PPD-1940			1		1	
941	GUN:	Sub-Machine, 7.62mm, Model PPD-1940 Degtyarov			2		2	
484	GUN:	Sub-Machine, 7.62mm, Model PPSH-1941 Shpagin	5	1	4	2	9	3
1409	GUN:	Sub-Machine, 7.62mm, Model PPS-1943, Sudarev	3				3	
533	GUN:	Sub-Machine, 7.62mm, Exp., Mf'd 1942, Standardized 43			1		1	
1135	GUN:	Sub-Machine, 9mm, Copy of British Sten			1		1	
1166	PISTOL:	Automatic, 7.62mm, Model TT-1933, Tokarev Manufactured 1941	2		2		4	
1362	RIFLE:	Cal. .22	1		1		2	
726	RIFLE:	7.62mm, Model 1891, Moisin Nagant (See K)				2		2
726A	RIFLE:	7.62mm, Model 1891, Moisin Nagant, converted to single shot, used by Chinese	1				1	
910	RIFLE:	7.62mm, Model 1891, Moisin Nagant, Mf'd by Swiss			1	1	1	1
613	RIFLE:	7.62mm, Model 1891/30, Moisin Nagant (See D & K)	3		2	1	5	1
615	RIFLE:	7.62mm, Model 1891/30, Moisin Nagant, Old Type			1		1	
916	RIFLE:	7.62mm, Model 1895, Moisin Nagant, Czarist Rifle			1		1	
577	RIFLE:	7.62mm, Semi-Full Automatic, AVT-1940 Tokarev			1		1	
671	RIFLE:	7.62mm, Semi-Full Automatic, AVS-1936 Seminov(See K)				1		1
610	RIFLE:	7.62mm, Semi-Automatic, SVT-1938 Tokarev			1		1	

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Small Arms con't			KOREA		WW II		TOTAL	
			S	U	S	U	S	U
629	RIFLE:	7.62mm, Semi-Automatic, SVT-1940 Tokarev			2		2	
783	RIFLE:	7.62mm, Semi-Automatic, SVT 1940 Tokarev w/six port muzzle brake (See K)			8	3	8	3
618	RIFLE:	7.62mm, Snipers, Model 1891/30 Moisin Nagant			1		1	
914	RIFLE:	10.6mm Berdan, Single Shot, Mf'd 1879						1
933	RIFLE:	10.6mm, Berdan						1
875	RIFLE:	10.8mm, Berdan, Single Shot, Mf'd at Colt's Firearms Mfg. Co.						1
894	RIFLE:	11.15mm, Model 1867, Berdan, Single Shot						1
1058	RIFLE:	A/T, 14.5mm, PTRD-1941 Degtyarov	5		1		6	
1053	RIFLE:	A/T, 14.5mm, PTRS-1941 Seminov (See D)	3	1	1	1	4	2
1205	REVOLVER:	Service, Cal. .22, Model 1898 Nagant			1		1	
414	REVOLVER:	Service, 7.62mm, Model 1895 Nagant, Mf'd in Liege			1		1	
ACCESSORIES, Etc.								
407 B	BARREL:	Spare for 7.62mm Tank Machine Gun, Old Type	2				2	
484 B	BARREL:	Spare for 7.62mm Model PPSH-1941 Sub-machine Gun	2				2	
620	BAYONET:	Moisin Nagant Rifle	2		3		5	
1338	BAYONET:	Model 1938 & 1940 Tokarev Rifles			1		1	
619	BAYONET:	Model 1940 Tokarev Rifle			1		1	
484 C	JACKET:	Barrel for 7.62mm Model PPSH-1941 Sub-Machine Gun	7				7	
484 G	JACKET:	Barrel, Development Group for 7.62mm Model PPSH 1941 Sub-Machine Gun		1				1
1395 A	MECHANISM:	Trigger, Electric for Model DTM Tank MG	1	1			1	1
1394 C	MOUNT:	Carriage for 7.62mm Model 1943 Goryunov MG	1				1	
749 A	MOUNT:	Carriage for 7.62mm Maxim Machine Gun	3		1		4	
1054 C	MOUNT:	Carriage for 12.7mm Model 1938 DSHK Machine Gun (See H)	3			1	3	1
1075	MOUNT:	Tripod, Ground for Model 1939 Heavy Machine Gun			1		1	
484 A	STOCK:	7.62mm, Model PPSH-1941 Sub-Machine Gun	1				1	
ARTILLERY--Code FMAR								
1261 C	CARRIAGE:	76.2mm Gun, Model 1942 (See G)						
1397 D	CARRIAGE:	Transport for 120mm Mortar, Model 1938 & 1943	2				2	
1261 A	GUN:	76.2mm, Model 1942 (See J)						
246	GUN:	76.2mm, Model 1936 w/carriage				1		1
986	GUN:	76.2mm, Model 1939 w/muzzle brake, w/carriage			1		1	
279	GUN:	76.2mm, Model 1941 w/muzzle brake, w/carriage			1		1	
504	GUN:	122mm, Model 1931/37 w/carriage		2	1		1	2
504 A	GUN:	122mm, Model 1931/37 (See J)						

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Artillery Con't			KOREA		WW II		TOTAL	
			S	U	S	U	S	U
1417	GUN:	A/A, 37mm, Model 1939 w/carriage	5				5	
1400	GUN:	A/A, 85mm, Model 1939 w/carriage	1				1	
1400 A	GUN:	A/A, 85mm, Model 1939		1				1
745	GUN:	A/A, 88mm, Soviet Model 1939 w/carriage (Modified 85mm for use by Germany)		2				2
771	GUN:	A/T, 45mm, Model 1932 w/carriage			1		1	
972	GUN:	A/T, 57mm, Model 1941, ZIS-2 w/carriage				1		1
1399	GUN:	A/T, 57mm, Model 1953 w/carriage	2				2	
1261	GUN:	A/T, 76.2mm, Model 1942 w/carriage	1			2	1	2
1191	GUN:	A/T, 100mm, Model 1944 w/carriage				1		1
503	GUN:	Howitzer, 152mm, Model 1937 w/carriage			1		1	
659	GUN:	Regimental, 76.2mm, Model 1927 w/carriage	3	1	1		4	1
1416	GUN:	Self-Propelled, 76.2mm, Model SU-76		6				6
1403	GUN:	Tank, 85mm, Model 1944 (See J)						
1404	GUN:	Tank, 122mm, Model 1943, From JS II Tank (See J)						
770	HOWITZER:	122mm, Model 1910/30 w/carriage				1		1
968	HOWITZER:	122mm, Model 1938 w/carriage	3		1			4
759	HOWITZER:	152mm, Model 1909/30 w/carriage			1		1	
983	HOWITZER:	152mm, Model 1938, Breech 1934/37, w/carriage				1		1
809	HOWITZER:	203mm, Model 1931 w/tracked carriage				1		1
1102	MORTAR:	50mm, Model 1938			1		1	
1104	MORTAR:	50mm, Model 1940			1		1	
811	MORTAR:	82mm, Model 1937				1		1
1408	MORTAR:	82mm, Model 1937, 1942-43 Version	2				2	
424	MORTAR:	120mm, Model 1938	1			1	1	1
1397	MORTAR:	120mm, Model 1943, Variant II	3				3	
1401	MORTAR:	120mm, Model Unidentified, Short Tube	1				1	
AUTOMOTIVE--Code FMCV								
244	CAR:	Armored, BA-64, 4 x 4, Mounts 7.62mm Tank MG	1				1	
251	CARRIER:	Ammunition, 2 wheel	2				2	
250	ENGINE:	12 cylinder In-Line for 76.2mm SP Gun, SU-76	4				4	
246 B	ENGINE:	12 cylinder, Tank, Diesel for T34/85 Tank	6				6	
245	MOTORCYCLE:	2 cylinder w/side car	1	1			1	1
13	TANK:	Medium, T34 w/76mm Tank Gun (short) Cal. length 30.5			1	1	1	1
246	TANK:	Medium, T34/85		7				7
246 A	TANK:	Medium, T34/85 w/Commanders Turret		1				1
247	TANK:	Medium, T34/85 w/new frontal welding	1	1			1	1
14	TANK:	Heavy, KV-1 w/76mm Tank Gun (short) Cal. length 30.5				1		1

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Automotive Con't		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
246	TRUCK: Cargo, 4 ton, 4 x 2, 6 cylinder, Model ZIS-150		1				1
249	TRUCK: 1/4 ton, 4 x 4, Model 67 B		1				1
252	TRUCK: Cargo, 2 ton, 4 x 2, Model GAZ-51		1				1
	FIRE CONTROL--Code FMFC						
794	ADAPTER: Mortar Sight, 82mm to 120mm	2				2	
802	CIRCLE: Aiming, Model BMT		1				1
785	CIRCLE: Aimimg, Model Unidentified	1	1			1	1
803 B	CRADLE: Heightfinder, Model DIA, 4 meter base	1				1	
789	DIRECTOR: A/A, Model Puazo 3 w/controls & trailer	1	1			1	1
798	DRUM: Range for 122mm Howitzer, Model 1938	2				2	
807	GLASSES: Field, 8 x 40						1
788	HEIGHTFINDER: Model DIA 1, 4 meter base, 24 X	2				2	
790B	LATHE: Adjusting for Rangefinder, 1 meter base, Model ZD	1				1	
670	PERISCOPE: TP 4x			1		1	
307	PERISCOPE: Tank, Model PT4-Z for Heavy KV Tank				1		1
795	QUADRANT: Gunner's	4				4	
790	RANGEFINDER: 1 meter base, Model ZD w/accessories	2				2	
786	SIGHT: Gun, 57mm, ZIS-2	1				1	
784	SIGHT: Gun, Model Unidentified	1				1	
792	SIGHT: Mortar, 50mm, Model PZP (See K)	2				2	
793	SIGHT: Mortar, 82mm, Model PZP	3				3	
799	SIGHT: Mortar, Model MP-41 for 82mm & 120mm Mortar	3				3	
800	SIGHT: Mortar, Model MP-42 for 82mm & 120mm Mortar	10					10
801	SIGHT: Mortar, Model MPB 82/41 for 82mm Mortar	3					3
791	SIGHT: Mortar, Model MP-82-YC for 82mm Mortar	2					2
776	SIGHT: Mortar, Model MPM-44 for 120mm Mortar (See E)						
493	SIGHT: Open, AA, Front for Flexible A/C Machine Gun			1		1	
781	SIGHT: Open, AA, Front for 12.7mm Model DSHK-1938 MG	1				1	
775	SIGHT: Open, AA, Front for 12.7mm Model DSHK-1938 MG (Dual)	2	1			2	1
494	SIGHT: Open, AA, Rear for Flexible A/C Machine Gun			1		1	
782	SIGHT: Open, AA, Rear for 12.7mm Model DSHK-1938 MG	1				1	
783	SIGHT: Open, AA, Rear for 12.7mm Model DSHK-1938 MG	1				1	
500	SIGHT: Open, AA, Unidentified			1		1	
780	SIGHT: Open w/mount for Machine Gun (Tank or Armored Car)	1				1	
777	SIGHT: Tank, 85mm Gun, Model 1944 (See E)	4				4	
778	SIGHT: Telescopic, Model 1942	7				7	
804	SIGHT: Telescopic, Model Unidentified	1				1	
786A	STAKE: Aiming for Model DIA 1 Heightfinder	2				2	
779	TELESCOPE: Battery Commander, 10 x 45	3				3	

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		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
463	TELESCOPE: Battery Commander, 10 x 50			1		1	
592	TELESCOPE: Panoramic, Model Unidentified	6		3		9	
797	TELESCOPE: Sniper's Rifle for Model 91/30 Moisin Nagant			1		1	
518	TELESCOPE: Sniper's Rifle, Tokarev			1		1	
796	THEODOLITE: Model Unidentified (See L)						
803C	TRIPOD: Heightfinder, Model DIA 6, 4 meter base	1				1	
790A	TRIPOD: Rangefinder, 1 meter base, Model ZD	1				1	
	MISCELLANEOUS ITEMS--Code FMMISC						
1195	BELT: Metallic, 7.62mm (See A)	1				1	
1194	BELT: Metallic, 12.7mm, (See H)	1				1	
1193	BOX: Ammunition for 12.7mm Ammunition	2				2	
15	CARRIER: Magazine, 7.62mm, capacity 3 ea			4		4	
43	DRUMS: Metal for Machine Gun Ammunition			2		2	
1197	EXTINGUISHER: Fire, Liquid Type, 2 qt. capacity	2				2	
420	GUN: Signal, Improvised, Rifle Action			1		1	
1205	KIT: Cleaning & Repair for 7.92mm VZ-26 Machine Gun	5				5	
1212	KIT: Spare Parts & Tools for 120mm Mortar, Model 1943	1				1	
632	KIT: Tool for 7.62mm Tokarev Semi-Automatic Rifle (See K)						
1214	KIT: Tool for 122mm Gun, Model 1931/37		1				1
1213	LINK: Dis-integrating, 7.62mm for A/C Machine Gun	10				10	
15A	MAGAZINE: 7.62mm, Drum Type for Machine Gun (See A)	3		6		9	
480	MAGAZINE: 7.62mm, Drum Type for Tank Machine Gun (See A)	9	1	4	1	13	2
631	MAGAZINE: 7.62mm, Tokarev Rifle			4		4	
268	MAGAZINE: 7.62mm, Model PPSH-1941 Sub-Machine Gun (See A & K)	1		2	3	3	3
1199	MAGAZINE: 7.62mm, Model 1934/38 Sub-machine Gun			2		2	
1196	MAGAZINE: 7.62mm, Model 1940 Sub-Machine			1		1	
120Z	MICROSCOPE: Toolmakers Model BMI (See C)						
1215	LINK: Track, Tank, JS-111						1
1200	LINK: Track, Tank, T34		1				1
1190	PISTOL: Signal, 27mm	9	3	1		10	3
607	SCABBARD: Bayonet			1		1	
1211	SET: Gauge, Cylindrical & Snap	1				1	
1203	SET: Lettering, Metal Stamping (See B)						
1196	TORCH: Blow, 1 qt. capacity	2				2	

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AMMUNITION--Code FMAM

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			KOREA		WW II		TOTAL	
			S	U	S	U	S	U
2249	BOMB:	Fragmentation, 6 lb, 50mm dia. (See F)						
2161	BOMB:	Demolition				1		1
2248	BOMB:	HE, General Purpose, 22 lbs., 107mm (See F)						
2246	BOMB:	HE, General Purpose, 200 lbs., 200mm dia. (See F)						
2250	BOMB:	HE, General Purpose, 230 lbs., 280mm (See F)						
2247	BOMB:	HE, Improvised from 107mm HE Projectile, 45 lbs.		1				1
2251	BOMB:	HE, Improvised from 150mm HE Projectile, 80 lbs.		1				1
2165	CTG:	Signal, 27mm, ass't (See F)	45	1			45	1
2260L	CTG:	7.62mm, Linked, 1 ea AP-1, Type B-32 & 1 ea Type ZP, Explosive Incendiary (100 per belt)	586				586	
216	CTG:	7.62mm, AP-I, Type B-32, Red Band, Black Tip	1038		3489	2	4527	2
1080	CTG:	7.62mm, AP, Type B-30, Black Tip			3070	2	3070	2
1079	CTG:	7.62mm, Ball, Heavy, Type "D", Yellow Tip	6192		878	4	7070	4
217	CTG:	7.62mm, Ball, Light, Type "L"	7077		3806	20	10883	20
2123	CTG:	7.62mm, Ball, Type "P" for Tokarev Pistol	5040		5324	27	10364	27
2260	CTG:	7.62mm, Explosive Incendiary, Type ZP	6160				6160	
1218	CTG:	7.62mm, Tracer, Type "T", Green Tip	5280			4	5280	4
2168	CTG:	12.7mm, AP, Type B-30, Black Tip	18				18	
2258	CTG:	12.7mm, API, Type B32	6746				6746	
2124	CTG:	12.7mm, API-T, Type B3T, Red Band Purple Tip	2427			3	2427	3
2230	CTG:	12.7mm, Explosive Projectile	5				5	
2259	CTG:	14.5mm, API, Type B-32	3372				3372	
2125	CTG:	14.5mm, API, Type BS-41, Black Tip, Red Band	377	4		6	377	6
2231	C/R:	20mm for A/C Cannon	87				87	
2262	C/R:	20mm, HE, Type OZT for A/C Cannon, SHVAK	61				61	
2151	C/R:	23mm, API, Model B-2				1		1
2264	C/R:	23mm, API, Model BZ for A/C Cannon (See F)	3149				3149	
2263	C/R:	23mm, HE, Type OZT for A/C Cannon	60				60	
1947	C/R:	37mm, HE, Model UOR-137 (See D)						
2274	C/R:	45mm, APHE-T, Model UBR-243 (See F)	629				629	
1121	C/R:	45mm, APHE-T, Model UBR-1-243Z (See D)	9				9	
1120	C/R:	45mm, HE w/FuzeKTM-1, Model UO-243 (See D)	444				444	
2178	C/R:	45mm, HVAP-T, Model UBR-243P (See F)	299			1	299	
1935	C/R:	57mm, API-T, Model UBZR-271 (See F)	4			1	4	1
2269	C/R:	57mm, HE, Model UO-271 w/Fuze KTM-1 (See F)	19				19	
2228	C/R:	57mm, HVAP-T, Model UBR-271P						1
2267	C/R:	76.2mm, APHE, Model UBR-354B (See F)	169				169	
212	C/R:	76.2mm, AP-T, Model UBR-354 BS				3		3
213	C/R:	76.2mm, AP-T, Model UBR-354A				1		1
2265	C/R:	76.2mm, HE, Model UO-353 w/Fuze KTM-1 (See F)	29				29	
2038	C/R:	76.2mm, HE, Model UOF-353M w/Fuze KTM-1				2		2
2272	C/R:	76.2mm, HE, Model UO-354AM w/Fuze KTM-1 (See F)	19				19	

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			S	U	S	U	S	U
2266	C/R:	76.2mm, HE, Model UOF-354M w/Fuze KTM-1 (See F)	4				4	
2270	C/R:	76.2mm, HE, Model UO-361D w/o Fuze (See F)	15				15	
2271	C/R:	76.2mm, HE, Model Unidentified w/PD Fuze (See F)	19				19	
1818	C/R:	76.2mm, HE, w/PD Fuze				1		1
2273	C/R:	76.2mm, HE, Model Unidentified w/Fuze KTMZ-1 (See F	49				49	
2268	C/R:	76.2mm, HEAT, Model UBP-353M (See F)	4				4	
2153	C/R:	76.2mm, HVAP, Model UBR-354P (See F)	134				134	
2179	C/R:	76.2mm, HE, Old Type, WW I						1
1892	C/R:	76.2mm, HE 39, Fuzed, Old Type, WW I						1
1950	C/R:	76.2mm, HE 294, Fuzed, Old Type, WW I						1
2180	C/R:	76.2mm, Shrapnel, Old Type, WW I						1
2175	C/R:	85mm, AP, Model UBR-365K	104	1				1
2174	C/R:	85mm, HE, Model UO-365	377	1			377	1
2261	C/R:	85mm, HE, Model UO-365K w/Fuze T-5	138				138	
2176	C/R:	85mm, HVAP-T, Model UBR-365P	8	1			8	1
1894	C/R:	100mm, AP, Model UBR-412				1		1
2245	DISPLAY:	Panel, Ammunition, 7.62mm, Type "P" for Tokarev Pistol		1				1
2198	FUZE:	Base, MD-5 w/tracer for 45mm, 57mm & 76.2mm Rds				1		1
2191	FUZE:	Bomb, AB-1 (See F)	1			1	1	1
2254	FUZE:	Bomb, Model ADA (See F)						
2192	FUZE:	Bomb, Model AGP				1		1
2232	FUZE:	Bomb, Model AM-A (See F)	29				29	
884	FUZE:	Bomb, Model APUV				1		1
2252	FUZE:	Bomb, Model APUV-1 (See F)	15	1			15	1
2253	FUZE:	Bomb, Model AVSH-2 (See F)	1	1			1	1
2189	FUZE:	Bomb, Model Unidentified				1		1
2188	FUZE:	Bomb, Model Unidentified				1		1
2193	FUZE:	Bomb, Model Unidentified				1		1
2209	FUZE:	Combination, Model Unidentified				2		2
2206	FUZE:	Combination, 22 CEK, Model Unidentified (See F)				2		2
2225	FUZE:	Combination, 30 CEK, Model Unidentified				2		2
2224	FUZE:	Combination, 30 CEK, Model Unidentified				3		3
2201	FUZE:	Combination, 35 CEK, Model Unidentified				1		1
2220	FUZE:	Combination, 45 CEK, Model Unidentified				3		3
2207	FUZE:	Combination, 45 CEK, Model Unidentified				2		2
2223	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2211	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2202	FUZE:	Combination, 130 CEK, Model Unidentified				1		1
2208	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2190	FUZE:	Combination, 150 CEK, Model Unidentified				1		1
2255	FUZE:	Combination, Model 42-M (See F)						
2213	FUZE:	Combination, Model TM-4B				2		2

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			S	U	S	U	S	U
2194	FUZE:	Combination, T-5	198			2	198	2
2187	FUZE:	Impact, Model AGDT-A for 132mm Rocket				2		2
2199	FUZE:	Impact, Model AM-B				1		1
2204	FUZE:	Impact, Model GBMZ-1				1		1
2279	FUZE:	Impact, Model GVMZ-7	4	1			4	1
2186	FUZE:	Impact, KT-1 for 45mm & 76.2mm Rds.				2		2
2197	FUZE:	Impact, KT3-2				1		1
2185	FUZE:	Impact, KTM-1 for 45mm, 57mm & 76.2mm Rds.	23			2	23	2
2195	FUZE:	Impact, KTM3-2 for 76.2mm Rds.				1		1
2196	FUZE:	Impact, Model MG-8 for 37mm & 40mm AA Rds.				1		1
2222	FUZE:	Impact, Model MP for 50mm & 82mm Mortar Shells				2		2
2237	FUZE:	Impact, Model MP-82	1	1			1	1
2205	FUZE:	Impact, Model PG-6 for 122mm & 152mm Rds.				3		3
2184	FUZE:	Impact, Model RGM for 107mm, 122mm & 152mm rds (See F)				1		1
2214	FUZE:	Impact, Model UGT-2				1		1
2218	FUZE:	Impact, Model UGT for 107mm & 203mm Rds.				3		3
2221	FUZE:	Impact, Model ZGT for 76mm & 107mm Rds.				2		2
2212	FUZE:	Impact, M-1 for 50mm, 82mm & 120mm Mortar Shells				1		1
215	FUZE:	Impact, Model 5 (See F)	634			1	634	1
2200	FUZE:	Impact, Model M50				1		1
2210	FUZE:	Impact, Model AGT				1		1
2217	FUZE:	Impact, Model GT				1		1
2244	FUZE:	Impact, Model Unidentified (See F)						
2216	FUZE:	Time, 139 CEK, Model Unidentified, Red Band				4		4
2215	FUZE:	Time, BM-2, 30 CEK				1		1
2219	FUZE:	Time, T-5				1		1
2203	FUZE:	Time, Model Unidentified				4		4
2162	GRENADE:	A/T, RPG, Model 1943 (See F)	433			3	433	3
219	GRENADE:	Hand, Fragmentation, Model F-1, Fuzed (See D) (See F)	455	2		2	455	4
2173	GRENADE:	Hand, Offensive Type, Model RG-42 (See F)	137			2	137	2
911	GRENADE:	Hand, Stick w/fragmentation jacket RGD-Dyakonov				1		1
2256	CTG:	Ignition for 120mm Mortar Shell	71				71	
2233B	CASE:	Ctg., 122mm w/charge, Model ZH-471 for Model 31/37 Gun	18	2			18	2
2157A	CASE:	Ctg., 122mm, Model ZH-462 (See F)	1	2			1	2
2229A	CASE:	Ctg., 122mm, Model ZHN-471	1				1	
2158B	CASE:	Ctg., 122mm, w/charge, Model ZH-463 for Model 1938 Howitzer	3				3	
2158AX	CASE:	Ctg., 122mm, Model ZH-463 for Model 1938 Howitzer, Steel Wrapped		1				1

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			S	U	S	U	S	U
2158A	CASE:	Ctg., 122mm w/charge, Model ZH-463 for Model 1938 Howitzer, Steel Wrapped	13	1			13	1
2066A	CASE:	Ctg., 152mm, Model ZH-544				1		1
2171A	INCREMENT:	82mm Mortar Shell (See F)	73				73	
1936	PROJ:	76.2mm, AP, Model BR-350				1		1
2181	PROJ:	76.2mm, HE, Model OF-350 (2 pc. proj.)				2		2
2182	PROJ:	76.2mm, HE, Model OF-350 A (1 pa, proj.)				1		1
2235	PROJ:	85mm, HE, w/o Fuze, Model O-365				1		1
2154	PROJ:	85mm, APHE-T, Model BR-365K				1		1
2155	PROJ:	100mm, APHE, Model BR-412				1		1
2156	PROJ:	100mm, HE, Model F-412				1		1
2233	PROJ:	122mm, APBC-T, Model BR-471B	47	1			47	1
2167	PROJ:	122mm, APHE, Model BR-471				1		1
2157	PROJ:	122mm, HE, Model OF-462	2			1	2	1
2072	PROJ:	122mm, HE, Model OF-460				1		1
2229BX	PROJ:	122mm, HE, Model OF-471				2		2
2229	PROJ:	122mm, HE, Model OF-471N	1				1	
1497	PROJ:	122mm, Semi-Fixed, Model OF-462 for Model 1938 Howitzer		1		1		2
2158	PROJ:	122mm, Shaped Charge, Model BP-460A	18	2		6	18	8
2066	PROJ:	152mm, HE, Model OF-540				2		2
2071	PROJ:	152mm, Concrete Piercing, Model G-530				1		1
2159	PROJ:	203mm, HE				1		1
2021	PROJ:	203mm, APHE, w/BD Fuze				1		1
2160	PROJ:	280mm, HE				1		1
2183	SHELL:	Mortar, 50mm, HE, Model O-822				3		3
2171	SHELL:	Mortar, 82mm, HE, Model O-832D w/M5 Fuze (See F)	499	1			499	1
2177	SHELL:	Mortar, 120mm, Model OF-843		2				2
1829	SHELL:	Mortar, 120mm, Model OF-843A (See F)	423	2			423	2
WEAPONS--Satellite Countries--Code FMAR								
762B	BARREL:	Spare for 7.92mm VZ-26 BRNO Machine Gun	5				5	
762	GUN:	Light Machine, 7.92mm, Model VZ-26 BRNO (Chinese)	8				8	
455	GUN:	Light Machine, 7.92mm, ZBVZ BRNO, Mf'd for China	1				1	
1420	GUN:	Light Machine, 7.92mm, Model VZ-26 BRNO (Mf'd in Canada for China)	1				1	
1423	GUN:	Light Ma chine, 7.92mm, ZBMd 30, CUGIR (Czech BRNO Pattern) Roumanian	1				1	
1415	GUN:	Heavy Machine, 7.92mm, Maxim	4	3			4	3
1396	GUN:	Sub-Machine, 9mm, Paratroopers Model					2	

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Satellite Countries Con't		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
1398	GUN: Sub-Machine, 9mm, Standard Model (Czech)					1	
1430	GUN: Sub-Machine, 11mm, Copy of US M3A1		2				2
1426	PISTOL: Automatic, 7.62mm		1				1
1424	PISTOL: Single Shot, 7.62mm, Guerilla Weapon		1				1
1426	PISTOL: Single Shot, 7.62mm, Guerilla Weapon, Mauser Pattern		1				1
1418	THROWER: Grenade, Improvised w/Model 38 Rifle Action Japanese	1				1	
1415A	MOUNT: Tripod for Heavy Maxim Machine Gun	7				7	
1427	MORTAR: 60mm w/bipod & base plate, Copy of US M2, Chinese	2				2	
1429C	MORTAR: Base Plate, Model Unidentified		1				1
1428B	MORTAR: Bipod, 60mm, Model Unidentified		2				2
1428A	MORTAR: Tube, 60mm, Model Unidentified		2				2
1402	RIFLE: Recoilless, 57mm, Model 1936, Chinese Copy of US T15E13	1	1			1	1
1402A	TRIPOD: Experimental for 57mm Recoilless Rifle						1
FIRE CONTROL--Code FMFC							
806	SIGHT: Mortar, 60mm, Model Chiang Kai Shek					2	
AMMUNITION--Code FMAM							
860	CTG: 7.92mm, Ball, Chinese	42				42	
2263	CTG: 9mm, Ball for Sub-Machine Gun, Chinese					50	
2236	C/R: 57mm, HE, Recoilless	75				75	
2238	ROCKET: 4 in., HE, Model 102A3, Chinese copy of US Round	52				52	
2275	SHELL: Mortar, 60mm, Model Unidentified, Chinese (See F)	929				929	
2275	SHELL: Mortar, 60mm, Model Unidentified unfuzed Chinese	928				928	
2276	SHELL: Mortar, 60mm, Model Unidentified, Fuzed, Chinese (See F)	9				9	
2278	SHELL: Mortar, 81mm, Model Unidentified, Chinese	7	1			7	1
2277	SHELL: Mortar, 82mm, Model Unidentified, Chinese & US Markings (See F)	224				224	
MISCELLANEOUS ITEMS--Code FMMISC							
491	MAGAZINE: 7.92mm for Model VZ-26 Machine Gun BRNO	15				15	
1204	UNIFORM: Padded, North Korean Army, Coat & Breeches	1				1	

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WEAPONS, NATIONALIST CHINA	KOREA		WW II		TOTAL	
	S	U	S	U	S	U
1410 GUN: Sub-Machine, 9mm, Copy of US M3A1					1	
1411 GUN: Sub-Machine, 9mm, Copy of British Sten					1	
MISCELLANEOUS ITEMS, NATIONALIST CHINA--Code FMMISC						
1208 KIT: Cleaning for M3A1 Sub-Machine Gun, Nationalist					2	
1209 KIT: Cleaning for British Sten Copy of Sub-Machine Gun					1	
1206 MAGAZINE: 9mm for M3A1 Sub-Machine Gun, Nationalist					7	
1207 MAGAZINE: 9mm for British Sten Copy of Machine Gun					4	
1210 POUCH: Magazine, Canvas for M3A1 Sub-Machine Gun, Nationalist					2	

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9-2, FEL

SID NO. 0403/0410. | RESTRICTED | COUNTRY USSR 24987

MIC NO.

REPORT NO. ORD OIN 2390 | WDGS — INTELLIGENCE REPORT | I. D. NO. 782699

SUBJECT: Plating on Russian Light Machine Gun Barrel (Degtyrev)

FROM: OCofORD | REFERENCES: APG Report (ORD OIN 2390)

EVALUATION: A-1 | DATE OF INFORMATION: 21 March 1951 | DATE OF REPORT: 13 April 1951

INCL. 12 | PREPARED BY: Ordnance Corps, Dept/Army | SOURCE: Captured Material

SUMMARY OR SID REPORT:

In conjunction with Messrs. Brown and Wagner of the Small Arm Section, Development and Proof Services, Aberdeen Proving Ground, Maryland, an examination and test has been made concerning plating in Soviet Small Arms barrels. The Soviet Light Machine Gun barrels examined, were plated. The plating is chromium. Depth of plating has not been ascertained. It is not known to what extent this plating is carried out nor when the practice commenced.

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U. S. C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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13 April 1951

SUBJECT: Plating on Russian Light Machine Gun Barrel (Degtyrov)

1. This office has heard numerous reports about a plating in Soviet Small Arms barrels, especially those intended for automatic fire.

2. In conjunction with Messrs. Brown and Wagner of the Small Arm Section, who had also heard of this plating, an examination and test has been made. The Soviet Light Machine Gun barrels examined, were plated. The plating is chromium. It is a plating job but not as nice a job as if done in this country. Depth of plating has not been ascertained.

3. It is assumed that the matter of erosion does not worry the Soviets in this instance, but that this procedure has been resorted to, that cleaning of the bore in combat may be reduced to a minimum.

4. Subsequent examination of other barrels reveals that PP Sub-Machine Gun and 12.7 mm Degtyarov Heavy Machine Guns also have plated barrels. It is not known to what extent this plating is carried out nor when the practice commenced.

1 Incl.
Cpy of Report on
Barrel Plating

T. F. COLLERAN
Director
Development and Proof Services

OIN 002380

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ABERDEEN PROVING GROUND, MARYLAND
LABORATORY REPORT

DATE: 21 March 1951 PROJECT NO.: 1013-806-0

REF: G. A. Gustafson
Small Arms Branch
A & A Division

SYSTEM 5708

Report of

Analysis of Plating on Russian Light Machine Gun Barrel (Degtyrov)

Results

The plating has been identified as chromium plating.

Leo Brown

LEO BROWN
Small Arms Branch
A & A Division

Observed by: R. Wagner

Reported by: M. Rosenfeld

Approved by: /s/ C. F. Pickett
C. F. Pickett, Chief, Pt & Chem Lab Br

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G-2, GHQ
INTER - OFFICE MEMORANDUM

(For use within G-2 only)

GB/JSCB/CCB/FLS/jfv

File No: **Subject:** Transmittal of Hokkaido CIC Report. **Date:** 9 April 1951

FROM: Jt Sp Ops Br **TO:** Th/Intel **PHONE:** 26-8975 **NAME:** Lt Col Smith

Comment Number

Transmitted herewith is Hq 6th CIC District Summary of Information, subject: Soviet Mine (S/I D6-204 (10)), dtd 31 March 1951. 1.

1 Incl:
as indicated above

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SUMMARY OF INFORMATION

DATE: 31 March 1951

PREPARING OFFICE: HEADQUARTERS, 6th CIC District, APO 309 S/I D6-204 (10)

SUBJECT: SOVIET MINE

CODE FOR USE IN INDIVIDUAL PARAGRAPH EVALUATION

OF SOURCE:		OF INFORMATION:	
COMPLETELY RELIABLE	A	CONFIRMED BY OTHER SOURCES	1
USUALLY RELIABLE	B	PROBABLY TRUE	2
FAIRLY RELIABLE	C	POSSIBLY TRUE	3
NOT USUALLY RELIABLE	D	DOUBTFULLY TRUE	4
UNRELIABLE	E	IMPROBABLE	5
RELIABILITY UNKNOWN	F	TRUTH CANNOT BE JUDGED	6

SUMMARY OF INFORMATION

Map Reference: AMS L761 24/895-2510

Reference: S/R, D6-110, Wakkanai Area, Subject; Possible Soviet Mine, 08/0840/I
S/R, D6-115, Wakkanai Area, Subject; Mine, 08/1548/I

An identified Soviet mine (See EXHIBIT I, attached to original only) was discovered at 1600 hours, 5 March 1951, about one mile north of Aza-Kitasato, Embetsu-cho, Teshio-gun, Hokkaido, by Iwato, Hideo (U)(1), a fisherman. The mine, about three feet in diameter and dark colored, was found on the beach.

At 1400 hours, 7 March 1951, a representative of the Otaru Headquarters of the Maritime Safety Agency exploded the mine. The mine was identified as a Soviet RM-4 type. (C-3)

SOURCE
Teshio National Rural Police and Maritime Safety Agency

Wakkanai Area
LEGEND: (1) Iwato, Hideo (kanji unk)(Japanese) (U) Aza-Kitasato, Embetsu-cho, Teshio-gun, Hokkaido.

Key: U - Communist Affiliation Unknown

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Intell Report:

SUBJECT: Inventory - USSR Items - Including Satellite Countries

FROM: G-2 ADMIN

TO:

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Deputy	( )	Operations	( )
Secretariat	( )	PDM	( )
ADC	( )	Fn Mil Ln	( )
Deputy for Adm	( )	Plans & Estimates	( )
Ex Adm	( )	Special Intel	( )
Ex MIS Div	(2)	Geog Branch	( )
Ex CI Div	( )	CI Division	( )
Ex T/ Intel	(1)	Operations	( )
Sp Asst MIS Div	( )	Coll & Pub	( )
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COUNTRY USSR (Including Satellite Countries)

MIC NO.

REPORT NO. OIN 2007 RP 95-51 WDGS - INTELLIGENCE REPORT I. D. NO. 76794

SUBJECT: INVENTORY - USSR Items - Including Satellite Countries--28 February 1951

FROM: OCofORD REFERENCES: APG Report (OIN 2007)

EVALUATION: A-1 DATE OF INFORMATION: DATE OF REPORT: 28 February 1951

INCL. 6 PREPARED BY: Ordnance Corps, Dept/Army SOURCE: Captured Material

SUMMARY OR SID REPORT:

The inclosed Inventory (8 pp) consists of the following items:

ARTILLERY	Page 1
AUTOMOTIVE	Page 3
FIRE CONTROL	Page 4
MISCELLANEOUS	Page 5
AMMUNITION	Page 5

Satellite Items Page 3

NOTE: This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U.S.C.-31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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INVENTORY

U.S.S.R. ITEMS

Including Satellite Countries

28 February 1951

767194

ARTILLERY	Page 1
AUTOMOTIVE	Page 3
FIRE CONTROL	Page 4
MISCELLANEOUS	Page 5
AMMUNITION	Page 5

Satellite Items Page 3

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FMAR Artillery

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		KOREA		WW II		TOTA
		S	U	S	U	S
407 B	BARREL: Spare for 7.62mm Tank MG	2				2
484 B	BARREL: Spare for 7.62mm Model PPSH-1941 SMG	2				2
620	BAYONET: For Moisin Nagant Rifle	4		3		7
1338	BAYONET: For Model 1938 & 1940 Tokarev Rifles			1		1
619	BAYONET: For Model 1940 Tokarev Rifle			2		2
1192	CARBINE: 7.62mm, Model 1891, Moisin Nagant, Swiss Mf'd.				1	
616	CARBINE: 7.62mm, Model 1938, Moisin Nagant	1		2		3
1276	CARBINE: 7.62mm, Model 1944, Moisin Nagant, w/folding Bayonet	1		2		3
1397 D	CARRIAGE: Transport for 120mm Mortar, Model 1938 & 43	1				1
1261 C	CARRIAGE: 76mm Gun, Model 1942 (See note a)					
1394	GUN: Heavy Machine, 7.62mm, Model 1943, Goryunov		1		1	
7	GUN: Light Machine, 7.62mm, Model DP, Degtyarov	8	1	1	2	9
1406	GUN: Light Machine, 7.62mm, Model DPM w/stock DT	1				1
621	GUN: Light Machine, 7.62mm, Model DP w/stock DT				1	
1392	GUN: Machine, A/C, 7.62mm, Degtyarov	1				1
227	GUN: Machine, Flex., A/C, 7.62mm, SHKAS, Shpitalny-Komaritsky				2	
407	GUN: Machine, Tank, 7.62mm, Model DT, Degtyarov	1	2	2		3
1395	GUN: Machine, Tank, 7.62mm, Model DTM, Degtyarov	3	1			3
1060	GUN: Machine, 7.62mm, Model 1939			1		1
1296	GUN: Machine, 7.62mm, Maxim, Bronze				1	
749	GUN: Machine, 7.62mm, Model 1910, Maxim			1		1
1393	GUN: Machine, 7.62mm, Maxim, W/C, Modified water-jacket	4				4
1054	GUN: Machine, 12.7mm, Model DSHK, Degtyarov (See Note g)	3			1	3
1405	GUN: Machine, A/C, Fixed, 12.7mm, Model UB	1				1
1235	GUN: Sub-machine, 7.62mm, Model 1934/38			1		1
1042	GUN: Sub-machine, 7.62mm, Model PPD-1940			1		1
941	GUN: Sub-machine, 7.62mm, Model PPD-1940, Degtyarov			1		1
484	GUN: Sub-machine, 7.62mm, Model PPSH-1941, Shpagin	5	1	4	1	9
533	GUN: Sub-machine, 7.62mm, Exp., Mf'd 1942, Standardized 1943			1		1
1135	GUN: Sub-machine, 9mm, Copy of British Sten			1		1
484 C	JACKET: Barrel for 7.62mm Model PPSH-1941 SMG	7				7
484 G	JACKET: Barrel Development Group for Model PPSH-1941 Sub-machine Gun (For display)		1			
1395 A	MECHANISM: Trigger, Electric for Model DTM Tank MG	1	1			1
1394 C	MOUNT: Carriage for 7.62mm 1943 Goryunov MG	1				1
749 A	MOUNT: Carriage for 7.62mm Maxim Machine Gun	3		1		4
1054 C	MOUNT: Carriage for 12.7mm Model DSHK-1938 MG (See Note h)	2			1	2
1075	MOUNT: Tripod for Model 1939 Machine Gun, 7.62mm			1		1
1166	PISTOL: Automatic, 7.62mm, Model TT-1933, Tokarev			1		1

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		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
1362	RIFLE: Cal. .22			1		1	
726	RIFLE: 7.62mm, Model 1891, Moisin Nagant	1			2	1	4
726 A	RIFLE: 7.62mm, Model 1891, Moisin Nagant, converted to single shot, used by Chinese	1				1	
910	RIFLE: 7.62mm, Model 1891, Moisin Nagant, Mf'd by Swiss			1	1	1	1
613	RIFLE: 7.62mm, Model 1891/30, Moisin Nagant	3		2	2	5	2
615	RIFLE: 7.62mm, Model 1891/30, Moisin Nagant, Old Type			1		1	
916	RIFLE: 7.62mm, Model 1895, Moisin Nagant, Czarist Rifle			1		1	
577	RIFLE: 7.62mm, Semi-Full Automatic, AVT-1940 Tokarev			1		1	
671	RIFLE: 7.62mm, Semi-Full Automatic, AVS-1936 Seminov				2		2
610	RIFLE: 7.62mm, Semi-Automatic, SVT-1938 Tokarev			1		1	
629	RIFLE: 7.62mm, Semi-Automatic, SVT-1940 Tokarev			2		2	
783	RIFLE: 7.62mm, Semi-Automatic, SVT-1940 Tokarev w/six port muzzle brake						
618	RIFLE: 7.62mm, Sniper's, Model 1891/30, Moisin Nagant			1		1	
914	RIFLE: 10.6mm, Berdan, Single Shot, Mf'd 1879					1	
933	RIFLE: 10.6mm, Berdan					1	
875	RIFLE: 10.8mm, Berdan, Single Shot (Mf'd at Colt's P.T. Firearms Co.)					1	
894	RIFLE: 11.15mm, Model 1867, Berdan, Single Shot					1	
1058	RIFLE: 14.5mm, A/T, PTRD-1941, Degtyarov	5		1		6	
1053	RIFLE: 14.5mm, A/T, PTRS-1941, Seminov, Semi-automatic	2	1	1	1	3	2
1205	REVOLVER: Service, Cal. .22, Model 1898, Nagant			1		1	
414	REVOLVER: Service, 7.62mm, Model 1895, Nagant, Mf'd at Liege			1		1	
484 A	STOCK: for 7.62mm, Sub-machine Gun, Model PPSH-1941	1				1	
771	GUN: A/T, 45mm, Model 1932 w/carriage			1		1	
972	GUN: A/T, 57mm, Model 1941 (ZIS-2) w/carriage				1		1
1399	GUN: A/T, 57mm, Model 1943 w/carriage	2				2	
1261	GUN: A/T, 76.2mm, Model 1942 w/carriage				1		1
1261 A	GUN: A/T, 76.2mm (See Note b)						
246	GUN: 76.2mm, Model 1936 w/carriage				1		1
986	GUN: 76.2mm, Model 1939 w/muzzle brake, w/carriage			1		1	
279	GUN: 76.2mm, Model 1941 w/muzzle brake, w/carriage			1		1	
659	GUN: Regimental, 76.2mm, Model 1927 w/carriage	2	1	1		3	1
1400	GUN: A/A85mm, Model 1939 w/carriage	1				1	
745	GUN: A/A, 88mm, Soviet Model 1939 w/carriage (Modified 85mm for use by Germany)				2		2
1191	GUN: A/T, 100mm, Model 1944 w/carriage				1		1
504	GUN: 122mm, Model 1931/37 w/carriage			1		1	
504 A	GUN: 122mm, Model 1931/37 (See Note c)						
503	GUN: Howitzer, 152mm, Model 1937 w/carriage			1		1	

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FMAR--Artillery		KOREA S	KOREA U	WW II S	WW II U	TOTAL S	TOTAL U
1403	GUN: Tank, 85mm, Model 1944 (See Note d)						
1404	GUN: Tank, 122mm, Model 1943 (JS II Tank) (See Note e)						
770	HOWITZER: 122mm, Model 1910/30 w/carriage				1		1
968	HOWITZER: 122mm, Model 1938 w/carriage	2		1		3	
759	HOWITZER: 152mm, Model 1909/30 w/carriage			1		1	
983	HOWITZER: 152mm, Model 1938 (Breech 1934/37)				1		1
809	HOWITZER: 203mm, Model 1931 w/tracked carriage				1		1
1102	MORTAR: 50mm, Model 1938			1		1	
1104	MORTAR: 50mm, Model 1940			1		1	
811	MORTAR: 82mm, Model 1937				1		1
1408	MORTAR: 82mm, Model 1937, 1942-43 Version	2				2	
424	MORTAR: 120mm, Model 1938				1		1
1397	MORTAR: 120mm, Model 1943, Variant II	2				2	
1401	MORTAR: 120mm, Short Tube	1				1	
Weapons from Satellite Countries:							
1396	GUN: Sub-machine, 9mm, Paratroopers Model (Czech)					2	
1398	GUN: Sub-machine, 9mm, Standard Model (Czech)					1	
1402	RIFLE: Recoilless, 57mm, Model 1936 (Chinese copy of U.S. T15E13) (Chinese)	1	1			1	1
Miscellaneous:							
1204	UNIFORM: Padded, North Korean Army (Coat & Breeches)	1				1	
Ammunition:							
2236	C/R: 57mm, HE for Recoilless Rifle, (Chinese)	58				58	
2238	ROCKET: 4 in., HE, Model 102A3 (Copy of U.S. Round) (Chinese)	6	1			6	1
FMCV--Automotive:							
244	CAR: Armored, BA-64, 4 x 4 Mounts 7.62mm Tank MG	1				1	
246 B	ENGINE: Tank, 12 cylinder Diesel for T34/85 Tank	11				11	
245	MOTORCYCLE: 2 cylinder w/side car	1				1	
13	TANK: Medium, T-34 w/76mm Tank Gun (short) Caliber length 30.5			1	1	1	1
246	TANK: Medium, T34/85		1				1
246A	TANK: Medium, T34/85 w/Commander's turret	1				1	
247	TANK: Medium, T34/85 w/new frontal welding	2				2	
14	TANK: Heavy, KV-1 w/76mm Tank Gun (short) Caliber length 30.5				1		1

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		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
794	ADAPTER: Mortar Sight, 82mm to 120mm	2				2	
785	CIRCLE: Aiming, No Model Designation	1	1			1	1
789	DIRECTOR: A/A, Model Puazo 3 w/controls & trailer	1				1	
798	DRUM: Range for 122mm Howitzer, Model 1938	2				2	
788	HEIGHTFINDER: Model DIA 1, 4 meter base, 24 X, with cradle & tripod	1				1	
790B	LATHE: Adjusting, 1 meter base Rangefinder, Model ZD	1				1	
670	PERISCOPE: T.P., 4 X			1		1	
795	QUADRANT: Gunner's	2				2	
790	RANGEFINDER: 1 meter base, Model ZD w/accessories	2				2	
307	PERISCOPE: Tank, Model PT4-Z for heavy KV Tank				1		1
786	SIGHT: Gun, 57mm, ZIS-2	1				1	
784	SIGHT: Gun, No Model Designation	1				1	
792	SIGHT: Model PZP for 50mm Mortar	3				3	
793	SIGHT: Model PZP for 82mm Mortar	3				3	
799	SIGHT: Model MP-41 for 82mm & 120mm Mortars	3				3	
800	SIGHT: Model MP-42 for 82mm & 120mm Mortars	10				10	
791	SIGHT: Model MP-82-YC for 82mm Mortar	2				2	
776	SIGHT: Model MPM-44 for 120mm Mortar (See Note f)						
493	SIGHT: Open, AA, Front for Flexible A/C MG			1		1	
781	SIGHT: Open, AA, Front for 12.7mm Model DSHK-1938 MG, Single	1				1	
775	SIGHT: Open, AA, Front for 12.7mm, Model DSHK-1938 MG, Dual	1	1			1	1
494	SIGHT: Open, AA, Rear for Flexible A/C MG			1		1	
782	SIGHT: Open, AA, Rear for 12.7mm DSHK-1938 MG	1				1	
783	SIGHT: Open, AA, Rear for 12.7mm DSHK-1938 MG	1				1	
500	SIGHT: Open, AA, Unidentified			1		1	
780	SIGHT: Open w/mount for MG, Tank or Armored Car	1				1	
777	SIGHT: Tank, 85mm Gun, Model 1944 (See Note j)	1				1	
778	SIGHT: Telescopic, Model 1942	3				3	
788A	STAKE: Aiming for Model DIA I Heightfinder	1				1	
779	TELESCOPE: Battery Commander, 10 x 45	3				3	
463	TELESCOPE: Battery Commander, 10 x 50			1		1	
592	TELESCOPE: Panoramic, No Model Designation	5		3		8	
797	TELESCOPE: Sniper's for Model 91/30 Moisin Nagant Rifle			1		1	
518	TELESCOPE: Sniper's for Tokarev Rifle			1		1	
796	THEODOLITE:	1				1	
790A	TRIPOD: Rangefinder, 1 meter base, Model ZD	1				1	

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FMMISC--Miscellaneous		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
1195	BELT: Metallic, 7162mm	2				2	
1194	BELT: Metallic	1				1	
1193	BOX: Ammunition for 12.7mm Ammunition	2				2	
15	CARRIER: Magazine, 7.62mm, Capacity 3 ea			4		4	
43	DRUMS: Metal, Empty for Machine Gun Ammuntion			2		2	
1197	EXTINGUISHER: Fire, Liquid Type, 2 qt. capacity	2				2	
420	GUN: Signal, Russian Rifle Action			1		1	
632	KIT: Tool for 7.62mm Tokarev Rifle			1		1	
15 A	MAGAZINE: 7.62mm, Drum Type for Machine Gun	3		7		10	
480	MAGAZINE: 7.62mm, Tank Machine Gun, Degtyarov	9	1	5	1	14	2
631	MAGAZINE: 7.62mm for Tokarev Rifle			3		3	
268	MAGAZINE: 7.62mm, for Model PPSH-1941 Sub-machine Gun	1		2	4	3	4
1199	MAGAZINE: 7.62mm, Model 1934/38 Sub-machine Gun			2		2	
1198	MAGAZINE: 7.62mm, Model 1940 Sub-machine Gun			1		1	
1200	LINK: Track, T34 Tank		1				1
1190	PISTOL: Signal, 27mm	1		1		2	
607	SCABBARD: Bayonet			1		1	
1203	SET: Lettering, Metal Stamping (See Note 1)						
1196	TORCH: Blow, 1 qt. Capacity	2				2	
1202	MICROSCOPE: Toolmakers "BMI" (See Note m)						
FMAM-- Ammunition:							
2161	BOMB: Demolition				1		1
2165	CTG: Signal, 27mm	19	1			19	1
216	CTG: 7.62mm, AP-I, Type B-32, Red Band, Black Tip			3489	2	3489	2
1080	CTG: 7.62mm, AP, Type B-30, Black Tip			3070	2	3070	2
1079	CTG: 7.62mm, Ball, Heavy, Type "D", Yellow Tip	472		878	4	1350	4
217	CTG: 7.62mm, Ball, Light, Type "L"	497		3806	20	4303	20
2123	CTG: 7.62mm, Ball, Type "P" for Tokarev Pistol			5314	27	5314	27
1218	CTG: 7.62mm, Type "T" Green Tip				4		4
2168	CTG: 12.7mm, AP, Type B-30, Black Tip	18				18	
2124	CTG: 12.7mm, API-T, Type B3T, Red Band, Purple Tip	87			3	87	3
2230	CTG: 12.7mm, Explosive Projectile	5				5	
2125	CTG: 14.5mm, AP-I, Type BS-41, Black Tip, Red Band		1		1		2
2172	CASE: Cartridge, 122mm		1				1
2234	CASE: Cartridge, 122mm, for Model 1938 Howitzer, Model ZN-463, Steel, Wrapped Case	1	1			1	1
1497A	CASE: Cartridge, 122mm, Model ZH-462		1				1
2229A	CASE: Cartridge, 122mm, Model ZHN-471						0
2066A	CASE: Cartridge, 122mm, Model ZH-544				1		1

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FMAM--Ammunition			KOREA		WW II		TOTAL	
			S	U	S	U	S	U
2231	C/R:	20mm for A/C Cannon	87				87	
2151	C/R:	23mm, AP-I, Model B-2				1		1
1947	C/R:	37mm, HE, Model UOR-137				1		1
1121	C/R:	45mm, APHE-T, Model UBR-243Z	9			1	9	1
1120	C/R:	45mm, HE w/Fuze KTM-1, Model UO-243	4			1	4	1
2178	C/R:	45mm, HVAP-t, Model UBR-243P	4			1	4	1
1935	C/R:	57mm, API-T, Model UBZR-271				1		1
212	C/R:	76mm, AP-T, Model UBR-354 BS				3		3
213	C/R:	76mm, AP-T, Model UBR-354A				1		1
1950	C/R:	76mm, HE 294, Fuzed, Old Type, WW I						1
2038	C/R:	76mm, Model UOF-353M w/Fuze KTM-1		1		1		2
1892	C/R:	76mm, HE 39, Fuzed, Old Type, WW I						1
2179	C/R:	76mm, HE, Old Type, WW I						1
1818	C/R:	76mm, HE w/PD Fuze				1		1
2153	C/R:	76mm, HVAP, Model UBR-354P				4		4
2180	C/R:	85mm, Shrapnel, Old Type, WW I						1
2174	C/R:	85mm, HE, Model UO-365	11	1			11	1
2176	C/R:	85mm, HVAP-T, Model UBR-365P	1	1			1	1
1894	C/R:	100mm, AP, Model UBR-412				1		1
2245	DISPLAY:	Panel, 7.62mm Ammunition Type "P" Pistol		1				1
2198	FUZE:	Base, MD-5 w/tracer, 45mm, 57mm, 76mm Rounds				1		1
2191	FUZE:	Bomb, AB-1				1		1
2192	FUZE:	Bomb, Model AGP				1		1
2232	FUZE:	Bomb, Model AM-A	24				24	
884	FUZE:	Bomb, Model APUV				1		1
2189	FUZE:	Bomb, Model Unidentified				1		1
2188	FUZE:	Bomb, Model Unidentified				1		1
2193	FUZE:	Bomb, Model Unidentified				1		1
2209	FUZE:	Combination, Model Unidentified				2		2
2206	FUZE:	Combination, 22 CEK, Model Unidentified				2		2
2225	FUZE:	Combination, 30 CEK, Model Unidentified				2		2
2224	FUZE:	Combination, 30 CEK, Model Unidentified				3		3
2201	FUZE:	Combination, 35 CEK, Model Unidentified				1		1
2220	FUZE:	Combination, 45 CEK, Model Unidentified				3		3
2207	FUZE:	Combination, 45 CEK, Model Unidentified				2		2
2223	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2211	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2202	FUZE:	Combination, 130 CEK, Model Unidentified				1		1
2208	FUZE:	Combination, 130 CEK, Model Unidentified				2		2
2190	FUZE:	Combination, 150 CEK, Model Unidentified				1		1
2213	FUZE:	Combination, Model TM-4B				2		2
2194	FUZE:	Combination, T-5	10			2	10	2
2187	FUZE:	Impact, Model AGDT-A for 132mm Rocket				2		2

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FMAM--Ammunition		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
2199	FUZE: Impact, Model AM-B				1		1
2204	FUZE: Impact, Model GBMZ-1				6		6
2186	FUZE: Impact, KT-1 for 45mm & 76mm Rounds				2		2
2197	FUZE: Impact, KT3-2				1		1
2185	FUZE: Impact, KTM-1 for 45mm, 57mm, 76mm Rounds	23			2	23	2
2195	FUZE: Impact, KTM3-2 for 76mm Rounds				1		1
2196	FUZE: Impact, Model MG-8 for 37mm & 40mm AA Rounds				1		1
2222	FUZE: Impact, Model MP for 50mm & 82mm Mortar Shells				2		2
2237	FUZE: Impact, Model MP-82	1	1			1	1
2205	FUZE: Impact, Model PG-6 for 122mm & 152mm Rounds				3		3
2184	FUZE: Impact, Model RGM gor 107mm & 152mm Rounds				1		1
2214	FUZE: Impact, Model UGT-2				1		1
2218	FUZE: Impact, Model UGT for 107mm & 203mm Rounds				2		2
2221	FUZE: Impact, Model ZGT for 76mm & 107mm Rounds				2		2
2212	FUZE: Impact, M-1 for 50mm, 82mm, 120mm Mortar Shells				1		1
215	FUZE: Impact, Model 5	5			1	5	1
2200	FUZE: Impact, Model M50				1		1
2210	FUZE: Impact, Model AGT				1		1
2217	FUZE: Impact, Model GT				1		1
2244	FUZE: Impact, Model Unidentified	1				1	
2216	FUZE: Time, 139 CEK, Red Band, Model Unidentified				4		4
2215	FUZE: Time, BM-2, 30 CEK				1		1
2219	FUZE: Time, T-5				1		1
2203	FUZE: Time, Model Unidentified				4		4
2162	GRENADE: A/T, RPG, Model 1943	2			3	2	3
219	GRENADE: Hand, Fragmentation, Model F-1, Fuzed	36	1		2	36	3
2173	GRENADE: Hand, Offensive Type, Model RG-42	38	1		1	38	2
911	GRENADE: Hand, Stick w/Fragmentation jacket, RGD-Dyakonov				1		1
2152	PROJ: 57mm HE				1		1
1936	PROJ: 76mm, AP, Model BR-350				1		1
2181	PROJ: 76mm, HE, Model OF-350 (2 pc. proj.)				2		2
2182	PROJ: 76mm, HE, Model OF-350 A (1 pc. proj.)						
2235	PROJ: 85mm, HE, w/o Fuze, Model O-365		1				1
2154	PROJ: 85mm, APHE-T, Model BR-365 K				1		1
2155	PROJ: 100mm, APHE, Model BR-412				1		1
2156	100mm, HE, Model F-412				1		1
2233	PROJ: 122mm, APBC-T, Model BR-471 B	14	1			14	1
2167	PROJ: 122mm, APHE, Model BR-471				1		1

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		KOREA		WW II		TOTAL	
		S	U	S	U	S	U
2157	PROJ: 122mm, HE, Model OF-462				2		2
2072	PROJ: 122mm, HE, Model OF-460				1		1
2229	PROJ: 122mm, HE, Model OF-471				2		2
1497	PROJ: 122mm, Semi-Fixed, Model OF-462		1		1		2
2158	PROJ: 122mm, Shaped Charge, Model BP-460 A	2	1		6	2	7
2066	PROJ: 152mm, HE, Model OF-540				2		2
2071	PROJ: 152mm, Concrete Piercing, Model G-530				1		1
2159	PROJ: 203mm, HE				1		1
2021	PROJ: 203mm, APHE, w/BD Fuze				1		1
2160	PROJ: 280mm, HE				1		1
2183	SHELL: Mortar, 50mm, Model O-822				3		3
2171	SHELL: Mortar, 82mm, HE, Model)-832D w/M5 Fuze		1				1
2177	SHELL: Mortar, 120mm, Model OF-843		1				1
1829	SHELL: Mortar, 120mm, Model Of-843 A		1				1

Following items shipped off-post or to another agency on-post:

(a) This item shipped to Rock Island Arsenal for test.
(b) This item shipped to Watertown Arsenal for test.
(c) This item shipped toWatertown Arsenal for test.
(d) This item shipped to Watertown Arsenal for test.
(e) This item shipped to Watertown Arsenal for test.
(f) This item shipped to Fire Control Lab., Frankford Arsenal.
(g) Two (2) each shipped to Springfield Armory for Test.
(h) Two (2) each shipped to Springfield Armory for test.
(j) One (1) each shipped to Frankford Arsenal for test.
(k) Two (2) each shipped to Springfield Armory for test.
(l) This item shipped to Ass't Chief of Staff, G-2, Washington, D.C.
(m) This item transferred to Ballistic Research Laboratory, APG, Md.

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DO NOT DETACH
G-2 GHQ FEC

14478

23 March 1951

SUBJECT: Probable Soviet Mine

FROM: JSOB

TO: T/Intel

A CofS, G-2	( )	Theater Intelligence Div	(2)
Deputy	( )	Operations	( )
Secretariat	( )	PDM	( )
ADC	( )	Fn Mil Ln	( )
Deputy for Adm	( )	Plans & Estimates	( )
Ex Adm	( )	Special Intel	( )
Ex MIS Div	( )	Geog Branch	( )
Ex CI Div	( )	CI Division	( )
Ex T/Intel	( )	Operations	( )
Sp Asst MIS Div	( )	Coll & Pub	( )
Sp Asst 441st CIC Det	( )	441st CIC	( )
Sp Asst Fiscal	( )	JSOB	( ) Intel
Sp Asst Radio	( )	MIS Division	( )
Sp Asst Historical	( )	ATIS	( )
Sp Asst PSB	( )	TID	( )
Sp Asst JSOB	( )	Special Projects	( )
Admin Officer	( )	Historical Division	( )
Personnel (Mil) (Civ)	( )	Public Safety Branch	( )
Jap Liaison	( )		( )

Info	( )	Approval	( )	Signature	( )	Draft Reply	( )
Action	( )	Concur	( )	Initials	( )	Info for Reply	( )
File	( )	Comment	( )	Dispatch	( )	Brief	( )

DATE ALL COMMENTS

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0400 USSR

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Authority NND 951506

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1447(3)
1968

SUMMARY OF INFORMATION

DATE: 15 March 1951

PREPARING OFFICE: HEADQUARTERS, 6th CIC District, APO 309 S/I D6-1G2 (10)

SUBJECT: PROBABLE SOVIET MINE

CODE FOR USE IN INDIVIDUAL PARAGRAPH EVALUATION

OF SOURCE:		OF INFORMATION:	
COMPLETELY RELIABLE	A	CONFIRMED BY OTHER SOURCES	1
USUALLY RELIABLE	B	PROBABLY TRUE	2
FAIRLY RELIABLE	C	POSSIBLY TRUE	3
NOT USUALLY RELIABLE	D	DOUBTFULLY TRUE	4
UNRELIABLE	E	IMPROBABLE	5
RELIABILITY UNKNOWN	F	TRUTH CANNOT BE JUDGED	6

SUMMARY OF INFORMATION

Map Reference: AMS L561 23/960-2545

At approximately 1000 hours, 4 February 1951, SUBJECT (see Exhibit I, attached to original only) was found caught in the ice in the Okhotsk Sea, about 300 feet offshore at Aza Toimaki, Esashi-cho, Hokkaido. SUBJECT was safely exploded by representatives of the MSA on 8 February 1951. SUBJECT is believed to have been built within the last three years. (C-3)

SOURCE

Wakkanai National Rural Police

WAKKANAI AREA

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23432 1969

SUMMARY OF INFORMATION

DATE: 15 Mar 51

PREPARING OFFICE: HEADQUARTERS, 6th CIC District, APO 309

S/I, D6-164 (10)

SUBJECT

POSSIBLE SOVIET MINE

CODE FOR USE IN INDIVIDUAL PARAGRAPH EVALUATION

OF SOURCE:		OF INFORMATION:	
COMPLETELY RELIABLE	A	CONFIRMED BY OTHER SOURCES	1
USUALLY RELIABLE	B	PROBABLY TRUE	2
FAIRLY RELIABLE	C	POSSIBLY TRUE	3
NOT USUALLY RELIABLE	D	DOUBTFULLY TRUE	4
UNRELIABLE	E	IMPROBABLE	5
RELIABILITY UNKNOWN	F	TRUTH CANNOT BE JUDGED	6

SUMMARY OF INFORMATION

(Reference: S/R 6th District, 29 Jan 51, subject: "Discovery of Mine," and S/R D6-6, 2 Feb 51, subject: "Discovery of Mine."

At approximately 0600 hours, 28 January 1951, SUBJECT (see Exhibit I, attached to original only) was discovered floating six feet offshore near Awabikotan, Aza-Sukuton-misaki, Funadomari-mura, Rebun-gun, Hokkaido by Sasaki, Hideichi (U)(1). The Otaru MSA was notified. Their representative safely accomplished the destruction of SUBJECT on 1 February 1951. (C-3)

SOURCE

Wakkanai National Rural Police

Wakkanai Area

LEGEND:

(1) Sasaki, Hideichi (佐々木秀一)(U)(Japanese), Aza-Sukuton, Funadomari-mura, Rebun-gun, Hokkaido.

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GENERAL HEADQUARTERS
FAR EAST COMMAND
Military Intelligence Section, General Staff

APO 500
19 March 1951

CI Div

SUMMARY OF INFORMATION

SUBJECT: Ship's Planking Found

At Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido, at approximately 1430 hours, 21 January 1951, Masuda, Tomiji (1), discovered a piece of ship's planking (see Inclosure 1) which appeared to be from the deckhouse. The planking is 7 feet long, 3.5 feet wide, and 2 inches thick. Two portholes of approximately 5 inches in diameter are in the planking. Two pieces of electrical equipment, which appear to be sockets, and a length of wire are attached to the planking. The sockets bear the following lettering in the Russian language:

Type KGP 10/N4 (ТИП КГП 10/Н4)

Type SHGP 10/250 (ТИП ШГП 10/250)

LEGEND: (1) Masuda, Tomiji (升田 富次)(Japanese)
#72 Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido

1 Incl:
Photo, Ship's Planking

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APO 500
19 March 1951

CI Div

SUMMARY OF INFORMATION

SUBJECT: Ship's Planking Found

At Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido, at approximately 1430 hours, 21 January 1951, Masuda, Tomiji (1), discovered a piece of ship's planking (see Inclosure 1) which appeared to be from the deckhouse. The planking is 7 feet long, 3.5 feet wide, and 2 inches thick. Two portholes of approximately 5 inches in diameter are in the planking. Two pieces of electrical equipment, which appear to be sockets, and a length of wire are attached to the planking. The sockets bear the following lettering in the Russian language:

Type KGP 10/N4 (ТИП КГП 10/НЧ)

Type SHGP 10/250 (ТИП ШГП 10/250)

LEGEND: (1) Masuda, Tomiji (升田 富次)(Japanese)
#72 Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido

1 Incl:
Photo, Ship's Planking

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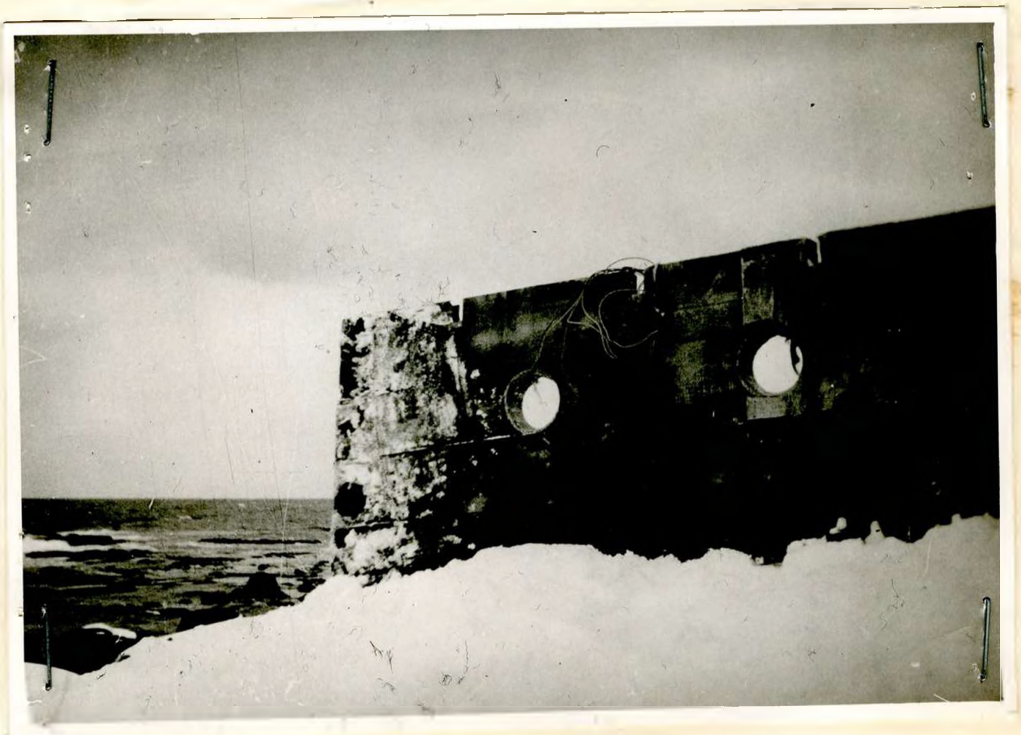

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Incl 1 to Encl 5

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APO 500
26 February 1951

CI Div

SUMMARY OF INFORMATION

SUBJECT: Ship's Planking Found

At Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido, at approximately 1430 hours, 21 January 1951, Masuda, Tomiji (1), discovered a piece of ship's planking (see Inclosure 1) which appeared to be from the deckhouse. The planking is 7 feet long, 3.5 feet wide, and 2 inches thick. Two portholes of approximately 5 inches in diameter are in the planking. Two pieces of electrical equipment, which appear to be sockets, and a length of wire are attached to the planking. The sockets bear the following lettering in the Russian language:

Type KGP 10/N4 (ТИП КГП 10/Н4)

Type SHGP 10/250 (ТИП ШГП 10/250)

LEGEND: (1) Masuda, Tomiji (升田富次)(Japanese)
#72 Aza Harauta, Nishi Shimamaki-mura, Shimamaki-gun, Hokkaido

1 Incl:
Photo, Ship's Planking

SOURCE: S/I, D6-114 (10), subj as above, dtd 26 Feb 51
EVALUATION: Fairly reliable, probably true.

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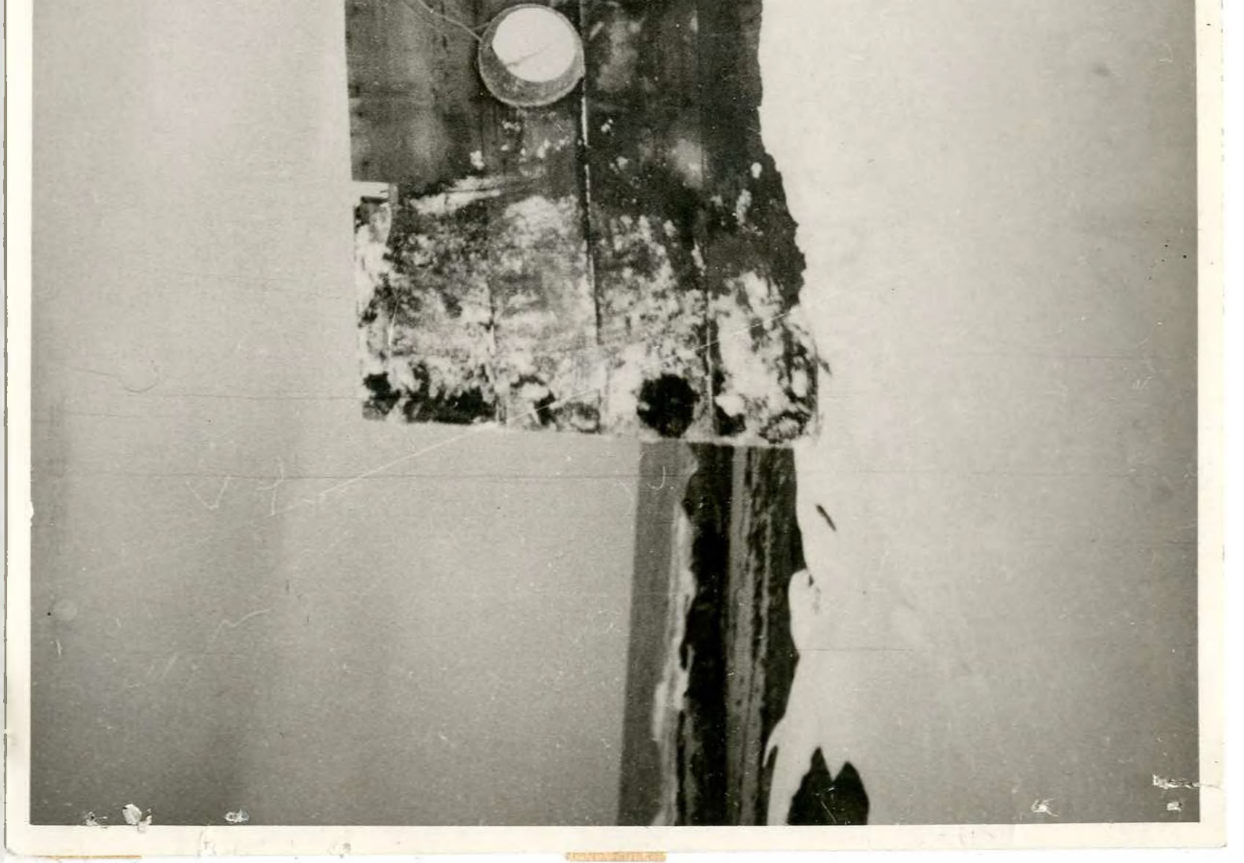

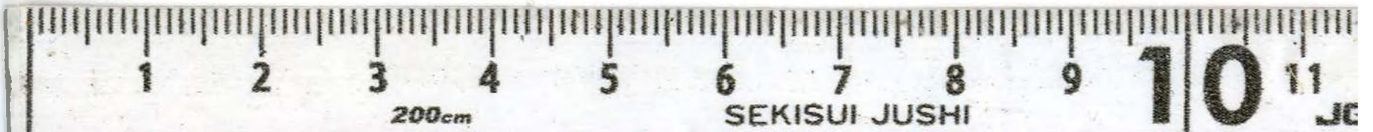

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G-2, FEC-1

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THE DIRECTORATE OF MILITARY INTELLIGENCE
AHQ OTTAWA

TRANSLATION
OF

767257

FOREIGN TITLE

Evakuatsiya Avariynykh Tankov

ENGLISH TITLE

RECOVERY OF DAMAGED TANKS

SUMMARY

ORIGINAL AUTHOR

Eng. Col. B. SMIRENSKY

ORIGINAL LANGUAGE

Russian

NOTES

Tank Journal No. 1, 1944.
Military Publication of the National
Commissariat for The Defence

DATE MAR 5 1951

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RECOVERY OF DAMAGED TANKS

1. Recovery of tanks from the battle field - is a comparatively new undertaking. It is therefore very important to take advantage of experiences gathered during World War II, so as to pass it on to tank and recovery units.

2. The basic difficulty during recovery operations - is the weight of tanks. This requires considerable tractive effort. The proceeding becomes still more complicated when a tank with damaged running gear and control mechanism encounters obstacles on its way.

3. When proceeding to recover a tank, it is first of all essential to remove it from its location; this requires a certain effort which will depend on the position of the tank and the condition of its gear.

4. Approximate figures characteristic of such efforts are enumerated in this table, set up according to experience acquired in recovering tanks on the Western Front.

APPROXIMATE TRACTIVE EFFORT (IN TONS) REQUIRED TO TOW TANKS

Position of damaged Tank	TYPES OF TANKS			Condition of running gear
	Light	Medium	Heavy	
In dry ditch, crater, road ditch	10	20	35	In working order
In an anti-tank ditch, ravine or gully (steep)	20	35	70	Same
In a river with hard bottom; sunken up to the base of turret, or higher	35	70	140	Same
In a swamp, or water with slimy bottom	70	140	220	Motor part and running gear frozen, tracks do not turn

5. If the motor of a damaged tank is in working order and its power can be utilized, the figures for the tractive towing force required can be respectively reduced.

6. In order to give a true picture of the meaning of these figures we are bringing data on power and hand-tackles and energy on tractor hooks in first gear (in kgs).

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TACKLE:	TRACTORS:	ENERGY ON THE HOOK	REMARKS
3 t	STZ-3-5	2 800	
5 t	CHTZ-60-65	5 200	
	STZ-2	5 000	
	KOMINTERN	6 000	
10 t	"VOROSHILOVETS"	10 000	
15 t	" "	-	Tackle of Tractor 15 t

7. The following increase of tractive force can be achieved by using blocks pulley blocks (compound pulley system) with a definite number of cable branches, as shown on chart No. 1:

---

8. The table shows, that in order to tow a tank "KV" along a level road, when the running gear is in working order, 3 tractors CHTZ are required, or two "VOROSHILOVETS", or two German towers "FAMO". On an incline the necessary tractive force increases: In order to tow a KV tank it becomes necessary to use four tractors CHTZ, three tractors "VOROSHILOVETS" or three German towers "FAMO".

9. A 5-ton hoisting tackle with 4 cables gives an exertion of 20 tons: The exertion of a hoisting tackle is calculated according to the formula:

$$S = P \times n \times K,$$

where:

S - Resulting exertion

P - Initial tractive exertion

n - Number of cables

K - Friction coefficient of losses on blocks, taken at 0,9. (friction).

10. Thus, coming back to our table, we can say that in order to tow a light tank out of a ditch it is sufficient to have a 5-ton winch and a block with two cable branches; for a medium weight tank - with four cable branches; for a heavy tank: with 7 branches or, taking into consideration that K = 0,8, even 9 cable branches.

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11. When an effort of 70, 140 or more ton is necessary, progressive pulleys are used which, apart from fixed blocks, also have anchored blocks - which are movable or "wandering".

12. A tank which has been moved from place and towed out onto the road is recovered by towing, by tractor of a definite power, depending on the condition of the running gear of the tank and condition of the road.

13. In view of the varied conditions which happen in practice, it is difficult to establish definite data as to the required tractive force. Not one single case of a tank being stuck, or the character of its damage: - tracks, bottom, rollers, etc., is identical to another. Nevertheless, based on experience of the Don front, and other fronts, one can assume - as an approximate picture - the following data about the quantity of towcars necessary in order to tow domestic and German tanks:

NAME OF TRACTORS	Type of Road									
	Level Road					Road with incline				
	TANKS BEING TOWED									
	KV	T-34	T-70 T-60	T-3	MK-IV Churchill	KV	T-34	T-70 T-60	T-3	MK-IV Churchill
NATI 3-5	-	-	1	2	-	-	-	2	4	-
"KOMINTERN"	3	2	-	1	3	4	3	-	2	4
"VOROSHILOVETS"	2	1	-	-	2	3	2	-	-	3
CHTZ -65-60	3	2	-	1	3	4	3	-	2	4
DEMAG - 6 t	-	-	1	-	-	-	-	2	-	-
"KRUPP" 12 t	3	2	-	1	3	4	3	-	2	4
"FAMO" 18 t	2	1	-	-	2	3	2	-	-	3
"KRAUSS-MORPHY" 18 t	3	2	-	-	3	5	4	-	-	5
"INTERNATIONAL" TD-18	3	2	-	-	3	4	3	-	-	4

14. The above mentioned table is only the first approximate estimate and in every particular case it can be subject to changes.

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15. Preparation of tanks for towing plays an important role in the recovery. When the running gear and control mechanisms of a tank which is stuck are not in order, it is altogether impossible to move them without preliminary preparations; the preparation of tanks to be towed consists in eliminating all obstructions which would hamper their movement - placing of tracks, rollers, elimination of impediments in control mechanism, straightening out of bottom by means of an explosion with a charge, elimination of protruding parts by means of a gasoline cutter, hauling out and raising of tanks.

16. In cases of complete absence of tracks, rollers or even axles, the tank can be recovered on a trailer, i.e., a four or 8-wheel vehicle on pneumatic tires (See chart 2).

17. In order to load a tank onto a trailer the platform is lowered to the ground, the tank is drawn up on the platform which is then hoisted up, then the trailer is hooked on to the tow car. The loading capacity of a 4-axle trailer is - 36 and 45 T. Its fixed coupling to the tractor does not require any special brakes.

18. On the Central Front captured German trailers were used very effectively for recovering tanks; their advantage consists in the fact that in using them one can tow a tank easily over long distance with a minimum of towing means.

19. In the absence of trailers for towing, wooden runners (slides) can be utilized, or skis, or special sleighs, reinforced with special iron cables and cramps. Loading of tanks onto skis or sleighs is done by elevating them with the aid of hoisting jacks; or placing the slides, skis or sleighs under them; or hauling them up along supports with the aid of a hoisting pulley or a tractor.

20. At the beginning of transport it is recommended to use a long cable for towing (not less than 500 m) - in case of mines, and only after having covered 10 - 15 m. to change to a short one (10m). It is essential that all damaged tanks should be thoroughly looked over all ammunition taken out - in order to avoid any possible accidents.

21. The recovery road should be examined by the driver beforehand, so that all peculiarities of the road such as - turns, hills, descents - should be known to him.

- - - - - - - - - -

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Chart No. 1

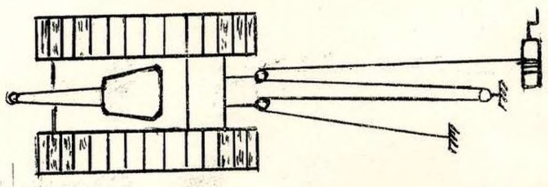
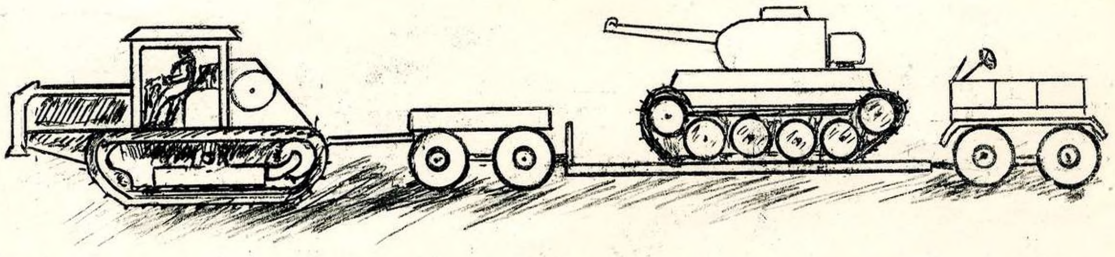


Chart No. 2



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24 December 1950

Ordnance Technical Intelligence Report No. 509-26.
(Madsen Machine Gun and Soviet Machine Gun, type unknown).

1. On 22 November 1950 this unit shipped from the Pyongyang, Korea airstrip (K-24) aboard aircraft C46, No. 478411 a Madsen Light Machine Gun and a Soviet Machine Gun of unknown type or make, to the 192 Ordnance Co. APO 59, for further shipment to the CG, AFG, Md.

2. The following characteristics and data are on the Madsen Machine Gun.

TYPE:	Light machine gun.
CALIBER:	Eight (8) mm.
SIGHTS:	200 to 2000 yds., in increments of 100 yds.
LENGTH:	Forty (40) inches.
WEIGHT:	Twenty-one (21) pounds.
:	Recoil operated, magazine fed, forty (40) round magazine. The gun is cocked when the bolt is open. When the chamber is empty the bolt stays forward. The gun will fire full or semi-automatic.

3. This weapon was picked up North of Anju, Korea from the hands of the Chinese. Markings on the weapon are in Chinese. The rate of fire selection lever is indicated in Chinese. See photo No. O-26.

4. An unknown type of machine gun was also picked up at the Pyongyang, Korea airfield. This weapon is solenoid-fired as indicated in photo No. O-28 from a twenty-four (24) volt system.

5. This weapon appears to have a rotary type bolt. This unit was unable to determine the type of feeding. The detail stripping was not accomplished by this unit as it is better that this weapon be stripped at the Aberdeen Proving Ground. The weapon is gas operated.

6. Photographs No. O-26 and O-27 are of the Madsen Light MG. Photo's O-28 thru O-31 are of a Soviet, rotary type bolt, machine gun.

E N D

of no USSR.

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FOR: T/Sutil

No Value

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976



Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Light Machine Gun
(Telephone, etc.)

Type Gun Madsen
(Field, etc.)

Made by _____
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 1950 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top. ☐

Remarks:

Captured from Chinese north of Anju. Markings are in Chinese. Close-up of markings on rate-of-fire selection lever.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2/50—5M

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DECLASSIFIED
Authority NND 985506

DECLASSIFIED
Authority NND 853506

Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Light Machine Gun
(Telephone, etc.)

Type 8mm Madsen
(Field, etc.)

Made by _____
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 1950 (Date) N. Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Captured from Chinese north of Anju. Markings are in Chinese. Close-up of markings on rate-of-fire selection lever.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ (Number) In _____ (Office)

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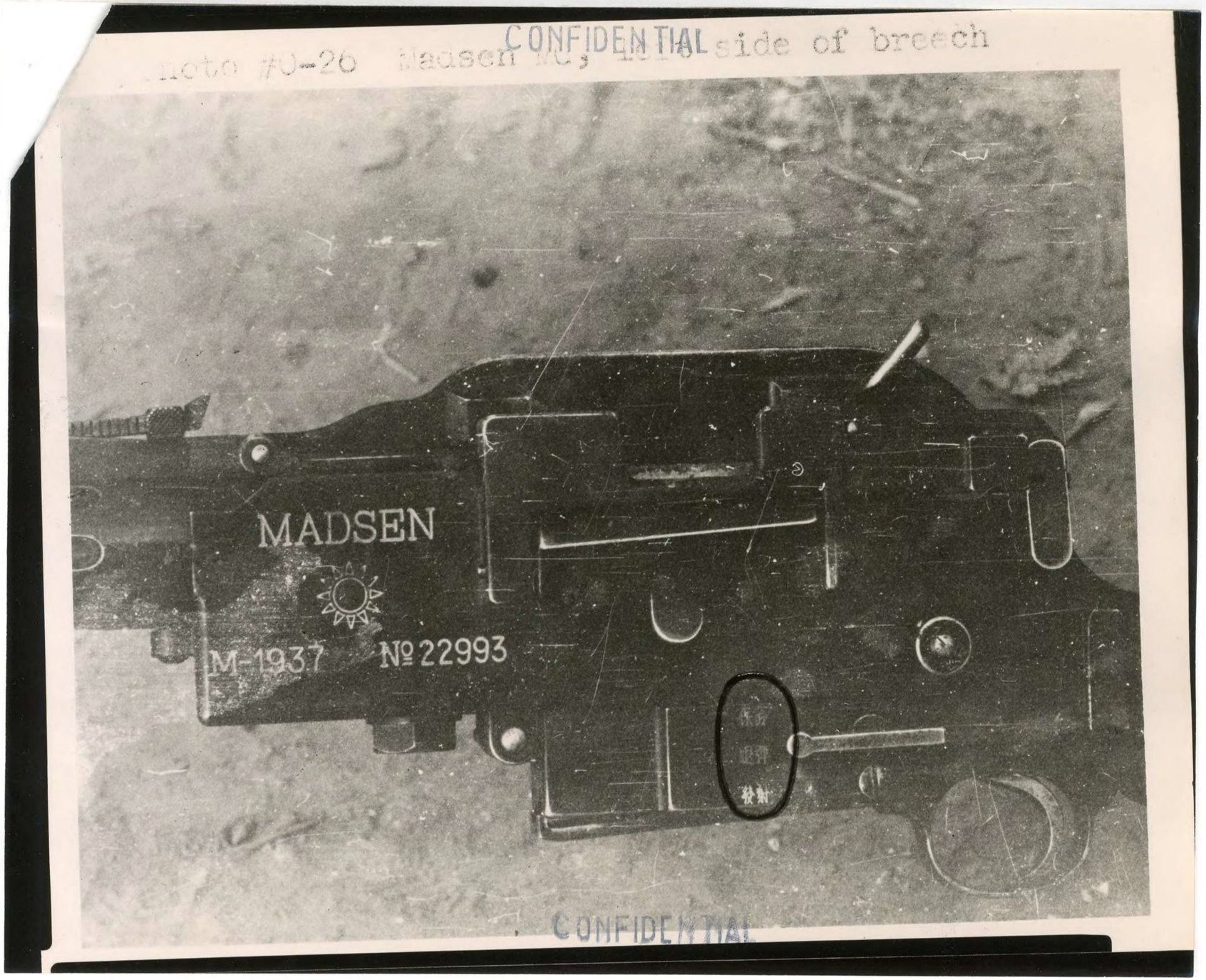
Photo #0-26 Madsen MG, left side of breech



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Authority NND 853506



CONFIDENTIAL

Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Light Machine Gun
(Telephone, etc.)

Type Gun Madsen
(Field, etc.)

Made by _____
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 1950 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Captured from Chinese north of Anju. Markings are in Chinese.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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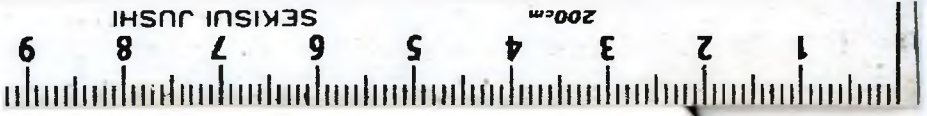
(Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2/50—5M



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Authority NND 853506

Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Light Machine Gun
(Telephone, etc.)

Type 8mm Madsen
(Field, etc.)

Made by _____
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 1950 (Date) N. Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Captured from Chinese north of Anju. Markings are in Chinese.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ (Number) In _____ (Office)

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(Classification)

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Photo #0-27 Madsen MG, left side overall view



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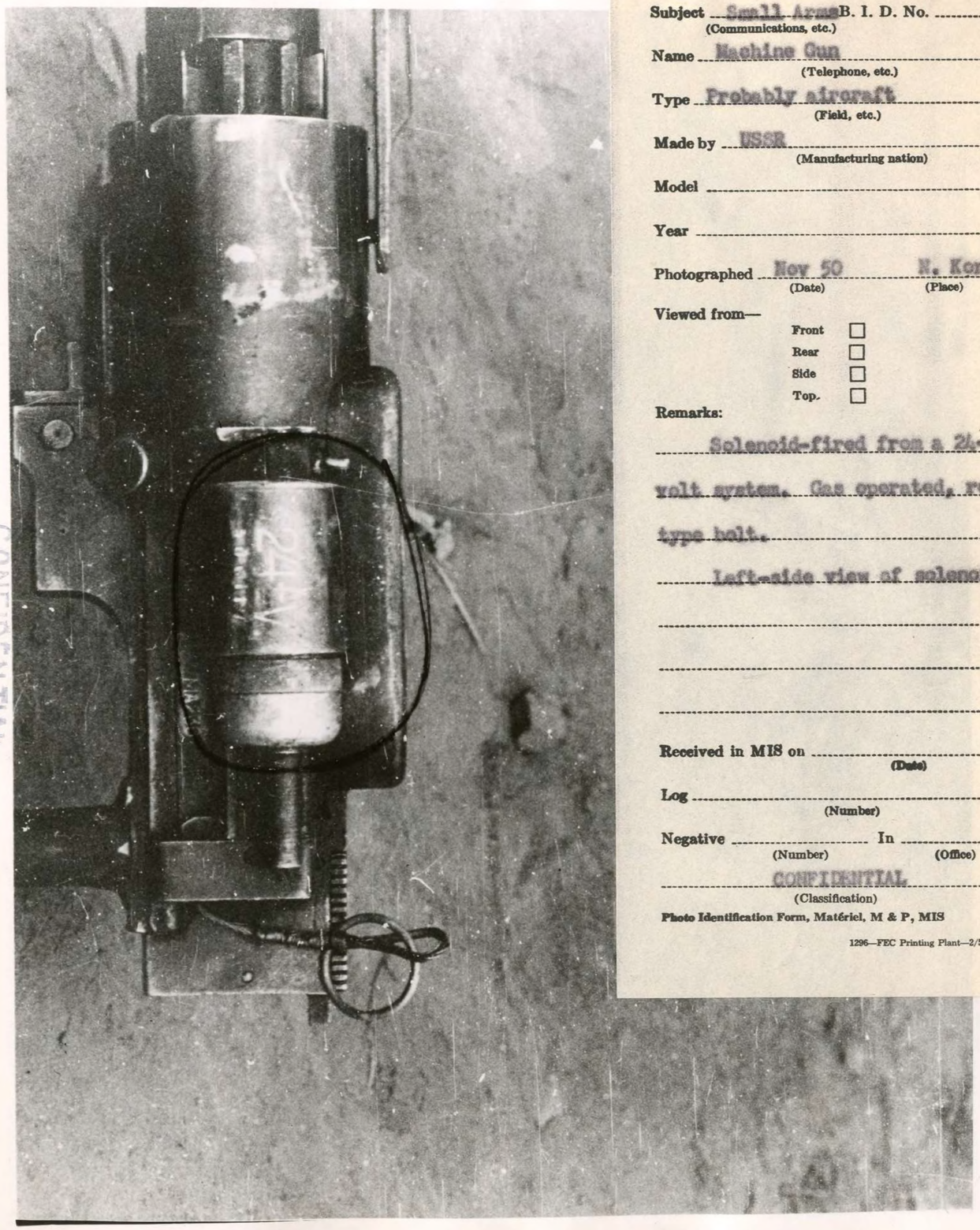

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Subject Small Arms (Communications, etc.) B. I. D. No. .....

Name Machine Gun (Telephone, etc.)

Type Probably aircraft (Field, etc.)

Made by USSR (Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 (Date) N. Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid-fired from a 24-volt system. Gas operated, rotary type bolt.

Left-side view of solenoid.

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

CONFIDENTIAL (Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2/50—5M

DECLASSIFIED
Authority NND 853506

Subject Small Arms (Communications, etc.) B. I. D. No. .....

Name Machine Gun (Telephone, etc.)

Type Probably aircraft (Field, etc.)

Made by USSR (Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 (Date) N. Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Solenoid-fired from a 24-volt system. Gas operated, rotary type bolt.

Left-side view of solenoid.

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

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1296—FEC Printing Plant—2/50—5M

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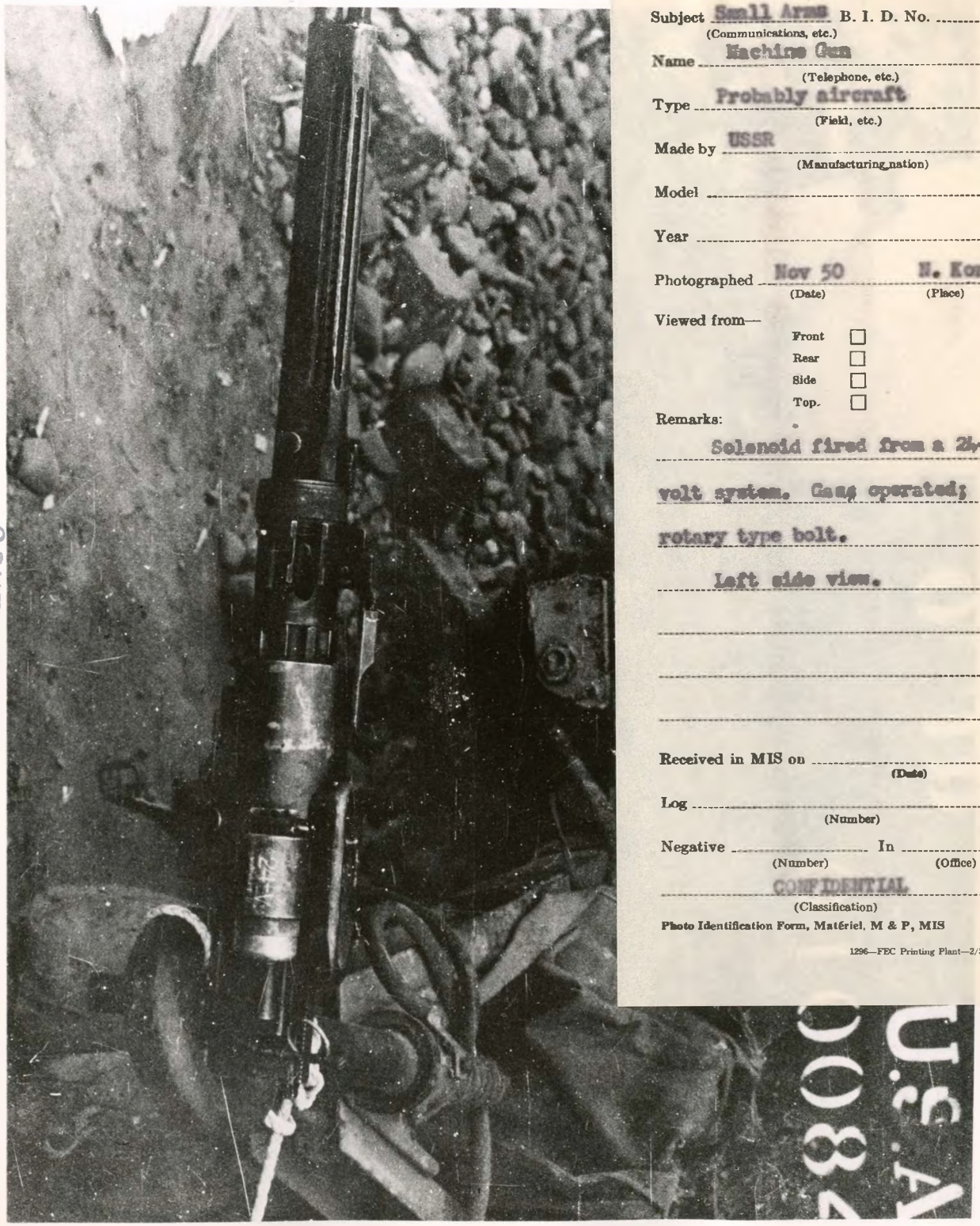
Authority NND 851506



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Subject Small Arms B. I. D. No. .....
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Left side view.

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

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(Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2/50—5M

DECLASSIFIED
Authority NND 853506

Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 50 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Left side view.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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Photo #0-29 Soviet [illegible] Left side view



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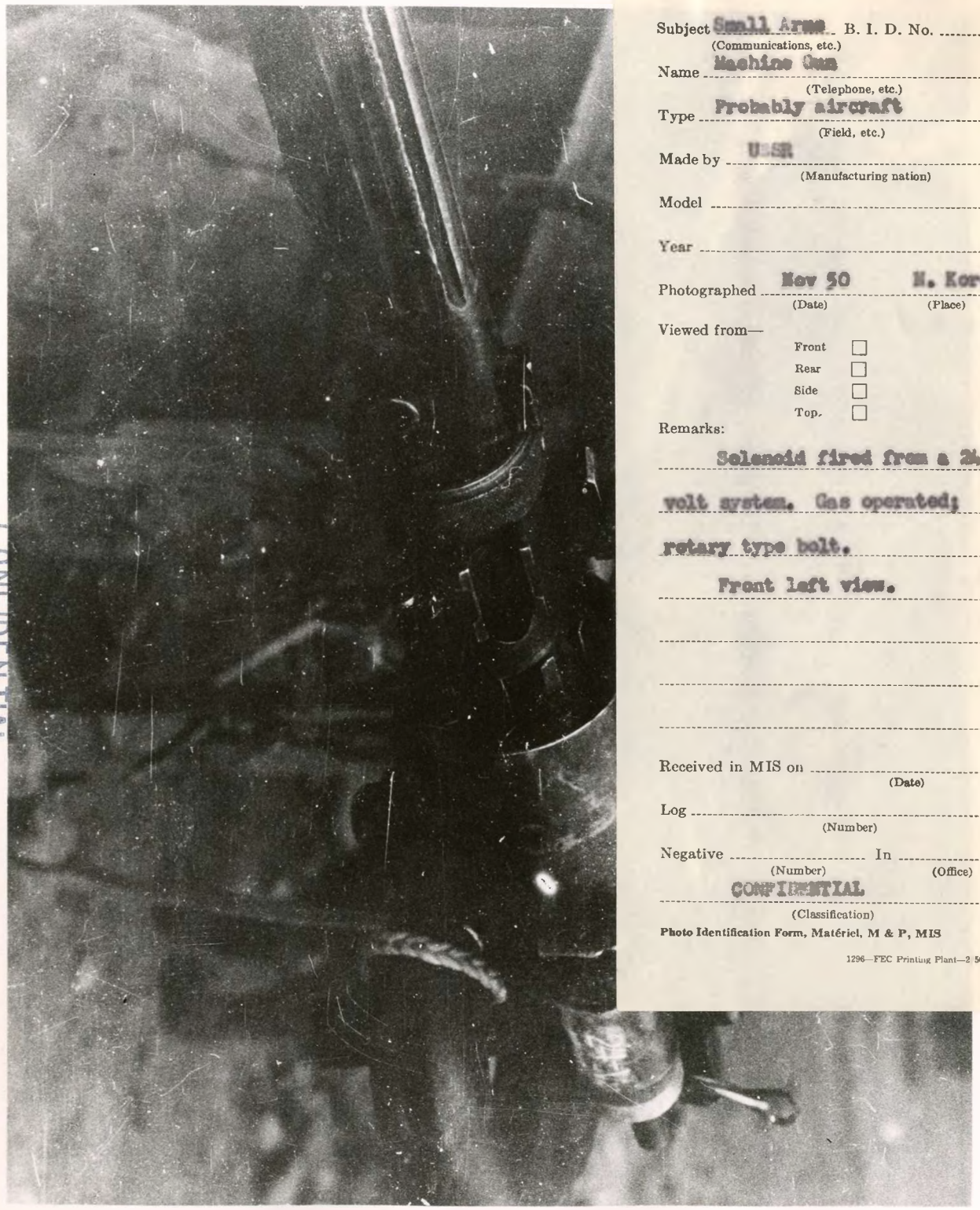

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Subject Small Arms B. I. D. No. .....
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Front left view.

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2 50—5M

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Authority NND 853506



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Authority NND 853506

Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Nov 50 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Front left view.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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1296--FEC Printing Plant--2 50—5M

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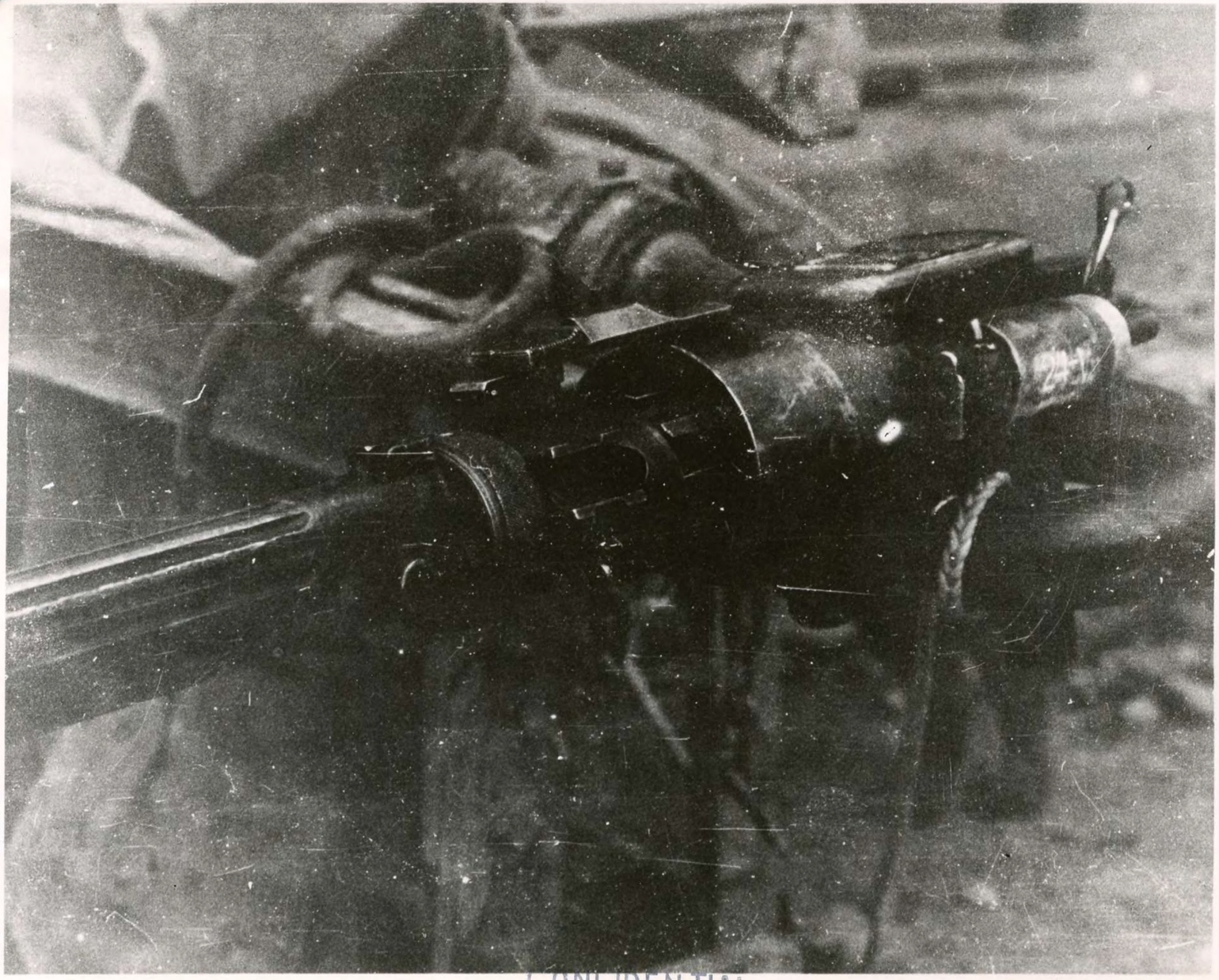
Photo 10-31 Soviet MS, Front left view



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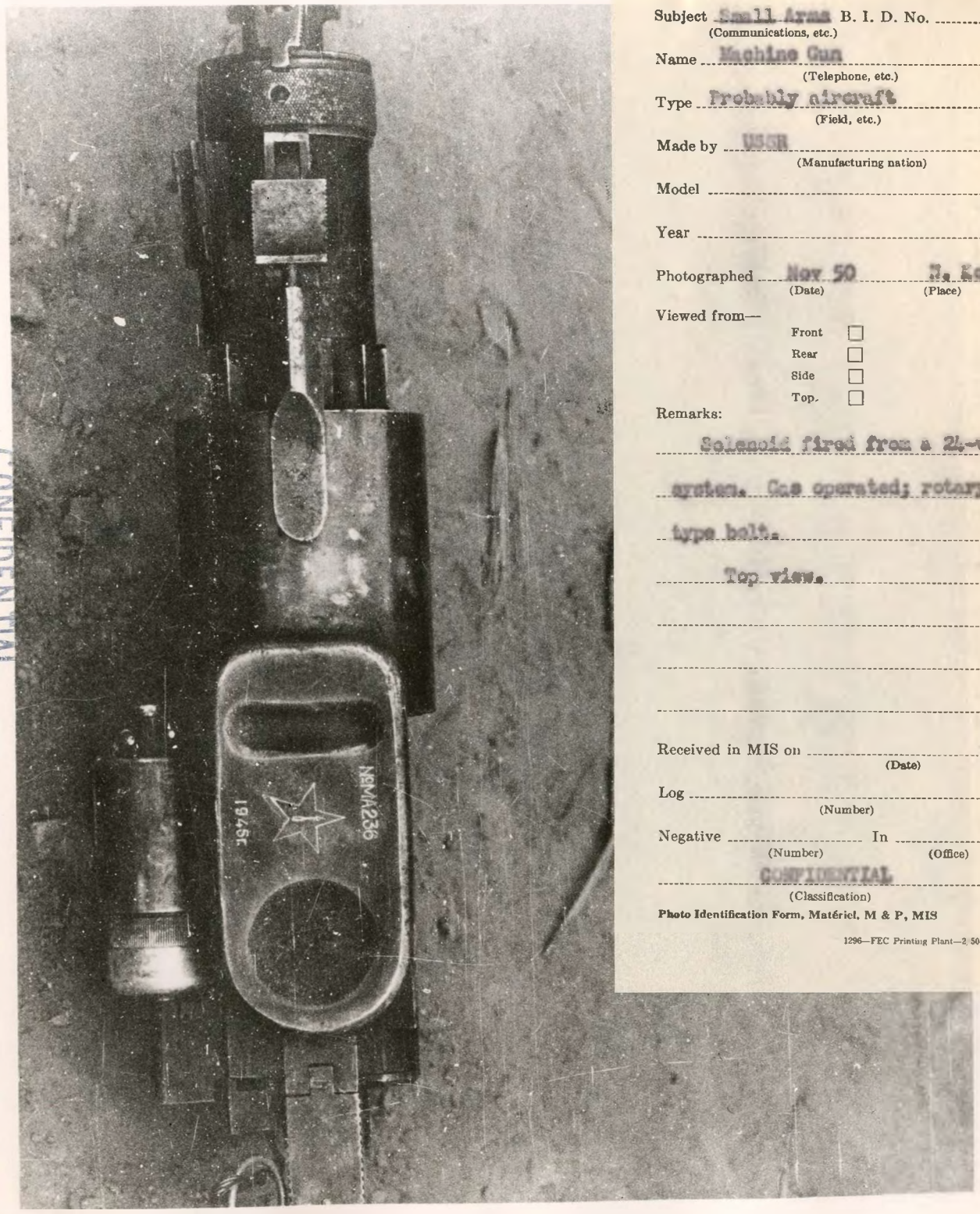

CONFIDENTIAL

Subject Small Arms B. I. D. No. .....
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 N. Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Top view.

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

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(Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 853506

Subject Small Arms B. I. D. No. .....
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type Probably aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model .....

Year .....

Photographed Nov 50 (Date) N. Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Solenoid fired from a 24-volt system. Gas operated; rotary type bolt.

Top view.

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... (Number) In ..... (Office)

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(Classification)

Photo Identification Form, Matériel, M & P, MIS

1296—FEC Printing Plant—2, 50—5M

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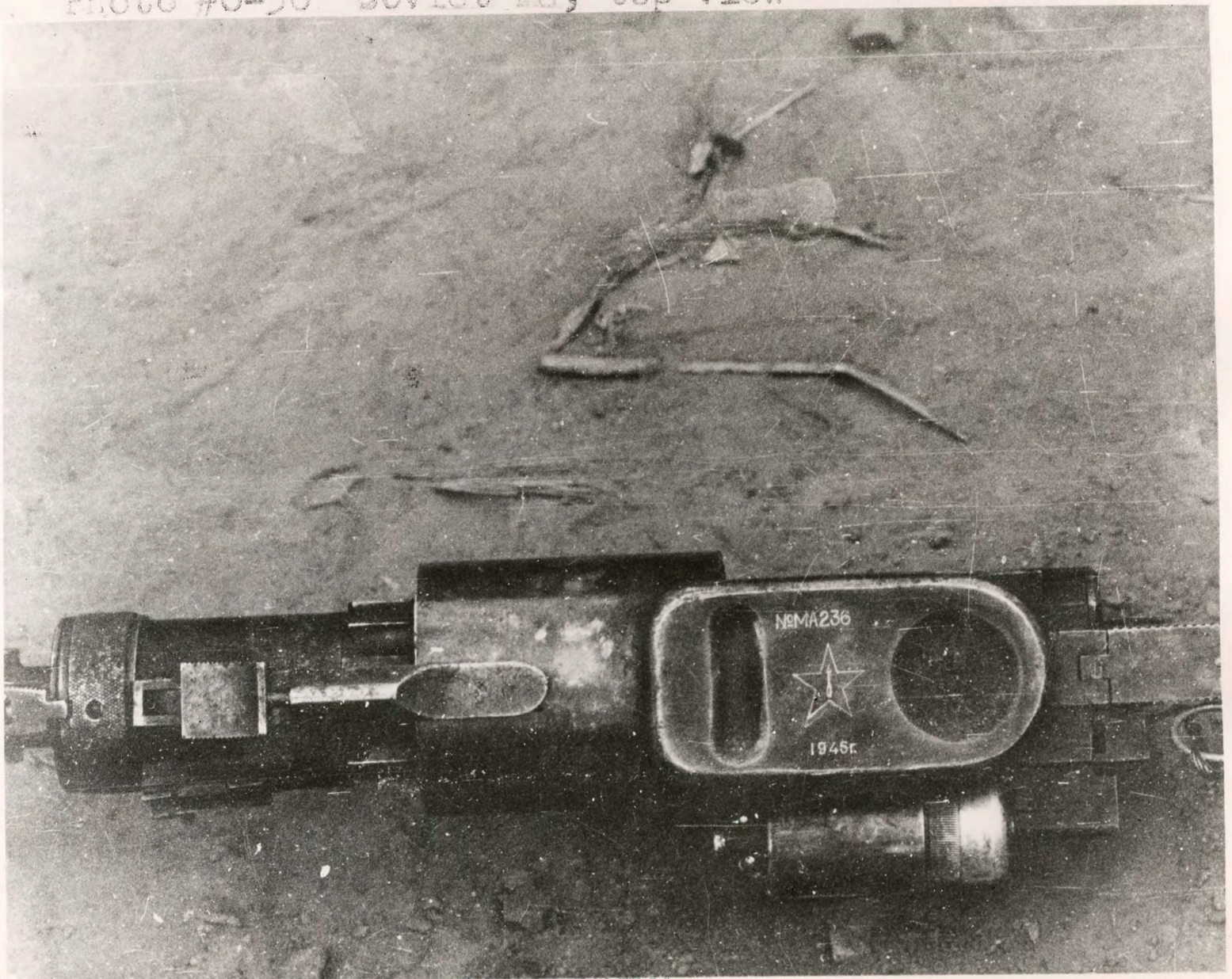
Authority NND 851506

CONFIDENTIAL

Photo #0-30 Soviet MG, top view



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Authority NND 851506

ADVATIS Special Report-012
4 Jan 51

Source of Request: Tech Intel.

ADVATIS Interrogation Report

PERSONAL DETAILS:

PW NAME: LIM KYONG SOO
PW NUMBER: 49282
RANK: Lt
AGE: 23
DUTY: Co CO
UNIT: 105th Armored Div, Technical Bn (306 Unit), 3rd Co
EDUCATION: 6 years Elementary School
OCCUPATION: Lathe Operator
PLACE OF CAPTURE: CHINCH'ON
DATE OF CAPTURE: 2 Oct 50
PLACE OF BIRTH: KOREA, HANGYONG NAMDO, WONSAN, YONG-DONG, #24
HOME ADDRESS: KOREA, HANGYONG NAMDO, WONSAN, SOMSHUNG-NI, #14
INTERROGATOR: Lt HOLBERT (ATIS)
Cpl NAGAOKA (ATIS)
DATE: 3 Jan 50

ASSESSMENT:

PW has definitely seen these two new type tanks but is not familiar with operating statistics. His memory concerning details of construction, angles and distances was fair. He appeared to draw heavily on his imagination in several instances. Reliability - fair to poor.

INTERROGATION FOLLOWING THE OUTLINES GIVEN IN D/A PUBLICATION (AC/S G-2)
"A GUIDE TO THE COLLECTION OF TECHNICAL INTELLIGENCE" DATELINED
WASHINGTON, JULY 1950, CHAPTER: ARMORED VEHICLES, PAGES 1-5

DESCRIPTION OF RUSSIAN HEAVY TANK E-64

1. Hull

A. Side View

(1) Idler wheel at front

(2) Drive sprocket at rear center drive

(3) Length of track on ground approx 5 m

(4) 3 track support rollers

(5) Track wheels measure 80 cm in diameter (6 double wheels)

(6) Track wheels in line and have track support rollers (see figure #1, a/m booklet).

(7) Track wheels were internal individually sprung.

NOTE: Crank arms cannot be seen from the outside but are visible after removing track wheels. Crank arms go through the armor into the interior of the tank.

(8) Design

(a) For plate angle see sketch #1 and #2.

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(b) Thickness of armor plate

Front slope plate - 80cm

Turret - 9cm (Front of turret slightly thicker due to gun mantlet but plate is same thickness all around.)

Turret roof - 4 cm

Thickness of front slope plate was judged by thickness of the driver escape hatch, observed while opened. Thickness of turret top was judged by thickness of the commander's hatch.

(c) Sections were all welded.

(d) Plate interlocking is not employed.

(e) For shape of nose and hull refer to sketch #3.

(9) Tank hull was rolled flat plate and turret appeared to be cast.

(10) Overall length of tank - 6 m

(11) No sponson

B. Front View

(1) Width over tracks 2.8 m

(2) Width overall Em

(3) Angle to vertical of hull above fender 40°

(4) Vertical hull below Fender plate

(5) Width of each track - 80 cm

(6) For type of hull construction see sketch #3

2. TURRET

A1 Front View

(1) Armor is cast

(2) Commander's cupola is fitted and located slightly to the rear and to the right of center.

(3) Angle of side plates to vertical is 25°

B. For plan view refer to sketch #4

C. Side View

(1) Turret roof is flat

(2) Refer to sketch #1 for shape and angle of turret front. Curved gun mantlet is external.

(3) Angle of turret rear plate to vertical: 20°-25°

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D. Mantlet is external and curved.

E. One 121 mm gun (hearsay)

(1) The gun projects one meter beyond the nose of the tank.

(2) Gun does not have muzzle brake

(3) Length of projectile is not known. Length of shell case approx 80 cm. No other details known.

(4) Fixed ammunition

(5), (6), (7) & (8) Angles of depression and elevation, performance, mount, and fire control devices unknown.

F. Auxiliary armament

(1) No coaxial machine gun

(2) There is a front hull machine gun in movable mount.

(3) No other auxiliary weapons

3. Miscellaneous

(1) E-64 powered by one 900 HP diesel engine (hearsay)

(2) Maxm road speed approx 60 km per hour. Maxm cross country speed approx 40 km per hour. The tank cannot traverse exceedingly in muddy terrain.

(3) Type of transmission is automatic. There are 6 forward speeds and 5 reverse speeds.

(4) Type of steering gear unknown.

(5) Turret can be traversed electrically or by hand. Traversed by separate engine, independent from vehicle engine.

(6) Tank is not amphibious or submersible, but can ford up to 1.3 m deep water, if bottom is solid.

(7) Official army nomenclature is E-64.

(8) Not used for bridge laying.

(9) General information:

Weight - 64 Ton
Ground Clearance - 40 cm
Number of crew - 6 men
Fuel capacity - unknown
Range of action: road - 200 km
Maxm trench crossing ability - 2.5 or 3 m
Climbing ability - 40°- 45°

Note: Normal Russian tank turrets are usually mounted on front portion of the hull, however PW stated that E-64 tank turret was mounted on rear portion of the hull. Refer to sketch #1 and #2.

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DESCRIPTION OF RUSSIAN MEDIUM TANK B-32

1. Hull

   A. Side View

      (1) Idler wheel at rear

      (2) Drive sprocket at front

      (3) Length of track on ground: 3.8 m

      (4) 2 double support rollers - 1 front and 1 rear (See Sketch #5)

      (5) 5 double track wheels, approx 60 cm in diameter.

      (6) Track wheels were in line (See figure #1 a/m D/A publication)

      (7) External vertical coil spring.

      NOTE: There are 2 smaller (diameter 50 cm) wheels, one between the 1st and 2nd andone between the 4th and 5th track wheels. (Refer to sketch #5) FW believes, but does not know definitely, that these wheels are connected with track wheels.

      (8) Design:

         (a) Refer to sketch #8 for angles of plate

         (b) Refer to sketch #8 for approx thickness of plate

         (c) Plates were all welded

         (d) Plates interlocking was not employed

         (e) Refer to sketch #8 for shape of nose and hull

      (9) Armor was cast

      (10) Overall length of tank is 5 m

      (11) No sponson

   B. Front View

      (1) Width over tracks: Approx 2.5 m

      (2) Overall width: approx 2.6 m

      (3) Angle to vertical of hull above fender 40°

      (4) Vertical hull below fender plate

      (5) Width of each track: Approx 35 cm

      (6) Refer to sketch #8 for type of hull construction

2. Turret

   A. Front View

      (1) Cast

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(2) Commander's cupola was fitted.

B. Refer to sketch #7 for plan view

C. Side View

(1) Turret roof was flat.

(2) See sketch #5 for shape and angle of turret front. Gun mantlet was external and curved.

(3) Angle of turret plate to verticle is 20°

D. External and curved mantlet

E. 85 mm Gun

(1) one 85 mm gun extending approx 1.7 m beyond the nose.

(2) Gun has muzzle brake of single baffle type.

(3) Ammo: approx 60 cm long. Muzzle velocity is unknown. High explosive and smoke and armor piercing shells were fired.

(4) Ammunition is fixed

(5) Maximum angle of elevation 30°-35°. Depression 10°.

(6) Capable of piercing 5 cm armor plate at a range of 2 km.

(7) Gun is mounted in orthodox manner with recoil system.

(8) Periscope sight

F. Auxiliary Armament

(1) No coaxial machine gun

(2) There is a front hull machine gun in movable mount.

(3) There is an anti-aircraft machine gun pedestal on back deck of the tank. This pedestal is removable.

3. Miscellaneous

(1) B-32 powered by one 600 HP diesel engine with 6 cylinders

(2) Road speed - Max 60 km per hour. Cross country speed - unknown

(3) Manually operated transmission. 6 speeds forward; number of reverse speeds unknown.

(4) Type of steering gear unknown

(5) Tank turret traversed by hand or by electricity. Operated from the vehicle engine.

(6) Fording ability - 1m. The tank is not amphibious or submersible.

(7) Official army nomenclature - B-32 (hearsay).

(8) Weight - 32 ton

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Ground clearance - approx 40 cm

Height - 2.9 m

Number of crew - 5 men

Road action range - approx 250 km

Range of cross country action - approx 150 to 180 km

Trench crossing ability - approx 2 m

Fording - 1m

Gradient - 40°

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LEGEND (Sketch 1 & 2)

1. 121 mm Gun
2. Drivers Escape Hatch
3. Commanders Cupola
4. Four way periscope
5. 360° rotating turret
6. Gun Mantlet
7. Tool Box
8. Fuel Tank
9. Hull Superstructer
10. MG Slot
11. Steel Cable
12. Idler Wheel
13. Track Wheels
14. Track Support Rollers
15. Driving Sprocket
16. Single Tracks
17. Four spare caterpillars

LEGEND (Sketches #5, #6, #7 and #8, #9)

1. Single baffle muzzle brake
2. 85 mm Gun
3. Machine Gun slot
4. Driver Escape Hatch
5. Head Light
6. 4 way periscope
7. periscope
8. Turret
9. Commanders Cupola
10. Auxiliary Fuel Tank
11. Removable AA Machine Gun Pedestal
12. Engine Cover
13. Engine Cover
14. Driving Sprocket
15. Track Support Rollers
16. Track Wheels
17. Wheel Description unknown
18. Idler Wheel

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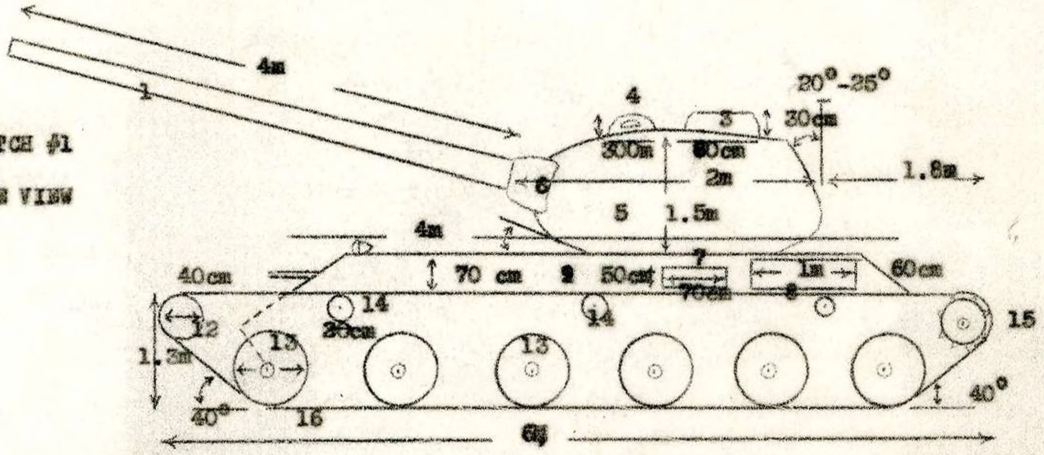
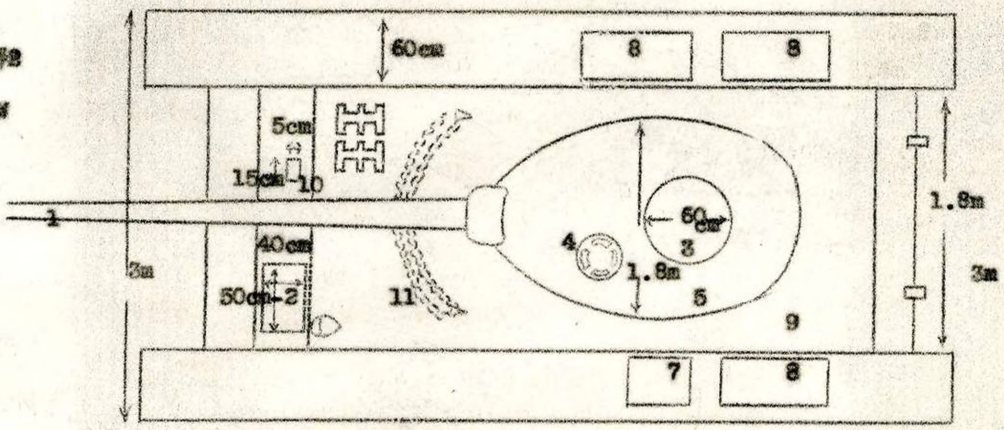
SKETCH #1

SIDE VIEW



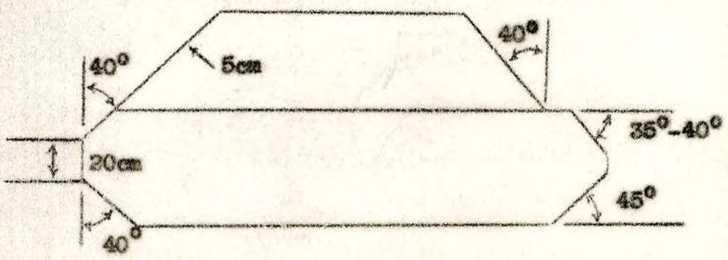
SKETCH #2

TOP VIEW



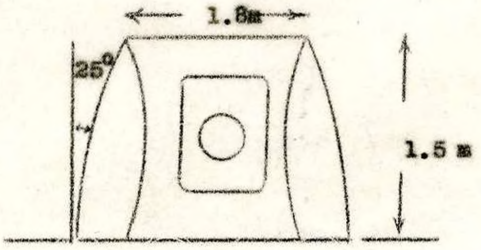
SKETCH #3

Hull Side View



SKETCH #4

Turret Front View



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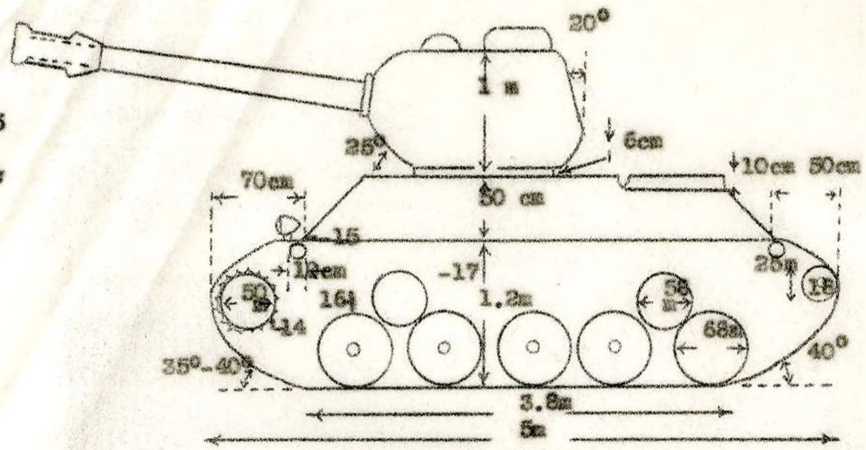
RUSSIAN TANK T-32

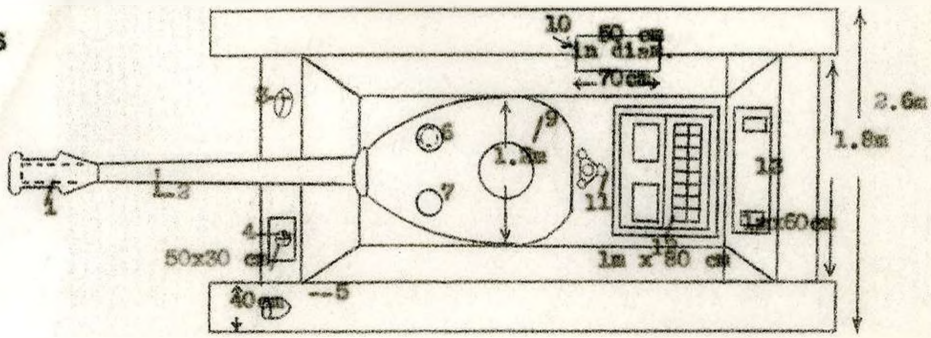
SKETCH #5

Side View



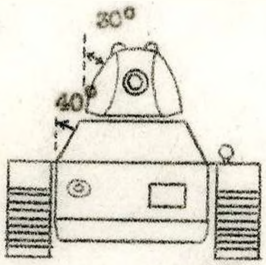
SKETCH #6

Top View



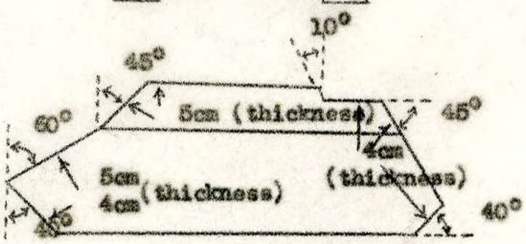
SKETCH #7

Front View



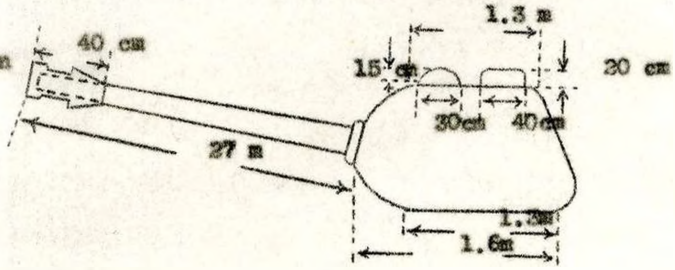
SKETCH #8

Hull Side View



SKETCH #9

Turret and Gun



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Authority NND 851506

Ordnance Technical Intelligence Report No. 509-24
(Serial Number Markings on T34/85 Tanks).

1. Here is a list of markings found on Soviet T34/85 Tanks found in Korea. All five (5) of these tanks were destroyed near the main entrance to Aseom City, Korea.

603 A 0322

I. (a) Center at junction of top and bottom frontal plates 603 11 0315

(b) Top, rear, left side of turret.

(c) Top, right side of breech. Originally two (2) rows of numbers (This row of numbers punched out) 608 T 1442

II. (a) Center, at junction of top and bottom frontal plates. 608 3814

(b) Left of center, at junction of top and bottom frontal plates. 7907 ПЦ

(c) Top, right side of breech. (Originally two (2) rows of numbers, the bottom row was punched out). (rest punched out) 608 T 1462

III. (a) Center, at junction of top and bottom frontal plates. 608 3821

(b) Left of center, at junction of top and bottom frontal plates.

(c) Top, right side of breech. Originally two (2) rows of No's. (top row punched out)

IV. (a) Center, at junction of top and bottom frontal plates. 602 ДЧ-0224

(b) Left of center, at junction of top and bottom frontal plates. 2 0038 H

(c) Top, right side of turret. Originally two rows of markings. 602 Д 0260 (top row punched out)

(d) Top, rear, left side of turret.

V. (a) Center, at junction of top and bottom frontal plates 457052

(b) Top, right side of breech. 3 ИС С55
3-1358 45Г.

END

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0400 - USSR

4/6

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Authority NND 851506

31 December 1950

MARKINGS REPORT #3

1. The following markings were obtained from four SU-76 self-propelled guns captured in North Korea above Hungnam. On each vehicle a stamped marking was found just above the driver escape hatch to the right of the hatch hinge. Painted numerals, found on three vehicles, appear to be the vehicle serial numbers, since they are similar to SU-76 serial numbers listed in captured log books. Painted numerals were found either inside the vehicle below the gun or outside the vehicle on the upper right front plate of the superstructure.

a. Serial number markings:

Vehicle	Stamped Marking	Painted Marking
1	-1801131	None
2	-181350	821416
3	P1057	741157
4	P1093	821443

b. Engine and gun markings:

Vehicle	Front Engine	Rear Engine	Gun
1	1562422	1562448	18420-1945
2	1564246	1564222	17983-1945
3	1561860	1561898	18515-1945
4	15164389	1514899	19416-1945

E N D

0400-USSR

DECLASSIFIED
Authority NND 851506

20 December 1950

Ordnance Technical Intelligence Report No. 509-25.
(Serial Numbers on Soviet T/34/85 Tanks and Soviet SU 76's).

1. This is a list of serial numbers found on Soviet T/34/85 tanks and SU 76's.

2. Where a number was purposely destroyed it is so stated in the report. Where it was impossible to read the number a question mark (?) has been inserted into the report. Where the number was under water it is so stated and where there were no numbers at all a blank is left.

3. In addition to numbers on the front center of the top frontal plate some numbers were found on the front left of the top frontal plate. These numbers are indicated as such in this report.

4. When a number was painted on the tank tur ret this number is also indicated on the report as such.

Tank No. 447

1. **Front Center**

B 3127 43954

65-700	3 709	☆ 1

Breech

3ИС - С53

4889 ⊓ 1945 Г

Tank No. 435

2. **Front Center**

223085

Front Left

100 2631

13 3

Breech 3ИС С53

3-0968 △ 1945 Г

Tank No. 243

3. **Front Center**

Ш 47121 287948		1 709	☆ 2

Breech 3ИС - С53

3-3402 △ 1945 Г

---

4. Front Center

1237

0400 USSR - X ~~To T/B file~~

T/Intell File Copy

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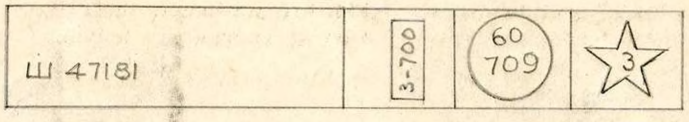
4. **Front Center**



Breech

ЗИС - С53

3-1870 △ 1945 ⌐

---

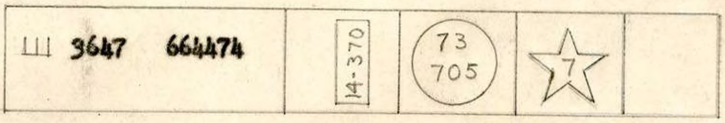
5. **Breech** **SU 76**

ЗНС3 - ??30

2077 ??? 6776

Tank No. 515

6. **Front Center**



Breech

ЗИС - С55

5-611 1945 ⌐

---

7. **Front Center** P-С-50231 7855

Breech

ЗИС С53

4028 ⌐⌐ 1945 ⌐

Tank No. 231

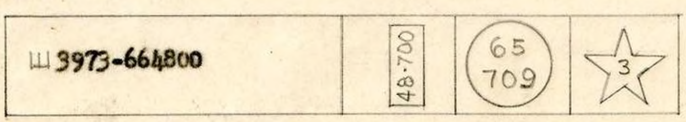
8. **Front Center** 602 ⌐ 202

Breech ЗИС С53

3-3745 1945 ⌐

---

9. **Front Center**



Breech

markings destroyed

---

13. **Front Center** 604 0501  **Tank No. 204**

Breech 3 ИС -053

1032 -Н Δ 1946

---

14. **Front Center** 400083
C8781 **Tank No. 244**

Breech

3 ИС -053

3-3164 1945

Tank No. 226

15. **Front Center** 602 260

Breech

3 ИС - 053

7581 1946

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10. Front Center Tank No. 509

457110	3-700	73 709	7

Breech

3 MC - C53

3-1639 1945

---

11. Front Center

Ш46879	687766	?	58 709	3

Breech

under water

---

12. Front Center

Ш 47029	681859	75-700	35 709	2

Breech

under water

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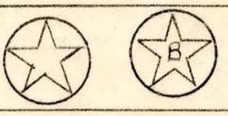
16. **Front Center**

211630 or (211G30) 

Breech

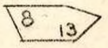
ЗИС -Q53

Б 4251 1945Г

---

17. **Front Center** **Tank No. 255**

601Г 60 **Front Left** 601Г 2461

Breech 

3-3813

---

18. **Front Center** **Tank No. 254**

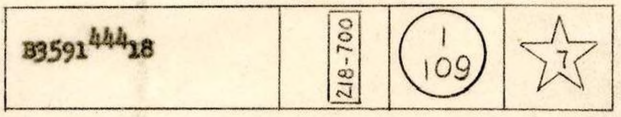
608 Г 1444 **Front Left** 607 / 3684

Breech ЗИС -Q53

7878 ⌐¬ 1946Г

---

19. **Front Center**



Breech

ЗИС -Q-53

Б-6346 △ 1945 Г

---

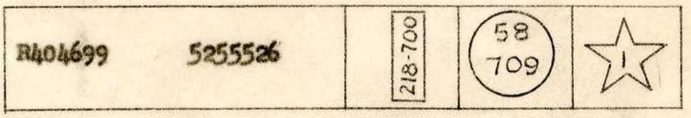
20. **Breech** **S.U.**

ЗИС -3-01-50

6752K103

---

21. **Front Center**



Breech

ЗИС -Q53

5825 ⌐¬ 1945 Г

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22. **Breech** **S.U.**

3И С -3-51-50

6832 K105

---

23. **Front Center**

602 ⌐┐ 0246 (B)

Turret, Left Rear, Top 3И С -053

0195H 1946⌐

---

24. **Front Center** 601 ⌐ 72

Front Left 6012487

Breech 3И С 055
this row destroyed

---

25. **Front Center** **Tank No. 353**

604 ⌐┐ 0498 (3)

Front Left

603170453

43/14	43/5	43/14	43/5

Breech

3 И С -053

13

0370-H △ 1945⌐

Turret, Left Rear, Top

604 ⌐ 6458

---

26. **Front Center** 603 ⌐ 406

Front Left 603 ⌐ 2806

Breech 3 И С -053

7439 ⌐⌐ 1945⌐

---

27. **Front Center** numbers destroyed **Tank No. 442**

Breech 3 И С 053

3-0268 △ 1945⌐

---

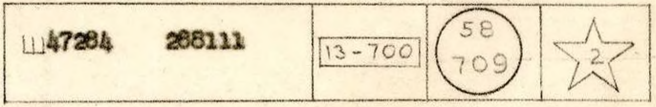
31. Front Center numbers destroyed  Tank No. 227

Breech 3 И С -053

32863-1945 Г

---

32. Front Center Tank No. 424

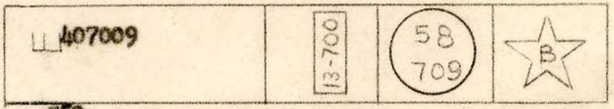


Breech 3 И С 053

6679 1945 Г

---

33. Front Center

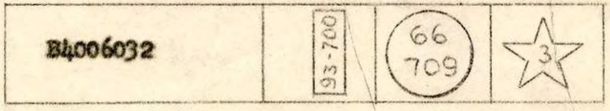


Breech 3 И С -053

6105 1945 Г

---

34. Front Center



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28. Front Center — Tank No. 444

B3056 43883		165-700	1/709	?	4

Breech

3 И 0 -053

5-5477 △ 1945 ⌐

---

29. Front Center 604 ⌐0576 (B)

Front Left 604 ⌐0572

Breech 3 И 0 0-53

1037-H △ 1946 ⌐

Turret, Left Rear, Top 604 ⌐0557

---

30. Front Center — Tank No. 408

603 ⌐0351 (B)

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Breech 3 И С -053

3-1420 △ 1945 ⌜

---

35. Front Center Tank No. 248

Ш47122 287949	178-730	58 709	2

Breech

3 И С -053

3-3019 △ 1945 ⌜

---

36. Breech 3 И С -3-51-50 (44) S.U.

4826K9550

---

37. Front Center

601B203	3-700	60 709	3

Breech 3 И С 053

3-2533 1945 ⌜

---

38. Front Center 6 02 ⌜ 276

Front Left 602 ⌜ 2639

Breech 1946 ⌜ -rest destroyed

---

39. Front Center 602 ⌜ 204 Tank No. 409

Front Left 601 ⌜ 2428

Breech (this row destroyed)

70360 (rest destroyed)

---

40. Front Center 1 ⌐ 47116 Tank No. 221

Front Left 288003

Breech 3 ОИ 053

3-3362

---

41. Front Center Tank No. 210

B3034	43861

Breech ??? 3766 ??

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42. Front Center

4901	74121726

58
708

10

Breech 3 И С -С-55

N13869 ⌋ 1945 ⌈

END

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Authority NND 851506

SECRET

24193

DO NOT DETACH
G-2, GHQ, FEC

SUBJECT: Approximate Maximum Ranges at Which Soviet Weapons Can Defeat United States Armor

FROM : G-2 ADMIN

TO :

18 Aug 1950

AC of S, G-2	( )	Theater Intelligence	(3)
Deputy, G-2	( )	Operations	( )
Ex O, FEC	( )	PDM	( )
Ex O, SCAP	( )	Foreign Mil Liaison	( )
Ex O, Admin	( )	Targets Branch	( )
Spec Asst Adm	( )	Spec Projects Br	( )
Spec Asst Th/Intell	( )	Geographical Br	( )
Spec Asst CI/DIV	( )	CI DIV	( )
Spec Asst 441st CIC	( )	Operations	( )
Spec Asst Fiscal	( )	JSOB	( )
Spec Asst Radio	( )	Coll & Pub	( )
Spec Asst JSOB	( )	441st CIC	( )
Spec Asst MIS DIV	( )	MIS DIV	( )
Spec Asst Historical	( )	ATIS	( )
Spec Asst PSB	( )	TID	( )
Japanese Liaison	( )	Historical Div	( )
Admin Officer	( )	Public Safety Div	( )
Personnel	( )		( )
	( )		( )

Info	(✓)	Approval	( )	Signature	( )	Draft Reply	( )
Action	( )	Concur	( )	Initials	( )	Info for Reply	( )
File	(3)	Comment	( )	Note & File	( )	Brief	( )

COMMENT: (Date All Comments)

18 Aug 50
1. For information only.
SS.

This can be used in conjunction with EN armor chart - characteristics etc. Publication in DIS. ←

Copy to MIS DIV, TID

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Authority NND 851506

SECRET

24193

GENERAL HEADQUARTERS
FAR EAST COMMAND

CHECK SHEET

Mr. Gerke 57-8196

(Do not remove from attached sheets)

File No:

Subject: Approximate Maximum Ranges at which Soviet Weapons Can Defeat United States Armor

Note No.

From: Ord O To: G-2 Date: 16 Aug 1950

1. Attached hereto is a copy of a letter recently received from G-2 GSUSA and an analysis table showing maximum ranges at which Soviet weapons can defeat U.S. armor.

2. Subject matter is forwarded for your information and dissemination.

1 Incl
a/s

Info copy to G-3 U. N.

24045
73

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24193

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GENERAL HEADQUARTERS
FAR EAST COMMAND

CHECK SHEET

Mr. Gerke 57-8195

(Do not remove from attached sheets)

File No: Subject: Approximate Maximum Ranges at which Soviet Weapons Can Defeat United States Armor

Note No | From: Ord O To: G-2 Date: 16 Aug 1950

1. Attached hereto is a copy of a letter recently received from G-2 GSUSA and an analysis table showing maximum ranges at which Soviet weapons can defeat U.S. armor.

2. Subject matter is forwarded for your information, and dissemination.

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Mr. Gerke 57-8196

Approximate Maximum Ranges at which Soviet Weapons Can Defeat United States Armor

Ord O G-2 16 Aug 1950

1. Attached hereto is a copy of a letter recently received from G-2 GSUSA and an analysis table showing maximum ranges at which Soviet weapons can defeat U.S. armor.

2. Subject matter is forwarded for your information and dissemination.

1 Incl
a/s

Info copy to G-2 _____ U. N. _____

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Authority NND 851506

SECRET

G-2/IT/472.94

3 AUG 1950

SUBJECT: Approximate Maximum Ranges at which Soviet Weapons Can Defeat United States Armor

TO: Commander-in-Chief, Far East
ATTN: A. C. of S., G-2
APO 500, c/o Postmaster
San Francisco, California

1. Reference is made to your cable number CX 57509 of 9 July.

2. Attached is a table giving Ordnance calculations on the approximate maximum range at which certain Soviet tank and self-propelled guns can defeat United States armor.

3. It is to be noted that the range value tabulations are rough approximations since reliable data is not available regarding either the exterior or terminal ballistic performance of Soviet armor-piercing projectiles.

4. It is to be further noted that angle of attack has been selected in each case whereby the angle of inclination of plate, as listed, can be considered as the angle of obliquity of the impacting projectile (neglecting angle of fall which is negligible). For example, the angle of attack on the front upper hull of the M24 is taken for this tabulation as 0° (the line of fire parallel to the longitudinal axis of the tank). An angle of attack, other than 0° for this condition would result in a higher angle of obliquity.

1 Incl
Table

(sgd.) A. R. BOLLING
A. R. BOLLING
Major General, GSC
Deputy A. C. of S., G-2

24045

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Authority NND 851506

SECRET

3 AUG 1950

O-2/IT/475.94

SUBJECT: Approximate Maximum Ranges at which Soviet Weapons Can Defeat United States Armor

TO: Commander-in-Chief, Far East
ATTN: A. C. of S., G-2
APO 500, c/o Postmaster
San Francisco, California

1. Reference is made to your cable number CX 87509 of 9 July.

2. Attached is a table giving Ordnance calculations on the approximate maximum ranges at which certain Soviet tank and self-propelled guns can defeat United States armor.

3. It is to be noted that the range value tabulations are rough approximations since reliable data is not available regarding either the exterior or terminal ballistic performance of Soviet armor-piercing projectiles.

4. It is to be further noted that angle of attack has been selected in each case whereby the angle of inclination of plate, as listed, can be considered as the angle of obliquity of the impacting projectile (neglecting angle of fall which is negligible). For example, the angle of attack on the front upper hull of the M24 is taken for this tabulation as 0° (the line of fire parallel to the longitudinal axis of the tank). An angle of attack, other than 0° for this condition would result in a higher angle of obliquity.

1 Incl
Table

(sgd.) A. R. BOLLING

A. R. BOLLING
Major General, GSC
Deputy A. C. of S., G-2

AUG 13 6779

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Authority NND 851506

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U. S. TANKS		Approx. Max. Ranges (yds) at which Soveit Wpns can Defeat U.S. Armor			
		76mm Tank Gun 17.7 # Proj. MV 2172 f/m	85mm Tank Gun 20.4 # Proj. MV 2598	122mm Tank Gun 55 # Proj. MV 2562	122mm S.P. Gun 55 # Proj. MV 2625
M24 (20 Tons)					
Hull					
Front Upper	1" @ 60°	1500	2000	3000	3000
Front Lower	1" @ 45°	3000	3000	3000	3000
Side-Above Fender	1" @ 12°	3000	3000	3000	3000
Side-Below Fender	1" @ 12°	3000	3000	3000	3000
Turret					
Front	1.5" @ 25°	3000	3000	3000	3000
Sides	1" @ 25°	3000	3000	3000	3000
M4A3 (35 Tons)					
Hull					
Front Upper	2.5" @ 47°	200	1300	2500	2800
Front Lower	2.5" @ 45°	200	1300	2700	3000
Side-Above Fender	1.5" @ 0°	3000	3000	3000	3000
Side-Below Fender	1.5" @ 0°	3000	3000	3000	3000
Turret					
Front	*3.5" Curved	1000	2500	3000	3000
Sides	2.5" @ 0°	2000	3000	3000	3000
M26 & M46 (46 Tons)					
Hull					
Front Upper	4" @ 46°	No	No	400	700
Front Lower	3" @ 53°	No	No	1100	1400
Side-Above Fender	3" @ 0°	1500	3000	3000	3000
Side-Below Fender	3" @ 0°	1500	3000	3000	3000
Turret					
Front	*4" Curved	500	2000	2800	3000
Sides	*3" "	1500	3000	3000	3000

* Figures shown are for hit on that portion of curve where longitudinal axis of impacting projectile would form 90° angle with tangent to curve at impacting point.

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19082

6750

385.2 Enemy

G-2, GHQ
INTER - OFFICE MEMORANDUM

(For use within G-2 only) MISD/CSM/RML/bp

File No: **Subject:** Pictures of Russian Mortar **Date:** 12 July 1950

FROM: MIS Div **TO:** T/Intel **PHONE:** 26-8578
Attn: P&E **NAME:** Capt Lovelace

Comment Number

1. Herewith (Incl 1) are pictures taken of 120mm Russian mortar captured in OSAN Area, Korea, on 6 Jul 50, and subsequently air shipped to G-2, GHQ. 1.

2. Preliminary study of this mortar indicates:
   a. That it is apparently a M-1938 mortar.
   b. That it was manufactured in 1945.
   c. That tires are a type of sponge rubber.

3. Additional information on this piece of equipment will be available in G-2 upon completion of analysis by Ordnance personnel.

1 Incl
Pictures of 120mm
Russian Mortar

CSM

- C.S.M. -

0400 USSR.

I.

15745

Permanent Record—Do not Detach

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SEKISUI JUSHI

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WO# 345

2 cc

2 negs for Dr. Smith
& enclosed prints

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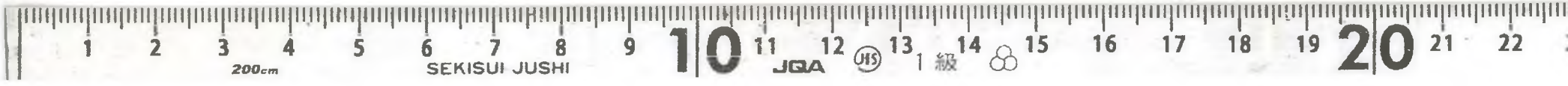
Authority NND 825150 6







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Authority NND851506

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Ok
22 Jul

G-2 GHQ, FEC
THEATER INTELLIGENCE DIVISION

12 Jul 1950

TO:

COL FORTIER
LT COL WHITMORE 2
CAPT BLOCH
CAPT BUTTERY
CWO HENRY

OPERATIONS:
LT COL COLE 3 LHC

PLANS & ESTIMATES:
LT COL DAVIDSON 4

TRAINING:
LT COL SHAW

TARGETS:
MAJ PRICE

FOREIGN MILITARY LIAISON:
LT COL WILMETH

GEOGRAPHICAL SECTION:
DR WILSON

FOR:

INFORMATION
NECESSARY ACTION
RETURN TO T/INT (EX GRP)
FILE T/Int

Two photos withdrawn

DO NOT DETACH

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Authority NND 851506

SECRET

19082

DO NOT DETACH
G-2, GHQ, FEC

SUBJECT: Picture of Russian Motor

FROM : G-2 ADMIN

TO :

12 JUL 1950

AC of S, G-2	( )	Theater Intelligence	(1)
Deputy, G-2	( )	Operations	( )
Ex O, FEC	( )	PDM	( )
Ex O, SCAP	( )	P & E	( )
Ex O, Admin	( )	Foreign Mil Liaison	( )
Spec Asst Adm	( )	Targets Branch	( )
Spec Asst Th/Intell	( )	Spec Projects Br	( )
Spec Asst CI/Div	( )	Geographical Br	( )
Spec Asst 441st CIC	( )	CI DIV	( )
Spec Asst Fiscal	( )	Operations	( )
Spec Asst Radio	( )	JSOB	( )
Spec Asst JSOB	( )	Coll & Pub	( )
Spec Asst MIS Div	( )	441st CIC	( )
Spec Asst Historical	( )	MIS DIV	( )
Spec Asst PSB	( )	ATIS	( )
Japanese Liaison	( )	TID	( )
Admin Officer	( )	Historical Div	( )
Personnel	( )	Public Safety Div	( )

Info ( )	Approval ( )	Signature ( )	Draft Reply ( )
Action ( )	Concur ( )	Initials ( )	Info for reply ( )
File ( )	Comment ( )	Note & file ( )	Brief ( )

COMMENT: (Date all comments)

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RECEIVED
12 JUL 1960
G H Q

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Authority NND 851506

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G-2, GHQ
INTER - OFFICE MEMORANDUM

31502

(For use within G-2 only)

File No: **Subject:** Intelligence/Japan **Date:** 3 October 1950

FROM: G-2 Document Research Section **TO:** ~~G-2 Division~~ Thru: JSOB **PHONE:** 26-8140 **NAME:** Mr. G. E. Aurell

T/Intell

Comment Number

Report No. 142 — 1.

The following information has been received from a reliable informant. Date of information: 25 September 1950; evaluation: B-6.

1. A V2-3 Rocket Projectile launching base is reportedly located in "ANAJIRU" (Japanese phonetics), Kamchatka.

2. Twenty Coastal Patrol boats have reportedly been detailed to SUISO TO, Kunashiri Island, Chishimi (Kuriles). They are of about 200-ton size and are equipped with one automatic canon (KIKAN HO) and six machine guns.

3. Since August 1950 the following ships are believed to have been stationed at "HITO-KAPPU" (Japanese phonetics) harbor, Etorofu Island, Chishima (Kuriles):

1 light cruiser, 3,500-ton class
1 "CHIBIRISHI" (Japanese phonetics) destroyer of 2,900-ton class
2 "RESHI-CHIERINUI" (Japanese phonetics) destroyers of 1,500-ton class

A Torpedo Boat flotilla is also believed to be stationed at "HITOKAPPU".

4. The Soviet Pacific Fleet's Submarine and Torpedo Boat flotilla bases are said to be located in "TARINSUKAYA" (Japanese phonetics) Kamchatka, Soviet Territory.

5. Among the ships of the Japanese Fleet taken over by the Soviets in September 1945, the two destroyers, KIRI and HATSUZAKURA reportedly are currently detailed to PETROPAVLOVSK, Kamchatka.

6. A Soviet Jet Fighter Unit has allegedly been stationed at the KENEBETSU Airfield, Etorofu Island, Chishima. This unit reportedly numbers thirty planes.

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Authority NND 851506

SECRET

G-2, GHQ
INTER - OFFICE MEMORANDUM

31503

(For use within G-2 only)

File No: **Subject:** Intelligence/Japan **Date:** 3 October 1950

FROM: G-2 Document Research Section **TO:** ~~G. I. Division~~ Thru: JSOB T/Intell **PHONE:** 26-8140 **NAME:** Mr. G. E. Aurell

Comment Number 1.

Report No. 143

The following information has been received from a reliable informant. Date of information: 7 September 1950; evaluation: B-6.

The Soviet Far East Air Force has allegedly constructed 19 air bases in the Chishima Group (Kuriles) and new construction is being currently undertaken in six locales.

0706 USSR

GEA

SECRET

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29211

SL5906

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Authority NND 851506

511TH ORDNANCE TECHNICAL
INTELLIGENCE DETACHMENT
APO 358

7 October 1951

SUBJECT: Technical Report 511-13

TO: Ordnance Officer
EUSAK APO 301
Attn. Capt. Hansler

1. On 25 September 1951, while engaged in the activity of locating and the plotting of the positions of enemy weapons and tracked vehicles, this unit found, on the grounds of the police station at Chungsanha-ri, Korea, a Soviet 12.7 mm Machine Gun, "UBK".

2. With the assistance of the 6004th AISS Det. 1, it was found to be of the Berezina series. And in all probability was part of the armament of the Il-10, or Ilyushin 10 Attack bomber.

3. Information as to the characteristics and ammunition data used by this caliber gun was obtained from the manual, "Characteristics and Performance Handbook, Foreign Aircraft Armament" dated 1 November 1950.

4. This report contains the following:

a. Physical characteristics of the gun

b. Disassembly and assembly of the gun

c. Data for the 12.7 mm aircraft machine gun ammunition

d. Armor penetration performance

e. Two photographs

/s/ GEORGE A. GREENHAM
/t/ GEORGE A. GREENHAM
1st Lt. Ord. Corps
Commanding

1 Incl: (4 attached lists)
(2 photographs)

12.7 mm Aircraft MG, Berezina, "UBK"
(fixed-unsynchronized)

Caliber	12.7 mm (0.500 in)	Recoiling parts	
Weight (lb)	47.20	Weight (lb)	5.2
Overall length (in)	53.00	Travel (in)	7.01
Width (in)	5.9	Direction of loading	R.H. only
Height (in)	6.3	Muzzle booster	none
Rifling		Performance	
Length (in)	35	Cyclic rate (rpm)	800-1000
No. of grooves	8	Muzzle velocity (fps)	2805-2871
Groove depth (in)	0.0066	Max. chamber pressure (psi)	44,000
Groove width (in)	0.11	Cooling	aircooled
Type	1 turn in 15 in. uniform R.H.		

0400 USSR

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The 12.7 mm "UBK" is a gas operated, aircooled, belt fed aircraft machine gun. It corporates some features of the Cal. .50 Browning, but with variations. The feed takes place from the right hand side of the gun, and is not interchangeable. It is, however, orthodox in current feed practice including the use of a disintegrating metal linked belt. At this point the first major change is observed. The metal links contrary to common practice, with a R. H. feed, fall away downward and to the R.H. side of the gun. The cartridge cases follow the more normal practice of ejection from the left side of the gun.

The "UBK" is charged pneumatically. The air control valve may be operated electrically or mechanically from a push button mounted in the cock pit.

Cyclic rate is adjusted by means of four settings on the gas jet, 3.2, 3.0, 2.8, and 2.6 mm.

Firing the gun is subject to the overriding control of the synchronizing gear. The actual triggering is pneumatic, operated electrically from a push button on the control stick, under a safety cover.

The recoil and counter recoil of the moving parts is orthodox in principle and exhibits no outstanding features. Locking is accomplished by a sliding wedge that is forced into a recess in the breech block prior to firing.

There is a spring gun mount for this weapon. The forward part of the gun is supported flexibly in the mount by two trunnions on the receiver. The rear end of the weapon incorporates a sliding plate moving in a rigid yoke.

12.7 mm Aircraft MG, Berezina, "UBK"
Dismassembly and assembly

To disassemble:
Remove spring gun mount from gun by taking out the set screws from each of the trunnion locking bolts. Unlock the trunnion locking bolts by giving each a three-quarter turn counter-clockwise. Slide the gun to the rear and off the mount.

Unlock the back plate by disengaging the spring lever retaining pin and turning it to the left. Slide back plate right to left and off.

Slide the sear assembly housing to the rear and off.
Remove the following parts in this order:
Triggering assembly retaining pin.
Triggering assembly housing.
Charger arm and slide.
Piston and bolt carrier connector.
Bolt and bolt carrier.
Breech lock.
Feed slide.
Receiver barrel lock.
Barrel and attached gas system assembly from receiver.
Belt feed slide bracket.
Belt feed assembly housing.
Gas system assembly from the barrel.

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To assemble:

Replace the parts in this order:
Belt feed assembly housing.
Belt feed slide bracket.
Attach gas system assembly to barrel.
Replace barrel and gas system assembly into the receiver.
Receiver barrel lock.
Breech lock.
Bolt carrier and bolt.
Attach connector to bolt carrier and piston.
Pneumatic charger arm and slide.
Triggering assembly housing.
Insert retaining pin connecting charger arm to triggering assembly housing.
Sear assembly housing
Back plate.
Replace gun on to spring gun mount.

12.7 mm Ammunition Data
Aircraft Machine Guns

Complete Rd.	API	BZR-46 (API Phos)	APIT BZT	Inc. "Z"	HEI
Weight (gr)	1914-2068	2043	1971	1929-2053	1932
Length (in)	5.73-5.79	5.77	5.79	5.73-5.79	5.66
Projectile					
Weight	707-721	721	705	679-691	597
Length	2.48-2.52	2.52	2.5	2.51-2.54	2.12
Rotating band material	none	none	none	none	none
Type of fuse	none	none	none	none	none
A.P. Core					
Weight (gr)		275	243.8	none	none
Dia. (in)	0.43		0.43		
Material		hardened steel	hardened steel		
H. E. Filler	none	none	none		
Weight (gr)					22.2
Incend. Filler					
Type	Ba (NO_3) 2 Al., Mg.	Phosphorous	Ba (NO_3) 2 Al., Mg.		
Weight (gr)	16.1	16.5	15.1		20.8
Tracer					
Len. of trace			2600 yd		
Propellant					
Type powder	pyroxyl smokeless		pyroxyl smokeless	pyroxyl smokeless	pyroxyl smokeless
weight	270-293	244	262	270-293	252
Cartridge case					
Type	rimless	rimless	rimless	rimless	rimless
Weight(gr)	1003	1003	1003	1003	1003
Length (in)	4.24-4.25	4.24-4.25	4.24-4.24	4.24-4.25	4.24-4.25
Base Dia (in)	0.85	0.85	0.85	0.85	0.85
Material	brass	brass	brass	brass	brass
Vol. (cu in)	1.40	1.40	1.40	1.40	1.40
Primer		perc	perc	perc	perc
Composition	*	*	*	*	*
No of vents	2	2	2	2	2
Crimping					
Method	segment 2 rows	segment 2 rows	segment 2 rows		segment 2 rows

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Performance					
M.V. (fps)	2838-2887	2580	2887-2936	2838-2887	2400
Muzzle Energy		10,646		12,174	7,628
Lubrication	None	None	None	None	None

API-After penetration 75% of the rounds ignite.

2/ -When fired at gas containers protected by two one-inch boards no less than 80" of hits should ignite.

* The primer composition of these rounds is made up of: Mercury fulminate 16%, Potassium chlorate 55%, and Antimony 28.5%

12.7 mm Ammunition Data
Aircraft Machine Guns

The following is the armor penetration performance of the 12.7 mm API round and the 12.7 mm APIT-BZT round:

For the API round			For the APIT-BZT round		
Range Yds	Armor Thickness	Striking Angle Degrees	Range Yds	Armor Thickness	Striking Angle Degrees
110	0.886	90	110	0.79	90
330	0.787	90	330	0.63	90
110	0.472	30	110	0.39	30
330	0.039	30	330	0.31	30

END

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Authority NND 951506





Subject Small Arms B. I. D. No. _____
(Communications, etc.)

Name Machine Gun
(Telephone, etc.)

Type 12.7mm, Aircraft
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model Berezina "UBK"

Year _____

Photographed Sept 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☒
Top ☐

Remarks:

Right side facing

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Materiel, M & P, MIS

18313—FEC P&PC—10/51—5M

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Authority NND 851506

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SECRET

511TH ORD TECH INTEL DET
I CORPS APO 358
Soviet, 12.7mm Aircraft MG, Berezina, "UBK"
Right side facing
Photo by 51st Sig Bn

SECRET

DECLASSIFIED
Authority NND 951506

SECRET

Subject Small Arms B. I. D. No. .....
(Communications, etc.)

Name Machine Gun .....
(Telephone, etc.)

Type 12.7mm, Aircraft .....
(Field, etc.)

Made by USSR .....
(Manufacturing nation)

Model Berezina "UBK" .....

Year .....

Photographed Sept 51 (Date) Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☑
Top ☐

Remarks:

Left side facing .....

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Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

Secret .....
(Classification)

Photo Identification Form, Matériel, M & P, MIS

18313—FEC P&PC—10/51—5M

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Authority NND851506



DECLASSIFIED
Authority NND851506

SECRET

511TH ORD TECH INTEL DET
I CORPS APO 358
Soviet, 12.7mm Aircraft MG, Berezina, "UBK"
Left side facing
Photo by 51st Sig Bn

SECRET

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Authority NND851506

WITHDRAWAL NOTICE

ACCESS RESTRICTED NND851506 468

The item identified below has been withdrawn from this file:

File Designation U.S.S.R. 0400 WEAPONS
RPT. TB-2333-51

Date 8 September 1951

From 8244 ARMY UNIT

To —

In the review of this file this item was removed because access to it is restricted. Restrictions on records in the National Archives are stated in general and specific record group restriction statements which are available for examination. The item identified above has been withdrawn because it contains: 1|2|5

☒ Security-Classified Information

☐ Otherwise Restricted Information

NSA
Authority

1/29/85
Date

GENERAL SERVICES ADMINISTRATION

GSA FORM 7117 (2-72)

GSA DC 72-10421

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Authority NND 951506

GENERAL HEADQUARTERS
FAR EAST COMMAND
Office of the Chemical Officer

1 October 1951

TECHNICAL INTELLIGENCE REPORT

SOVIET 150-POUND WP-FILLED AERIAL BOMB

I Situation

On 14 August 1951 a WP-filled aerial bomb bearing markings in Russian script was found in the 3d Infantry Division sector of Korea. Report of the investigating officer follows:

II Exhibits

a. The bomb was forwarded to the 42d Chemical Laboratory Detachment for examination and chemical analysis of its contents. The results of the examination are included in this report.

III Report of Examination

a. Examination and analysis indicate that the bomb is of Soviet origin, contained approximately 95 pounds of WP and closely resembles the Soviet General Purpose 220-Pound (Welded) Bomb.

IV Remarks

None

-- - - - - -

COVER PAGE

Report #34

CMTR Number 5-1

17 August 1951

CMTR: WP filled bomb (probable Soviet origin)

Report made by 51st Chemical Technical Intelligence Detachment

Location of Reporting Unit - Taegu Korea

- - - - - - - - -

WP filled bomb (probable Soviet origin)

I. INTRODUCTION

A. On 14 August 1951 the 51st Cml TID was informed by Technical Intelligence Coordinator G-2 EUSAK that a WP filled bomb had been recovered in 3rd Inf Division Section.

B. Basis for Investigation: to secure all possible information on following Dept of Army Specific Requests for Information:

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1. Control No. CW-732, Chemical Materiel, North Korea
2. Control No. CW-733, Chemical Materiel, China

II. DESCRIPTION of CAPTURED MATERIEL (see attached photo)

A. One bomb whose general appearance resembles the Soviet GENERAL PURPOSE 220 LB (WELDED) BOMB, with small variations in dimensions.

B. Dimensions

1. Body length: approx 30.25 inches
2. Overall length: " 41. "
3. Max. diameter: " 11. "
4. Tail unit: length approx 13 1/2 in. width 8 1/2 in.
5. Weight: approx 149 lbs.

C. Filling: WP (white phosphorus)

D. Body Construction: The body is formed of a heavy cast steel nose section, a cylindrical main body section, and a conical base section. The nose and base sections are welded to the main body section. The nose fuze adapter consists of a machined steel ring which is screwed to the nose section. The ring is threaded internally to receive the fuze. There is no provision for a tail fuze.

E. Tail Construction: The tail unit consists of four vanes welded to the conical base section of the bomb body. Struts are welded between the vanes to form a square box.

F. Suspension: Single point. Suspension lug fastened to bomb body by means of a bolted circular band.

III. MARKINGS

A. Body of bomb appears to have been painted black originally but very little paint remained at time of recovery.

B. One white band on body below ogive.

C. One green band on body below white band.

D. Stamped near suspension lug on the circular steel band: 735-П-16 44

E. Stamped on nose near fuze well: 13 98 44

F. Stamped on nose fuze adapter: 735

G. Numerals stamps on filling plug illegible due to hammering.

IV. DETAILS OF INVESTIGATION

A. Sub-team BAKER, 51st Cml T.I.D. investigated and contacted 3rd Inf DIVISION DAO Section (Major DETMAN) and 512 Ordnance Technical Intelligence Detachment. Following information was obtained: o/a 11 August 1951 an infantry patrol from 65th Inf. Reg't 3rd Inf. DIV. discovered the bomb at (T-580475 VIC village of CHIAM-NI (approx 40 miles NE of UIJONGBU). Apparently the bomb was towed and left about 45 feet from a wooden bridge.

B. The fuze-well was filled with TNT similar to that being presently used by the enemy (OCF). There were seven (7) non-electric blasting caps in the booster. The caps were given to Capt. Cole of Engineer Tech Intell Det. A fuze adapter was found near the bomb but no fuze. A Soviet type AMA fuze fits the adapter.

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C. During the disarming and examination of bomb by Ordnance personnel the WP started to burn spontaneously when filling plug was removed so sand and water were put in thru the filling plug. It should be noted by personnel examining contents of bomb subsequent to this report that the moist sand was not in the bomb when originally discovered.

V. DISPOSITION

A. Disarmed bomb being shipped via AIR to 43rd Ord Laboratory Det Camp Ojime (Japan) APO 43 for further study.

VI. SUMMARY

A. One WP filled bomb (of probable Soviet origin) weighing approx 149 lbs was recently recovered from CCF o/a 11 Aug 51 at CE 880 475 by an infantry patrol of 65th Inf Regt, 3rd DIV.

B. Although the bomb is of aerial type it was obviously not dropped from air but intended for use as incendiary and demolition as indicated by the modification with blasting caps instead of the usual fuze. Also the location of bomb near wooden bridge.

E N D

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Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Diagram of bomb.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Diagram of bomb.

Received in MIS on _____
(Date)

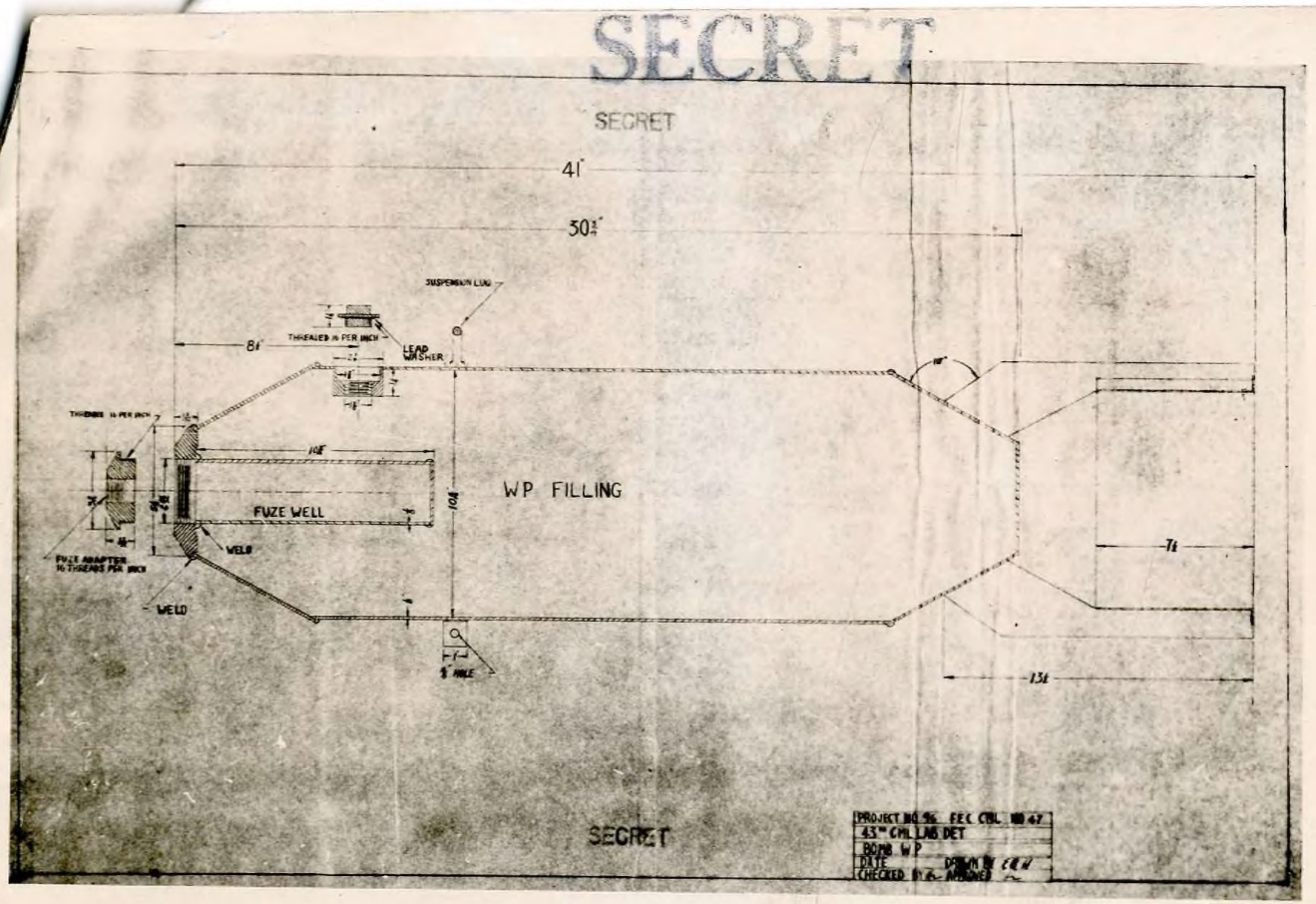
Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Markings on suspension band.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Markings on suspension band.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 851506



Project 96



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Aerial Bomb (Telephone, etc.)

Type White Phosphorus (Field, etc.)

Made by Probable USSR Origin (Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 (Date) Japan (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Markings on bushing.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Markings on bushing.

Received in MIS on _____
(Date)

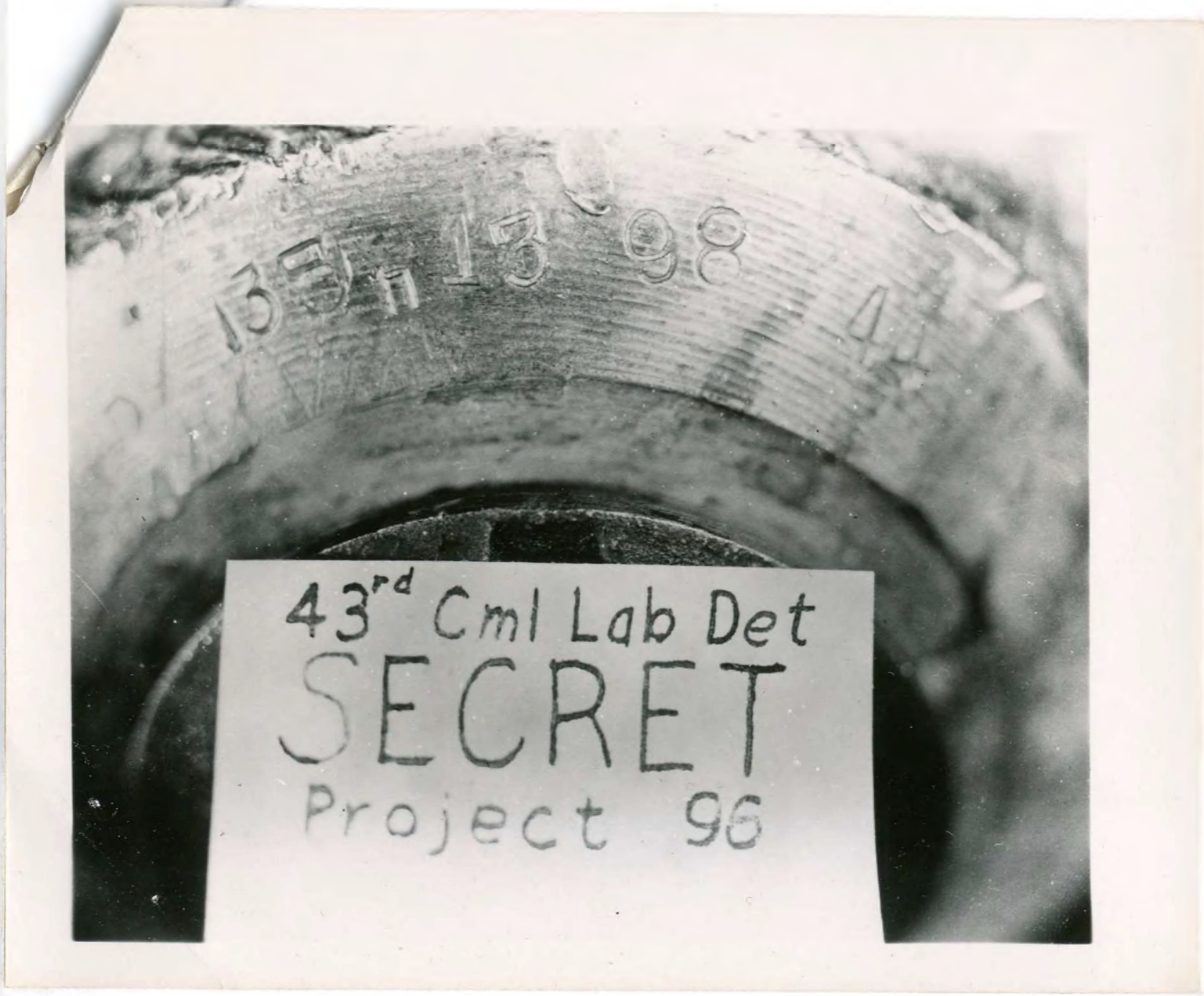
Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506



DECLASSIFIED
Authority NND 951506



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Aerial Bomb (Telephone, etc.)

Type White Phosphorus (Field, etc.)

Made by Probable USSR Origin (Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 (Date) Japan (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Markings on Fuze Adapter.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Markings on Fuze Adapter.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Materiel, M & P, MIS

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Top view of filler plug showing markings.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep 51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Top view of filler plug showing markings.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep51 Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Side view of bomb showing filler plug.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed Sep5[illegible] Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Side view of bomb showing filler plug.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

SECRET



43rd Cml Lab Det
SECRET
PROJECT 96

SECRET

DECLASSIFIED
Authority NND 851506

Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Aerial Bomb (Telephone, etc.)

Type White Phosphorus (Field, etc.)

Made by Probable USSR Origin (Manufacturing nation)

Model _____

Year _____

Photographed August 1951 (Date) Korea (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Side view showing filler plug.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed August 1951 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Side view showing filler plug.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 851506



SECRET

Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Aerial Bomb (Telephone, etc.)

Type White Phosphorus (Field, etc.)

Made by Probable USSR Origin (Manufacturing nation)

Model _____

Year _____

Photographed August 1951 (Date) Korea (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Left front quarter-view showing fuze well and filler plug.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, I & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aerial Bomb
(Telephone, etc.)

Type White Phosphorus
(Field, etc.)

Made by Probable USSR Origin
(Manufacturing nation)

Model _____

Year _____

Photographed August 1951 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left front quarter-view showing fuze well and filler plug.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, I & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 851506

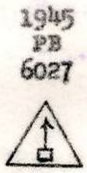
HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

20 September 1951

SUBJECT: Markings from Captured Enemy Materiel
Reports Control Symbol, ID 47/1

1. This report is based on information contained in markings reports received from the Technical Intelligence Coordinator Team, ROK I Corps.

Soviet Carbine, M1944



Soviet Light Machine Gun, 7.62mm DP











North Korean Sub-machine Gun, PPSH, 7.62mm





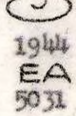
Soviet Sub-machine Gun, 7.62mm PPSH











0400 USSR
7042

DECLASSIFIED
Authority NND 851506


1944
АЗ
5169

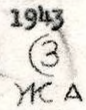

1944
АП
4645

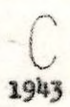

1944
ИБ
3547


1944
ГЕ
9126


1944
ЛБ
5725


1945
БГ
5195


1943
ЖА
3346


1943
ОР 770

1942
БА
1682

1943
БЖ
2447

БА
5021


1943
АГ
7262


1944
ИР 538


1942
ЗЯ
923


1945
ГГ
1663

1943
ЛЖ
6767


1944
АВ
8796

1944
ЗА
5880

1944
ВЕ
8997

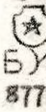

1944
ВБ
9997


1943
БА 3935

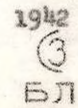

1942
КН 855

1944
ИА
5487


1943
ЛЖ 3693


1943
БЖ
8775


1943
АВ
7375


1942
БЛ
6290

Soviet Submachine Gun, 7.62mm PPS M1943

DECLASSIFIED
Authority NND 851506

Soviet Rifle, 7.62mm, M1891/30

1940
ПГ 7669



1933
21495



1933
28326



1934
21905



1933
19906



1938
УК 6054



1933
3354



1938
01798



1943
ОР 5937



1944
РО 524



1938
79163





1932
11734



1935
00649





1934
24374

1943
КГ 13645



1931
65436

1945
ФХ 1789



1938
СШ 1634



1939
ДГ 3906



1939
УСУ 2215



1934
34532



1938
ДВ 1234



1951 (aic)
23608



1933
39802



1937
128063





1938
21607

1948
РИ 1368



1938
114038



DECLASSIFIED
Authority NND 851506

1932
38682



1937
515
P
4



1939
АГ 5039



1942
БГ 7165





1942
БУ 342

1933
ЯМІ
310





1944
МИ
751

1933
82990





1939
ЖУ 2215



1932
101585

1938
ПЩ 1348



END

DECLASSIFIED
Authority NND 851506

528-T.2 28 September 1951

SUBJECT: Captured Enemy Hand Grenade

1. The attached photographs are of a fragmentation hand grenade captured from North Korean Forces by the 5th Regt, 1st Marine Division. The circumstances surrounding the capture are unknown.

2. The grenade is similar in design to the Soviet F-1 Defensive Hand Grenade with the following exceptions:

a. The grenade has a metal screw in the base.

b. A hard rubber plug is in the detonator well which is presumed to be a shipping plug.

c. There are no markings of any nature on the grenade.

3. There are forty (40) serrations on the grenade, which is filled with an explosive which appears to be cast TNT.

4. The standard U.S. practice grenade has a similar design, in-as-much as the base is bored and tapped to facilitate reloading with a reduced charge for training purposes. It is possible that the North Korean Forces may be utilizing the practice grenade with a metal screw plug and standard explosive filler in lieu of the standard type of grenade.

5. The grenade is being turned in to the Army Ordnance Technical Intelligence Coordinator.

E N D

8753

DECLASSIFIED
Authority NND 851506

528TH ORDNANCE TECHNICAL INTELLIGENCE DETACHMENT
APO 909, c/o Postmaster
San Francisco, California

18 September 1951

SUBJECT: Soviet 76-mm Mountain Gun Model 1909
(528th-T-1)

1. Three (3) Soviet 76-mm Mountain Guns (Howitzer) Model 1909 were captured at DT405194 and DT 375185 by the 38th Infantry Regt of the 2nd Inf Division on 3 or 4 September 1951 from North Korean Forces. The Breech Block and Sights are missing on two weapons and the Breech Block, Recoil Mechanism, Wheels, Axle, and Sight are missing from the third weapon. One (1) weapon is being kept by the 2nd Inf Div and one (1) by the 38th Inf Regt of the 2nd Inf Division for instructional purposes. The third weapon is presently located at the 702nd Ordnance Maintenance Company and will be shipped to the 533rd Ordnance R&C Company at Mason, Korea.

2. All markings that were obtainable from the three weapons are as follows:

Gun # 1, located at 2nd Infantry Division:

Sight Mount:

Г N292 БА

[У]

3" ___ 13г

N2 ___ 17

Elevation Scale:

3" ___ 13г

N27 ___ 17

Gun #2, located at 38th Infantry Regt of 2nd Infantry Division:

Tube: [г] 142 [г] 167 _ 174 _ 202

Carriage: (PLATE) [206]

Recoil mechanism complete on Gun # 2.

Sight Mount:
ФУГАСН ГРАНАТЫ
N № 2 . 31К
№ 2709
1935 г

0400 USSR

SECRET

7632

DECLASSIFIED
Authority NND 851506

Gun # 3, located at 792nd Ordnance Maintenance Company:

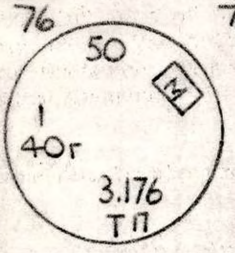
Tube: 582

3. Five (5) complete rounds of HE ammunition for these weapons has been shipped to Heunde Ammunition Depot. The projectiles are the same as those used in the Soviet 76-mm AT Gun Model 1942 and the weapon of the Soviet SU-76, but the cartridge case is shorter and therefore has a smaller propelling charge. The standard Soviet KTM-1 fuse is used.

The markings from the ammunition is as follows:

Projectile	Reverse side	Casing
AГ/80	835	40-352
B - 53	186045	76-09
O-P-350	76	7/14 ГРИСМ G 43
		9-B-53

Base of Case —



4. These are the first weapons of this type to be encountered in Korea. Complete physical data on this weapon may be found on pages 11 and 12 of DA Pamphlet No. 30-4-1 on Foreign Military Weapons and Equipment dated 1 January 1951.

END

DECLASSIFIED
Authority NND 851506

Subject Artillery B. I. D. No. _____
(Communications, etc.)

Name Gun (Howitzer)
(Telephone, etc.)

Type 76mm
(Field, etc.)

Made by Czarist Russia
(Manufacturing nation)

Model 1909

Year _____

Photographed 15 Sep 51 Korea
(Date)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Head-on view

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

18313—FEC P&PC—10 51—5M

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SEKISUI JUSHI
JGA
1 級

DECLASSIFIED
Authority NND 851506

Subject artillery (Communications, etc.) B. I. D. No. _____

Name Gun (Howitzer) (Telephone, etc.)

Type 76mm (Field, etc.)

Made by Czarist Russia (Manufacturing nation)

Model 1909

Year _____

Photographed 15 Sep 51 Korea (Date)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Head-on view

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & I, MIS

18313—FEC P&PC—10/51—5M

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506



Subject Artillery (Communications, etc.) B. I. D. No. _____

Name Gun (Howitzer) (Telephone, etc.)

Type 76mm (Field, etc.)

Made by Czarist Russia (Manufacturing nation)

Model 1909

Year _____

Photographed 16 Sep 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

View of breech ring

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

18313—FEC P&PC—10/51—5M

DECLASSIFIED
Authority NND 951506

Subject Artillery (Communications, etc.) B. I. D. No. .....

Name Gun (Howitzer) (Telephone, etc.)

Type 76mm (Field, etc.)

Made by Czarist Russia (Manufacturing nation)

Model 1909

Year .....

Photographed 16 Sep 51 (Date) Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

View of breech ring

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

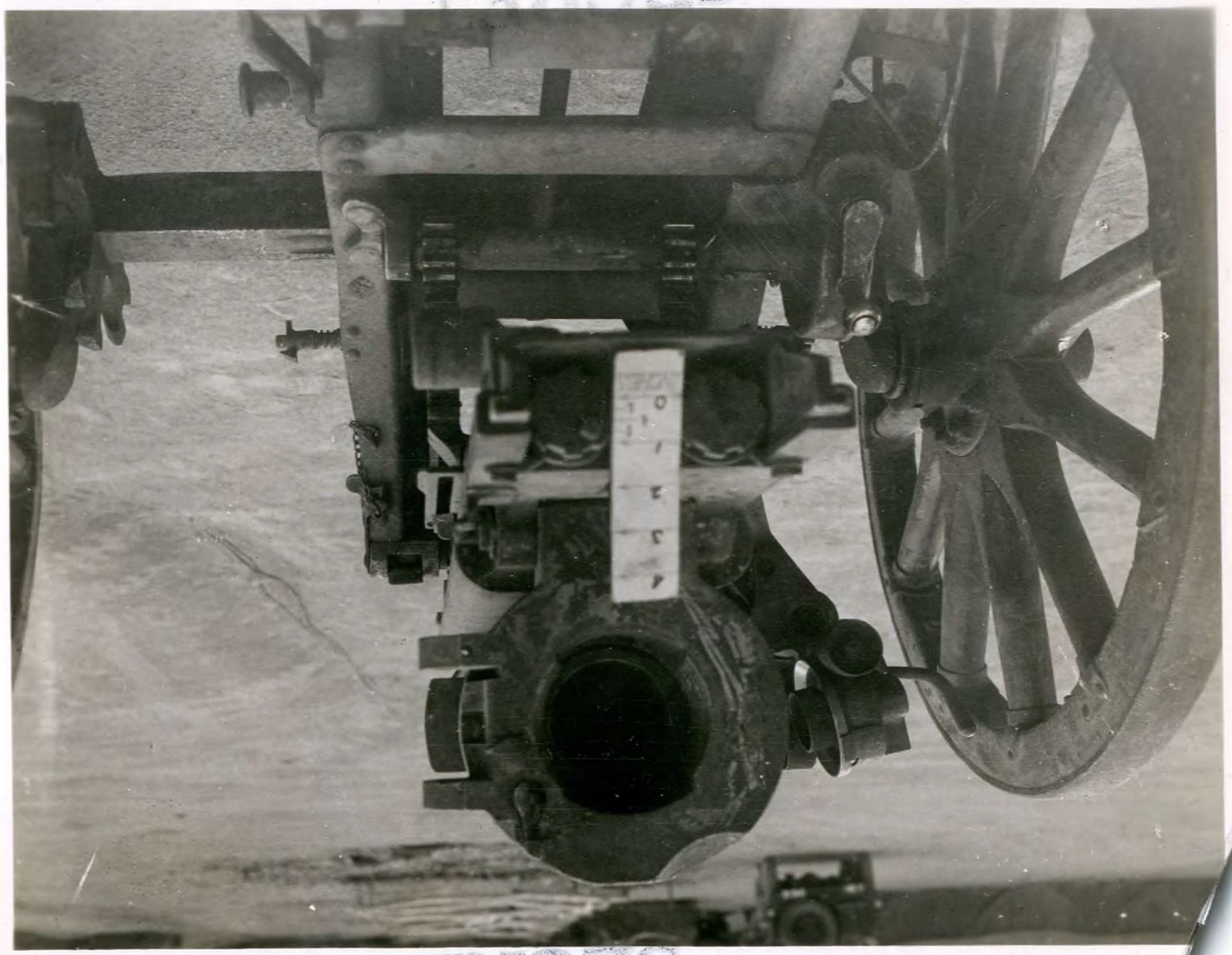
SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

18313—FEC P&PC—10 51—5M

DECLASSIFIED
Authority NND 851506

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

RESTRICTED

U.S. ARMY PHOTO 15 SEPT 1951

76MM MOUNTAIN GUN, 1909, BREECH RING.

PHOTOGRAPHER LT R.A. LYNE
528TH OTID

DECLASSIFIED
Authority NND 951506



SECRET

Subject Artillery (Communications, etc.) B. I. D. No. .....

Name Gun (Howitzer) (Telephone, etc.)

Type 76mm (Field, etc.)

Made by Czarist Russia (Manufacturing nation)

Model 1900

Year .....

Photographed 15 Sep 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Rear view showing trail

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & F, MIS

18313—FEC P&PC—10 51—5M

DECLASSIFIED
Authority NND 851506

Subject Artillery B. I. D. No. _____
(Communications, etc.)

Name Gun (Howitzer)
(Telephone, etc.)

Type 76mm
(Field, etc.)

Made by Czarist Russia
(Manufacturing nation)

Model 1909

Year _____

Photographed 15 Sep 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rear view showing trail

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & F, MIS

18313—FEC P&PC—10/51—5M

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

RESTRICTED

U.S. ARMY PHOTO 15 SEPT 1951

76MMMMOUNTAIN GUM, 1909, REAR VIEW

PHOOTGRAPHER LT R.A. LYNE
528TH OTID

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506



Subject Artillery B. I. D. No. _____
(Communications, etc.)

Name Gun (Howitzer) _____
(Telephone, etc.)

Type 76mm _____
(Field, etc.)

Made by Czarist Russia _____
(Manufacturing nation)

Model 1909 _____

Year _____

Photographed 15 Sep 51 (Date) Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Front view showing axle

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & F, MIS

18313—FEC P&PC—10/51—5M

DECLASSIFIED
Authority NND 851506

Subject Artillery B. I. D. No. .....
(Communications, etc.)

Name Gun (Howitzer) .....
(Telephone, etc.)

Type 76mm .....
(Field, etc.)

Made by Czarist Russia .....
(Manufacturing nation)

Model 1909 .....

Year .....

Photographed 15 Sep 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Front view showing axle .....

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Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

SECRET .....
(Classification)

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18313—FEC P&PC—10/51—5M

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RESTRICTED

U.S. ARMY PHOTO 15 SEPT 1951

76MM MOUNTAIN GUN, 1909, FRONT VIEW SHOWING AXLE.

PHOTOGRAPHER LT R.A. LYNE
528TH OTID

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Subject Artillery B. I. D. No. .....
(Communications, etc.)

Name 6m (Howitzer)
(Telephone, etc.)

Type 76mm
(Field, etc.)

Made by Czarist Russia
(Manufacturing nation)

Model 1909

Year .....

Photographed 15 Sep 51 (Date) Korea (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left rear three quarter view

Received in MIS on .....
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(Telephone, etc.)

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Made by Czarist Russia
(Manufacturing nation)

Model 1909

Year _____

Photographed 15 Sep 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Left rear three quarter view

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Model 1909

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Photographed 15 Sep 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left side view

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- Side ☐
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Left side view

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Viewed from—

- Front ☐
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- Side ☐
- Top ☐

Remarks:

Right front three quarter view

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

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- Top ☐

Remarks:

Right front three quarter view

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- Side ☐
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Remarks:

Right side view

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Model 1909

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Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right side view

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508th ORDNANCE
TECHNICAL INTELLIGENCE DETACHMENT

13 September 1951

SUBJECT: Technical Intelligence Report 508/27
(Packaging Data for Captured Ammunition)

1. Captured ammunition shipped to Heunde Ammunition Depot arrives either in its original containers or as loose individual rounds. During the past week, all ammunition and components, still in their original containers, has been inspected and data for this report compiled. In cases where one or two pounds difference existed in overall weight of container between types of ammunition of the same caliber, one set of figures covers all types.

2. To date all Chinese ammunition checked by this unit has been packed in wooden boxes. The 75mm and 105mm artillery boxes have the joints and lid tarred or glued shut in addition to being nailed or screwed. All of the wooden boxes are permanently closed, utilizing side, top and bottom cleating, no hinge and hasp system is in use. The preservation of rounds is accomplished by either tarpaper wrapping or sealed metal containers. In a few instances, regardless of type or caliber of ammunition, no preservation method of any kind was used; the rounds were completely unprotected. Opening of the tarpaper and/or sealed metal container revealed considerable moisture, due no doubt to the lack of any type of moisture absorbing compound in the packing. Mortar and artillery rounds were solidly chocked with well fitted wooden blocks. Sufficient fuzes, powder bags, increments, etc were packed with their respective rounds. In most cases fuzes were in sealed metal containers in the box, similar to the Japanese style of packaging used in World War II.

3. Russian packaging differed mainly by the use of the hinged and hasped lid and the heavy coating of a grease like preservative, rather than tarpaper wrapping or sealed metal containers. Only the Russian small arms ammunition was in sealed galvanized metal containers, and no moisture absorbing compound was in evidence. For combat areas, the Russians use a stamped metal carrier or container to transport fuzed 82mm mortar rounds ready for firing. These containers hold three or four rounds and have a carrying handle and hinged lid. The 57mm rounds have a four round capacity perforated rack that is easily carried on the back of one man. Small arms ammunition is boxed either loose or in clips, or in metallic link belts packed in metal or wooden carrying cases.

4. None of the packaging methods used by either the Chinese or Russians were in any way equal to the US methods. Standard size cases for any one caliber or type of Chinese ammunition was rare, while Russian containers, though uniform for separate calibers, would not stand up under rough handling. All of these instances mentioned are proof of an inferior and poorly developed system of packaging and no doubt present difficult logistic problems for using troops. Data on all packaged ammunition presently available in the Depot is included in this report.

CAPTURED AMMUNITION PACKAGING DATA

I Russian Ammunition.

1. 7.62mm Ball (Pistol and SMG)
Dimensions.....19" x 13¼" x 6"
Gross Weight...75 lbs
Rd weight.....167 gr
Rds per box....2240
70 rounds per cardboard box, sixteen boxes in sealed galvanized metal container, two metal containers per wooden case.

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2. 7.62mm Ball (5 rd clip)
Dimensions.....19" x 13½" x 6"
Gross weight....47 lbs
Rd weight.....351 gr
Rds per box.....600
Three 5 round clips per cardboard box, twenty boxes in sealed galvanized metal container, two metal containers per wooden case.

3. 7.62mm Heavy pointed ball (loose)
Dimensions.....19" x 13½" x 6"
Gross weight....60 lbs
Rd weight.....378 gr
Rds per box.....880
20 rounds per paper package, twenty-two packages in sealed galvanized metal container, two metal containers per wooden box.

4. 7.62mm Tracer (loose)
Dimensions.....19" x 13½" x 6"
Gross weight....57 lbs
Rd weight.....348 gr
Rds per box.....880
20 rounds per paper package, twenty-two packages in sealed galvanized metal container, two metal containers per wooden case.

5. 12.7mm API
Dimensions.....19" x 13½" x 6"
Gross weight....65 lbs
Rd weight.....2050 gr
Rds per box.....170
85 rounds packed loose in paper wrapping per sealed galvanized metal container, two metal containers per wooden case.

6. 12.7mm Metallic belt linked (wooden box)
Dimensions.....13½" x 8" x 8½"
Gross weight....20 lbs
Rd weight.....2050 gr
Rds per box.....41
41 rounds in metallic link belt in hinged wooden box.

7. 12.7mm Metallic belt linked (metal box)
Dimensions.....11½" x 6⅛" x 8"
Gross weight....25 lbs
Rd weight.....2050 gr
Rds per box.....41
41 rounds in metallic link belt in metal box designed with hinged lid, belt feed opening, lid lock and gun attachment bracket.

8. 14.5mm API w/o TC core
Dimensions.....19" x 13½" x 6"
Gross weight....53 lbs
Rd weight.....3650 gr
Rds per box.....84
42 rounds packed loose in paper wrapping per sealed galvanized metal container, two containers per wooden box.

9. 26mm Pyrotechnic Signal (White)
Dimensions.....28½" x 20½" x 10"
Gross weight....118 lbs
Rd weight.....0.3 lbs (approx)
Rds per box.....520
130 rounds per sealed galvanized metal container, four metal containers per wooden box.

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10. 26mm Pyrotechnic Signal (White)
Dimensions.....25" x 20⅛" x 10½"
Gross weight....113 lbs
Rd weight.....0.3 lbs (approx)
Rds per box.....400
100 rounds per sealed galvanized metal container, four metal containers per wooden box.

11. Grenade, Fragmentation, F-1
Dimensions.....19" x 13⅛" x 8"
Gross weight....35 lbs
Rd weight.....1.25 lbs (fuzed)
Rds per box.....20
Fuzes packed, 10 fuzes per cylindrical metal container two containers per box or 20 fuzes per rectangular metal container one container per box, grenades individually wrapped in waterproof paper with or without plastic shipping plug in fuze well and packed in compartments in box.

12. Grenade, HEAT, RPG-43
Dimensions.....34" x 18" x 10"
Gross weight....95 lbs
Rd weight.....2.65 lbs
Rds per box.....20
10 assembled handles per rectangular metal container, two containers per box, grenade bodies individually wrapped in waterproof paper. In most instances, fuzes are packed separately and not packed in box.

13. 23mm HEI-T & API
Dimensions.....38" x 15" x 7"
Gross weight....133 lbs
Rd weight.....1.04 lbs
Rds per box.....90
30 rounds packed loose in paper wrapping per sealed galvanized metal container, three metal containers per wooden box.

14. 37mm HE w/fuze
Dimensions.....26" x 18" x 11"
Gross weight....147 lbs
Rd weight.....3.5 lbs
Rds per box.....30
Rounds held in place by contour blocking, two levels, 15 rounds in each level. Hinged lid

15. 37mm HE w/o fuze
Dimensions.....24⅛" x 18" x 10½"
Gross weight....124 lbs
Rd weight.....2.75 lbs
Rds per box.....30
Rounds held in place by contour blocking, two levels, 15 rounds in each level, plastic shipping plug in fuze well. Hinged lid

16. 45mm HE w/fuze
Dimensions.....20⅛" x 15" x 9"
Gross weight....86 lbs
Rd weight.....7.2 lbs
Rds per box.....10
Rounds held in place by contour blocking, one level. Hinged lid

17. 45mm HE w/o fuze
Dimensions.....20⅛" x 15" x 9"
Gross weight....78 lbs
Rd weight.....6.3 lbs
Rds per box.....10
Rounds held in place by contour blocking, one level, plastic shipping plug in fuze well. Hinged lid.

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18. 45mm APHE-T
Dimensions.....20½" x 15" x 9"
Gross weight....67 lbs
Rd weight.....5.5 lbs
Rds per box.....10
Rounds held in place by contour blocking, one level. Hinged lid.

19. 45mm HVAP-T (Metal carrying case)
Dimensions.....19½" x 14" x 3⅝"
Gross weight....35 lbs
Rd weight.....4.2 lbs
Rds per box.....5
Rounds secured in case by built in pressed metal contour blocking, case has hinged lid, finger tip pressure latches and carrying handle.

20. 57mm HE w/fuze
Dimensions.....32 3/4" x 21 3/4" x 6½"
Gross weight....118 lbs
Rd weight.....15.9 lbs
Rds per box.....5
Rounds held in place by contour blocking, one level. Hinged lid.

21. 57mm HE w/o fuze
Dimensions.....32 3/4" x 21 3/4" x 8½"
Gross weight....109 lbs
Rd weight.....15 lbs
Rds per box.....5
Rounds held in place by contour blocking, one level. Hinged lid.

22. 57mm APHEI-T
Dimensions.....31" x 21" x 8"
Gross weight....98 lbs
Rd weight.....13.5 lbs
Rds per box.....5
Rounds held in place by contour blocking, one level. Hinged lid.

23. 57mm HVAP-T
Dimensions.....32 3/4" x 21 3/4" x 8½"
Gross weight....95 lbs
Rd weight.....9.75 lbs
Rds per box.....5
Rounds held in place by contour blocking, one level. Hinged lid.

24. 57mm APHEI-T (Metal carrying rack)
Dimensions.....30" x 15" x 4½"
Gross weight....77 lbs
Rd weight.....13.5 lbs
Rds per box.....4
Rounds secured in carrying rack by pressed metal contour blocking and strapping.

25. 57mm HVAP-T (Metal carrying rack)
Dimensions.....30" x 15" x 4½"
Gross weight....63 lbs
Rd weight.....9.75 lbs
Rds per box.....4
Rounds secured in carrying rack by pressed metal contour blocking and strapping.

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26. 76mm HE w/fuze
Dimensions.....31" x 21" x 8"
Gross weight....130 lbs
Rd weight.....20 lbs
Rds per box.....5
Rounds held in place by contour blocking. Hinged lid on box.

27. 76mm HE w/o fuze
Dimensions.....37" x 21" x 6½"
Gross weight....120 lbs
Rd weight.....19.1 lbs
Rds per box.....4
Rounds held in place by contour blocking. Hinged lid on box.

28. 76mm HE w/o fuze
Dimensions.....31" x 21" x 8"
Gross weight....126 lbs
Rd weight.....19.1 lbs
Rds per box.....5
Rounds held in place by contour blocking. Hinged lid on box.

29. 76mm APHEI-T
Dimensions.....31" x 21" x 8"
Gross weight....130 lbs
Rd weight.....20 lbs
Rds per box.....5
Rounds held in place by contour blocking. Hinged lid on box.

30. 76mm HVAP-T
Dimensions.....31" x 21" x 8"
Gross weight....107 lbs
Rd weight.....13 lbs
Rds per box.....5
Rounds held in place by contour blocking. Hinged lid on box.

31. 85mm HE w/fuze
Dimensions.....44½" x 21" x 8"
Gross weight....140 lbs
Rd weight.....29.9 lbs
Rds per box.....4
Rounds held in place by contour blocking. Hinged lid on box.

32. 85mm HE w/o fuze
Dimensions.....37" x 21" x 6½"
Gross weight....135 lbs
Rd weight.....29 lbs
Rds per box.....4
Rounds held in place by contour blocking. Hinged lid on box.

33. 122mm HE How w/fuze
Dimensions.....29" x 12" x 8¼"
Gross weight....148 lbs
Rd weight.....61 lbs
Rds per box.....2
Projectiles and cases held in place by contour blocking and partitions, cases in center of box, projectiles on either side. Sliding lid on box.

34. 82mm Mortar w/fuze (10 fin)
Dimensions.....24" x 19" x 10½"
Gross weight....110 lbs
Rd weight.....8.5 lbs (w/fuze)
Rds per box.....10

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35. 82mm Mortar w/fuze (10 fin)
Dimensions.....21" x 19½" x 11"
Gross weight....105 lbs
Rd weight.....8.5 lbs (w/fuze)
Rds per box.....10

36. 82mm Mortar w/o fuze (10 fin)
Dimensions.....24" x 19" x 10½"
Gross weight....105 lbs
Rd weight.....7.9 lbs (w/o fuze)
Rds per box.....10

37. 82mm Mortar w/o fuze (10 fin)
Dimensions.....21" x 18½" x 11½"
Gross weight....105 lbs
Rd weight.....7.9 lbs w/o fuze
Rds per box.....10

All 82mm Mortar rounds as listed above, were packed in boxes identical in design and construction with exception of exterior dimensions. All rounds were held in place by contour blocking, rounds w/o fuzes were packed with and without shipping plugs in fuze well. Hinged lid on boxes.

38. 82mm Mortar w/fuze (Metal carrying case) (10 fin)
Dimensions.....15" x 21" x 4"
Gross weight....30 lbs
Rd weight.....8.9 lbs
Rds per box.....3
Rounds secured in case by built in pressed metal contour blocking, case has hinged lid, finger-tip pressure latches and carrying handle.

39. 107mm Mortar w/o fuze
Dimensions.....31" x 21" x 8½"
Gross weight....115 lbs
Rd weight.....18 lbs
Rds per box....4
Rounds held in place by contour blocking, one level.

40. 120mm Mortar w/o fuze
Dimensions.....31" x 13" x 7"
Gross weight....97 lbs
Rd weight.....35 lbs
Rds per box.....2
Rounds held in place by contour blocking.

41. 120mm Mortar w/o fuze
Dimensions.....37" x 13" x 9½"
Gross weight....108 lbs
Rd weight.....35 lbs
Rds per box.....2
Rounds held in place by contour blocking.

42. 120mm Mortar w/fuze
Dimensions.....31" x 13" x 9½"
Gross weight....96.25 lbs
Rd weight.....36.25 lbs
Rds per box.....2
Rounds held in place by contour blocking.

43. Fuze, KTM-1
Dimensions.....20½" x 15" x 9"
Gross weight....115 lbs
Fuze weight.....0.9 lbs
Fuzes per box...100

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25 fuzes paper wrapped, packed in drilled wooden blocks in sealed galvanized metal containers, four metal containers per wooden box.

44. Fuze, KDM-1
Dimensions.....20" x 18⅛" x 7"
Gross weight....96 lbs
Fuze weight.....0.9 lbs
Fuzes per box...80
20 fuzes paper wrapped, packed in drilled wooden blocks in sealed galvanized metal containers, four metal containers per wooden box.

45. Fuze, GVMZ-7
Dimensions.....20" x 18⅛" x 7"
Gross weight....85 lbs
Fuze weight.....1.25 lbs
Fuzes per box...40
10 fuzes paper wrapped, packed in drilled wooden blocks in sealed metal containers, four metal containers per wooden box.

46. Fuze, M-5
Dimensions.....20" x 18⅛" x 7"
Gross weight....55 lbs
Fuze weight.....0.6 lbs
Fuzes per box...120
30 fuzes paper wrapped, packed in drilled wooden blocks in sealed galvanized metal containers, four metal containers per wooden box.

47. Wooden Box Mine
Dimensions.....11" x 12⅛" x 7"
Gross weight....18 - 20 lbs
Explosive weight 13 - 15 lbs
This mine is complete minus fuze when shipped, has hinged pressure lid, lid locking strip and carrying handle.

II Chinese Ammunition

1. 6.5mm Ball
Dimensions.....15" x 9⅛" x 7"
Gross weight....33 lbs
Rd weight.....
Rds per box.....500
5 round clips packed loose in sealed galvanized metal containers, 100 clips per container, one container per wooden box.

2. 7.7mm Ball Type 92 (semi-rim)
Dimensions.....20" x 10⅛" x 9"
Gross weight....55 lbs
Rd weight.....
Rds per box.....600
30 rounds in Hotchkiss type MG clip, one clip per cardboard container, twenty containers per wooden box.

3. 7.7mm Ball Type 92 (semi-rim)
Dimensions.....18⅛" x 10⅛" x 8⅛"
Gross weight....55 lbs
Rd weight.....
Rds per box.....600
30 rounds in Hotchkiss type MG clip, one clip per cardboard container, twenty containers per wooden box.

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4. 7.7mm Ball Type 92 (semi-rim)
Dimensions.....20" x 9" x 9"
Gross weight....60 lbs
Rd weight.....
Rds per box.....600
30 rounds in Hotchkiss type MG clip, one clip per cardboard container, twenty containers per wooden box.

5. 7.7mm Ball Type 92 (semi-rim)
Dimensions.....28" x 9⅛" x 10⅛"
Gross weight....100 lbs
Rd weight.....
Rds per box.....1380
Three 5 round clips per cardboard container, ninety-two containers per wooden box.

6. 7.7mm Ball Type 99 (rimless)
Dimensions.....28" x 9⅛" x 10"
Gross weight....120 lbs
Rd weight.....
Rds per box.....1380
Three 5 round clips per cardboard container, ninety-two containers per sealed metal container, one metal container per wooden box.

7. 7.92mm Ball
Dimensions.....18⅛" x 10" x 7⅛"
Gross weight....41 lbs
Rd weight.....
Rds per box.....560
20 rounds per cardboard box, twenty-eight cardboard boxes per wooden box.

8. 7.92mm Ball
Dimensions.....11⅛" x 6⅛" x 7"
Gross weight....55 lbs
Rd weight.....
Rds per box.....1000
1000 rounds loose in sealed galvanized metal container, one container per wooden box.

9. Cal..303 Ball (rimmed)
Dimensions.....15⅛" x 9" x 8"
Gross weight....37 lbs
Rd weight.....
Rds per box.....500
20 rounds per cardboard container, twenty-five cardboard containers per sealed galvanized metal container, one metal container per wooden box.

10. Cal..45 Ball
Dimensions.....14" x 8" x 6⅛"
Gross weight....35 lbs
Rd weight.....
Rds per box.....1000
50 rounds per cardboard container, twenty containers per wooden box.

11. Cal..45 Ball
Dimensions.....16" x 6⅛" x 7⅛"
Gross weight....45 lbs
Rd weight.....
Rds per box.....800
800 rounds packed loose in sealed galvanized metal container, one container per wooden box.

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12. Cal..45 Ball
Dimensions.....12" x 7" x 6½"
Gross weight....35 lbs
Rd weight.....
Rds per box.....500
500 rounds packed loose in sealed galvanized metal container, one container per wooden box.

13. Grenade, Stick, serrated body
Dimensions.....17" x 8" x 7 3/4"
Gross weight....39 lbs
Rd weight.....1 lb
Rds per box.....20
Loose in box with straw packing.

14. Grenade, Stick, short body (wood cap)
Dimensions.....20" x 11 3/4" x 8½"
Gross weight....44 lbs
Rd weight.....1.1 lbs
Rds per box.....30
Loose in box with straw packing.

15. Grenade, Stick, short body (wood cap)
Dimensions.....19½" x 12" x 6½"
Gross weight....35 lbs
Rd weight.....1.1 lbs
Rds per box.....20
Loose in straw packing.

16. Grenade, Stick. short body (metal cap)
Dimensions.....26½" x 9½" x 5½"
Gross weight....35 lbs
Rd weight.....1.1 lbs
Rds per box.....26
Loose in box with straw packing.

17. Grenade, Stick, long body, light (metal cap)
Dimensions.....21" x 9 3/4" x 6½"
Gross weight....30 lbs
Rd weight.....1.25 lbs
Rds per box.....20
Rounds held in place by contour blocking, straw packing.

18. Grenade, Stick, long body, heavy (metal cap)
Dimensions.....23" x 10½" x 7½"
Gross weight....37 lbs
Rd weight.....1.4 lbs
Rds per box.....20
Loose in box with straw packing

19. Grenade, Stick, egg body
Dimensions.....20½" x 10 3/4" x 6½"
Gross weight....30 lbs
Rd weight.....0.9 lbs
Rds per box.....20
Loose in box with straw packing.

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20. Grenade, Fragmentation, North Korean
Dimensions.....19½" x 14½" x 6½"
Gross weight....50 lbs
Rd weight.....1.25 lbs
Rds per box.....30
Grenades individually packed in cardboard boxes, fuzed, thirty boxes per wooden box.

21. 70mm Type 92
Dimensions.....19" x 15" x 7"
Gross weight....45 lbs
Rd weight.....10 lbs w/o fuze
Rds per box.....3
Projectiles and cases held in place by contour blocking separated by partitions, fuzes in sealed cylindrical metal containers.

22. 75mm American Type 48
Dimensions.....28" x 11½" x 7"
Gross weight....55 lbs
Rd weight.....18 lbs
Rds per box.....2
Rounds individually packed in sealed cylindrical cardboard containers, two containers per wooden box.

23. 75mm Type 94
Dimensions.....27" x 13" x 7½"
Gross weight....50 lbs
Rd weight.....20 lbs w/o fuze
Rds per box.....2
Rounds held in place by contour blocking, fuzes in sealed cylindrical metal containers.

24. 75mm Type 38
Dimensions.....25½" x 11" x 6 3/4"
Gross weight....56 lbs
Rd weight.....19 lbs
Rds per box.....2
Rounds held in place by contour blocking, fuzes in sealed cylindrical metal containers.

25. 105mm Type 91
Dimensions.....21" x 15" x 9"
Gross weight....60 lbs
Rd weight.....43 lbs w/o fuze
Rds per box.....1
Projectile and case held in place by contour blocking separated by partitions, fuze in sealed cylindrical metal container.

26. 105mm US Type
Dimensions.....31" x 14½" x 9"
Gross weight....95 lbs
Rd weight.....35 lbs (projectile only)
Rds per box.....2 (projectile only)
Projectiles held in place by contour blocking, no cases in box.

27. 60mm Mortar
Dimensions.....21½" x 13" x 7½"
Gross weight....50 lbs
Rd weight.....3 lbs
Rds per box.....10
Rounds held in place by contour blocking, fuzes in drilled wooden block, increments in waterproof tar sealed packages, ignition cartridges in rounds.

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28. 60mm Mortar
Dimensions.....27½" x 11½" x 6½"
Gross weight....45 lbs
Rd weight.....3 lbs
Rds per box.....10
Rounds held in place by contour blocking, fuzes and increments in sealed rectangular metal container, ignition cartridges in rounds.

29. 60mm Mortar
Dimensions.....21" x 11½" x 8½"
Gross weight....44 lbs
Rd weight.....2.9 lbs
Rds per box.....10
Rounds held in place by contour blocking, fuzes in drilled wooden block, increments and ignition cartridges in sealed cylindrical metal container.

30. 60mm Mortar
Dimensions.....19 3/4" x 10" x 7½"
Gross weight....43 lbs
Rd weight.....3.25 lbs
Rds per box.....11
Rounds loose in box packed with straw, fuzes, increments and ignition cartridges packed in sealed rectangular metal container.

31. 60mm Mortar
Dimensions.....15" x 13" x 7½"
Gross weight....35 lbs
Rd weight.....2.6 lbs
Rds per box.....8
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges packed in sealed rectangular metal container.

32. 60mm Mortar
Dimensions.....14 3/4" x 10½" x 7½"
Gross weight....34½ lbs
Rd weight.....3.4 lbs
Rds per box.....6
Rounds held in place by contour blocking, fuzes packed in sealed rectangular metal containers, increments in waterproof tar sealed package, ignition cartridges in rounds.

33. 60mm Mortar
Dimensions.....22½" x 12½" x 6 3/4"
Gross weight....33 lbs
Rd weight.....3.25 lbs
Rds per box.....6
Rounds held in place by contour blocking, fuzes packed in sealed rectangular metal containers, increments packed in sealed cylindrical metal containers, ignition cartridges in rounds.

34. 60mm Mortar
Dimensions.....16" x 11½" x 8"
Gross weight....31½ lbs
Rd weight.....3.1 lbs
Rds per box.....6
Rounds individually packed in tar sealed cylindrical cardboard containers, fuzes, increments and ignition cartridges in sealed rectangular metal container.

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35. 60mm Mortar
Dimensions.....15" x 10½" x 7"
Gross weight....30 lbs
Rd weight.....3 lbs
Rds per box.....6
Rounds held in place by contour blocking, fuzes in drilled wooden block, increments in sealed cylindrical metal container, ignition cartridges in rounds. Complete unit in sealed galvanized metal container in wooden box.

36. 81mm Mortar
Dimensions.....18" x 9" x 6"
Gross weight....22 lbs
Rd weight.....8.2 lbs
Rds per box.....2
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges in sealed rectangular metal container in center of box.

37. 81mm Mortar
Dimensions.....19" x 13" x 7"
Gross weight....38 lbs
Rd weight.....8 lbs
Rds per box.....3
Rounds held in place by contour blocking, fuzes in drilled wooden block, increments and ignition cartridges in waterproof tar sealed package.

38. 81mm Mortar
Dimensions.....20" x 11" x 6"
Gross weight....37 lbs
Rd weight.....8.2 lbs
Rds per box.....3
Rounds held in place by contour blocking, fuzes in drilled wooden block, increments and ignition cartridges in waterproof tar sealed package.

39. 81mm Mortar
Dimensions.....21" x 13½" x 6"
Gross weight....42 lbs
Rd weight.....8.2 lbs
Rds per box.....4
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges in sealed rectangular metal container.

40. 82mm Mortar
Dimensions.....18" x 9" x 6"
Gross weight....24 lbs
Rd weight.....8.9 lbs
Rds per box.....2
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges in sealed rectangular metal container.

41. 82mm Mortar
Dimensions.....18" x 11" x 6"
Gross weight....34 lbs
Rd weight.....8.5 lbs
Rds per box.....3
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges in sealed cylindrical metal container.

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42. 82mm Mortar
Dimensions.....21½" x 16" x 6"
Gross weight....44 lbs
Rd weight.....8.9 lbs
Rds per box.....4
Rounds held in place by contour blocking, fuzes, increments and ignition cartridges in sealed cylindrical metal container.

43. 120mm Mortar, long
Dimensions.....40" x 7" x 8"
Gross weight....35 lbs
Rd weight.....28 lbs w/o fuze
Rds per box.....1
Rounds held in place by contour blocking.

44. 120mm Mortar, short
Dimensions.....25⅝" x 13" x 8"
Gross weight....80 lbs
Rd weight.....25 lbs w/o fuze
Rds per box.....2
Rounds held in place by contour blocking.

45. Bangalore Torpedo w/fuze
Dimensions.....60" x 8" x 6"
Gross weight....75 lbs
Rd weight.....10 lbs
Rds per box.....6
Rounds held in place by contour blocking.

46. Bangalore Torpedo
Dimensions.....53" x 7½" x 7"
Gross weight....65 lbs
Rd weight.....9.5 lbs
Rds per box.....6
Rounds held in place by contour blocking.

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HEADQUARTERS
533d ENGINEER TECHNICAL INTELLIGENCE TEAM (RESEARCH)

9 September 1951

Report No. 109

SUBJECT: MD-2 Detonator

1. This report is based on information contained in Special Report No. 64, 557th ETIT (C).

2. SOURCE: While neutralizing an enemy minefield at DT 085317 on 21 Aug 51, the 7th ROK Engineer C Battalion located 14 different types of Soviet type MD-2 detonators. Subsequent experimentation and reporting was accomplished by members of the 557th ETIT (C).

3. GENERAL: Although this item has been previously reported, the information in this report is designed to give a more accurate and detailed description of the various types of the item. It is also designed to augment information contained in EUSAK Engineer TIB, dated 18 November 1950.

4. DESCRIPTION:

a. Basically, the operation of all types of MD-2 detonators is as follows: A striker of a standard Soviet fuze pierces the percussion cap housing, detonating the fulminate of mercury therein. The resultant detonating wave travels down the flash tube and enters a hole in the intermediate charge cup. Thus, the lead azide of this cup is detonated. This intensified detonating wave then ignites the base charge (tetryl) and the resultant explosion detonates the booster block or other high explosive in contact with the detonator. It should be noted here that some enemy mines (TMD-B's, TM-41's etc.) are fitted with booster blocks to insure detonation of the main charge. However, tests conducted by members of the 557th ETIT (C) show that the MD-2 detonator is capable of exploding any standard U.S. or Soviet explosive.

b. The differences in construction of the MD-2 detonators reported herein can be summarized briefly as follows:

(1) Quantity of base charge (tetryl) ((G-H) x area of B on the diagram on next page)

(2) Quantity of intermediate charge (lead azide) (H x area of B on diagram)

(3) Voids between the flash tube and intermediate charge (F on diagram)

(4) Lengths of flash tube.

(5) Types of fuze adapters.

(6) Types of percussion cap retainer.

For a complete listing of measurements and characteristics for each of the 14 different types of MD-2 detonators, see Table of Measurements.

c. In conjunction with this report tests were conducted by the 557th ETIT (C) to determine the relative readings produced by three basic types of the MD-2 detonators upon an SCR-625 mine detector. The detonators used were #1 (plastic), #4 (aluminum) and #8 (steel). The detector was zeroed before each reading and the search coil was placed over each detonator at distances of 3", 6" and 9" from the detonators. Results are as follows:

6689
0400 USSR

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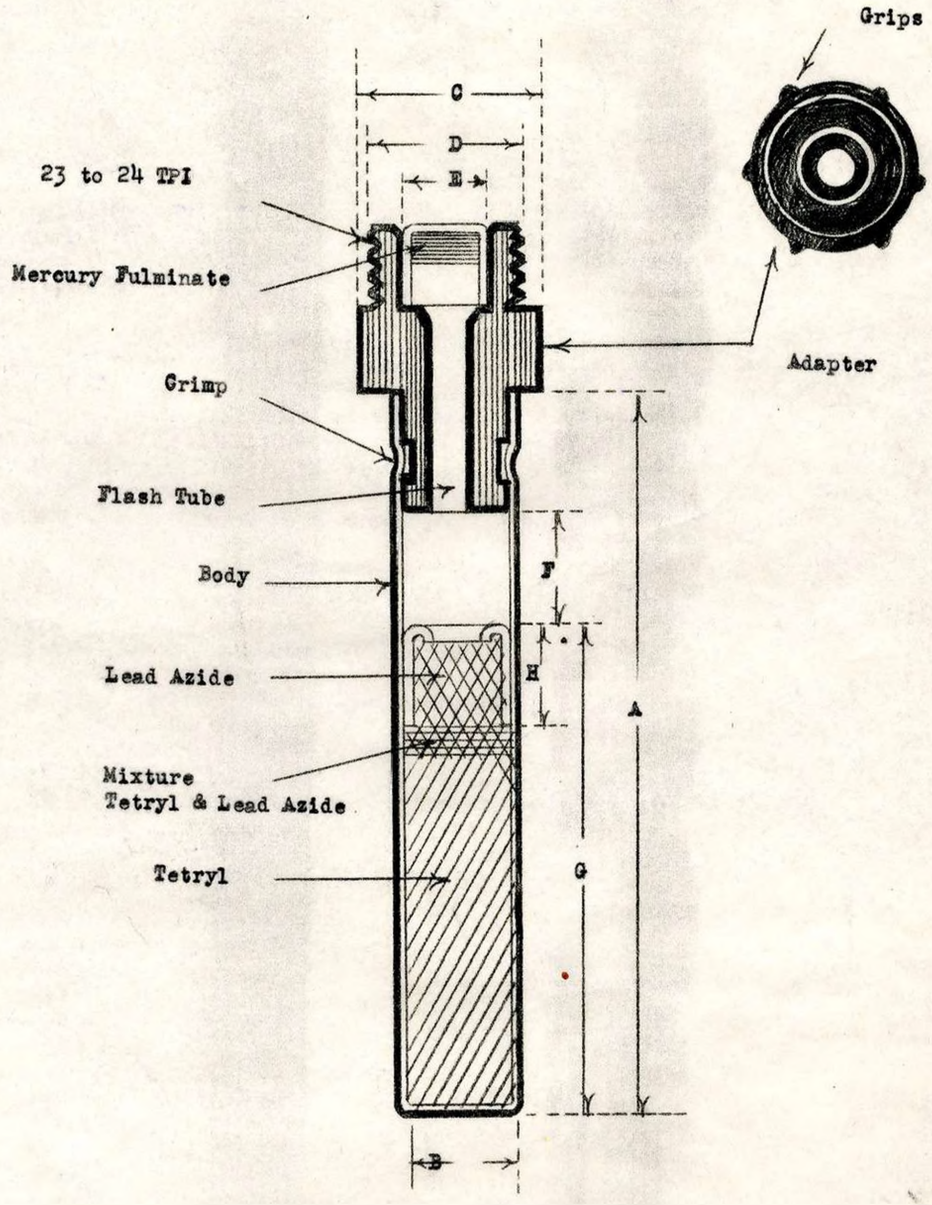
MD - 2 DETONATOR



NOTE: For specific dimensions of the 14 various MD-2 Detonators, see Table of Measurements

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Detonator	Type	Dial Readings 3"	6"	9"
# 1	plastic	6	2	0
# 4	aluminum	1	1	0
# 8	steel	4	1	1

An unusual fact is evinced in that # 1 detonator gave a higher reading at 3" than any of the others. This reading was confirmed by many repitions of the experiment. Generally, it appears that the aluminum detonator represents the best anti-detecting type.

d. Experiments were also conducted to test the sensitivity of the MD-2 detonator. These tests proved that the detonator is safe to handle and transport. It is apparent that the cup housing the lead azide provides sufficient protection to the lead azide if accidental dropping or crushing occurs during transport. Some of the detonators, however, have a mixture of tetryl and lead azide below the cup and above the base charge consequently this area must be considered very sensitive. Although the detonator may be considered fairly safe, caution must be exercised when handling this detonator.

5. REMARKS: The differences shown in this report may be attributed, by assumption, to the following factors:

a. Different places of manufacture.

b. Faulty or flexible specification.

c. Quality of workmanship.

See inclosure 1 for photo of items on which this report is based.

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TABLE OF MEASUREMENTS

Detonator No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flash tube length	.56	.44	.46	.44	.42	.42	.42	.42	.49	.44	.43	.39	.32	.36
Diameter	.13	.12	.11	.12	.12	.13	.12	.12	.12	.12	.12	.12	.12	.12
Adapter type	plastic	plastic	plastic	Aluminum	Aluminum	Zinc Alloy	Aluminum	Steel	Steel	Zinc Alloy	Aluminum	Aluminum	Steel	Aluminum
Shoulder (C)	.47	.5	.54	.54	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Thickness	.28	.28	.28	.25	.28	.28	.25	.28	.25	.28	.25	.25	.25	.25
# Grip	6	6	6	6	6	knurled	knurled	knurled	knurled	6	8	12	knurled	11
Retainer	Tin foil	Tin foil	Paper	Paper	Paper	Paper	Paper	Tin foil	Paper	Paper	Paper	Paper	Paper	Paper
A	1.91	1.86	1.91	1.91	1.86	1.82	1.90	1.82	1.82	1.88	1.80	1.81	1.83	1.82
B	.27	.28	.28	.28	.27	.28	.28	.28	.28	.28	.27	.28	.27	.28
D	.44	.44	.36	.33	.36	.42	.40	.40	.38	.38	.38	.40	.36	.40
E	.22	.22	.27	.24	.24	.24	.30	.22	.22	.28	.24	.23	.24	.24
F	.34	.34	.38	.28	.40	.34	.46	.32	.20	.50	.36	.35	.36	.35
G	1.24	1.24	1.10	1.06	1.06	1.06	1.04	1.12	1.24	1.02	1.06	1.07	1.08	1.08
H	.28	.28	.28	.28	.28	.28	.28	.28	.25	.25	.28	.28	.28	.28

NOTE: All measurements are in inches

END

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TR-2229-51

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508th ORDNANCE
TECHNICAL INTELLIGENCE DETACHMENT

7 September 1951

SUBJECT: Technical Intelligence Report 508/26
(Captured Russian Ammunition at Heunde Ammunition Depot)

1. The Heunde Ammunition Depot (MF155903) is the base collecting point for all types of captured ammunition. In order to give a complete picture of all the different types of ammunition encountered in the combat zone, this unit obtained samples from the depot of the ammunition on hand and prepared the following report. In many cases the items have already been reported on by Ordnance Technical Intelligence Units in the theatre. These items are repeated here to make this an up to date and complete record. The few items missing were captured in such a small quantity that the rounds have already been allocated and shipped to the ZI.

2. The report accompanies this cover sheet. Photographs are numbered and referenced in the written portion. The report is presented in the following form:

CAPTURED AMMUNITION IN KOREA

Russian Ammunition
1. Small Arms and Grenades
2. Artillery and Mortars
3. Fuzes
4. Bombs and Mines

3. Further information on the various types of ammunition, if desired, may be obtained from the following sources written on this subject:

Complete Round Data for Soviet Ammunition
Ordnance Intelligence, 8 Nov 1950
Ordnance Intelligence pamphlets published by
APG Md
Ordnance Technical Intelligence Reports File
EUSAK, GHQ, and Washington, DC

CAPTURED AMMUNITION IN KOREA

Russian Ammunition

1. Small Arms and Grenades

a. Small Arms (Photos 1 thru 7)

The following types of small arms ammunition have been recovered:

7.62mm Ball
7.62mm Ball, Heavy pointed ball, Tracer, API
12.7mm API, API-T
14.5mm API, API w/TC core
26mm Pyrotechnic Signal, red and green

These are all standard rounds known to have been in use during World War II. For complete ballistic data see Complete Round Data for Soviet Ammunition, Ordnance Intelligence, 8 Nov 1950 and ST-F-9-2000-1, Ordnance Intelligence.

b. Grenades (Photos 8 thru 11)

The following types of grenades have been recovered and are pictured as follows:

0400 USSR

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Frag F-1
Offensive RG-42
Anti-Tank HEAT RPG-43
Anti-Tank HEAT RPG-6

One other Anti-Tank grenade which has been reported on, is the concussion type RPG-40 grenade, but none were available in the dump at the time this report was being made. The Fragmentation grenade is similar to the US type. The Offensive grenade is in little use, probably due to its ineffectiveness. The HEAT grenades, while effective against armor up to four inches thick, seem to be used more for offensive purposes than anti-tank in this theatre.

2. Artillery and Mortars (Photos 12 thru 40)

a. Artillery - 20mm - 122mm (photos 12 thru 37)

20mm HEI, AP (Photos # 12 & 13)

HEI
Overall length...132mm Case length...99mm Proj. length...52mm
Fuze... K-6

AP
Overall length...132mm Case length...99mm Proj. length...61mm
Fuze...none

The HEI projectile is painted black, the fuze is silver color with a red cap. Removal of the fuze discloses the cylindrical cast charge of explosive incendiary compound. The AP projectile is painted black. There were no markings on the case or projectile of either round. Fuze markings were as follows: K-6 398 24 44 ⌐

23mm HEI-T (Photo # 14)

Overall length...236mm Case length...151mm Proj. length...86mm
212mm w/o fuze
Fuze...K-20M

There are no projectile or case markings except for two numbers stamped on the base of the case, they were: 513 above the primer and 48 below. The projectile is painted black with a green stripe above the rotating band. The fuze is silver colored. Removal of the fuze discloses the cylindrical cast charge of explosive incendiary compound. A small tracer element is an integral part of the base of the projectile. Propellant is smokeless powder contained in a silk bag. Fuze markings were as follows: K-20M 572 58 48 ⌐

23mm API (Photo # 15)

Overall length...236mm Case length...151mm Proj. length...101mm
Fuze...none

There are no projectile or case markings except for two numbers stamped on the base of the case, they were: 606 above the primer and 48 below. The projectile is painted black. The windshield is filled with an incendiary compound which evidently ignites from the heat and pressure developed by impact. The armor piercing core is not tungsten carbide but a type of case hardened steel. Propellant is smokeless powder contained in a silk bag.

37mm HE-T (Photo # 16)

Overall length...384mm Case length...258mm Proj. length...107mm
321mm w/o fuze
Fuze...M ⌐-7

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The projectile has a small tracer element in the base, and the high explosive filler is believed to be TNT. Markings on the round are as follows:

Case

45 P - 167
37 - 39
7/14 ⌐P 12/49 C
183 - 50 - 67
Φ

Projectile

114
8 - - 48
37

A - IX - 2
OP - 167

Fuze....M ⌐-7 -37 72 - 50 ⌐ 3M ⌂

37mm AP-T (Photo # 17)

Overall length...384mm Case length...258mm Proj. length...157mm
Fuze...none

This is a standard armor piercing round with a tracer element screwed into the base of the projectile. A sheet metal windshield covers the pointed armor piercing nose. Markings on the round are as follows:

Case

45 P - 167
37 - 39
7/14 ⌐P 34/45 C B/B
176 - 50 - 67
Φ

obliterated

Projectile

50 - 67
⊏P - 167

45mm HE (Photo # 18)

Overall length...445mm Case length...310mm Proj. length...209mm
402mm w/o fuze
Fuze...KTM-1

This projectile is outstanding due to its length and the fact that over half of it is inside of the shell case when assembled. The filler is nose loaded, cast TNT. Markings on the round are as follows:

Case

45 O - 243
45 - 32
45 - 37
45 - 42
4/1 CB 145/45 C 4Φ
97 - 49 - 66

Projectile

144
8 - 43
45

17 - 66

Fuze...KTM-1 ⊓13 -49 ⌐ 564

45mm EVAP-T (Photo # 19)

Overall length...415mm Case length...310mm Proj. length...120mm
Fuze...none

This is the "arrowhead" type projectile with a tungsten carbide core. The ballistic cap is aluminum and is screwed with a right hand thread to the projectile body. Markings on the round are as follows:

Case

45P - 243 ⊓
45 - 32 - 37
7/14 CV 21/44 P B/B
226 - 50 - 22

Projectile

(Stamped in the metal)
8 - 6 - 189 - 45

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45mm APHE-T (Photo # 20)

Overall length...454mm Case length...310mm Proj. length...207mm
Fuze...M[illegible]-5

The projectile has a base detonating fuze with an attached tracer element. The filler is base loaded, cast TNT. A sheet metal windshield covers the blunt armor piercing nose. Two projectiles were recovered, the only differences were in outward appearance (notice two grooves in projectile on left) and the different shaped tracer element. Markings on the round are as follows:

Case

[illegible] P - 243
45 - 32
45 - 37
45 - 42
7/7 CB 2/38 B
113 - 50 - [illegible]

Projectiles

[illegible] -214 - 39 50 [illegible]
M[illegible]-5

Fuze...M[illegible]-5 350 [illegible] 194 - 39 [illegible]

45mm APHEI-T (Photo # 21)

Overall length...454mm Case length...310mm Proj. length...207mm
Fuze...M[illegible]-5

This round is identical to the APHE-T round with the exception of the incendiary explosive filler in place of the regular TNT filler. Markings on the round are as follows:

Case

[illegible] - 243

45 - 32/34 - 37
7/7 5CM [illegible] B/B
41
38 - 49 - [illegible]

Projectile

obliterated with exception of
M[illegible]-5

Fuze...M[illegible]-5 350 [illegible] 43 - 43 [illegible]

57mm HE (Photo # 22)

Overall length...677mm Case length...480mm Proj. length...240mm
626mm w/o fuze
Fuze...KTM-1

This is a standard high explosive projectile. The filler is nose loaded, cast TNT. Two types of projectiles were found. The only difference between them being the addition of a second rotating band positioned below the original band. The double rotating band projectile was painted silver, and the paint peeled and chipped readily from the round. Possibly this is a rust preventative. Markings on the rounds are as follows:

Case

[illegible] 0 - 271
57 - 43
12/7 CB 46/44 B/B
48 - 47 - [illegible]

Single Rotating Band Projectile

12
24 - 44 47 - [illegible]
57

Fuze...KTM-1 276 -45 [illegible]

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Case

Ч О - 271 Ч
57 - 41
57 - 43
12/7 CB 45/45 K
335 - 50 - [53]

Double Rotating Band Projectile

12
88 - 45
57

Т
О - 271 Ч

Fuze...K54-1 П-30 -obliterated З И Д

57mm HVAP-T (Photo # 23)

Overall length...612mm Case length...480mm Proj. length...153mm
Fuze...none

This is the "arrowhead" type projectile with a tungsten carbide core. The ballistic cap is aluminum and is screwed with a right hand thread to the projectile body. Markings on the round are as follows:

Case

ЧБР - 271 П
57 - 41
57 - 43
12/7 CB 51/44 K B/B
obliterated - 49 - [53]

Projectile

(Stamped in the metal)
429 - 45 - 8 - 38

57mm APHE-T

Overall length...676mm Case length...480mm Proj. length...231mm
Fuze...М Д-7

The projectile has a base detonating fuze with an attached tracer element. The filler is base loaded, cast TNT with an incendiary base. Though the case markings indicated regular TNT the projectile was HEI. This was found to be true in the 76mm and 85mm rounds also. A sheet metal windshield covers the blunt armor piercing nose. Markings on the round are as follows:

Case

ЧБ Р - 271
57 - 41
57 - 43
14/7 CB 1/49 K
466 - 50 - [34]
Ф

Projectile

80
4 - 49
57

А - IX - 2
М Д-7
Б Р - 271

Fuze...М Д-7 3260 6 -45

57mm APHEI-T (Photo # 24)

Overall length...676mm Case length...480mm Proj. length...231mm
Fuze...М Д-7

This round is identical to the APHE-T with the incendiary explosive filler. Markings on the round are as follows:

Case

ЧБЗ Р - 271
57 - 41
57 - 43
14/7 CB 3 K
48
170 - 48 - [34]

Projectile

80
4 - 48
57

А - IX - 2
М Д-7
Б Р - 271

Fuze...М Д-7 3260 8 -47 Г

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76mm HVAP-T (Photo # 25)

Overall length...531mm Case length...384mm Proj. length...173mm
Fuze...none

This is the "arrowhead" type projectile with the tungsten carbide core. The ballistic cap is either the threaded aluminum type or the sheet metal press fit type. Markings on the round are as follows:

Case

Projectile

76mm HE (Photo # 26)

Overall length...644mm Case length...384mm Proj. length...301mm
Fuze...KTM-1 603mm w/o fuze

Overall length...617mm Case length...384mm Proj. length...263mm
Fuze...P No. 16

Case markings on the high explosive rounds varied considerably and two different designs of projectiles were found. The blunt nose projectiles were of 1938-39 vintage and the fuze used, P No. 16 is identical in interior design to the KTM-1. No doubt the exterior design was changed in later years. The filler in both instances was nose loaded, cast TNT. Markings on some of the rounds were as follows:

76mm HE (Photo # 26)

Case

Projectile

Fuze...KTM-1

Case

Projectile

Fuze...KTM-1

Case

Projectile

Fuze...KTM-1

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Case

4/1 5/30 K VIII
28 30
OCM ВЛ -42

Projectile

76

Fuze... П No 16 А Д Е 42/К 39

76mm HEAT (Photo # 27)

Overall length...597mm Case length...384mm Proj. length...282mm
584mm w/o fuze
Fuze... БК

The projectile consists of a body, stand-off cap and cone, the filler is base loaded, cast TNT. The fuse is of the point initiating type. The case is identical to all other 76mm cases in its construction. Markings on the round are as follows:

Case

УБ А - 353 К
76 - 27
ВДК 41/obliterated
269 - 45 - 906
СЕРЕЛЯТЬЛ О
БРОАВ ЦЕЛЯН

Projectile

ТГ - 50 Е 114
БП - 350К 44 - 44
76
К

Fuze...БК 677 23 45

76mm APHEI-T (Photo # 28)

Overall length...619mm Case length...384mm Proj. length...244mm
Fuze...К Д -7

The projectile has a base detonating fuze with an attached tracer element. The explosive filler is base loaded, cast incendiary explosive compound. A sheet metal windshield covers the blunt armor piercing nose. Markings on the round are as follows:

Case

УБР - 354 Б
76 - 02/30 - 36
9/7 СВ 37/45 С В/В
223 - 50 - 22
Fuze...К Д -7 3260 3 -49 Г

Projectile

К Д -7 - 50 - 22 А - IX - 2
582 - 126 - 43 50 - 22
76 БР - 350 Б

76mm Shrapnel (Photo # 29)

Overall length...617mm Case length...384mm Proj. length...220mm
Fuze.... ЗБ П -10 (no other markings)

The projectile contains steel balls approximately 1 cm in diameter set in rosin. There is a black powder flash channel down the center, with a small expelling charge at the bottom. Markings on the round are as follows:

Case

УШ - 353
4/1 - 9/50 Р
38 - 41 - 74

Projectile

obliterated

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85mm HE (Photo # 30)

Overall length...983mm Case length...628mm Proj. length...344mm
Fuze...KTM-1

Overall length...979mm Case length...628mm Proj. length...286mm
Fuze...T-5

There are two sizes of projectiles depending upon the type fuze used. Both projectiles have a filler of regular TNT. Markings on the round are as follows:

Case

П О - 365 К
85 - 39
85 С ЧИ ТАНК
Н Т - 314/1 6/46 Т
168 - 49 - 22

Projectiles

56 Т
31 - 49 О - 365 К
85
+ + +

Fuze...KTM-1 ЗИ-433 -47 г

Case

У О - 365
85 - 39
14/7 СВ 11/41 К В/В
2 - 42 - 373

Projectile

Т
496 - 41 48 - 1456
85 0 - 365
+

Fuze... T-5 no markings

85mm HVAP-T (Photo # 31)

Overall length...653mm Case length...628mm Proj. length...257mm
Fuze...none

This is the "arrowhead" type projectile with a tungsten carbide core. The ballistic cap is aluminum and is screwed with a right hand thread to the body of the projectile. Markings on the round are as follows:

Case

УБР - 365 П
85 - 39
85 С ЧИ ТАНК
85 4ИВ РУШКА
14/7 СВ 1/49 Т
169 - 49 - 53

Projectile

obliterated

85mm APHEI-T (Photo # 32)

Overall length...822mm Case length...628mm Proj. length...267mm
Fuze...МД-5

In all the projectiles checked of the APHE-T or APHEI-T type as shown by case markings, the filler was found to be an aluminum base incendiary explosive compound. Therefore only the APHEI-T round will be reported here. Two types of projectiles were recovered. The base fuze was inset in projectile on the right whereas it protruded from the projectile on the left. This was the only difference. Markings on the rounds are as follows:

Case

УБ Р - 365 К
85 - 39
85 С ЧИ ТАНК
14/7 СВ 9/45 К УФ
63 - 49 - 22

Projectile

522 А - IX - 2
30 - 48 МД-5
85 БР - 365 К
+

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Case	Projectile	
463		
P - 365 K		
85 - 39	obliterated	obliterated
14/7 CB 12/45 T B/B		
1108 - 45- [53]	85	

Fuze...M Д -8 3260 107 44 Г

122mm Howitzer HE (Photo # 33)

Overall length...720mm Case length...284mm Proj. length...504mm
Fuze...P Г M-2

Overall length...674mm Case length...284mm Proj. length...485mm
Fuze... Д -1

Projectiles of two different lengths have been found but both are nose loaded with cast TNT. Cases are all one size but are constructed of different materials. To date there have been recovered, brass, steel, and steel wrapped cases. Only the brass and steel cases were available for this report. Propellant consists of a black powder igniter pad at the bottom, tubular grains in small bags and larger bags of multiperforated (7 perforations) cylindrical grains. The round is semi-fixed with a cardboard closing cap pressed into the case on top of the propelling charge. Markings on the round are as follows:

Brass Case	Projectile	
Ж - 463 M		
122 - 38	AT/80	0 Ф - 462
9/7 CB 54/45 K B/B	611	122
4/1 CB 49/45 K B/B	312 - 45	
149 -obliterated- 53		

Steel Case	Projectile	
3 АЯД - H 1		
122 - 38	AT/90	515
301 - 6 - 66	0 462 A	29 - 45
		122

Fuze... Д -1 42-M 111 45 Г 431
Fuze... Г M-2 350 217 45 Г

122mm Howitzer HEAT (Photo # 34)

Overall length....591mm Case length....284mm Proj. length....335mm
566mm w/o fuze
Fuze....B-229

The projectile consists of a body, stand-off cap and cone, the filler is base loaded, cast TNT. The fuze is the point initiating type. The case is the standard howitzer type. Markings on the round are as follows:

Case	Projectile	
No specific cases	Т Г - 50	12
marked for the HEAT	БП - 460 a	134 - 44
round were found	48 - 135	122
		-- -- --

Fuze...B-229

122mm Howitzer Shrapnel (Photo # 35)

Overall length....615mm Case length....285mm Proj. length....322mm
Fuze....TSQ T-6

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Authority NND 851506

This is a standard shrapnel round, found in limited quantities in the theatre, none of the projectiles were in condition for disassembly. No markings were discernable on any of the projectiles.

122mm Gun APHE-T (Photo # 36)

Overall length...1145mm Case length...785mm Proj. length...420mm
Fuze...M ⊓ -8

The projectile has a base detonating fuze with an attached tracer element. The explosive filler is base loaded, cast TNT. A sheet metal windshield covers the blunt armor piercing nose. Markings on the round are as follows:

Case	Projectile
114	A - IX - 2
obliterated 7 - 49	M ⊓ -8
122 H	⊟ P - 4716

Fuze...M ⊓ -8 3260 107 44 ⊓

122mm Gun HE (Photo # 37)

New projectile
Overall length...1270mm Case length...785mm Proj. length...548mm
Fuze...P ⊓ M-2 and ⊓ -1

Old projectile
Overall length...1220mm Case length...785mm Proj. length...463mm
Fuze... ⊔ ⊓ T-2

This is a standard high explosive projectile, the filler is nose loaded cast TNT. Two types of projectiles were found, the shorter projectile was found only with the T-2 fuze assembled in it. Markings on the rounds are as follows:

Case		New Projectile
⊓ O ⊓ ⊟ ⊓ OAE ⊟	AT/80	C ⊟ - 18 - 45
122	50 - $\boxed{39}$	122
122 - 31	471 - H	+ +
22/ PC 9/49 T		
29/ PCB /9 T		
902 - 49 - $\boxed{29}$		

Case	Old Projectile
	71
	1931
	209
Obliterated	122 M 4
	H

Fuze... ⊔ ⊓ T-2 36 30 ⊓ KO 350

b. Mortars (Photos 38 thru 40)

82mm HE (Photo # 38)

There are at present two types of 82mm mortar rounds being used. The overall length of both rounds is 275mm. The primary difference between the two rounds is the fin design and increments used. One round has ten fins and uses a "ring" shaped increment (O-832 ⊓); the other has six fins and uses a "boat" shaped increment (see FT-F-52-1). Typical markings are as follows:

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Ten Fin

637
175 - 44
82

AT/80
0-832

Six Fin

12
186 - 39
82

H - 2
0-832

107mm HE (Photo # 39)

Construction is very similar to the 120mm mortar round. No increments were recovered with the round. The body is cast steel, the filler, cast TNT. Overall length of round without fuze is 492mm. Markings are as follows:

0 Φ AT/80
47 - [357]

All other markings obliterated

120mm HE (Photo # 40)

There seems to be only one standard type of ammunition for all models of the 120mm mortar. The body of the round may be of cast iron or cast steel. Increments are the "ring" type or long tubular silk bags of black powder (see ST-P-9-201, Ord Intel, Aug 50). Typical markings are as follows:

0 Φ AT/80
48 - [redacted] A

12
88 - 45
120
+

3. Fuzes

a. GVMZ, GVMZ-1, GVMZ-7 (Photo # 41)

Point detonating, super-quick or delay type of fuzes. Positioning of the set screw in the fuze body determines whether the function is super-quick or delay. The fuzes are setback armed and use the compressed heated air principle to ignite a primer.
Basic use is in the 120mm Mortar, with limited use in the 122mm Howitzer.

b. M-4, M-5 (Photo # 42)

Point detonating super-quick type of fuzes. There is no outside safety wire or tab. The fuzes are setback armed and function on impact when the striker is driven into a primer.
Basic use is in the 82mm and 120mm Mortars.

c. MT-82 (Photo # 43)

Point detonating, super-quick type of fuze. There is no outside safety wire or tab. The fuze is setback armed and functions on impact when the striker is driven into a primer.
Basic use is in the 122mm HEAT round, however the Complete Round Charts list the fuze as also being used in the 82mm Mortar Smoke round, (not recovered in Korea).

d. KTM-1, KTMZ-1, P No. 16 (Photo # 44)

Point detonating fuzes of identical interior design though outward appearances differ. The P No 16 is believed to be the original or basic model of the series and later modified to the KTM exterior design. The only difference in the function of the fuzes is caused by the insertion of a delay pellet in the primer chamber of the P No 16 and the KTMZ-1, the KTMZ-1 and KTM-1 being of similar construction in all respects, the Z in the nomenclature specifying delay pellet added. All are setback armed and bore safe.
Basic use is in the 45mm, 57mm 76mm and 85mm Guns.

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e. D-1, T-5, T-6, P-10 (Photo # 45)

Time and super-quick type of fuzes. All are of the standard powder train time construction. All are setback armed.
Basic use is in the 76mm, 85mm, and 122mm Gun and 122mm Howitzer.

f. MD-2, MD-5, MD-6, MD-7, MD-8, MD-10 (Photo # 46)

Base detonating, delay type of fuzes. All are basically identical in construction varying only in size depending on projectile in which used. All are setback armed and function on impact when a primer is driven against a striker. They are generally found with a tracer element attached.
Basic use is in the 45mm, 57mm, 76mm, 85mm, and 122mm APHE-T and APHEIT rounds.

g. AMA, AV-1, APUV-1 (Photo # 47)

These are vane armed bomb fuzes and their basic function is as follows:
AMA.....Instantaneous, nose fuze
AV-1.....26 sec delay, nose and tail fuze
APUV-1...Variable delay, nose and tail fuze

h. BM, K-6, K-20M (Photo # 48)

Point detonating, super-quick or super sensitive type of fuzes. All are setback armed. The K-6 and K-20M are super sensitive fuzes used in the 20mm Aircraft Cannon round. The BM is a super-quick fuze used in the 76mm HEAT round.

i. V-229 (Photo # 49)

Point detonating, super-quick type of fuze, setback armed.
Basic use is in the 122mm and 152mm HEAT rounds.

j. MG-37 (Photo # 50)

Point detonating, bore safe type of fuze, requires centifrigul force to arm.
Basic use is in the 37mm round.

k. M-1 (Photo # 51)

Point detonating, super-quick type of fuze, setback armed.
Basic use is in the obsolete 50mm Mortar and is now being used in the 82mm and 120mm Mortars.

l. RGM-2 (Photo # 52)

Point detonating, super-quick or delay type of fuze. Positioning of the set screw in the fuze body determines whether the function is super-quick or delay. It is setback armed and bore safe. Basic use is in the 122mm and 152mm Howitzer HE rounds.

m. UGT-2 (Photo # 53)

Point detonating, super-quick type of fuze, seldom used in later manufactured rounds.
Basic use is in the 122mm Gun HE round.

4. Bombs and Mines (Photos 54 thru 57)

a. Bombs (Photos # 54, 55, & 56)

Recovered to date are three different sizes of fragmentation bombs, the 20 lb, 50 lb and the 220 lb. All are of extremely crude construction which no doubt causes very irregular flight. All are threaded for the AMA bomb fuze. The filler is cast TNT. The 20 lb bomb appears to have been constructed from a 107mm Mortar round and the 50 lb bomb is without question a 122mm HE round with fins attached.

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There were no markings on any of the bombs.

b. Mines (Photo # 57)

There is only one type of mine available for this report, this is the TMD-B wooden box mine. The mine is intended primarily for anti-tank purposes but can be set as an anti-personnel mine. No detonators have been found with unemplaced mines and detonators have not been returned with emplaced mines recovered. The mine is cheap and easy to make, the filler being 13 to 15 pounds of TNT, total weight of mine being 18 to 20 pounds. The dimensions are approximately 10¾" x 12⅜" x 5¼". The mine is functioned by pressure being applied to pressure boards on the top of the box, one of the boards being hinged and having an attached pressure block bearing on the detonator. No discernable markings were apparent on any mines recovered.

E N D

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SECRET

For: T/Intl

SECRET

TB-2267-51

DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62 & 12.7mm MG
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62 & 12.7mm MG
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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(Number)

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(Number) (Office)

SECRET
(Classification)

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Authority NND 851506

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Authority NND 951506

8A/FEC-51-28714 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE SMALL ARMS AMMO, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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PUBLICATION UNLESS RELEASED BY GHQ PIO



DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm Ball
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

7.62 MM PISTOL - BALL - S.M.G.

SECRET

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm Ball
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

SECRET

SMALL ARMS

RUSSIAN



7.62 MM BALL PISTOL - S.M.G.

SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28716 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE 7.62MM BALL PISTOL,
S. M. G., KOREA.

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(167TH SIG PHOTO CO)

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PUBLICATION UNLESS RELEASED BY GHQ PIO

2

DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left to Right: Ball; Heavy Ball; Tracer.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left to Right: Ball; Heavy Ball; Tracer.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 951506

DECLASSIFIED
Authority NND 851506

BA/FEG-51-28715 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE SMALL ARMS AMMO, KOREA.
L-R: 7.62MM BALL; M.62M HEAVY POINT BALL;
AND 7.62MM TRACER.

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(167TH SIG PHOTO CO)

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Authority NND 851506



Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm API
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

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Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 7.62mm API
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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Authority NND 851506

DECLASSIFIED
Authority NND851506



4

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Authority NND851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 12.7mm API & API-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 12.7mm API & API-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 851506

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Authority NND 851506

BA/FEC-51-26717 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE SMALL ARMS AMMO, KOREA.
12.7MM API, AND 12.7MM API-T.

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(167TH SIG PHOTO CO)

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5

1 2 3 4 5 6 7 8 9 10 11 12 13
200cm SEKISUI JUSHI JQA JIS

DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 14.5mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right: API.

Left: API w/tungsten carbide core.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Small Arms Ammo
(Telephone, etc.)

Type 14.5mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right: API.

Left: API w/tungsten carbide core.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 851506

SA/FEC-51-28708 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE SMALL ARMS AMMO, KOREA.
L-R: 14.5MM API W/T C COKE; AND 14.5MM API.

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Authority NND 951506

DECLASSIFIED
Authority NND851506



SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Pyrotechnic Ammo
(Telephone, etc.)

Type 26mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Pyrotechnic Ammo
(Telephone, etc.)

Type 26mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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Authority NND 851506

DECLASSIFIED
Authority NND 951506

SA/FEC-51-28707 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE 26MM PYROTECHNIC SIGNAL, KOREA.

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(167TH SIG PHOTO CO)

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1



DECLASSIFIED
Authority NND851506

SECRET

Subject Demolitions, Explosive Devices (Communications, etc.) B. I. D. No. _____

Name Hand Grenade (Telephone, etc.)

Type Defensive (Field, etc.)

Made by USSR (Manufacturing nation)

Model F-1

Year _____

Photographed Aug 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Demolitions, Explosive
Subject Devices B.I.D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type Defensive
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model F-1

Year

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 955506

SA/FEC-51-28710 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE GRENADE, FRAG-F-1, KOREA.

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DECLASSIFIED
Authority NND 851506

Subject Demolitions, Explosive Devices B.I.D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type Offensive
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RG-42

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

DECLASSIFIED
Authority NND 851506

Subject Demolitions, Explosive Devices (Communications, etc.) B.I.D. No. _____

Name Hand Grenade (Telephone, etc.)

Type Offensive (Field, etc.)

Made by USSR (Manufacturing nation)

Model RG-42

Year _____

Photographed Aug 51 (Date) Korea (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND851506

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DECLASSIFIED
Authority NND 951506

SECRET

Subject Demolitions, Explosive Devices B. I. D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-43

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Demolitions, Explosive
Subject Devices B.I.D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type RKAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-43

Year

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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DECLASSIFIED
Authority NND 851506



8A/FEC-51-28709 .7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE GRENADE, HEAT RPG-43, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK) (167TH SIG BHOTO CO)

STAFF DISTRIBUTION ONLY--NOT FOR PUBLICATION UNLESS RELEASED BY GHQ PIO

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Authority NND 851506

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Authority NND851506





Subject Demolitions, Explosive Devices B. I. D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-6

Year

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Demolitions, Explosive Devices B.I.D. No. _____
(Communications, etc.)

Name Hand Grenade
(Telephone, etc.)

Type RKAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-6

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 85 1506

DECLASSIFIED
Authority NND 955506

8A/FEC-51-28711 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE GRENADE, HEAT PRG-6, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)

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DECLASSIFIED
Authority NND851506





Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 20mm HEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 20mm HEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND 955150 6

BA/TEC-51-28012 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 20MM HEI-T PROJECTILES AND METALLIC CLIP CAPTURED BY THE 508TH ORD TECH INSTALLATION DET, US EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POSUDINSKY (GHE)
2ND SIG CO
STAFF DISTRIBUTION ONLY [redacted] NOT FOR PUBLICATION UNLESS RELEASED BY GHQ PIO

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DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name 20mm Ammo
(Telephone, etc.)

Type AP
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name 20mm Ammo
(Telephone, etc.)

Type AP
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



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DECLASSIFIED
Authority NND 963506

SA/FEC-51-28007 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 20 MM AP PROJECTILES AND METALLIC CLIP CAPTURED BY 508TH ORD TECH INSTALLATION DET, US EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
STAFF DISTRIBUTION ONLY ---- NOT FOR PUBLICATION UNLESS RELEASED BY GHQ FEC

M

DECLASSIFIED
Authority NND 851506



SECRET

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 23mm HEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 23mm HEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



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DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 963506

8A/FEC-51-28031 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 23MM HEI-T PROJECTILE
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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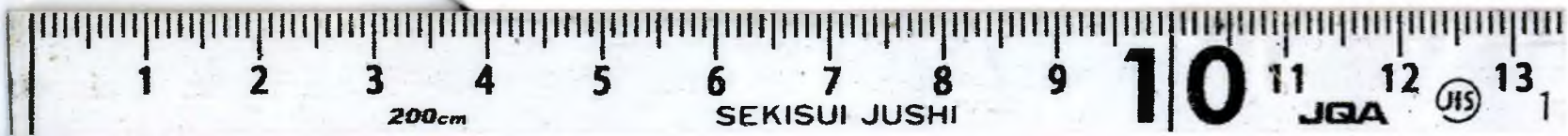
PUBLICATION UNLESS RELEASED BY GHQ PIO

14



DECLASSIFIED
Authority NND 851506



SECRET



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 23mm API
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name MG Ammo
(Telephone, etc.)

Type 23mm API
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

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DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 963506

8A/FEC-51-28030 1 AUG 51

CAPTURED EQUIPMENT:

RUSSIAN TYPE 23MM API PROJECTILE CAPTURED BY THE 508TH ORD TECH INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY(GHE)
2ND SIG CO
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1
1

15



DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 37mm HE-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UOR-167

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 37mm HE-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UOR-167

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



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BA/FEC-51-28029 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 37MM HE-T PROJECTILE
CAPTURED BY THE 50TH ORD TECH
INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO

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DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 37mm AP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-167

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 37mm AP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-167

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



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DECLASSIFIED
Authority NND 951506

BA/FEC-51-28028 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 37MM AP-T PROJECTILE
CAPTURED BY THE 508TH ORD TECH
INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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PUBLICATION UNLESS RELEASED BY GHQ PIO

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DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Artillery Shells
(Telephone, etc.)

Type 45mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells
(Telephone, etc.)

Type 45mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

SECRET



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DECLASSIFIED
Authority NND 851506

8A/FEC-51-28027 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 45MM HE PROJECTILE CAPTURED BY 508TH ORD TECH INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GE -
2ND SIG CO
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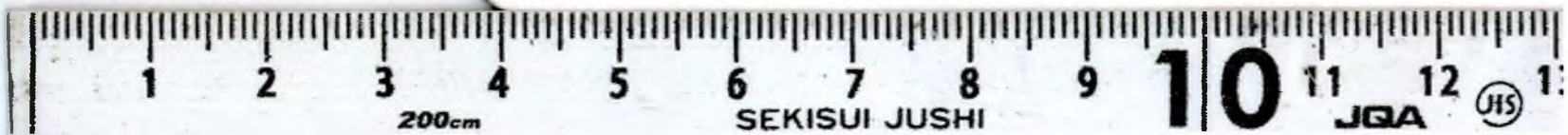

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-243P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-243P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

SECRET

45MM HVAP-T
RUSSIAN



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28026 1 AUGUST 195[illegible]

CAPTURED EQUIPMENT:

RUSSIAN TYPE 45MM HVAP-T PROJECTILE CAPTURED BY THE 508TH ORD TECH INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GE
2ND SIG CO
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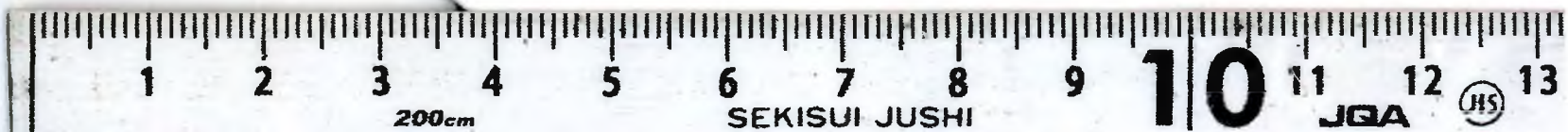
19



DECLASSIFIED
Authority NND 951506



SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm APHE-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model URR-243

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm APHE-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-243

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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DECLASSIFIED
Authority NND 851506

8A/FEC-51-28025 1 AUG 51

CAPTURED EQUIPMENT:

RUSSIAN TYPE 45MM APHE-T PROJECTILE
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
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DECLASSIFIED
Authority NND 951506

2

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm APHEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 45mm APHEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

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SECRET



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DECLASSIFIED
Authority NND 825150 6

DECLASSIFIED
Authority NND 955506

8A/FEC-51-28024 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 45MM APHEI-T PROJECTILES
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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21



DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells
(Telephone, etc.)

Type 57mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UO-271U

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells
(Telephone, etc.)

Type 57mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UO-271U

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND 955506

8A/FEC-51-28020 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 57MM HE PROJECTILES CAPTURED BY THE 508TH ORDNANCE TECHNICAL DETACHMENT, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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22

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 57mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-271P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 57mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-271P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

RUSSIAN



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28018 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 57MM HVAP-T PROJECTILE
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE,
2ND SIG CO
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PUBLICATION UNLESS RELEASED BY GHQ PIO

23



DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 57mm API-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model USZR-271

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Artillery Shells, O/R
(Telephone, etc.)

Type 57mm API-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model USZR-271

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

RUSSIAN



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28010 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 57MM APHEI-T PROJECTILES
CAPTURED BY THE 500TH ORD TECH INSTALLATION
DETACHMENT, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE,
2ND SIG CO
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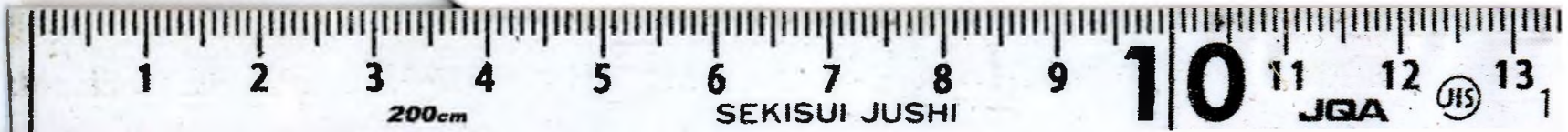
2+



DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-354 P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBR-354 P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

RUSSIAN



SECRET

251

DECLASSIFIED
Authority NND 851506

8A/FEC-51-28025 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 76MM HVAP-T PROJECTILES
CAPTURED BY THE 50TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO

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DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Projectiles & C/R
(Telephone, etc.)

Type 76mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Projectiles & C/R
(Telephone, etc.)

Type 76mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

RUSSIAN



SECRET

DECLASSIFIED
Authority NND 851506

26

BA/FEC-51-28009 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 76 MM HE PROJECTILES CAPTURED
BY THE 50BTH ORDNANCE TECHNICAL INSTALLATION
DETACHMENT, UNITED STATES EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX FOBUDINSKY (CHE)
2ND SIG CO

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DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND 963506

8A/FEC-51-28022 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 76MM HEAT PROJECTILES
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
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27

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm APHEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 76mm APHEI-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28021 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 76MM APHEI-T PROJECTILES
CAPTURED BY THE 508TH ORD TECH DET,
U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX PODUDINSKY (ONE)
2ND SIG CO
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28

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type Shrapnel
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model USh-353D

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type Shrapnel
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model USh-353P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID

76MM SHRAPNEL
RUSSIAN



SECRET

DECLASSIFIED
Authority NND 955506

8A/FEC-51-28011 1 AUGUST 1951

CAPTURED EQUIPMENT:

76 MM SHRAPNEL PROJECTILES (RUSSIAN TYPE)
CAPTURED BY THE 508TH ORD TECH INSTAL DET,
U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE).
2ND SIG CO
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PUBLICATION UNLESS RELEASED BY GHQ PIO

29

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 85mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 85mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND851506

30

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 85mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBP-365P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 85mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UBP-365P

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

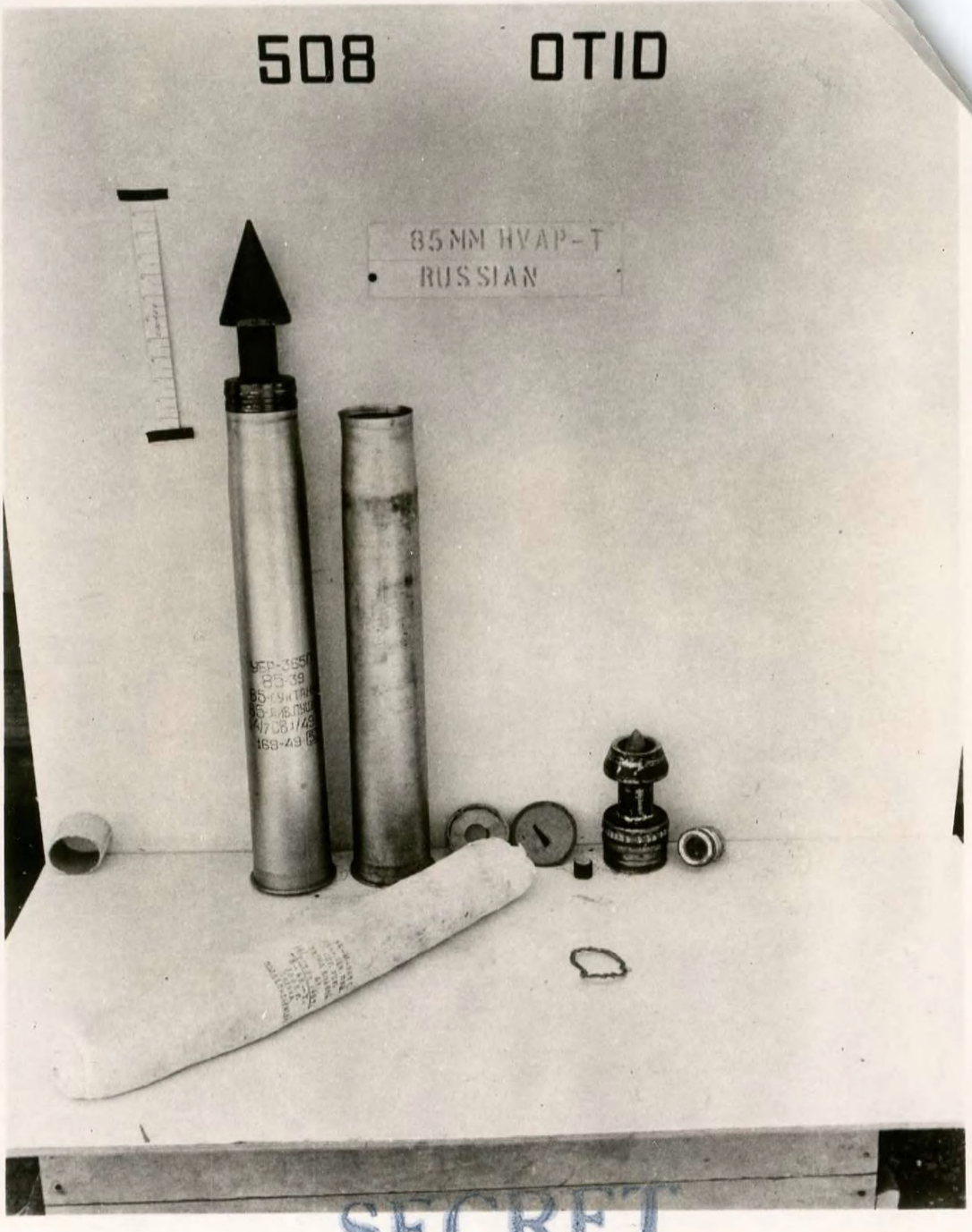
SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

DECLASSIFIED
Authority NND 963506

8A/FEC-51-28008 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 85 MM HVAP PROJECTILES CAPTURED BY THE 508TH ORDNANCE TECHNICAL INSTALLATION DETACHMENT, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE, 2ND SIG CO
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31



DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type APH H-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type APH R-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

8A/FEC-51-28013 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 85 MM APHEI-T PROJECTILES
CAPTURED BY THE 508TH ORD TECH INSTALLATION
DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
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32

DECLASSIFIED
Authority NND 951506

DECLASSIFIED
Authority NND 951506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28017 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 122MM HOW HE PROJECTILES
CAPTURED BY THE 508TH ORDNANCE TECHNICAL
INSTALLATION DETACHMENT, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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33

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

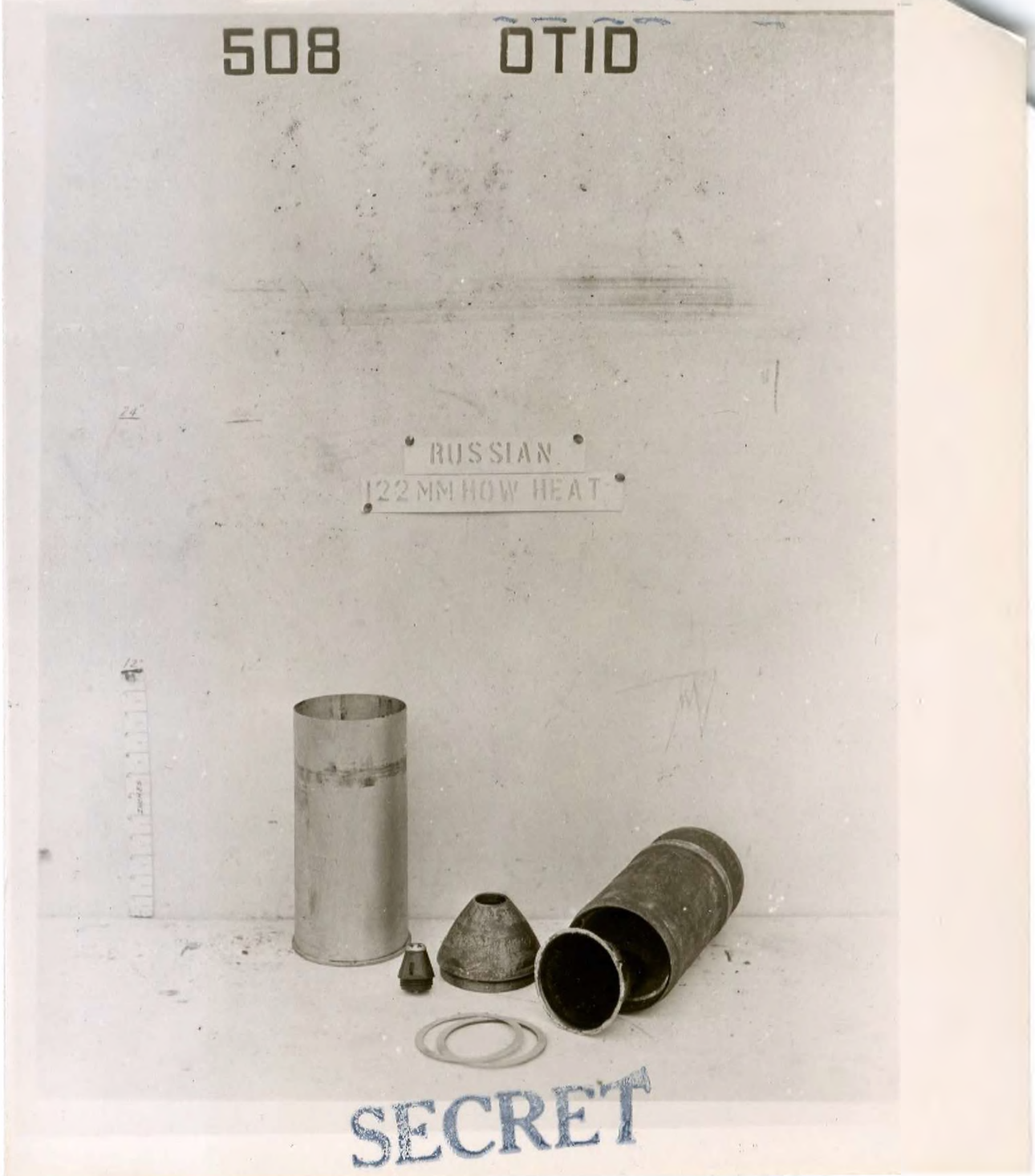
SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

DECLASSIFIED
Authority NND851506

34

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm Howitzer Shrapnel
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Artillery Shell
(Telephone, etc.)

Type 122mm Howitzer Shrapnel
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET

508 OTID



SECRET

DECLASSIFIED
Authority NND851506



3 5

DECLASSIFIED
Authority NND 951506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 122mm AMM-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Artillery Shell, C/R
(Telephone, etc.)

Type 122mm APHE-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28014 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 122MM GUN APHE-T PROJECTILES CAPTURED BY THE 508TH ORD TECH INSTALLATION DET, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
STAFF DISTRIBUTION ONLY ---- NOT FOR PUBLICATION UNLESS RELEASED BY GHQ PIO

36



DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 122mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Artillery Shells, C/R
(Telephone, etc.)

Type 122mm HE
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28016 1 AUGUST 1951

CAPTURED EQUIPMENT:

RUSSIAN TYPE 122MM GUN HE PROJECTILES CAPTURED BY THE 508TH ORDNANCE TECHNICAL INSTALLATION DETACHMENT, U S EIGHTH ARMY.

U S ARMY PHOTO BY CPL ALEX POBUDINSKY (GHE)
2ND SIG CO
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37

DECLASSIFIED
Authority NND851506





SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Mortar Shells
(Telephone, etc.)

Type 82mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model G-832

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

With increments and ignition cartridges.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Mortar Shells
(Telephone, etc.)

Type 82mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model C-832

Year

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

With increments and ignition cartridges.

Received in MIS on
(Date)

Log
(Number)

Negative (Number) In (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

RUSSIAN

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

3

DECLASSIFIED
Authority NND851506



SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Morter Shell
(Telephone, etc.)

Type 107mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Mortar Shell
(Telephone, etc.)

Type 107mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

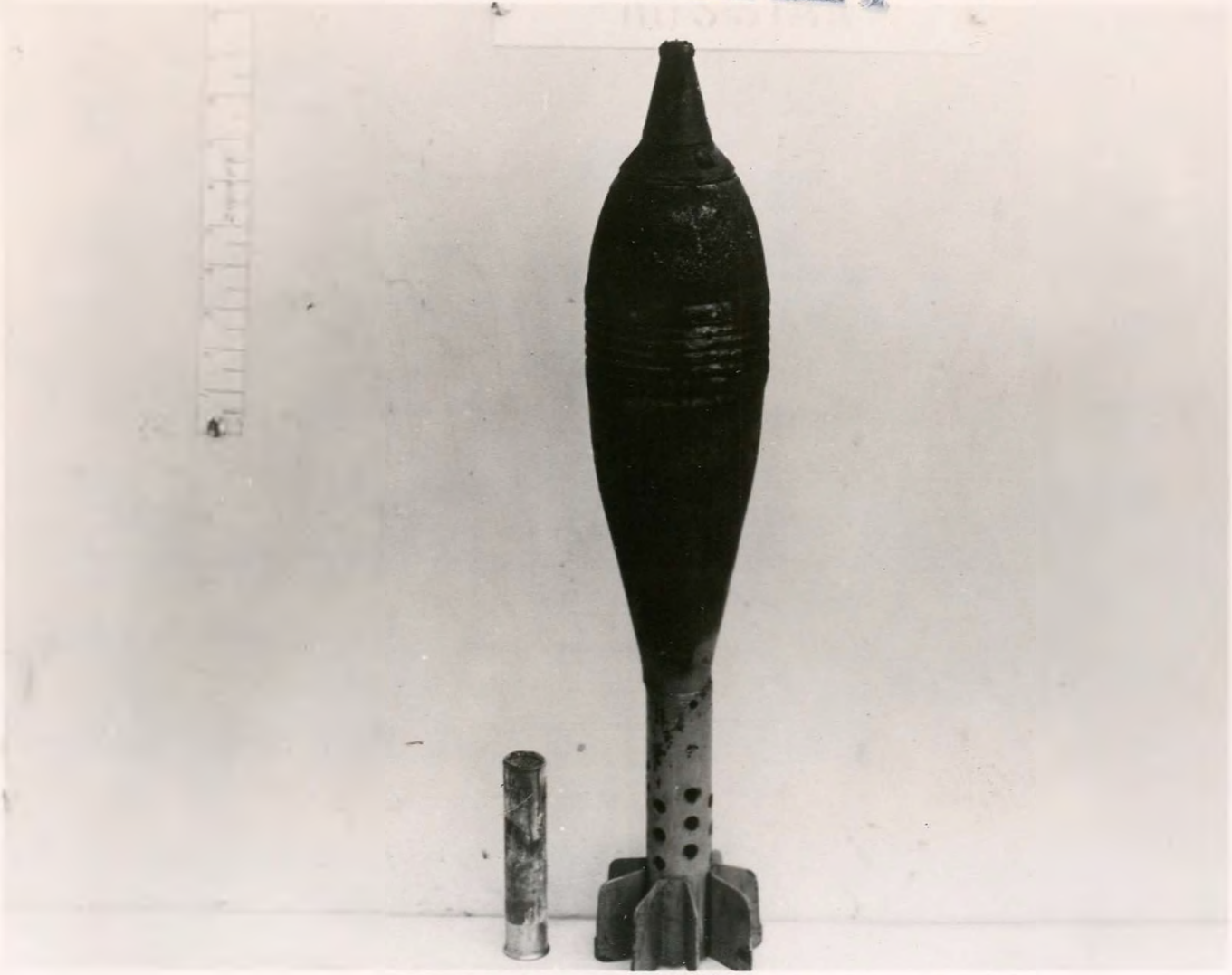
Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 825150 6

SA/FEC-51-28704 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE 107MM MORTAR SHELL WITH IGNITION CARTRIDGE AND FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)

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39

DECLASSIFIED
Authority NND 951506

DECLASSIFIED
Authority NND 851506



Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Mortar Shell
(Telephone, etc.)

Type 120mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Mortar Shell
(Telephone, etc.)

Type 120mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



SECRET

SECRET

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28705 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE 120MM MORTAR SHELL, WITH IGNITION CARTRIDGE AND FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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XO



DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model GVMZ; GVMZ-1; GVMZ-7

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model GVMZ; GVMZ-1; GVMZ-7

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

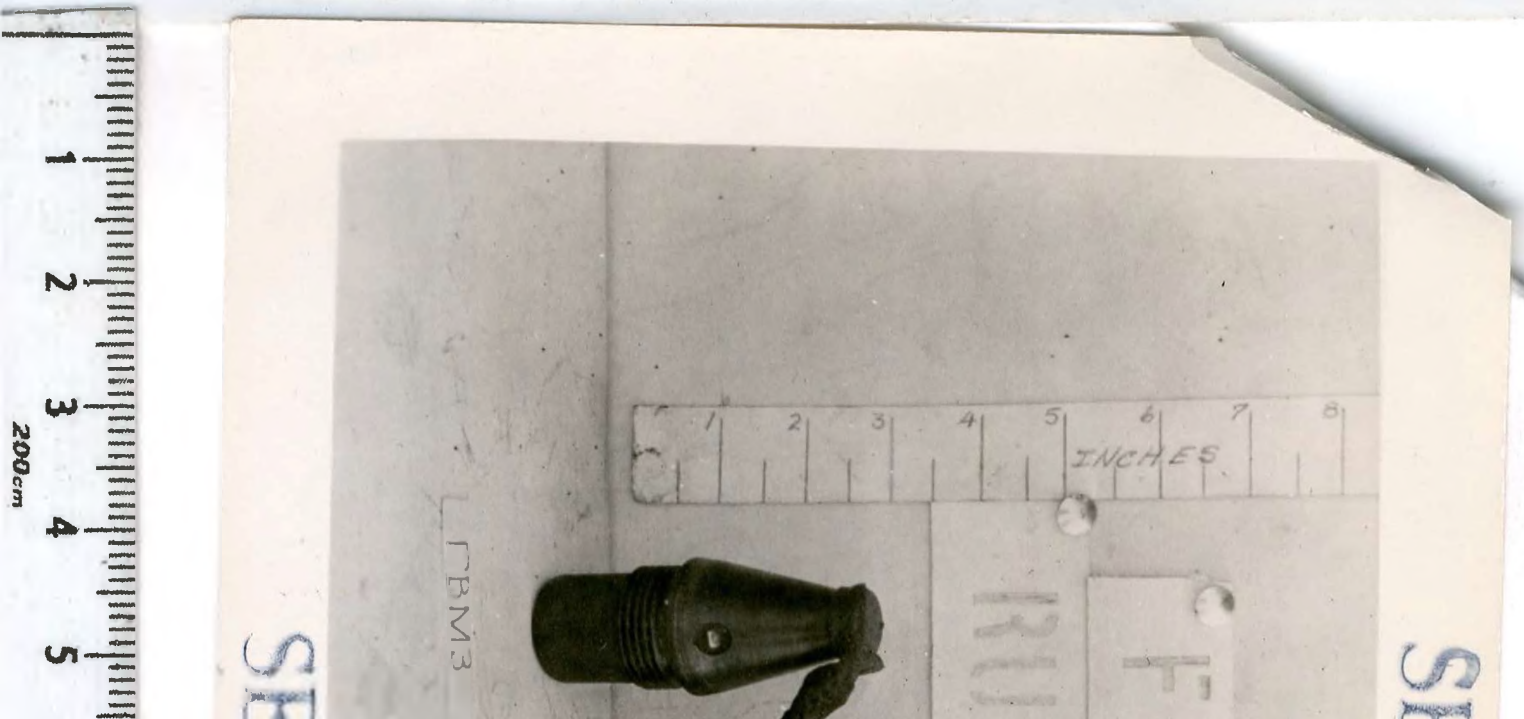
ECRET



ECRET

6 7 8 9 10 11 12 13 14
SEKISUI JUSHI
JQA JIS 1級

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 951506

SA/FEC-51-28698 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE FUSES, KOREA.
L-R: TBM-3; TBM3-1; AND TBM3-7.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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41

DECLASSIFIED
Authority NND851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Mortar
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M-4; M-5

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. ____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Mortar
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M-4; M-5

Year

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

8A/FEC-51-28703 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE M-4 AND M-5 FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK) (167TH SIG PHOTO CO)

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42

DECLASSIFIED
Authority NND 851506

1 2 3 4 5 6 7 8 9 10 11 12 13
200cm SEKISUI JUSHI JQA JIS

DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Mortar
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model MP-82

Year _____

Photographed Aug 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Mortar
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model MP-82

Year _____

Photographed Aug 51 Koren
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28697 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE MN-82 FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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A3



DECLASSIFIED
Authority NND 951506



SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model See below

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left: Unknown model.

Right: KTM-1.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model See below

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left: Unknown model.

Right: KTM-1.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 985506

44

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(16TH SIG PHOTO CO)

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)

PNQ-15, AND KTM-1.

CAPTURED RUSSIAN MADE FUSES, KOREA. L-R:

ENEMY EQUIPMENT:

8A/FEC-51-2869b 7 AUG 51

DECLASSIFIED
Authority NND 851506



SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model T-6; T-6, D-1; P-10

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model T-5; T-6, D-1; F-10

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 85 1506

DECLASSIFIED
Authority NND 825506

SA/FEC-51-28702 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE FUSES, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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A5



DECLASSIFIED
Authority NND 851506



SECRET

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model See below

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
MD-5; MD-6; MD-7; MD-8; MD-10.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model See below

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
MD-5; MD-6; MD-7; MD-8; MD-10.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 825150 6

DECLASSIFIED
Authority NND 955150 6

SA/FEC-51-28695 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE FUSES, KOREA.

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44



DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model AN-A; AV-1, AFUV-1

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

AM-A
AB-1
A119B-1

SECRET

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model AN-A; AV-1, AFUV-1

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

SA/FEC-51-28713 7 AUG 51

ENEMY EQUIPMENT:

L-R: AM-A; AB-1; AND ANYB-1, CAPTURED RUSSIAN MADE FUSES, KOREA.

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(167TH SIG PHOTO CO)

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DECLASSIFIED
Authority NND 851506



SECRET

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model K-6; K-20M; 6M

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuzes
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model K-5; K-20M; 3M

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

84

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(16/IH SIG PHOTO CO)

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)

CAPTURED RUSSIAN MADE FUSES, KOREA.

L-R:K-6; K2OM; AND 6-M.

ENEMY EQUIPMENT:

BA/FEC-51-2R700 7 AUG 51

DECLASSIFIED
Authority NND 951506

SECRET

B-229

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V-229

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V-229

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

SA/FEC-51-28701 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE B-229 FUSE, KOREA.

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(167TH SIG PHOTO CO)

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49

DECLASSIFIED
Authority NND 851506





Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model MG-37

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type _____
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model MG-37

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28696 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE MT-37 FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

STAFF DISTRIBUTION ONLY--NOT FOR
PUBLICATION UNLESS RELEASED BY GHQ PIO

50



DECLASSIFIED
Authority NND 851506

SECRET

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Mortar, PD
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M-1

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Mortar, PD
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M-1

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

8A/FEC-51-28693 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE M-1 FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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PUBLICATION UNLESS RELEASED BY GHQ PIO

51

1 2 3 4 5 6 7 8 9 10 11 12 13
200cm SEKISUI JUSHI JQA JIS

DECLASSIFIED
Authority NND851506

SECRET

PTM-2

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RM-2

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RM-2

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28712 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

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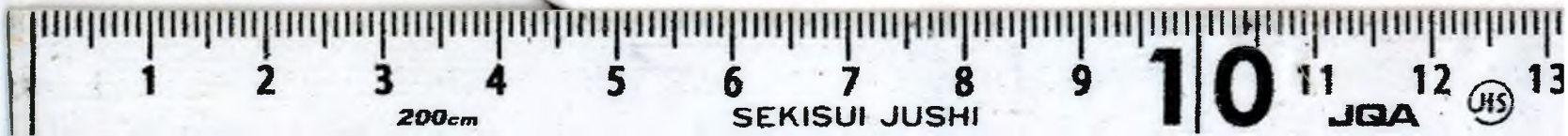
PUBLICATION UNLESS RELEASED BY GHQ PIO

52



DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery, FD
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model UGT-2

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Fuze
(Telephone, etc.)

Type Artillery, FD
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model VGT-2

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



SECRET

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 951506

8A/FEC-51-28699 7 AUG 51

ENEMY EQUIPMENT:

CAPTURED RUSSIAN MADE YFT-2 FUSE, KOREA.

U S ARMY PHOTO BY CPL GENE LAGRONE (SK)
(167TH SIG PHOTO CO)

STAFF DISTRIBUTION ONLY--NOT FOR
PUBLICATION UNLESS RELEASED BY GHQ PIO

53



DECLASSIFIED
Authority NND 951506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aircraft Bomb
(Telephone, etc.)

Type 20 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Aircraft Bomb
(Telephone, etc.)

Type 20 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

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_____

_____

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND851506

5-4

DECLASSIFIED
Authority NND 851506



Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Bomb
(Telephone, etc.)

Type 50 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Bomb
(Telephone, etc.)

Type 50 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND851506

55

DECLASSIFIED
Authority NND851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Aircraft Bomb
(Telephone, etc.)

Type 220 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Aircraft Bomb
(Telephone, etc.)

Type 220 lb Frag Bomb
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

SECRET



SECRET

DECLASSIFIED
Authority NND851506



56

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Mine
(Telephone, etc.)

Type TMD-B Box Mine
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 951506

Subject Ammunition B. I. D. No. _____
(Communications, etc.)

Name Mine
(Telephone, etc.)

Type TMD-B Box Mine
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Aug 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

_____

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_____

_____

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506



DECLASSIFIED
Authority NND851506

59

DECLASSIFIED
Authority NND851506



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Rocket motor, 132mm, Soviet, set screw. (Secret sign is six inches long).

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

0400 USSR

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Rocket
(Telephone, etc.)

Type 132mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 Tokyo, Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rocket motor, 132mm, Soviet, set screw. (Secret sign is six inches long).

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

0400 USSR

DECLASSIFIED
Authority NND 985506

DECLASSIFIED
Authority NND 851506

SECRET

FEC-51-34058 25 SEPT 51

CAPTURED SOVIET ROCKET ~~MOTOR~~ MOTOR:

ROCKET ~~MOTAR~~ MOTOR, 132MM, SOVIET, SET SCREWS (SECRET SIGN IS SIX INCHES LONG).

U S ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND 851506



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rocket motor, 132mm, Soviet, showing set screw.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Rocket
(Telephone, etc.)

Type 132mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 Tokyo, Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Rocket motor, 132mm, Soviet, showing set screw.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND851506

SECRET

FEC-5 1-34060 25 SEPT 51

CAPTURED SOVIET ROCKET ~~MOTOR~~ MOTOR.

ROCKET ~~MOTOR~~ MOTOR, 132MM, SOVIET, SHOWING SET SCREW. (SECRET SIGN IS 6" LONG).

U S ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND 851506



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rocket motor, 132mm, Soviet, showing base; (Secret sign is six inches long).

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Rocket
(Telephone, etc.)

Type 132mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 Tokyo, Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rocket motor, 132mm, Soviet, showing base; (Secret sign is six inches long).

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 851506

SECRET

FEC-51-34057 25 SEPT 51

CAPTURED SOVIET ROCKET ~~MORTAR~~ MOTOR.

ROCKET ~~MORTAR~~ MOTOR, 132MM, SOVIET, SHOWING BASE; (SECRET SIGN IS SIX INCHES LONG)

U S ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND 851506



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Rocket motor 132mm, Soviet, showing markings (Secret sign is 6" long).

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Rocket motor 132mm, Soviet, showing markings (Secret sign is 6" long).

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 985506

DECLASSIFIED
Authority NND 851506

SECRET

FEC-51-34056 25 SEPT 51

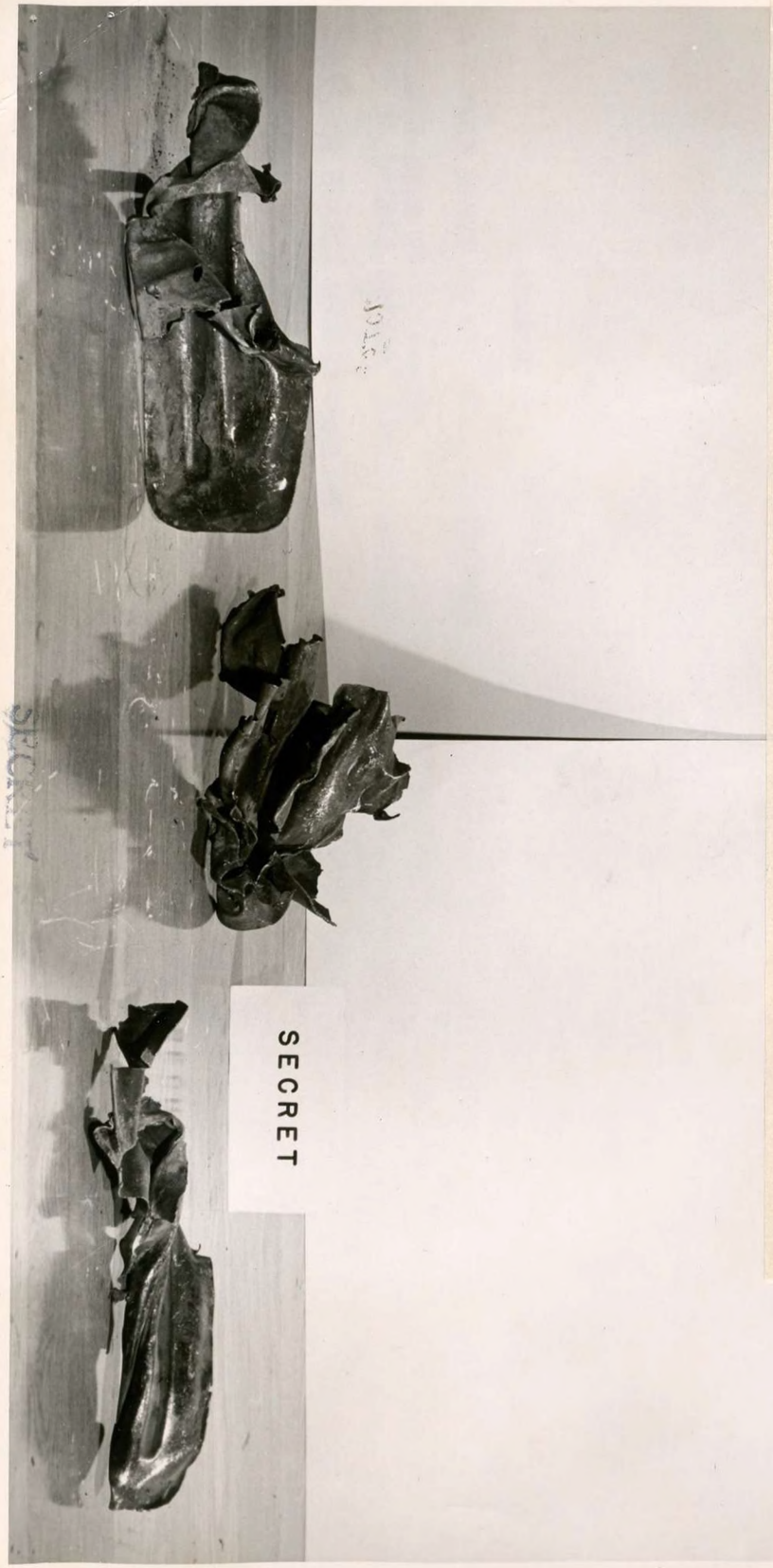
CAPTURED SOVIET ROCKET ~~MORTAR~~ MOTOR:

ROCKET ~~MORTAR~~ MOTOR, 132MM, SOVIET, SHOWING MARKINGS(SECRET SIGN IS 6" LONG)

U.S. ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND 851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Rocket
(Telephone, etc.)

Type 132mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 Tokyo, Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Fins to Rocket motor, 132mm, Soviet (Secret sign is 6" long).

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506

Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Fins to Rocket motor, 132mm, Soviet (Secret sign is 6" long).

Received in MIS on _____ (Date)

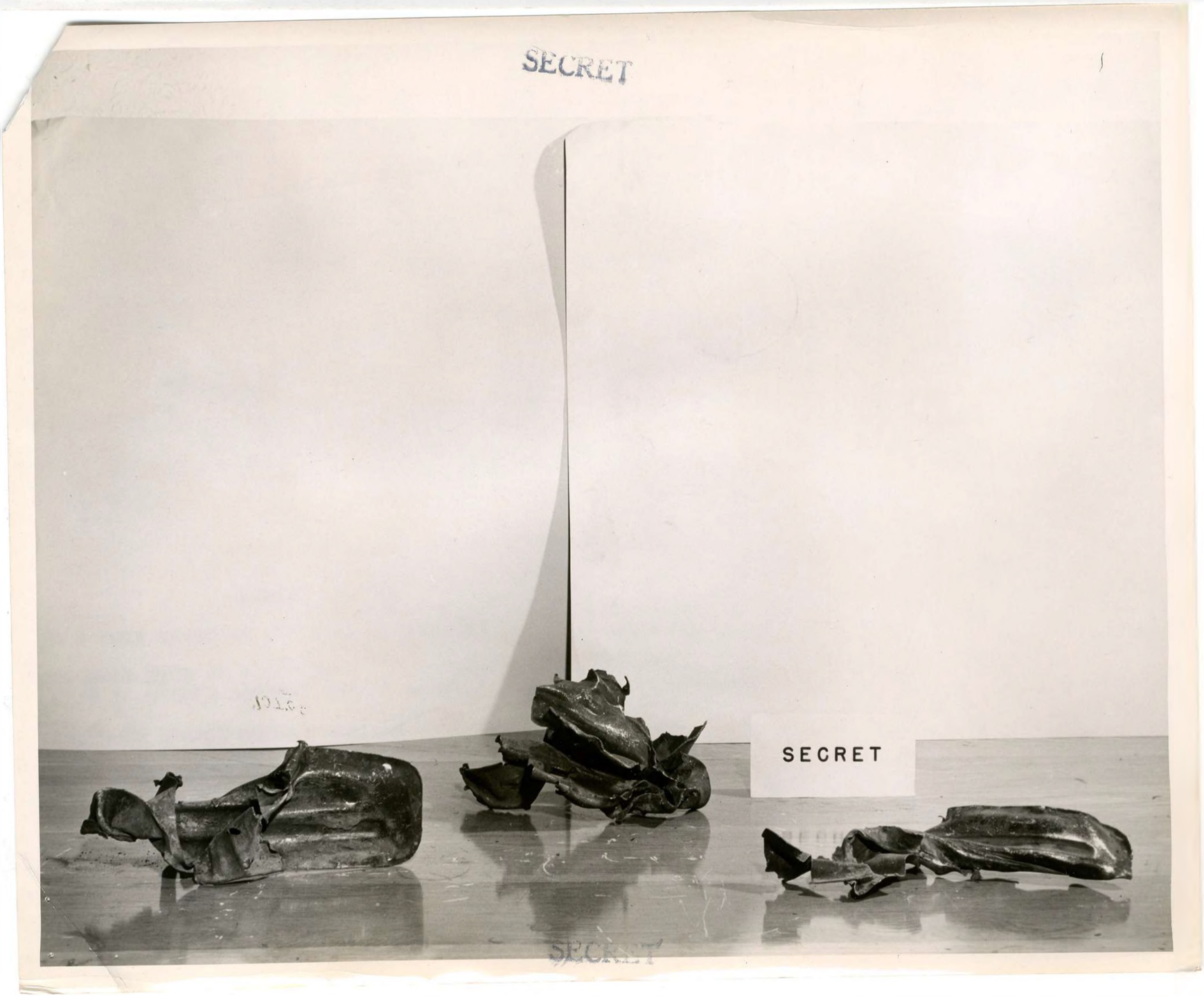
Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND851506

SECRET

FEC-51-34054 25 SEPT 51

CAPTURED SOVIET ROCKET ~~MORTAR~~ MOTOR:

FINS TO ROCKET ~~MORTAR~~ MOTOR, 132MM, SOVIET,
(SECRET SIGN IS 6" LONG).

U S ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND851506



Subject Ammunition (Communications, etc.) B.I.D. No. ____

Name Rocket (Telephone, etc.)

Type 132mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M13

Year ____

Photographed 25 Sep 51 (Date) Tokyo, Japan (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Captured Soviet Rocket Motor:

Rocket Motor, 132mm, Soviet.

Received in MIS on ____ (Date)

Log ____ (Number)

Negative ____ (Number) In ____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Rocket
(Telephone, etc.)

Type 132mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M13

Year _____

Photographed 25 Sep 51 Tokyo, Japan
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Captured Soviet Rocket Motor:

Rocket Motor, 132mm, Soviet.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

DECLASSIFIED
Authority NND 985506

DECLASSIFIED
Authority NND851506

SECRET

FEC-51-34059 25 SEPT 51

CAPTURED SOVIET ROCKET ~~MORTAR~~ MOTOR:

ROCKET ~~MORTAR~~ MOTOR, 132MM , SOVIET.

U S ARMY PHOTO BY CPL ALEX KLEIN(NME)

SECRET

DECLASSIFIED
Authority NND 951506

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

25 September 1951

SUBJECT: Markings from Captured Enemy Materiel
Reports Control Symbol, ID 47/1

1. This report is based on information contained in markings reports received from the Technical Intelligence Coordinator Team, ROK I Corps.

Rifle, Soviet, 7.62mm, M1891/30


СО 1757
1938


3748
1933


122998
1937


22794
1937


29046
1934


ФГ 1869
1942


35021
1933


43751
1938


95378
1933


23378
1926


94459
1937


ПБ 1655
1938


ФЛ 3070
1942


34686
1934


ЛИ 1124
1939


9170
1937


РЧ 3144
1942


14924
1933


140538
1932


ЗА 8957
1943


ГП 1937
1942


ЧН 1338
1938


68117
1931


11762
1933

7222
0400 455R

DECLASSIFIED
Authority NND 851506


СТ 2231
1938


156841
1935


СВ 1436
1942


68468
1932


56410
1931


АС 5815
1942


РН 5088
1942


ЛА 1590
1938


ЛА 3372
1939


103429
1937


НГ 5373
1939


УО 5329
1938


ЛУ 4830
1939


50354
1932


72564
1931


ВИ 1392
1939


ФА 6213
1942


АМ 4253
1939


8149
1925


ТШ 1715
1943


КР 326
1942


26652
1934


СТ 5036
1944


ПИ 3629
1938


16409
1933


4254
1932


КТ 9062
1943


118137
1932

DECLASSIFIED
Authority NND 851506



16433
1933



94891
1935



ИМ 2097
1939



144015
1932



74342
1931



АО 2412
1939



97893
1933



163525
1937



648
1933



94444
1937



140644
1932



66527
1932



ФА 6298
1942



803
1933



139775
1932



185673
1937



1942 г
СЧ 3241



1933 г
18709



1938
ЧН 5225



1943
АМ 2099



1933 г
14270



1942 г
ФГ 1995



1943
Ю И 5821



1942
ЗЕ 1163

DECLASSIFIED
Authority NND 851506



1935
111866



1934
56111



КШ 5284
1943

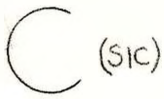


4904
1939

7.62mm M1941, PPSH



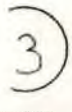
1942
2179



1945
151



1944
БЛ 7907



1943
ЕТ 79



АЕ 6651
1944



БЖ 6443
1944



АЛ 5071
1943



НД 1680
1943



НД 2791
1944



ГН 4297
1944



КИ 671
1943



БЖ 7864
1943



БЛ 7673
1944



АЖ 3790
1944



ЗН 6488
1943



03 553
1944



ЕА 4290
1944



ЕО 2954
1942



ЦЛ 121
1945



АГ 190
1945



БЖ 8433
1943



НГ 6512
1943

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7.62mm, M1941, PPSH



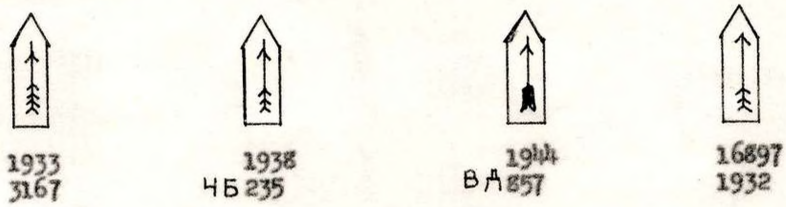
ЕГ 4522 1943 | ГМ 4781 1943 | ЕЖ 9049 1943 | ЖА 8162 1943

НБ 6314 1943 | ГП 4260 1946 | АБ 1176 1944 | ЖА 863 1944



ДА 493 | КБ 5215 1944 | ВЖ 3037 1944

7.62mm, Light Machine Gun, DP



1933 3167 | 1938 ЧБ 235 | 1944 ВД 857 | 16897 1932

1752 1936 | 899 1931 | АЕ 655 1944 | КБ 901 1944

КФ 750 1944 | БА 335 1945 | ИЯ 137 1944 | ИХ 813 1944

КА 810 1944 | АИ 520 1944

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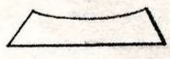
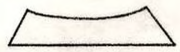
7.62mm Heavy Machine Gun, Maxim M1910













АР 845
No date

7.62mm, Carbine, M1938



7.62mm PPS M1943



7.62mm, PPSH, M1941, North Korean



E N D

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Authority NND851506

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

6 September 1951

SUBJECT: Markings from Captured Enemy Materiel

1. This report is based on information contained in markings reports forwarded by the Technical Intelligence Coordinator Team, ROK I Corps.

a. Soviet Rifle, 7.62mm, M1891/30


99812
1932


33422
1932


277537
1937


ч K 3808
1938


ПХ 3478
1942


23102
1933


НМ 5503
1938


НМ 2385
1939


ч 9130
1938


ЖН 1555
1938


L 24954
1937


130
1933


ЖН 5273
1939


ДВ 5253
1938


СП 1942
741


1942
50374


ЖИ 1939
3677

6006

0400455R

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1933
14290



1933
29402



1938
НН 0873



1932
3862



1939
АР 4024



1933
22353



1936
32286



1938
ПФ 2984



1937
117499



1932
374



1936
981



1942
СП 477



1937
197325



108057
1925



ЛА 4126
1938



ИН 2925
1939



СП 1851
1942



25910
1933



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Authority NND 951506

b. Soviet Sub-machine Gun, 7.62mm, PPSH, M1941



3742
1943



ПЕ 7834
1944



922
1943



Г 51668
1944



ВН 601
1944



ЖА 156
1944



ВН 1305
1943



ТН 9365
1944



ЕИ 961
1943



1944
ЗБ 7641



1944
БЖ 2360



1945
ГП 673



1945
БЗ 3367



1945
Г 176973



СИ 349
1942



ГА 7113
1944



БС 1008
1942



ГИ 5762
1944



ЛИ 7763
1944



АР 9015
1945



ПП 5265
1943

c. North Korean, Sub-machine Gun, 7.62mm, PPSH, M1941



LL 701
1949

DECLASSIFIED
Authority NND 851506

d. Soviet Light Machine Gun, 7.62mm, DP



ИВ 178
1942



НХ 776
1944



НР 250
1944



ЦР 1944
447



З Ч 1944
991



1939 Г
СП 606

e. Soviet, Maxim HMG, 7.62mm, M1910 (on M1931 dual-purpose mount).

4051
1945



АП 406
1944

f. Soviet, Carbine, 7.62mm, M1938

ПА 1942 Г
3349



END

DECLASSIFIED
Authority NND 851506

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

5 September 1951

SUBJECT: Markings from Captured Enemy Materiel

1. This report is based on information contained in markings reports forwarded by the Technical Intelligence Coordinator Team, ROK I Corps and a vehicle nameplate forwarded by S-2, 5th Infantry Regiment.

a. Soviet Sub-machine Gun, 7.62mm, PPSH, M1941


1945
НР 226


1943
ПГ 471


1942
Я А
483


1944
4345


1942 Г
512


1944
37116


1944
ЖА 667


ГИ 7763
1944


1944
БЗ 8514


1944
ЖА 3682


1944
ЖА 2009


ИБ 6260
1944


АБ 6126
1944

БА 6213
1944


З А 5430
1944

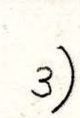

ГИ 3690
1944

6030

0400 USSR

DECLASSIFIED
Authority NND 851506

3)



1943
МЕ
7706



1944
А Ж 6633



И Б 6260
1944

АБ 6126
1944



Б А 6213
1944

3 A



5430
1944



Г И 3690
1944

b. North Korean Sub-machine Gun, 7.62mm, PPSH, M1941



2Н 423
1950



LL 701
1944



1950
2Н 749



1950
О 124

c. Soviet, Rifle, 7.62mm, M1891/30

1938
Ч К64





1937
234085



1937
95010

1938
И В 3578



1937
234085

1937
95010



1933
19524



1938
ЖТ 1205

1932 Г
104537



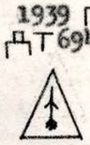
1942
НПЧ 754



DECLASSIFIED
Authority NND 851506



1933
98407



1939
6942



1932
111392

d. Soviet Light Machine Gun, 7.62mm, DP



1938
HK 328



1942
KB 736



1944
B 3970



1944
BE 354



1938
1071

e. Soviet Sub-machine Gun, 7.62mm, PPS, M1943



1943
HK
882

f. Chinese Light Machine Gun, Air-cooled, approximately 7.62mm:





3400

Vehicle No. 1

a. Make and Model - Soviet ZIS - 150

b. Nameplate: 150 4

207055

273410

END

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Authority NND 851506

HEADQUARTERS
920th Ordnance Technical Intelligence Detachment

7 September 1951

SUBJECT: Letter Report 920-8: Soviet 132mm Rocket

1. Narrative:

On the morning of 4 September 1951, four Soviet 132mm rockets landed in the 7th Infantry Division area; two in the 31st Regiment area (CT 82803965), and two in the 17th Regiment area (CT 815420). The two which landed the 17th Regiment area overshot the tank park by 150 yards, and those in the 31st Regiment area landed in the vicinity of hillside outposts, one of these last leaving a crater 7 feet long, 18 inches deep, 36 inches wide, and throwing a spray 18 feet from crater center, in sandy loam. No casualties were incurred by any of the projectiles.

2. Data extracted from examination of fragments:

a. Approximate length (incomplete motor section) - 24 3/4"
b. Diameter of motor section (approximate) - 132mm
c. Thickness of walls - .152" - .172"
d. Recognition features - light casing, internally threaded end, large set screw at base.
e. Markings:

1	2	3	4
(painted) Г-В 4+7609	(stamped) РХ-44	(stamped) 62 U NPФ 74 H M3	42373 (stamped) ЛР (set screw)
(stamped) ПХ-44			

f. Fins and warhead assemblies: no specimens recovered intact.

3. Conclusions and observations:

Upon examination of fragments and data, it is the opinion of this unit that the rockets were of the Soviet RBS-132 type. Recent evidence (see PIR #312, Hq 1st Marine Division, 011800 - 021800 Sept 1951) indicates the presence of Soviet rocket launchers in North Korea. Both regiments reported ground flashes and no sound, indicating that the rockets were launched from the ground.

HEADQUARTERS
920th Ordnance Technical Intelligence Detachment

8 September 1951

SUBJECT: Letter Report 920-8A: Soviet 132mm Rocket

In addition to the original information presented in Letter Report 920-8, 7 September 1951, the following data, concerning the initial appearance of this rocket, has been obtained:

On the night of 5 September 1951, the 17th Infantry Regiment reported the following enemy offensive artillery activity in the vicinity of CT 845359:

0400 USSR

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2215 hours - 4 air bursts
2225 hours - 4 air bursts
2235 hours - 4 ground bursts
2255 hours - 4 air bursts
0033 hours - 4 air bursts

This activity was mistaken for air-bombing at the time, due to the air bursts and the fact that no reports were audible to indicate artillery fire. In addition, three unidentified aircraft were reported overhead. The flash of the rocket being launched was interpreted as being an aerial flare, and the detonation as that of an aerial bomb. The rockets were apparently launched to the front of the 31st Regiment, to the west of the 17th, as the 17th saw the flashes in that sector and thought that the 31st was being bombed. No casualties were inflicted by any of the rockets, and no additional rockets were reported for the period 0100 6 September - 1000 8 September 1951.

E N D

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SECRET
SECURITY
INFORMATION

TR-2503-51
2

510TH ORDNANCE TECHNICAL
INTELLIGENCE DETACHMENT
APO 59

5 December 1951

SUBJECT: 510th Ordnance Technical Intelligence Report No. 510-19 (Modified, Gun, sub-mach, 7.62 mm, Soviet, PPS, M-1943)

1. This weapon has been modified to increase the rate of fire by cutting one and thirteen-sixteenth (1-13/16) inches from the back of the bolt and reducing the length of the receiver by two and one-half (2-1/2) inches. The same recoil spring is used thereby giving a faster return of the bolt to the firing position. See photograph No. 510-19-1 for comparison of the modified bolt and one of the standard model.

2. Photograph No. 510-19-2 shows modified Soviet, sub-machine Gun, PPS, M-1943 on left and standard Soviet, sub-machine Gun, PPS, M-1943, on the right.

3. Markings found on this weapon are as follows:

a. On Bolt Cocking Handle

СП 504

4. This weapon has not been fired by this unit; therefore, the rate of fire is unknown.

5. This weapon is now located at the 533d Ordnance Depot, Masan, Korea.

END

0400 USSR.

SECRET
SECURITY
INFORMATION

DECLASSIFIED
Authority NND 951506

Subject Small Arms (Communications, etc.) B.I.D. No. _____

Name Submachine Gun (Telephone, etc.)

Type Modified PPS M-43 (Field, etc.)

Made by USSR (Manufacturing nation)

Model _____

Year _____

Photographed 4 Dec 51 (Date) Wonsan, Korea (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Modified PPS M-1943 Soviet SMG bolt on left and standard bolt on the right.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

RESTRICTED SECURITY INFORMATION (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND 851506

Photograph No. 510-19-1

Showing modified IIS, M-1943
sub-mach gun bolt on left
and standard IIS, M-1943
sub-mach gun bolt on right.

Photographer: 2nd Lt, J.B.Taylor
510th C.T.I.D.

4 December 1951 Masan Korea

STAFF DISTRUBITION ONLY--NOT FOR
PUBLICATION UNLESS RELEASED BY
GHQ FIO.

DECLASSIFIED
Authority NND 951506

Subject Small Arms B.I.D. No. _____
(Communications, etc.)

Name Submachine Gun
(Telephone, etc.)

Type Modified PPS M-43
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed 4 Dec 51 Masan, Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Comparison of modified PPS M-1943 Soviet SMG with standard model on the right.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

RESTRICTED SECURITY INFORMATION
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



DECLASSIFIED
Authority NND851506

Photograph No. 510-19-2

Comparison of modified PPS,M-1943 Soviet,sub-mach gun,with standard model on right.

Photographer: 2ndLt,J.B.Taylor
510th O.T.I.D.

4 December 1951 Masan Korea

STAFF DISTRUBITION ONLY--NOT FOR PUBLICATION UNLESS RELEASED BY GHQ FIO.

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Authority NND 851506

526TH ORDNANCE TECHNICAL INTELLIGENCE DETACHMENT

7 June 1951

SUBJECT: Soviet HEAT Hand Grenade, RPG-6

1. The attached photographs are of the Soviet HEAT Hand Grenade RPG-6. This grenade utilizes the shaped charge principle and will penetrate up to 3.94 inches of armor. It has an overall length of 13.5 inches and weighs 2.4 lbs. This grenade has an all-ways-impact fuze.

2. Before throwing the grenade, a safety pin with a small piece of cloth attached to the handle, is pulled out releasing the hand safety (b-Incl #2) which, when thrown, releases the spring loaded secondary safety (c-Incl #2) which in turn allows the striker in the handle, held by a creep spring, to move forward upon impact and strike the detonator (g-Incl #2), setting off the grenade.

3. When the grenade is thrown and the hand safety (b- Incl #2) releases, a cloth ribbon (f- Incl #2) fastened to both the hand safety and the end of the handle, is pulled out of the handle by the weight of the hand safety. Combined drag of the ribbon and the hand safety stabilizes the grenade while in flight.

4. The grenade may be thrown from 17 to 25 yards with reasonable accuracy.

5. The grenade is packed in a disassembled condition with the grenade body, grenade handle and detonator separated.

E N D

Photos USSR

DECLASSIFIED
Authority NND 851506



Subject Demolitions, Explosive Devices B.I.D. No. _____
(Communications, etc.)

Name Grenade
(Telephone, etc.)

Type Hand, HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-6

Year unk

Photographed 2 Jun 51 (Date) Korea (Place)

Viewed from—

3/4

Front ☐
Rear ☒
Side ☐
Top ☐

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ (Number) In _____ (Office)

CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS



Subject Demolitions, Explosive Devices B.I.D. No. _____
(Communications, etc.)

Name Grenade
(Telephone, etc.)

Type Hand, HEAT
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model RPG-6

Year unk

Photographed 2 June 51 (Date) Korea (Place)

Viewed from—

3/4

Front ☐
Rear ☒
Side ☐
Top ☐

Remarks:

Disassembled

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ (Number) In _____ (Office)

CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506

Incl #1 CONFIDENTIAL



CONFIDENTIAL

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ In _____ (Office)

_____ (Number)

CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS



CONFIDENTIAL

CONFIDENTIAL

Received in MIS on _____
(Date)

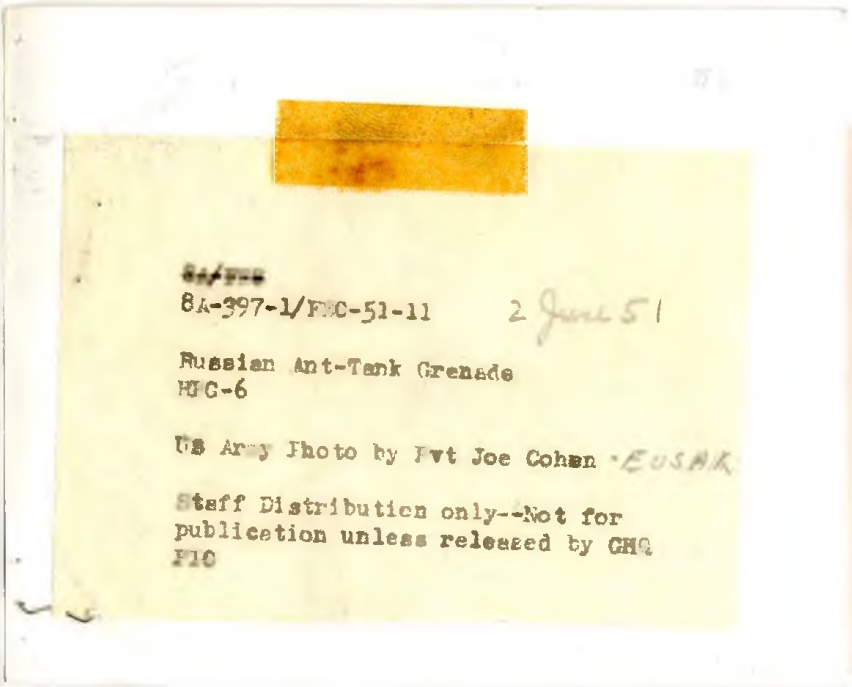
Log _____
(Number)

Negative _____ In _____
(Number) (Office)

CONFIDENTIAL
(Classification)

Photo Identification Form, Materiel, M & P, MIS





8A-397-1/FEC-51-11 2 June 51

Russian Ant-Tank Grenade
HEC-6

US Army Photo by Pvt Joe Cohen - EUSAK

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FEC



DECLASSIFIED
Authority NND 853506

DECLASSIFIED
Authority NND 851506



Subject Demolitions, Explosive Device (Communications, etc.) B.I.D. No. .....

Name Grenade (Telephone, etc.)

Type Hand, HEAT (Field, etc.)

Made by USSR (Manufacturing nation)

Model RPG-6

Year .....

Photographed ..... (Date) (Place)

Viewed from—

3/4

- Front [X]
- Rear [ ]
- Side [ ]
- Top [ ]

Remarks:

Disassembled

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

CONFIDENTIAL (Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND 851506



Incl #3 CONFIDENTIAL

.....

.....

.....

.....

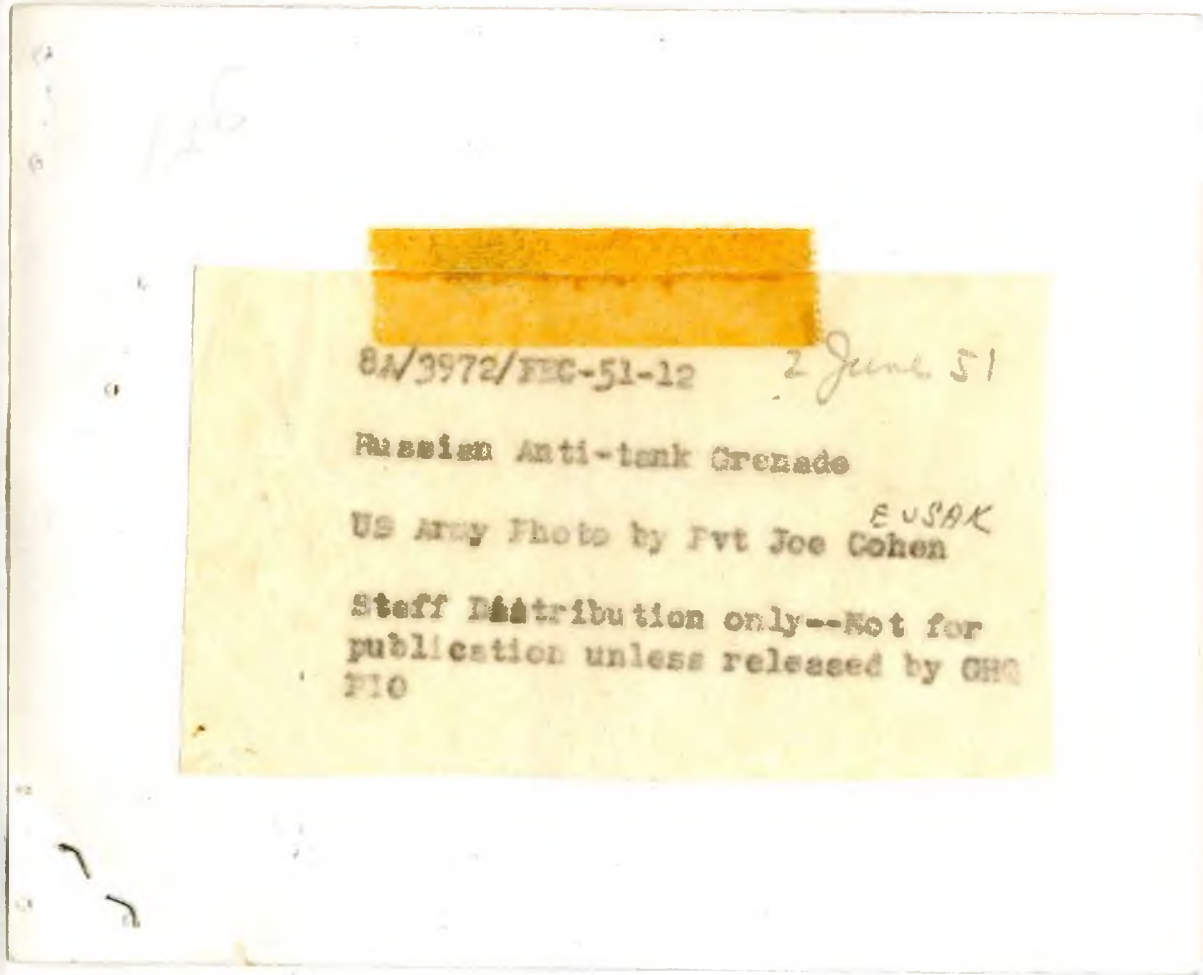
Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

.....CONFIDENTIAL.....
(Classification)

Photo Identification Form, Matériel, M & P, MIS



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Authority NND 851506

8A/3972/FEC-51-12 2 June 51

Russian Anti-tank Grenade

US Army Photo by Pvt Joe Cohen EUSAK

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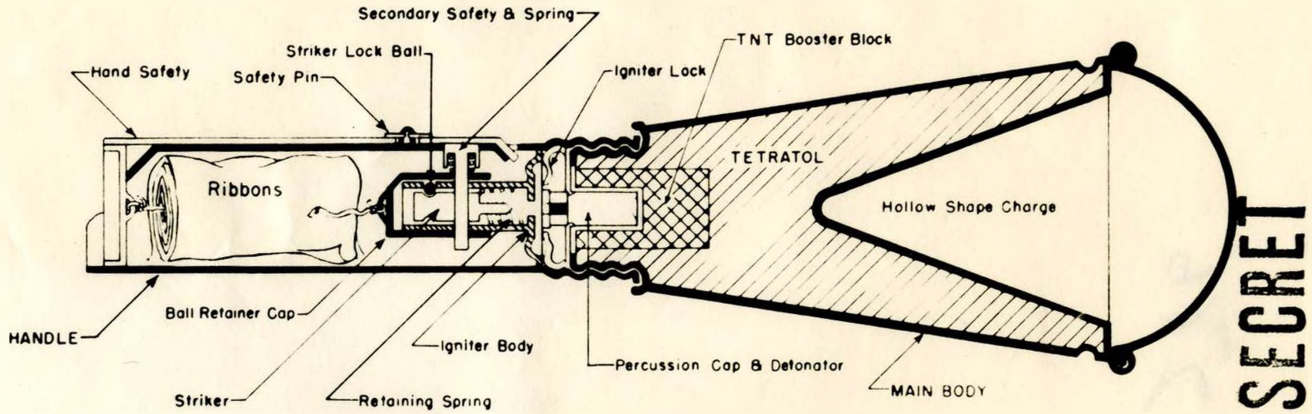
RUSSIAN RPG-6 HEAT HAND GRENADE

SECRET



SECRET

NOTE: This grenade is dangerous after thrown. It must be blown in place if the hand safety and ribbon stabilizer have been ejected.

RULES FOR THROWING GRENADE

1. Insert the Igniter into the body of Grenade and screw in the Handle as far as possible
2. Grasp the Grenade with the right hand; with the left hand pull the Safety Pin
3. Throw the Grenade hard against the target

IT IS DANGEROUS TO:

1. Disassemble the handle of the grenade
2. Touch unexploded grenade.

ENGR X CORPS

Incl #4

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND851506

286

DECLASSIFIED
Authority NND 951506

510TH ORDNANCE TECHNICAL
INTELLIGENCE DETACHMENT

7 July 1951

SUBJECT: 510th Ordnance Technical Intelligence
Report No. 510-14
(Soviet, 76mm Shape Charge Projectile
with Tracer Element)

1. On 12 June 1951 this unit received from the 5th Marine Regiment, 1st Marine Division twenty (20) rounds of Soviet, 76mm, Shape Charge Ammunition.

2. All twenty (20) shell casings had no propellant even though they were fixed rounds.

3. All rounds were fitted with the Soviet, point detonating, MD fuse. The twenty (20) fuses bore the same markings. Markings from one (1) of the fuses is as follows:

20 - 45 г МД 677

4. The end of the ogive is painted black. The balance of the projectile is not greased or painted.

5. The explosive charge in the projectile weighs one (1) pound and is a cast compound very similar to tetrytol. The explosive is believed to be 50% TNT and 50% RDX.

6. Markings on the round:

Projectile

114
31 - 44
76
Н
БЛ-350М

Shell casing

У60-353М
76-27
ВТМ 5 8/44/РВ/8
136-45-906
СТРЕЛЯТЬ
ПО БРОНЕЦЕЛЯМ

7. See attached drawings "A" and "B" for data pertaining to this projectile.

3017

04004SSR

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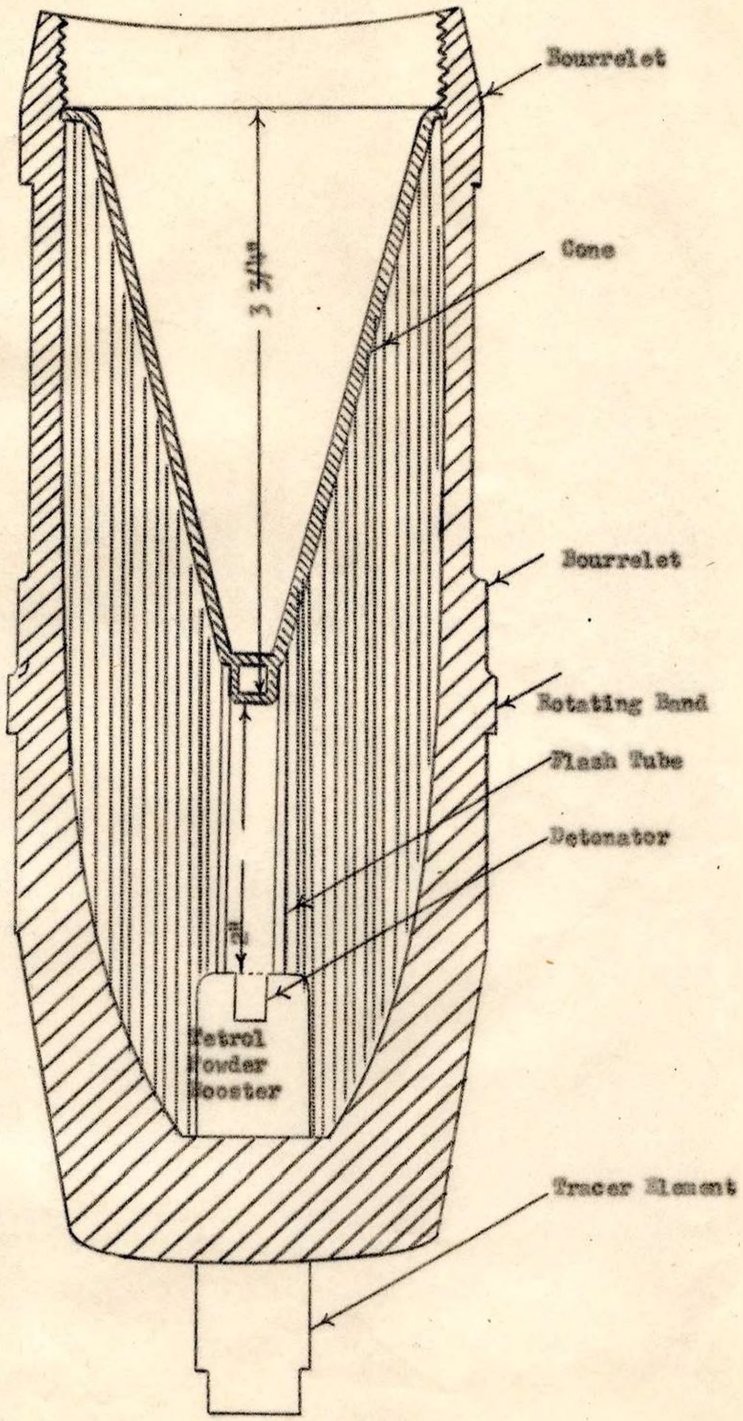
Authority NND 851506

SOVIET, 76MM, SHAPE CHARGE

DRAWING "A"



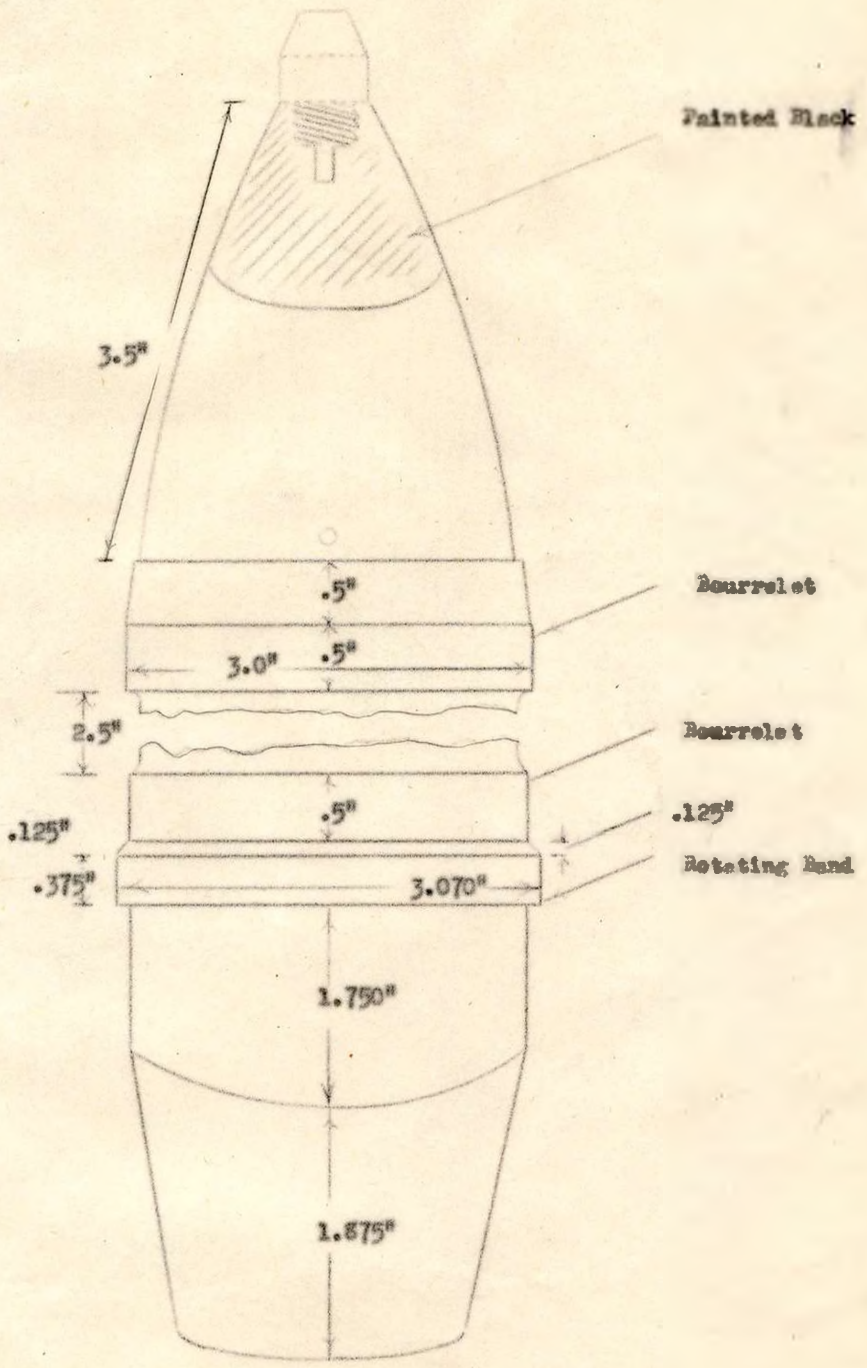
FULL SCALE

DECLASSIFIED
Authority NND 951506

SOVIET, 76MM, SHAPE CHARGE PROJECTILE (NOT TO SCALE)

DRAWING "B"

SOVIET, MM, FUZE



END

DECLASSIFIED
Authority NND 851506

508th ORDNANCE
TECHNICAL INTELLIGENCE DETACHMENT

17 July 1951

SUBJECT: Technical Intelligence Report 508/22
(The two types of Russian 76mm HVAP-T projectiles)

1. On 16 July 1951 at the enemy ammunition area, Haunde, this unit had the opportunity to examine the two types of Russian 76mm HVAP-T projectiles.

2. The overall outside dimensions of the two projectiles are identical. The essential difference is the ballistic cap. On one projectile the cap is aluminum and screwed with a right hand thread to the body. On the other projectile is a sheet metal cap with a press fit to the body. (See inclosed photos) The lack of markings on the projectile and the identical markings on the cases give no indication as to which is the most recent manufacture. However it is assumed that the aluminum cap and its screw type fit being more expensive to produce is the earlier of the two models. The Complete Round Data book of 8 Nov 1950 lists the two projectiles as having the same weight, ballistic characteristics, and effective penetration.

3. Case markings for these projectiles are as follows:

УБР - 354 П
76 - 02/30 - 36
9/7 СВ 10/45 Р 8/8
134 - 49 - $\boxed{22}$

4. Inclosed with this report is a photograph of the projectiles with their differences as noted.

G-2, GHQ, FEC COMMENT: a. This report should be Number 23.
b. The statement relative to lack of markings on the projectiles is incorrect as projectile markings are visible in the photograph.

END

0400 USSR

DECLASSIFIED
Authority NND 851506

Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Projectile
(Telephone, etc.)

Type 76mm HVAP-T
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model _____

Year _____

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Left: with aluminum threaded ballistic cap.

Right: with sheet metal crimped ballistic cap.

Received in MIS on _____
(Date)

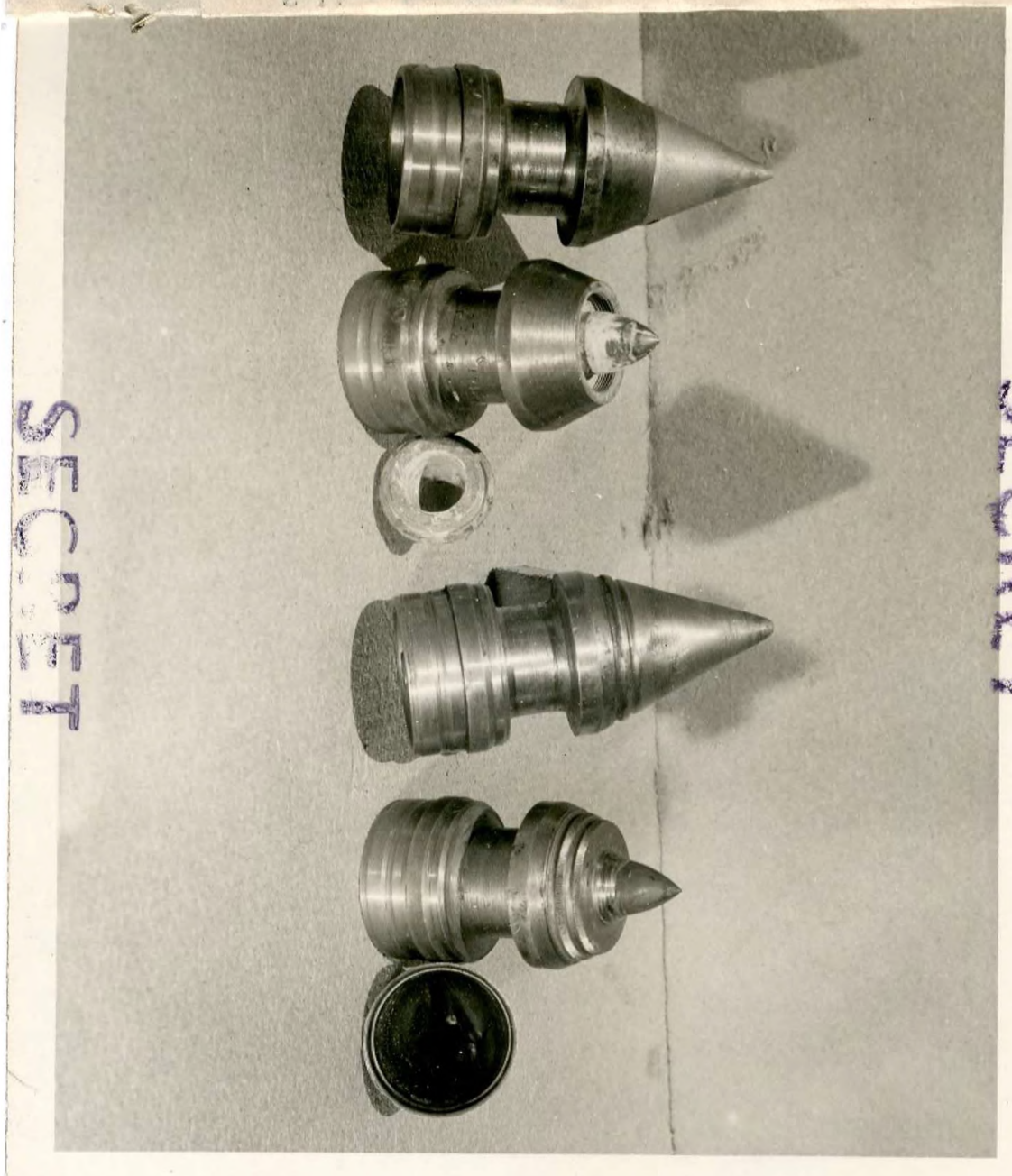
Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



SECRET

SECRET

DECLASSIFIED
Authority NND851506



254

U S Army Photo
SA/756-1/FEC-51 18 July 51

Two types of 76 M M Russian H V Ap-T projecfiles, Left to Right, HVAP-T projecgile with aluminum threaded ballistics cap; HVAP-T projectile with sheet metal pressed fit cap. 08/ z3.

Photograph by 508th Ordnance Technicas Intelligence detachment.

For staff distribution only-Not for publication unless released by GHQ PIO.

DECLASSIFIED
Authority NND 851506

508th ORDNANCE
TECHNICAL INTELLIGENCE DETACHMENT

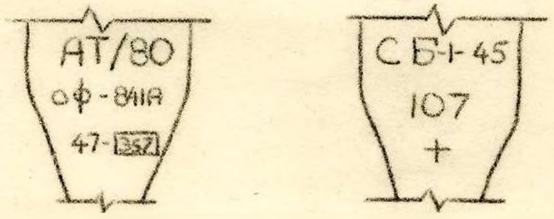
29 June 1951

508/22

SUBJECT: Captured Ordnance Materiel
(Russian 107mm Mortar round)

1. On 27 June 1951 at the Heunde Ammunition Depot, one round of Russian 107mm Mortar ammunition was brought in with a shipment of captured ammunition from the forward area.

2. In overall appearance the round closely resembles the Russian 120mm Mortar round, lacking only in body diameter. The cast steel body has a fuze adapter with a composition nose plug inserted. The fuse well will take the standard mortar fuze, GVMZ. The body assembly was unpainted but the tail stem and fin had at one time been painted light blue. Markings on the body in black were as follows:



One side reverse side

3. The projectile is cast loaded TNT with a removable cast auxillary booster. There was no ignition cartridge in the base, however the 120mm mortar cartridge fit perfectly on trial. The overall weight of the round is approximately 17.5 pounds with a maxium range of 6859 yards. (Complete round chart)

4. Inasmuch as this is the only round of its type seen by this unit, the possibility that the 107mm Mortar is being used in any number at all, is questionable. This weapon is listed as obsolete in recent publications. A search of the captured materiel dump is now underway in an attempt to locate the weapon.

5. A drawing of the round giving pertinent dimensions and a photograph are attached to this report as inclosures.

END

0400 USAR

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Authority NND851506



Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Mortar
(Telephone, etc.)

Type 107mm
(Field, etc.)

Made by U.S.S.R.
(Manufacturing nation)

Model _____

Year _____

Photographed June 51 Korea
(Date) (Place)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:
HE Shell for Soviet 107mm
Mortar

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

1503-51

DECLASSIFIED
Authority NND 851506

SECRET



SECRET

Received in MIS on _____
(Date)

Log _____
(Number)

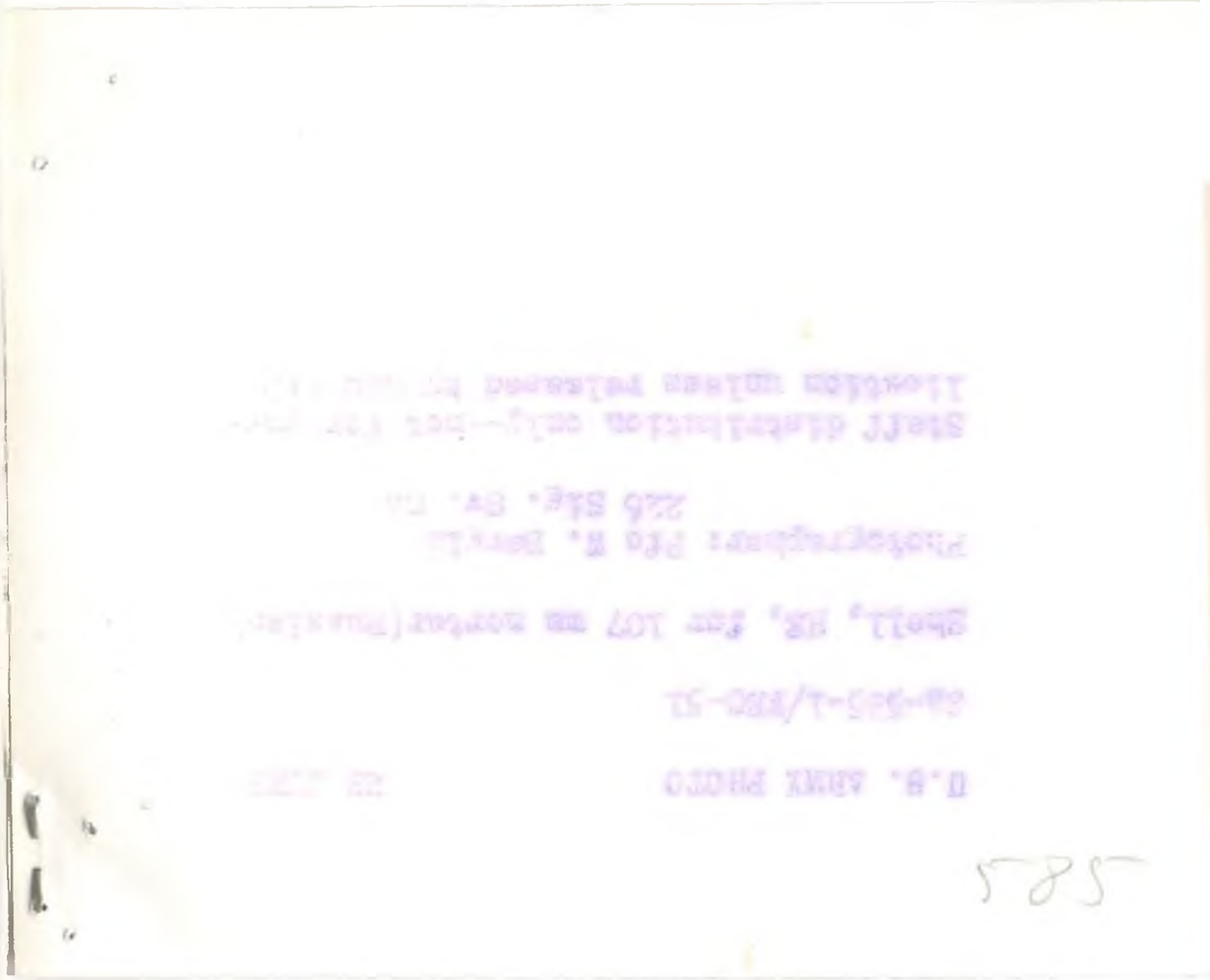
Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

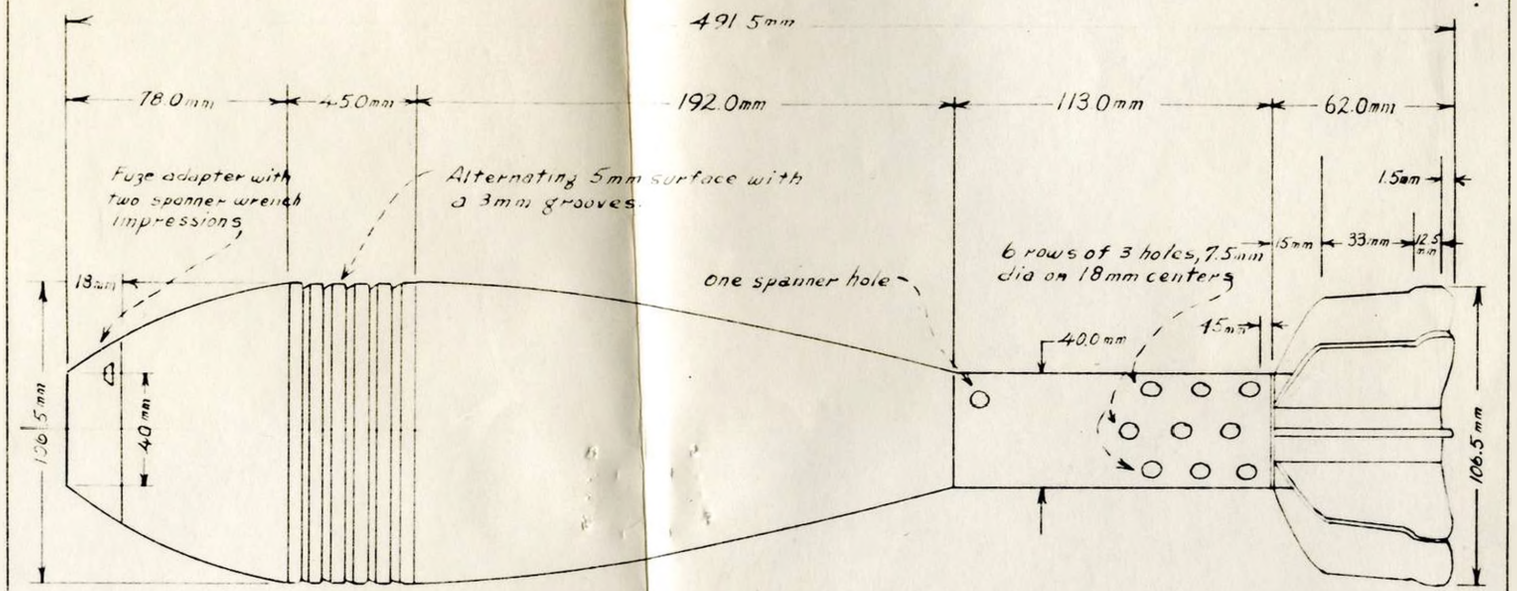
1503-51

DECLASSIFIED
Authority NND 985506





SECRET



Scale (MM) ½ : 1

HE ROUND for 107MM RUSSIAN MORTAR

508/22

SECRET

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Authority NND 851506

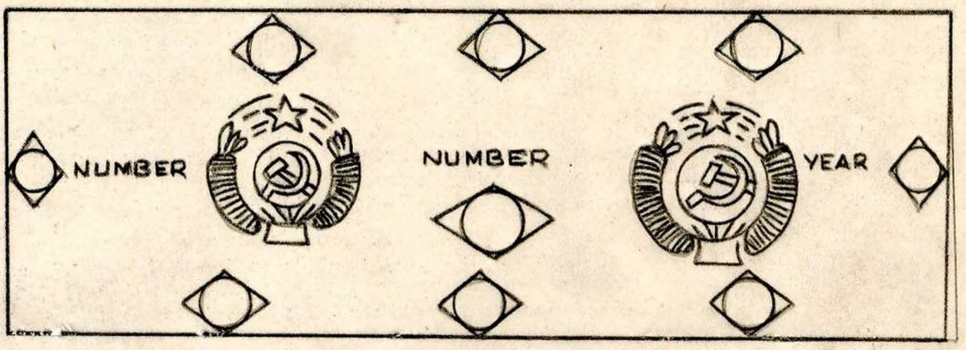
DECLASSIFIED
Authority NND 985150

37

DECLASSIFIED
Authority NND 851506

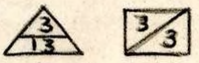
6. These are the markings that were found on the weapon:

The tags on the new type and old type weapon all had this type tag and this kind of design on the tag.



New Type Gun

Carriage	61699	52- Y -167	1944
Cradle	61777	52- Y -167	1944
Tube		37-39-01-45 1279 10868 20120 1943	





Old Type Gun

Carriage	45792	52- Y -167	1942
Cradle	45537	52- Y -167	1942
Tube		37-39-01-45 2852 12734 14579 1944	





The inspectors stamp on the axle assemblies of both guns were the same:





G-2, GHQ, FEC Comment: "It is felt that the terms "old model" and "new model" should not be used in describing these suspension system differences until additional materiel and documents have been examined."

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Authority NND 851506

509TH ORDNANCE TECHNICAL
INTELLIGENCE DETACHMENT

30 June 1951

SUBJECT: Ordnance Technical Intelligence Report No. 509-47
(New Modal Soviet 37mm AA Gun, M1939)

1. This weapon was found in the Ordnance Collecting Point at Wonsan, Korea.

2. This weapon is identical with the M1939, 37mm AA Gun except for the suspension system. The new model uses an exposed vertical spring system for individual suspension whereas the older model uses an inclosed spring system with double support arms.(See photographs A and B for comparison)

3. There is a tendency for the center shaft (this shaft goes thru the vertical spring) to bind and wear in the upper and lower support holes. (See "A" on photograph B) There are no bearing inserts in the support holes. It is a steel on steel surface and the shaft support holes do not have a fine finish as they should have to be practical as bearing surfaces. The lubrication of these surfaces is accomplished by spraying or squirting them with a lubricant, whereas on the older type weapon there are grease fittings for lubrication.

4. This type of suspension system is found on the Soviet 25mm AA Gun, M1940.

5. Characteristics:

Caliber	37mm	Practical rate of fire	25-30 rpm
Weight	2100 kg	Cyclic rate of fire	130-150 rpm
Tube Length	91.1in.		
Feeding Device	5 rd. clip	Maximum Range, Vertical with HE-T	19,800 ft

DECLASSIFIED
Authority NND 851506



SECRET

Subject Artillery B.I.D. No. _____
(Communications, etc.)

Name Antiaircraft Gun
(Telephone, etc.)

Type 37mm
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model M1939

Year _____

Photographed Jun 51 Korea.
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

View of direct, exposed spring suspension.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

Photo Identification Form, Matériel, M & P, MIS

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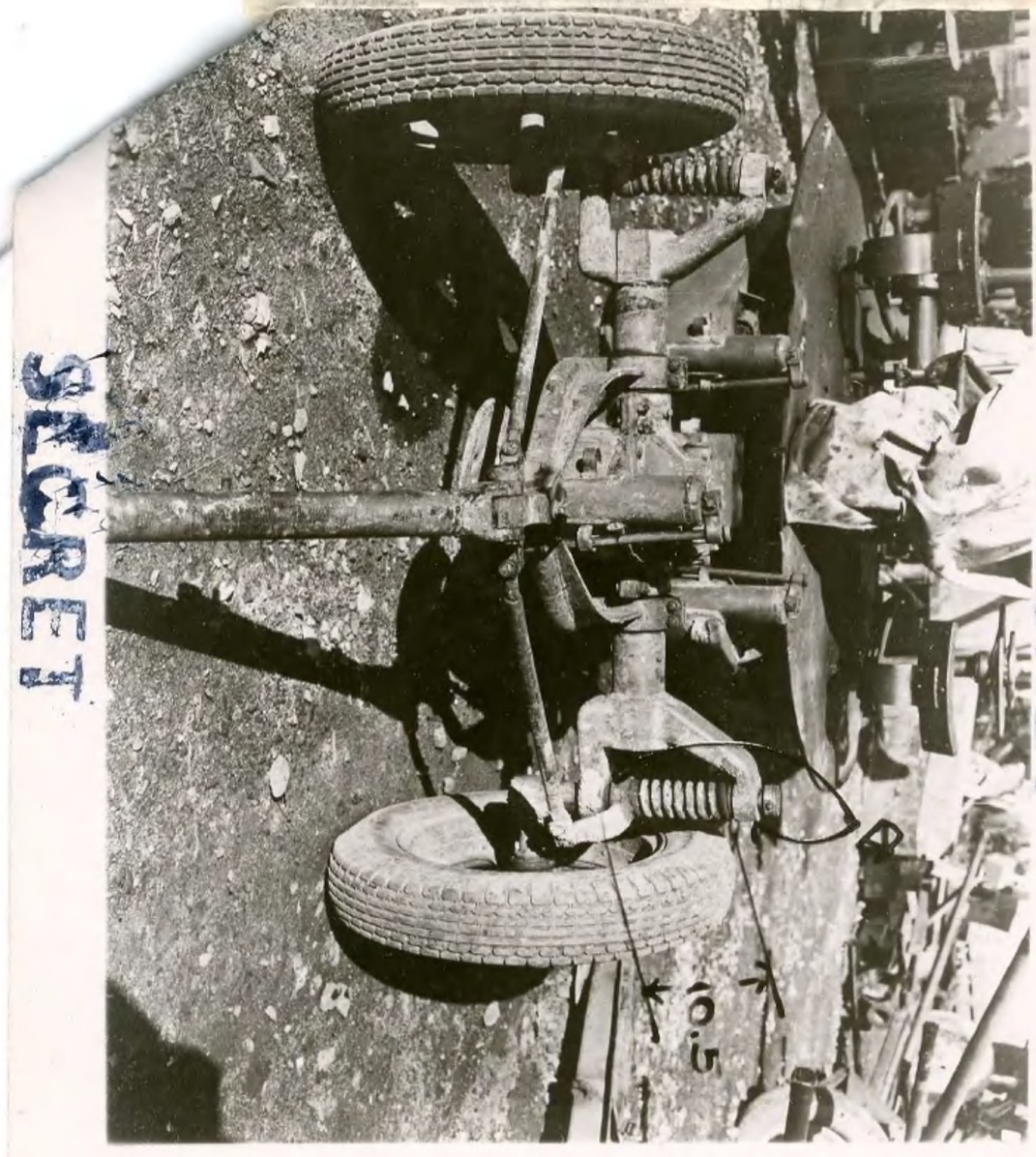
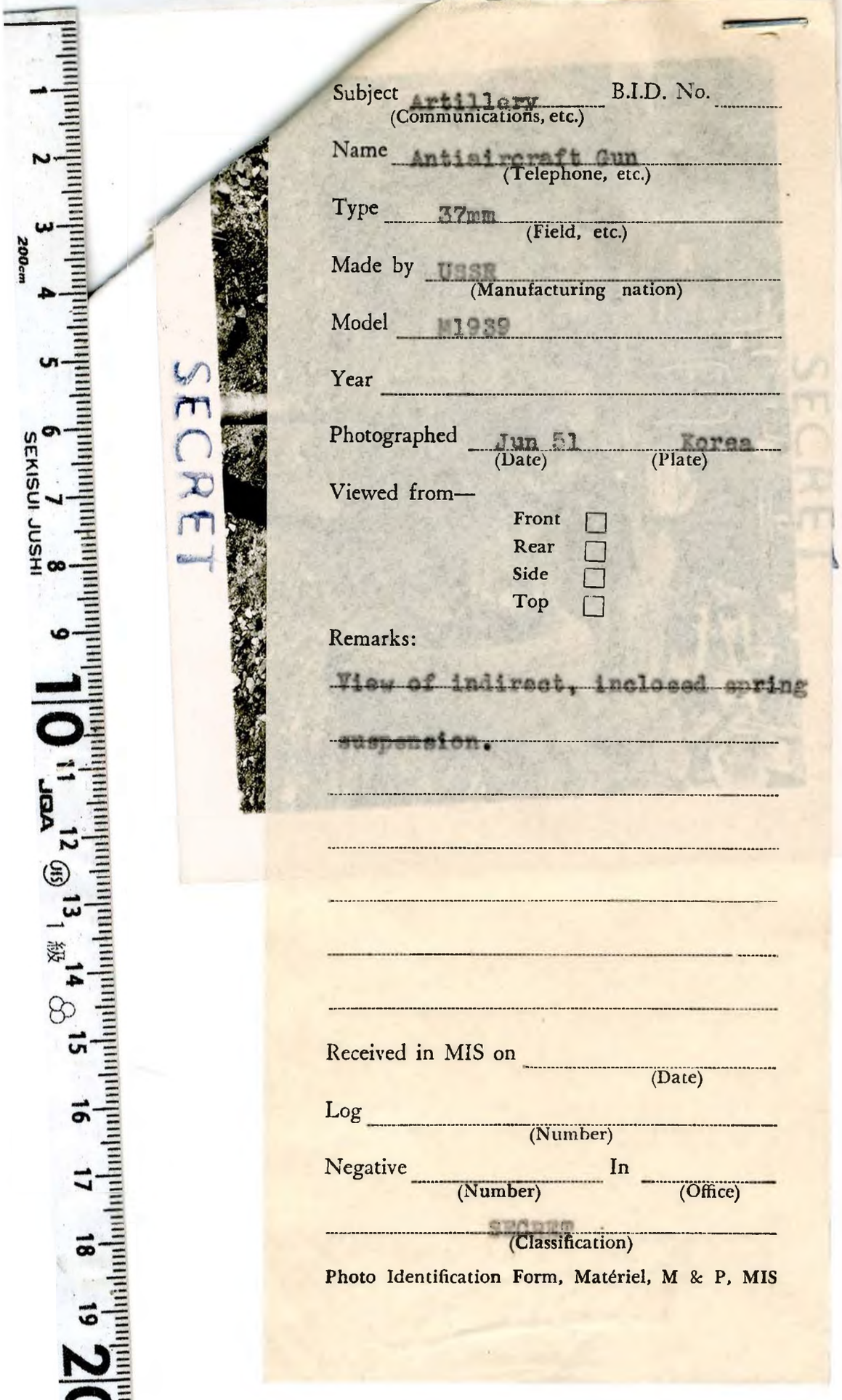
Authority NND851506



DECLASSIFIED
Authority NND 851506



Subject Artillery (Communications, etc.) B.I.D. No. .....

Name Antiaircraft Gun (Telephone, etc.)

Type 37mm (Field, etc.)

Made by USSR (Manufacturing nation)

Model M1939

Year .....

Photographed Jun 51 (Date) Korea (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

View of indirect, inclosed spring suspension.

Received in MIS on ..... (Date)

Log ..... (Number)

Negative ..... (Number) In ..... (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

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DECLASSIFIED
Authority NND 85 1506

DECLASSIFIED
Authority NND 851506

509TH ORDNANCE TECHNICAL
INTELLIGENCE DETACHMENT

27 June 1951

SUBJECT: Ordnance Technical Intelligence Report No. 509-46
(New Variant of the Soviet 120mm Mortar, M1943)

1. This weapon, a Soviet 120mm Mortar, M1943, new Variant was found at the Ordnance Collecting Point at Masan, Korea.

2. Mortar Specifications:

Caliber	120mm
Weight, traveling	approx. 1130 lbs.
Weight, firing position	approx. 600 lbs.
Length of bore	61 inches
Overall length	75.5 inches
Weight of HE projectile	35.2 lbs.
Maximum range	6562 yds.
Ammunition	HE, Smoke, Practice
Muzzle velocity	892 fps

Sight used: MP-1 telescopic sight, or MP-82-YC collimator sight.
Weapon can be either drop fired or fired by a firing mechanism.

3. The following markings were found on the base cap:



№5116
52M
1943
3544 5746

4. The base cap on this variant screws into the tube; the firing pin is in the base of the tube and the firing mechanism is in the base cap as compared to the other 1943 variants where the base cap screws on the outside of the tube and the firing pin and firing mechanism are both in the base cap. There are two cap screws at the base of the tube that are turned down, after the base cap has been screwed into place, locking the base cap in it's proper position.

5. The firing mechanism is actuated by the firing lever. There are three(3) camned surfaces on the firing lever (see drawing). One (1) surface is for drop firing, one (1) surface is a locking cam, and the third surface is the cocking and firing cam. The locking cam sets in the slot on the bottom of the firing mechanism (see drawing). As the firing lever is pulled, the lever rotates against the cam plunger in the base of the firing plunger (see drawing) pulling the firing plunger down against the firing plunger spring. After the firing lever has rotated 90 degrees it cams the cam plunger in, causing the firing plunger to be released with spring tension. The firing plunger strikes the base of the firing pin in the base of the tube causing the firing pin to move upward to strike the cap of the ignition cartridge.

6. If the firing lever is rotated 180 degrees, the drop fire cam on the firing lever forces the firing plunger up against the base of the firing pin; this moves the firing pin upward, the firing lever is then locked in place and the mortar is ready for drop firing.

7. This mortar also uses a different type bipod. (None recovered to date). The bipod clamp surfaces on this new variant are of a different width than those

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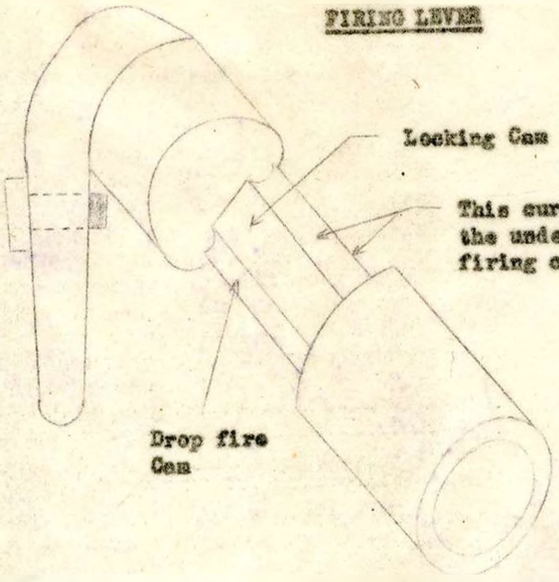
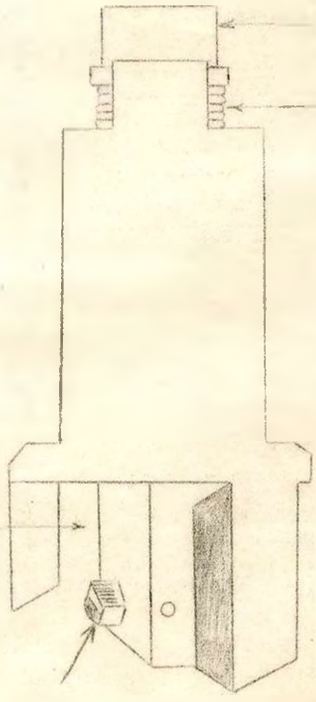
Authority NND851506

FIRING LEVER



FIRING MECHANISM



Firing Cam on firing Lever pulls down on flat surface of plunger, pulling firing plunger downward, as firing lever rotates, plunger is cammed in releasing firing plunger.

In locked position the locking cam's position is here.

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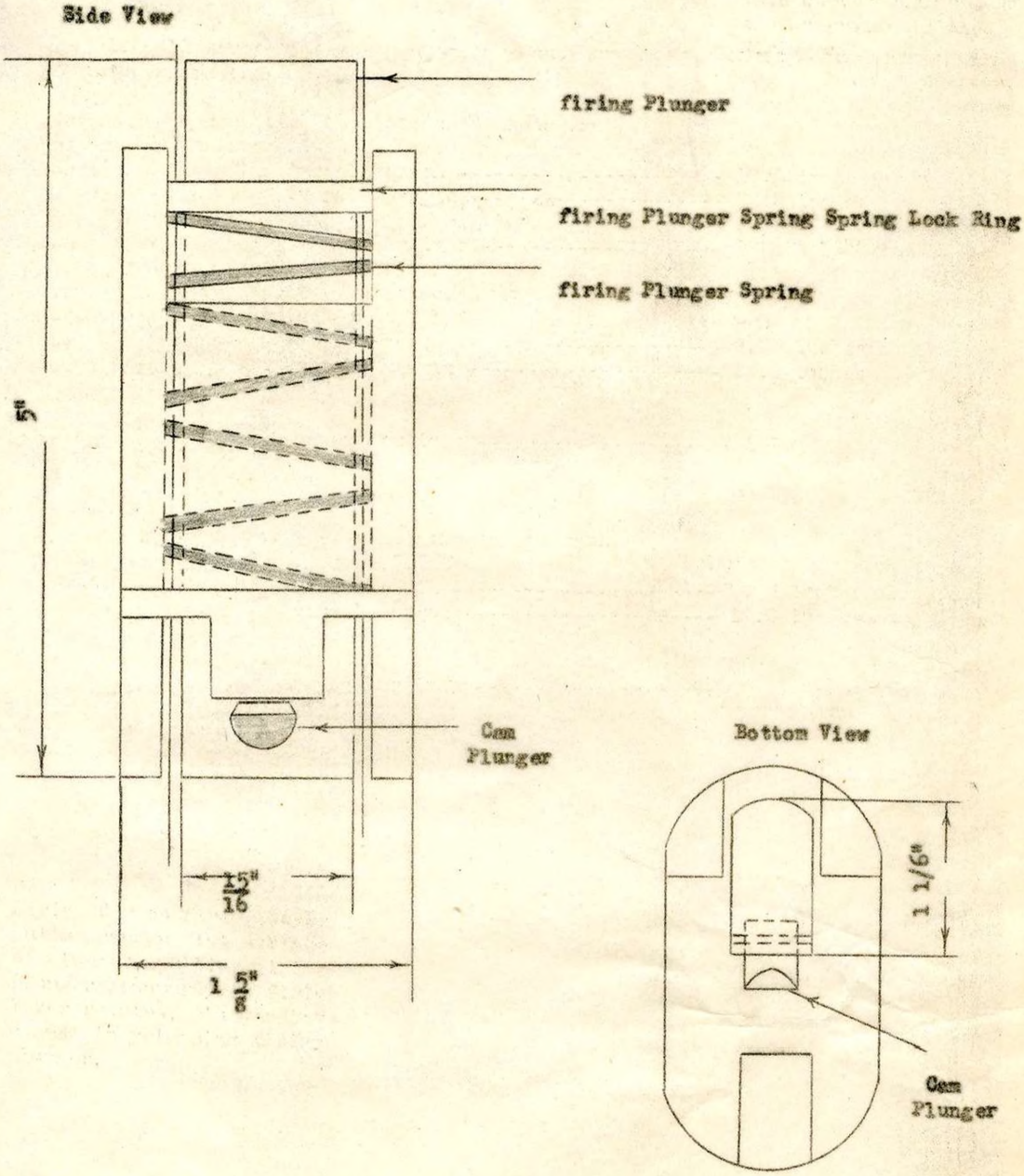
Authority NND 851506

FIRING MECHANISM



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Authority NND 851506

on the other M1938 and M1943, 120mm mortars.

Width of bipod clamp surfaces on:

New variant mortar	2 inches
Other M1938 & M1943 mortars	3.5 inches

The bipod clamp surfaces on the new variant mortar are 20 inches apart while on the other M1938 & M1943 mortars these surfaces ajoin one-another.

G-2, GHQ, FEC Comment: "One Soviet 120mm, M1943, New Variant Mortar is being shipped to Aberdeen Proving Ground in Shipment S-88."

E N D

DECLASSIFIED
Authority NND 951506



SECRET

Subject _____ B.I.D. No. _____
(Communications, etc.)

Name 120mm
(Telephone, etc.)

Type _____
(Field, etc.)

Made by U.S.S.R.
(Manufacturing nation)

Model M1943, New Variant

Year _____

Photographed June 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
View of bipod clamp surfaces

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SEKISUI JUSHI 200cm JQA JIS 1級

DECLASSIFIED
Authority NND851506



SECRET

SECRET

509-46

Soviet 120mm Mortar,M1943,new Variant
View of bipod clamp surfaces

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506



SECRET

Subject Morter B. I. D. No. [redacted]
(Communications, etc.)

Name 120mm
(Telephone, etc.)

Type
(Field, etc.)

Made by U.S.S.R.
(Manufacturing nation)

Model M1943, New Variant

Year

Photographed June 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

View of (1) firing lever (2) firing mechanism (3) firing mechanism housing

Received in MIS on
(Date)

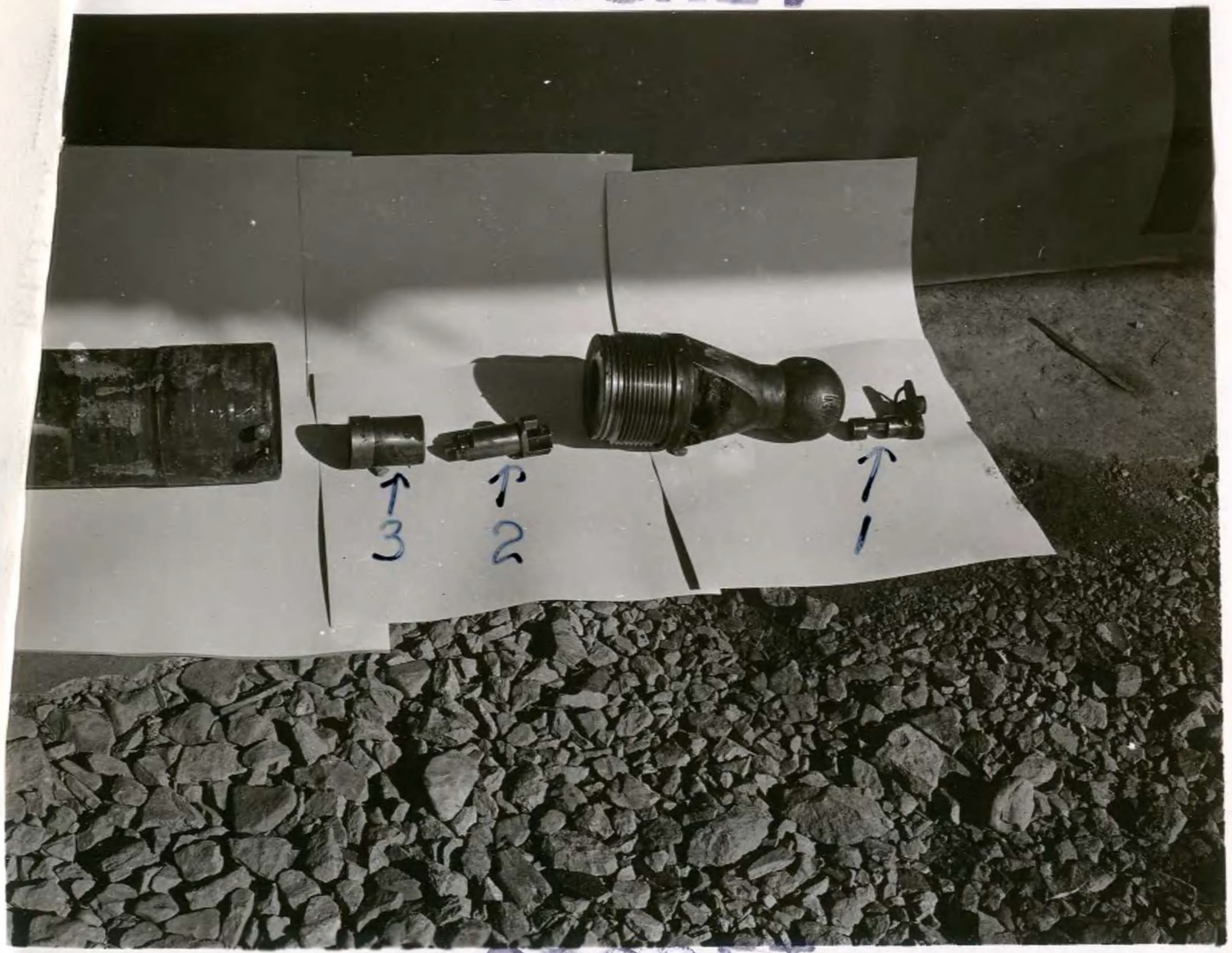
Log
(Number)

Negative In
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET



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DECLASSIFIED
Authority NND 85 1506

509-46

K C

Soviet 120mm Mortar,M1943,new Variant
1)Firing Lever
2)Firing Mechanism
3) " " Housing

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506



Subject Mortar B. I. D. No. _____
(Communications, etc.)

Name 120mm
(Telephone, etc.)

Type _____
(Field, etc.)

Made by U.S.S.R.
(Manufacturing nation)

Model M1943, New Variant

Year _____

Photographed June 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

View of (1) base of firing pin and (2) head of firing plunger

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

SECRET

SECRET

DECLASSIFIED
Authority NND 85 1506

509-46

D

Soviet 120mm Mortar,M1943,new Variant
1)Base of firing pin
2)Head of firing plunger

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

D



Subject ..... B.I.D. No. .....
(Communications, etc.)

Name 120mm
(Telephone, etc.)

Type .....
(Field, etc.)

Made by U.S.S.R.
(Manufacturing nation)

Model M1943, New variant

Year .....

Photographed June 51 Korea
(Date) (Place)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Firing components

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

Secret
(Classification)

Photo Identification Form, Matériel, M & P, MIS

DECLASSIFIED
Authority NND851506



SECRET

SECRET

509-46

B

Soviet 120mm Mortar, M1943, new Variant
Firing components

DECLASSIFIED
Authority NND 851506

DECLASSIFIED
Authority NND 851506

HEADQUARTERS
5334 ENGINEER TECHNICAL INTELLIGENCE TEAM (RESEARCH)

16 July 1951

Report No. 101

SUBJECT: Soviet TNT Block (400 Grams)

1. This report is based on information contained in Special Report No. 54, 557th ETIT (C).

2. SOURCE:

a. The item described herein was found at DT 162285 by D Co. 1st Marine Engineer Battalion.

3. DESCRIPTION:

a. The explosive in the block is pressed TNT and measures 2" x 2" x 4". It has a 3/8" x 1 3/4" detonator well and a knurled fuze adapter (threaded bushing) the outside measurements of which are 15/32" x 5/8". The inside diameter is 3/8" with 26 TPI. The block is wrapped in light blue paper (see incl. 1).

4. REMARKS:

a. The Soviet TNT block was previously reported in EUSAK Engineer Technical Intelligence Bulletin # 6, dated 18 Nov 50 and this report is intended to augment that report.

b. The item described herein is on hand at this organization and will be forwarded upon request.

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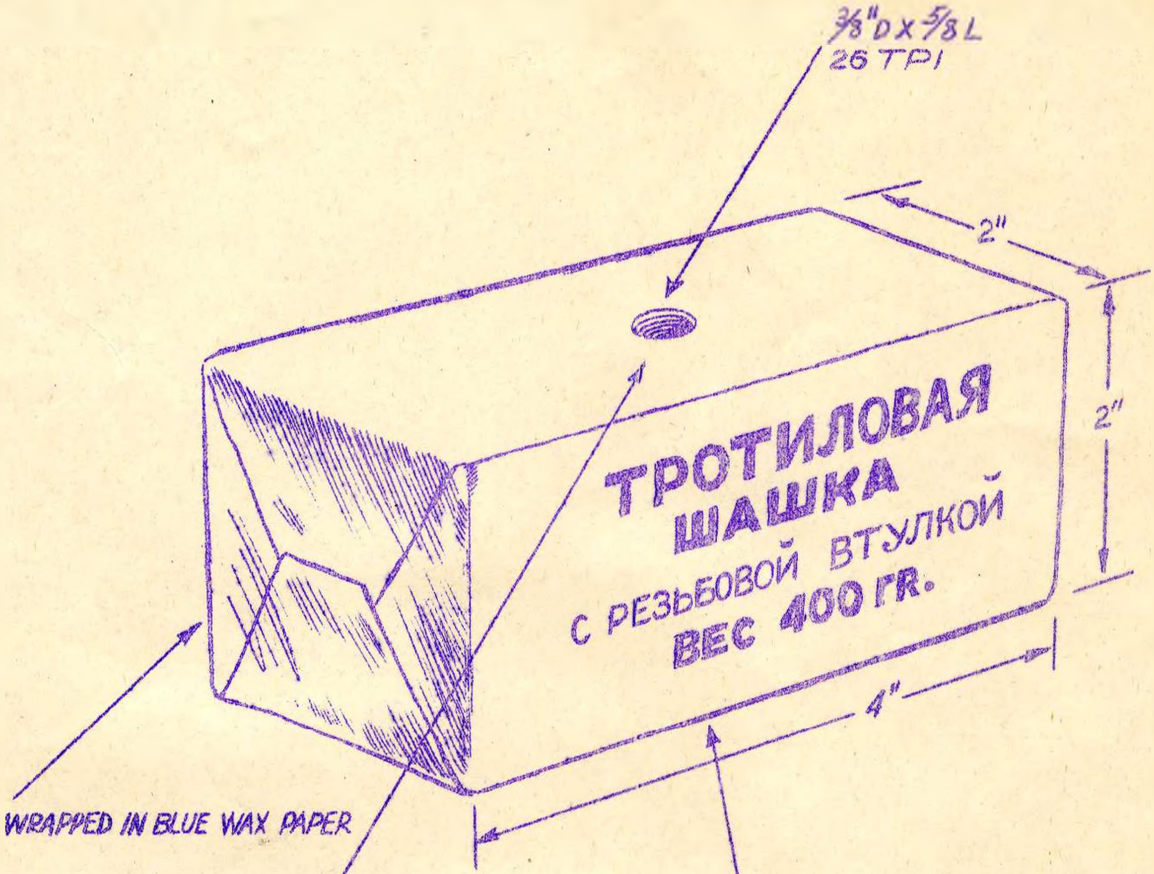
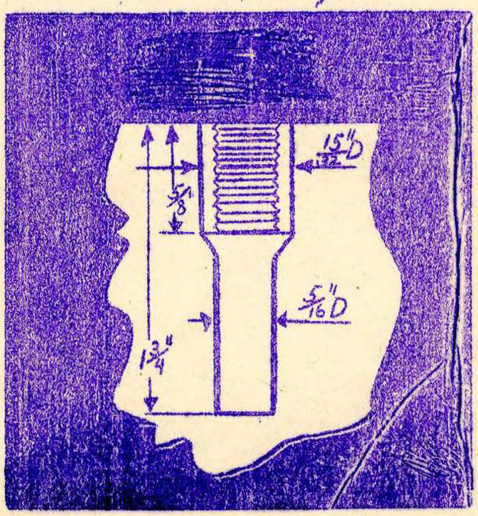
DECLASSIFIED
Authority NND 851506

CONFIDENTIAL

RUSSIAN TNT BLOCK
(400 GRAMS)





TRANSLATION :

TROTYL (TNT) BLOCK
WITH TREADED BUSHING
WT. 400 GRAMS

CONFIDENTIAL

TJ3-1776-51

DECLASSIFIED
Authority NND 851506

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

3 August 1951

SUBJECT: Markings from Captured Enemy Materiel

1. The information contained in this report is based on reports prepared by the Technical Intelligence Coordinator Team, ROKA I Corps.

a. Soviet GAZ - 51 (4 x 2)

(1) Engine Markings:

Stamped: 51☆ 262447☆

Raised markings on side of engine ЛА 3
НМ МО ЛОТОВР
12 - 1002015

(2) Nameplate:

	195 [ ]
239117	162812

b. Soviet GAZ - 51 (4 x 2)

(1) Engine Markings:

Stamped: 63☆ 209286☆

Raised markings on side of engine: 3Л3
НИМО ЛОТОВР
12 - 1002015

(2) Nameplate:

	194 [9]
174437	101925

a. Soviet Rifle, 7.62mm, M 1891/30

(1) 1944
ГЛ2018



(2) 1938
ИКА4175



(3) 1937
154897



(4)



1938
НС1024

0400 USSR

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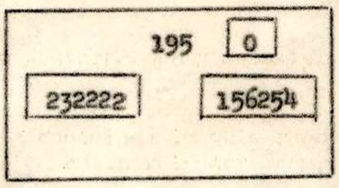
Authority NND 851506

b. Soviet GAZ - 51 (4 x 2)

(1) Nameplate:



e. Soviet GAZ - 51 (4 x 2)

(1) Engine Markings:

Stamped: 51 ★ 264451 ★

Raised markings on side of engine: И М МО П ОТОВА
12 - 1002015

(2) Nameplate missing.

(3) Painted on frame: М 185828

E N D

DECLASSIFIED
Authority NND 851506

FILE UNDER:

INDEX SHEET

DATE:

FROM: TO:

SUBJECT:

DOCUMENT FILED UNDER:

DECLASSIFIED
Authority NND 851506

CONFIDENTIAL

Subject Artillery B.I.D. No. _____
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year _____

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Right side view.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

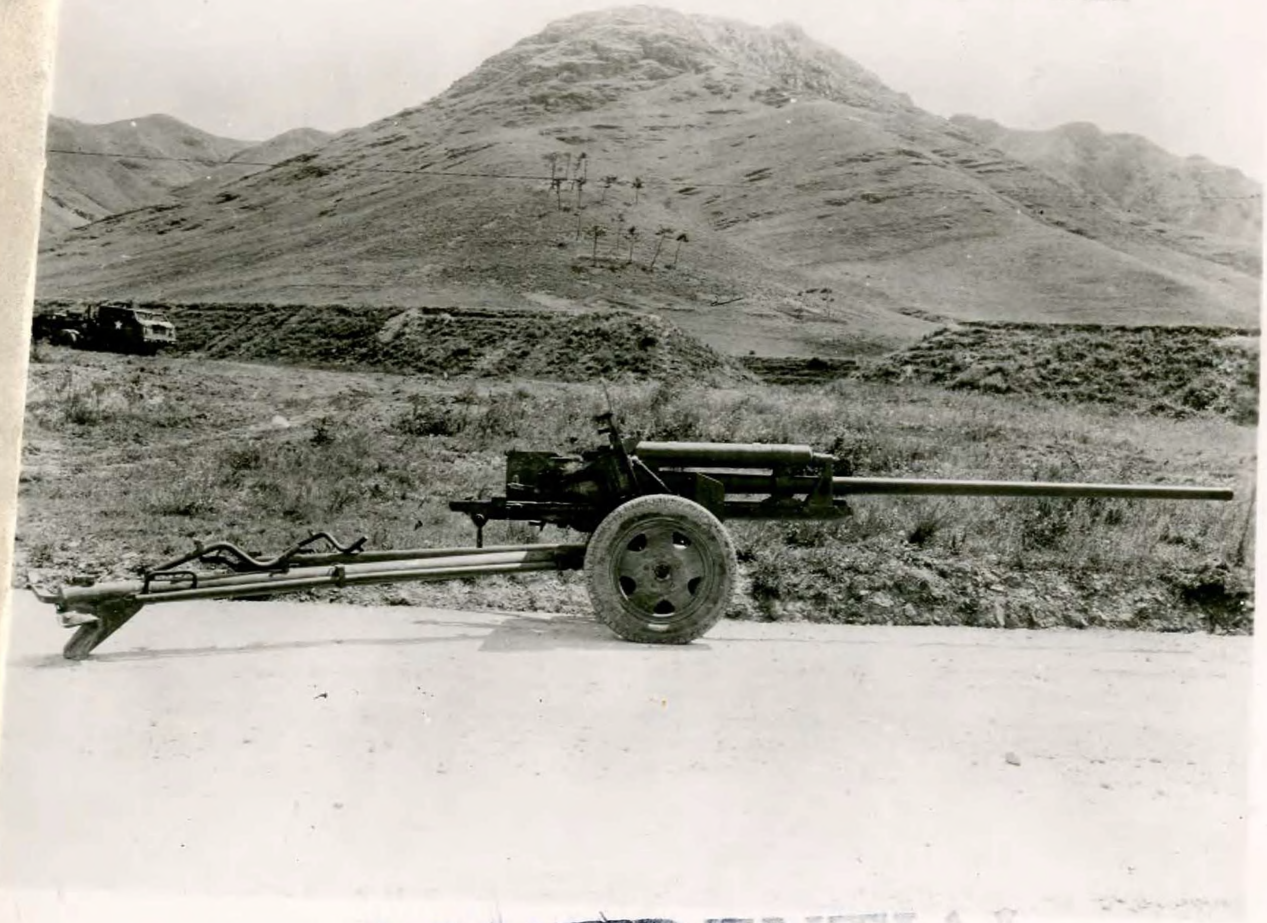
CONFIDENTIAL
(Classification)

Photo Identification Form, Matériel, M & P, MIS

0400455R

DECLASSIFIED
Authority NND 963506

CONFIDENTIAL



CONFIDENTIAL

DECLASSIFIED
Authority NND 851506



CONFIDENTIAL SECRET

Subject Artillery B.I.D. No. .....
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type [redacted]
(Field, etc.)

Made by [redacted]
(Manufacturing nation)

Model [redacted]

Year [redacted]

Photographed [redacted] [redacted]
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Close-up of markings, right side of breech ring.

Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

[redacted]
(Classification)

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Authority NND851506



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Authority NND 851506

Subject Artillery B.I.D. No. .....
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year .....

Photographed Jul 51 Torso
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right rear view.

Received in MIS on .....
(Date)

Log .....
(Number)

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(Classification)

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Authority NND 85 1506

(Communications, etc.)
Subject
BTD No.

DECLASSIFIED
Authority NND851506

Subject Artillery B.I.D. No. .....
(Communications, etc.)

Name Artillery Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year .....

Photographed Jul 52 Force
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right front view.

.....

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Received in MIS on .....
(Date)

Log .....
(Number)

Negative ..... In .....
(Number) (Office)

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(Classification)

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DECLASSIFIED
Authority NND 851506

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Authority NND851506

FILE UNDER:

INDEX SHEET

DATE:

FROM: TO:

SUBJECT:

DOCUMENT FILED UNDER:

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Authority NND 851506

Subject Armored Vehicles (Communications, etc.) B.I.D. No.

Name Generator (Telephone, etc.)

Type on T-34/85 Engine (Field, etc.)

Made by USSR (Manufacturing nation)

Model G-73

Year Mfgd May 1948

Photographed Jun 51 (Date) Tokyo (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☒
- Top ☐

Remarks:

Mounted on right side of engine.

24 volts, 1500 watts.

Received in MIS on (Date)

Log (Number)

Negative (Number) In (Office)

SECRET (Classification)

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0400 USSR

SECRET

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SEKISUI JUSHI

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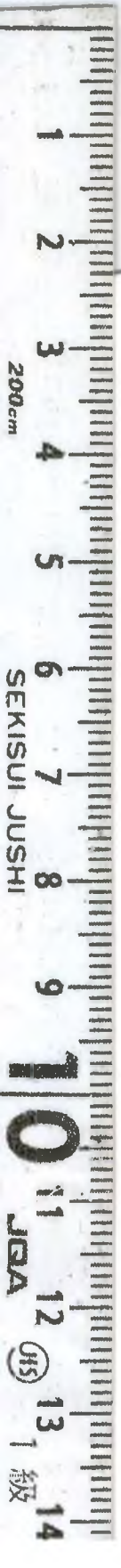



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Authority NND 951506

SECRET

Subject _____
(Communications, etc.)

Name Oil filter
(Telephone, etc.)

Type on T-34/85 Engine
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model Unknown

Year _____

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☒
Top ☐

Remarks:

Viewed from left side. Some markings appear on the back end.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

SECRET
(Classification)

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JQA JIS 1級

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Authority NND851506



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Authority NND 851506

SECRET

Subject _____
(Communications, etc.)

Name Tank Engine
(Telephone, etc.)

Type for T-34/85
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V-2

Year Mfgd 1949

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

Front [X]
Rear [ ]
Side [ ]
Top [X]

Remarks:

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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Authority NND851506

SECRET

SECRET

DECLASSIFIED
Authority NND 851506

Subject _____
(Communications, etc.)

Name Tank Engine
(Telephone, etc.)

Type T-34/85
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V-2

Year _____

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

Front [X]
Rear [ ]
Side [ ]
Top [ ]

Remarks:
View of lower left portion of forward fore of engine showing location of rectangle on which type and serial number is stamped.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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Authority NND 985506

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Authority NND851506

SECRET

Subject _____
(Communications, etc.)

Name Fuel Injection Unit
(Telephone, etc.)

Type on T-34/85 Engine
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model NK-10

Year Mfgd 1949

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

- Front ☒
- Rear ☐
- Side ☐
- Top ☐

Remarks:

View of front end of injection unit showing significant markings.

Received in MIS on _____
(Date)

Log _____
(Number)

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(Number) (Office)

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(Classification)

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Authority NND851506

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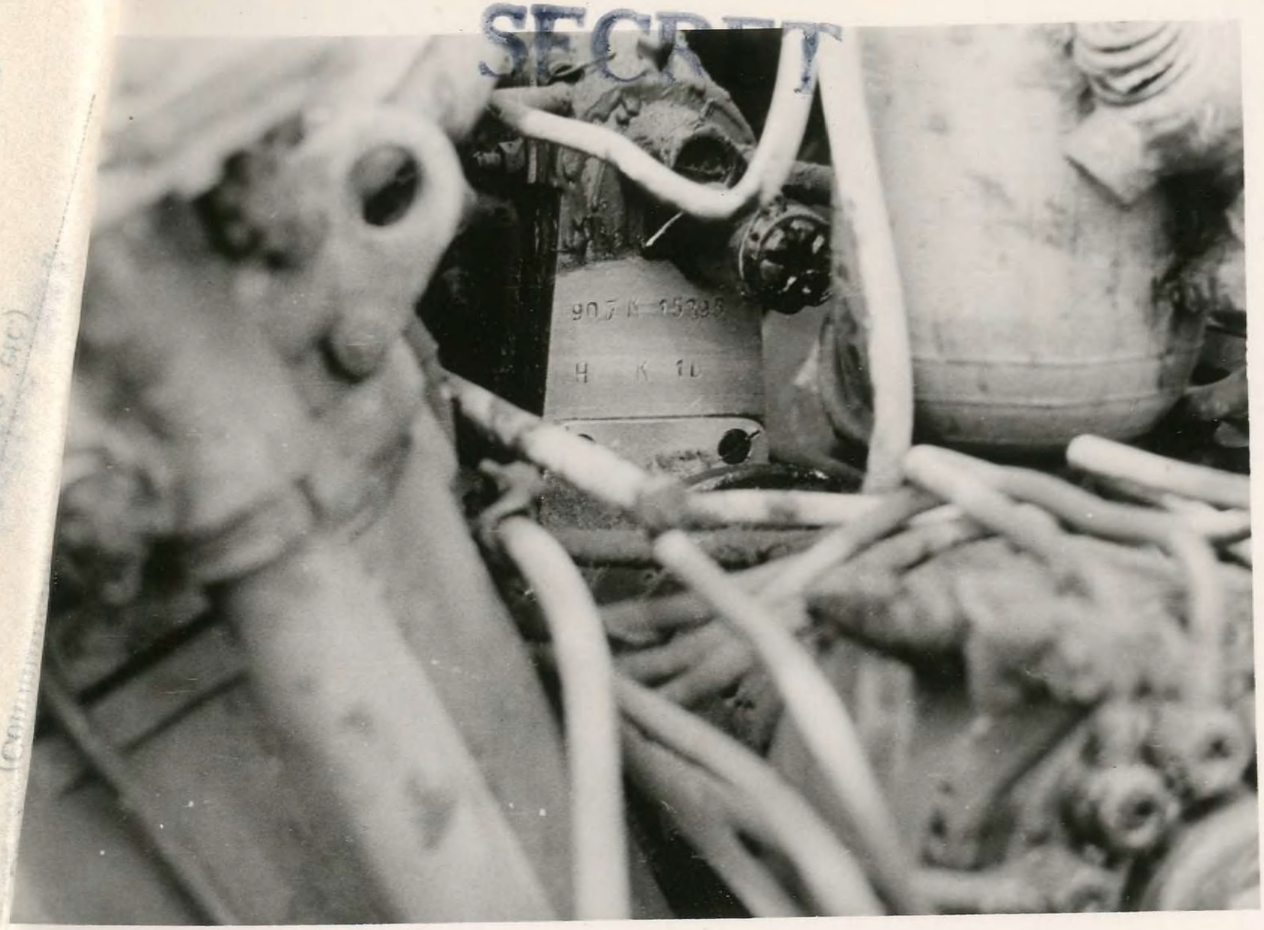

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(Continued)

Name Tank Engine
(Telephone, etc.)

Type T-34/85
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V2

Year

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Top view of forward portion.

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

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(Classification)

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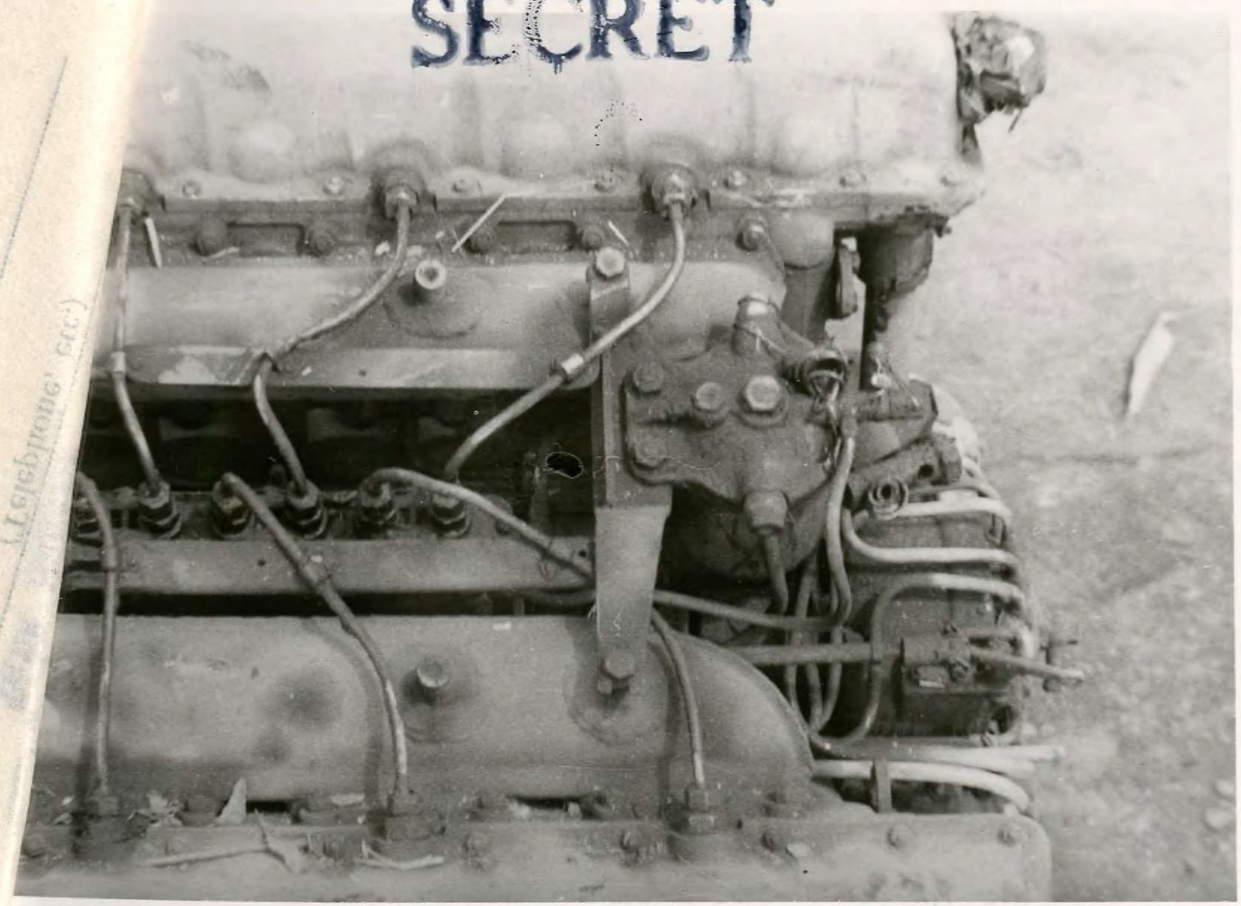

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Authority NND851506

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Authority NND 851506

(Communications, etc.)

Name Tank Engine
(Telephone, etc.)

Type T-34/85
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model V2

Year Mfgd Jul 1949

Photographed Jun 51 Tokyo
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

View of lower left front portion showing rectangle with main marking.

Received in MIS on
(Date)

Log
(Number)

Negative In
(Number) (Office)

SECRET
(Classification)

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Authority NND 851506

512TH ORDNANCE
TECHNICAL INTELLIGENCE DETACHMENT

20 July 1951

SUBJECT: Technical Intelligence Report #512/13 (Bomb, Fragmentation, 51 lb., Modified 122mm Projectile, Howitzer, HE, Soviet)

1. On 25 June 1951, the 84th Combat Engineer Company at CS0680, was bombed by enemy aircraft.

2. This unit received a message thru Armored Section, I Corps, that an unexploded bomb was at the above location.

3. The 15th EOD Squad recovered the UXB and turned it over to this unit for identification and evaluation.

4. The UXB is a Soviet Bomb, Fragmentation, 51 lb., modified 122mm Howitzer, HE, projectile.

5. Photographs and data on characteristics of this bomb are attached hereto. This information compares favorably with Bomb, Fragmentation, Type AO-25M1 as described on page I-2-C-2 of the USAF-USN Handbook on Characteristics and Performance of Foreign Aircraft Armament, dated 1 Nov 50.

BOMBS USSR

FRAGMENTATION, 51 lbs.

DESIGNATION	AO-25M1
FUZING	Nose AM-A instantaneous impact fuze
BODY LENGTH	19.25 ins.
OVERALL LENGTH w/o FUZE	41.0 ins.
OVERALL LENGTH w/FUZE	42.25 ins.
MAXIMUM DIAMETER	4.8 ins.
TOTAL WEIGHT w/FUZE	51.33 lbs.
SUSPENSION	None
BODY CONSTRUCTION	The bomb body consists of a 122mm Howitzer, HE, projectile. Although there is no rotating band installed, the rotating band groove and keying have been cut into the bomb body. An adapter is used, threaded internally to receive the fuze.
TAIL CONSTRUCTION	The tail consists of four (4) pressed steel vanes spot welded to a tail cone. The tail cone is arc welded, to the base of the bomb body.
IDENTIFICATION	Bomb is painted very dark gray with a single light blue band around the body at the base of the ogive. The light blue band is approximately 0.75 ins. wide.

0450 USA

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Authority NND 851506

MARKINGS ON TAIL ---------- None

MARKINGS ON BODY ----------

OGIVE	BODY
3 KM M-33 40 ⑦	UU10

MARKINGS ON FUZE ---------- AM-A 1TM3 MN8Z 39r

END

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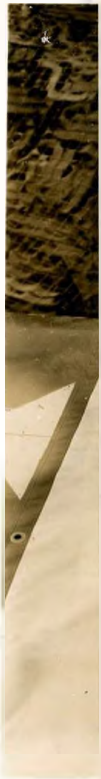
Authority NND 951506



Subject Ammunition (Communications, etc.) B.I.D. No.

Name Bomb (Telephone, etc.)

Type AO-2541 (Field, etc.)

Made by USSR (Manufacturing nation)

Model 82 Pound Fragmentation

Year

Photographed 10 Jul 51 (Date) Uijongbu, Korea (Plate)

Viewed from—

- Front ☐
- Rear ☐
- Side ☐
- Top ☐

Remarks:

Bomb Fragmentation 82 lb. Soviet Modified 120mm Mortar, HE. Horizontal-looking forward from tail to nose.

Received in MIS on (Date)

Log (Number)

Negative (Number) In (Office)

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Subject Ammunition B.I.D. No. _____
(Communications, etc.)

Name Bomb
(Telephone, etc.)

Type AO-26M1
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model 51 Round Fragmentation

Year _____

Photographed 16 Jul 51 Dijonlu, Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Bomb Fragmentation, 51 lb Soviet
AO-6 Type, Horizontal-Close up
showing AO-6 Type and rotating
band slot and keying on modified
122mm projectile.

Received in MIS on _____
(Date)

Log _____
(Number)

Negative _____ In _____
(Number) (Office)

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(Classification)

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Authority NND 851506

SECRET



SECRET

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Log _____ (Number)

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_____ (Classification)

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122mm projectile.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

_____ (Classification)

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U S Army Photo
8A-512-13-4/ FEC-51 18 July 51

I Corps Hqs.Uihongbu,Korea.
Bomb Fragmentation,51 lb.Sovert,
Am-A Fuze.Horizontal-Close up
Showing AM-A Fuze and rotating
band slot and Keying on modified
122 M M projectile.

Photographer; 512 Ordnance.

Staff distrubition only Not for
publication unless released by
GHQ PIO.

51

U S Army Photo
8A-512-13-3/FEC-51 18 July

I Corps Hqs. Uijonobu,Korea.
Bomb Fragmentation 51lb. Soviet
"Modified 122M M Howitzer,H &."
Horigontal- Looking Forward from
tail to Nose.

Photograph by 512nd Ordnance.

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publication unless released by
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Authority NND 851506

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Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Bomb (Telephone, etc.)

Type AO-25M1 (Field, etc.)

Made by USSR (Manufacturing nation)

Model 51 pound Fragmentation

Year _____

Photographed 18 Jul 51 (Date) Uijonobu Korea (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Bomb,Fragmentation, "51 lb. Soviet "Modified 122mm Howitzer HE." Full length horizontal-showing fuze vanes bent back tight to fuze body. Exactly as recovered from 6 foot depth.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

_____ (Classification)

Photo Identification Form, Matériel, M & P, MIS



Subject Ammunition (Communications, etc.) B.I.D. No. _____

Name Bomb (Telephone, etc.)

Type AO-25M1 (Field, etc.)

Made by USSR (Manufacturing nation)

Model 51 pound fragmentation

Year _____

Photographed 18 Jul 51 (Date) Uijonobu, Korea (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Bomb-Fragmentation, 51 lb. Soviet. (Modified 122mm Howitzer, HE. Full length-Horizontal-Showing fuze vanes rebent to original position- after recovery.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

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Authority NND 851506



fuse body. Exactly as recovered from 6 foot depth.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

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position after recovery.

Received in MIS on _____ (Date)

Log _____ (Number)

Negative _____ (Number) In _____ (Office)

SECRET (Classification)

Photo Identification Form, Matériel, M & P, MIS

U S Army Photo
8A-512-13-2/FEC-51 18 July 51

I Corps Hqs. Uijongbu, Korea.
Bomb-Fragmentation,51 lb.Soviet.
(Modigied 122 M M Howitzer,H.E.
Full length -Horizontal-Showing
fuze banes rebent to original
position- after recovery.

Photographer by 512nd Ordnance.

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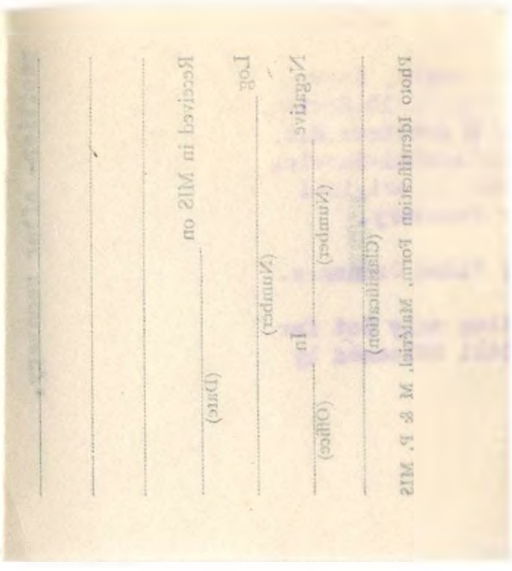
publication untill released by
GHQ PIO.



U S Army Photo
8A/-512-13-1/FEC-51 18 July 51

I Corps Hqs. Uijongbu,Korea.
Bomb,Fragmentation,"51 lb.Sobiet
"Modified 122 M M Howezter H.E."
Full length horizontal-Showing
fuze vanes bent back tight to fuze
body.Cxactily as recovered from
6 foot depth.

photograph by 512 Ordnance.

Staff distrubition only Not for
publication unless released by
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Authority NND 851506

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Assistant Chief of Staff, G-2 Intelligence

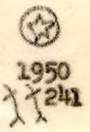
4 August 1951

SUBJECT: Markings from Captured Enemy Materiel

The information contained in this report is based on reports prepared by I ROK Corps Technical Intelligence Coordinator Team, dated 26 July 1951. Information was gathered in the current I ROK Corps sector.

a. North Korean Sub-Machine Gun, 7.62mm, PPSH, M 1941.





b. Soviet Light Machine Gun, 7.62mm, Model DP

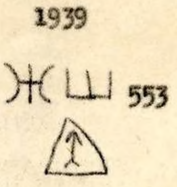


c. Soviet Sub-Machine Gun, 7.62mm, PPSH, M1941.



d. Soviet Rifle, 7.62mm, M1891/30





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SUBJECT:

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Authority NND 951506

Subject Artillery B.I.D. No.
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Close-up of markings on right side of breech ring.

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Authority NND 851506

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Subject [illegible]
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model SIS-2

Year

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right rear view.

Received in MIS on
(Date)

Log
(Number)

Negative (Number) In (Office)

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RESTRICTED

Name _____

(Telephone, etc.)

(Telephone, etc.)

(Telephone, etc.)

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Authority NND 851506

RESTRICTED

Subject Ar...
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:

Right front view.

Received in MIS on
(Date)

Log
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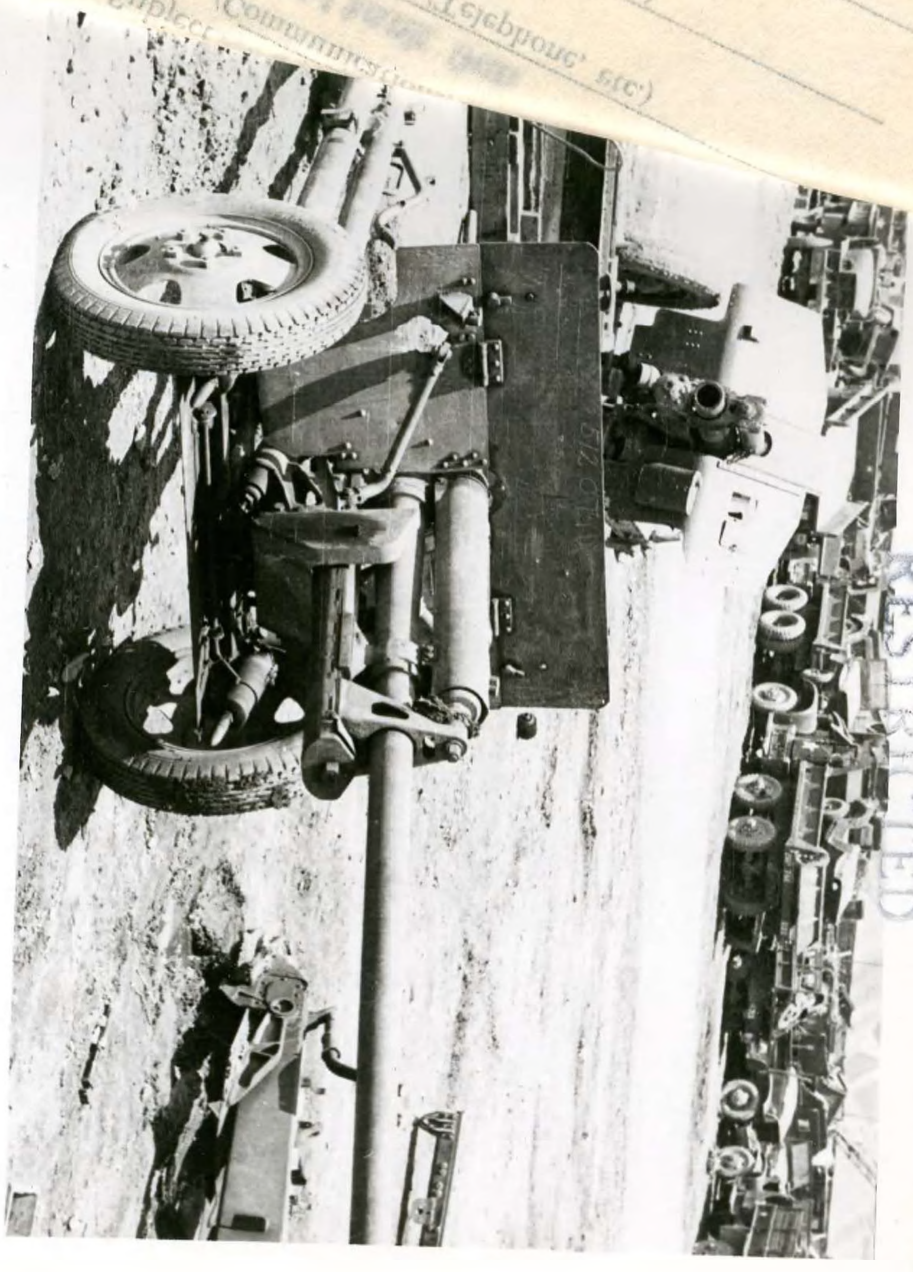

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DECLASSIFIED
Authority NND 951506

RESTRICTED

Subject _____
(Communications, etc.)

Name Antitank Gun
(Telephone, etc.)

Type 57mm M1943
(Field, etc.)

Made by USSR
(Manufacturing nation)

Model ZIS-2

Year _____

Photographed Jul 51 Korea
(Date) (Plate)

Viewed from—

Front ☐
Rear ☐
Side ☐
Top ☐

Remarks:
Right side view.

Received in MIS on _____
(Date)

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(Classification)

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Authority NND 851506

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Authority NND 851506

(Classification Stamp) RESTRICTED

CIS ID DIA TRANSLATION

REQUESTED BY	REGISTRY NUMBER	I. D. NUMBER
Ordnance	P-2898 B	641407
TRANSLATION OF OR FROM: Russian		INITIALS OF TRANSLATOR

REFERENCES: Designing and manufacture of artillery systems (Proektirovanie i proizvodstv artilleriiskikh sistem) IId Part. By Col. (Engineer) K.K.Greten and Col.S.A. Prikhodko

SUBJECT: Ministerstva Vooruzhennykh Sil Soiuza SSR, Moskva - 1949.

Colonel K. K. Greten (engineer) and Colonel S. A. Prikhodko. Effect of the shot on the gun carriage and the calculation of counterrecoil mechanisms.

The book deals with the forces acting on the gun carriage when the shot is fired and gives the theoretical basis for the calculation of the counterrecoil mechanisms, and also practical methods for the calculation of the latter.

The book is intended for use as a textbook for the Artillery Academy and may be used as a handbook in other higher institutions of learning.

The book may also serve as a handbook for designers and engineer-technical employees of plants and proving-grounds engaged in working out and testing artillery weapons.

FOREWORD

In the second part of the course "Designing of Artillery Systems" we consider the effect of the shot on the gun carriage and the calculation of the counterrecoil mechanisms, that is, those problems which must be solved first of all in the designing of artillery weapons.

The possibility of calculating the forces acting upon the gun carriage as a whole and upon its separate parts will enable us in the future to make more accurate calculations for stability and to plan correct methods for design solutions which will insure meeting, in a satisfactory manner, the requirements made of present-day weapons.

In writing the book the authors used the latest published works dealing with the problems discussed and took into account the experience gained in employing our own and foreign materiel in the years of the Great Patriotic War.

The introduction, Chapters I, II, and VII were written by Colonel

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REP 1-9-52
Auth Capt Gonzalez
No. of copies 22

0400 USSR

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K. K. Greten (engineer), and Chapters III, IV, V, and VI were written by Colonel S. A. Prikhodko.

The authors wish to express their deep gratitude to the Hero of Socialist Labor, Lieutenant General I. I. Ivanov (Engineer of the Artillery Service), who took upon himself the work of criticizing the second part, and also to Major General E. I. Lerman (Engineer of the Artillery Service) and to Colonel A. N. Kupriyanov (Engineer of the Artillery Service), who, in examining the manuscript, gave a number of valuable suggestions.

All suggestions and reports of errors will be gratefully received by the authors.

Colonel K. K. Greten (Engineer)

Colonel S. A. Prikhodko

INTRODUCTION

Problem of the Theory of Gun Carriages

The basic problem of the theory of gun carriages is the study of the effect of the shot on the artillery weapon, and also the determination of the theoretical principles which constitute the basis of the rational calculation and designing of present-day gun carriages and their mechanisms.

With this in view the theory of gun carriages deals with the following: first, determination of the forces and reactions appearing during the time of the shot in the different parts of the gun carriage, and also between the gun carriage and the base on which the gun is placed, and a study of the relative and absolute displacements of the artillery weapon as a whole and of its separate parts taking place as a result of the action of these forces; second, determination of the stresses appearing at the time of the shot in the separate parts of the gun carriage, and the determination of the most favorable dimensions of the carriage from the point of view of reliability in operation and also from the point of view of the demands made of the carriage, both as to the mount and as to the artillery vehicle.

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BRIEF HISTORICAL SURVEY OF THE DEVELOPMENT OF THE THEORY OF GUN CARRIAGES

The beginning of the theory of gun carriages in Russia dates back to 1808, when Major General of Artillery Gogel (Artillery Journal 1808, No. 6) published an article analyzing experience in the firing of guns under various conditions. This article draws conclusions concerning the dependence of the path of recoil of the gun upon the weight of the gun, the angle of elevation, and the initial velocity of the projectile.

This same journal (No. 3 for 1809) published an article of Colonel (of Artillery) Platto, giving concrete considerations pertaining to the constructio and calculations of the running gear (1) of gun carriages. The author of the article gives a theoretical substantiation of his views and numerical examples for calculations.

Later on, in 1825, there was published abroad the work of Poisson, devoted to the theoretical investigation of the effect of the shot on the carriage. In this work the effect of the shot on the carriage was likened to a blow, and the ground and the carriage were assumed to be absolutely firm. The first assumption was justified by the fact that the technique of the experiment at the time did not provide any experimental study of the effect of the shot on the weapon.

In the works appearing abroad in the 19th century, after the work of Poisson, the effect of the powder gases on the carriage was no longer considere as a blow, but as an ordinary force varying in accordance with a definite law. However, this had comparatively little practical importance, because the authors, in their conclusions, did not give the law of the change of pressure of powder gases, assuming that the carriage and the ground were absolutely

(1) Trans. note: It is possible that this is the same error that occurs on page 10, line 7 from bottom, listed in errata. If so, it would be "trail parts" instead of "running gear".

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solid and also that the pressure of the gases on the bottom of the projectile and on the base of the bore of the gun were the same.

We should note that then, in considering the problem of the secondary action of the gases, the investigators limited themselves to the qualitative side.

In 1891, P. A. Shiff, of the Professor Mikhailovsky Artillery Academy, published an article under the title "Experiment in the Application of the Theory of Elasticity to the Study of the Effect of the Shot on the Carriage".

Professor Shiff, after having made certain assumptions as to the form of the gun carriage and the character of the loads on its separate parts, and having applied also the conclusions of the theory of elasticity, determined the deformation and stress in the various part of the gun carriage depending upon the pressure of the powder gases on the base of the bore and the design data for the carriage. The work of Shiff was the first attempt to take into account the elastic characteristics of the carriage and it should be regarded as worthy of study and of further development.

Just as one did not by any means cease at once to liken the effect of the shot on the carriage to a blow, so after the works of Professor Shiff up to the present time we have continued to regard the carriage (or mount) and the ground as absolutely solid bodies, whereas the influence of the elastic qualities of the carriage and the tendency of the ground to yield are fully evident. This is explained by the fact that the relationships derived by Shiff, in addition to the aforementioned assumptions, did not always correspond to reality and were characterized by great complexity and cumbersomeness, which makes it difficult to employ them for practical purposes.

We should note that further progress in the theory of gun carriages is conceivable chiefly in this direction, namely, the taking into account of the elastic characteristics of the gun carriage and the base.

Among the other deserving works published in the field of the theory of

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gun carriages is that by Kane appearing in 1897 and dealing with the theory of the hydraulic brake. In this work the author gives his generally-known formula which constitutes at the present time the basis for the calculation of hydraulic brakes.

Later on, in a pamphlet published in 1896, a Russian artilleryman, Colonel Durlyakhov, proposed to include in the formula of Kane the correction factor k so that the theory will agree better with what we have in actual practice. In this same article Durlyakhov proposed an approximate law for the changes in pressure of the powder gases on the basis of time. The essence of his proposal consists in the replacement of the effective curve $p = f(t)$, by a broken line, the construction of which is determined by the given values p_m, l_m, l_0 and v_0.

At the present time the methods of constructing the curve $p = f(t)$, proposed by Durlyakhov, and also by other investigators, do not have any essential practical importance, because in our artillery practice "Tables for the Solution of the Problems of Interior Ballistics" of the Artillery Committee of the Chief Artillery Administration of the Red Army, based on the solution of the basic problem of interior ballistics by the method of Colonel General of Artillery Professor N. F. Drozdov, have come to be used universally.

We should also mention the course "Theory of Gun Carriages" of Professor G. D. Grodsky of the Mikhailovsky Artillery Academy, published in 1906. This course gives for the first time the investigations carried out in the field of hydraulics as applicable to the hydraulic brake of the recoil and a great deal of attention was paid to the spiral cylindrical springs. In the period 1934-1942, Grodsky published a number of works dealing with the separate problems of the theory of gun carriages. Of these we should mention two, namely, "Theory of the Dynamic Compression of Spiral Springs" and "The Dynamic Compression of Spiral Springs when the Movement of Its Free End is Given". The value of the latter works consists in the fact that they consider the problems of the dynamic calculation of the spring counterrecoil mechanisms.

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In spite of the cumbersomeness of the mathematical conclusions, the ultimate formulas are simple and have importance from the standpoint of application, because they give results that are in complete agreement with practical data.

During the last 25 years there have appeared in our own literature in the field of theory of gun carriages a number of outstanding works. Among these works we should mention first of all the works of the talented designer, lecturer of the Artillery Academy of the Soviet Army, Professor F. F. Lender. His works are devoted to the investigation of a number of problems dealing with the theory of gun carriages. We should note in particular his works dealing with the effect of the shot on the carriage, the investigation of the counterrecoil and the practical schemes for braking of the counterrecoil, and also the investigation of the work of cylindrical spiral springs as applied to the calculation of spring counterrecoil mechanisms.

The outstanding works dealing with the theory of carriages by our able designers, former professors of the Artillery Academy of the Soviet Army, Hero of Socialist Labor Lieutenant-General of the Engineer-Artillery Service I. I. Ivanov and Major General of the Engineer-Artillery Service A. A. Tolochkov are also deserving of serious attention.

The work of I. I. Ivanov "Principles of the Calculation and Designing of Gun Carriages" is in reality the first systematic course dealing with the theory of carriages. It considers in a very thorough manner all the basic problems connected with the calculation of a wheel carriage.

The work of A. A. Tolochkov, "Effect of the Shot on the Carriage" contains a number of new investigations and conclusions, among which we should mention the derivation of the formula for the coefficient of the action of the powder gases and the method of calculating split trails.

In completing the present brief survey of the development of the theory of carriages we should not fail to mention the work of Rear Admiral Bravin (Engineer) "New Method of Calculating the Hydraulic Brakes of Artillery Systems". This work gives a method for calculating the hydraulic brake of

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the recoil, taking into account the influence of the factor of the compression of the liquid and the variability of the correction factor

In conclusion we take the liberty of calling the attention of the reader to the fact that our own literature dealing with the theory of carriages is very extensive and contains a thorough investigation in this field of artillery science. In addition to this, all the present-day problems of the theory of carriages, of the elastic characteristics of the carriage and of the ground, the dynamic calculation of artillery springs and the separate parts of the carriage, methodology of the calculation of the hydraulic brakes of the recoil, and a number of others, if not completely solved, are at least posed for the first time by our own investigators and designers.

By studying these works the artillery engineer will find in them much of value for his practical work.

DEVELOPMENT IN THE CONSTRUCTION OF CARRIAGES. RIGID CARRIAGES.

On the basis of the method of absorbing the energy of the recoil, gun carriages may be divided into rigid and elastic.

The rigid gun carriages are the oldest types in use and are characterized by simplicity of construction. The carriage proper or mount consisted of two steel side plates or trails, fastened into a single whole by bolts with bracing sleeves, and connecting parts -- steel sheets, perpendicular to the trails and fastened to them by means of flanges or angle pieces. For greater stability, the trails were sometimes fastened by cover plates, attached at the most dangerous places, and by angle pieces fastened along the edge of the trails over their contour, and one also made trails with the edges bent inward or outward. In the trails of guns of large calibers, each trail is provided with a box section, made up of two parallel steel sheets, and of a thick steel "enclosing part" bent to conform to the contour of the trail. All this

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was fastened into a single assembly by means of rivets passed through openings in the "enclosing part" and sheets.

Fig. 1 (Page 9)

The carriage was either placed directly on the ground or on a platform (carriage-mount), or it was placed on a so-called turning or traversing frame provided with rollers (frame-carriage), or, finally, it had on the front parts an axle with two wheels for moving it (wheel-carriage).

A representative of the carriage-mount is the carriage model 1866 (fig. 1) for the half-pood smooth-bore mortar (fortress). It consists of trails, connected with bolts, passed through wooden brace "cushions". Angle-irons are fastened to the lower part of the trails and through the intermediary of these angle-irons the carriage rests on the platform. The trunnions of the mortar are placed in the trunnion sockets of the trails; the coverplates on the trunnion sockets are fastened to the trails by means of bolts.

The elevator mechanism consists of wooden "degree cushions" covered with iron (angles of elevation: 6°, 12°, 18°, 30° and 45°). In order to keep the mortar from tilting backwards when the shot is fired under angles of 30 and 45 degrees, it is held by a chain tightened by a turnbuckle.

When the shot is fired, the whole system slides on runners along the

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platform. The energy of recoil is absorbed by the forces of friction generated between the runners and the platform.

As a representative of the rigid wheel-carriages we may take the carriage of the nine-pound field gun model 1867 (fig. 2). It consists of a mount and a set of wheels with an axle. The axle-tree clip is placed in rectangular recesses of the face part of the carriage; below, the axle is fastened to the trails by binding pieces. The recesses in the trails are reinforced by cover plates.

In order to prevent the ends of the axle from bending forward when the shot is fired, as a result of the reaction from the wheels, special braces are put on the ends of the axles through the intermediary of lugs, the rear ends of which are fastened to the ends of a bolt passed through the middle part of the trail.

For preventing the bending of the ends of the axle upward they are fastened below by angle-irons. Later on, one made axles of steel with an increased carbon content, giving to the axle-tree clip at the same time a rectangular section with a vertically placed large side.

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The elevator mechanism of the carriage of the nine-pound field gun was a double elevating screw, and for the horizontal laying use was made of a handspike.

The energy of the recoil when the shot is fired was absorbed by the force of friction generated during the recoil between the trail part of the carriage, the wheels, and the ground. For firing the next shot it was necessary to push the gun forward, and in doing so to use up a great deal of time and slow up considerably the rate of fire. For lessening the effect of the shot on the carriage, and also for shortening the length of the recoil of the weapon in order to increase the rate of fire, the elastic coupling of certain parts of the carriage was introduced in later models of the carriage.

Representatives of this category of carriages are the field carriages designed by the talented Russian artilleryman Lieutenant General Engelhardt for gun model 1877, mortar model 1889, and gun model 1895.

Fig. 3 (Page 11)
Legend: 1-buffer or shock absorber.

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In carriage model 1877 (fig. 3) the elastic connection of the axle with the carriage was introduced for the purpose of preventing the bending of the ends of the axle forward when the shot is fired. The axle may undergo a forward displacement relative to the trails by compressing, through the intermediary of a tie-rod, a shock absorber placed between the trails. After the shot is fired, the force of elasticity of the shock absorber returns the axle to its initial position.

The elevating mechanism in this carriage consists of two screws with opposite threads, screwed into each other. The purpose of this construction of the elevator mechanism was to increase the speed of laying for range. For laying for direction (traversing) the carriage was equipped with a handspike and hand rails on the trail part of the mount.

The small spade, fastened below to the trail part of the carriage, was intended not for giving stability during fire but for increasing the friction during recoil, thus shortening the length of the recoil of the gun.

Carriage model 1895 (fig. 4), designed for the purpose of increasing the rate of fire, is characterized chiefly by the presence of an elastic spade. When the shot is fired the carriage is displaced relative to the spade, fastened by hinges to the carriage and to the shock absorber bolt; the shock absorber column is placed in the trail casing. The spade, stuck in the ground, remains in place, and under the action of the force of recoil, with the sliding of the carriage backwards the shock absorber is compressed, as a result of which a part of the energy of recoil is absorbed and there is a shortening in the length of the recoil. After the shot is fired the carriage is returned to its initial position by the force of elasticity of the compressed shock absorber, requiring almost no counterrecoil by hand.

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Fig. 4 (Page 12)

This construction, and also the presence of a traversing mechanism with the shifting of the face part of the carriage along the axle, made it possible to bring the rate of fire up to 4 shots a minute. The bending of the ends of the axle forward was prevented by the presence of the axle shock absorber.

The result of the short length of the recoil was instability of the carriage and the disturbance of laying. The rather large magnitude of the force of the compressed shock absorber column struck a strong blow against the solid ground during the counterrecoil.

The carriage model 1889 (fig. 9) for the six-inch field mortar was the first solution in Europe of the problem of the wheel carriage for mortars. The difficulty in the solution of the problem was this: most of the firing

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was executed under high angles of elevation with the result that a great force acted upon the wheels, which, together with the axle in the rigid carriages, are the least stable parts.

Fig. 5 (Page 13)
Legend: 1-axle;
2-buffer on chain;
3-elastic pedestal.

The constructional solution of the problem was arrived at by passing through the axle-tree clip two bolts connected with the trail by hinges. On these bolts, above the axle, one placed the shock absorber columns with steel spacers between the shock absorbers. At the places of the hinge fastenings of the shock absorber bolts there were suspended, also by hinges, two elastic pedestals. When the shot was fired the front part of the carriage, under the action of the vertical components of the force of recoil, settled relative to the axle, compressing the columns of the shock absorber until the elastic pedestals made contact with the ground. After this there takes place an elastic compression of the pedestals. Hence, the axle and the wheels are subjected to only a part of the vertical component of the force of recoil.

The horizontal component of the force of recoil causes the recoil of the weapon, and during the recoil the supporting pedestals, turning

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counterclockwise, compress the shock absorber on the chain running from the lower part of the pedestal backwards and upwards.

After the termination of the action of the force of the recoil, when the shock absorber columns on the axle again lift the carriage, the supporting pedestals, by the force of the compressed shock absorbers on the chain, will be thrown back and will catch the spring hooks on the lower part of the carriage without interfering with the counterrecoil of the gun.

The elevating mechanism consists of a worm sector, fastened on the right trunnion, and a worm with a handwheel, fastened to the right trail. The laying for direction is done by means of a handspike.

Fig. 6 (Page 11)

The carriage for the six-inch gun of 200 poods of the system of Captain Markevich (fig. 6) also belongs to the type of rigid wheel carriages. The carriage consists of the mount, a set of wheels, hydraulic brake, and two support sectors. The carriage has separate wheels for firing (of small diameter) and separate ones for marching (of large diameter), and also trunnion sockets, for firing position and for marching. The piston of the hydraulic brake of the recoil is connected with the middle part of the mount

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below, and the cylinder is fastened to the pedestal, attached to the platform for fire on the axle. The pedestal serves as an axis of rotation in laying for direction. In order to prevent breaks of the wheels during fire, two support sectors are suspended on the ends of the axle. When the shot is fired under the action of the vertical component of the force of recoil, the front part of the carriage sags and the support sectors rest on the platform, relieving in this way the wheels. Under the action of the horizontal component of the force of the recoil the gun moves back and is braked by the hydraulic brake and by the movement of the wheels upward along the counterrecoil wedges. The counterrecoil takes place under the action of the force of gravity along the counterrecoil wedges.

The gun has an elevator mechanism of the sector type. The laying for direction is done by the rotation of the gun relative to the pedestals, by means of levers.

The carriage of the fortress gun model 1867 or model 1877 (fig. 7) is a representative of rigid frame carriages. It consists of a carriage with box trails and a traversing frame. The trails are fastened to each other and to the bottom by transversal braces. When the shot is fired, the carriage recoil along the frame and together with it may easily be turned with the traversing mechanism in laying for direction. For this purpose the frame is provided with rollers, through the intermediary of which it rests on the guide race of the platform. As an axis of rotation there is a pintle placed in the pedestal, on which there is a draw bar fastened to the traversing frame in front.

When the shot is fired the frame is held in place by the pintle, while th mount slides backwards and upwards along the inclined runners. For shortening the length of recoil the carriage is provided with a hydraulic brake (at first with a friction brake, with cross braces). The counterrecoil of the carriage takes place under the action of the force of gravity along an incline

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plane. At the end of the counterrecoil the carriage strikes against the support shock absorber on the front end of the frame.

Fig. 7 (Page 15)

For producing an artificial recoil, the carriage has a recoil winch. For facilitating both artificial recoil and the counterrecoil, the carriage is provided with rollers on elbow axles, which, during the time of the recoil when the shot is fired, are raised up so that the mount does not roll on them but slides along the frame; before the beginning of the recoil, however, the rollers automatically drop (the same is done by hand in artificial recoil) and do not rise again until the end of the counterrecoil. Hence, in the first part of the course of the counterrecoil, the mount moves at an accelerated rate, on rollers, and by hand is slowed up, because it is braked by the force of the friction of sliding.

To prevent jumping of the mount when the shot is fired under small angles of elevation there are in the front part some holding devices by means of which the mount is connected with the longitudinal projections along the sides of the frame.

The elevating mechanism consists of two cog sectors with an appropriate

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cog transmission.

For convenience in loading the carriage has a lifting crane.

ELASTIC CRRIAGES. CARRIAGES WITH RECOIL OF THE BARREL ALONG THE AXIS OF THE BORE.

The essential difference between elastic carriages and rigid carriages is the fact that the former consist of two parts joined with each other by means of an elastic connection. When the shot is fired, these parts are displaced mutually with respect to each other. As a result of the presence of this same elastic connection, the aforementioned parts must come back into the initial position for the next shot.

The above described frame carriage, taken as a whole together with the traversing frame, is the prototype of the elastic field carriage which was first worked out and realized with the 2.5 inch field and rapid-fire mountain guns as early as 1872 by the outstanding Russian artilleryman, self-taught inventor, V. S. Baranovsky.

The carriage of the gun of the Baranovsky design was of the slide type, that is, of the same type as that on the basis of which one constructed the carriage considered below for the rapid-fire gun model 1900, and was provided with a hydraulic recoil brake and spring counterrecoil. For laying for direction the carriage had a screw traversing mechanism with shifting of the mount along the axle, and for giving immobility to the whole gun when the shot is fired there is a rigid spade. In addition to this, one should note that the wheels of the carriage were for the first time provided with metallic hubs, covered on the ends.

Several mountain guns of the Baranovsky system were used in the Russo-Turkish War in 1877, but on the whole the guns of his construction were not to be used extensively. During the time of the testing of charges on the Main Artillery Proving Grounds Baranovsky was killed by the premature ignition of a charge. The tragic death of this talented inventor delayed for at least 20-25

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years the final working out in Russian artillery of carriages with recoil along the axis of the bore.

When the semi-rapid fire gun model 1900 was worked out in Russia, one used for it the carriage designed by Engelhardt, based on the type of carriage of the Baranovsky gun.

The carriage of the three-inch gun model 1900 of the semi-rapid fire type (fig. 8) consists of slides on which the barrel is set through the intermediary of a trunnion and an elevating screw, and of a base formed by the mount and the axle with wheels. Bronze runners along which the slides move when the shot is fired are fastened to the upper edges of the trails. Between the trails there is a hydraulic brake, the piston of which is attached to the mount and the cylinder of which is fastened to the slides.

Above the cylinder, parallel to the upper edge of the trails the operating rod is fastened in two transversal couplings. The operating rod has on it rubber buffers, the rear buffer resting on the trail transversal coupling, and the front one resting in the lug on the slides. This buffer (shock absorber) column forms the counterrecoil mechanism. Between the shock absorbers there are steel gaskets to eliminate friction between the buffers and the operating rod.

When the shot is fired, the mount, held by the spade, remains in place; the barrel, however, with the slides and the cylinder of the brake, moves back along the runners of the mount, and a part of the energy of the recoil is absorbed by the hydraulic brake and the rest of it is expended in the compression of the buffers (shock absorbers) of the counterrecoil mechanism.

Fig. 8 (Page 17)

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After the termination of the recoil, the buffers, being released, push forward the slides together with the barrel and the cylinder. For decreasing the speed of the counterrecoil, a part of the energy is absorbed by the brake of the counterrecoil. During the recoil and the counterrecoil a part of the energy of the recoiling parts is absorbed by the friction of the faces of the rubber buffers against the steel gaskets with the compression of the buffers during the time of the recoil and the release of them during the time of the counterrecoil.

For increasing the stability of the carriage, the axle runs not under the trails but through the middle face part and is of the elbow type, so that its ends are above the axle-tree clip.

The carriage has a traversing mechanism, making possible the laying of the gun for direction by $\pm$ 1° by the rotation of the mount relative to the point of support of the spade with shifting of the face part along the axle.

The angle of laying for range is from $-$ 6.5° to + 17 degrees.

In this carriage, steel hubs for the wheels were used for the first time.

The advantage of a carriage of this construction consists in the fact that here the lower part is subjected to the action not only of the force of pressure of the powder gases but also to the action of another force, namely, the force of resistance of recoil, which is exceeded many times by the force of pressure of the powder gases, thus permitting a considerable decrease in the weight of the system as a whole. The recoil of the weapon during the shot may be made small, while the mount itself remains immobile; the counterrecoil takes place quickly and automatically, thus increasing the rate of fire.

A subsequent improvement in these carriages was the cradle carriage, or carriage with recoil of the barrel along the axis of the bore.

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Fig. 9 (Page 18)

Here it is necessary to state that simultaneously with the working out of the 2.5 inch field gun and mountain gun, the Russian inventor-artilleryman Baranovsky designed the construction of a mount for a gun of this calibre to be used on a sloop, upon orders of the Navy Department. In its design engineer Baranovsky anticipated the designers of western Europe by at least 15 years.

What was regarded as something new at the exposition in Paris in 1889, namely, the recoil of the barrel along the axis of the bore, had already been realized by inventor Baranovsky in a sloop mount for his gun.

The carriage of the sloop gun had a yoke cradle in which the barrel recoiled along the axis of the bore. The counterrecoil mechanism, the hydraulic brake, and the spring counterrecoil were placed vertically on the pintle and connected with the recoiling barrel by means of a chain connection.

The construction of the carriage with the recoil of the barrel along the axis of the bore has a number of advantages over those previously considered and came to be used extensively in all forms of artillery at the beginning of the 20th century.

The first representative in our artillery of this category of carriages is carriage model 1902 for the three-inch rapid-fire field gun (fig. 9).

The carriage consists of a mount with a set of wheels and a cradle, in which the barrel recoils when the shot is fired. The mount is of the box trail type with a recess in the upper plate for possibility of recoil at high

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angles of elevation. For lowering the center of gravity of the gun, the axle is of the elbow type. The traversing mechanism provides an angle of traverse of plus or minus 3 degrees (the displacement of the face part of the mount is along the axle). The hand spike is used for rough laying for direction. The immobility of the gun is assured by the spade.

The cradle is cylindrical with guide ribs along which the barrel slides during recoil and counterrecoil. The trunnions of the cradle lie in the trunnion sockets on the face part of the mount, and the rear part of the cradl is supported by the elevator mechanism with two screws set in rotation by a handwheel through a gear drive. Inside the cradle are the hydraulic recoil brake, the cylinder of which is connected with the lug of the barrel, and the piston rod, fastened in the front part of the cradle. The screw sorings of the counterrecoil are put on the cylinder of the brake.

The carriage provides for laying for range in limits of minus 5 to plus 16° 40′ and a rate of fire of 15-20 shots a minute.

On the carriage one used for the first time a shield cover for protection of the gun crew against bullets and small splinters.

Here also it is necessary to note that the first gun shield was introduce in 1904 by the talented Russian artilleryman Lieutenant Colonel Kuriak, who used it in his battery. The shields were made by the crews of the batteries. The tactical experience of the battery showed that the present-day field guns cannot get along without such shields. Towards the end of the Russo-Japanese War all countries provided their new field guns with shields.

The carriages of the other models of artillery weapons used in the armament of our own artillery did not differ at all in principle from the carriage of the gun model 1902. The difference consisted only in the arrangement of the separate mechanisms and assemblies. For example, the the 122 mm howitzer model 1909 one used the equilibrating mechanism in connection with the drawing of the trunnion backwards, and in the 122 mm howitzer model 1910,

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just as in other models of the system of Schneider, the counterrecoil mechanisms were mounted on slides, recoiling with the barrel, a procedure which increased the weight of the recoiling parts. In these systems the counterrecoil mechanism was hydro-pneumatic and the elevating mechanism was the sector type.

FURTHER DEVELOPMENT IN THE CONSTRUCTION OF CARRIAGES. PRESENT DAY CARRIAGES AND THEIR MECHANISMS.

The experience of the first World War resulted in demands for a considerable increase in the angle of fire in the horizontal plane, without a change in the setting of the trail.

The efforts to meet this demand were not made at once along the line of employment of a split trail carriage. For example, in order to give to the 75 mm field gun Saint-Chamond, model 1923 (fig. 10), an angle of horizontal fire of 40 degrees one made a carriage with a triangular shaped frame, which replaced the split trail type. The sharp increase in the transversal dimensions of the trail parts of the carriage caused inconveniences in the operation of the gun, and, hence, this solution of the problem of design was not used very much.

Another design making it easy to obtain a large angle of horizontal fire, without the employment of split trails, is the placing of the wheels on a circular platform. In the center of the platform there is a vertical axis which, by special tension members, is connected with the mount so as to assure reliable operation of the carriage, because the platform is fastened by stakes driven into the ground. An example of such a design is the 75 mm Vickers gun (fig. 11). This method of giving a large angle of horizontal fire is also used in certain heavy guns abroad. Sometimes the wheels are disengaged in the firing position and the rotation is on a pintle resting on a ball pivot in a ball thrust bearing on the support plate. The carriage of the 210 mm German mortar model 18 (fig. 12) is an example of such a carriage.

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Fig. 10 (Page 20)

In the firing position, the mortar rests on the ground -- in front, through the intermediary of the base plate, and behind, through the intermedia of the trail support. The base plate is fastened to the ground by braces and by stakes driven in to the ground. In operating the traversing mechanism, the trail part of the carriage rolls along an arc-shaped guide of the trail support. The traversing mechanism is in the trail part. The traversing mechanism provides for the turning of the mortar $\pm$ 6°. If larger turns are needed, the trail part may be lifted and the weapon turned by hand, the trail part of the mount being moved on rollers along the guide of the base plate. The rollers serve for placing the weapon in a horizontal position.

A carriage construction with split trails assuring an angle of horizontal laying of about 60° is the one that has come to be most extensively used in present day field artillery.

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cay field artillery.

Fig. 12 (Page 21)

The following requirements are made of anti-aircraft guns: large angle of vertical fire and horizontal fire of 360 degrees, and also rapid change of the gun from the march position to the firing position. These requirements determine the general scheme of construction of carriages of anti-aircraft guns

Figures 15 and 16 show the medium calibre anti-aircraft gun with the 4-trail carriage in the firing position and in the travel position.

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Fig. 11 (Page 21)

In our artillery, for wheel carriages of present field artillery, this construction is the prevailing one. Exceptions are constituted by the old model guns on wheel carriages and certain high-powered guns which we have in our armament. Figures 13 and 14 show our 76 mm gun model 1942 and the 122 mm howitzer model 1938, whose carriage construction is characteristic for present

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The small calibre anti-aircraft guns and sometimes the medium calibre ones also are mounted on a four-wheel vehicle (fig. 17); in the firing position the wheels are disengaged.

In general, the carriages of present day artillery weapons may be divided into two basic groups:

(1) carriages with mobile artillery pieces

(2) carriages with stationary or immobile artillery pieces.

The mobile mounts are used with guns equipped for movement with carriers making possible the conduct of fire directly from the ground.

The stationary artillery mounts include guns which are connected immovably with the base of the mount, constructed ahead of time at a specified point in the locality (stationary antiaircraft mounts, coastal artillery) or forming a part of some construction (vessels).

The stationary or semi-stationary mounts also include those which — even though they have traction devices (carriers) for movement by reason of the character of the connection with the base/mounts of the stationary type are similar to (antiaircraft mounts on vehicles, railway mounts, airplane mounts).

The construction of the carriage and the method of connecting it with the base on which the gun rests during the time the shot is fired depend upon the purpose of the gun in question, the conditions under which it is employed, and also upon the method of transport.

In further discussion of the problems of the theory of carriages we shall have in mind chiefly the wheel carriage of field guns both monobar and the split trails. As a variety of the wheel type field carriage, we have the field carriage with tracks. In principle the latter does not differ at all from the wheel carriage. The difference consists only in the fact that here, instead of wheels, we use tracks, which give great capacity for cross-country travel, due to the lessening of the specific pressure on the ground.

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Fig. 13 (Page 22)

Fig. 14 (Page 22)

Fig. 15 (Page 23)

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Fig. 16 (Page 24)

Fig. 17 (Page 24)

The wheel carriage of present-day artillery pieces usually consists of the following assemblies:

1) the cradle with recoil system (recoil brake, counterrecoil, brake of the counterrecoil);

2) the upper carriage or swivel;

3) laying mechanisms, for range and for direction;

4) equilibrator mechanism;

5) a lower carriage with trails, a spade and handspike;

6) running gear (carrier): axle with wheels (or caterpillar tread), cushion parts and brakes;

7) shield cover;

8) mechanisms for fastening in the travel position;

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9) certain additional mechanisms (for example, in weapons of large calibre: lifting cranes, jacks, mechanisms for bringing the weapon to the angle of loading, etc).

In concluding the consideration of the question of the development of the construction of carriages we shall dwell on the construction of the different kinds of carriages of a present-day artillery piece -- the mortar.

The most typical construction of the carriage of the present-day mortar is the bipod mount, used for firing and not having, as a rule, for transport any carrier connected organically with it.

In the majority of cases the present-day mortar mount is a rigid system. The mechanisms for laying are mounted on the bipod. The force of recoil is transmitted to the ground through a base plate. For moderating the action of the shot on the bipod mount and in order to provide for the recoil of the barrel along the axis of the bore when the shot is fired, through the settling of the ground, the barrel with the bipod is connected through the intermediary of the shock absorber.

In figure 18 we have a general view of our 120 mm mortar.

In conclusion we should emphasize that all the present-day constructions of models of our own artillery has been worked out under the direction of the designers-artillerymen of the Stalin School of Heroes of Socialist Labor, V. G. Grabin, I. I. Ivanov, F. F. Petrov and V. I. Shavyrin.

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Fig. 18 (Page 26)

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CHAPTER I

EFFECT OF THE SHOT ON THE CARRIAGE

1. Effect of the shot on the rigid carriage

We shall consider the effect of the shot on a piece with a rigid carriage, that is, one in the case of which the barrel is rigidly connected with the carriage and is stationary with respect to it during the time the shot is fired.

Besides, we shall assume that

1) fire is conducted at an angle of elevation $\varphi > 0$;

2) the piece is mounted on a horizontal base;

3) the spade cuts into the ground and hinders the displacement of the carriage;

4) during the time of the shot the wheels of the carriage press against the ground all the time;

5) all the forces acting on the piece lie in the vertical plane of symmetry of the piece;

6) the carriage and the base on which the piece is set are absolutely rigid bodies.

The forces acting on the piece during the time of the shot will be the following under the given conditions:

P_{KH} --(1) resultant force exerted in the bore of the barrel when the shot is fired, applied to the base of the bore and directed along its axis in a direction contrary to that of the movement of the projectile;

Q_6 (2)--the force of the weight of the piece in firing position, applied to its center of gravity and directed vertically and downward;

(1) P_{KH} = pressure of the powder gases in the bore.

(2) Q_6 = weight of gun in firing position.

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$N_{x\sigma}$ and $T_{x\sigma}$ --the vertical and horizontal components of the reaction of the ground on the spade, directed as shown in Figure 19 (for simplification, the point of application of the reaction of the ground C is assumed to lie in the plane of the base);

$N_{\Omega\sigma}$ --the vertical reaction of the ground against the wheels.

We assume that during the time of the shot the gun remains in equilibrium, that is, it conserves its stability and immobility. By stability we shall understand that condition of the gun during the time of the shot when the wheels are pressed against the ground, and by immobility that condition of the gun when there is an absence of displacement of the carriage on the ground.

We apply to the given case the well known conditions of the equilibrium of the system known from mechanics:

$$\Sigma X_i = 0; \quad \Sigma Y_i = 0; \quad \Sigma M_i = 0$$

where X_i -- projection of the force on the axis OX;

Y_i --projection of the force on the axis OY;

M_i --the moment of the force relative to the axis perpendicular to the plane of the drawing.

The axis of coordinates are directed as shown in Figure 19. As the axis of the moments we take the perpendicular to the plane of the drawing passing throug the point C.

Figure 19 (Page 28)

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Besides, we designated by:

h —the arm of the action of the force P_{kH} relative to the axis passing through the point C perpendicular to the plane of the diagram:

L —the horizontal distance from the point C to the point of support of the wheels;

D —the horizontal distance from the point C to the center of gravity of the gun.

In addition to this, we assume that the axis of the bore of the barrel intersects the axis of the trunnion.

Then

$$\left.\begin{aligned} \Sigma X_i &= P_{KH}\cos\varphi - T_{\text{кб}} = 0; \\ \Sigma Y_i &= N_{\text{лб}} - Q_{\text{б}} - P_{KH}\sin\varphi + N_{\text{кб}} = 0; \\ \Sigma M_i &= P_{KH}h + N_{\text{лб}}L - Q_{\text{б}}D = 0. \end{aligned}\right\} \quad (1)$$

By solving the last equation of the system (1) for the reaction $N_{\text{лб}}$, we obtain:

$$N_{\text{лб}} = \frac{Q_{\text{б}}D - P_{KH}h}{L}. \quad (2)$$

We determine the value of the arm h, introducing the notation:

H —height of the line of fire or the distance of the axis of the bore of the barrel to the horizontal with $\varphi = 0$;

$d_{\text{ц}}$ —the distance between the axis of the trunnion and the point C along the horizontal.

As we can see from Figure 19,

$$h = a - b,$$

and

$$a = H\cos\varphi \quad \text{and} \quad b = d_{\text{ц}}\sin\varphi.$$

consequently

$$h = H\cos\varphi - d_{\text{ц}}\sin\varphi. \quad (3)$$

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By substituting this value of h in the expression (2) and solving the first two equations of the system (1) for T_{x6} and $N_{\alpha 6}$, we obtain the following system of formulas for determining the reaction T_{x6}, $N_{\alpha 6}$, and N_{x6}:

$$\left.\begin{aligned} T_{x6} &= P_{KH} \cos\varphi ; \\ N_{\alpha 6} &= \frac{Q_6 D - P_{KH}\,(H\cos\varphi - d_K \sin\varphi)}{L} ; \\ N_{x6} &= P_{KH} \sin\varphi + Q_6 - N_{\alpha 6} . \end{aligned}\right\} \quad (4)\ 2$$

From the expressions obtained we can see that the reactions of the base on the carriage are functions of the angle of elevation.

In a stable gun the wheels will press against the ground all the time and the reaction $N_{\alpha 6}$ will be greater than zero, and in the limit case it will be equal to zero.

On the basis of the expression for $N_{\alpha 6}$ from system (4) the conditions for stability are written as follows:

$$Q_6 D - P_{KH}\,(H\cos\varphi - d_K \sin\varphi) \geqslant 0$$

or

$$Q_6 D \geqslant P_{KH}\,(H\cos\varphi - d_K \sin\varphi). \quad (5)\ 2$$

The left part of the inequality (5) represents the moment stabilizing the gun and the right part represents the moment upsetting the gun.

The condition of immobility of the weapon is expressed by the equation

$$T_{x6} = P_{KH} \cos\varphi . \quad (6)\ 2$$

For the case of fire under an angle of elevation $\varphi = 0$ the condition of immobility will have the following form:

$$T_{x6} = P_{KH} , \quad (7)\ 2$$

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and the conditions of stability will be :

$$Q_6 D \geq P_{KH} H. \qquad (6)\ 30$$

Inasmuch as the permissible specific pressure upon the ground is equal to $P_{y\,g} = 2.5 \div 4.5\ kg/cm^2$, and the force P_{kDmax}, corresponding to the moment of the maximum pressure of the powder gases, reaches several tens of tons in the small calibres, and several hundreds of tons in guns of large calibre, we must conclude that the conditions for immobility of guns with a rigid carriage are practically unrealizable, because they would require spades that are too cumbersome, unsuitable both as to weight and as to dimensions.

We must say the same concerning the stability of a gun on a rigid carriage with $\varphi = 0$, because the value of the force P_{kDmax} is several times greater than the weight of the gun on a rigid mount (carriage) we should have to take the ratio of the arms D:H also equal to several tens, something which cannot be realized in practice.

From the conditions of immobility (6) it follows that with an increase in the angle of elevation φ the value P_{KH} decreases proportionally to $\cos \varphi$. It is possible with the given dimensions of the spade to ensure the immobility of the weapon by lowering the specific pressure on the ground to a value less than the permissibl

From the conditions of stability (5) it follows that the stability of the gun increases with an increase in the angle of elevation. In reality, with an increase in the angle of elevation the right part of the inequality (5), that is, the value of the upsetting moment, is decreased with an increase in the angl φ by decreasing the arm

$$h = H \cos \varphi - d_u \sin \varphi.$$

With a certain value of the angle $\varphi > 0$ the value of the arm h becomes equal to zero, which will correspond to the passage of the line of action of the force P_{KH} through the point C. With further increase in the angle of elevat

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the upsetting moment changes its sign and will act in the same direction as the stabilizing moment of the weight $Q_5 D$, as a result of which stability will be completely assured.

Hence, it follows that the stability of a gun on a rigid mount may easily be provided in the case of a gun intended for fire under high angles of elevation. In the case of pieces in which the direction of the action of the force P_{kH} passes under all angles of elevation through the point of support, as for example mortars, the stability of the piece is assured.

2. Effect of the shot on pieces with recoil of the barrel along the axis of the bore

In a piece with recoil of the barrel along the axis of the bore, the barrel is placed on a cradle so that when the shot is fired it can, together with certain other parts, move along it parallel to the axis of the bore of the barrel in the direction opposite to the movement of the projectile. The cradle is connected through the trunnions with the mount and, by means of the elevating mechanism, can, together with the barrel, swing in a vertical plane with the given angles of elevation. The displacement of the barrel along the guides of the cradle during the time of the shot is called recoil, and the barrel together with the parts participating in the recoil are called recoiling parts.

For absorbing the vis viva (kinetic energy) of the recoiling parts, energy acquired by them under the action of the force P_{kH}, and after this for moving them back into the initial position we have the hydraulic recoil brake, the counter-recoil and the counterrecoil brake, forming the recoil mechanism.

Owing to the connection of the barrel with the mount through the intermediacy of the recoil mechanisms, the latter is not subjected to the direct action of the great force P_{kH} but experiences only the effect of the reaction of the recoil mechanisms. This reaction is much less than the force $P_{kH\ max}$ (30 to 40 times), thus making it possible without any special difficulty to ensure proper strength of the carriage (mount), and the stability and immobility of the piece during

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the shot. In this case the immobility is obtained by the employment of a spade of small dimensions.

During the shot the following forces act on the recoiling parts:

P_{kH} --the resultant force, acting in the bore of the barrel in the direction of its axis; the components of this resultant are: in the period of the movement of the projectile along the bore--the force of the pressure of the powder gases against the bottom of the bore, the force of the friction of the powder gases against the walls of the bore, the force of the resistance of the grooves, and, after the departure of the projectile from the bore of the barrel, the reacting force of the gases escaping from the bore of the barrel, the force of pressure of the powder gases on the cross-section of the bore, and in the presence of muzzle brake, also the force developed by the latter.

Q_o --the force of gravity of the recoiling parts, applied to the center of gravity of the latter.

Since the elements of the recoiling parts are usually placed non-symmetrically with respect to the axis of the bore of the barrel, the center of gravity of the recoiling parts lies outside the axis of the bore of the barrel, above or below it. The distance between the projection of the trajectory of the center of gravity of the recoiling parts during recoil upon the vertical plane of symmetry and axis of the bore of the barrel is designated by e_o.

K --the total resistance of the recoil brake and the counterrecoil brake taking into account the force of friction on the gaskets and collars. For simplification of the conclusions, in accordance with the representation in Figure 20, we shall suppose the axis of the recoil and counterrecoil brake to coincide. We designate the distance from the direction of the action of the force K to the center of gravity of the recoiling parts by h'_3.

N_1 and N_2 are respectively the front and rear normal reaction of the cradle.

$T_1 = fN_1$ and $T_2 = fN_2$ --corresponding to the normal reactions of the force of friction.

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$T = f(N_1 + N_2) = T_1 + T_2$ ---the total force of friction on the guides

Figure 20 (Page 32)

As a result of the fact that the resultant K has a point of application outside the axis of the bore and also that the center of gravity of the recoiling parts is below it, the recoiling parts tend to turn clockwise around the center of gravity; hence, the forward reaction N_1 is directed downward, and the rear reaction N_2 is directed upward.

We take as the origin the coordinates of the center of gravity of the recoiling parts and direct the coordinate axes as shown in Figure 20. By including among the external forces the force of inertia of the recoiling parts $\frac{Q_0}{g}\frac{d^2x}{dt^2}$ and bearing in mind its direction in the period of accelerated recoil, on the basis of the principle of Dalambert, the equation of equilibrium of the recoiling parts may be written in the following form (as the axis of the moments, we take the perpendicular to the plane of the diagram at the origin of the coordinates).

$$\left.\begin{aligned} \Sigma X_i &= P_{KH} - K - f(N_1 + N_2) + Q_0 \sin\varphi - \frac{Q_0}{g}\frac{d^2x}{dt^2} = 0; \\ \Sigma Y_i &= N_2 - N_1 - Q_0 \cos\varphi = 0; \\ \Sigma M_i &= P_{KH} e + K h'_3 + f N_2 h'_2 + f N_1 h_1 - N_2 l_2 - N_1 l_1 = 0. \end{aligned}\right\} \quad (9)$$

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The first equation of the system (9) is no other than the equation of the movement of the recoiling parts, which may be written in the following form:

$$\frac{Q_0}{g}\frac{d^2X}{dt^2} = P_{KH} - K - T + Q_0 \sin\varphi, \qquad (10)\ 32$$

where X is the magnitude of the path of recoil at the moment considered; $Q_0 \sin\varphi$ is the component of the weight of the recoiling parts in the direction of the recoil.

By designating the resultant of all the forces of the right part of equation (10), with the exception of the force P_{kH}, through R, that is, supposing

$$R = K + T - Q_0 \sin\varphi, \qquad (11)\ 33$$

the equation (10) may be written in this form:

$$\frac{Q_0}{g}\frac{d^2X}{dt^2} = P_{KH} - R. \qquad (12)\ 34$$

The equation obtained is called the equation of the brake recoil.

In this equation the brake recoil R is the combined force of the resistance of the recoil. As we can see from expression (11), the force of resistance to the recoil is a resultant of the forces of resistance of the hydraulic brake of the recoil and of the counterrecoil, taking into account the forces of friction in the gaskets and collars, the forces of friction on the guides of the cradle and the axial component of the force of gravity of the recoiling parts.

We consider the determination of the reaction of the ground against the lower parts of the carriage and the conditions of immobility and stability for the case of the monobar carriage supposing that:

1) firing is conducted at an angle of elevation $\varphi > 0$;

2) the weapon is set up on a horizontal base;

3) the spade cuts into the ground and prevents the displacement of the carriage;

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4) during the time of the shot the wheels of the carriage press against the ground all the time;

5) all the forces acting on the carriage lie in the vertical plane of symmetry of the gun;

6) the carriage and the base on which the gun is placed are absolutely rigid bodies.

For driving back the recoiling parts and "replacing them" by the corresponding reaction against the cradle, we obtain the following equalizing forces acting on the cradle (Figure 21):

N_1, N_2, N_1, N_2,—reactions of the recoiling parts on the cradle;

K —the total resistance of the recoil brake and the counterrecoil, taking into account the forces of friction in the baskets (stuffing boxes) and in the collars:

$Q_{\text{д}}$ —weight of the gun in firing position after the substraction of the weight of the recoiling parts ($Q_{\text{д}} = Q_{\text{б}} = Q_{\text{о}}$);

$N_{\text{л}\text{б}}$ and $N_{\text{х}\text{б}}$ —the face and trail vertical reaction of the ground on the carriage;

$T_{\text{х}\text{б}}$ —horizontal reaction of the ground on the spade.

We shall regard the reaction $N_{\text{х}\text{б}}$ as applied to the center of gravity of the supporting surface of the trail plate (plateau) and the reaction $T_{\text{х}\text{б}}$ as applied to the center of gravity of the supporting surface of the spade.

By the line S — S we shall designate the trajectory of the center of gravity of the recoiling parts.

Figure 21 (Page 34)

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In addition to this we use the following notation:

l_1--distance along the axis of the bore from the center of gravity of the recoiling parts O to the line of the action of the reaction N_1;

l_2--the distance along the axis of the bore from from the center of gravity of the recoiling parts to the line of the action of the reaction N_2;

l_3--the distance along the axis of the bore from the line of action of the reaction N_2 up to the point C of the application of the reaction of the ground to the trail part of the carriage;

h--the distance along the perpendicular between the trajectory of the center of gravity of the recoiling parts during the recoil and the point C;

h_1--the distance along the perpendicular between the lower surface of the guides of the cradle and the point C;

h_2--the distance along the perpendicular between the upper surface of the cradle guides and the point C;

h_3--the distance along the perpendicular between the direction of the action of the force K and the point C;

L--the horizontal distance from the line of action of the reaction $N_{\text{л}6}$ to the point C;

L_0--the horizontal distance from the center of gravity of the recoiling parts O to the point C;

$L_{\text{л}}$--the horizontal distance from the center of gravity of the carriage to the point C.

Assuming that during the time of the shot the gun remains stable and immobile, we draw up the equation of equilibrium.

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We direct the X-axis horizontally, counting as positive the direction from left to right. We direct the Y-axis vertically, counting as positive the direction from the bottom upwards. As an axis of the moments we take the perpendicular to the plane of the drawing at the point C of the intersection of the reaction T_{x6} and N_{x6}. The forces applied to the carriage and their projection on the axis of the coordinates are given in Table 1.

Table 1

Forces	Projection of Forces: On the X-axis	Projection of Forces: On the Y-axis
N_1	$N_1 \sin\varphi$	$N_1 \cos\varphi$
fN_1	$fN_1 \cos\varphi$	$-fN_1 \sin\varphi$
N_2	$-N_2 \sin\varphi$	$-N_2 \cos\varphi$
fN_2	$fN_2 \cos\varphi$	$-fN_2 \sin\varphi$
K	$K \cos\varphi$	$-K \sin\varphi$
Q_a	0	$-Q_a$
N_{a6}	0	N_{a6}
N_{x6}	0	N_{x6}
T_{x6}	$-T_{x6}$	0

The equations of equilibrium are written in the following form :

$$\left.\begin{aligned}
\Sigma X_i &= K\cos\varphi + fN_2\cos\varphi - N_2\sin\varphi + fN_1\cos\varphi + \\
&\quad + N_1\sin\varphi - T_{x6} = 0\,; \\
\Sigma Y_i &= Q_a + K\sin\varphi + fN_2\sin\varphi + N_2\cos\varphi + \\
&\quad + fN_1\sin\varphi - N_1\cos\varphi - N_{a6} - N_{x6} = 0\,; \\
\Sigma M_i &= N_{a6}L - Q_a L_a + Kh_3 + fN_2h_2 - N_2l_3 + fN_1h_1 + \\
&\quad + N_1l_4 = 0
\end{aligned}\right\} \quad (13)\ 35$$

We represent the first two equations of system (13) in the following form:

$$T_{x6} = K\cos\varphi + f(N_1+N_2)\cos\varphi - (N_2-N_1)\sin\varphi\,; \quad (14)\ 35$$

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$$N_{x6} = Q_u + K \sin\varphi + f(N_1 + N_2)\sin\varphi + \\ + (N_2 - N_1)\cos\varphi - N_u \qquad (15)\ 36$$

Since in accordance with the notation adopted,

$$f(N_1 + N_2) = T,$$

on the basis of the second equation of system (9)

$$N_2 - N_1 = Q_0 \cos\varphi,$$

and on the basis of equation (11)

$$K + T = R + Q_0 \sin\varphi,$$

then, after substitution of these values in equation (14) and (15), we obtain

$$T_{x6} = (R + Q_0 \sin\varphi - Q_0 \sin\varphi)\cos\varphi; \\ T_{x6} = R\cos\varphi; \qquad (16)\ 36$$

$$N_{x6} = Q_u + K\sin\varphi + T\sin\varphi + Q_0\cos^2\varphi - N_{u6}$$

or, bearing in mind that

$$\cos^2\varphi = 1 - \sin^2\varphi,$$

$$N_{x6} = Q_u + Q_0 + (K + T - Q_0\sin\varphi)\sin\varphi - N_{u6}$$

and finally

$$N_{x6} = Q_0 + R\sin\varphi - N_{u6}. \qquad (17)\ 3$$

where $Q_6 = Q_u + Q_0$ ---weight of the piece in the firing position.

Since on the basis of the second equation of system (9)

$$N_2 = N_1 + Q_0\cos\varphi,$$

then, after the substitution of this value of N_2 in the third equation of this same system, and also after the appropriate transformations, we shall have:

$$N_1(l_1 + l_2) = P_{KH}\, e + Kh_3 + fN_2h_2 + fN_1h_1 - Q_0l_2\cos\varphi. \qquad (18)\ 36$$

By carrying out this same substitution in the third equation of system (13), the latter may be rewritten in the following form:

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$$N_1(l_1+l_2)=Q_{\text{д}}L_{\text{д}}+$$

$$+Q_0 l_3\cos\varphi-N_{\text{д}6}L-Kh_3-fN_2h_2-fN_1h_1. \qquad (19)$$

As we see, the left parts of equations 18 and 19 are identical. By equating their right parts, after the obvious transformations, we obtain

$$P_{KH}e+N_{\text{д}6}L+K(h_3+h_3)+fN_2(h_2+h_2)+ \qquad (20)$$
$$+fN_1(h_1+h_1)-Q_0(l_2+l_3)\cos\varphi-Q_{\text{д}}L_{\text{д}}=0.$$

As follows from Figure 21,

$$h_3+h_3=h_2+h_2=h_1+h_1=h$$

and

$$(l_2+l_3)\cos\varphi=L_0+h\sin\varphi.$$

In accordance with this, equation (20) may be rewritten in the following for

$$P_{KH}e+N_{\text{д}6}L+Kh+fhN_2+$$
$$+fhN-(L_0+h\sin\varphi)Q_0-Q_{\text{д}}L_{\text{д}}=0$$

or

$$P_{KH}e+N_{\text{д}6}L+h(K+ \qquad (21)$$
$$+T-Q_0\sin\varphi)-Q_0L_0-Q_{\text{д}}L_{\text{д}}=0.$$

by substituting in equation (21)

$$K+T=R+Q_0\sin\varphi;$$
$$Q_0L_0+Q_{\text{д}}L_{\text{д}}=Q_6D,$$

we obtain

$$N_{\text{д}6}L+P_{KH}e+Rh-Q_6D=0$$

Where D is the horizontal distance between the center of gravity of the gun in the firing position and the point C of the application of the reaction of the ground to the trail part of the carriage.

Hence, as a result of the transformations carried out we obtain the conditions of equilibrium of the system, when the shot is fired, in the following for

$$T_{x6}=R\cos\varphi; \qquad (22)$$

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$$N_{л6} = \frac{Q_6 D - P_{KH} e - R h}{L} ; \quad (23)$$

$$N_{x6} = R \sin \varphi + Q_6 - N_{л6} . \quad (24)$$

If during the time of the recoil the gun remains stable, that is, if the wheels of the carriage do not separate from the base, the reaction $N_{л6}$ will be greater than zero, and in the limiting case equal to zero. Consequently, the conditions of stability may be written in the form of the following inequality:

$$Q_6 D - P_{KH} e - R h \geq 0 \quad (25)$$

or

$$P_{KH} e + R h \leq Q_6 D \quad (26)$$

If in case of the placing of the center of gravity of the recoiling parts on the axis of the bore of the barrel the value $e = 0$, then the conditions of stability may be represented as follows:

$$R h \leq Q_6 D \quad (27)$$

The equation (22) $T_{x6} = R \cos \varphi$ represents the conditions of immobility of the gun when the shot is fired.

From equations (22), (23), and (24), expressing the conditions of equilibrium of the system when the shot is fired, we obtain directly the basic assumption for the effects of the shot on the artillery piece with recoil along the bore of the barrel, which may be formulated in the following manner (fig. 22)

"The effect of the shot on the carriage of the artillery piece with recoil of the barrel along the axis of the bore in the plane of fire is essentially the action of a force equal in value to the resistance of the recoil R directed parallel to the axis of the bore of the barrel in the direction of recoil and passing through the center of gravity of the recoiling parts, and to the action of a couple with the moment $P_{KH} e$ ".

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In the case when the center of gravity of the recoiling parts lies on the axis of the bore of the barrel, that is, when the arm e is equal to zero, the effect of the shot in the plane of fire amounts to the action of only one force P_{KH}.

Fig. 22 (Page 38)

The moment $P_{KH}e$ is called the moment of a dynamic couple, and the arm e is called the arm of the dynamic couple.

The equation of equilibrium of the gun may be applied in calculations of the constructional dimensions of the parts of the carriage: the trail, axle, spade, and the trail sheet (plateau), and also in the calculation from the conditions of stability of the permissible force of resistance to recoil.

We may arrive at these same conclusions pertaining to the effect of the shot on the gun with recoil along the axis of the bore of the barrel by a shortened method, considering the system as a whole (fig. 23).

We assume that fire is conducted under the same conditions as those listed above.

The gun with recoil along the axis of the bore of the barrel, as a result of the displacement of the recoiling parts, represents from the point of view of mechanics, a variable system, to which internal forces are applied, in addition to the external ones.

Hence, in order to draw up the equation of equilibrium of the gun it is

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necessary to add to the external forces acting on it, in accordance with the principle of Dglambert, also the force of inertia of the recoiling parts

$$\frac{Q_0}{g}\frac{d^2X}{dt^2} = P_{KH} - R,$$

applying it at the center of gravity of the latter.

The external forces acting on the gun will be the following:

P_{KH} — the resultant force applied to the bottom of the bore along its axis in the direction of recoil;

Q_6 — the force of the weight of the gun in the firing position;

N_{x6} and T_{x6} — the vertical and horizontal reaction of the ground against the trail;

$N_{\alpha 6}$ — vertical reaction of the ground against the wheels.

Fig. 23 (Page 39)

In order to generalize our reasoning we assume that the center of gravity of the recoiling parts is located at a certain distance e below the axis of the bore of the barrel.

In the period of accelerated recoil, that is, when $P_{KH} - R > 0$, the force of inertia $\frac{Q_0}{g}\frac{d^2X}{dt^2}$ is directed in a sense opposite to

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the direction of recoil.

Taking the direction of the coordinated axes as shown in figure 23, we write the equation of equilibrium. As the axis of the moments we take the straight line passing through the point C and perpendicular to the plane of fire.

$$\left.\begin{aligned}
\Sigma X_i &= P_{KH}\cos\varphi - \frac{Q_0}{g}\frac{d^2X}{dt^2}\cos\varphi - T_{x6} = 0;\\
\Sigma Y_i &= N_{n6} - Q_6 + \frac{Q_0}{g}\frac{d^2Y}{dt^2}\sin\varphi - P_{KH}\sin\varphi + N_{x6} = 0;\\
\Sigma M_i &= P_{KH}(h+e) - \frac{Q_0}{g}\frac{d^2X}{dt^2}h + N_{n6}L - Q_6 D = 0.
\end{aligned}\right\} \quad (28)\ 39$$

Solving the equation of system (28) for the reactions T_{x6}, N_{n6}, N_{x6}, we find:

$$T_{x6} = \left(P_{KH} - \frac{Q_0}{g}\frac{d^2Y}{dt^2}\right)\cos\varphi;$$

$$N_{n6} = \frac{Q_6 D - P_{KH}(h+e) + \frac{Q_0}{g}\frac{d^2X}{dt^2}h}{L};$$

$$N_{x6} = \left(P_{KH} - \frac{Q_0}{g}\frac{d^2X}{dt^2}\right)\sin\varphi + Q_6 - N_{n6}.$$

By substituting in these equations the expression of the force of inertia

$$\frac{Q_6}{g}\frac{d^2X}{dt^2} = P_{KH} - R,$$

we obtain:

$$T_{x6} = R\cos\varphi; \quad (22)\ 4$$

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$$N_{\Pi 6} = \frac{Q_6 D - P_{KH} e - Rh}{L}; \qquad (23)\ \text{bis}$$

$$N_{X6} = R \sin\varphi + Q_6 - N_{\Pi 6}, \qquad (24)\ \text{bis}$$

that is, the same expressions which were previously obtained.

3. Conditions of stability of the gun during the time of recoil

We shall consider more in detail the inequality (26)

$$P_{KH} e + Rh \leq Q_6 D,$$

expressing the condition of stability of the gun during the time of the recoil.

The left side of the inequality represents the moment upsetting the gun, and the right side represents the moment which gives the weapon stability.

During the recoil the common center of gravity of the gun is shifted to the trail of the carriage, and, consequently, the value of the arm D in the right side of the inequality is a variable value.

We find the value of the moment $Q_6 D$ in function of the course of the recoiling parts X.

The full weight of the gun in the firing position Q_6 may be represented as the sum of Q_0 (the weight of the recoiling parts) and Q_H (the weight of the immobile parts of the gun), that is,

$$Q_6 = Q_0 + Q_H.$$

We assume that:

$D_{0\varphi}$ — the horizontal distance up to the center of gravity of the gun from the point C before the shot with a given angle of elevation φ;

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D — the same distance at the moment of the recoil considered;

L_o — the horizontal distance to the center of gravity of the recoiling parts from the point C before the shot;

L_x — the same distance at the moment of recoil considered;

L_H — the horizontal distance up to the center of gravity of the immovable parts of the carriage from the point C (constant value during the time of the recoil).

Fig. 24 (Page 41)

Then on the basis of well-known principle of mechanics,

$$Q_6 D = Q_o L_x + Q_H L_H, \qquad (29)\ 41.$$

From figure 24 it follows that:

$$L_x = L_o - X\cos\varphi.$$

By substituting this value of L_x in the equation of moments (29) we obtain

$$Q_6 D = Q_o(L_o - X\cos\varphi) + Q_H L_H$$

or

$$Q_6 D = Q_o L_o + Q_H L_H - Q_o X\cos\varphi.$$

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For the moment of the beginning of the recoil

$$D = D_{0\varphi} \text{ and } X = 0;$$

consequently,

$$Q_0 D_{0\varphi} = Q_0 L_0 + Q_H L_H;$$

and

$$Q_0 D = Q_0 D_{0\varphi} - Q_0 X \cos\varphi. \quad (30)\ 42$$

We introduce the expression (30) in the inequality (26), after which the condition of stability during the time of recoil is written in the following form:

$$P_{KH} e + Rh \leq Q_0 D_{0\varphi} - Q_0 X \cos\varphi. \quad (31)\ 42$$

From a consideration of the condition ascertained for the stability of the gun during recoil we may draw at once the following conclusions:

1. The stability of the gun in the period of the action of the powder gases on the bottom of the bore of the barrel increases in proportion as the arm of the dynamic couple e decreases.

Since the resultant P_{KH} is a large value, then, in the presence of even an insignificant arm e it is very difficult to obtain stability of the weapon in the period of the action of the powder gases. Hence, in designing carriages we should try by appropriate placing of the recoiling masses of the gun to make their center of gravity coincide with the axis of the bore of the barrel.

2. The less the force of braking of recoil R and the shorter the arm h of this force relative to the point G, the better the stability of the weapon. However, it is necessary to bear in mind that a decrease of the force R makes it necessary to increase the length of recoil, because with a decrease in the force of resistance to the recoil, the work in absorbing the energy of the recoiling parts must be effected over a longer distance.

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As to shortening the arm h , we will say that with the given minimum angle of elevation φ , at which the system should be stable, this is possible only by lowering the height of the line of fire, and this in its turn is limited by the convenience of moving the mechanisms and the employment of the piece.

3. The stability of the weapon increases with an increase in its weight in the firing position Q_δ and the increase in the distance D_{o_φ} from its center of gravity to the spade (point C). However, the weight Q_δ is generally limited by the requirements of mobility for the piece, depending upon the purpose for which it is to be used, as a result of which it may be changed only within very narrow limits. The value of D_{o_φ} depends on the total length of the carriage and is determined in accordance with the permissible pressure on the trail part of the gun before the shot is fired and its stability during the time of the counterrecoil.

4. With an increase in the angle of elevation φ the stability of the gun is increased, because as a result of the decrease in the length of arm h the left side of the inequality is decreased, while the right side is increased, since the second member of the right side $Q_o X \cos\varphi$ is decreased. As we can easily see, for a certain value of the angle φ, the inequality is converted into an equality, and after this changes its sign to the opposite. The smallest angle of elevation at which the piece still remains stable is called the limiting angle of stability or the limiting angle of rotation.

5. The stability of the gun decreases in proportion as the recoil decreases. Since during the recoil the right side of the inequality decreases in accordance with the linear law with an increase in the path of the recoil X , then for insuring stability of the gun it is necessary to change in a corresponding manne the left side of this inequality also.

6. With an increase in the wieght of the recoiling parts Q_o the stability of the gun is increased.

From a consideration of the inequality it follows immediately that the

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reverse conclusion is true, because with an increase of Q_0 the right side decreases. However, simultaneously with a decrease in the right side, with an increase of Q_0 there will be a decrease in the left side as a result of a decrease in R, and the decrease in the latter takes place much quicker than the decrease in the right part.

While limiting ourselves here to general remarks, we shall give the proof of this statement (principle) in the explanation of the problem dealing with recoil (see pages 128-129).

4. The limiting angle of stability of the gun.

As we have already pointed out in the consideration of the condition of stability of the gun during recoil at a certain value of the angle of elevation $\varphi_{пр}$ the inequality (31)

$$P_{кн} e + Rh \leq Q_0 D_{0\varphi} - Q_0 X \cos\varphi$$

is converted into an equality, and with angles less than the angle $\varphi_{пр}$ the inequality changes its sign to the opposite, indicating the instability of the gun with these values of the angles.

Hence, the limiting angle of stability $\varphi_{пр}$ is the least angle of elevation at which the gun still remains stable.

Sometimes the angle $\varphi_{пр}$ is called the limiting angle of rotation of the gun. In the latter case we should regard angle $\varphi_{пр}$ as the maximum angle of elevation at which the gun changes from instability to stability.

Keeping in mind what has just been said, we write the conditions of stability, with an angle of elevation $\varphi_{пр}$ in the following form:

$$P_{кн} e + Rh_{пр} = Q_0 D_{0пр} - Q_0 X \cos\varphi_{пр}. \quad (32)$$

The value $h_{пр}$ in the equality (32) is the arm of the action of the force R, and $D_{пр}$ is the arm of action of the force Q_0 relative to the point C before the shot with an angle of elevation equal to $\varphi_{пр}$.

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Fig. 25 (Page 44)

For the determination of the value of the arm $h_{пр}$ we use figure 25 in which are represented the following:

O — the axis of the trunnion of the gun;

$H_ц$ — height of the axis of the trunnion above the horizon of the base;

$d_ц$ — distance along the horizontal from the axis of the trunnion O to the point C;

AB — axis of the bore of the barrel;

CD — trajectory of the center of gravity of the recoiling parts during recoil;

GF — line, passing through the axis of the trunnion O parallel to the axis of the bore of the barrel;

h — arm of action of the force R relative to point C;

ΔH — distance between the point C and the horizontal of the base.

The rest of the values are understandable from the drawing.

From the sketch it follows that

$$h = mg - mn = mp + pg - mn; \qquad (33)44$$

$$mp = (H_ц + \Delta H)\cos\varphi; \qquad (34)44$$

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$$pg = d\ ; \qquad (35)\ 44$$

$$mn = d_4 \sin\varphi\ . \qquad (36)\ 44$$

By substituting the expressions (34), (35), and (36) in equation (33), we obtain:

$$h = (H_4 + \Delta H)\cos\varphi + d - d_4 \sin\varphi.$$

Designating by H the height of the line of fire (the distance between the axis of the bore of the barrel with $\varphi = 0$ and the horizon of the base), we have directly from the drawing:

$$H = H_4 + d + e,$$

whence

$$H_4 = H - d - e.$$

By introducing this value of H_4 in the expression (33) we obtain:

$$h = (H - d - e + \Delta H)\cos\varphi + d - d_4 \sin\varphi.$$

Designating the multiplier with cos φ by H', that is, supposing

$$H' = H - d - e + \Delta H, \qquad (37)\ 45$$

we finally obtain:

$$h = d + H'\cos\varphi - d_4 \sin\varphi. \qquad (38)\ 45$$

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For the angle of elevation $\varphi_{\Pi P}$ the expression (38) may be rewritten in the following form:

$$h_{\Pi P} = d + H' \cos \varphi_{\Pi P} - d_K \sin \varphi_{\Pi P}. \qquad (39)$$ 45

We find the expression for the moment $Q_0 D_{\Pi P}$.

For any angle of elevation the equation of the moments of the force of gravity of the gun for the point C may be written in the following form:

$$Q_0 D_{0\varphi} = Q_H L_H + Q_K L_K,$$

where by $Q_H L_H$ and $Q_K L_K$ we designate the moments of the force of gravity of the lower parts of the gun and of the rocking parts of the gun respectively.

The center of gravity of the oscillating parts may be placed either before the trunnions (system with equilibrating mechanism) or behind the trunnions (system without any equilibrating mechanism). In addition to this, the center of gravity of the oscillating parts may be placed below or above the axis of the trunnions with $\varphi = 0$.

In keeping with this, with the placing of the center of gravity of the oscillating parts in front of the trunnions the expression for the arm L_K of the action of the force of gravity of the oscillating parts Q_K relative to the point C may be written as follows:

$$L_K = d_K + l_K \cos(\varphi \mp \alpha),$$

where l_K -- the distance from the axis of the trunnion to the center of gravity of the oscillating parts;

α -- the angle between the line of direction from the axis of the trunnion to the center of gravity of the rocking parts and the axis of the bore; the angle α is taken with a minus sign when the center of gravity is located below the axis of the trunnion, and with the plus sign when the center of gravity is

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located above the axis of the trunnion (with $\varphi = 0$).

In the placing of the center of gravity of the oscillating parts behind the trunnions the expression for L_K may be written in the following form:

$$L_K = d_U - l_K \cos(\varphi \mp \alpha).$$

In this case the angle α is taken with a plus sign with the location of the center of gravity of the oscillating parts below the axis of the trunnion and with a minus sign when the center of gravity of the oscillating parts is above the axis of the trunnions.

For further conclusions we take as a basis the case when the center of gravity of the oscillating parts is located in front of the trunnions. Then the equation of the moments of the force of gravity of the gun for any angle of elevation should be written in the following form:

$$Q_G D_{o\varphi} = Q_H L_H + Q_K [d_U + l_K \cos(\varphi \mp \alpha)] =$$

$$= Q_H L_H + Q_K d_U + Q_K l_K \cos(\varphi \mp \alpha)$$

or

$$Q_G D_{o\varphi} = Q_H L_H + Q_K d_U + Q_K l_K \cos\alpha \cos\varphi \pm Q_K l_K \sin\alpha \sin\varphi$$

with $\varphi = 0$

$$Q_G D_{oo} = Q_H L_H + Q_K d_U + Q_K l_K \cos\alpha,$$

where by D_{oo} we designate the value of the arm $D_{o\varphi}$ with $\varphi = 0$.

With $\varphi = \varphi_{пр}$

$$Q_G D_{пр} = Q_H L_H + Q_K d_U + Q_K l_K \cos\alpha \cos\varphi_{пр} \pm$$

$$\pm Q_K l_K \sin\alpha \sin\varphi_{пр}$$

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or

$$Q_6 D_{\pi p} = Q_6 D_{oo} - Q_K l_K \cos\alpha +$$
$$+ Q_K l_K \cos\alpha \cos\varphi_{\pi p} \pm Q_K l_K \sin\alpha \sin\varphi_{\pi p}. \quad (39a)\ 46$$

By substituting the expressions (39) and (39a) in the condition for stability (32), we obtain:

$$P_{KH} e + R(d + H' \cos\varphi_{\pi p} - d_{\text{ц}} \sin\varphi_{\pi p} =$$
$$= Q_6 D_{oo} - Q_K l_K \cos\alpha + Q_K l_K \cos\alpha \cos\varphi_{\pi p} \pm$$
$$\pm Q_K l_K \sin\alpha \sin\varphi_{\pi p} - Q_o X \cos\varphi_{\pi p}$$

or, after transformation:

$$(RH' + Q_o X - Q_K l_K \cos\alpha) \cos\varphi_{\pi p} - (R d_{\text{ц}} \pm Q_K l_K \sin\alpha) \sin\varphi_{\pi p} =$$
$$= Q_6 D_{oo} - Q_K l_K \cos\alpha - P_{KH} e - R d. \quad (40)\ 47$$

In a more rigid derivation it would be necessary to substitute in the preceding equality the expression of R instead of its combined force of resistance:

$$R = \Phi_0 + \Pi + R_f - Q_o \sin\varphi_{\pi p} = S - Q_o \sin\varphi_{\pi p}.$$

Such a substitution would give an equation of the fourth degree, relative to $\sin\varphi_{\pi p}$, of the form

$$A + B \sin\varphi_{\pi p} + C \sin^2\varphi_{\pi p} + D \sin^3\varphi_{\pi p} + E \sin^4\varphi_{\pi p} = 0,$$

the solution of which, even though possible, is not convenient for obtaining an expression suitable for investigation. Hence, in further derivations we

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shall suppose that R does not depend upon φ.

In a practical calculation of the value φ_{np} on the basis of the relationship (function) obtained below we take into account this assumption, finding by successive approximations the value of φ_{np} in a more precise manner.

Having taken equation (40) as a basis, we make use of the following trigonometric identity in the derivation of the expression for the limiting angle of stability:

$$a\cos\alpha - b\sin\alpha = \sqrt{a^2+b^2}\cos\left(\alpha+\operatorname{arctg}\frac{b}{a}\right) = c.$$

We give the derivation of this identity. From figure 25a it follows that

$$a = r\cos\beta;$$

$$b = r\sin\beta;$$

$$\cos\beta = \frac{a}{r};$$

$$\sin\beta = \frac{b}{r};$$

$$\beta = \operatorname{arctg}\frac{b}{a};$$

$$r = \sqrt{a^2+b^2}.$$

Fig. 25a (Page 47)

By using the well known trigonometric relationship

$$\cos(\alpha+\beta) = \cos\alpha\cos\beta - \sin\alpha\sin\beta,$$

we may write the following after substituting in it the value of $\cos\beta$ and $\sin\beta$:

$$\cos(\alpha+\beta) = \cos\alpha\cdot\frac{a}{r} - \sin\alpha\cdot\frac{b}{r} = \frac{a\cos\alpha - b\sin\alpha}{r}$$

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or, after substituting $\beta = \operatorname{arctg}\frac{b}{a}$ and $r = \sqrt{a^2+b^2}$,

$$\cos\left(\alpha + \operatorname{arctg}\frac{b}{a}\right) = \frac{a\cos\alpha - b\sin\alpha}{\sqrt{a^2+b^2}}$$

and finally:

$$a\cos\alpha - b\sin\alpha = \sqrt{a^2+b^2}\cdot\cos\left(\alpha + \operatorname{arctg}\frac{b}{a}\right) = c.$$

In our case:

$$\alpha = \varphi_{\Pi P};$$
$$a = RH' + Q_0 X - Q_K l_K \cos\alpha;$$
$$b = Rd_{\text{ц}} \pm Q_K l_K \sin\alpha;$$
$$c = Q_\delta D_{00} - Q_K l_K \cos\alpha - P_{KH} e - Rd.$$

Since

$$\sqrt{a^2+b^2}\cos\left(\alpha + \operatorname{arctg}\frac{b}{a}\right) = c,$$

then

$$\cos\left(\alpha + \operatorname{arctg}\frac{b}{a}\right) = \frac{c}{\sqrt{a^2+b^2}}$$

and, also:

$$\alpha = \arccos\frac{c}{\sqrt{a^2+b^2}} - \operatorname{arctg}\frac{b}{a}.$$

By substituting here the values α, a, b and c for our case, we finally obtain

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$$\varphi_{\pi p} = \arccos \frac{RH' + Q_0 X - Q_H l_K \cos\alpha}{\sqrt{(RH' + Q_0 X - Q_H l_K \cos\alpha)^2 + (Rd_4 \pm Q_K l_K \sin\alpha)^2}} -$$

$$- \operatorname{arctg} \frac{Rd_4 \pm Q_K l_K \sin\alpha}{RH' + Q_0 X - Q_N l_K \cos\alpha}, \qquad (41)\ 48$$

where the plus sign before the nember $Q_K l_K$ corresponds to the location of the center of gravity of the oscillating parts below the axis of the trunnion, and the sign minus corresponds to the location of the center of gravity of the oscillating parts above the axis of the trunnion.

For the case of the location of the center of gravity of the oscillating parts behind the axis of the trunnion, we may obtain the following formula with similar reasoning:

$$\varphi_{\pi p} = \arccos \frac{Q_0 D_{00} + Q_K l_K \cos\alpha - P_{KH} e - Rd}{\sqrt{(RH' + Q_0 X + Q_K l_K \cos\alpha)^2 + (Rd_4 \mp Q_K l_K \sin\alpha)^2}} -$$

$$- \operatorname{arctg} \frac{Rd_4 \mp Q_K l_K \sin\alpha}{RH' + Q_0 X + Q_K l_K \cos\alpha}, \qquad (41a)\ 49$$

where the minus sign before the nember $Q_K l_K$ corresponds to the location of the center of gravity of the oscill-ting parts below the axis of the trunnion, and the plus sign corresponds to the location of the center of gravity of the oscillating parts above the axis of the trunnion.

In practical calculations of the value of $\varphi_{\pi p}$ on the basis of the formula (41) or (41a), we rust in the first approximation take

$$R = S = \Phi_0 + \Pi + R_f$$

and calculate $\varphi_{\pi p}$.

With the value of $\varphi_{\pi p}$ obtained in the first approximation we must repeat the calculation, supposing that

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$$R = S - Q_0 \sin \varphi_{\Pi P}$$

In view of the relatively small values of the magnitude $Q_0 \sin \varphi_{\Pi P}$, we may limit ourselves to the second approximation. The calculation of $\varphi_{\Pi P}$ should be carried out for three moments — the moment of the maximum value of the force P_{KH}, the moment at the end of the period of the action of the powder gases, and the moment at the end of the recoil.

From a consideration of the expression (41) for $\varphi_{\Pi P}$ we have at once the conclusion that other conditions remaining the same $\varphi_{\Pi P}$ will be all the smaller, the greater Q_σ, D_{00} and l_K, and the smaller R, H', e, d and α.

The weight in the firing position Q_σ for a gun of a given type and purpose is a fixed value which cannot be increased arbitrarily. But with a given magnitude Q_σ we may create an additional stabilizing moment by the employment of special muzzle brakes.

The magnitude D_{00} may be increased by lengthening the trail, but this is not desirable because it leads either to a decrease in the turning capacity of the gun on the march, as a result of an increase in the total length of the vehicle, or to a complication in the construction of the trail (the folding trail part).

The value of the force of resistance to recoil R may be decreased by increasing the length of the recoil, but this is a disadvantage because it decreases the rate of fire and leads to certain difficulties in the working out of the system. For a decrease of the force R it is expedient to increase the weight of the recoiling parts or employ a muzzle brake.

It is possible to decrease the value of $\varphi_{\Pi P}$ by decreasing the value of H', that is, the height of the line of fire H, or by decreasing the length of the arms e and d. However, a considerable decrease in the height of the line of fire H renders more difficult the placing of the mechanisms when we make the designs create a number of inconveniences in the operation of the gun and leads to the necessity of decreasing the clearance, the magnitude of which, for

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present-day guns, should not be less than 300-350 mm.

A decrease in the clearance may be avoided by the employment of a variable height of the line of fire: a smaller one for the small angle of elevation and a larger one for the large angles of elevation and for travelling (crank axle).

We should try to reduce the arm d to zero, but a decrease in it involves the same difficulties as a decrease of H.

The value of the arm of the dynamic couple may be decreased by an appropriate placing of the mass of the recoiling parts.

In addition to this, we should mention the employment of the double recoil and "rolling out" as methods of increasing the stability of the gun.

The angle $\varphi_{\eta\rho}$ is one of the most important characteristics of the field artillery system, and its value is assigned in keeping with the purpose of the artillery piece.

As shown by the experience of the Great Patriotic War, all of the field pieces up to a calibre of 152 mm may be employed for fire against tanks by direct laying. This kind of fire requires great stability of the piece with small angles of elevation. Hence, in designing guns and howitzers we should have, regardless of their purpose, a minimum limiting angle of stability for the piece. For anti-tank guns and regimental and divisional pieces it is desirable to have this angle equal to zero, and for howitzers and heavy guns we should have it equal to about 10-12 degrees.

In conclusion we should note that the reasoning given is valid only for a gun on a carriage with wheels with rigid tires. In the case of a gun on a carriage with wheels having elastic tires we shall have a turning of the theoretical stability of the gun due to the force of elasticity of the tires and with $N_{\eta\delta} > 0$.

5. Effect of the shot on an unstable gun. Jumping of the gun.

The stability of a gun on a carriage with wheels with rigid tires during the time of the shot is assured by having the stabilizing movement greater than the

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upsetting moment, that is, if during the time of the recoil of the barrel we have the following inequality:

$$P_{KH}e + Rh < Q_6 D_{o\varphi} - Q_o X \cos\varphi .$$

With equality of the moments, the gun will tend to jump, and if the upsetting moment exceeds the other it will jump, tending to turn relative to the point C.

A jump of the gun will always take place when the shot is fired under an angle of elevation less than the angle $\varphi_{\Pi P}$ corresponding to the given conditions of fire. Keeping in mind the case of fire under an angle of elevation $\varphi < \varphi_{\Pi P}$, we shall consider the effect of the shot on an unstable gun and determine the functional relation for the calculation of the elements of rotary movement of the system: the angular velocity ω and the angular displacement θ depending on the time.

Besides, we assume that:

1) before the shot the gun is placed on a horizontal surface;

2) fire is conducted when the barrel is in a middle position relative to the carriage ($\varphi = 0$);

3) all the external forces applied to the gun act in the vertical plane of symetry of the gun.

Beginning at a certain moment of the recoil, when the overturning moment exceeds the moment of stabilization, the gun receives a turning movement relative to the point C of application of the reaction of the ground.

At a certain moment of time let us suppose that we have (see fig. 26):

O —the position of the center of gravity of the recoiling parts;

O'' —the position of the center of gravity of the lower ("immobile") parts of the gun;

O' —the position of the center of gravity of the gun in the firing position.

Besides, the gun was turned in the plane of symmetry by the angle θ,

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reckoned from the line of the horizon.

We erect from the point C a perpendicular to the direction of the axis of the bore (to the direction of the recoil).

We designate the distance from the center of gravity of the recoiling parts O to the perpendicular in the direction of the recoil by

$$l_x = l_o - X,$$

where l_o is the initial value of this distance before the recoil;

X — the path of the recoil.

We designate by l_H the distance from the point C to the center of gravity of the "immovable" part of the gun O".

We designate by D_{oO} the distance from the point C to the center of gravity of the gun at the given moment in the horizontal direction.

We designated by Σ_i on the diagram the elementary mass of the recoiling parts, and by r_i the distance from it to the point C.

We find the equation of the turning movement of the gun relative to the point C in the form proposed by Dalambert. For this purpose we write the equation of the moments of the forces acting on the gun, adding to the external forces the forces of inertia.

Fig. 26 (Page 52)

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The external forces acting on the gun are:

P_{KH} -- the force of the pressure of the powder gases on the base of the bore;

$Q_б = Q_o + Q_H$ -- the weight of the gun.

The sum of the moments of the external forces for the point C are equal to

$$P_{KH}(h+e) - Q_б D_{oo}$$

The moment of the force of the weight of the system in the firing position may be represented in the following form:

$$Q_б D_{oo} = Q_H L_H \cos\theta + Q_o(L_o - X\cos\varphi)\cos\theta$$

or

$$Q_б D_{oo} = (Q_H L_H + Q_o L_o - Q_o X\cos\varphi)\cos\theta,$$

where L_H -- is the horizontal distance from the point C to the center of gravity of the immobile parts of the gun;

L_o -- the horizontal distance from the point C to the center of gravity of the recoiling parts in the initial position (before the recoil).

with $\theta = \varphi = 0$

$$Q_б D_{oo} = Q_б D_{oo} = Q_H L_H + Q_o L_o,$$

consequently,

$$Q_б D_{oo} = (Q_б D_{oo} - Q_o X\cos\varphi)\cos\theta.$$

The final expression for the sum of the moments of the external forces for the point C may be written in the following form:

$$P_{KH}(h+e) - (Q_б D_{oo} - Q_o X\cos\varphi)\cos\theta.$$

The forces of inertia acting on the gun under the conditions considered

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are the force of inertia of the immobile part of the gun and the force of inertia of the recoiling parts. The force of inertia of the recoiling parts is the resultant:

a) of the force of inertia of the recoiling parts in "transferable" movement;

b) of the force of inertia of the recoiling parts in relative movement;

c) of the Coriolis force of inertia.

The force of inertia of the recoiling masses in "transferable" movement is the resultant of centrifugal force

$$\sum m_i \omega^2 r_i^2 ,$$

where r_i is the distance from the axis of rotation to the center of the elementary mass m_i and the tangential force of inertia

$$\sum m_i r_i \frac{d\omega}{dt} ,$$

directed in the sense opposite to the direction of rotation.

The moment of the centrifugal force of inertia relative to the point C is evidently equal to zero.

The moment of the tangential force of inertia is equal to:

$$-\sum m_i r_i^2 \frac{d\omega}{dt} .$$

The force of inertia of the recoiling masses in relative movement is equal t

$$M_0 \frac{dV}{dt} .$$

The moment of this force relative to the point C is equal to

$$-M_0 \frac{dV}{dt} h.$$

The Coriolis force of inertia applied to the recoiling parts is directed in the sense of rotation and is equal to

$$M_0 \omega V \sin \alpha ,$$

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where α is the angle between the line of direction of the velocity of the recoil V and the axis of the transferable movement. In the case considered $\alpha = \frac{\pi}{2}$. Consequently, the moment of the Coriolis force of inertia relative to the point C is equal to

$$2M_0 \omega V l_x ,$$

where l_x is the arm of the application of the force relative to the point C.

The magnitude l_x is a variable decreasing with the recoil:

$$l_x = l_0 - X ,$$

where l_0 is the initial value of the arm l_x before the shot with a given value of the angle φ.

The sum of the momentsof the forces of inertia acting on the recoiling parts during the jump of the gun is equal to:

$$-\sum m_i h_i^2 \frac{d\omega}{dt} - M_0 \frac{dV}{dt} h + 2M_0 \omega V l_x$$

or

$$-\left[l_0 + M_0 (h^2 + l_x^2)\right] \frac{d\omega}{dt} - M_0 \frac{dV}{dt} h + 2M_0 \omega V l_x ,$$

where l_0 is the moment of inertia of the mass of the recoiling parts relative to their center of gravity;

$h^2 + l_x^2$ is the square of the distance from the center of gravity of the recoiling parts to the point C at a certain moment of time t.

With the observation of the condition of immobility of the gun and the disturbance of the condition of stability, the mass of the immobile parts of the gun participate only in the rotary movement relative to the point C. Hence, the moment of inertia of the immobile part of the gun is equal to

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$$-\left(l_H + \frac{Q_H}{g} l_H^2\right)\frac{d\omega}{dt},$$

where l_H is the moment of inertia of the immobile part of the gun relative to its center of gravity.

Hence, the equation of the moment in the form of Dalarbert for the non-stable syster may be written in the following form;

$$P_{KH}(h+e) - (Q_0 D_{00} - Q_0 X\cos\varphi)\cos\theta - M_0\frac{dV}{dt}h -$$

$$-\left[l_0 + M_0(h^2 + l_\pi^2)\right]\frac{d\omega}{dt} + 2M_0\omega V l_\pi - \left(l_H + \frac{Q_H}{g} l_H^2\right)\frac{d\omega}{dt} = 0$$

or, after the substitution of the values $l_x = l_0 - X$ and the elementary transformations:

$$P_{KH}(h+e) - (Q_0 D_{00} - Q_0 X\cos\varphi)\cos\theta - M_0\frac{dV}{dt}h -$$

$$-\left[I_6 - M_0(2l_0 - X)X\right]\frac{d\omega}{dt} + 2M_0\omega V(l_0 - X) = 0, \quad (42)\ 55$$

where

$$I_6 = l_0 + M_0(h^2 + l_0^2) + l_H + \frac{Q_H}{g} l_H^2.$$

In accordance with the theorem of Coriolis the projection of the relative acceleration of the recoiling parts $\frac{dV}{dt}$ is equal to the sum of the projections of the absolute acceleration, of the transferable acceleration, taken with the reverse sign, and of the additional centrifugal acceleration.

When projection of the absolute acceleration of the recoiling parts in the direction of the recoil is equal to:

$$\frac{1}{M_0}(P_{KH} - R),$$

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where

$$R = \Phi_0 + \Pi + R_f - Q_0 \sin(\varphi + \theta).$$

As it follows from figure 26, the projection of the centrifugal acceleration of the center of the mass of the recoiling parts in the direction of the recoil is equal to:

$$\omega^2 (l_0 - X),$$

and the projection of the tangential acceleration in the direction of the recoil is equal to:

$$h \frac{d\omega}{dt}.$$

The projection of the Coriolis acceleration on the direction of recoil is equal to zero.

Consequently, for the product of the mass by the acceleration of the relative movement of the recoiling parts we shall have the following expression:

$$M_0 \frac{dV}{dt} = P_{KH} - R - M_0 \left[\omega^2 (l_0 - X) + h \frac{d\omega}{dt}\right]. \quad (43)\ 55$$

After substituting $M_0 \frac{dV}{dt}$ from expressions (43) in expression (43) and supposing, in view of the smallness of the angle θ, $\cos\theta = 1$, we may write:

$$P_{KH} e + Rh - Q_0 D_{00} + Q_0 X \cos\varphi + M_0 h (l_0 - X)\omega^2 + M_0 h^2 \frac{d\omega}{dt} - \left[l_0 - M_0 (2l_0 - X) X\right] \frac{d\omega}{dt} + 2M_0 V (l_0 - X)\omega = 0$$

or

$$\left\{l_0 - M_0 \left[(2l_0 - X)X + h^2\right]\right\} \frac{d\omega}{dt} = M_0 h (l_0 - X)\omega^2 + 2M_0 V (l_0 - X)\omega + P_{KH} e + Rh + Q_0 X \cos\varphi - Q_0 D_{00}. \quad (44)\ 56$$

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The coefficients with $\frac{d\omega}{dt}$, ω^2 and ω and the free member of equation (44) are functions of the time t and during all the time of the recoil (first period of the jump) they may simply be given or they may be tabular or graphical. In view of this, the solution of differential equation (44) cannot be found in a finite form for the period of the recoil of the barrel. For a practical approximated solution of the problem we break up the period of the recoil, beginning with the moment of the beginning of the jump, into sufficiently small intervals of time, equal or unequal in value, in the course of which we take the values of the coefficients and of the free member as constant and equal to their average values.

Having divided the left and right parts of equation (44) by the coefficient with $\frac{d\omega}{dt}$ and designating the average values of the coefficients for the interval of time $\Delta t_j = t_j - t_{j-1}$ by

$$a_i = \frac{P_{KH} e_1 + Rh + Q_0 X \cos\varphi - Q_6 D_{00}}{I_6 - M_0 [2 l_0 - X) X + h^2]},$$

$$2b_i = \frac{\alpha M_0 V (l_0 - X)}{I_6 - M_0 [(2 l_0 - X) X + h^2]},$$

$$c_i = \frac{M_0 h (l_0 - X)}{I_6 - M_0 [2 l_0 - X) X + h^2]},$$

where

$$I_6 = I_0 + M_0 (h^2 + l_0^2) + I_H + \frac{Q_H}{g} l_H^2,$$

the equation (44) may be re-written in this form:

$$\frac{d\omega}{dt} = a_i + 2 b_i \omega + c_i \omega^2$$

or, by separating the variable:

$$dt = \frac{d\omega}{a_i + 2 b_i \omega + c_i \omega^2} \qquad (45)\ 56$$

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By integrating the equation (45) in the limits from t_{i-1} up to t and from ω_{i-1} up to ω_i we shall have:

$$\Delta t_i = t_i - t_{i-1} = \int_{\omega_{i-1}}^{\omega} \frac{d\omega}{a_i + 2b_i\omega + c_i\omega^2} \quad (46)$$

where ω_i and ω_{i-1} are the respective angular velocities of rotation of the cam for the end and the beginning of the interval of time Δt_i for which the coefficients a_i, b_i and c_i are calculated.

The integral $\int \frac{d\omega}{a_i + 2b\omega + c\omega^2}$ represents the tabular integral equal to

$$\frac{1}{\sqrt{\Delta}} \operatorname{arctg} \frac{b + c\omega}{\sqrt{\Delta}} + C_1$$

with $\Delta > 0$;

$$\frac{1}{2\sqrt{-\Delta}} \ln \frac{\sqrt{-\Delta} - b - c\omega}{\sqrt{-\Delta} + b + c\omega} + C_2$$

with $-\Delta > 0$;

$$-\frac{1}{b + c\omega} + C_3$$

with $\Delta = 0$;

where $\Delta = ac - b^2$

Consequently, for the case when

$$\Delta_i = a_i c_i - b_i^2 > 0,$$

$$\Delta t_i = \frac{1}{\sqrt{\Delta_i}} \operatorname{arctg} \frac{b_i + c_i\omega_i}{\sqrt{\Delta_i}} + C_{1,i},$$

where

$$C_{1,i} = \frac{1}{\sqrt{\Delta_i}} \operatorname{arctg} \frac{b_i + c_i\omega_{i-1}}{\sqrt{\Delta_i}}$$

$$\Delta t_i = -\frac{1}{b_i + c_i \omega_i} + C_{3,i},$$

where

$$C_{3,i} = \frac{1}{b_i + c_i \omega_{i-1}},$$

The value ω_{i-1} going into the constants of the integration is taken from the calculation for the interval of time Δt_{i-1}. For the calcualtion of the coefficients a_i, b_i and C_i we must have the functional relationship $R = f(t)$, $V = f(t)$, $X = f(t)$ and $P_{KH} = f(t)$ from the solution of the converse problem of recoil or from experience.

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where

$$-\Delta_i = -a_i c_i + b_i^2 > 0,$$

$$\Delta t_i = \frac{1}{2\sqrt{-\Delta_i}} \ln \frac{\sqrt{-\Delta_i} - b_i - c_i w_i}{\sqrt{-\Delta_i} + b_i + c_i w_i} + C_{2,i},$$

where

$$C_{2,i} = -\frac{1}{2\sqrt{-\Delta_i}} \ln \frac{\sqrt{-\Delta_i} - b_i - c_i w_{i-1}}{\sqrt{-\Delta_i} + b_i + c_i w_{i-1}}$$

when

$$\Delta_i = 0,$$

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For the second period of the jump of the gun we may assume, neglecting the displacement of the recoiling parts during counterrecoil, $V = 0$ and $X = \lambda$. With these conditions the coefficient $2b_i = 0$, and the coefficients will be constants for all the second period.

The equation (45) for the second period of the jump of the gun should be written as follows:

$$dt = \frac{d\omega}{a_2 + c_2 \omega^2} \qquad (47)\ 58$$

By integrating equation (47) in the limits from t_0 to t_i and from ω_0 to 0, corresponding to the end of the first period, and by index 1 the values corresponding to the end of the second period, we find the duration of the second period Δt_0:

$$\Delta t_0 = t_i - t_0 = \frac{1}{\sqrt{a_i c_i}} \operatorname{arctg}\left(\sqrt{\frac{c_i}{a_i}}\,\omega_0\right).$$

Having the values of the angular velocities in function of the time for the first period of the jump of the weapon and the duration of the second period we can construct the curve $\omega = f(\omega)$ and then by the numerical or graphical method we can find the value of the angle of jump of the gun θ_0.

The method given above for the calculation of the elements of rotary movement of the gun during the jump assures accuracy of calculation, but it is cumbersome in practical application, because when we take into account all the phenomena present during the jump of the gun, it is not possible to obtain finite functional relationships that are convenient for calculation.

Hence, we give below an approximation method for calculating the elements of rotary movement of the system, a method which is convenient for practical employment and at the same time provides satisfactory accuracy for practical calculations.

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Taking the values of the moments of the forces acting upon the gun during the time of the recoil as the average values on the basis of time, the equation of the moments for the point C may be written in the following form:

$$(P_{KH}e)_{CP} - (Q_6 D)_{CP} + R_{CP}h - I_6 \varepsilon_1 = 0, \qquad (48)58$$

where I_6 -- is the mean value of the moment of inertia of the mass of the gun in the firing position relative to the point C;

ε_1 -- the mean angular acceleration of the gun for the jump in the period of the recoil.

From equation (48) we obtain the following expression for the determination of the angular acceleration ε_1:

$$\varepsilon_1 = \frac{(P_{KH}e)_{CP} + R_{CP}h - (Q_6 D)_{CP}}{I_6} \qquad (49)\ 58$$

The value I_6 entering into the expression (49) may be calculated by the ordinary existing methods of approximate calculation of the momentsof inertia for bodies of complex configuration.

After the cessation of the action of the forces P_{KH} and R , the weapon will continue its jump. For this period the value of the negative acceleration ε_2 , by analogy with the expression (49), may be determined as

$$\varepsilon_2 = \frac{(Q_6 D)_{CP}}{I_6}. \qquad (50)\ 59$$

Consequently, the angular displacements of the gun will be equal to:

$$\theta_1 = \frac{\omega_0^2}{2\varepsilon_1}; \quad \theta_2 = \frac{\omega_0^2}{2\varepsilon_2},$$

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where ω_0 —is the maximum value of the angular velocity of rotary movement of the gun relative to the point C;

θ_1 —the angular displacement of the gun during the time of the action of positive acceleration;

θ_2 —the angular displacement of the gun during the time of the action of negative acceleration.

We shall assume that θ_0 is equal to:

$$\theta_0 = \theta_1 + \theta_2$$

or

$$\theta_0 = \frac{\omega_0^2}{2\varepsilon_1} + \frac{\omega_0^2}{2\varepsilon_2},$$

whence we obtain:

$$\omega_0 = \sqrt{\frac{\theta_0}{\frac{1}{2\varepsilon_1} + \frac{1}{2\varepsilon_2}}} \qquad (51)\ 59$$

The time of the first period of the jump (time of the action of the force N) may be found from the expression

$$t_0 = \frac{\omega_0}{\varepsilon_1}$$

or, after substitution from expression (51) of the expression for ω_0:

$$t_0 = \sqrt{\frac{2\theta_0}{\varepsilon_1 + \varepsilon_2} \cdot \frac{\varepsilon_2}{\varepsilon_1}}. \qquad (52)\ 59$$

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After solving equation (52) for θ_0, we shall have:

$$\theta_0 = t_0^2 \cdot \frac{\varepsilon_1}{\varepsilon_2} \cdot \frac{\varepsilon_1 + \varepsilon_2}{2} . \qquad (53)\ 59$$

After substituting in expression (53) the values ε_1 and ε_2 we finally obtain the following expression for the determination of θ_0 :

$$\theta_0 = t_0^2 \left[\frac{(P_{KH} e)_{cp} + R_{cp} h}{(Q_6 D)_{cp}} - 1 \right] \frac{(P_{KH} e)_{cp} + R_{cp} h}{2 I_6} . \qquad (54)\ 60$$

In practical calculations the time may be taken equal to the time of the recoil t_{0r}.

Knowing the angular displacement of the gun, from the simplest geometrical considerations we can easily determine the linear displacement of any of its points with reference to the line of the horizon.

6. Reaction of the support on a monobar carriage for cases when the shot is fired with lateral deviation of the barrel from the mean plane of fire. Lateral (transversal) stability of the gun.

The deviation of the direction of the axis of the bore of the barrel from the mean plane of fire is a characteristic peculiarity of field artillery guns provided with an upper carriage making it convenient to lay the gun for direction.

It may happen that an artillery gun with a carriage of such construction, being completely stable during the time of the shot with the position of the axis of the bore of the barrel in the plane of symmetry of the gun, will have a tendency to be unstable in a lateral direction during the time of fire with a deviation of the barrel from the plane of symmetry of the gun (disturbance of lateral stability). This may take place both in guns with a monobar carriage provided with an upper carriage and in guns with split trails during fire without separation of the latter.

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We consider the most general case when the shot is fired under an angle of elevation $\varphi > 0$, and the upper carriage, together with the barrel, turns to the right by an angle ψ relative to the plane of symetry of the gun.

We assume that the gun is set up on a horizontal base and that it conserves stability and immobility during the time of the shot.

In the time of the shot the following forces and reactions will act on the gun:

Q_6 -- the weight of the gun in the firing position;

R --a force equal to the resistance of the recoil;

M $P_{KH} e$--the moment of the dynamic couple;

M_{6P}--the reactive moment from the transversal component of the normal pressure on the driving edge of the grooves;

T_{x6} N_{x6} L_{x6} --the respective longitudinal, normal, and lateral tangential components of the reaction of the support of the spade;

N_1, L_1, N_2, L_2,--the respective normal and lateral tangential components of the reaction of the support of the left and right wheels.

We shall regard as unknowns the componerts of the reaction of the support on the spade and wheels. In their determination we assume that

1) the center of gravity of the recoiling parts lies in the vertical plane passing through the axis of the bore of the barrel and located below the latter; and that

2) the axis of rotation of the upper carriage relative to the lower (pintle) is placed vertically.

The coordinate axes are placed as shown in Figure 27.

We place the axes of the moments as follows:

--parallel to the axis OX -- perpendicular to the plane of the drawing viewed from behind at the point O_1 of the intersection of the line of action of the reaction N, with the plane parallel to the plane of support and at a distance from it equal to ΔH ;

--parallel to the axis OZ -- perpendicular to the plane of the drawing

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viewed from the side and at point C of the application of the reaction of the ground on the spade;

--parallel to axis OY -- perpendicular to the plane of the drawing viewed from above at the point A of rotation of the upper carriage relative to the lower.

The angle ψ will be regarded as positive with a deviation of the barrel to the right and negative with a deviation of the barrel to the left.

We introduce the notation:

L --the horizontal distance from the axis of the wheel up to the point of application of the reaction of the ground to the spade;

D --projection on the axis OX of the distance between the center of gravity of the gun in the firing position and the point C ; D -- the value of the variable, changing with the change in the path of the recoil X and the angles ψ and φ .

Bearing in mind that the projection of the value X of the path of the recoil on the axis OX is equal to X cos φ cos ψ , on the basis of considerations analogous to those in derivation of expression (30) for the moment of the force of the weight of the gun in the case of the placing of the axis of the bore of the barrel in the plane of symmetry of the system, we may write the following expression for the projection of the moment of the force of the weight of the system relative to the axis parallel to axis OZ and passing through point C on axis OX:

$$Q_0 D = Q_0 D'_{0\varphi} - Q_0 X \cos\varphi \cos\psi,$$

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Fig. 27 (Page 62)

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whence we obtain:

$$D = D'_{o\varphi} - X \cos\varphi \cos\psi \frac{Q_o}{Q_6},$$

where $D'_{o\varphi}$ -- is the initial value D with $X = 0$ and the given values of angles ψ and φ.

For the determination of the value $D'_{o\varphi}$ we write the equation of moments:

$$D'_{o\varphi} Q_6 = D_H Q_H + D'_6 Q_6,$$

where by D_H and D'_6 we designate respectively the distances along the axis X from the point C to the center of gravity of the lower carriage and the rotating part, and by Q_H and Q_6 -- the weight of the lower carriage and the rotating part.

Designating by l_6 the distance along the horizontal from the axis of the pintle up to the center of gravity of the rotating part, we may write

$$D'_6 = d_6 \pm l_6 \cos\psi;$$

consequently,

$$D'_{o\varphi} = D_H \frac{Q_H}{Q_6} + (d_6 \pm l_6 \cos\psi)\frac{Q_6}{Q_6}.$$

With $\psi = 0$:

$$D'_{o\varphi} = D_{o\varphi} = D_H \frac{Q_H}{Q_6} + (d_6 \pm l_6)\frac{Q_6}{Q_6},$$

where d_6 -- is the distance along the horizontal from the axis of the pintle to the point C.

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Fig. 28 (Page 63)

We also introduce the notation:

B —the distance between the wheels;

r —the projection on the axis OZ of the distance from the center of gravity of the gun to the point of support of the left wheel; the value r is also variable, changing with the path of recoil (length) X and the angles φ.

Bearing in mind that the projection of the value X of the path of recoil on axis OZ is equal to X cos φ cos ψ, the expression for r may be written in the following form:

$$r = r'_{0\varphi} - X \cos\varphi \sin\psi \frac{Q_0}{Q_6},$$

where $r'_{0\varphi}$ —is the initial value of r with X = 0 and the given values of the angles ψ and φ.

For the determination of the value of $r'_{0\varphi}$ we may write the equation of the moments:

$$r'_{0\varphi} Q_6 = \frac{B}{2} Q_H + r'_B Q_B,$$

where by r'_B we designate the distance along the axis Z from the point of support of the left wheel up to the center of gravity of the rotating parts.

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For r'_B we may write the expression (fig. 28):

$$r'_B = \frac{B}{2} \pm l_B \sin\psi ;$$

consequently

$$r'_{0\varphi} = \frac{B}{2}\frac{Q_H}{Q_0} +$$

$$+ \left(\frac{B}{2} \pm l_B \sin\psi\right)\frac{Q_H}{Q_0}$$

with $\psi = 0$

$$r'_{0\varphi} = r_{0\varphi} = \frac{B}{2} .$$

We designate by H the height of the point A, at which the vertical axis of rotation of the upper carriage intersects the trajectory of the center of gravity of the recoiling parts, above the level of point C of the application of the reaction of the ground to the spade (fig. 29).

Fig. 29 (Page 64)

Legend: 1 --axis of pintle;

2 --center of gravity of recoiling parts.

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As it follows from the diagram

$$H = (d_B - d_u) tg\,\varphi + \frac{d}{\cos\varphi} + H_u + \Delta H$$

With $\varphi = 0$

$$H_0 = H' = H_u + d + \Delta H$$

In what follows we shall introduce the following notation for sake of brevity:

$$\angle - D = \omega;$$
$$\angle - d_B = \beta.$$

We shift the force of resistance to recoil R to the point A and resolve into components for the axes of coordinates:

$$|R_x| = R\cos\varphi\cos\psi;$$
$$|R_y| = R\sin\varphi;$$
$$|R_z| = R\cos\varphi\cdot\sin\psi.$$

We represent the moment $M = P_{KH} e$ by a vector perpendicular to the plane of fire, constructed at the point of the center of gravity of the recoiling parts and directed to the left relative to the direction of fire.

We represent the moment M_{BP} by a vector directed along the axis of the bore in the direction of the flight of the projectile.

We resolve the vector M into two components lying in the horizontal plane:

$$|M_x| = M\sin\psi;$$
$$|M_z| = M\cos\psi.$$

We resolve the vector M_{BP} into three components parallel to the axes of the coordinates:

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$$|M_{BP,x}| = M_{BP} \cos\varphi \cdot \cos\psi;$$
$$|M_{BP,y}| = M_{BP} \sin\varphi;$$
$$|M_{BP,z}| = M_{BP} \cos\varphi \sin\psi.$$

Supposing the gun to the stable and immovable, we write the equation of its equilibrium under the action of the forces mentioned above:

$$\left.\begin{aligned}
&\Sigma X_i = R_x - T_{xG} = 0;\\
&\Sigma Y_i = -R_y - Q_G + N_1 + N_2 + N_{xG} = 0;\\
&\Sigma Z_i = R_z - L_{xG} - L_1 - L_2 = 0;\\
&\Sigma M_{oz} = R_x H - R_y d_B - Q_G D + (N_1 + \\
&\qquad + N_2) L + M_z - M_{BPz} = 0;\\
&\Sigma M_{ox} = (L_1 + L_2)\Delta H - N_{xG}\frac{B}{2} + \\
&+ Q_G r - N_2 B - R_z H + R_y \frac{a}{2} - M_x - \\
&\qquad - M_{BP,x} = 0;\\
&\Sigma M_{oy} = (L_1 + L_2)(L - d_B) - L_{xG} d_B + \\
&\qquad + M_{BP,y} = 0.
\end{aligned}\right\}$$

Fig. 55 (Page 65)

Hence, we obtain six equations for the determination of the seven unknowns N_{xG}, T_{xG}, L_{xG}, N_1, N_2, L_1 and L_2.

However, the reactions L_1 and L_2 may be considered as forces of cohesion of the wheel (or caterpillars) with the ground and proportional to the normal reactions N_1 and N_2. The coefficient of proportionality will be

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the coefficient of cohesion μ of the rim of the wheel with the base on which the gun is placed. Under these conditions the number of unknowns in the system of equation (55) is reduced to five. For the determination of the reactions L_1 and L_2 we have two equations:

$$\left.\begin{aligned} L_1 &= \mu N_1, \\ L_2 &= \mu N_2 \end{aligned}\right\} \qquad (56)\ 66$$

The value of the coefficient of cohesion depends on the construction of the tires and the character of the ground forming the base. In the practice of designing tractors, the coefficient of cohesion with the ground in the transversal direction μ is taken equal to 0.6 -- 0.8 of the coefficient of cohesion in the longitudinal direction φ. Below in Table 2 we give the values of the coefficient μ for ballon tires and caterpillars with various kinds of ground. In drawing up the table we have taken $\mu = 0.7\,\varphi$.

Table 2 (page 66)

COEFFICIENTS OF COHESION IN THE TRANSVERSAL DIRECTION

CHARACTERISTICS OF THE BASE	BALLOON TIRES	CATERPILLARS
Asphalt	0.5	-
Smooth country road:		
dry clay ground	0.6	0.7
dry sandy ground	0.5	0.8
dry black earth	0.4	0.6
Moist meadow, mown	0.5	0.8
Moist meadow, not mown	0.4	0.4
Moist stubble	0.4	0.6
Tillable ground that has been lying idle	0.4	0.4
Freshly plowed field	0.3	0.5
Rolled snowy road	0.2	0.4

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By solving simultaneously the equations of the system (55), we find the unknowns N_1, N_2, N_{x6}, L_{x6}, L_1, and L_2.

The conditions of lateral or transverse stability is written inthhe following form:

$$\left.\begin{aligned} N_1 &> 0, \\ N_2 &> 0. \end{aligned}\right\} \qquad (57)\ 66$$

The conditions, however, of transversal immobility are determined by the resistance of the ground to the forces L_{x6} L_1 and L_2.

From the second equation of the system (55) we have:

$$N_1 + N_2 = R_y + Q_6 - N_{x6}. \qquad (58)\ 66$$

By substituting the expression (58) in the fourth equation of system (55) we find the expression for N_{x6}.

$$N_{x6} = Q_6(1-D) + R_y(1-d_6) + R_x H - M_{BP,Z} + M_z$$

OR

$$N_{x6} = \frac{Q_6 a + R_{x2} b + R_x H - M_{BP,Z} + M_z}{L} \qquad (59)\ 67$$

From the third equation of system (55) we have:

$$L_1 + L_2 = R_z - L_{x6}; \qquad (60)\ 67$$

from the other side, on the basis of the sixth equation of system (55) we may write:

$$L_1 + L_2 = L_{x6}\frac{d_0}{b} - \frac{M_{BP,Y}}{b}. \qquad (61)\ 67$$

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By equating the right parts of equation (60) and (61) and solving the equation obtained for L_{x6} we obtain:

$$L_{x6} = \frac{R_z l + M_{BP,y}}{L} \qquad (62)\ 67$$

By substituting the expression (60) in the fifth equation of the system (55), we obtain the following expression for the determination of N_2 with known values of L_{x6} and N_{x6} :

$$N_2 = \frac{R_z(\Delta H - H) - L_{x6}\Delta H - N_{x6}\frac{B}{2} + Q_6 N + R_y \frac{B}{2} - (M_x + M_{BP,x})}{B} \qquad (63)\ 67$$

In addition, on the basis of the second and third equations of system (55) we obtain:

$$N_1 = R_y + Q_6 - N_2 - N_{x6} \qquad (64)\ 67$$

and

$$T_{x6} = R_x . \qquad (65)\ 67$$

On the basis of equation (56) we have:

$$\left.\begin{aligned} L_1 &= \mu N_1 , \\ L_2 &= \mu N_2 . \end{aligned}\right\} \qquad (66)\ 67$$

The investigation of the derived functional relationships gives the following conclusions as to the transversal stability of field artillery with the direction of grooves adopted by us for the bore of the barrel:

1. The pressure is increased on the left wheel and decreased on the right

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as a result of the presence of reaction of the rotating projectile.

2. The pressure on the wheel opposite the direction of the turn of the barrel is increased.

3. The case of fire with a turn of the barrel to the right of the middle position is more dangerous for lateral stability.

4. A gun stable with the barrel in the middle position may prove to be unstable with lateral deviations of the barrel.

5. With an increase in the angle of elevation, the stability is improved.

6. The component of the moment of the dynamic couple tends to turn the gun around the pointof support of the wheel opposite the direction of the turn of the barrel.

7. The lateral stability of the gun is better at the end of the recoil, because in this case the moments M and M_{BP} are equal to zero.

In concluding our consideration of the problem of the lateral stability of the gun we shall introduce the expression for the determination of the limiting angle of transversal stability of the gun $\psi_{пр}$, that is, the maximum value of the angle ψ at which the gun will still be stable in the transversal direction.

For the determination of the normal reaction on the right wheel we obtained the expression (63):

$$N_2 = \frac{R_z(\Delta H - H) - L_{xG}\Delta H - N_{xG}\frac{B}{2} + Q_G r +}{B}$$

$$\frac{+ R_y\frac{B}{2} - (M_x + M_{BP,x})}{B}$$

In the limiting case with $\psi = \psi_{пр}$, $N_2 = 0$, that is, the numerator the expression (63) is equal to zero.

In further consideration of the case we shall neglect the effect of the turn of the barrel (the rotating part) on the change in the values of r and

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D, that is, we shall suppose:

$$\nu = \nu_{0\varphi} = \frac{B}{2};$$

$$D = D_{0\varphi} - X\cos\varphi. \qquad (67)\ 68$$

We substitute in the numerator of the expression (63) the values of L_{x6} and N_{x6} respectively from the expressions (62) and (59) and by equating it with zero, and also bearing in mind the expression (67), we may write:

$$R_z\left[\Delta H\left(1-\frac{\nu}{L}\right)-H\right]+Q_0\left(1-\frac{\omega}{L}\right)\frac{B}{2}+R_y\left(1-\frac{\nu}{L}\right)\frac{B}{2}-$$

$$-R_x\frac{H}{L}\frac{B}{2}-(M_x+M_{BP,x})+(M_{BP,z}-M_z)\frac{B}{2L}- \qquad (68)\ 69$$

$$-M_{BP,y}\frac{\Delta H}{L}=0$$

After the substitution of the values R_x, R_y, R_z, M_x, M_y, M_z, $M_{BP,x}$, $M_{BP,y}$ and $M_{BP,z}$ in the equation (68) and appropriate groupingof the members we shall have:

$$\left[\left(\frac{H}{L}\frac{B}{2}R+M_{BP}\right)\cos\varphi+M\frac{B}{2L}\right]\cos\Psi_{\Pi P}-$$

$$-\left\{\left[\Delta H\left(1-\frac{\nu}{L}\right)R-HR+M_{BP}\frac{B}{2L}\right]\cos\varphi-M\right\}\sin\Psi_{\Pi P}=$$

$$=Q_6\left(1-\frac{\omega}{L}\right)\frac{B}{2}-\left[M_{BP}\frac{\Delta H}{L}-\left(1-\frac{\nu}{L}\right)\frac{B}{2}R\right]\sin\varphi$$

OR

$$\left[\left(\frac{H}{L}\frac{B}{2}R+M_{BP}\right)\cos\varphi+M\frac{B}{2L}\right]\cos\Psi_{\Pi P}-$$

$$-\left\{\left[\left(\Delta H\frac{d_6}{L}-H\right)R+M_{BP}\frac{R}{2L}\right]\cos\varphi-M\right\}\sin\Psi_{\Pi P}=$$

$$=Q_6\frac{D}{L}\frac{B}{2}-\left(M_{BP}\frac{\Delta H}{L}-\frac{d_6}{L}\frac{R}{2}R\right)\sin\varphi.$$

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By introducing the notation:

$$a' = \left(\frac{H}{L}\frac{B}{2}R + M_{BP}\right)\cos\varphi + M\frac{B}{2L},$$

$$b' = \left[\left(\Delta H\frac{d_\Phi}{L} - H\right)R + M_{BP}\frac{B}{2L}\right]\cos\varphi - M,$$

$$c' = Q_G\frac{P}{L}\frac{B}{2} - \left(M_{BP}\frac{\Delta H}{L} - \frac{d_\Phi}{L}\frac{B}{2}R\right)\sin\varphi,$$

we arrive at the well-known trigonometric identity:

$$a'\cos\psi_{NP} - b'\sin\psi_{NP} = c',$$

the solution of which gives the following dependence of the angle ψ_{NP} on the constants a', b' and c':

$$\psi_{NP} = \arccos\frac{c'}{\sqrt{a'^2+b'^2}} - \operatorname{arctg}\frac{b'}{a'}. \qquad (69)\ 69$$

7. Reaction of the support on the carriage with split trails.

We shall consider the most general case, when fire is conducted under an angle of elevation $\varphi > 0$, and the barrel together with its rotating part turns by an angle ψ relative to the plane of symmetry of the gun.

We assume that the gun is set up on a horizontal base and that it conserves stability and immobility during the time of the shot.

We multiply the weight of the gun in the firing position Q_G by two components: Q_{KBO} --weight of the wheels and the axle and Q_{JC} --weight of the carriage and the barrel without the weight of the wheels and axle, that is, we take:

$$Q_G = Q_{KBO} + Q_{JC}.$$

Then, during the time of the shot, the following moments and forces will act on the carriage:

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$M = P_{KH} e$ --the moment of the dynamic couple;

M_{BP} --reactive moment from the transversal component of the normal pressure on the driving edges of the grooves;

R --force of resistance to recoil;

$N_{ЛБ}$ --frontal reaction of the pintle, connecting the lower carriage with the axle;

R_1 and R_2 --reactions of the base on the left and right trails respectively;

$Q_{ЛС}$ --weight of the carriage with the barrel.

Of the enumerated forces the unknowns are the reactions: $N_{ЛБ}$ and R_1 and R_2.

The coordinated axes are placed as shown in figure (30).

We place the axes of the moments as follows: the one parallel to axis OX -- perpendicular to the plane of the back view at the point C_1 of application of the reaction of the ground to the left spade; the one parallel to axis OZ -- perpendicular to the plane of the drawing viewed from the side at point C_1; the one parallel to the axis OY -- perpendicular to the plane of the drawing when viewed from above at the point A of the rotation of the upper carriage relative to the lower.

We resolve the reactions R_1 and R_2 into components parallel to the coordinated axes: N_1, T_1, L_1 and N_2, T_2, L_2. We resolve the force R, shifted to point A, into three components, parallel to the coordinated axes:

$$[R_x] = R \cos\varphi \cos\psi;$$
$$[R_y] = R \sin\varphi;$$
$$[R_z] = R \cos\varphi \sin\psi.$$

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Fig. 30 (Page 71)

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We resolve the vectors of the moments $M = P_{KH}e$ and M_{BP} into components parallel to the coordinated axes:

$$[M_x] = M \sin\varphi;$$
$$[M_z] = M \cos\psi;$$
$$[M_{BP,x}] = M_{BP} \cos\varphi \cos\psi;$$
$$[M_{BP,y}] = M_{BP} \sin\varphi;$$
$$[M_{BP,z}] = M_{BP} \cos\varphi \sin\psi.$$

We introduce the notation:

L --horizontal distance from the line of support of the wheels to the line $C_1 C_2$, passing through the point of application of the reaction of the ground on the spade;

D --distance a long the axis OX from the center of gravity of the mass of weight Q_{ac} up to the line $C_1 C_2$;

d_{BP} --horizontal distance from the axis of rotation of the upper carriage to the line $C_1 C_2$;

b --distance between the points C_1 and C_2;

h --projection on the axis OZ of the distance from the point of application of the reaction of the ground on the left spade to the center of gravity of the mass of weight Q_{ac};

H --distance along the vertical between the line $C_1 C_2$ and the point A.

In addition to this, we suppose that

1) the point of application of the reaction of the pintle N_{ped} lies in the plane passing through the axle and the line of support of the wheel;

2) the axis of the pintle is placed behind the axle.

Let us note also that the values L, h and d_{BP} are constants depending upon the constructional dimensions of the carriage.

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Just as in the case of a monobar carriage, the value H is determined by the expression (see figure 29):

$$H = (d_B - d_u)\,tg\,\varphi + \frac{d}{\cos\varphi} + H_u + \Delta H$$

The value D and r are determined by the functional relations:

$$D = D'_{o\varphi} - X\cos\varphi\cos\psi\,\frac{Q_o}{Q_{sc}};$$

$$r = r'_{o\varphi} - X\cos\varphi\,\sin\psi\,\frac{Q_o}{Q_{sc}},$$

where $D'_{o\varphi}$ -- the initial value of D with $X = 0$ and the given values of angles ψ and φ -- is determined by the expression (see figure 28)

$$D'_{o\varphi} = D_H\,\frac{Q_H}{Q_{sc}} + (d_H \pm l_H\cos\varphi)\,\frac{Q_B}{Q_{sc}},$$

where by Q_H we designate the weight of the lower carriage without the weight of the running parts of the carriage (wheel, axle cushioning), and by D_H -- the distance along the axis OX from the line C_1C_2 up to the center of gravity of the lower carriage without the running parts.

With $\psi = 0$

$$D'_{o\varphi} = D_{o\varphi} = D_H\,\frac{Q_H}{Q_{sc}} + (d_B \pm l_B)\,\frac{Q_H}{Q_{sc}}.$$

$r_{o\varphi}$ --the initial value r with $X = 0$ and the given values of the angles ψ and φ -- is determined by the expression:

$$r_o = \frac{l}{2}\,\frac{Q_H}{Q_{sc}} + \left(\frac{l}{2} \pm l_B\,\sin\psi\right)\frac{Q_H}{Q_{sc}}.$$

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with $\psi = 0$

$$r_0 = \frac{l}{2}.$$

Since the piece is assumed to be stable and immovable (stationary), we may regard it as being in equilibrium under the action of the forces and moments mentioned above.

We draw up the equation of equilibrium:

$$\left.\begin{aligned}
\Sigma X_i &= R_x - T_1 - T_2 = 0;\\
\Sigma Y_i &= N_1 + N_2 + N_{\text{лб}} - Q_{\text{лс}} - R_y = 0;\\
\Sigma Z_i &= R_z - L_1 + L_2 = 0;\\
\Sigma M_{0z} &= R_x H - R_y d_B - Q_{\text{лс}} D + N_{\text{лб}} L + M_z - M_{BP,z} = 0;\\
\Sigma M_{0x} &= -R_z H + R_y \frac{l}{2} - N_2 l + Q_{\text{лс}} r -\\
&\quad - N_{\text{лб}} \frac{l}{2} - M_x - M_{BP,x} = 0;\\
\Sigma M_{0y} &= T_1 \frac{l}{2} - T_2 \frac{l}{2} + L_2 d_B - L_1 d_B + M_{BP,y} = 0.
\end{aligned}\right\}$$

Since the number of unknowns is seven -- $N_{\text{лб}}$, N_1, N_2, T_1, T_2, L_1 and L_2 and the number of the equations of equilibrium six, the problem of determining the reaction is statically indeterminable and for its solution it is necessary to introduce still another condition. We take this additional condition, in accordance with the proposal of General A. A. Tolochkov, in the form of a functional relationship between the lateral components of the reaction of the ground on the spades L_1 and L_2, assuming that the reactions L_1 and L_2 are inversely proportional to the distances to the plane of fire from the point of support of the spades C_1 and C_2, which we may replace by way of approximation by the relationship

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$$\frac{L_2}{L_1} = \frac{\sin \beta_1}{\sin \beta_2}, \qquad (71)\ 74$$

where β_1 and β_2 are the angles between the plane of fire and the middle planes os the trails (figure 31).

This functional relationship (71) is given by General Tolochkov without derivation. It may be derived if we imagine the lower carriage to be in the form of a flat frame and employ the methods of structural mechanics. The latter circumstance enables us to consider this solution of the problem as sufficiently substantiated with the initial assumption of absolute rigidity of the ground and the "face casing" of the carriage.

Fig. 31 (Page 74)

We obtain the expressions for the reaction by solving the system of equations (68) in combinations with the condition (71) in the following sequence.

From the third equation of the system (68) we have:

$$L_1 - L_2 = R_z; \qquad (72)\ 74$$

further, on the basis of the sixth equation of the system (68), we may write:

$$T_1 = T_2 + (L_1 - L_2)\frac{2d_0}{l} - M_{BP,y}\frac{2}{l}. \qquad (73)\ 74$$

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By substituting the expression (72) in expression (73) we shall have:

$$T_1 = T_2 + R_z \frac{2d_0}{l} - M_{BP,Y} \frac{2}{l}. \quad (74)\ 74$$

By eliminating from expression (74) the value T_2 determined from the first equation of the system (68):

$$T_2 = R_x - T_1 \quad (75)\ 74$$

we obtain the following expression for the determination of T_1 :

$$T_1 = \frac{l}{2}\left(R_x + R_z \frac{2d_0}{l} - M_{BP,Y} \frac{2}{l}\right)$$

or, bearing in mind that

$$d_0 \cdot \frac{l}{2} = c\,\mathrm{ctg}\,\beta,$$

where β -- is the angle between the axis of symmetry of the carriage and the direction towards the point C_1 (C_2) from the point β (figure 31).

$$T_1 = \frac{l}{2}\left(R_x + R_z\, c\,\mathrm{ctg}\,\beta - M_{BP,Y} \frac{2}{l}\right). \quad (76)\ 75$$

By substituting the expression (76) in expression (75) we, obtain the following expression for the determination of T_2 :

$$T_2 = \frac{l}{2}\left(R_x - R_z\, c\,\mathrm{ctg}\,\beta + M_{BP,Y} \frac{2}{l}\right). \quad (77)\ 75$$

On the basis of the additional condition (71) we may write

$$\left.\begin{aligned} L_1 &= \frac{\sin\beta_2}{\sin\beta_1} L_2; \\ L_2 &= \frac{\sin\beta_1}{\sin\beta_2} L_1. \end{aligned}\right\} \quad (78)\ 75$$

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After substituting expression (78) in equation (72) we obtain the following expression for the determination of L_1 and L_2 :

$$L_1 = \frac{\sin\beta_2}{\sin\beta_2 - \sin\beta_1} R_z ; \qquad (79)\ 75$$

$$L_2 = \frac{\sin\beta_1}{\sin\beta_2 - \sin\beta_1} R_z . \qquad (80)\ 75$$

In addition, from the fourth equation of system (68) we have:

$$N_{\pi 6} = \frac{Q_{\pi c} D + R_y d_6 - R_x H - M_z + M_{6p,z}}{L}, \qquad (81)\ 75$$

after which from the fifth equation of system (68) we find:

$$N_2 = \frac{Q_{\pi c} n - R_x H + R_y \frac{l}{2} - N_{\pi 6} \frac{l}{2} - M_x - M_{6p,x}}{l}. \qquad (82)\ 75$$

Knowing the value of reactions $N_{\pi 6}$ and N_2, from the second equation of system (68) we may find the reaction N_1 :

$$N_1 = Q_{\pi c} + R_y - N_{\pi 6} - N_2 \qquad (83)\ 75$$

Hence, we have determined all seven of the unknown reactions.

After combining in a system all the formulas necessary for the calculation of the reaction of the base on the carriage we obtain:

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$$N_{RG} = \frac{Q_{RC} D + R_y a_B - R_x H - M_z + M_{BP,z}}{L};$$

$$N_2 = \frac{Q_{RC} r - R_z H + R_y \frac{l}{2} - N_{RG} \frac{l}{2} - M_x - M_{BP,x}}{l};$$

$$N_1 = Q_{RC} + R_y - N_{RG} - N_2;$$

$$T_1 = \frac{l}{2}\left(R_x + R_z \operatorname{ctg}\beta - M_{BP,Y}\frac{2}{l}\right);$$

$$T_2 = \frac{l}{2}\left(R_x - R_z \operatorname{ctg}\beta + M_{BP,Y}\frac{2}{l}\right);$$

$$L_1 = \frac{\sin\beta_2}{\sin\beta_2 - \sin\beta_1} R_z;$$

$$L_2 = \frac{\sin\beta_1}{\sin\beta_2 - \sin\beta_1} R_z.$$

(84) 76

where

$$D = D_{0\varphi} - X\cos\varphi\cos\psi\frac{Q_0}{Q_{RC}};$$

$$r = r'_{0\varphi} - X\cos\varphi\sin\psi\frac{Q_0}{Q_{RC}};$$

$[R_x] = R\cos\varphi\cos\psi$; $[M_x] = M\sin\psi$; $[M_{BP,x}] M_{BP}\cos\varphi\cos\psi$;

$[R_y] = R\sin\varphi$; $[M_z] = M\cos\psi$; $[M_{BP,y}] M_{BP}\sin\varphi$;

$[R_z] = R\cos\varphi\sin\psi$; $[M_{BP,z}] M_{BP}\cos\varphi\sin\psi$.

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The value of the reaction $N_{\mathcal{RG}}$ may be even less than zero, but in a stable gun its absolute value should be less than the weight of the wheels and the axle, because it is only in this case that the wheels will not separate from the ground (in case of non-elastic tires on the wheels).

CHAPTER II

RECOIL OF THE BARREL OF THE GUN

1. GENERAL CONSIDERATIONS

As was shown earlier, one of the problems of the theory of carriages is the determination of the law of movement of the separate parts of the artillery piece, taking place under the action of the forces and reactions coming into play when the shot is fired, in particular the determination of the elements of movement of the recoiling parts of the gun.

Generally speaking, this problem may be solved by integration of the equation of the movement of the recoiling parts:

$$\frac{Q_0}{g}\frac{d^2X}{dt^2} = P_{KH} - R.$$

But for this purpose it is necessary first of all to know the law of change of the resultant forces of the pressure of the powder gases on the bottom of the bore P_{KH} and the forces of resistance to recoil R in function of time.

The law of change of the force of resistance to recoil is generally determined in the designing of the carriage, in keeping with the requirements which are made of the gun designed, in the form of a relatively simple functional relationship, convenient for integration of the equation of movement of the recoiling parts in finite form.

As to the resultant forces of the presure of the powder gases in the bore of the barrel during the time of the movement of the projectile along the bore, we will say that as a result of the absence of a solution of the main problem of interior balistics in a finite form in function of the time the law of the

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changes of the force P_{KH} cannot be presented directly in a form convenient for integration of the equation of movement of the recoiling parts.

The problem of the integration may be solved by numerical methods, but this is not always convenient because its renders difficult the investigation of the functional relationship.

In view of this, one proposed a number of approximate methods of expressing the law of changes of the force P_{KH} depending on time.

In 1896, Colonel Durlyakhov of Russian artillery proposed to replace the true curve of the change of the force P_{KH} by a broken line (fig. 32). For the construction of the broken line it is necessary to know from experience the values P'_m, l_m, l and v_0. The force of pressure of the powder gases on the bottom of the projectile and on the bottom of the bore is taken to be identical.

Such a method of expressing the law of change of the force P_{KH} gives a distorted picture of its change in function of time, but it gives the same value of the impulse of the force P_{KH} as with the real law of its change.

Figure 32 (page 78)

In 1900, the French artilleryman Vallier proposed the following formula for the expression of the force P_{KH} in the period of the movement of the projectile along the bore:

$$P_{KH} = P_{max}\left(\frac{t}{t_m}\left(1-\frac{t}{t_m}\right)\right)^{\beta}.$$

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when β is the index of "progressiveness" ≥ 1.

This formula reflects the real law of the change of the force P_{KH} with greater precision than the simplest model of Burlyakov. The degree of approximation to the actual law depends upon haw successful we are in selecting the constant parameters t_m and β. The integration of this expression does not present any difficulty, but the general functional relationships are rather unwieldy. For simplification and speeding up the calculation, Vallier drew up a table of auxiliary functions.

Finally, we may point to the method of the analytical expression of the law of change of the force P_{KH} proposed by Prof. Grodsky. Proceeding from the fact that the separate sectors of the curve expressing the effective law of change of the force P_{KH} agree very closely with a certain parabola of the second degree, Prof. Grodsky proposed to express the law of the change of the force P_{KH} with three members of the second degree in function of the time t the coefficients of which are different for the different parts of the diagram (graph).

As the basis of the method we take the results of the solution of the main problem of interior balistics in function of course of the projectile. The difference in pressure on the bottom of the bore and on the bottom of the projectile, and also the influence of the resistance of the grooves are taken into account by the introduction of appropriate coefficients.

The method of Prof. Grodsky approximates very closely the effective law of change of the force P_{KH} but the functional relationships obtained are rather cumbersome and the process of calculation is labor-consuming.

From a consideration of the various methods of analytical expression of the law of change of the force P_{KH} we find that no one of them is of practical value, because it either does not give the required accuracy or, if the accuracy is satisfactory, it leads to cumbersome functions and requires labor consuming calculations.

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Hence, for determination of the elements of movement of the recoiling parts of the gun we shall apply below to the system of recoiling parts — projectile — charge the law of amount of movement. This makes it possible, by using the tabular methods of solving the problem of interior ballistics and avoiding direct integration of the equation of movement of the recoiling parts, for us to obtain in a relatively simple manner the necessary functions for the time of the movement of theprojectile along the bore. The intermediate stage in the transition to a consideration of the effective retarded recoil ("brake recoil") is the consideration of the so-called free recoil, by which we understand that recoil of the gun while the shot is being fired when the recoiling parts, projectile and charge, are under the influence of the action of the internal forces alone, namely, the forces of pressure of the powder gases acting in the bore of the barrel and the force of resistance of the movement of the projectile and charge along the bore. Such recoil may be realized in practice if we force the gun to recoil during the shot along a well-polished horizontal surface, when the friction between the latter and the recoiling parts and the force of resistance of the air may be neglected in comparison with the force of pressure of the powder gases.

We shall now consider the process of free recoil. At the moment when the force of pressure of the powder gases in the bore of the barrel reaches the value $P_0 = SP_0$, called the force of energy of translation, necessary for overcoming the resistance of the cutting of the driving band of the projectile in the grooves — the projectile is set in movement. Simultaneously with the projectile, the recoiling parts of the gun also begin to move, and in proportion as the pressure of the powder gases develops and the projectile moves along the bore, the velocity of the recoiling parts will increase.

After the departure of the driving band of the projectile from the bore of the barrel the powder gases, escaping from the bore, create a reacting force, which, acting still for a considerable time, increases perceptibly the velocity

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of the recoiling parts.

If after the cessation of the action of the powder gases it is possible for the recoiling parts, in free recoil, to move farther, this movement would take place from inertia at the constant velocity which the recoiling parts acquire at the moment of the cessation of the escape of powder gases from the bore of the barrel.

The equation of the movement of the recoiling parts with free recoil, or simply the equation of free recoil, is written in the following form:

$$\frac{Q_0}{g}\frac{d^2L}{dt^2} = P_{KH}$$

where L is the path (distance travelled) of the recoiling parts with free recoil or the length of free recoil.

The theory of carriages with free recoil considers the movement of the recoiling parts during the time of action on them of the force of pressure of the powder gases. This action is usually broken up into two periods: the period of the movement of the projectile along the bore and the period of the subsequent action of the powder gases, beginning at the moment of the departure of the projectile from the bore (and, to be more precise, at the moment of the departure of the driving band from the grooves) and terminates when the pressure in the bore of the barrel is equal to atmospheric pressure.

With effective ("brake" or retarded" recoil the movement of the recoiling parts during the time of the action of the powder gases on the bottom of the bore takes place under the influence of the resultant forces P_{KH} and of the force of resistance to recoil R. The latter is made up of the forces of resistance of the recoil brake, the counter recoil, and the friction of the "guide cradles" and of the resistance in the tightening devices of the counterrecoil mechanism (gaskets and collars).

After the end of the period of the secondary action of the gases the movement of the recoiling parts will take place only under the action of the

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force of resistance to recoil R. This movement continues until such time as the vis viva (kinetic energy) of the recoiling parts which has accumulated in the period of action of the force P_{KH} on the recoiling parts, is absorbed by the work of the force of resistance to recoil R, or, in other words, until the velocity of recoil becomes zero.

For convenience of investigating retarded ("braked" recoil) recoil it is divided into two periods:

--first period -- from the beginning of recoil to the end of the period of the secondary action;

--second period -- from the end of the first period up to the moment of the stopping of the recoiling parts at the end of the recoil.

2. FORCES ACTING ON THE BOTTOM OF THE BORE OF THE BARREL DURING THE SHOT

1. General considerations.

When the shot is fired, the force P_{KH} acts in the direction of the axis of the bore of the barrel. As pointed out above, the components of this resultant are: in the period of the movement of the projectile along the bore -- the force of the presure of the powder gases in the bore, the force of friction of the powder gases against the walls of the bore, and the force of resistance of the grooves, and after the flight of the projectile from the bore of the barrel -- the reacting force of the gases escaping from the bore and the force of pressure of the powder gases on the muzzle crosssection. In the presence of a muzzle brake there will act, in the period of the secondary action in the direction of the axis of the bore of the barrel, still another force, namely, that generated by the muzzle brake.

2. Period of movement of the projectile along the bore.

We shall now consider first the force P_{KH} in the period of the movement of the projectile along the bore. In the determination of the expression for the force P_{KH} we shall take into account only two of its components -- the

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force of pressure of the powder gases in the bore and the force of resistance of the grooves; the third component -- the force of friction of the powder gases against the walls of the bore is not taken into account, because of its indeterminate character.

In keeping with the assumptions made for interior ballistics we shall suppose that under the usual conditions of fire from a rifled gun the movement of the projectile will start when there is generated in the powder chamber of the barrel, as a result of the burning of a part of the charge, a pressure sufficient for cutting the driving band into the grooves of their full depth. This pressure is called the pressure for overcoming the inertia of the projectile (force of energy of translation) and is designated by p_0. The gradualness of the cutting and the growing resistance of the driving band are usually not taken into account, on the assumption that the forming of the projections on the band takes place instantaneously when the pressure reaches the value p_0. Since with retarded recoil the value of the force of the initial resistance to recoil is somewhat less than the initial value of the force $P_{KH} = P_0$, and with free recoil is generally absent, then, sinultaneously with the beginning of the movement of the projectile, the recoiling parts of the gun start to move under the action of the resultant force P_{KH}, which may be considered as the difference between the force of pressure of the powder gases in the bore of the barrel and the force of resistance of the grooves. The general expression for the resultant P_{KH} may be written in the following form:

$$P_{KH} = sp_{KH} - \gamma, \qquad (85)\ 81$$

where P_{KH} is the pressure of the powder gases on the bottom of the bore of the barrel at the given moment:

s is the area of the transversal section of the bore taking into account the grooves;

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Υ is the force of resistance of the grooves.

Interior ballistics gives the following expression for the force of resistance of the rifling to the progressive movement of the projectile:

$$\Upsilon = k_{HP}\left(SP_{cH} + mv^2 k\right) \qquad (86)\ 82$$

for rifling of increasing twist and

ctg = cotan
tg = tan

$$\Upsilon = k_{HP} SP_{cH} \qquad (87)\ 82$$

for rifling of constant twist, where

$$k_{HP} = \frac{1}{1 + \frac{1}{\lambda}\,\frac{ctg\,\alpha - v_1}{tg\,\alpha + v_1}}, \qquad (88)\ 82$$

$$k_\alpha = \frac{tg\,\alpha_g - tg\,\alpha_0}{L_{HP}}. \qquad (89)\ 82$$

In the expressions for the coefficients k_{HP} and k_α we have designated:

λ — coefficient, depending upon the type of projectile; for a carriage-testing projectile $\lambda = 0.5$, for armour piercing thick walled projectiles $\lambda = 0.56$ and for high explosive thick walled projectiles $\lambda = 0.64 \div 0.68$; 0.68; α, α_0 and α_g — angle of twist of the rifling with the given path of the projectile along the bore, at the beginning of the rifling and at the muzzle section;

L_{HP} — length of the rifled part of the bore of the barrel.

The value of the coefficient k_{HP}, calculated for different values of λ and a length of the course of the grooves $h = \pi\, ctg\,\alpha$, given in table 3 below.

The value of $\tan\alpha$ for the case of the parabolic rifles is determined by the equation

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$$tg\,\alpha = tg\,\alpha_0 + k_\alpha l_\pi. \qquad (90)\ 82$$

l_π changes from zero to $L_{HP} = l_g - \alpha$, where α is the distance from the bottom of the projectile to the front part of the driving band.

Hence, the expression for P_{KH} may be rewritten in the following form:

$$P_{KH} = sp_{KH} - k_{HP}\,sp_{cH} - k_{HP}k_\alpha mv^2 \qquad (91)\ 82$$

for rifling of increasing twist and

$$P_{KH} = sp_{KH} - k_{HP}\,sp_{cH} \qquad (92)\ 82$$

for rifling of uniform twist.

Since $P_{KH} = kp_{cH}$ where k is a certain coefficient taking into account the pressure on the bottom of the fore in excess of the pressure on the bottom of the projectile, we may write the following:

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TABLE FOR DETERMINATION OF COEFFICIENT k_{HP}

h \ λ	0.50	0.56	0.64	0.68
18	0.0327	0.00365	1.0416	0.0440
19	0.0303	0.0338	0.0384	0.0408
20	0.0281	0.0314	0.0357	0.0379
22	0.0246	0.0274	0.0313	0.0331
24	0.0218	0.0243	0.0277	0.0294
26	0.0195	0.0218	0.0248	0.0263
28	0.0176	0.0197	0.0224	0.0238
30	0.0160	0.0179	0.0204	0.0217
32	0.0147	0.0164	0.0188	0.0199
34	0.0136	0.0152	0.0173	0.0184
36	0.0126	0.0141	0.0161	0.0170
38	0.0117	0.0131	0.0150	0.0159
40	0.0110	0.0123	0.0140	0.0149

for the case of rifling of increasing twist:

$$P_{KH} = sp_{KH}\left(1 - \frac{k_{HP}}{k}\right) - k_{HP}\, k\, \alpha\, m v^2 \qquad (93)\ 83$$

and for rifling of constant twist:

$$P_{KH} = sp_{KH}\left(1 - \frac{k_{HP}}{k}\right) \qquad (94)\ 83$$

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We shall find the expression for the coefficient k, taking into account the functional relationship between the pressure on the bottom of the bore P_{CH} and the pressure on the bottom of the projectile P_{KH}. For this purpose we make use of the law of "amount of movement", applying it to the system of recoiling parts — projectile — charge, with retarded recoil, which may be written in the following form:

$$-M_0 \frac{dV}{dt} + m \frac{dw}{dt} + \frac{dK}{dt} = R \qquad (95)\ 84$$

where V is the velocity of the retarded recoil;

w — absolute velocity of the projectile;

K — amount of pressure of the charge;

R — the force of resistance to recoil.

We find the expression for $\frac{dK}{dt}$, using the hypothesis of Piober which assumes that the velocity of the movement of the products of combustion and of the unburned parts of the charge in the different sections of the initial air space change in accorcance with the linear law, and that the velocity of the particles of the charge in direct contact with the base of the projectile is equal to the velocity of the projectile w, and the particles of the charge in direct contact with the base of the bore, is equal to the velocity of the "last" V_w (velocity of retarded recoil). Then the law adopted for the change in the velocity is graphically represented by the sloping straight line represented in Figure 33.

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If we take the distance between the bottom of the projectile and the bottom of the bore at a certain moment as unity, the velocity w_x of the elements of the charge in the section of the bore, at a distance x from its bottom, will, as we can easily see from the drawing, be as follows:

$$w_x = (w+V)x - V. \qquad (96)\ 84$$

Supposing that the mass of the charge expands uniformly in the initial air space, and designating the mass of the charge by μ, we shall have the following expression for the elementary mass:

$$d\mu = \mu\, dx$$

and the amount of movement of this elementary mass, at a distance x from the bottom of the bore, will be equal:

$$dK = u\, w_x\, dx \qquad (97)\ 84$$

or, after substitution of the value w_x, from the expression (96),

$$dK = \mu\left[(w+V)x - V\right]dx \qquad (98)\ 85$$

We obtain the full amount of movement of the charge by intergrating the equation (98) in the limits from zero to 1:

$$K = u\int_0^1 \left[(w+V)x - V\right]dx = \mu\,\frac{w-V}{2}. \qquad (99)\ 85$$

The derivative from the amount of movement of the charge on the basis of time is equal to

$$\frac{dK}{dt} = \frac{\mu}{2}\,\frac{dw}{dt} - \frac{\mu}{2}\,\frac{dV}{dt}. \qquad (100)\ 85$$

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Having substituted this expression for $\frac{dK}{dt}$ in the equation for the amount of movement (95) we may write:

$$-\left(M_0+\frac{\mu}{2}\right)\frac{dV}{dt}+\left(m+\frac{\mu}{2}\right)\frac{dw}{dt}=R. \qquad (101)\ 85$$

As one can see from equation (101), with the assumptions made by us, the phenomenon takes place as if one half of the mass of the charge moved with the gun and the second half with the projectile.

Here we may note that this formulation pertains only to the external form of the equation (101). In reality, if we designate the abscissa of the point on the axis of the bore at which the absolute velocity of the particles of the charge is equal to zero by x_0, then on the basis of equations (96) we may write:

$$0=(w+V)x_0-V,$$

whence

$$x_0=\frac{V}{w+V}$$

and

$$1-x_0=\frac{w}{w+V}.$$

Hence, it follows that the mass of the charge, located to the left of the point x_0 is equal to

$$\mu\frac{V}{w+V},$$

and that located to the right of the point x_0 is equal to

$$\mu\frac{w}{w+V}.$$

In equation (101), by removing M_0 from the parentheses and placing it

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with the multiplier $\frac{dV}{dt}$ and removing M from the parentheses and placing it with multiplier $\frac{dw}{dt}$ we may write:

$$-\left(1+0{,}5\frac{K}{M_0}\right)M_0\frac{dV}{dt}+\left(1+0{,}5\frac{\mu}{m}\right)m\frac{dw}{dt}=R \qquad (102)\ 86$$

or

$$M_0\frac{dV}{dt}=\frac{1}{1+0{,}5\frac{\mu}{M_0}}\left[\left(1+0{,}5\frac{\mu}{m}\right)m\frac{dw}{dt}-R\right]. \qquad (103)\ 86$$

Considering, for simplification of further derivations, the case of rifling of constant twist, we have the following on the basis of the equation of retarded recoil and the expression (96):

$$M_0\frac{dV}{dt}=P_{KH}-R=sp_{KH}-k_{HP}sp_{CH}-R. \qquad (104)\ 86$$

In addition to this,

$$m\frac{dw}{dt}=sp_{CH}-r=sp_{CH}-k_{HP}sp_{CH}. \qquad (105)\ 86$$

Having substituted expressions (104) and (105) in equation (103) we shall have

$$sp_{KH}-k_{HP}sp_{CH}-R=\frac{1}{1+0{,}5\frac{\mu}{M_0}}\left[\left(1+0{,}5\frac{\mu}{m}\right)sp_{CH}(1-k_{HP})-R\right] \qquad (105a)\ 86$$

or, solving for P_{KH}, after transformation

$$P_{KH}=\frac{1}{s\left(1+0{,}5\frac{\mu}{M_0}\right)}\left\{0{,}5R\frac{\mu}{M_0}+sp_{CH}\left[1+0{,}5\frac{\mu}{m}-\right.\right.$$

$$\left.\left.-k_{HP}\left(0{,}5\frac{\mu}{m}-0{,}5\frac{\mu}{M_0}\right)\right]\right\}. \qquad (106)\ 86$$

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Supposing in view of its very small value that $0.5\frac{\mu}{M_0} = 0$, we obtain the following expression, establishing the connection between the pressure on the bottom of the bore P_{KH} and the pressure on the bottom of the projectile P_{CH}:

$$P_{KH} = \left[1 + 0.5\frac{\mu}{m}(1 - k_{HP})\right] P_{CH} \qquad (107)\ 86$$

or

$$P_{KH} = \left[1 + 0.5\frac{\omega}{q}(1 - k_{HP})\right] P_{CH}. \qquad (108)\ 86$$

If we consider the phenomenon as taking place in such a way that the force of the ballistic pressure acting on the transversal section of the bore of the barrel, where the absolute velocity of the products of combustion of the powder is equal to zero $\left(\varkappa_0 = \frac{V}{\omega + V}\right)$, communicates to the mass $\left(1 + 0.5\frac{\mu}{M_0}\right)M_0$ the acceleration $\frac{dV}{dt}$, then the first member of equation (102) may be represented as follows:

$$\left(1 + 0.5\frac{\mu}{M_0}\right) M_0 \frac{dV}{dt} = P_0 - R = SP - k_{HP}\, SP_{CH} - R, \qquad (109)\ 87$$

and the second member --

$$\left(1 + 0.5\frac{\mu}{m}\right) m \frac{d\omega}{dt} = P_0 = \left(1 + 0.5\frac{\mu}{m}\right) SP_{CH}(1 - k_{HP}), \qquad (110)\ 87$$

where P is the ballistic pressure obtained from a solution of the main problem of interior ballistics.

By substituting expressions (109) and (110) in equation (102) we shall have:

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$$-SP + k_{HP} SP_{CH} + R + \left(1 + 0{,}5\,\frac{\mu}{m}\right) SP_{CH}\,(1 - k_{HP}) = R,$$

from which, after transformation, we obtain:

$$P = \left[1 + 0{,}5\,\frac{\omega}{g}\,(1 - k_{HP})\right] P_{CH}, \qquad (111)\ 87$$

that is, an expression analogous to expression (108).

Since the expression (108), establishing the connection between the pressure P_{KH} and the pressure P_{CH}, obtained by neglecting the small value of $0{,}5\,\frac{\mu}{M_0}$, as not influencing essentially the value of P_{KH}, then, in the solution of the practical problem we may consider $P_{KH} = P$, that is, suppose the pressure P, obtained from the solution of the main problem of interior ballistics to be equal to the pressure on the bottom of the bore.

Hence, the coefficient k, taking into account the excess of pressure P_{KH} over pressure P_{CH}, is determined by the expression

$$k = 1 + 0{,}5\,\frac{\omega}{g}\,(1 - k_{HP}) \qquad (112)\ 87$$

or, neglecting the value of k_{HP},

$$k = 1 + 0{,}5\,\frac{\omega}{g} \qquad (113)\ 87$$

Taking the value k in accordance with expression (113), the expression for the presure on the bottom of the bore P_{KH} may be written as follows:

$$P_{KH} = \left(1 + \frac{1}{2}\,\frac{\omega}{g}\right) P_{CH} \qquad (114)\ 87$$

The latter functional relationship is called the formula of Sarro, and the coefficient of $\frac{\omega}{g}$, equal to 0.5, is called the coefficient of Piober.

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The expressions (110) and(114) give results close to what we actually have, on condition that the diameter of the bottom of the powder chamber differs little from the calibre of the barrel. With a great difference between the diameter of the bottom of the chamber and the calibre of the barrel, as Prof. V. E. Slukhotsky has shown, the expression for the pressure of the powder of gases on the bottom of the bore will be the following

$$p_{KH} = \left(1 + 0{,}5\frac{\omega}{q}\right)\left(\frac{d}{d_1}\right)^{0{,}6} p_{CH} \qquad (115)\ 88$$

or

$$p_{KH} = \left[1 + 0{,}5\frac{\omega}{q}(1 - k_{HP})\right]\left(\frac{d}{d_1}\right)^{0{,}6} p_{CH}, \qquad (116)\ 88$$

where d is the calibre of the barrel;

d_1 — the diameter of the bottom of the powder chamber.

The curve of the changes of the force P_{KH} in the time of the movement of the projectile along the bore is represented in Figure 34.

Figure 34 (page 88)

3. Period of secondary action of the gases.

We shall now consider the expression for the resultant P_{KH} during the time of the secondary action of the powder gases.

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The nature of the force P_{KH} during the time of the secondary action differs from the nature of the same in the time of the movement of the projectile along the bore. After the departure of the driving band of the projectile from the bore of the barrel, the powder gases, escaping to the outside, still continue for some time to exert a reaction effect upon the recoiling parts, perceptibly increasing their velocity. The reacting force, created by the gases escaping from the bore of the barrel, also determines the value of the force P_{KH} in the period of the secondary action of the powder gases.

The theoretical formulas for the determination of the force P_{KH} in the period of the secondary action (as for example that of Prof. V. E. Slukhotsky) derived by assuming that the escape of the powder gases from the bore of the barrel in the period of the secondary action takes place as if the section of the bore of the barrel at the muzzle face were the smallest section of a nozzle. In addition to this, in the derivation of the formula one did not take into account the velocity which the powder gases have in the bore of the barrel before the departure of the projectile, and the process is supposed to have been established. The assumptions made distort the true picture of the process.

This forces us to adopt some approximate empirical expression for the law of change of the force P_{KH} in the period of the secondary action.

The simplest expression of the law of change of the force P_{KH} during the period of the secondary action in the form of a linear function of the time was proposed in 1900, simultaneously by our artilleryman Durlyakov and the French artilleryman Vallier. The linear law of change of the force P_{KH} in the period of the secondary action is called the law of Durlyakov-Vallier and is expressed analytically by the function

$$P_{KH} = P_0\left(1 - \frac{t}{t'}\right), \qquad (117)\ 89$$

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where t is the time, calculated from the beginning of the period of the secondary action;

t' —the duration of the period of the secondary reaction;

$P_\partial = sp_\partial$ —the force of pressure of the powder gases at the moment of the departure of the projectile from the bore.

The duration of the period of the secondary reaction, with the linear law, is determined from the condition of constancy of the impulse of the force P_{KH} with the linear and effective law of change. The linear law "minimizes by several fold" the duration of the secondary action of the powder gases and does not express the effective character of the change in the force P_{KH}.

In spite of this, the law of Durlyakov-Vallier, up until lately, has been extensively used in the practice of designing.

At the present time we are considering the problem of rejecting the linear law of the force P_{KH} in the period of the secondary action and the adoption of another more precise one reflecting the actual process of the change of the force P_{KH} in the period of the secondary action.

Prof. G. D. Grodsky proposed the parabolic law, which may be represented analytically by the function

$$P_{KH} = P_\partial \left(1 - \frac{t}{t'}\right)^2. \qquad (118)\ 90$$

Such an expression of the law, reflecting more correctly the change of the force P_{KH} in the period of the secondary action, has a defect in that it also gives a reduced value for the duration of the period of the secondary action, exeeeding by only 50% the time t', determined from the law of Durlyakov-Vallier

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Figure 35 (page 90)

A more nearly perfect analytical expression of the change of the force P_{KH} in the period of the secondary action was proposed by Rear Admiral (engineer) Bravin in the form of an exponent function

$$P_{KH} = P_0 e^{-\frac{t}{b}}, \qquad (119)\ 90$$

where e is the base of the Naperian logarithms;

b ---the parameter of the exponent function.

The duration of the period of the secondary action and the value of the parameter b are determined from the conditions of constancy of the impulse of the force with the actual law of change of the force P_{KH} and the law expressed by formula (119), giving the conditions of the pressure in the bore at the end of the period of the secondary action.

The change of the force P_{KH} in the period of the secondary action with the linear law of Durlyakov-Vallier, with the parabolic law of Prof. Grodsky, and with the exponential law of Prof. Bravin is shown in Figure 35.

From now on we shall take as a basis the exponential law of Prof. Bravin. Taking into account the extensive employment, in actual practice, of the linear law of Durlyakov-Vallier, in the derivation of the functional relationships for the period of the secondary action, we shall give them both for the law of Prof. Bravin and for the linear law of Durlyskov-Vallier.

The form of the curve of the change of the force P_{KH} for the time of the action of the powder gases on the bottom of the bore is represented in

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Figure 36.

Figure 36 (page 91)

Legend: 1. Period of action of the powder gases (first period of retarded recoil)

2. Period of free recoil

3. Period of free recoil

3. Free recoil

1. First period of free recoil.

As we have already stated before, we are to understand by free recoil that recoil during the shot when the recoiling parts, projectile and charge, are subject only to the action of the internal forces: the forces of pressure of the powder gases and the force of resistance to the movement of the projectile along the bore, that is, recoil without braking with an angle of elevation $\varphi = 0$. Besides, no external forces act upon the recoiling parts in the direction of the recoil.

For the determination of the elements of movement of the recoiling parts in the first period of the free recoil we apply the law of conservation of the "amount of movement" to the system: recoiling parts -- projectile -- charge.

We shall recall that before the shot is fired the system is at rest and that with respect to the system considered the force P_{KH} is an internal force.

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Hence, on the basis of the law of conservation of the "amount of movement" we shall see that the sum of the amount of movement of the recoiling parts, projectile and charge, during the time of the movement of the projectile along the bore is equal to zero, that is,

$$-M_0 W + mw + K = 0. \qquad (120)\ 93$$

Here our notation is as follows:

$M_0 = \frac{Q_0}{g}$ is the mass of the recoiling parts;

W --the absolute velocity of the movement of the recoiling parts with free recoil;

$m = \frac{q}{g}$ --the mass of the projectile;

w --the absolute velocity of the movement of the projectile;

K --the amount of movement of the charge at the moment considered.

We shall take the hypothesis dealing with uniform distribution of the mass of burning and unburned parts of the charge in the initial air space and suppose that the velocity of the particles of the charge changes from W at the bottom of the bore to w at the bottom of the projectile, in accordance with the linear law. On the basis of the reasoning employed in deriving the expression (99) for the amount of movement of the charge in case of retarded recoil, we may obtain the following expression for the amount of movement of the charge in case of free recoil:

$$K = \mu \frac{w - W}{2}. \qquad (121)\ 92$$

Substituting this value of K in the equation for the amount of movement (120) we obtain

$$-M_0 W + mw + \mu \frac{w - W}{2} = 0$$

or

$$\left(M_0 + \frac{\mu}{2}\right) W = \left(m + \frac{\mu}{2}\right) w. \qquad (122)\ 92$$

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From equation (122) we obtain the following functional relationship between the velocity of the recoiling parts W with free recoil and the absolute velocity of the projectile in the period of movement along the bore:

$$W = \frac{m + 0,5\ \mu}{M_0 + 0,5\ \mu} w. \qquad (123)\ 92$$

Bearing in mind that the velocity of free recoil W is equal to the first derivative from the length of free recoil on the basis of time $\frac{dL}{dt}$, and that the absolute velocity of the projectile w is equal to the first derivative from the absolute path of the projectile x on the basis of time $\frac{dx}{dt}$ may write on the basis of expression (123):

$$dL = \frac{m + 0,5\ \mu}{M_0 + 0,5\ \mu} dx,$$

whence, by integrating the left and right parts in the limits from 0 to L and from 0 to X respectively, we obtain the following functional dependence of the path of the free recoil on the absolute path of the projectile:

$$L = \frac{m + 0,5\ \mu}{M_0 + 0,5\ \mu} x. \qquad (124)\ 92$$

In order to be able to make direct use of the results of the solution of the main problem of interior ballistics, which gives a connection between the relative paths and the relative velocities of the projectile, we introduce into expressions (123) and (124) the relative velocity v and relative path l (distance), instead of the absolute velocity of the projectile w and its absolute path x.

For this purpose we make use of the equations of mechanics connecting the elements of movement of a body in absolute and relative movements, applying these equations with respect to the charge:

$$w = v + (-W). \qquad (125)\ 93$$

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$$x = l + (-L).$$ (126) 93

By substituting in expression (123) for the velocity of free recoil the value of the absolute velocity of the projectile (125), we may write:

$$W = \frac{m + 0.5^{-}\mu}{M_0 + 0.5^{-}\mu}(v - W);$$

$$\frac{M + m + \mu}{M + 0.5^{-}\mu} W = \frac{m + 0.5^{-}\mu}{M + 0.5^{-}\mu} v,$$

whence we finally obtain:

$$W = \frac{m + 0.5^{-}\mu}{M + m + \mu} v.$$ (127) 93

Analogously, we may obtain the expression for the path of the free recoil L as a function of the relative path of the projectile l:

$$L = \frac{m + 0.5^{-}\mu}{M + m + \mu} l.$$ (128) 93

By substituting the masses of the respective weights, we obtain the following final expressions for the calculation:

$$W = \frac{q + 0.5^{-}\omega}{Q_0 + q + \omega} v$$ (129) 93

$$L = \frac{q + 0.5^{-}\omega}{Q_0 + q + \omega} l.$$ (130) 93

For the moment corresponding to the maximum pressure of the powder gases in the bore of the barrel p_m we have the following expression for the velocity and the path of the free recoil:

$$W_m = \frac{q + 0.5^{-}\omega}{Q_0 + q + \omega} v_m,$$ (131) 93

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$$L_m = \frac{q + 0{,}5\,\omega}{Q_0 + q + \omega}\, l_m . \qquad (132)\ 93$$

For the moment of departure of the projectile from the bore of the barrel we may write in a corresponding manner:

$$W_\partial = \frac{q + 0{,}5\,\omega}{Q_0 + q + \omega}\, v_\partial , \qquad (133)\ 94$$

$$L_\partial = \frac{q + 0{,}5\,\omega}{Q_0 + q + \omega}\, l_\partial . \qquad (134)\ 94$$

Here the index m designates the values corresponding to the moment of the maximum pressure of the powder gases in the bore, and the index ∂ the values corresponding to the moment of the departure of the projectile from the bore of the barrel.

Expressing the velocity of free recoil at the moment of departure of the projectile from the bore by the initial (absolute) velocity of the projectile v_0, we may write:

$$W_\partial = \frac{q + 0{,}5\,\omega}{Q_0 + 0{,}5\,\omega}\, v_0 \qquad (135)\ 94$$

or, neglecting the magnitude $0.5\,\omega$ in comparison with Q_0 in the denominator:

$$W_\partial = \frac{q + 0{,}5\,\omega}{Q_0}\, v_0 . \qquad (135a)\ 94$$

The duration of the first period of free recoil is equal to the time of the movement of the projectile along the bore t_∂.

2. Second period of free recoil.

a) The exponential law of change of the force P_{KH}. We shall now consider the method of determining the elements of movement of the recoiling

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parts in the second period of free recoil (the period of secondary action). For finding the elements of movement in the second period of the free recoil, we make direct use of the equation of free recoil:

$$\frac{Q_0}{g}\frac{d^2l}{d^2t} = P_{KH}, \qquad (136)\ 94$$

the two-fold integration of which gives the dependence of the velocity of the free recoil W and thepath of the free recoil L on the time.

For this purpose we substitute in the first part of equation (136) the value of force P_{KH}, determined in accordance with Prof. Bravin by the expression (119).

By substituting we may write:

$$\frac{Q_0}{g}\frac{d^2l}{d^2t} = P_0 e^{-\frac{t}{b}}. \qquad (137)\ 94$$

Bearing in mind that $\frac{d^2l}{d^2t} = \frac{dW}{dt}$ the equation (137) may be re-written as follows:

$$\frac{Q_0}{g}\frac{dW}{dt} = P_0 e^{-\frac{t}{b}}$$

or

$$dW = \frac{g}{Q_0} P_0 e^{-\frac{t}{b}} dt. \qquad (138)\ 95$$

By integrating the differential equation (138) in the limits from W_0 to W and from 0 to t, we obtain the following expression for the velocity of the free recoil in the period of the secondary action:

$$W = W_0 + \frac{g}{Q_0} P_0 b \left(1 - e^{-\frac{t}{b}}\right). \qquad (139)\ 95$$

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Bearing in mind that $W = \frac{dL}{dt}$ on the basis of the equation (139) we may write:

$$dL = W_0\,dt + \frac{g}{Q_0} P_0 b\left(1 - e^{-\frac{t}{b}}\right) dt. \qquad (140)\ 95$$

By integrating the differential equation (140) in the lirits from L_0 to L and from 0 to t, we obtain the following expression for the length of the free recoil in the period of the secondary action:

$$L = L_0 + W_0 t + \frac{g}{Q_0} P_0 b\left[t - b\left(1 - e^{-\frac{t}{b}}\right)\right]. \qquad (141)\ 95$$

In considering the free recoil in the period of the secondary action we shall usually be interested in the elements of movement of the recoiling parts at the end of this period, that is, for the moment of time $t = t'$, when the velocity of the free recoil reaches its maximum magnitude W_{max}.

Supposing that in formulas (139) and (141) $t = t'$, we shall have the following expression for the determination of the velocity of recoil W_{max} and the length of the free recoil L_K at the end of the second period:

$$W_{max} = W_0 + \frac{g}{Q_0} P_0 b\left(1 - e^{-\frac{t'}{b}}\right); \qquad (142)\ 95$$

$$L_K = L_0 + W_0 t' + \frac{g}{Q_0} P_0 b\left[t' - b\left(1 - e^{-\frac{t'}{b}}\right)\right]. \qquad (143)\ 95$$

As to formula (142) for the determination of the maximum velocity of the free recoil W_{max}, we will say that in practical calculations it is not used. In further theoretical derivations we shall use it as an auxiliary.

In practical calculations, however, and in investigations, we sue the empirical formula for W_{max} obtained from tests.

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$$W_{max} = \frac{g+\beta\omega}{Q_0} v_0, \qquad (144)\ 96$$

where β is the coefficient of the action of the powder gases, varying in rather wide limits, depending upon the conditions of loading.

Formula (144) may also be obtained theoretically, for which purpose we apply to the system recoiling parts — charge in the period of the secondary action the law of constancy of the amount of movement.

We shall suppose that at a certain moment of time the recoiling parts have a velocity W; that the powder gases escape from the bore of the barrel having a velocity U, and that the per second discharge of gases is equal to G.

During the elementary interval of time dt the following mass of gas excaped through the muzzle face of the barrel:

$$\frac{G}{g} dt = \varepsilon dt.$$

The increment of the amount of movement of this mass is equal to

$$U \varepsilon dt.$$

This amount of movement should be equal to the increment of movement of the recoiling parts, which, if we neglect the mass of gases still remaining in the bore, is expressed as follows:

$$\frac{Q_0}{g} dW.$$

Consequently, we have:

$$\frac{Q_0}{g} dW = U \varepsilon dt. \qquad (145)\ 96$$

Having integrated this equation in the limits from W_0 to W and from 0 to t, we obtain:

$$\frac{Q_0}{g}(W - W_0) = \int_0^t U \varepsilon dt$$

or

$$W = \frac{g}{Q_0} \int_0^t U \varepsilon dt + W_0 \qquad (146)\ 96$$

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For W_∂ we have the functional relationship (135a):

$$W_\partial = \frac{g + 0{,}5\,\omega}{Q_0}\, v_0 .$$

By substituting this value W_∂ in equation (146) we obtain:

$$W = \frac{g}{Q_0}\int_0^t U \varepsilon dt + \frac{g + 0{,}5\,\omega}{Q_0}\, v_0 . \qquad (147)\ 97$$

In the integrand of the expression of the right part of equation (147) we have U — the velocity of the escape of gases and ε the mass discharge persecond. The velocity U depends upon the pressure of the gases in the bore. The mass escape per second ε depends upon the velocity U, on the area of the cross-section of the bore, and on the density of the powder gases in the bore.

Bearing in mind that U and ε are certain functions of time, retaining their sign, we may, for the moment of the end of the period of secondary action, remove from under the sign of the integral the magnitudes ε and U with their mean (average) values. In this case we obtain:

$$W_{max} = \frac{g}{Q_0}\varepsilon_{cp} U_{cp} t' + \frac{g + 0{,}5\,\omega}{Q_0}\, v_0 ; \qquad (148)\ 97$$

but for the interval of time $t = t'$ we have:

$$\varepsilon_{cp} = \frac{\omega}{g t'} .$$

Hence, we may write:

$$W_{max} = \frac{\omega U_{cp}}{Q_0} + \frac{g + 0{,}5\,\omega}{Q_0}\, v_0 \qquad (149)\ 97$$

or, taking

$$U_{cp} = \gamma v_0 . \qquad (150)\ 97$$

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where γ is a certain coefficient.

$$W_{max} = \frac{g + (0,5 + \gamma)\omega}{Q_0} v_0. \qquad (151)\ 97$$

Designating

$$0,5 + \gamma = \beta,$$

we obtain

$$W_{max} = \frac{g + \beta\omega}{Q_0} v_0,$$

that is, the formula (144).

The coefficient γ, entering into the expression for coefficient β has a simple physical meaning -- it shows how many times the mean velocity of the escape of the powder gases exceeds the initial velocity of the projectile.

For the determination of the magnitude of the coefficient of action of the powder gases β there exist a number of theoretical and empirical formulas. Below we shall consider these functional relationships in detail. For the present, however, supposing the magnitude of the coefficient β to be known, we find the expression for the time of the secondary action t' and the parameter of the exponent function b.

Designating the pressure of the powder gases on the bottom of the bore at the end of the period of the secondary action by p_k, on the basis of formula (119) we may write:

$$sp_k = p_3 e^{-\frac{t'}{b}}; \qquad (152)\ 98$$

in practice the magnitude p_k may be taken equal to 2 kg/cm^2, which corresponds approximately to the critical relationship of the pressures.

Bearing in mind that $p_3 = sp_3$, we may obtain from equation (152):

$$\frac{p_k}{p_3} = e^{-\frac{t'}{b}}. \qquad (153)\ 98$$

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Above we obtained the following expression for determination of the velocity of the free recoil at the end of the period of the secondary action W_{max} and the lengths (path) of the free recoil $L_к$ corresponding to this:

$$W_{max} = W_д + \frac{g}{Q_0} P_д b \left(1 - e^{-\frac{t'}{b}}\right); \qquad (142)\ 98$$

$$L_к = L_д + W_д t' + \frac{g}{Q_0} P_д b \left[t' - b\left(1 - e^{-\frac{t'}{b}}\right)\right]. \qquad (143)\ 98$$

Substituting in these expressions the value $e^{-\frac{t'}{b}}$ from expression (153) and bearing in mind that $P_д = SP_д$, we may write the following expression for W_{max} and $L_к$:

$$W_{max} = W_д + \frac{g}{Q_0} b \left(P_д - SP_к\right); \qquad (142a)\ 98$$

$$L_к = L_д + W_д t' + \frac{g}{Q_0} b \left[P_д t' - b\left(P_д - SP_к\right)\right]. \qquad (143a)\ 98$$

The increment of the velocity of free recoil ΔW during the period of secondary action is:

$$\Delta W = W_{max} - W_д = \frac{g}{Q_0} b \left(P_д - SP_к\right). \qquad (154)\ 98$$

On the other hand, on the basis of the expression for the maximum velocity of free recoil (144) and the expression for the velocity of free recoil at the moment of the departure of the projectile from the bore of the barrel (135), we may write:

$$\Delta W = W_{max} - W_д = \frac{g + \beta\omega}{Q_0} v_0 - \frac{g + 0{,}5\omega}{Q_0} v_0$$

or

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$$\Delta W = \frac{(\beta - 0,5)\omega}{Q_0} v_0 . \qquad (155)\ 99$$

Equating the right parts of the equation (154) and (155) we obtain:

$$\frac{g}{Q_0} b(P_\partial - sP_K) = \frac{(\beta - 0,5)\omega}{Q_0} v_0$$

or

$$g b(P_\partial - sP_K) = \omega(\beta - 0,5) v_0 . \qquad (156)\ 99$$

Solving the "equality" (156) for the value b we obtain:

$$b = \frac{(\beta - 0,5)\omega v_0}{g(P_\partial - sP_K)} . \qquad (157)\ 99$$

Solving logarithmically the expression (153) we have:

$$-\frac{t'}{b} = \ln \frac{P_K}{P_\partial}$$

or

$$\frac{t'}{b} = 2,303 \lg \frac{P_\partial}{P_K} ,$$

from which we obtain the following expression for the determination of the duration of the period of secondary action:

$$t' = 2,303\, b \lg \frac{P_\partial}{P_K} \qquad (158)\ 99$$

The duration of the free recoil from the beginning of the movement of the recoiling parts until they reach their maximum velocity W_{max} is equal to:

$$t_K = t_\partial + t' . \qquad (159)\ 99$$

Hence, we obtain the following system of formulas for calculation of the elements of movement of the recoiling parts with free recoil in theperiod of

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the secondary action:

$$W = W_\partial + \frac{g}{Q_0} P_\partial b \left(1 - e^{-\frac{t}{b}}\right);$$

$$L = L_\partial + W_\partial t + \frac{g}{Q_0} P_\partial b \left[t - b\left(1 - e^{-\frac{t}{b}}\right)\right];$$

$$W_{max} = \frac{g + \beta\omega}{Q_0} v_0$$

or $$W_{max} = W_\partial + \frac{g}{Q_0} b \left(P_\partial - S P_K\right);$$

$$L_K = L_\partial + W_\partial t' + \frac{g}{Q_0} b \left[P_\partial t' - b\left(P_\partial - S P_K\right)\right];$$

$$t' = 2{,}303\, b \lg \left(\frac{P_\partial}{P_K}\right);$$

$$b = \frac{(\beta - 0{,}5)\omega v_0}{g\left(P_\partial - S P_K\right)};$$

$$t_K = t_\partial + t'.$$

(160) 100

It is appropriate to give a practical method for calculating the function $e^{-\frac{t}{b}}$, making unnecessary the employrent of tables.

Knowing the parameter b, we may take values of the time t, multiples of the parameter b, that is, take for the calculation $t = b$; $t = 2b$; $t = 3b$ etc.

Since with $t = b$ we have:

$$\left(e^{-\frac{t}{b}}\right)_1 = e^{-1} = \frac{1}{e} = \frac{1}{2{,}718},$$

Then with $t = 2b$ we have

$$\left(e^{-\frac{t}{b}}\right)_2 = e^{-2} = \frac{1}{e^2} = \frac{1}{(2{,}718)^2};$$

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with $t = 3b$

$$\left(e^{-\frac{t}{b}}\right)_3 = e^{-3} = \frac{1}{} = \frac{1}{(3,718)^3} \quad etc.$$

As concerns the finite value of the function $e^{-\frac{t}{b}}$, that is $e^{-\frac{t'}{b}}$, we will say that, as it follows from formula (147),

$$e^{-\frac{t'}{b}} = \frac{P_k}{P_0}.$$

b) the linear law of change of the force P_{KH}. If we take the linear law of the change of the force P_{KH} in the period of the secondary action in accordance with Durlyskhov-Vallier, that is, suppose that

$$P_{KH} = P_0\left(1 - \frac{t}{t'}\right), \qquad (161)\ 101$$

then the equation of the free recoil may be written in the following form:

$$\frac{Q_0}{g}\frac{d^2L}{dt^2} = P_0\left(1 - \frac{t}{t'}\right). \qquad (162)\ 101$$

or

$$\frac{Q_0}{g}\frac{dW}{dt} = P_0\left(1 - \frac{t}{t'}\right). \qquad (163)\ 101$$

From equation (163) we obtain:

$$dW = \frac{g}{Q_0} P_0\left(1 - \frac{t}{t'}\right)dt; \qquad (164)\ 101$$

by integrating equation (164) in the limits from W_0 to W and from 0 to t we have:

$$W - W_0 = \frac{g}{Q_0} P_0\left(t - \frac{t^2}{2t'}\right),$$

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whence

$$W = W_д + \frac{g}{Q_0} P_д \left(1 - \frac{t}{2t'}\right) t. \qquad (165)\ 101$$

Bearing in mind that $W = \frac{dL}{dt}$, we may write:

$$dL = W_д\, dt + \frac{g}{Q_0} P_д \left(t - \frac{t^2}{2t'}\right) dt. \qquad (166)\ 101$$

By integrating the equation (166) in the limits from L_0 to L and from 0 to t, we obtain:

$$L = L_д + W_д t + \frac{g}{Q_0} P_д \left(1 - \frac{t}{3t'}\right) \frac{t^2}{2}. \qquad (167)\ 101$$

For the moment of the end of the period of the secondary action $t = t'$, $W = W_{max}$ and $L = L_K$. On the basis of equations (166) and (167) we shall have:

$$W_{max} = W_д + \frac{g}{Q_0} P_д \frac{t'}{2}; \qquad (168)\ 101$$

$$L_K = L_д + W_д t' + \frac{g}{Q_0} P_д \frac{t'^2}{3} \qquad (169)\ 101$$

For the finding of the time t' we proceed in the following manner.

By transferring $W_д$ in equation (168) from the right part to the left we may write:

$$W_{max} - W_д = \frac{g}{Q_0} P_д \frac{t'}{2}. \qquad (170)\ 102$$

By substituting in the left part of the equation the value of W_{max} from formula (144) and $W_д$ from expression (135a), we obtain:

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$$\frac{g+\beta\omega}{Q_0}v_0 - \frac{g+0{,}5\omega}{Q_0}v_0 = \frac{gP_д}{2Q_0}t',$$

or

$$\omega(\beta-0{,}5)v_0 = \frac{gP_д}{2}t', \qquad (171)\ 102$$

from which

$$t' = \frac{2\omega(\beta-0{,}5)v_0}{gP_д}.$$

Hence, with the linear law of change of force P_{KH} in the period of the secondary action, we obtain the following system of formulas for the calculation of the elements of movement of the recoiling parts in the period of the secondary action:

$$\left.\begin{aligned} W &= W_д + \frac{g}{Q_0}P_д\left(1-\frac{t}{2t'}\right)t;\\ L &= L_д + W_д t + \frac{g}{Q_0}P_д\left(1-\frac{t}{3t'}\right)\frac{t^2}{2};\\ W_{max} &= \frac{g+\beta\omega}{Q_0}v_0;\\ L_K &= L_д + W_д t' + \frac{g}{Q_0}P_д\frac{t'^2}{3};\\ t' &= \frac{2\omega(\beta-0{,}5)v_0}{gP_д};\\ t_K &= t_д + t'. \end{aligned}\right\} \qquad (172)\ 102$$

Figure 37 gives the form of the curves of change of velocity and the lengths of free recoil, depending upon the time with the exponential and linear laws of change of the force P_{KH} during the period of the secondary action.

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Figure 37 (page 102)

4. COEFFICIENT OF ACTION OF THE POWDER GASES

1. Empiric Formulas.

The precision of the value W_{max} ascertained by formula (144) will depend upon the "reliability" of the value of the coefficient of the action of the powder gases β taken in the calculation.

For the determination of the value of the coefficient of action β there are a number of empiric formulas, as for example the French formula:

$$\beta = \frac{1300}{v_0}; \qquad (173)\ 103$$

the formula of the Krupp plants

$$\beta = 0{,}67\sqrt{\frac{g}{\omega}}; \qquad (174)\ 103$$

the formula ANII

$$\beta = 0{,}15 + \frac{1400}{v_0}. \qquad (175)\ 103$$

In connection with formula (174) we must say that it may be reduced to the same form as formulas (173) and (175), that is, to the form $\beta = a + \frac{b}{v_0}$, since the initial velocity of the projectile v_0 is a function of the relative weight of the charge $\frac{\omega}{g}$.

From a comparison of the empiric formulas cited it obviously follows that with one and the same conditions each of the formulas mentioned will give a value β different from those which will be obtained on the basis of the

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other formulas. Such a result is not a matter of chance, because each of the formulas, just as all empiric formulas, are correct within the limit of those conditions for which it was derived.

Hence, it is difficult to say which of these formulas is the best and which the worst. It would be more appropriate to evaluate the formula from the point of view as to whether or not it suits those conditions for which the problem is solved.

The basic weakness of the empiric formulas for β, determining the field of their application, is the fact that all of them represent β as a function of only one initial velocity v_0, whereas β is a complicated function not only of one initial velocity v_0 but of a number of other factors determining the condition of the gas at the moment of the departure of the projectile from the bore of the barrel.

2. Formula of V. E. Slukhotsky

The theoretical formulas for the determination of the coefficient β, derived on the basis of the theory of the escape of gases, taken into account to a sufficient degree the factors determining the value of the coefficient. Among such formulas we may point to the formula of V. E. Slukhotsky, which may be recommended for practical calculations, since it agrees well with experience. We shall give the formula of V. E. Slukhotsky without deriving it:

$$\beta = \left(\frac{k+1}{k}\right)\left(\frac{2}{k+1}\right)^{\frac{3}{2}} \frac{C_0}{v_0}; \qquad (176)\ 104$$

Here k is the exponent of the apolytrope;

$C_0 = \sqrt{gk\,\frac{P_0}{\gamma_0}}$ is the velocity of the propagation of sound in the gas under the pressure P_0.

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where g is the acceleration of the force of gravity;

$p_д$ --the muzzle pressure of the powder gases;

$\gamma_д$ --the density of the powder gases at the moment of departure of the projectile from the bore, equal to

$$\gamma_д = \frac{\omega}{W_0 + sl_д},$$

where S is the area of the cross section of the bore;

$l_д$ --the complete path (distance travelled) of the projectile along the bore;

W_0 --the volume of the powder chamber.

The formula of V. E. Slokhutsky may also be represented in this form:

$$\beta = \frac{A}{v_0}\sqrt{\frac{p_д \chi}{\Delta}}, \qquad (177)\ 104$$

where A is the coefficient depending upon the index of the polytrope ;

Δ --the density of the loading;

$\chi = \frac{W}{W_0}$ --the coefficient of the expansion, which shows how many times the total volume of the bore of the barrel is greater than the volume of the powder chamber.

From this formula we can see that the coefficient β is directly proportional to the square root of the muzzle pressure and the coefficient of expansion and inversely proportional to the initial velocity and the square root of the density of the charge.

For simplification of calculations on the basis of formula (177) we have drawn up Table 4 (below) of the values of β_τ for $v_0 = 600$ m/sec and $p_д = 600$ kg/cm^2 with different Δ and χ, which are the "entering" numbers of the table.

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VALUE OF COEFFICIENT β_χ FOR CASE $P_a = 600$ kg/cm^2 $V_0 = 600$ m/sec TABLE 4

χ \ Δ	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80
10.0	4.96	4.44	4.05	3.75	3.51	3.31	3.14	2.99	2.86	2.75	2.65	2.56	2.48
9.5	4.84	4.33	3.95	3.63	3.42	3.22	3.06	2.92	2.79	2.68	2.59	2.50	2.42
9.0	4.71	4.21	3.84	3.55	3.33	3.14	2.98	2.84	2.72	2.61	2.52	2.43	2.35
8.5	4.58	4.09	3.74	3.46	3.23	3.05	2.89	2.76	2.64	2.54	2.45	2.36	2.29
8.0	4.44	3.97	3.62	3.36	3.14	3.00	2.81	2.68	2.56	2.46	2.37	2.29	2.22
7.5	4.30	3.84	3.51	3.25	3.04	2.86	2.72	2.59	2.48	2.38	2.30	2.22	2.15
7.0	4.15	3.71	3.39	3.14	2.94	2.77	2.63	2.50	2.40	2.30	2.22	2.14	2.08
6.5	4.00	3.58	3.27	3.03	2.83	2.68	2.53	2.41	2.31	2.22	2.14	2.07	2.00
6.0	3.84	3.44	3.14	2.91	2.72	2.56	2.43	2.32	2.22	2.13	2.06	1.98	1.92
5.5	3.68	3.29	3.00	2.78	2.60	2.45	2.33	2.22	2.12	2.04	1.97	1.90	1.84
5.0	3.51	3.14	2.86	2.65	2.48	2.34	2.22	2.12	2.03	1.95	1.88	1.81	1.76
4.5	3.33	2.98	2.72	2.52	2.35	2.22	2.10	2.01	1.92	1.85	1.78	1.72	1.66
4.0	3.14	2.81	2.56	2.37	2.22	2.09	1.98	1.89	1.81	1.74	1.68	1.62	1.57
3.5	2.94	2.63	2.40	2.22	2.08	1.96	1.86	1.77	1.70	1.63	1.57	1.52	1.47

For finding the values of β it is necessary, on the basis of known Δ and χ to find from the table the value β_χ and then on the basis of the formula

$$\beta = \frac{21{,}5\sqrt{P_a}}{\tau}\beta_\chi$$

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to find the real value of β.

3. Formula of A. A. Tolochkov.

Another theoretically based formula for the determination of the coefficient of the action of the powder gases β is the formula of A. A. Tolochkov. We give its derivation.

The derivation of the formula boils down to the rational calculation of the integral $\int U_\varepsilon dt$, entering into the formula (147), and the integral

$$\int_0^t P_{KH}\, dt.$$

Figure 38 (page 106)

In the second period of the free recoil we have to deal with the escape of owder gases from the bore of the barrel.

In the movement of the powder gases in the bore of the barrel we may, for sake of simplification of the solution of the problem neglect the external forces acting on the gases, namely: the force of gravity, the force of friction against the walls of the barrel and, in addition to this, regard the movement of the particles of gas to be taking place in only one direction along the axis of the bore. We place the X - axis along the axis of the bore of the barrel, taking as positive the direction from the muzzle face to the bottom of the bore (Fig. 38).

We shall now consider a certain section of the bore located at a distance from the muzzle face. During an elementary interval of time dt there

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passes through this section a mass of gas $\varepsilon_x dt = \frac{\sigma_x}{g} dt$ with a velocity U_x.

While at a distance $x+dx$ from the muzzle face this mass of gases had a velocity

$$U_x + \frac{\partial U_x}{\partial x} dx.$$

Consequently, the increment of the amount of movement of this mass of gases in the interval of time dt, in the course of which it travels over the path dx will be

$$\varepsilon_x dt \frac{\partial U_x}{\partial x} dx,$$

and the increment of the amount of movement of all the masses of gases in the bore of the barrel during the time dt will be

$$\int_0^L \varepsilon_x dt \frac{\partial U_x}{\partial x} dx, \qquad (179)\ 107$$

where L is the length of the bore of the barrel.

For the calculation of the integral (172) we make the following assumption.

We shall suppose that the velocity of the particles of gas is expressed by a linear function of x of the form

$$U_x = U \frac{L-x}{L}, \qquad (180)\ 107$$

where U is the velocity of the gases at the muzzle face.

From the expression (180) we obtain:

$$\frac{\partial U_x}{\partial x} = \frac{U}{L}. \qquad (181)\ 107$$

Further, in order to take into account the unstable character of the escaping gases, we assume that the mass-second discharge ε_x is also a linear function of x, assuming that

$$\varepsilon_x = \varepsilon \frac{L-x}{L}, \qquad (182)\ 107$$

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where 6 is the mass-second discharge through the muzzle section of the bore.

From expressions (180) and (182) it follows that the greatest velocity and the greatest mass discharge (escape) will be in the muzzle section, while at the bottom of the bore the velocity and mass discharge will be equal to zero.

Substituting the values of $\frac{\partial u_x}{\partial x}$ (181) and ε_x (182) under the sign of the integral (179) we obtain:

$$\int_0^t \varepsilon_x dt \frac{\partial u_x}{\partial x} dx = -u_6 dt \int_0^t \frac{L-x}{L^2} dx = -\frac{\varepsilon u dt}{2}. \quad (183)\ 107$$

Assuming the process of escape to be aliabatic, we shall have the equation of the condition of the gas in the following form:

$$\left(\frac{p}{p_0}\right)^{\frac{1}{k}} = \frac{w}{w_0}, \quad (184)\ 107$$

where p_0 and w_0 --are the pressures and the specific volume respectively at the moment of the departure of the projectile from the bore of the barrel;

p and w --these same values at a certain moment of time t.

Bearing in mind that the specific volume is inversely proportional to the mass of the gas in the bore of the barrel at the given moment, the equation (184) may be rewritten in the following form:

$$\left(\frac{p}{p_0}\right)^{\frac{1}{k}} = \frac{\mu - \int_0^t \varepsilon dt}{\mu}, \quad (185)\ 108$$

where μ is the mass of the charge;

$\int_0^t \varepsilon dt$ --the mass of the powder gases of the charge, escaping at the moment t considered.

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By differentiating the equation (185) we may write:

$$d\left[\left(\frac{P}{P_э}\right)\right]^{\frac{1}{k}} = -\frac{\varepsilon dt}{\mu}, \qquad (186)\ 108$$

whence

$$\varepsilon dt = -\frac{\mu}{k} P_э^{-\frac{1}{k}} P^{\frac{1-k}{k}} dp. \qquad (186)\ 108$$

On the other hand, if we suppose that after escaping from the muzzle face the gases expand to atmospheric pressure, then the velocity of the gases at the muzzle face may be expressed by the formula of St. Benain:

$$U = \sqrt{\frac{2gk}{k-1} P_a w_a \left[\left(\frac{P}{P_a}\right)^{\frac{k-1}{k}} - 1\right]} =$$

$$= \sqrt{gkp_a w_a} \sqrt{\frac{2}{k-1}\left[\left(\frac{P}{P_a}\right)^{\frac{k-1}{k}} - 1\right]}. \qquad (187)\ 108$$

Hence, the expression for the increment of the amount of movement of all the mass of gases during a moment of time dt equal in absolute value to the elementary impulse of the force $P_{кн}$, may be written in the following form:

$$dl = \frac{\omega U dt}{2} = -\frac{\omega}{2g} \frac{P_a}{k}^{-\frac{1}{k}} P^{\frac{1-k}{k}} dP \times$$

$$\times \sqrt{gkP_a w_a} \sqrt{\frac{2}{k-1}} \sqrt{\left(\frac{P}{P_a}\right)^{\frac{k-1}{k}} - 1};$$

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$$dI = -\frac{\omega}{2g}\,\frac{P_\partial}{k}^{-\frac{1}{k}}\sqrt{\frac{2}{k-1}}\sqrt{P^{\frac{k-1}{k}} - P_a^{\frac{k-1}{k}}}\times$$

$$\times\sqrt{P_a^{\frac{k-1}{k}}}\sqrt{\frac{2g}{k(k-1)}\,P_a^{\frac{1}{k}}\,w'_a}\,. \qquad (188)\ 109$$

Neglecting, in view of its small value, the magnitude $P_a^{\frac{1-k}{k}}$ under the sign of the radical, the expression (188) may be written as follows:

$$dI = -BP^{\frac{k-1}{k}}P^{\frac{1-k}{k}}\,dP = -BP^{\frac{1-}{2k}}\,dP,$$

where

$$B = \frac{\omega}{2g}\,P_\partial^{-\frac{1}{k}}\sqrt{\frac{2g}{k(k-1)}\,P_a^{\frac{1}{k}}\,w'_a} \qquad (189)\ 109$$

Bearing in mind that the increment of the amount of movement of the recoiling parts in the period of the secondary action of the gases is equal to the full impulse of the force P_{KH} during this same period, that is,

$$\frac{Q_0}{g}(W_{max} - W_\partial) = \int dI = I_{II},$$

and by integrating the right side of equation (189) in the limits $P = P_\partial$ to $P = P_a$, we obtain:

$$\frac{Q_0}{g}(W_{max} - W_\partial) = -B\int_{P_a}^{P} P^{\frac{1-k}{2k}}\,dP = \frac{2k}{k+1}B\left(P_\partial^{\frac{k+1}{2k}} - P_a^{\frac{k+1}{2k}}\right)$$

or, neglecting the value $P_a^{\frac{k+1}{2k}}$ in comparison with the value $P_\partial^{\frac{k+1}{2k}}$:

$$\frac{Q_0}{g}(W_{max} - W_\partial) = \frac{2k}{k+1}BP_\partial^{\frac{k+1}{2k}}. \qquad (190)\ 109$$

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By substituting in equation (190) the value of the coefficient B, we shall have:

$$Q_0(W_{max}-W_0)=\frac{\omega}{k+1}\sqrt{\frac{2kP_0(gw_0)}{k-1}} \qquad (191)\ 109$$

Since on the basis of expression (156)

$$W_{max}-W_0=\Delta W=\frac{(\beta-0.5)\omega}{Q_0}v_0,$$

the equation (191) may be written in the following form:

$$(\beta-0.5)v_0=\frac{1}{k+1}\sqrt{\frac{2k}{k-1}P_0(gw_0)},$$

whence we obtain the final expression for the coefficient of action of the gases β in accordance with A. A. Tolochkov:

$$\beta=0.5+\frac{\sqrt{2k}}{(k+1)\sqrt{k-1}}\cdot\frac{1}{v_0}\sqrt{P_0(gw_0)} \qquad (192)\ 110$$

(The author represents by v_{01} the specific volume of powder gases corresponding to a unit mass.)

For convenience of practical calculations we transform the second member of the expression (192).

The specific volume of the powder gases at the moment of the departure of the projectile from the bore of the barrel may be represented as follows:

$$w_0=\frac{W_c+W_0}{\omega}=s\frac{(l_0+l_0)}{\omega}=\frac{\left(1+\frac{l_0}{l_0}\right)}{\frac{l_0}{\omega}}=\frac{1+\lambda_0}{\Delta}$$

Applying the factor $\sqrt{g}$ to the coefficient in the second member, the expression (192) may be written as follows:

$$\beta=0.5+\frac{\sqrt{2gk}}{(k+1)\sqrt{k-1}}\frac{1}{v_0}\sqrt{\frac{P_0(\varphi+\lambda_0)}{\Delta}}$$

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If in the calculation we assume the following dimensions: for P_∂ — kg/cm²; for Δ — kg/dm³; for v_0 — m/sec, for g — dm/sec², the final expression for β may be represented in the following form:

$$\beta = 0.5^\circ + A \frac{1}{v_0} \sqrt{P_\partial (1 + \lambda_\partial)} \qquad (193)\ 110$$

where

$$A = \frac{\sqrt{2gk}}{(k+1)\sqrt{k-1}}.$$

VALUES OF COEFFICIENT A TABLE 5

k	A
1.20	15.6
1.25	13.9
1.30	12.7
1.35	11.6
1.40	10.9

The values of coefficient A with $g = 98.1$ dm/sec and the different values of the index of the polytrope k are given in Table 5.

In the employment of formula (193) for different systems it is necessary to take into account the relationship between the volume occupied by the gases at the moment of the departure and the surface of this volume, because the value of the index of the polytrope k depends on this relationship. For guns of high power ($v_0 > 600$ m/sec) we may take $k = 1.3 \div 1.35$, and for guns of small power ($v_0 < 600$ m/sec) $k = 1.25 - 1.30$. For mortars we may take $k = 1.2$.

5. RETARDED (EFFECTIVE) RECOIL.

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1. General Considerations.

In present-day artillery weapons the force of resistance to recoil R_{max} is made up of 1/40 to 1/30 of the force $P_{KH\ max}$, reaching the greatest values with short recoils.

In the first period of retarded recoil the movement of the recoiling parts takes place under the action of the resultant of two forces -- the force P_{KH} and the force of resistance to recoil R, and in the greater part of the first period the movement of the recoiling parts will be accelerated.

At the moment when the driving force -- P_{KH} and the braking force -- R become equal in value, the recoiling parts will have their maximum velocity, as follows from the equation of retarded recoil:

$$\frac{q_0}{g}\frac{d^2x}{dt^2} = P_{KH} - R.$$

Beginning with this moment and up until the end of the recoil, the movement of the recoiling parts will be retarded.

In the second period of the retarded recoil the movement of the recoiling parts takes place exclusively under the action of the force of resistance to recoil R.

The movement of the recoiling parts continues until the kinetic energy of the recoiling parts, accumulated in the first period of the recoil, is absorbed by the work of the force of resistance or, in other words, until the velocity of recoil returns to zero.

The distance travelled by the recoiling parts during the time from the beginning of the recoil up to the moment of stopping is called the length of the recoil and is designated by λ.

As we ascertained earlier, the force of resistance to recoil (or the combined force of resistance to recoil) R, the retarded recoil, is the resultant of the following forces:

R_f --the force of friction on the "guiding cradles" and in the packing mechanisms of the recoil brake and the counter-recoil mechanism;

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Π --the force of resistance of the counter-recoil mechanism;

Φ --the force of resistance of the recoil brake;

$Q_0 \sin\varphi$ --the axial component of the weight of the recoiling parts, that is,

$$R = \Phi + \Pi + R_f - Q_0 \sin\varphi.$$

The law of change of the force R may be selected, generally speaking, arbitrarily. The most natural braking is braking with a constant force over all the length of the recoil. In reality, taking into account the fact that the energy of the recoiling parts should be absorbed by the work of the force of resistance R, and, bearing in mind that the work of the force of resistance R is expressed by the area of the diagram $R = f(x)$, it follows from the simple geometric considerations that with a given length of recoil λ the braking force, the total load on the carriage and the other dimensions of the parts will be a minimum with R = const.

Figure 39 (page 112)

In stationary artillery mounts and in field artillery weapons firing under high angles of elevation (short recoil), when the stability of the gun is known to be assured, the braking of the recoil is calculated in this way (Figure 39).

In field (not fixed in position) artillery weapons, for assuring stability with a given weight of the system, a more rational method is to brake with constant force, in conformity with the change in the stability of the system during recoil

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In the first period of the recoil it would be advantageous, as a rule, to dispense with braking, that is, to employ free recoil, which would make possible an increase in the stability and an improvement in the accuracy of fire of the weapon. In practice, however, it is not possible to employ free recoil, because in addition to the force of friction in the guiding parts and packing arrangements, and also the force of resistance of the counter-recoil, the recoil will be braked by a hydraulic brake even when it is not desinged for it, excepting the case of an incomplete filling with liquid (sic).

As we shall show later on, the resistance of a hydraulic brake is increased with an increase in the velocity of recoil and with a decrease in the openings for the forcing out of the liquid. However, it would be impossible from the standpoint of construction to make openings of such dimensions that with the velocities of recoil taking place in the first period of the recoil the resistance would not be considerable.

As a result of the conditions summerated, the most rational scheme of braking the recoil in field artillery weapons is that kind in which the resistance to recoil in the first period of recoil is increased from a certain minimum value, greater than the initial force of the counter-recoil, up to the maximum, beginning with which, in the second period of the recoil, it decreases in conformity with the decrease in stability of the gun during recoil (Figure 40).

Sometimes, with the arm of the dynamic couple $e = 0$, for the purpose of decreasing the length of recoil λ it will be advantageous to effect the braking in the first period of the recoil with a constant force of resistance, decreasing it in the second period in conformity with the stability of the gun (Figure 40).

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Figure 40 (Page 113)

The law which we have selected for the change in the force of resistance to recoil R is applied by effecting a change in the force of resistance of the recoil brake ϕ_0 such that with the given values of II, R_f and $Q_0 \sin\varphi$ the following conditions will be observed for any values of the length of recoil x :

$$\phi_0 = R - II - R_f + Q_0 \sin\varphi. \qquad (194)\ 113$$

For observing the conditions (meeting the requirements) (194) in the calculation of the recoil brake it is necessary to know the elements of movement of the recoiling parts in the law of braking selected. To this problem we shall devote the rest of the present section.

2. The Determination of the Elements of Retarded Recoil for the Period of the Movement of the Projectile Along the Bore.

We make use of the law of the conservation of the amount of movement just as in the determination of the elements of free recoil.

Noting that before the shot the system of recoiling parts — projectile — charge is in a state of rest, and bearing in mind that on the basis of the relationship to the system considered the force P_{KH} is an internal force, and the force of resistance to recoil R is an external force, we shall see that, on the basis of the law of the conservation of the amount of movement, the sum of the amount of movement of the recoiling parts, charge and projectile, during the time of the movement of the projectile along the bore, willbe equal to the impulse of the external force R, that is,

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$$-M_0V + mw + K = \int_0^t R\,dt, \qquad (195)\ 113$$

where V is the velocity of the retarded recoil.

By replacing in equation (195) the absolute velocity of the projectile w by its expression depending upon the relative velocity of the projectile v and the velocity of the recoil V

$$w = v + (-V) = v - V$$

and taking, on the basis of the considerations given above (see Section 2, pages 84 and 85), the expression for the amount of movement of the charge in the form

$$K = \mu\,\frac{w-V}{2} = \mu\,\frac{v-2V}{2},$$

the equation (195) may be rewritten in the following form:

$$-M_0V + m(v-V) + \mu\,\frac{v-2V}{2} = \int_0^t R\,dt$$

or

$$(M_0 + m + \mu)V = (m + 0.5\mu)v - \int_0^t R\,dt, \qquad (196)\ 114$$

or from which we obtain the following expression for the velocity of the retarded recoil:

$$V = \frac{m+0.5\mu}{M_0+m+\mu}\,v - \frac{1}{M_0+m+\mu}\int_0^t R\,dt. \qquad (197)\ 114$$

Bearing in mind that $V = \frac{dX}{dt}$ and $v = \frac{dl}{dt}$ we may write on the basis of the expression (196):

$$dX = \frac{m+0.5\mu}{M_0+m+\mu}\,dl - \frac{1}{M_0+m+\mu}\,dt\int_0^t R\,dt \qquad (198)\ 114$$

Integrating the equation (198) in the appropriate limits, we obtain the

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following expression for the path (length) of retarded recoil:

$$X = \frac{m + 0.5\mu}{M_0 + m + \mu} l - \frac{1}{M_0 + m + \mu} \int_0^t dt \int_0^t R\, dt. \qquad (199)\ 114$$

Since the masses are proportional to the corresponding weights, the expressions for the velocity and path of retarded recoil may be written in the following form:

$$V = \frac{q + 0.5\omega}{Q_0 + q + \omega} v - \frac{g}{Q_0 + q + \omega} \int_0^t R\, dt; \qquad (200)\ 114$$

$$X = \frac{q + 0.5\omega}{Q_0 + q + \omega} l - \frac{g}{Q_0 + q + \omega} \int_0^t dt \int_0^t R\, dt. \qquad (201)\ 114$$

But $\frac{q + 0.5\omega}{Q_0 + q + \omega} v = W$ — the velocity of free recoil and $\frac{q + 0.5\omega}{Q_0 + q + \omega} l = L$ — the path of free recoil; consequently, for the period of movement of the projectile along the bore of the barrel we finally obtain the following expressions for determination of the velocity and paths of the retarded recoil:

$$V = W - \frac{1}{M_0'} \int_0^t R\, dt, \qquad (202)\ 115$$

$$X = L - \frac{1}{M_0'} \int_0^t dt \int_0^t R\, dt, \qquad (203)\ 115$$

where

$$M_0' = \frac{Q_0 + q + \omega}{g}$$

At first glance it seems that the transition from expressions (202) or (203) to the equation of movement of retarded recoil does not lead to its usual form:

$$\frac{Q_0}{g} \frac{d^2X}{dt^2} = P_{KH} - R.$$

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We shall show that the expression for the velocity of retarded recoil (202) or the expression for the length of retarded recoil (203) may be obtained directly from the equation for the movement of retarded recoil.

In reality, bearing in mind that

$$P_{KH} = sp_{KH} - k_{HP}\, sp_{CH} \quad \text{and} \quad sp_{CH}(1-k_{HP}) = m\frac{dw}{dt},$$

and substituting the right part of expression (105) in the equation of the movement of retarded recoil, we may write:

$$M_0 \frac{dV}{dt} = \frac{1}{1+0.5\frac{\mu}{M_0}}\left[\left(1+0.5\frac{\mu}{m}\right)m\frac{dw}{dt} - R\right]$$

or

$$(M_0+0.5\mu)\,dV = (m+0.5\mu)\,dw - R\,dt.$$

By integrating the left and right sides in the corresponding limits we shall have

$$(M_0+0.5\mu)V = (m+0.5\mu)w - \int_0^t R\,dt$$

or, bearing in mind that

$$w = v - V,$$

$$(M_0+m+\mu)V = (m+0.5\mu)v - \int_0^t R\,dt,$$

whence

$$V = \frac{m+0.5\mu}{M_0+m+\mu}v - \frac{1}{M_0+m+\mu}\int_0^t R\,dt$$

or

$$V = W - \frac{1}{M_0'}\int_0^t R\,dt.$$

If in the derivation of the formulas establishing relationship between the elements of the free recoil and the retarded recoil we start directly from

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the equation of the retarded recoil

$$M_0 \frac{d^2X}{dt^2} = P_{KH} - R,$$

then, after a twofold integration of it, we may write:

$$V = \frac{1}{M_0}\int_0^t P_{KH}\,dt - \frac{1}{M_0}\int_0^t R\,dt;$$

$$X = \frac{1}{M_0}\int_0^t dt\int_0^t P_{KH}\,dt - \frac{1}{M_0}\int_0^t dt\int_0^t R\,dt.$$

In a special case when $R = 0$:

$$W = \frac{1}{M_0}\int_0^t P_{KH}\,dt,$$

$$X = \frac{1}{M_0}\int_0^t dt\int_0^t P_{KH}\,dt$$

and, consequently,

$$V = W - \frac{1}{M_0}\int_0^t R\,dt \qquad (202a)\ 116$$

and

$$X = L - \frac{1}{M_0}\int_0^t dt\int_0^t R\,dt. \qquad (203a)\ 116$$

The expressions obtained for V and X may be extended to all the period of action of the powder gases for transition from the elements of free recoil to the elements of retarded recoil.

In the literature dealing with the theory of carriages these expressions are known under the name "transition formulas".

From now on we shall make use of the transition formulas in the derivation of the approximate relationships for the purpose of simplifying our deductions.

The way in which formulas (202) and (203) differ from transition formulas (202a) and (203a) consists in the value of the coefficient with the second

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member; in the transition formulas it is equal to $\frac{g}{Q_0} = \frac{1}{M_0}$. This same value of the coefficient may also be used in formulas (202) and (203) if we assume that the values g and ω are negligibly small in comparison with the value Q_0. Such an assumption for the value ω is fully acceptable under ordinary conditions, both for guns and for mortars. As concerns the value g we will say that this assumption would be rather "rough" and would distort the true values of the elements of retarded recoil.

3. The Determination of the Elements of Retarded Recoil for the Period of the Secondary Action of the Gases.

For finding the elements of movement of the recoiling parts in retarded recoil in the period of the secondary action of the powder gases, we make direct use of the equation of movement of retarded recoil, which, bearing in mind that $\frac{d^2X}{dt^2} = \frac{dV}{dt}$, may be written in the following form:

$$M_0 \frac{dV}{dt} = P_{KH} - R. \qquad (204)\ 117$$

On the basis of the equation of movement (204) we may write the differential equation for the determination of the velocity of retarded recoil:

$$dV = \frac{1}{M_0} P_{KH}\, dt - \frac{1}{M_0} R\, dt. \qquad (205)\ 117$$

Taking as the starting point for the recording of time the beginning of the period of secondary action and integrating equation (205) in the limits from V_∂ to V and from 0 to t we obtain:

$$V = V_\partial + \frac{1}{M_0}\int_0^t P_{KH}\, dt - \frac{1}{M_0}\int_0^t R\, dt \qquad (206)\ 117$$

Bearing in mind that $V = \frac{dX}{dt}$, then on the basis of expression (206) we may write the following equation for the determination of the length of

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retarded recoil:

$$dX = V_0\,dt + \frac{1}{M_0}\,dt\int_0^t P_{KH}\,dt - \frac{1}{M_0}\,dt\int_0^t R\,dt. \qquad (207)\ 118$$

Integrating the equation (207) in the limits from X_0 to X and from 0 to t we obtain:

$$X = X_0 + V_0 t + \frac{1}{M_0}\int_0^t dt\int_0^t P_{KH}\,dt - \frac{1}{M_0}\int_0^t dt\int_0^t R\,dt. \qquad (208)\ 118$$

According to Professor Bravin, with the exponential law of change of the force P_{KH} in the period of the secondary action, that is supposing

$$P_{KH} = P_0 e^{-\frac{t}{b}},$$

we have:

$$\int_0^t P_{KH}\,dt = P_0\int_0^t e^{-\frac{t}{b}}\,dt = P_0 b\left(1 - e^{-\frac{t}{b}}\right); \qquad (209)\ 118$$

$$\int_0^t dt\int_0^t P_{KH}\,dt = P_0\int_0^t dt\int_0^t e^{-\frac{t}{b}}\,dt = P_0 b\left[t - b\left(1 - e^{-\frac{t}{b}}\right)\right]. \qquad (210)\ 118$$

Consequently, for the path and velocity of retarded recoil in the period of the secondary action we obtain the following expression

$$V = V_0 + \frac{1}{M_0}P_0 b\left(1 - e^{-\frac{t}{b}}\right) - \frac{1}{M_0}\int_0^t R\,dt; \qquad (211)\ 118$$

$$X = X_0 + V_0 t + \frac{1}{M_0}P_0 b\left[t - b\left(1 - e^{-\frac{t}{b}}\right)\right] - \frac{1}{M_0}\int_0^t dt\int_0^t R\,dt. \qquad (212)\ 118$$

With the linear law of change of the force P_{KH} in the period of the secondary action, according to Durlyakhov-Vallier, that is, supposing

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$$P_{KH} = P_0\left(1-\frac{t}{t'}\right),$$

we have:

$$\int_0^t P_{KH}\,dt = P_0\int_0^t\left(1-\frac{t}{t'}\right)dt = P_0\left(1-\frac{t}{2t'}\right)t; \qquad (213)\ 118$$

$$\int_0^t dt\int_0^t P_{KH}\,dt = P_0\int_0^t dt\int_0^t\left(1-\frac{t}{t'}\right)dt = P_0\left(1-\frac{t}{3t'}\right)\frac{t^2}{2}. \qquad (214)\ 118$$

After the substitution of the values of the integrals (213) and (214) in the expressions (207) and (208), we obtain the following functional relationship for the length and velocity of the retarded recoil in the period of the secondary action with the linear law of change of the force P_{KH} in accordance with Durlyakhov-Vallier:

$$V = V_0 + \frac{1}{M_0}P_0\left(1-\frac{t}{2t'}\right)t - \frac{1}{M_0}\int_0^t R\,dt; \qquad (215)\ 119$$

$$X = X_0 + V_0 t + \frac{1}{M_0}P_0\left(1-\frac{t}{3t'}\right)\frac{t^2}{2} - \frac{1}{M_0}\int_0^t dt\int_0^t R\,dt. \qquad (216)\ 119$$

4. Braking with a Constant Force the Resistance to Recoil (R = const.)

a) First period of recoil. In the given case the integrals of the lost members of the expressions for velocity of the retarded recoil in the first period (206), (211), and (215) and of the expression for the length of retarded recoil in the first period (203), (212), and (216) will be:

$$\int_0^t R\,dt = Rt; \qquad (217)\ 119$$

$$\int_0^t dt\int_0^t R\,dt = R\frac{t^2}{2}. \qquad (218)\ 119$$

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Substituting these expressions of the integrals in the formulas for velocity (202) and for the length (203) of retarded recoil in the period of movement of the projectile along the bore we obtain:

$$V = W - \frac{1}{M_0'} Rt; \qquad (219)\ 119$$

$$X = L - \frac{1}{M_0'} R\frac{t^2}{2}. \qquad (220)\ 119$$

whence:

for the moment of time $t = t_m$ ($P_{KH} = P_{KH\,max}$):

$$V_m = W_m - \frac{1}{M_0'} Rt_m; \qquad (221)\ 119$$

$$X_m = L_m - \frac{1}{M_0'} R\frac{t_m^2}{2}; \qquad (222)\ 119$$

for the moment of the departure of the projectile from the bore of the barrel ($t = t_д$):

$$V_д = W_д - \frac{1}{M_0'} Rt_д; \qquad (223)\ 120$$

$$X_д = L_д - \frac{1}{M_0'} R\frac{t_д^2}{2}. \qquad (224)\ 120$$

Substituting the values of the integrals (217) and (218) in the expressions for the velocity of retarded recoil in the period of the secondary action (211) and the path of retarded recoil in the period of secondary action (212) we shall have with the exponential law of the change of the force P_{KH}:

$$V = V_д + \frac{1}{M_0} P_д b\left(1 - e^{-\frac{t}{b}}\right) - \frac{1}{M_0} Rt; \qquad (225)\ 120$$

$$X = X_д + V_д t + \frac{1}{M_0} P_д b\left[t - b\left(1 - e^{-\frac{t}{b}}\right)\right] - \frac{1}{M_0} R\frac{t^2}{2}. \qquad (226)\ 120$$

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By making the corresponding substitution in the expressions for the velocity of retarded recoil in the period of the secondary action (215) and path of the retarded recoil in the period of the secondary action (216), we may write with the linear law of change of the force P_{KH}:

$$V = V_д + \frac{1}{M_0} P_д \left(1 - \frac{t}{2t'}\right) t - \frac{1}{M_0} R t ; \qquad (227)\ 120$$

$$X = X_д + V_д t + \frac{1}{2M_0} P_д \left(1 - \frac{t}{3t'}\right) t^2 - \frac{1}{2M_0} R t^2 . \qquad (228)\ 120$$

We find the elements of movement of the recoiling parts at the end of the period of the secondary action (the end of the first period) by substituting in expressions (225), (226), (227) and (228) $t = t'$.

With the exponential law of change of the force P_{KH}, for velocity and length of retarded recoil at the end of the first period, we shall have the expressions:

$$V_k = V_д + \frac{1}{M_0} P_д b \left(1 - e^{-\frac{t'}{b}}\right) - \frac{1}{M_0} R t' ; \qquad (229)\ 120$$

$$X_k = X_д + V_д t' + \frac{1}{M_0} P_д b \left[t' - b\left(1 - e^{-\frac{t'}{b}}\right)\right] - \frac{1}{2M_0} R t'^2 \qquad (230)\ 120$$

or, bearing in mind that in accordance with equality (153)

$$e^{-\frac{t'}{b}} = \frac{P_k}{P_д} ,$$

$$V_k = V_д + \frac{1}{M_0}\left[b(P_д - sP_k) - R t'\right] ; \qquad (231)\ 120$$

$$X_k = X_д + V_д t' + \frac{1}{M_0}\left\{b\left[P_д t' - b(P_д - sP_k)\right] - R\frac{t'^2}{2}\right\} , \qquad (232)\ 120$$

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where

$$t' = 2.303\, b \lg \frac{P_\partial}{P_K};$$

$$b = \frac{(\beta - 0.5)\omega v_0}{g(P_\partial - sP_K)}.$$

With the linear law of change of the force P_{KH} we have the following expression for the velocity and length retarded recoil at the end of the first period:

$$V_K = V_\partial + \frac{1}{M_0}\left(\frac{P_\partial}{2} - R\right)t'; \qquad (233)\ 121$$

$$X_K = X_\partial + V_\partial t' + \frac{1}{M_0}\left(\frac{P_\partial}{3} - \frac{R}{2}\right)t'^2, \qquad (234)\ 121$$

where

$$t' = \frac{2\omega(\beta - 0.5)v_0}{gP_\partial}.$$

The maximum velocity of the retarded recoil V_{max} will be reached in the period of the secondary action only when we have the relationship $P_\partial \geqq R$ — const. The reverse relationship, that is, $P_\partial < R$, may exist with short recoils (relatively greater than R) and with small muzzle pressure (Figure 41).

Figure 41 (Page 121)

With $P_\partial \geqq R$ the maximum velocity of the retarded recoil will be reached after a certain interval of time θ_1, counted from the beginning of the

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period of the secondary action, when we shall have the equality: $P_{KH} = R$.

For this moment we have:

$$M_0 \frac{d^2X}{dt^2} = P_{KH} - R = 0$$

or, with the exponential law of change of the force P_{KH} in the period of the secondary action:

$$P_\partial e^{-\frac{\theta}{b}} = R. \qquad (235)\ 121$$

Solving equation (235) for the value θ_1 we obtain

$$\theta_1 = 2.303\, b \lg \frac{P_\partial}{R}. \qquad (236)\ 122$$

Hence, for the maximum velocity of the retarded recoil we obtain the expression:

$$V_{max} = V_\partial + \frac{1}{M_0} P_\partial b \left(1 - e^{-\frac{\theta_1}{b}}\right) - \frac{1}{M_0} R\theta_1$$

or, bearing in mind that

$$P_{KH} = R = P_\partial e^{-\frac{\theta_1}{b}}$$

and

$$\frac{R}{P_\partial} = e^{-\frac{\theta_1}{b}},$$

$$V_{max} = V_\partial + \frac{1}{M_0} b(P_\partial - R) - \frac{1}{M_0} R\theta_1$$

or, finally:

$$V_{max} = V_\partial + \frac{1}{M_0}\left[bP_\partial - (b + \theta_1) R\right]. \qquad (237)\ 122$$

For the length up to the moment the recoiling parts reach the maximum velocity with retarded recoil on the basis of formula (226) we have the expression:

$$X_R = X_\partial + V_\partial \theta_1 + \frac{1}{M_0} P_\partial b\left[\theta_1 - b\left(1 - e^{-\frac{\theta_1}{b}}\right)\right] - \frac{1}{2M_0} P\theta_1^2$$

or, after substitution of the value $e^{-\frac{\theta_1}{b}}$ and the elementary transformations:

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$$X_R = X_\partial + V_\partial \theta_1 + \frac{1}{M_0}\left[P_\partial b(\theta_1 - b) + R\left(b^2 - \frac{\theta_1^2}{2}\right)\right].$$

(238) 122

In case $P_\partial < R$ the maximum velocity of the retarded recoil will take place in the interval of time from $t = t_m$ to $t = t_\partial$. The time θ_1 is found on the curve $P_{KH} = f(t)$ corresponding to the ordinate $P_{KH} = R = \text{const}$. On the basis of time we determine the corresponding velocity of the projectile v_1 and the corresponding path (length of travel) of the projectile l_1.

Knowing the velocity of the projectile v_1, the path (length of travel) of the projectile l_1 and the time θ_1, the maximum velocity of retarded recoil and the distance traveled by the recoiling parts corresponding to this velocity, are determined from the functional relationships for the period of the movement of the projectile along the bore (129) and (130):

$$V_{max} = W_1 - \frac{1}{M_0} R\theta_1;$$

$$X_R = L_1 - \frac{1}{M_0} R\frac{\theta_1^2}{2},$$

where

$$W_1 = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_1;$$

$$L_1 = \frac{q + 0.5\omega}{Q_0 + q + \omega} l_1.$$

With the linear law of change of force P_{KH} in the period of the secondary action, for the determination of θ_1 we shall have the equation (Fig. 42):

$$R_\partial\left(1 - \frac{\theta_1}{t'}\right) - R = 0,$$

whence we find:

$$\theta_1 = \frac{P_\partial - R}{R_\partial} t'$$

(239) 123

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Figure 42 (Page 123)

By substituting in the general expression for the velocity of retarded recoil in the period of the secondary action we may set:

$$V_{max} = V_0 + \frac{1}{M_0} P_0 \left(1 - \frac{\theta_1}{2t'}\right)\theta_1 - \frac{1}{M_0} R\theta_1. \quad (240)\ 123$$

By eliminating from expression (240) the length of the period of secondary action t', after the elementary transformations, we obtain:

$$V_{max} = V_0 + \frac{1}{M_0}\theta_1 \frac{P_0 - R}{2}, \quad (241)\ 123$$

where

$$\theta_1 = \frac{P_0 - R}{P_0} t'.$$

Substituting in the general expression for the length of retarded recoil in the period of secondary action $t = \theta_1$, we may set:

$$X_R = X_0 + V_0\theta_1 + \frac{1}{2M_0} P_0 \left(1 - \frac{\theta_1}{3t'}\right)\theta_1^2 - \frac{1}{2M_0} R\theta_1^2. \quad (242)\ 123$$

Eliminating from expression (242) the duration of the period of secondary action t', we obtain the following after elementary transformations:

$$X_R = X_0 + V_0\theta_1 + \frac{\theta_1^2}{M_0} \frac{P_0 - R}{3}, \quad (243)\ 124$$

where

$$\theta_1 = \frac{P_0 - R}{P_0} t'.$$

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b) Second period of recoil. After the end of the first period, the movement of the recoiling parts will take place solely under the action of the force of resistance to recoil R until the kinetic energy of the recoiling parts, acquired by them in the first period of the recoil, is absorbed by the work of the force R.

Since in the case considered by us the force R is constant, the movement of the recoiling parts in the second period will be uniformly retarded.

The equation of the movement in the second period is written as follows:

$$M_0 \frac{d^2X}{dt^2} = -R. \qquad (244)\ 124$$

Integrating the equation (244) twice in the limits from 0 to t, from V_K to V and from X_K to X, we obtain:

$$V = V_K - \frac{1}{M_0} Rt;$$

$$X = X_K + V_K t - \frac{1}{M_0} R\frac{t^2}{2}.$$

If we designate the duration of the second period of the recoil by θ_2, then for the end of the recoil ($t = \theta_2$) we shall have:

$$V_\lambda = 0 = V_K - \frac{1}{M_0} R\theta_2; \qquad (245)\ 124$$

$$X_\lambda = \lambda = X_K + V_K\theta_2 - \frac{1}{M_0} R\frac{\theta_2^2}{2}. \qquad (246)\ 124$$

From the first equation we find the duration of the second period:

$$\theta_2 = \frac{M_0 V_K}{R}. \qquad (247)\ 124$$

After this we find the total time of the recoil:

$$t_{OT} = t_K + \theta_2. \qquad (248)\ 124$$

Formulas (245) and (246) serve as checks in the calculation of the recoil, braked with a constant force of resistance.

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Figure 43 (Page 125)

Figure 44 (Page 125)

In the calculation of the recoil brake we use the value of the square of the velocity of recoil in the second period depending upon the length of recoil X. We shall find this relationship (Fig. 43).

We shall suppose that the recoiling parts moved from the beginning of the recoil over a distance X and that their velocity at this moment is equal to V. Then the kinetic energy of the recoiling parts will be equal to

$$M_0 \frac{V^2}{2}.$$

This kinetic energy should be absorbed by the work of the force of resistance R on the sector of a path equal to $\lambda - X$. Consequently,

$$\frac{M_0}{2} V^2 = R(\lambda - X). \qquad (249)\ 125$$

From equation (249) we obtain the following functional relationship for determination of V^2:

$$V^2 = \frac{2R}{M_0}(\lambda - X). \qquad (250)\ 125$$

The value of the magnitude V^2 in the second period is generally determined at intervals of 50 to 100 mm of the length of recoil.

The form of the curves $V = f(x)$ and $V = f(t)$ with braking by a constant force of resistance is represented in Figure 44 and 45.

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Figure 45 (Page 125)

5. Determination of the Constant Force of Resistance to Recoil R, Acting over all the Length of the Recoil. Vallier Formula.

At the end of the first period of retarded recoil the kinetic energy of the recoiling parts is equal to:

$$\frac{M_0}{2} V_K^2;$$

this kinetic energy should be absorbed by the work of the force of resistance to recoil R on the sector of the path $\lambda = X_K$, that is, the work of the force of resistance R on this sector of recoil is equal to

$$R(\lambda - X_K).$$

Consequently,

$$\frac{M_0}{2} V_K^2 = R(\lambda - X_K). \qquad (251)\ 126$$

We shall substitute in equation of work (251) the values V_K and X.

In accordance with formula (225)

$$V_K = V_0 + \frac{1}{M_0}[(P_0 - sP_K)b - Rt']. \qquad (225)\ 126$$

Bearing in mind that

$$V_0 = W_0 - \frac{1}{M_0} R t_0 \qquad (219)\ 126$$

and

$$W_{max} = W_0 + \frac{1}{M_0} b(P_0 - sP_K), \qquad (142)\ 126$$

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we may set:

$$V_K = W_{max} - \frac{1}{M'_0} R t_\partial - \frac{1}{M_0} R t' \qquad (252)\ 126$$

or

$$V_K = W_{max} - \alpha R, \qquad (253)\ 126$$

where

$$\alpha = \frac{1}{M'_0} t_\partial + \frac{1}{M_0} t' \qquad (254)\ 126$$

The path (length of travel) of the recoiling parts at the end of the first period of retarded recoil may be expressed by the equality:

$$X_K = X_\partial + V_\partial t' + \frac{1}{M_0}\left\{b[P_\partial t' - b(P_\partial - sP_K)] - R\frac{t'^2}{2}\right\}. \qquad (225)\ 126$$

Bearing in mind that

$$X_\partial = l_\partial - \frac{1}{M'_0} R \frac{t_\partial^2}{2}, \qquad (220)\ 127$$

$$L_K = L_\partial + W_\partial t' + \frac{1}{M_0} b[P_\partial t' - b(P_\partial - sP_K)], \qquad (143)\ 127$$

$$V_\partial = W_\partial - \frac{1}{M'_0} P t_\partial, \qquad (219)\ 127$$

the expression for X_K may be written in this form:

$$X_K = L_K - R\left[\frac{1}{M_0}\left(\frac{t_\partial^2}{2} + t_\partial t'\right) + \frac{1}{M_0}\frac{t'^2}{2}\right] \qquad (255)\ 127$$

or

$$X_K = L_K - \beta R, \qquad (256)\ 127$$

where

$$\beta = \frac{1}{M'_0}\left(\frac{t_\partial^2}{2} + t_\partial t'\right) - \frac{1}{M_0}\frac{t'^2}{2}. \qquad (257)\ 127$$

Substituting the expressions (253) and (256) in the work equation we may set:

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$$\frac{M_0}{2}(W_{max}-\alpha R)^2=R(\lambda-L_K+\beta R). \qquad (258)\ 127$$

By removing the parentheses and grouping the members in expression (258) we obtain for the determination of R the quadratic equation:

$$\left(\beta-\frac{M_0}{2}\alpha^2\right)R^2+(\lambda-L_K+M_0\alpha W_{max})R-\frac{M_0}{2}W_{max}^2=0 \qquad (259)\ 127.$$

or

$$AR^2+BR-C=0, \qquad (260)\ 127$$

where

$$A=\beta-\frac{M_0}{2}\alpha^2; \qquad (261)\ 127$$

$$B=M_0\alpha W_{max}+\lambda-L_K; \qquad (262)\ 127$$

$$C=\frac{M_0}{2}W_{max}^2, \qquad (263)\ 127$$

whence

$$R=\frac{-B+\sqrt{B^2+4AC}}{2A} \qquad (264)\ 127$$

in formula (264) the minus sign before the radical is dropped because it gives an "unreal" value of R.

We find the definitive expressions for the coefficients A and B:

$$A=\beta-\frac{M_0}{2}\alpha^2=\frac{1}{M'_0}\frac{t_0^2}{2}\left(1-\frac{M_0}{M'_0}\right); \qquad (265)\ 128$$

$$B=M_0\alpha W_{max}+\lambda-L_K=W_{max}\left(\frac{M_0}{M'_0}t_0+t'\right)+\lambda-L_K. \qquad (266)\ 128$$

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If we may neglect the values q and ω in comparison with the value Q_0, then

$$A = 0$$

and

$$B = W_{max} t_K + \lambda - L_K \qquad (267)\ 128$$

Instead of quadratic equation (260), for the determination of R, we shall have in this case the linear equation

$$BR - C = 0,$$

whence

$$R = \frac{C}{B}. \qquad (268)\ 128$$

By substituting the values of coefficients C and B from the expressions (263) and (267) respectively in formula (268), we obtain

$$R = \frac{\frac{M_0 W^2_{max}}{2}}{\lambda - L_K + W_{max} t_K}. \qquad (269)\ 128$$

The expression (269) is known by the name of Vallier's formula.

The Vallier formula may be obtained directly from equation (251) after substituting in it the values V_K and X_K on the basis of the formulas of transition (202a) and (203a).

We make use of the Vallier formula for proof of the assumption made earlier dealing with the increase in the stability of the gun during recoil with increase in the weight of the recoiling parts (see page 43).

From the equation of free recoil

$$M_0 \frac{dW}{dt} = P_{KH}$$

we obtain after its integration in the limits from 0 to t_K the following expression for the maximum velocity of free recoil:

$$W_{max} = \frac{1}{M_0} \int_0^{t_K} P_{KH} dt \qquad (270)\ 128$$

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and for the length of free recoil at the corresponding moment we shall have the expression

$$L_K = \frac{1}{n_0} \int_c^{t_K} dt \int_0^t P_{KH}\, dt. \qquad (271)\ 129$$

After dividing the numerator and the denominator of the right side of formula (269) by

$$M_0 = \frac{Q_0}{g}$$

and replacing of R_{max} and L_K by their values from expressions (270) and (271), formula (269) may be presented in the following form:

$$R = \frac{0.5\left(\int_0^{t_K} P_{KH}\, dt\right)^2}{M_0 \lambda - \int_c^t dt \int_0^t P_{KH}\, dt + \tau_K \int_0^{t_K} P_{KH}\, dt}. \qquad (272)\ 129$$

From expression (272) it follows that the force of resistance to recoil R with a required length of recoil λ and with the given law of change of force P_{KH}, which in its turn is determined by the ballistic characteristics of the gun (by the weight of the projectile, its initial velocity, characteristics of the charge), may be decreased by increasing the mass of the recoiling parts. Consequently, with an increase in the weight of the recoiling parts the stability of the gun is increased.

6. Braking of the Recoil with a Variable Force of Resistance.

a) General Considerations. We shall take the equation expressing the conditions of stability of an artillery weapon on a "wheeled mount" while firing under an angle of elevation $\varphi_{\text{пр}}$ (see formula (32), page 44):

$$P_{KH}\, e + R h_{\text{пр}} = Q_6 D_{\text{пр}} - Q_0 X \cos\varphi_{\text{пр}},$$

where

$$h_{\text{пр}} = c + H' \cos\varphi_{\text{пр}} - d_u \sin\varphi_{\text{пр}}.$$

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Solving this equation for R, we obtain:

$$R = \frac{Q_0 D_{\Pi P} - Q_0 X \cos\varphi_{\Pi P}}{k_{\Pi P}} - \frac{P_{KH} e}{k_{\Pi P}}. \qquad (273)\ 129$$

In this case, when the arm of the dynamic couple $e = 0$, we shall have:

$$R_{\Pi P} = \frac{Q_0 D_{\Pi P} - Q_0 X \cos\varphi_{\Pi P}}{k_{\Pi P}}. \qquad (274)\ 129$$

The value of the force of resistance to recoil $R_{\Pi P}$, determined from expression (274), is called the limiting resistance to recoil. We must regard the value $R_{\Pi P}$ as the maximum possible force of resistance which may be allowed in the given case, starting from the conditions of stability during fire under an angle of elevation $\varphi_{\Pi P}$.

Having rewritten the expression (274) in the form

$$R_{\Pi P} = \frac{Q_0 D_{\Pi P}}{k_{\Pi P}} - \frac{Q_0 X \cos\varphi_{\Pi P}}{k_{\Pi P}} X, \qquad (274)\ 130$$

we see that the value $R_{\Pi P}$ is the linear function of the path (length of travel) of recoil X, decreasing in proportion as X increases.

Figure 46 (Page 130)

The graph $R_{\Pi P} = f(X)$ is represented in Figure 46 in the form of a straight line AB, which is called the limiting straight line of stability.

Obviously, for assuring stability of the gun during the time of the shot, we must, for the purpose of obtaining a certain reserve of stability, have the force of resistance to recoil R somewhat less than $R_{\Pi P}$.

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Usually, we take $R = 0.5\, R_{пр}$. Then the value of the force R will be determined by the expression

$$R = 0.9\,\frac{Q_б D_{пр} - Q_0 X \cos\varphi_{пр}}{h_{пр}}, \qquad (275)\ 130$$

when $e = 0$ and

$$R = 0.9\,\frac{Q_б D_{пр} - Q_0 X \cos\varphi_{пр}}{h_{пр}} - \frac{P_{кн} e}{h_{пр}}, \qquad (276)\ 130$$

when $e > 0$.

Of course, the length of recoil λ with retarded recoil and a reserve of stability will be greater than one (λ_1) which would be sufficient for the absorption of the same energy of the recoiling parts with braking by force $R = R_{пр}$. Since the work of the force of resistance with lengths of recoil λ_1 and λ should be one and the same, then the areas (surface) $R_0\ R_{0,пр}$, $R_{\lambda_1,пр}\ R_{\lambda_1}$ and $R_{\lambda_1}\ R_\lambda\ \lambda\lambda$ for the case $e = 0$ (figure 47) and the areas $R_0\ R_{0,пр}$, $R_{\lambda_1,пр}$, $R_\lambda\ R_k\ R_m$ and R_λ, $R_\lambda\ \lambda\lambda_1$ for the case $e > 0$ (figure 48) will be equidimensional.

As was shown earlier, sometimes, with $e = 0$, for the purpose of decreasing the length of recoil λ the braking in the first period of the recoil can be effected to advantage with a constant force, equal to the calculated value of the force R, determined from expression (275) for a length of recoil corresponding to the end of the first period, that is, supposing (Figure 49):

$$R = R_к = 0.9\,\frac{Q_б D_{пр} - Q_0 X_к \cos\varphi_{пр}}{h_{пр}}. \qquad (277)\ 131$$

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Figure 47 (Page 131)

Figure 48 (Page 131)

Figure 49 (Page 131)

The expression (277) may not be used directly for calculating the value of R_K, because the value of X_K, on which it depends, is dependent in its turn on the value R_K.

But in braking with a constant force of resistance the value X_K, depending upon the corresponding length of free recoil is expressed by the formula (256):

$$X_K = L_K - \beta R_K. \qquad (278)$$ 132

Substituting this value of X_K in expression (277) we may set:

$$R_K = 0.9 \frac{Q_0 D_{\Pi P} - Q_0 (L_K - \beta R_K) \cos \varphi_{\Pi P}}{h_{\Pi P}};$$

$$R_K = \frac{0.9 (Q_0 D_{\Pi P} - Q_0 L_K \cos \varphi_{\Pi P})}{h_{\Pi P}} + \frac{0.9 Q_0 \beta R_K \cos \varphi_{\Pi P}}{h_{\Pi P}};$$

$$R_K = \frac{h_{\Pi P} - 0.9 Q_0 \beta \cos \varphi_{\Pi P}}{h_{\Pi P}} = 0.9 \frac{Q_0 D_{\Pi P} - Q_0 L_K \cos \varphi_{\Pi P}}{h_{\Pi P}}.$$

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Hence, we obtain the following expression for the calculation of R_K in the case considered:

$$R_K = 0.9\,\frac{R_0 D_{np} - Q_0 L_K \cos\varphi_{np}}{t_{np} - 0.9\,Q_0\,\beta\cos\varphi_{np}}, \qquad (279)\ 132$$

where

$$\beta = \frac{\Pi}{M_0'}\left(\frac{t_1^2}{2} + t_1 t'\right) + \frac{1}{M_0}\,\frac{t'^2}{2}.$$

We may limit ourselves to taking $X_K = L_K$, without determining R_K in a precise manner by formulas (279).

This indirectly increases the coefficient of reserve stability in the first period of the recoil, but gives a jump in the curves of velocity, length and resistance to recoil in transition from the first period of the recoil to the second.

The calculation of the elements of movement of the recoiling parts in the first period of the recoil is carried out in the same manner as for the case of braking with a constant force of resistance over all the length of the recoil.

For assuring the stability of the gun when the shot is fired, in the first period of the recoil with $\theta > 0$ the change of the force of resistance to recoil should satisfy the condition given in (276).

For simplifying the calculation of the elements of retarded recoil in the first period the value of the force of resistance R is taken as increasing in accordance with the linear law in function of time t determined by the equation $R = R_0 + R_K - R_0$ (280) 132, where R_0 is the initial resistance to recoil;

R_K --the resistance to recoil at the end of the first period.

In order that a hydraulic brake may go into action at once we must observe the following conditions:

$$R_t > \Pi_0 + R_f, \qquad (281)\ 132$$

where Π is the initial [illegible] recoil mechanism;

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R_f --the force of friction on the "directing cradles" and in the packing devices.

The value II is determined from the conditions of counter-recoiling and the holding of the recoiling parts with a maximum angle of elevation:

$$\Pi_0 = Q_0 (\sin \varphi_{max} + f \cos \varphi_{max} + \nu), \quad (282)\ 132$$

and R_f is determined by the expression

$$R_f = Q_0 (f \cos \varphi_{HP} + \nu), \quad (283)\ 132$$

where f is the coefficient of friction on the guides;

ν --the coefficient taking into account the friction in the packing devices.

Putting together, by members, expressions (282) and (283), we shall have:

$$\Pi_0 + R_f = Q_0 [\sin \varphi_{max} + f(\cos \varphi_{max} + \cos \varphi_{HP}) + 2\nu] \quad (284)\ 133$$

Supposing that $f = 0.2$, $\nu = 0.5$, $\sin \varphi_{max} = 1$ and $\cos \varphi_{HP} = 1$, we obtain from expression (284):

$$\Pi_0 + R_f = Q_0 (1 + 0.2 \cdot 1 + 1) = 2.2\, Q_0. \quad (285)\ 133$$

With sufficient reserve we may take

$$R_0 = (2 \div 2.5)\, Q_0. \quad (286)\ 133$$

The problem of the determination of the magnitude R_k will be considered later on, after derivation of the expressions for the determination of the elements of retarded recoil for the case $e > 0$.

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The graph of the force P_{KH} and of the force R for the case considered of $e > 0$ is represented in Figure 50.

b) The determination of the elements of retarded recoil with $e > 0$ in the period of the movement of the projectile along the bore. For the finding of the elements of retarded recoil in the period of the movement of the projectile along the bore with $e > 0$ we utilize the general expression for the velocity and length of retarded recoil:

$$V = W - \frac{1}{M_0'}\int_0^t R\,dt; \qquad (202)\ 133$$

$$X = L - \frac{1}{M_0'}\int_0^t dt\int_0^t R\,dt. \qquad (203)\ 133$$

We find the value of the integrals entering into the expressions (202) and (203), substituting under the sign of the integral the expression for R, determined by formula (280).

After substitution and integration we obtain:

$$\int_0^t R\,dt = \int_0^t \left(R_0 + \frac{R_K - R_0}{t_K}t\right)dt = \left(R_0 + \frac{R_K - R_0}{2t_K}t\right)t; \qquad (287)\ 134$$

$$\int_0^t dt\int_0^t R\,dt = \int_0^t dt\int_0^t \left(R_0 + \frac{R_K - R_0}{t_K}\right)dt =$$

$$= \left(R_0 + \frac{R_K - R_0}{3t_K}t\right)\frac{t^2}{2}. \qquad (288)\ 134$$

Hence, we obtain the following general functional relationship for the determination of the velocity and length of retarded recoil with $e > 0$:

$$V = W - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{2t_K}t\right)t; \qquad (289)\ 134$$

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$$X = L - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{3t_K}t\right)\frac{t^2}{2}, \qquad (290)\ 134$$

With the help of formulas (289) and (290) we determine the length of retarded recoil with $e > 0$ for the moments of time $t = t_m$ and $t = t_\partial$.

Figure 51 (Page 134)

Figure 51 represents the graph of the change of the force in the first period of the recoil with $e > 0$ depending upon the path of recoil X. We should notice that the graph of the force R in Figure 51 is represented in the form of a curve R_0 R_K. This is explained by the fact that in this graph the force R is given as a function of X, whereas in the graph Figure 50 it is represented as a function of time t.

For the purpose of assuring the stability of the gun during the time of the shot, with the law of the change of the force R which we have taken, it is necessary to make sure that the value of this force for the moment corresponding to the moment of the maximum pressure of the powder gases, obtained from the expression

$$R_m = R_0 + \frac{R_K - R_0}{t_K}t_m, \qquad (291)\ 134$$

is smaller than the value R_m, determined for this same moment from the expression

$$R_m = 0.9\,\frac{Q_0 D_{\text{пр}} - Q_0 X_m \cos\varphi_{\text{пр}}}{h_{\text{пр}}} - P_{\text{кн max}}\,e. \qquad (292)\ 135$$

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In the contrary case, it is necessary, by redistribution of the mass of the recoiling parts, to bring about a decrease in the arm e.

The magnitude of the limiting value of the arm $e = e_{пр}$, allowed by the condition of stability, may be found in the following manner.

On the basis of expression (273), determining the conditions of stability, we may set:

$$R_m = 0.9\,\frac{Q_6 D_{пр} - Q_0 X_m \cos\varphi_{пр}}{h_{пр}} - \frac{P_{кн\,max}\, e_{пр}}{h_{пр}} \quad (293)\ 135$$

Solving the equation (293) for $e_{пр}$, we obtain:

$$e_{пр} = \frac{0.9(Q_6 D_{пр} - Q_0 X_m \cos\varphi_{пр}) - R_m h_{пр}}{P_{кн\,max}}. \quad (294)\ 135$$

The magnitude R_m in formula (294) is determined from the expression

$$R_m = R_0 + \frac{R_к - R_0}{t_к}\, t_m,$$

and X_m from the expression

$$X_m = L_m - \frac{1}{M_0'}\left(R_0 + \frac{R_к - R_0}{3t_к}\, t_m\right)\frac{t_m^2}{2}.$$

The value of the arm taken in the calculations may satisfy the condition

$$e < e_{пр}.$$

c) Determination of the elements of retarded recoil with $e > 0$ in the period of the secondary action of the powder gases. With the exponential law of change of the force $P_{кн}$ in the secondary action we have for the velocity and length of the retarded recoil the following functional relationships:

$$V = V_д + \frac{1}{M_0} P_д b\left(1 - e^{-\frac{t}{b}}\right) - \frac{1}{M_0}\int_0^t R\,dt; \quad (211)\ 135$$

$$X = X_д + V_д t +$$

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$$+\frac{1}{M_0}P_0 b\left[t-b\left(1-e^{-\frac{t}{b}}\right)\right]-\frac{1}{M_0}\int_0^t dt\int_0^t R\,dt. \qquad (212)\ 135$$

For the beginning of the period of secondary action the resistance to recoil is expressed by the following equality:

$$R_0=R_0+\frac{R_K-R_0}{t_K}t_0. \qquad (295)\ 136$$

Bearing in mind that the reading of the time in the period of the secondary action starts from the beginning of the period, the law of the change of force of the resistance to recoil in the interval of time from t_0 to t_K (from 0 to t') should be written in the following form:

$$R=R_0+\frac{R_K-R_0}{t'}t. \qquad (296)\ 136$$

Substituting the value R, determined by formula (296), in the expressions for the velocity and length of the retarded recoil (211) and (212) with the exponential law of change of the force P_{KH} after integration we obtain:

$$V=V_0+\frac{1}{M_0}\left[P_0 b\left(1-e^{-\frac{t}{b}}\right)-\left(R_0+\frac{R_K-R_0}{2t'}t\right)t\right]; \qquad (297)\ 136$$

$$X=X_0+V_0 t+$$

$$+\frac{1}{M_0}\left\{P_0 b\left[t-b\left(1-e^{-\frac{t}{b}}\right)\right]-\left(R_0+\frac{R_K-R_0}{3t'}t\right)\frac{t^2}{2}\right\}. \qquad (298)\ 136$$

The value of the velocity of retarded recoil at the end of the period of secondary action V_K and of the length X_K are to be found from the functional relationships (297) and (298), assuming that in them $t=t'$:

$$V_K=V_0+\frac{1}{M_0}\left[b(P_0-sP_K)-\frac{R_0+R_K}{2}t'\right]; \qquad (299)\ 136$$

$$X_K=X_0+V_0 t'+$$

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$$+\frac{1}{M_0}\left\{b\left[P_д t' - b(P_д - sP_к)\right] - \frac{2R_д + R_к}{3}\,\frac{t'^2}{2}\right\}. \qquad (300)\ 136$$

The maximum velocity of the retarded recoil will be reached after an interval of time θ_1, counted from the beginning of the period of the secondary action, when we obtain the equality

$$P_д e^{-\frac{\theta_1}{b}} = R_д + \frac{R_к - R_д}{t'}\theta_1, \qquad (301)\ 136$$

the solution of which, for θ_1 is impossible by methods convenient for practical calculations. Hence, taking into account the "proximity" of the law of the change of force $P_{кн}$ and the comparatively slow increase in the force of resistance R in the period of the secondary action, we take the force of resistance to recoil R as a mean value expressed by the equality

$$R_{ср} = \frac{R_д + R_к}{2}. \qquad (302)\ 137$$

With this condition the equality (301) may be rewritten in the following form:

$$P_д e^{-\frac{\theta_1}{b}} = \frac{R_д + R_к}{2} \qquad (303)\ 137$$

or

$$e^{-\frac{\theta_1}{b}} = \frac{R_д + R_к}{2P_д}, \qquad (304)\ 137$$

Putting the latter equation in logarithmic form for the determination of the interval of time θ_1, we obtain the following expression:

$$\theta_1 = b \cdot 2.303 \lg \frac{2P_д}{R_д + R_к} \qquad (305)\ 137$$

Assuming in formulas (297) and (298) that $t = \theta_1$, we obtain the following expression for the determination of the maximum velocity of retarded recoil V_{max} and the length of the retarded recoil X_R corresponding to it:

$$V_{max} = V_д + \frac{1}{M_0}\left[P_д b\left(1 - e^{-\frac{\theta_1}{b}}\right) - \left(R_д + \frac{R_к - R_д}{2t'}\theta_1\right)\theta_1\right]; \qquad (306)\ 137$$

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$$X_R = X_д + V_д\theta_1 + \frac{1}{M_0}\left\{P_д b\left[\theta_1 - b\left(1 - e^{-\frac{\theta_1}{b}}\right)\right] - \left(R_д + \right.\right.$$
$$\left.\left. + \frac{R_K - R_д}{3t'}\theta_1\right)\frac{\theta_1^2}{2}\right\}. \quad (307)\ 137$$

From equality (301) for the function $e^{-\frac{\theta_1}{b}}$ we have the expression

$$e^{-\frac{\theta_1}{b}} = \frac{R_д}{P_д} + \frac{R_K - R_д}{P_д t'}\theta_1. \quad (308)\ 137$$

After the substitution of this value of the function in formulas (306) and (307) and the corresponding transformations, we obtain the following expression for the determination of V_{max} and X_R:

$$V_{max} = V_д + \frac{1}{M_0}\left[\left(P_д - R_д - \frac{R_K - R_д}{t'}\theta_1\right)b - \left(R_д + \right.\right.$$
$$\left.\left. + \frac{R_K - R_д}{2t'}\theta_1\right)\theta_1\right]; \quad (309)\ 138$$

$$X_R = X_д + V_д\theta_1 + \frac{1}{M_0}\left\{\left[P_д\left(\theta_1 - b\right) + b\left(R_д + \right.\right.\right.$$
$$\left.\left.\left. + \frac{R - R_д}{t'}\theta_1\right)\right]b - \left(R_д + \frac{R_K - R_д}{3t'}\theta_1\right)\frac{\theta_1^2}{2}\right\}. \quad (310)\ 138$$

Substituting the value R, determined with formula (296), in the expression for the velocity and length of retarded recoil in the period of secondary action with the linear law of change of the force P_{KH} (215) and (216) — after integration we may set:

$$V = V_д + \frac{1}{M_0}\left[P_д\left(1 - \frac{t}{2t'}\right) - R_д - \frac{R_K - R_д}{2t'}t\right]t; \quad (311)\ 138$$

$$X = X_д + V_д t +$$
$$+ \frac{1}{M_0}\left[P_д\left(1 - \frac{t}{3t'}\right) - R_д - \frac{R_K - R_д}{3t'}t\right]\frac{t^2}{2}. \quad (312)\ 138$$

For the end of the period of secondary action we find the velocity of retarded recoil V_K and the length of retarded recoil X_K from expressions (311) and (312), assuming that $t = t'$: RESTRICTED

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$$V_к = V_д + \frac{1}{M_0}\left(P_д - R_д - R_к\right)\frac{t'}{2}\ ; \qquad (313)\ 138$$

$$X_к = X_д + V_д t + \frac{1}{M_0}\left(P_д - R_д - \frac{R_к}{2}\right)\frac{t'^2}{3}\ . \qquad (314)\ 138$$

We now find the expressions for the maximum velocity of the retarded recoil and the length of retarded recoil corresponding to this velocity, with the linear law of change of force $P_{кн}$.

For the determination of the time θ_1 for the recoiling parts to reach the maximum velocity, in accordance with equality (301) we equate the expressions for forces $P_{кн}$ and R (Figure 52).

$$P_д\left(1 - \frac{\theta_1}{t'}\right) = R_д + \frac{R_к - R_д}{t'}\,\theta_1\ . \qquad (315)\ 138$$

Solving equation (315) for θ_1, we obtain the following expression for determining the interval of time from the beginning of the period of secondary action until the moment when the recoiling parts reach the maximum velocity:

$$\theta_1 = \frac{P_д - R_д}{P_д + R_к - R_д}\,t'\ . \qquad (316)\ 139$$

Figure 52 (Page 139)

Assuming that in formulas (311) and (312) $t = \theta_1$, we may write the following expressions for the maximum velocity of the retarded recoil V_{max} and the length of retarded recoil X_R corresponding to this velocity.

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$$V_{max} = V_0 + \frac{1}{M_0}\left[P_0\left(1-\frac{\theta_1}{2t'}\right) - R_0 - \frac{R_K - R_0}{3t'}\theta_1\right]\theta_1 . \quad (317)\ 139$$

$$X_R = X_0 + V_0\theta_1 + \frac{1}{M_0}\left[P_0\left(1-\frac{\theta_1}{3t'}\right) - R_0 - \frac{R_K - R_0}{3t'}\theta_1\right]\frac{\theta_1^2}{2} . \quad (318)\ 139$$

Eliminating t' from expressions (317) and (318) we obtain after transformation the following formulas for the determination of the velocity V_{max} and the length X_R:

$$V_{max} = V_0 + \frac{1}{M_0}\frac{P_0 - R_0}{2}\theta_1 , \quad (319)\ 139$$

$$X_R = X_0 + V_0\theta_1 + \frac{1}{M_0}\frac{P_0 - R_0}{3}\theta_1^2 . \quad (320)\ 139$$

For the calculation of the elements of retarded recoil in the first period in the case of $c > 0$, it is necessary to know the magnitude R_K, which is to be determined from the expression

$$R_K = 0.9\,\frac{Q_0 D_{\Pi P} - Q_0 X_K \cos\varphi_{\Pi P}}{h_{\Pi P}} \quad (321)\ 139$$

and is in its turn a function of the length of the retarded recoil at the end of the first period.

For finding the magnitude R_K we proceed in the following manner:

On the basis of the formula of transition (203a) we may, for the case considered, set:

$$X = L - \frac{1}{M_0}\int_0^t dt \int_0^t R\,dt = L - \frac{1}{M_0}\left(R_0 + \frac{R_K - R_0}{3t_K}\right)\frac{t^2}{2} .$$

For the end of the first period of retarded recoil $t = t_K$, $L = L_K$ and $X = X_K$;

$$X_K = L_K - \frac{1}{M_0}\left(R_0 + \frac{R_K - R_0}{3}\right)\frac{t_K^2}{2} = L_K - \frac{1}{M_0}\left(2R_0 + R_K\right)\frac{t_K^2}{(?)}$$

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Substituting this expression for X_K in formula (321), we shall have:

$$R_K = 0.9\,\frac{Q_6 D_{np} - Q_0\left[L_K - \frac{1}{M_0}(2R_0 + R_K)\frac{t_K^2}{\delta(?)}\right]\cos\varphi_{np}}{}\,,$$

whence we obtain the following formula for calculation of R_K:

$$R_K = 0.9\,\frac{Q_6 D_{np} - (Q_0 L_K - 0.33 g R_0 t_K^2)\cos\varphi_{np}}{h_{np} - 0.15 g t_K^2 \cos\varphi_{np}}\,. \qquad (321a)\ 140$$

The precise determination of R_K is necessary so that in transition from the first period of retarded recoil to the second period does not give a jump in the curves of resistance, velocity or length.

d) Second period of recoil. The law of change of the force of resistance to recoil R in the second period in braking with a variable force will be determined by the expression

$$R = m\,\frac{Q_6 D_{np} - Q_0 X \cos\varphi_{np}}{h_{np}}\,. \qquad (322)\ 140$$

The graph of the change of the force R over all the length of the recoil for the case of braking with a constant force in the first period of the recoil is given in Figure 49, and for the case of braking with a variable force in the first period it is given in Figure 51.

If in the calculation of the elements of movement of the recoiling parts in the first period the value of R is not determined precisely with formula (279) (in braking with a constant force of resistance in the first period) or with formula (321a) (in braking with a variable force of resistance in the first period) and we keep for the second period the same coefficient of reserve stability which was taken in the calculation of the value R_K for the first period of the recoil, assuming $X_K = L_K$, then at point $X = X_K$ we shall have a sharp jump in the force R. The value R_K for the end of the first period will be less than the value R_K for the beginning of the second

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period of the recoil. This is the result of different coefficients of "reserve stability" for the first and second periods, since by taking in the calculation of R_K for the end of the first period $X_K = L_K$, the coefficient of "reserve stability" for the first period was increased.

Bearing in mind that for the realization of such a scheme of braking, the regulating part of the recoil brake should have a correspondingly short transition of working profile, which is not desirable either from a constructional or from a manufacturing point of view, it is necessary in practice to take for the first and second periods of recoil one and the same coefficient of "reserve stability".

Figure 53 (Page 141) Figure 54 (Page 141)

We find the coefficient of reserve stability to be the following:

$$m = \frac{R_K}{R_{K,\,пр}} = 0.9\,\frac{Q_6 D_{пр} - Q_0 L_K \cos\varphi_{пр}}{Q_6 D_{пр} - Q_0 X_K \cos\varphi_{пр}}. \qquad (323)\ 141$$

In figures 53 and 54 the dotted line represents the course of the change of the force R with various coefficients of reserve stability in the first and in the second periods of the recoil.

LENGTH OF THE RECOIL IN BRAKING WITH A VARIABLE FORCE OF RESISTANCE

The energy of recoil at the moment of the end of the first period is

$$\frac{M_0}{2} V_K^2.$$

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This energy should be absorbed by the work of the variable force of resistance to recoil

$$R = 0.9\,\frac{Q_6 D_{np} - Q_0 X \cos\varphi_{np}}{h_{np}}$$

over the rest of the length of recoil $\lambda - X_K$, that is, the following conditions should be met

$$\frac{M_0}{2} V_K^2 = \frac{0.9}{h_{np}} \int_{X_K}^{\lambda} (Q_6 D_{np} - Q_0 X \cos\varphi_{np})\,dX, \quad (324)\ 142$$

whence, after integration and transformation we obtain:

$$Q_0 \cos\varphi_{np}\,\lambda^2 - 2Q_6 D_{np}\lambda + \frac{h_{np}}{0.9} M_0 V_K^2 + 2Q_6 D_{np} X_K - \quad (325)\ 142$$

$$- Q_0 \cos\varphi_{np} X_K^2 = 0.$$

Using the notation

$$A = Q_0 \cos\varphi_{np};$$

$$B = 2Q_6 D_{np};$$

$$C = \frac{h_{np}}{0.9} M_0 V_K^2 + 2Q_6 D_{np} X_K - Q_0 \cos\varphi_{np} X_K^2,$$

we obtain the following quadratic equation for the determination of the length of the recoil λ.

$$A\lambda^2 - B\lambda + C = 0, \quad (326)\ 142$$

whence

$$\lambda = \frac{B - \sqrt{B^2 - 4AC}}{2A}. \quad (327)\ 142$$

For obtaining a real value of λ we keep the minus sign before the radical.

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Figure 55 (Page 142)

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Before we pass to further calculation, it is necessary to verify the possibility of fire from a gun under the maximum angle of elevation.

As we can easily see from the sketch in Figure 55, for the possibility of recoil under the maximum angle of elevation it is necessary to satisfy the following in equality:

$$H_u \geq (\lambda + l_u)\sin\varphi_{max} \pm r\cos\varphi_{max}, \quad (328)\ 142$$

where l_u is the distance from the axis of the trunion to the breech face of the barrel;

r --the distance from the lower back point of the recoiling parts to the line passing through the trunions parallel to the axis of the bore of the barrel.

If we find that this condition is not satisfied, then we must either decrease the value l_u, that is, bring the trunions closer to the breech face or increase the height of the axis of the trunion, and this means also the height of the line of fire, employ a variable recoil, or, finally, employ all these means together, combining them with each other.

For the purpose of greater clearness it will be advantageous, after obtaining the length of the recoil, to trace to scale the general scheme of the gun designed and on the basis of it check the possibility of fire under the maximum angle of elevation, and also plan the method of solving this problem.

SQUARE OF THE VELOCITY OF THE RECOIL IN THE SECOND PERIOD

As we can see from Figure 56, the value of the force of resistance to recoil in the second period, corresponding to the path of recoil X, may be represented by the expression

$$R = R_\lambda + \frac{R_K - R_\lambda}{\lambda - X_K}(\lambda - X), \quad (329)\ 143$$

where

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$$R_\lambda = 0.9\,\frac{Q_0 D_{np} - Q_0\lambda\cos\varphi_{np}}{h_{np}}, \quad (330)\ 143$$

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$$R_K = 0.9\,\frac{Q_6 D_{пр} - Q_0 X_K \cos\varphi_{пр}}{h_{пр}}. \qquad (331)\ 143$$

Figure 56 (Page 143)

We shall suppose that the velocity of the recoiling parts at this moment is equal to V. Consequently, the kinetic energy of the recoiling parts at the moment when they travel the distance X, counted from the beginning of the recoil, will be

$$\frac{M_0}{2} V^2. \qquad (332)\ 143$$

This kinetic energy of the recoiling parts should be absorbed by the work of the force of resistance to recoil R on the rest of the sector of the path of recoil $\lambda - X$. The work of the force of resistance to recoil on the sector $\lambda - X$ will be

$$\frac{R + R_\lambda}{2}(\lambda - X). \qquad (333)\ 144$$

By equating the kinetic energy of the recoiling parts (332) with the work of the force of resistance (333) we may write:

$$\frac{M_0}{2} V^2 = \frac{R + R_\lambda}{2}(\lambda - X), \qquad (334)\ 144$$

whence we obtain the dependence of the square of the velocity of the retarded recoil upon the length of the recoil:

$$V^2 = \frac{(R + R_\lambda)(\lambda - X)}{M_0} \qquad (335)\ 144$$

Making use of formula (335) we can calculate the value of the square of the

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velocity of the retarded recoil for various values of the length of recoil X in the second period. For this purpose it is necessary first to calculate for these values the amount of the resistance to recoil R by formula (329). The calculation of V^2 is usually made for the length of recoil X at intervals of 50-100 mm.

DURATION OF THE SECOND PERIOD OF RECOIL

The velocity of retarded recoil at any moment of the second period is expressed by the equality

$$V = \frac{dX}{dt},$$

whence, for the differential of the time, we have the expression

$$dt = \frac{dX}{V}. \qquad (336)\ 144$$

By substituting in the expression for the square of the velocity of recoil in the second period (335) the value of R from formula (329), we may write the following expression for velocity V:

$$V = \sqrt{\frac{2R_\lambda}{M_0}(\lambda - X) + \frac{1}{M_0}\frac{R_K - R_\lambda}{\lambda - X_K}(\lambda - X)^2} \qquad (337)\ 144$$

or, removing from the sign of the radical $\frac{2R_\lambda}{M_0}(\lambda - X)$:

$$V = \sqrt{\frac{2R_\lambda}{M_0}(\lambda - X)}\,(\lambda - X)^{\frac{1}{2}}\sqrt{1 + \frac{R_K - R_\lambda}{2R_\lambda(\lambda - X_K)}(\lambda - X)}. \qquad (338)\ 144$$

Using for brevity the notation

$$\frac{M_0}{2R_\lambda} = a;\quad \frac{R_K - R_\lambda}{2R_\lambda(\lambda - X_K)} = b,$$

the expression (338) may be rewritten in the following form:

$$V = \frac{1}{\sqrt{a}}(\lambda - X)^{\frac{1}{2}}\sqrt{1 + b(\lambda - X)}. \qquad (339)\ 145$$

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By substituting the value of velocity V from expression (339) in the expression for the differential of time (336), we may set:

$$dt = \sqrt{a}\,\frac{(\lambda - X)^{-\frac{1}{2}}}{\sqrt{1 + b(\lambda - X)}}\,dX \qquad (340)\ 145$$

By integrating the left side of equation (340) in the limits from 0 to θ_2, where θ_2 is the duration of the second period of recoil, and the right side, in the limits from X_K to λ, we shall have:

$$\theta_2 = \sqrt{a}\int_{X_K}^{\lambda} \frac{(\lambda - X)^{-\frac{1}{2}}\,dX}{\sqrt{1 + b(\lambda - K)}} \qquad (341)\ 145$$

We shall introduce a new variable of integration

$$z = \sqrt{1 + b(\lambda - X)}\ ; \qquad (342)\ 145$$

then

$$(\lambda - X)^{-\frac{1}{2}} = \frac{\sqrt{b}}{\sqrt{z^2 - 1}} \qquad (343)\ 145$$

and

$$dz = \frac{-b\,dX}{2\sqrt{1 + b(\lambda - X)}}\ ,$$

whence

$$dX = -\frac{2}{b}\sqrt{1 + b(\lambda - X)}\,dz\ . \qquad (344)\ 145$$

The limits of the integration will be:

with $X = X_K$

$$z = z_K = \sqrt{1 + b(\lambda - X_K)}\ ;$$

with $X = \lambda$

$$z = 1\ .$$

After substituting the expressions (343) and (344) under the sign of the integral of expression (341) we may write:

$$\theta_2 = \frac{2\sqrt{a}}{\sqrt{b}}\int_{1}^{z_K} \frac{dz}{\sqrt{z^2 - 1}} \qquad (345)\ 146$$

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or

$$\theta_2 = \frac{2\sqrt{a}}{\sqrt{b}} \ln\left(z_K + \sqrt{z_K^2 - 1}\right). \qquad (346)\ 146$$

After the substitution in expression (346) of the value z_K, and also of the constants a and b we shall have:

$$\theta_2 = 2\sqrt{\frac{M_0(\lambda - X_K)}{R_K - R_\lambda}} \ln\left[\sqrt{1 + \frac{R_K - R_\lambda}{2R_\lambda}} + \sqrt{\frac{R_K - R_\lambda}{2R_\lambda}}\right]$$

or, finally, after transformations:

$$\theta_2 = \sqrt{\frac{M_0(\lambda - X_K)}{R_K - R_\lambda}} \ln \frac{R_K + \sqrt{R_K^2 - R_\lambda^2}}{R_\lambda}. \qquad (347)\ 146$$

For determination of the approximate value of the duration of the second period of recoil θ_2 we replace the variable value of the force of resistance R with its average value, which is expressed by the equality

$$R_{cp} = \frac{R_K + R_\lambda}{2},$$

and we shall suppose that this force acts during the interval of time θ_2.

Then, on the basis of equation of the amount of movement we may write:

$$R_{cp}\,\theta_2 = M_0 V_K,$$

whence we find

$$\theta_2 = \frac{M_0 V_K}{R_{cp}}$$

or, after substitution of the value of R_{cp}:

$$\theta_2 = \frac{2M_0 V_K}{R_\lambda + R_\lambda}. \qquad (348)\ 146$$

The total time of recoil t_{oT} will be:

$$t_{oT} = t_K + \theta_2. \qquad (349)\ 146$$

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6. TAKING INTO ACCOUNT THE INFLUENCE OF THE MUZZLE BRAKE IN THE CALCULATION OF THE ELEMENTS OF MOVEMENT OF THE RECOILING PARTS IN THE PERIOD OF SECONDARY ACTION

1. General considerations

The idea of muzzle brakes as a means for decreasing the energy of recoil appeared as early as the 60's of the last century. The muzzle brake was first employed in our artillery in 1862 with the three-pood "bomb" gun model 1838, in the form of 8 openings inclined to the axis of the bore under an angle of 45°, placed in the muzzle part of the barrel.

In our country as well as abroad, muzzle brakes were not extensively used in this period, because the problem of limiting the length of the recoil was solved by the employment of recoil brakes, and later on by transition to elastic gun carriages.

Much later, on the basis of the experience of the first World War, which called for an increase in the power of systems existing in armament during the time of the first World War and still in use in large numbers even after the end of this war, muzzle brakes came to be widely used in the modernization of these systems. The increasing energy of recoil resulting from an increase in the power of the shot was partially absorbed by the muzzle brake, making it possible to use the existing carriages.

Later on muzzle brakes came to be widely used in the standardization of carriages for pieces of different power and in the designing of new systems, when, for lessening the weight of the system in the firing position, it was necessary to lessen the effect of the shot on the carriage.

In the years of the Great Patriotic War, due to the necessity of combining in artillery weapons, two contradictory requirements, namely, power and maneuverability, the question of muzzle brakes became especially important. The employment of guns of medium caliber of field artillery for antitank defense makes it necessary to give them stability at small angles of elevation, and,

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as experience with infantry armament has shown, this may be done with a muzzle brake, which increases the stabilizing moment of the gun.

We distinguish 3 types of muzzle brakes: the active, the active-reactive, and the reactive.

The most widely used types of muzzle brakes are the active-reactive, represented in Figures 57 and 58. Depending upon the type of muzzle brake and the ballistic characteristics of the shot, the amount of energy of the recoil absorbed by the muzzle brake may vary from 25 to 65 % and more.

The muzzle brake comes into play at the moment of the beginning of the escape of powder gases through its "ports" (baffle openings) and acts throughout the period of escape. Before the beginning of the escape of powder gases the mechanical system, recoiling parts -- projectile -- charge, may be considered the same as in a gun without a muzzle brake, if we neglect the influence of the muzzle brake on the increase in the muzzle velocity and assume that the moment of the beginning of the escape of the powder gases coincides with the moment of the passage of the base of the projectile through the muzzle face.

Figure 57 (Page 148)

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Figure 58 (Page 148)

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The essential function of a muzzle brake of any type is first to decrease the amount of powder gases escaping from the bore of the barrel in an axial direction by having them escape through the "ports" of the muzzle brake, thus lessening the reacting force exerting its effect in the direction of the recoil, and, second, in brakes of the active-reactive type and the reactive type, the function is to channel a reactive force in the direction contrary to the recoil. As a result of this the resultant in the period of the secondary action of the powder gases will be less than it is in the absence of the muzzle brake. It may even have a direction contrary to the direction of recoil.

In addition to this, with the movement of the projectile along the "bore" of the muzzle brake, the force of pressure of the powder gases communicates to the projectile a supplementary impulse, increasing the velocity which it acquired at the moment of passing the muzzle face of the barrel.

Below we give an approximation of the theory of the muzzle brake, which may serve as a theoretical basis for its construction and in practice it is sufficiently complete for taking into account the presence of this brake in the designing of counter-recoil mechanisms.

Before we begin the explanation of the theory of the muzzle brake, we shall consider the basic formulas of gaso-dynamics relative to the escape of powder gases.

2. Formulas of velocity, discharge, and reactive force in the application to powder gases.

We shall take the well-known expression for the velocity of the escape of gases

$$U = \sqrt{\frac{2gk}{k-1} P_1 w_1 \left(1 - \left(\frac{}{}\right)^{\frac{k-1}{k}}\right)}, \qquad (350)\ 149$$

where g is acceleration of the force of gravity;

k —index of the polytrope;

P_1 —pressure in the container from which the escape takes place;

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w_1 --specific volume of the powder gases in the container;

$\varkappa$ --ratio of the pressure in the space to which the escape takes place to the pressure in the container p_1.

By replacing in expression (350) the product $p_1 w_1$ by $RT = f$, where R is the gas constant, and T--the temperature of the gases, we may set:

$$U = \sqrt{\frac{2gk}{k-1} f\left(1 - \varkappa^{\frac{k-1}{k}}\right)}. \qquad (351)\ 149$$

Using the notation

$$F_u(\zeta) = \sqrt{\frac{2gk}{k-1}\left(1 - \varkappa^{\frac{k-1}{k}}\right)}, \qquad (352)\ 149$$

we shall have the following expression for the velocity of escape:

$$U = F_u(\zeta)\sqrt{f}. \qquad (353)\ 149$$

The values of the functions $F_u(\zeta)$ with $k = 1.2$ for the escape of powder gases through a nozzle of the Laval type are given in Table 6 depending on $\zeta = \sqrt{\frac{S_a}{S_k}}$, where S_a and S_k correspond respectively to the section of the exit opening and of the critical opening of the nozzle (dimensions in $kg - m - sec$).

Table 6 (Page 15D)

$\zeta = \sqrt{\frac{S_a}{S_k}}$	$\varkappa_a = \frac{p_a}{p_1}$	$F_u(\zeta)$
1.0	0.564	3.27
1.2	0.200	5.21
1.4	0.125	5.89
1.6	0.083	6.38
1.8	0.058	6.66
2.0	0.042	6.91
2.2	0.032	7.12
2.4	0.026	7.30
2.6	0.021	7.45
2.8	0.017	7.60
3.0	0.014	7.72

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$\varkappa_a = \frac{p_a}{p_1}$ --the ration of the pressure in the exit section of the nozzle to the pressure in the container.

The effective velocity of the escape is less than the velocity determined by formula (353), derived for an ideal gas without taking into account the friction and certain other factors. For the effective velocity we shall have the expression

$$U = \varphi_1 F_u(\zeta) \sqrt{f}, \qquad (354)\ 150$$

where φ_1 is the coefficient of velocity determined by experiment (we may take $\varphi_1 = 0.8$ for the muzzle brake).

For the second-discharge (discharge per second) of gases we have the expression

$$G = s_k \left(\frac{2}{k+1}\right)^{\frac{1}{k-1}} \sqrt{\frac{2gk}{k+1}} \sqrt{\frac{p_1}{v_1}}\ ; \qquad (355)\ 150$$

by multiplying the numerator and denominator of the last factor of the expression under the radical by p_1, the formula (355) may be written in the following form:

$$G = s_k \left(\frac{2}{k+1}\right)^{\frac{1}{k-1}} \sqrt{\frac{2gk}{k+1}} \frac{p_1}{\sqrt{f}}.$$

Using as our notation

$$\left(\frac{2}{k+1}\right)^{\frac{1}{k-1}} \sqrt{\frac{2gk}{k+1}} = K_0$$

and

$$\frac{K_0}{\sqrt{f}} = A,$$

we shall have:

$$G = \frac{K_0}{\sqrt{f}} s_k p_1 = A s_k p_1, \qquad (356)\ 151$$

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where $A = \frac{K_0}{\sqrt{f}}$ is the constant, depending upon thenature of the gases and their temperature.

With $k = 1.2$, $K_0 = 2.032$.

The values of constant A with $k = 1.2$ and with certain values of f are given in Table 7.

Table 7 (Page 151)

f	A
900000	0.0068
850000	0.0070
800000	0.0072

By introducing in formula (356) the coefficient of discharge φ_2, taking into account the decrease in the critical section as a result of the compression of the stream, we may write:

$$G = \varphi_2 \frac{K_0}{\sqrt{f}} sP_1 = \varphi_2 A s_k P_1. \quad (357)\ 151$$

In accordance with the data of Rateau for the values $\varkappa_a = \frac{P_a}{P_1}$, close to 0, $\varphi_2 = 0.87$.

With the escape of gases towards the nozzle in the direction contrary to the escape of the powder gases, a reactive force will be applied. For the finding of the expression for the reactive force we write the equation of the amount of movement for the system nozzle -- charge.

The increment of the amount of movement for 1 second is equal to $\frac{G}{g} U$.

The reactive force R_c is applied to the nozzle and the force of static pressure in the exit section, the increment of which, over atmospheric pressure, is equal to $P_a - P_{at}$.

The equation of the amount of movement is written in the following form:

$$\frac{G}{g} U = R_c - s_a (P_a - P_{at}). \quad (358)\ 151$$

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Neglecting the value P_{at} in comparison with the pressure in the exit section of the nozzle, we obtain from expression (358):

$$R_c = \frac{G}{g} U + S_a P_a . \qquad (359)\ 151$$

We shall transform the expression (359), making use of the relationship for the second-discharge and the velocity. After substituting in the expression (359) the values of G and U from expression (357) and (354) we obtain:

$$R_c = \frac{\varphi_2 K_0 S_k P_1}{g\sqrt{f}} \varphi_1 F_u(\zeta)\sqrt{f} + S_k \frac{S_a}{S_k} P_1 \frac{P_a}{P_1} ;$$

bearing in mind that

$$\frac{S_a}{S_k} = \zeta^2 \quad \text{and} \quad \frac{P_a}{P_1} = \pi_a ,$$

we may set:

$$R_c = \varphi_1 \varphi_2 S_k P_1 \left[\frac{K_0 F_u(\zeta)}{g} + \frac{\zeta^2 \pi_a}{\varphi_1 \varphi_2} \right]. \qquad (360)\ 152$$

The second member in brackets plays the part of a correction for the first item and in its calculation we may take $\varphi_1 \varphi_2 = 1$. The expression in brackets is a function of only ζ, and, hence, using the notation

$$\frac{K_0 F_u(\zeta)}{g} + \zeta^2 \pi_a = F_R(\zeta), \qquad (361)\ 152$$

the expression (360) may finally be rewritten in the following form:

$$R_c = \varphi_1 \varphi_2 S_k P_1 F_R(\zeta). \qquad (362)\ 152$$

The values of function $F_R(\zeta)$ are given in table 8.

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Table 8 (Page 152)

$\zeta = \sqrt{\frac{S_\alpha}{S_k}}$	$F_R(\zeta)$
1.0	1.24
1.2	1.38
1.4	1.46
1.6	1.52
1.8	1.57
2.0	1.61
2.2	1.64
2.4	1.66
2.6	1.69
2.8	1.71
3.0	1.73

The expression (362) shows that the reactive force does not depend on the force of the powder f and is proportional to the product of the pressure in the container P_1 by the area of the critical section S_k. With an increase of $\zeta = \sqrt{\frac{S_\alpha}{S_k}}$ the value of the reactive force increases, but in proportion as we have an increase in ζ the growth of the value of the reactive force slows up.

3. The first period of work of the brake of reactive effect.

The muzzle brakes of reactive effect (Figures 59 and 59a) may be made together with the barrel or in the form of a cap piece. The walls of the passageway of a brake of this type may either be rifled or smooth, and in the later case the diameter of the passageway of the brake may be equal to or greater than the diameter of the section of the bore where the rifling is. The "ports" of the brake constitute the nozzles placed along the axis of the passageway (continuation of the bore of the gun). Each of the sections forms two nozzles, placed symmetrically with respect to the plane of fire.

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Figure 59 (Page 153)

Legend: 1. Section along CD

Figure 59a (Page 153)

Legend: 1. Section along AB

The axes of the nozzle are placed under a certain angle to the axis of the bore of the barrel. The projection of this angle on theplane perpendicular to the plane of fire and passing through the axis of the bore is designated by α, and on the plane perpendicular to the axis of the bore it is designated by β.

In the presence of an angle β the brake will create a pressure increasing the stabilizing moment of the gun.

In the work of the muzzle brake we may note two periods: the first period -- the period of movement of the projectile along the "bore" (passageway) of the brake, beginning with the moment of thepassage of the base of the projectile through the first section of the brake, and the second period -- the period of the escape of the powder gases from the bore of the barrel, beginning with the

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moment of the passage of the base of the projectile through the muzzle face of the brake.

We shall now consider the work of the brake of the reactive type in the first period, assuming for sake of simplicity in reasoning that the diameter of the "bore" of the brake is equal to the diameter of the bore of the barrel along the rifled part, or in other words, neglecting the escape of the powder gases in the direction of the bore of the barrel through the clearances between the walls of the "bore" of the brake and the body of the projectile.

In the movement of the projectile along the "bore" of the brake the sections of the brake will come into play in proportion as the projectile moves along. We shall regard the escape of powder gases in this case as taking place from a volume of the initial air space to the moment of the passage of the base of the projectile through the first section of the brake

$$W_z = W_0 + sl_z ,$$

where W_0 is the volume of the powder chamber;

l_z --the path (or length of travel) of the projectile along the bore of the barrel up to the first section of the muzzle brake.

With escape through the nozzle the total discharge of powder gases up to the given moment will be given by the following equality:

$$Y = \omega - \frac{W_z}{w} \qquad (363)\ 154$$

where w is the specific volume of the powder gases at the given moment.

The second-discharge of powder gases will be:

$$G_c = \frac{dY}{dt} = -\frac{W_z}{w^2}\frac{dw}{dt} . \qquad (364)\ 154$$

On the other hand, the second-discharge is determined by the expression (357). By equating the right sides of the expressions (357) and (364) we may write:

$$\varphi_2 \frac{K_0}{} s_1 p = -\frac{W_z}{w^2}\frac{dw}{dt} ,$$

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where S_t is the total area of the critical section of the nozzle, coming into play at a given moment;

p --the pressure in the bore at a given moment.

Supposing by way of an approximation that $p_1 w_1 = pw$, the latter equality may be rewritten in the following form:

$$\varphi_2 K_0 S_t \sqrt{\frac{p}{w}} = -\frac{W_z}{w^2}\frac{dw}{dt}. \qquad (365)\ 154$$

From equality (365) we obtain:

$$S_t\, dt = -\frac{W_z\, dw}{\varphi_2 K_0 \sqrt{p}\, w^{1.5}}. \qquad (366)\ 154$$

We ascertain the approximate law of change of the total area of the critical sections of the nozzles in proportion as the projectile moves along the passageway of the brake from the following considerations. The velocity of the projectile in the muzzle part of the bore of the barrel increases in a relatively slow manner. As the projectile moves along the passageway of the brake its velocity will increase still more slowly, as a result of the escape of powder gases through the nozzle.

Hence, the time of the movement of the projectile along the passageway of the muzzle brake t_T may be determined in an approximate manner from the relationship

$$t_T = \frac{l_T}{w_z}, \qquad (367)\ 155$$

where l_T is the length of the brake.

The "passage time" t of the movement of the projectile along the passageway of the muzzle brake may be determined in a corresponding manner from the relationship

$$t = \frac{l}{v_z}, \qquad (368)\ 155$$

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where ℓ is the length of travel of the projectile along the "bore" of the brake up to the given moment.

On the other hand, since the nozzles are distributed uniformly along the brake we may set

$$S_t = \frac{S_T}{\ell_T}\ell, \qquad (369)\ 155$$

where, by S_T we designate the total area of the critical sections of the openings of the brake.

By substituting in expression (369) the value of ℓ from the expression (368) we may set:

$$S_t = \frac{S_T}{\ell_T} v_z t. \qquad (370)\ 155$$

After substitution of expression (370) in formula (366) we shall have:

$$\frac{S_T}{\ell_T} v_z t dt = -\frac{W_z dw}{\varphi_2 K_0 \sqrt{P}\, w^{1.5}}. \qquad (371)\ 155$$

We shall express the right part of equation (371) in function of $\varkappa = \frac{P}{P_z}$,

where by P_z we designate the pressure in the bore of the barrel at the moment of the passage of the base of the projectile through the first section of the muzzle brake.

The pressure in the bore of the barrel at the given moment is expressed by the equality

$$P = P_z \varkappa;$$

from the adiabatic equation we have:

$$w = w_z \varkappa^{-\frac{1}{k}}, \qquad (372)\ 156$$

where w_z is the specific volume of the powder gases at the moment of the passage of the base of the projectile through the first section of the muzzle brake.

The specific volume w_z will be equal to:

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$$w_z = \frac{W_0 + sl_z}{\omega}. \qquad (373)\ 156$$

By differentiating the equation (372) we obtain:

$$dw = -\frac{1}{k} w_z \varkappa^{-\frac{k+1}{k}} d\varkappa. \qquad (374)\ 156$$

By substituting the expressions (372) and (374) in equation (371) we shall have:

$$\frac{s_T}{l_T} v_z t dt = -\frac{W_z}{k \varphi_2 K_0 \sqrt{P_z w_z}} \frac{d\varkappa}{\varkappa^{\frac{3k-1}{2k}}}. \qquad (375)\ 156$$

By integrating equation (375) in the limits from 0 to t and from 1 to $\varkappa$ we obtain:

$$\frac{s_T}{l_T} v_z \frac{t^2}{2} = \frac{W_z}{k \varphi_2 K_0 \sqrt{P_z w_z}} \frac{2k}{k-1} \left(\varkappa^{-\frac{k-1}{2k}} - 1\right) \qquad (376)\ 156$$

or

$$Bt^2 = \varkappa^{-\frac{k-1}{2k}} - 1, \qquad (377)\ 156$$

where

$$B = \frac{s_T v_z (k-1) \varphi_2 K_0 \sqrt{P_z w_z}}{4 l_T W_z}. \qquad (378)\ 156$$

Making use of equation (357), we may, for any moment of time, find the value $\varkappa$, and consequently also the value of the pressure in the bore of the barrel at the given moment $P = \varkappa P_z$. With $t = t_T$, $\varkappa = \frac{P_\partial}{P_z} = \varkappa_\partial$ and $P_\partial = P_z \varkappa_\partial$. Here by P_∂ we designate the pressure in the bore of the barrel at the moment of thepassage of the base of the projectile through the muzzle face of the brake.

We find the value $\varkappa$ from Table 9 on the basis of the "entering" value Bt^2.

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Table 9 (Page 157)

Bt^2	χ	Bt^2	χ
0.001	0.988	0.025	0.75
0.002	0.976	0.050	0.56
0.003	0.964	0.075	0.42
0.004	0.952	0.100	0.32
0.005	0.942	0.125	0.25
0.010	0.887	0.150	0.19
0.015	0.835	0.175	0.14
0.020	0.787	0.200	0.11

We now find the impulse of the reacting force during the period of the movement of the projectile along the "bore" of the brake.

The elementary impulse of the reacting force in the direction of the axis of the bore of the barrel will be equal to the following:

$$dI = R_c \cos\alpha\, dt. \qquad (379)\ 157$$

After substituting in expression (379) the value R from expression (362) we may set:

$$dI = \varphi_1 \varphi_2 F_R(\zeta) \cos\alpha\, p S_t\, dt. \qquad (380)\ 157$$

Replacing the pressure p with its expression by χ: $p = p_z \chi$ and $S_t dt = \frac{S_T}{l_T} v_z t\, dt$ from expression (375) we shall have:

$$dI = \varphi_1 F_R(\zeta) P_z \cos\alpha \frac{-W_z}{k K_0 \sqrt{P_z \omega_z}} \chi^{-\frac{k-1}{2k}} d\chi. \qquad (381)\ 157$$

By integrating equation (381) in the limits from 1 to χ_∂ we obtain:

$$I_1 = \varphi_1 F_R(\zeta) P_z \cos\alpha \frac{2 W_z}{K_0 \sqrt{P_z \omega_z}(k+1)} \left(1 - \chi_\partial^{\frac{k+1}{2k}}\right). \qquad (382)\ 157$$

The increment of the velocity of theprojectile during the time of the movement of the projectile along the "bore" of the "barrel brake" may be determined from the functional relationship

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$$\Delta v_z = \frac{S}{\varphi_m} \int_0^{t_T} p\,dt \cong \frac{S}{\varphi_m} \sum p\,\Delta t \qquad (385)\ 157$$

The muzzle velocity of the projectile, that is, the velocity at the moment of the passage of the base of the projectile through the muzzle face of the brake is as follows:

$$v_\partial = v_z + \Delta v_z . \qquad (384)\ 157$$

Having the value of the muzzle velocity v_∂ and the value of the impulse of the reacting force I_1, the expression for the velocity of the movement of the recoiling parts, in the case of braking with a certain muzzle brake, for the moment of the departure of the projectile from the "bore" of the brake may be written in the following form, on the basis of the expression (202):

$$W'_\partial = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_\partial - \frac{1}{M'_0} I_1 . \qquad (385)\ 158$$

The increment of the length of travel of the recoiling parts during the time of the movement of theprojectile in the muzzle brake may be determined in an approximate manner from the relationship

$$\Delta L'_z = \sum \varepsilon W' \Delta t \cong \frac{W'_z + W_\partial}{2} t_T \qquad (386)\ 158$$

and the length of travel of the recoiling parts at the moment of the departure of the projectile from the muzzle brake, when braking with a certain muzzle brake, from the relationship

$$L'_\partial = L'_z + \Delta L'_z . \qquad (387)\ 158$$

In formulas (386) and (387) we represent with index z the length and velocity of recoil, corresponding to the moment of the passage of the base of the projectile through the first section of the muzzle brake.

The component of the reacting force of the muzzle brake, stabilizing the gun, is given by the following equality for the given moment in the first period of work of the brake:

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$$Q_c = \varphi_1 \varphi_2 F_R (\zeta) \sin \beta p_{s_t}.$$

The stabilizing force will have its maximum value at the end of the first period when $P = P_0$ and $s_t = s_T$:

$$Q_{c\,max} = \varphi_1 \varphi_2 F_R (\zeta) \sin \beta p_0 s_T. \qquad (388)\ 158$$

By analogy with formula (362), the expression for the impulse of the stabilizing force during the time of the first period of work of the muzzle brake may be written in the following form:

$$I_c = \varphi_1 F_R (\zeta) p_z \sin \beta \frac{2 W_z}{K_0 \sqrt{p_z w_z} (k+1)} \left(1 - \chi_0 \frac{k+1}{2k}\right). \qquad (389)\ 158$$

4. The second period of the work of the muzzle brake

In the second period of work of the muzzle brake the escape of powder gases remaining in the bore will take place through all the openings of the muzzle brake and in the direction of the axis of the bore of the barrel through the muzzle openings of the "barrel brake".

The discharge of powder gases through the cross-section of the muzzle brake will drop in the direction from the first section to the muzzle face of the brake. The lack of uniformity in the discharge of power gases may be taken into account by introducing into the expression for the discharge a coefficient for utilization of gases η_c.

Assuming the discharge of powder gases in the cross-section of the first section to be uniformly distributed between the minimum sections of the nozzles s_k and the section of the "bore" of the brake s, the coefficient of the utilization of gases for the first section may be written as follows:

$$\eta_1 = 1 - \frac{s}{2 s_k + s}.$$

For the second section the coefficient of utilization of gases will be:

$$\eta_2 = \frac{s}{2 s_k + s} \left(1 - \frac{s}{2 s_k + s}\right),$$

where the first factor expresses the relative quantity of gases escaping through the cross-section of the second section, that is, the relative quantity of gases not utilized in the first section.

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The coefficient of utilization in the third section will be:

$$\eta_3 = \left(\frac{S}{2S_k + S}\right)^2 \left(1 - \frac{S}{2S_k + S}\right).$$

In the same manner we may find the coefficient of utilization for all the following sections.

The sum of all the coefficients gives the total coefficient of utilization η_∂.

However, the expression for η_∂ may be obtained much more simply if we bear in mind that the relative quantity of gases utilized will be fully determined by the quantity of gases not utilized.

The latter, however, with a single section, is equal to $\frac{S}{2S_k + S}$, and with n sections

$$\left(\frac{S}{2S_k + S}\right)^n,$$

as a result of which

$$\eta_\partial = 1 - \left(\frac{S}{2S_k + S}\right)^n \qquad (390)\ 159$$

From this formula it is evident that the value of η increases with an increase in the number of sections and with an increase in the ratio $\frac{2S_k + S}{S}$.

The increase in the number of sections above a certain limit is not desirable, because each following section gives a smaller and smaller increase in the coefficient.

The effectiveness of the muzzle brake in the second period will be determined not only by the coefficient of utilization of the powder gases but also by the absolute quantity of powder gases flowing through the openings of the brake. For this reason it is necessary to know the quantity of powder gases flowing through the openings of the brake in the first period.

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On the basis of formula (357) we may write the following expression for the elementary weight of thepowder gas:

$$dY = \varphi_2 A s_t p dt. \qquad (391)\ 160$$

But on the basis of the equation of the movement of the projectile

$$p dt = \frac{\varphi m}{s} dv. \qquad (392)\ 160$$

After substituting equation (392) in equation (391) we shall have:

$$dY = \varphi_2 A s_t \frac{\varphi m}{s} dv. \qquad (393)\ 160$$

Bearing in mind the character of the increase in the velocity of the projectile depending on the distance traveled in the bore of the muzzle brake and taking into account the uniformity of the distribution of the nozzles along the muzzle brake, we may employ the following approximate relationship for the change in the area of the openings of the flow in function of the velocity of the projectile:

$$s_t = s_T \frac{v - v_z}{v_\partial - v_z}. \qquad (394)\ 160$$

By substituting expression (394) in equation (393) we shall have:

$$dY = \varphi_2 \frac{\varphi m}{s} A s_t \frac{v - v_z}{v_\partial - v_z} dv. \qquad (395)\ 160$$

By integrating equation (395) in the limits from v_z to v_∂, we obtain the following expression for the determination of the absolute value of the discharge of powder gases in the first period:

$$Y_\partial = \frac{\varphi_2 A \varphi m s_T}{2s} (v_\partial - v_z). \qquad (396)\ 160$$

In the second period the following quantity of gases escape through the openings of the muzzle brake

$$(\omega - Y_\partial)\eta_\partial. \qquad (397)\ 160$$

We shall now find the expression for the impulse of the reacting force in

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the second period. For this purpose we take the expression for the reacting force

$$R_c = \frac{G_c U}{g} + S_a P_a$$

and, removing $\frac{G_c}{g}$ from the parentheses, obtain:

$$R_c = \frac{G_c}{g}\left(U + \frac{g S_a P_a}{G_c}\right). \qquad (398)\ 161$$

Using the notation

$$\varepsilon = \frac{g S_a P_a}{G_c} = \frac{g S_T \xi^2 p \varkappa_a}{G_c K_0 S_T P \sqrt{f}} = \frac{g \varkappa_a \xi^2 \sqrt{f}}{\varphi_a K_0}, \qquad (399)\ 161$$

we may set:

$$R_c = \frac{G_c}{g}(U + \varepsilon) = \frac{G_c}{g} V_e,$$

where V_e is the effective velocity of escape.

The impulse of the component of the reacting force in the direction of the axis of the bore of the barrel for a certain interval of time, counted from the moment of the passage of the base of the projectile through the muzzle face of the brake is equal to:

$$I_t = \int_0^t R_c \cos\alpha\, dt = \frac{V_e}{g}\cos\alpha \int_0^t G\, dt. \qquad (400)\ 161$$

For the full time of the escape t' we have

$$\int_0^{t'} G\, dt = (\omega - \gamma_2)\eta_2.$$

Consequently, the full impulse of the braking force in the second period, in the direction of the axis of the bore, may be stated as follows:

$$I_2 = \frac{(\omega - \gamma_2)\eta_2 V_e \cos\alpha}{g} \qquad (401)\ 161$$

We shall now consider the work of the muzzle brake of active effect (see Figures 57 and 58), and for simplification of the discussion we shall suppose that the brake consists of one chamber.

The gases escaping from the bore of the barrel encounter in their path the

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forward wall of the brake. The powder gases are partially reflected from the surface of the forward wall and flow in part through the axial opening.

When reflected from the front wall of the muzzle brake under a certain angle θ, a part of the powder gases flows through the lateral "port" of the brake, without encountering any wall in its path. The other part of the flow, which, after reflection from the front wall, encounters in its path the lateral walls of the brake and after reflection from them flows out into the atmosphere through the lateral "port", does not create a braking force and lessens the mass of gases flowing through the axial port of the front wall and, consequently, also the reacting force, this increasing the recoil.

The coefficient of utilization of the powder gases flowing through the one-chamber muzzle brake is expressed as follows:

$$\eta_\partial = \frac{S_c}{S_c + S_o}, \qquad (402)\ 162$$

where S_c is the area of the front wall after the subtraction of the area of the axial port;

S_o --the area of the axial opening.

In addition to this, in the calculation of the amount of movement of the mass of gas reflected from the front wall we must introduce a coefficient for utilization of the working surface of the front wall η, which will be equal to the ratio of that part of the surface of the front wall S_a (active part) from which the reflection of the stream takes place to all the working area of the front wall, that is,

$$\eta = \frac{S_a}{S_c}. \qquad (403)\ 162$$

The full coefficient of the utilization of the powder gases in the one chamber muzzle brake will be equal to

$$\eta'_\partial = \eta_\partial \eta = \frac{S_a}{S_c + S_o} \qquad (404)\ 162$$

Being reflected from the active part of the front wall, the powder gases create a reacting force, the impulse of which, by analogy with the brake

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of reactive effect, may be expressed in the following manner:

$$I_д = \frac{\omega \eta'_д V_e \cos\theta}{g}, \qquad (405)\ 162$$

where ϑ is the average angle of reflection.

In the calculation of V_e in this case we should take $\zeta = 1$ and $\chi_д = 0.564$.

The relative quantity of powder gases escaping through the muzzle port of the reactive brake or the brake of active-reactive effect will be expressed as follows:

$$1 - \eta_д.$$

This quantity of gas creates a reacting force in the direction of recoil, the impulse of which will be:

$$I_R = \frac{\omega}{g} V_e (1 - \eta) \qquad (406)\ 162$$

or, taking into account the amount of powder gases escaping during the time of the movement of the projectile along the bore of the muzzle brake:

$$I_R = \frac{\omega - Y_д}{g} V_e (1 - \eta_д). \qquad (407)\ 163$$

Here, just as in formula (405), for the calculation of V_e, we must take $\zeta = 1$ and $\chi_д = 0.564$.

The increment of the amount of movement of the recoiling parts during the period of secondary action with braking with one muzzle brake is expressed by the equality:

$$M_o \Delta W' = I_R - I_д,$$

whence

$$\Delta W' = \frac{I_R - I_д}{M_o}. \qquad (408)\ 163$$

The maximum velocity of recoil in braking with one muzzle brake is determined by the expression

$$W'_{max} = W'_д + \Delta W'.$$

The increment of the length of recoil during the period of secondary action may be determined in an approximate manner from the relationship

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$$\Delta L'_{\partial} = \frac{W'_{\partial} + W'_{max}}{2} t'.$$

The length of recoil by the end of the period of the secondary action may be expressed by the equality:

$$L'_{k} = L'_{\partial} + \Delta L'_{\partial}. \qquad (409)\ 163$$

5. Calculation of the influence of the muzzle brake by the Approximation Method

The calculation given below for the influence of the muzzle brake upon the elements of movement of the recoiling parts is based on the utilization of the characteristic effects of the action of the muzzle brake determined from experience.

Generally, as a measure of the efficiency of a muzzle brake we take the value ξ determined from the relationship

$$\xi = \frac{W^2_{max} - W^2_{\partial T}}{W^2_{max}}, \qquad (410)\ 163$$

where W_{max} is the maximum velocity of free recoil in the absence of a muzzle brake;

$W_{\partial T}$ --the velocity of recoil at the end of the period of the secondary action with braking with a single muzzle brake.

From the expression (410) we can see that the coefficient ξ expresses the relative amount of kinetic energy of the progressive movement of the recoiling parts absorbed by the muzzle brake.

If we do not consider the muzzle brake as a prolongation of the barrel and limit the length of the barrel to its muzzle face, the duration of the period of secondary action in the presence of a muzzle brake may deviate only to the larger side in comparison with the duration of theperiod of secondary action in the absence of the muzzle brake. The value of this deviation will depend on the construction of the muzzle brake.

In conformity with the assumption made pertaining to disregard of the

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influence of the presence of the muzzle brake on the increase in the muzzle velocity, we shall regard the duration of the period of the secondary action as the same both without and with the muzzle brake.

Figure 60 (Page 164

The velocity of recoil at the end of the period of secondary action in the presence of the muzzle brake $W_{\partial T}$ may be greater or less than the velocity of the free recoil at the beginning period of the secondary action W_{∂} depending upon the construction of the muzzle brake, which we shall characterize by the coefficient ξ .

The course of the curves $W = f(t)$ in the absnce of a muzzle brake ($\xi = 0$) and in the presence of a muzzle brake with a different measure of efficiency (ξ_1 and ξ_2) is represented in Figure 60.

During the period of the secondary action in the absence of a muzzle brake the increment of velocity of the free recoil may be expressed by the equality:

$$\Delta W = W_{max} - W_{\partial} . \qquad (411)\ 164$$

In braking with a muzzle brake the increment of the velocity of the recoiling parts at the end of the period of secondary action will be expressed by the equality:

$$\Delta W' = W_{\partial T} - W_{\partial} ; \qquad (412)\ 164$$

the increment of the velocity of recoil $\Delta W'$ be positive or negative depending upon the efficiency of the muzzle brake.

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Bearing in mind that, on the basis of the expression (410)

$$W_{\partial T} = \sqrt{1-\xi}\, W_{max},$$

we may set:

$$\Delta W' = \sqrt{1-\xi}\, W_{max} - W_{\partial}.$$

We shall find the relation between the impulse of force $P_{K\Pi}$, acting in the period of the secondary reaction in thepresence of the muzzle brake:

$$I_{\partial T} = M_0 \Delta W',$$

to the impulse of this force in the absence of a muzzle brake:

$$I = M_0 \Delta W.$$

After designating this relationship by χ, we may write:

$$\chi = \frac{I_{\partial T}}{I} = \frac{\Delta W'}{\Delta W} = \frac{W_{max}\sqrt{1-\xi} - W_{\partial}}{W_{max} - W_{\partial}}$$

or

$$\chi = \frac{\sqrt{1-\xi} - \frac{W_{\partial}}{W_{max}}}{1 - \frac{W_{\partial}}{W_{max}}} \qquad (413)\ 165$$

After substituting in expression (413) the expressions (144) and (135a), instead of W_{max} and W_{∂} we shall have:

$$\chi = \frac{\sqrt{1-\xi} - \frac{g + 0.5\omega}{g + \beta\omega}}{1 - \frac{g + 0.5\omega}{g + \beta\omega}}$$

or finally, after transformations:

$$\chi = \frac{\sqrt{1-\xi}\left(1 + \beta\frac{\omega}{g}\right) - \left(1 + 0.5\frac{\omega}{g}\right)}{(\beta - 0.5)\frac{\omega}{g}}. \qquad (414)\ 165$$

We shall assume that the relationship of the increment of velocities of recoil for any moment of time in theperiod of secondary action remains constant and equal to χ. Then, bearing in mind that the ratio of the increments of

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velocities is equal to the ratio of the impulses of the force P_{KH} in the presence of the muzzle brake $I_{\partial T}$ to the impulse of force P_{KH} without the muzzle brake I, and, with the assumption of the equality of time t in both cases, to the ratio of the forces themselves, we may write the following expression for the force P_{KH} in the period of secondary action in the presence of a muzzle brake:

$$P_{KH} = \chi P_{KH} \qquad (415)\ 166$$

Hence, we arrive at the conclusion that for taking into account the presence of a muzzle brake in the calculation of the elements of movement of the recoiling parts in the period of the secondary action of the force P_{KH} must be multiplied by the coefficient χ, determined by the expression (414), that is, for the calculation we take

$$P_{KH} = \chi P_{\partial} e^{-\frac{t}{b}} \qquad (416)\ 166$$

or

$$P_{KH} = \chi P_{\partial}\left(1 - \frac{t}{t'}\right) \qquad (417)\ 166$$

to the exponential or linear variation respectively of the force P_{KH} during the period of the secondary action.

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The coefficient χ may have both a positive value and a negative value, something which will be determined by the value of the coefficient ξ.

The graph of the change of force P_{KH} during the period of the secondary action with various values of the coefficient ξ is given in Figure 61.

We should take the same formulas for the calculation of the elements of retarded recoil in the presence of a muzzle brake that we take for the case of the absence of the muzzle brake, assuming in conformity with the above that $P'_{\partial} = \chi P_{\partial}$, and, consequently, that $(P_{\partial} - sp_k)' = \chi (P_{\partial} - sp_k)$. An exception is constituted by the formulas for the calculation of the time t' and parameter β; the coefficient χ should not enter into these, because they are deduced for free recoil in the absence of a muzzle brake.

In the calculation of the maximum velocity of retarded recoil V_{max} in the presence of a muzzle brake, it is necessary to bear in mind the following. If

$$P_{\partial} > R > \chi P_{\partial}$$

in braking with a constance force of resistance, or

$$P_{\partial} > R_{\partial} > \chi P_{\partial}$$

in braking with a variable force of resistance in the first period, the maximum velocity of retarded recoil will be reached at the moment of the departure of the projectile from the bore, that is, $V_{max} = V_{\partial}$.

7. Calculation of the Elements of Retarded Recoil in case of the Absence of Pressure to Overcome the Inertia of the Projectile

Calculation of the Elements of Retarded Recoil

In the derivation of the functional relationships determining the elements of retarded recoil with $p_0 \neq 0$, we proceed from the assumption that the movement of the recoiling parts begins simulatneously with the movement of the projectile in the bore of the barrel.

Since the initial value of the force P_{KH} will usually be greater than the force of resistance, this assumption will be correct with $p_0 \neq 0$ in the

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limits of accuracy of the assumption made in interior ballistics for the beginning of the movement of the projectile from the moment the pressure of the powder gases reaches the value p_0.

Obviously, in the case of the absence of the pressure for overcoming the inertia of the projectile ($P_0 = 0$), which in practice we shall have in rifled bores of barrels in firing shells with ready-prepared projections and in smooth bore barrels in firing mortars, the beginning of the movement of the recoiling parts will not coincide with the beginning of the movement of the projectile. In this case there will be a lag in the beginning of the movement of the recoiling parts behind the beginning of the movement of the projectile, and this lagging will be all the greater, the slower the increase in force P_{KH} and the greater the value of the force of the initial resistance to recoil R_0 (Figure 62).

For finding the functional relationship between the elements of movement of the recoiling parts in the period of the movement of the projectile along the bore and the elements of movement of the projectile, we apply to the system of recoiling parts -- projectile -- charge the equation of the amount of movement in differential form:

$$-M_0 dV + m\,dw + dK = R\,dt. \qquad (418)\ 168$$

Bearing in mind that with the hypothesis pertaining to the linear change in the velocity of the particles of the charge from the velocity V at the bottom of the bore to velocity w at the base of the projectile and with the uniform distribution of the mass of the charge in the initial air space, the amount of movement of a charge will be expressed by the equality:

$$K = \frac{\mu}{2}(w - V),$$

for the differential of the amount of movement of the charge we shall have the expression

$$dK = 0.5\,\mu\,(dw - dV). \qquad (419)\ 168$$

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Figure 62 (Page 168)

By substituting this value of dK in the equation of the amount of movement (418) we may set:

$$-M_0 dV + m dw + 0.5\mu (dw - dV) = R dt. \qquad (420)\ 168$$

since

$$w = v - V,$$

where v is the relative velocity of the projectile and

$$dw = dv - dV, \qquad (421)\ 168$$

this equation of the amount of movement may be rewritten in the following form:

$$-M_0 dV + m dv - m dV + 0.5\mu dv - \mu dV = R dt \qquad (422)\ 168$$

or

$$-(M_0 + m + \mu) dV + (m + 0.5\mu) dv = R dt \qquad (423)\ 168$$

The movement of the recoiling parts starts when the force P_{KH} reaches the value of the force of the initial resistance to recoil R_0. At this moment the velocity of the projectile reaches a certain value v_1. The pressure of the the powder gases, corresponding to this velocity of the projectile, the time of movement of the projectile, and the length of travel of the projectile along the bore are represented by p_1, t_1 and l_1 respectively.

By integrating the left and right parts in the corresponding limits, we may set:

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$$-(M_0+m+\mu)\int_0^V dV+(m+0.5\mu)\int_{v_1}^{v} dv=\int_0^t R\,dt \qquad (424)\ 169$$

or

$$-(M_0+m+\mu)V+(m+0.5\mu)(v-v_1)=\int_0^t R\,dt. \qquad (425)\ 169$$

Solving the equality (425) for V, we obtain:

$$V=\frac{m+0.5\mu}{M_0+m+\mu}(v-v_1)-\frac{1}{M_0+m+\mu}\int_0^t R\,dt. \qquad (426)\ 169$$

The first member of the expression (426) represents the velocity of free recoil which would appear on condition that the movement of the recoilingparts begin at the moment that the velocity of the projectile reaches the value v_1. This velocity of free recoil may be considered as the difference between two velocities:

$$\frac{m+0.5}{M_0+m+\mu}(v-v_1)=\frac{m+0.5\mu}{M_0+m+\mu}v-\frac{m+0.5\mu}{M_0+m+\mu}v_1.$$

In conformity with this, the expression for the velocity of the retarded recoil, may be rewritten in the following form:

$$V=\frac{m+0.5\mu}{M_0+m+\mu}v-\frac{m+0.5\mu}{M_0+m+\mu}v_1-\frac{1}{M_0}\int_0^t R\,dt. \qquad (427)\ 169$$

Bearing in mind that $V=\frac{dX}{dt}$ and $v=\frac{dl}{dt}$ on the basis of the expression (427) we may set:

$$dX=\frac{m+0.5\mu}{M_0+m+\mu}dl-\frac{m+0.5\mu}{M_0+m+\mu}v_1\,dt-\frac{1}{M_0}dt\int_0^t R\,dt. \qquad (428)\ 169$$

By integrating equation (428) in the corresponding limits we obtain:

$$\int_0^X dX=\frac{m+0.5\mu}{M_0+m+\mu}\int_{l_1}^{l} dl-\frac{m+0.5\mu}{M_0+m+\mu}v_1\int_0^t dt-\frac{1}{M_0}\int_0^t dt\int_0^t R\,dt$$

or

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$$X = \frac{m+0.5\mu}{M_0+m+\mu}(l-l_1) - \frac{m+0.5\mu}{M_0+m+\mu} v_1 t - \frac{1}{M_0'}\int_0^t dt \int_0^t R\,dt. \quad (429)\ 170$$

The first member of the expression (429) represents that length of free recoil which we would have on condition that the movement of the recoiling parts began from the moment that the length of travel of the projectile along the bore reached the value l_1. This length of travel of free recoil may be considered as the distance between two lengths:

$$\frac{m+0.5\mu}{M_0+m+\mu}(l-l_1) = \frac{m+0.5\mu}{M_0+m+\mu} l - \frac{m+0.5\mu}{M_0+m+\mu} l_1.$$

By introducing the designation of velocity and the length of free recoil and replacing the masses with the corresponding weights, the expression for the velocity and the length of retarded recoil may be written in the following form:

$$V = W - W_1 - \frac{1}{M_0'}\int_0^t R\,dt; \quad (430)\ 170$$

$$X = L - L_1 - W_1 t - \frac{1}{M_0'}\int_0^t dt \int_0^t R\,dt \quad (431)\ 170$$

where

$$W = \frac{g+0.5\omega}{Q_0+g+\omega} v;$$

$$W_1 = \frac{g+0.5\omega}{Q_0+g+\omega} v_1;$$

$$L = \frac{g+0.5\omega}{Q_0+g+\omega} l;$$

$$L = \frac{g+0.5\omega}{Q_0+g+\omega} l_1.$$

For calculation of W_1 and L_1 it is necessary to know the velocity of

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the projectile at the beginning of the movement of the recoiling parts v_1 and the corresponding length of travel of the projectile l_1. For the determination of the time of recoil it is necessary to know the interval of time t_1 passing from the beginning of the movement of the projectile up to the beginning of the movement of the recoiling parts.

At the moment of the beginning of the movement of the recoiling parts the force P_{KH} is expressed by the equality:

$$P_{KH_1} = sp_1\left(1 - \frac{k_{HP}}{k}\right) = R_0; \qquad (432)\ 170$$

from equality (432) we find:

$$P_1 = \frac{R_0}{s\left(1 - \frac{k_{HP}}{k}\right)}. \qquad (433)\ 171$$

The solution of the problem of interior ballistics gives the relationship p and v from l and t; on the basis of the pressure P_1 we find the corresponding value l_1 and on the basis of this we find the value of v_1 and of t_1.

In an approximate manner the value of the interval of time t_1 may be determined from the equation of the amount of movement:

$$\varphi m v_1 = sp_{cp}t_1 = \frac{1}{2}sp_1t_1; \qquad (434)\ 171$$

from equation (434) we obtain

$$t = \frac{2\varphi m v_1}{sp_1}, \qquad (435)\ 171$$

where φ is the "imaginary coefficient" (term not identified -- Trans)

The time counted from the beginning of the movement of the recoiling parts is expressed by the equality:

$$t = t_{CH} - t_1, \qquad (436)\ 171$$

where by t_{CH} we designate the time counted from the beginning of the movement of the projectile.

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The relations for the elements of movement of the recoiling parts in the period of the secondary action of the gases will be the same as for the case $p_0 \neq 0$.

The duration of the first period of retarded recoil is expressed by the equality:

$$t_K = (t_2 - t_1) + t'. \qquad (437)\ 171$$

The solution of the problem for the determination of the constant force of resistance to recoil R, acting over the whole length of recoil in the case $p_0 = 0$, just as in the case $p_0 \neq 0$, boils down to the finding of the value of the force of resistance R from the work equation:

$$\frac{M_0}{2} V_K^2 = R(\lambda - X_K). \qquad (438)\ 171$$

We shall substitute in the work equation (438) the values V_K and X_K.

In accordance with formula (235),

$$V_K = V_2 + \frac{1}{M_0}[(P_2 - sp_K)b - Rt'].$$

Bearing in mind that in accordance with formula (430) with R = const

$$V_2 = W_2 - W_1 - \frac{1}{M_0} Rt_2$$

and

$$W_{max} = W_2 + \frac{1}{M_0} b (P_2 - sp_K), \qquad (142)\ 172$$

we may write:

$$V_K = W_{max} - W_1 - \frac{1}{M_0} Rt_2 - \frac{1}{M_0} Rt' \qquad (439)\ 172$$

or, using the notation

$$W_{max} - W_1 = W'_{max} \qquad (440)\ 172$$

and

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$$\frac{1}{M_0'} t_\partial + \frac{1}{M_0} t' = \alpha,$$

$$V_K = W'_{max} - \alpha R. \qquad (441)\ 172$$

The length of travel of the recoiling parts to the end of the first period of retarded recoil with R = const is expressed by the equality:

$$X_K = X_\partial + V_\partial t' + \frac{1}{M_0}\left\{b[P_\partial t' - b(P_\partial - sP_K)] - R\frac{t'^2}{2}\right\}. \qquad (226)\ 172$$

Bearing in mind that in accordance with formula (431) with R = const

$$X_\partial = L_\partial - L_1 - W_1 t_\partial - \frac{1}{M_0'} R\frac{t_\partial^2}{2}, \qquad (442)\ 172$$

and

$$L_K = L_\partial + W_\partial t' + \frac{1}{M_0} b[P_\partial t' - b(P_\partial - sP_K)] \qquad (143)\ 172$$

and

$$V_\partial = W_\partial - W_1 - \frac{1}{M_0'} R t_\partial,$$

we may write:

$$X_K = L_K - L_1 - W_1 t_K - R\left(\frac{1}{M_0'}\frac{t_\partial^2}{2} + \frac{1}{M_0} t_\partial t' + \frac{1}{M_0}\frac{t'^2}{2}\right) \qquad (443)\ 172$$

or, using the notation

$$L'_K = L_K - L_1 - W_1 t_K \qquad (444)\ 172$$

and

$$\beta = \frac{1}{M_0'}\frac{t_\partial^2}{2} + \frac{1}{M_0'} t_\partial t' + \frac{1}{M_0}\frac{t'^2}{2},$$

$$X_K = L'_K - \beta R. \qquad (445)\ 172$$

By substituting the values X_K and V_K in the equation (438), removing the parentheses and grouping all the members in the first part of the equation, we obtain:

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$$\left(\beta - \frac{M_0}{2}\alpha^2\right) R^2 + \left(\lambda - L'_K + M_0 \alpha W'_{max}\right) R - \frac{M_0}{2} W'^2_{max} = 0 \qquad (446)\ 173$$

or

$$AR^2 + BR - C = 0, \qquad (447)\ 173$$

where

$$A = \beta - \frac{M_0}{2}\alpha^2,$$

$$B = M_0 \alpha W'_{max} + \lambda - L'_K;$$

$$C = \frac{M_0}{2} W'^2_{max},$$

that is, a quadratic equation, the solution of which gives the following expression for the determination of R:

$$R = \frac{-B + \sqrt{B^2 + 4AC}}{2A}; \qquad (448)\ 173$$

in expression (448), the minus before the radical sign is dropped because it gives "unreal" values of R.

After substituting in the expression of the coefficients of A and B the values of the magnitudes α and β, we may write the following work formulas for the determination of the coefficients A, B, and C:

$$A = \frac{1}{M'_0} \frac{t'^2_\partial}{2} \left(1 - \frac{M_0}{M'_0}\right);$$

$$B = W'_{max} \left(\frac{M_0}{M'_0} t'_\partial + t'\right) + \lambda - L'_K;$$

$$C = \frac{M_0}{2} W'^2_{max},$$

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where

$$W'_{max} = W_{max} - W_1;$$
$$L'_k = L_k - L_1 - W_1 t_k;$$
$$t_\partial = t_{CH,\partial} - t_1;$$
$$t_k = (t_{CH,\partial} - t_1) + t'.$$

We may determine the magnitude t_1, by calculating in the first approximation the value of R by formula (269).

8. SYSTEMATIC CALCULATION OF THE ELEMENTS OF RECOIL

The problem of the calculation is the determination of the velocities of the lengths of travel and the corresponding intervals of time for all the period of the recoil -- from the beginning of the movement of the recoiling parts until they stop. For the determination of the elements of movement of the recoiling parts in the period of the movement of the projectile along the bore of the barrel it is necessary to know the elements of the movement of the projectile for this same period.

Just as in the working out of a new design of an artillery weapon, so in the working out of the design of a carriage for an existing barrel with definite ballistic qualities, the initial data for the finding of the elements of movement of the projectile along the bore will be known: in the first case -- from the ballistic design of the barrel; in the second case -- from experiment.

The simplest and most precise method of determining the elements of movement of the projectile along the bore is the tabular method with the employment of the tables of the Chief Artillery Administration of the Red Army, based on the solution of the problem with the method of Professor N. F. Drozdov.

Below we explain this method.

The tables are drawn up in four parts: the first part includes the table of pressures; the second, the table of velocities; the third, the table of time;

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and the fourth, special tables for ballistic calculations.

The tables are characterized by the density of the charge, the values of which are given through intervals of 0.01.

The "entering numbers" of the tables of pressure, velocities, and time are of the magnitude

$$B = (sl_K)^2 \frac{g}{f\omega\varphi_g}$$

and the relative length of travel of the projectile.

$$\Lambda = \frac{l}{l_0}$$

In each of the first three parts, there are placed in each table at the end the precise values of the relative length of travel at the moment that the powder gases reach the maximum pressure Λ_m and the corresponding values of the magnitudes themselves p_m, v_m and t_m.

The tables are drawn up with the following data:

Force of the powder . . . . . f = 950000 kg/dm/kg

Covolume . . . . . α = 1.00 dm^3/kg

Specific weight of the powder . . . . . δ = 1.6 kg/dm^3

Pressure to overcome inertia of projectile . . . p_0 = 300 kg/cm^2

In addition to this, in drawing up the tables we have assumed:

$$\theta = 0.2\,;\ \varkappa = 1.06\,;\ \varkappa\lambda = 0.06\,.$$

The values of the velocities and the time of movement of the projectile along the bore have been calculated on the assumption that $\frac{\omega}{\varphi_g} = 1$ and $l_0 =$ dm.

As a result of this, the tables give not the real values of velocities and time but their conditional values.

The real value of velocity is determined from the expression

$$v = v_{Tabl} \sqrt{\frac{\omega}{\varphi_g}}\,;$$

The effective value of time is determined from the expression

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$$t = t_{Tabl}\, l_0 \sqrt{\frac{\varphi q}{\omega}}\, 10^{-6}$$

The fourth part of the table (table for ballistic calculations) gives for the various densities of charge the value of the conditional muzzle velocity depending upon the maximum pressure of the powder gases P_m and the relative length of travel of the projectile along the bore at the moment of departure $\Delta_д$.

At the end of each table there is given the value of the parameter B corresponding to the different values of the maximum pressure P_m.

We may use the following sequence in determining the elements of movement of the projectile.

In the designing of a new artillery weapon, at the time of calculating the carriage, we shall know the bollowing magnitudes on the basis of the solution of the problem of ballistic designing and from what is given in the design:

$v_д$ --the muzzle velocity;

P_m --the maximum pressure of the powder gases;

q --the weight of the projectile;

S --the area of the cross section of the bore of the barrel (or d--caliber);

Δ --the density of the charge;

ω --the weight of the charge;

$l_д$ --the path (length of travel) of the projectile along the bore of the barrel.

The following are to be determined:

$P_д$ --the muzzle pressure;

v_m --the velocity of the projectile at the moment of the maximum pressure;

t_m --the time of the movement of the projectile to the moment of maximum pressure;

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t_∂ --the full time of the movement of the projectile along the bore and, if necessary, a number of intermediate values of velocities of the projectile v_i and of the pressure of the powder gases corresponding to the time of the movement of the projectile t_i in the limits from 0 to t_m and from t_m to t_∂.

PRELIMINARY CALCULATIONS

The length of the chamber:

$$l_0 = \frac{W_0}{S} = \frac{\omega}{\Delta S};$$

relative length of travel of the projectile along the bore:

$$\Delta_\partial = \frac{l_\partial}{l_0};$$

"Imaginary coefficient":

$$\varphi = k + \frac{1}{3}\frac{\omega}{q},$$

where the magnitude k is taken to be equal as follows:

for a howitzer	1.06
for a gun	1.05
for lengths of guns (with a length of more than 40 calibres)	1.03

DETERMINATION OF THE ELEMENTS OF MOVEMENT OF THE PROJECTILE

For the determination of the desired values of p_∂, v_m, t_m and t_∂ we use all four parts of the tables. In each of the tables we use the pages corresponding to the given density of the charge.

From table IV (table of ballistic calculations) at the end of the column corresponding to the given value p_m, we find the value of the parameter B.

From table I (pressure), at the end of the column corresponding to the value of B found, and on line corresponding to the given value of Δ_∂, we find the value of the muzzle pressure p_∂. If necessary, we must carry out an interpolation for the values of B and Δ_∂.

From table II (velocities), at the end of the column corresponding to

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the value of B found, we find the values of Δ_m and $v_{m,tab}$. In case of necessity, we must carry out an interpolation for the value of B.

The effective length of travel of the projectile along the bore up to the moment of the maximum pressure is to be found from the functional relationship

$$l_m = \Delta_m l_0,$$

and the effective value of the velocity at the moment of the maximum pressure is found from the functional relationship

$$v_m = v_{m,tab}\sqrt{\frac{\omega}{\varphi q}}.$$

From table III (time), at the end of the column corresponding to the value of B found, we find the value $t_{m,tab}$, and on the line corresponding to the given value of Δ_∂ we find the magnitude $t_{m,tab}$. If necessary, we should carry out an interpolation for B and Δ_∂.

We find the effective time of movement up until the moment of maximum pressure from the relation

$$t_m = t_{m,tab} l_0 \sqrt{\frac{\varphi q}{\omega}}\, 10^{-6},$$

and the effective or actual value of the magnitude of the time of movement of the projectile along the bore is to be found from the expression

$$t_\partial = t_{\partial,tab} l_0 \sqrt{\frac{\varphi q}{\omega}}\, 10^{-6},$$

where l_0 is given in decimeters.

If necessary, after predetermining the intermediate values of magnitude Δ_i in the limits from 0 to Δ_m and from Δ_m to Δ_∂, we can find by analogous calculations the corresponding values of the velocities of the projectile v_i, of the length of travel of the projectile l_i and the time of the movement of the projectile t_i.

CALCULATION OF THE ELEMENTS OF THE RECOIL

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First Period (period of the movement of the projectile along the bore).

1. Velocity of the free recoil at the moment of the maximum pressure:

$$W_m = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_m.$$

2. Length of the free recoil at the moment of the maximum pressure of the powder gases:

$$L_m = \frac{q + 0.5\omega}{Q_0 + q + \omega} l_m.$$

3. Velocity of the free recoil at the moment of the departure of the projectile from the bore:

$$W_д = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_д$$

or

$$W_д = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_0.$$

4. Length of the free recoil in the moment of the departure of the projectile from the bore:

$$L_д = \frac{q + 0.5\omega}{Q_0 + q + \omega} l_д.$$

For the intermediate values of the time of the movement of the projectile t_i, in accordance with the values of velocities v_i and the lengths of travel l_i, the velocity and lengths of the free recoil may be calculated by the formulas:

$$W_i = \frac{q + 0.5\omega}{Q_0 + q + \omega} v_i; \quad L_i = \frac{q + 0.5\omega}{Q_0 + q + \omega} l_i.$$

The second period of free recoil (the period of the secondary action of the gases).

5. The force of the pressure of the powder gases at the beginning of the period of the secondary action:

$$P_д = sp_д.$$

6. The coefficient of the action of the powder gases:

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$$\beta = \frac{24.5\sqrt{P_д}}{v_0}\,\beta_T\,;$$

the magnitude β_T is taken from table 4 (See Page 105).

7. The parameter of the exponential function:

$$b = \frac{(\beta - 0.5)\,\omega\, v_0}{g(P_д - sP_к)}.$$

8. The maximum velocity of free recoil:

$$W_{max} = \frac{q + \beta\omega}{q_0}\, v_д.$$

9. The duration of the period of the secondary action:

$$t' = 2.303\, b\, \lg\left(\frac{P_д}{P_к}\right).$$

10. The path of the free recoil at the end of the period of the secondary action:

$$L_к = L_д + W_д t' + \frac{1}{M_0}\, b\,[P_д t' - b(P_д - sP_к)].$$

11. Total duration of the first and second periods of free recoil:

$$t_к = t_д + t'.$$

The intermediate values of the velocities and lengths of free recoil in the period of the secondary action for the moments of time $t_i < t'$ may be calculated in a corresponding manner from the formulas:

$$W_i = W_д + \frac{1}{M_0}\, P_д b\left(1 - e^{-\frac{t_i}{b}}\right);$$

$$L_i = L_д + W_д t_i + \frac{g}{q_0}\, P_д b\left[t_i - b\left(1 - e^{-\frac{t_i}{b}}\right)\right].$$

CALCULATION OF THE ELEMENTS OF RETARDED RECOIL

First period: Case $e > 0$.

12. Initial force of the resistance to recoil:

$$R_0 = (2 \div 2.5)\, q_0.$$

13. Resistance to recoil at the end of the first period:

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$$R_K = 0.9\,\frac{Q_6 D_{пр} - (Q_0 L_K - 0.33 g R_0 t_K^2)\cos\varphi_{пр}}{h_{пр} - 0.15 g t_K^2 \cos\varphi_{пр}}.$$

14. Velocity of retarded recoil at the moment of the maximum pressure of the powder gases:

$$V_m = W_m - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{2t_K} t_m\right) t_m.$$

15. Path of retarded recoil at the moment of the maximum pressure of the powder gases:

$$X_m = L_m - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{3t_K} t_m\right)\frac{t_m^2}{2}.$$

16. Velocity of the retarded recoil at the moment of the departure of the projectile from the bore:

$$V_д = W_д - \frac{1}{M_0'}\left(R_0 - \frac{R_K - R_0}{2t_K} t_д\right) t_д.$$

17. The length of the retarded recoil at the moment of the departure of the projectile from the bore:

$$X_д = L_д - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{3t_K} t_д\right)\frac{t_д^2}{2}.$$

The intermediate values of the velocities and lengths of retarded recoil are calculated in a corresponding manner by formulas:

$$V_i = W_i - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{2t_K} t_i\right) t_i;$$

$$X_i = L_i - \frac{1}{M_0'}\left(R_0 + \frac{R_K - R_0}{3t_K} t_i\right)\frac{t_i^2}{2}.$$

18. The resistance to recoil at the moment of the departure of the projectile from the bore of the barrel:

$$R_д = R_0 + \frac{R_K - R_0}{t_K} t_д.$$

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19. The time from the beginning of the period of the secondary action up to the time the recoiling parts reach their maximum velocity:

$$\theta_1 = b \cdot 2.303 \lg \frac{2P_\partial}{R_\partial + R_K}.$$

20. The maximum velocity of retarded recoil:

$$V_{max} = V_\partial + \frac{1}{M_0}\left[\left(P_\partial - R_\partial - \frac{R_K - R_\partial}{t'}\theta_1\right)b - \left(\frac{P_\partial + R_K - R_\partial}{2t'}\theta_1\right)\theta_1\right].$$

21. The length of retarded recoil at the moment of the maximum velocity of recoil:

$$X_R = X_\partial + V_\partial\theta_1 + \frac{1}{M_0}\left\{\left[P_\partial(\theta_1 - b) + b\left(R_\partial + \frac{R_K - R_\partial}{t'}\theta_1\right)\right]b - \left(R_\partial + \frac{R_K - R_\partial}{3t'}\theta_1\right)\frac{\theta_1^2}{2}\right\}.$$

22. Velocity of retarded recoil at the end of the first period:

$$V_K = V_\partial + \frac{1}{M_0}\left[b(P_\partial - sP_K) - \frac{R_\partial + R_K}{2}t'\right]$$

23. The path of retarded recoil at the end of the first period:

$$X_K = X_\partial + V_\partial t' + \frac{1}{M_0}\left\{b\left[P_\partial t' - b(P_\partial - sP_K)\right] - \frac{2R_\partial + R_K}{3}\frac{t'^2}{2}\right\}.$$

The intermediate values of the velocities and lengths of retarded recoil in the period of the secondary action for the moments of time may be calculated in a corresponding manner by the formulas:

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$$V_i = V_0 + \frac{1}{M_0}\left[P_0 b\left(1 - e^{-\frac{t_i}{b}}\right) - \left(R_0 + \frac{R_K - R_0}{2t'} t_i\right) t_i\right];$$

$$X_i = X_0 + V_0 t_i + \frac{1}{M_0}\left\{P_0 b\left[t_i - b\left(1 - e^{-\frac{t_i}{b}}\right)\right] - \left(R_0 + \frac{R_K - R_0}{3t'} t_i\right)\frac{t_i^2}{2}\right\}.$$

First period. Case $e = 0$.

13'. Resistance to recoil in first period:

$$R = R_K = 0.9\,\frac{Q_0 D_{\text{пр}} - Q_0 L_K \cos\varphi_{\text{пр}}}{h_{\text{пр}} - 0.9\,Q_0 \beta \cos\varphi_{\text{пр}}},$$

where

$$\beta = \frac{1}{M_0'}\left(\frac{t_0^2}{2} + t_0 t'\right) + \frac{1}{M_0}\,\frac{t_0^2}{2}.$$

14'. Velocity of retarded recoil at the moment of the maximum pressure of the powder gases:

$$V_m = W_m - \frac{1}{M_0'} R t_m.$$

15'. Length of retarded recoil at the moment of the maximum pressure of the powder gases:

$$X_m = L_m - \frac{1}{M_0'} R \frac{t_m^2}{2}.$$

16'. Velocity of retarded recoil at the moment of the departure of the projectile from the bore:

$$V_0 = W_0 - \frac{1}{M_0'} R t_0.$$

17'. Length of retarded recoil at the moment of the departure of the projectile from the bore:

$$X_0 = L_0 - \frac{1}{M_0'} R \frac{t_0^2}{2}.$$

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19'. Time from the beginning of the period of the secondary action up to the moment when the recoiling parts reach their maximum velocity:

$$\theta_1 = 2{,}303\, b \lg \frac{P_0}{R}.$$

20'. Maximum velocity of retarded recoil:

$$V_{max} = V_0 + \frac{1}{M_0}\left[bP_0 - (b+\theta_1)R\right].$$

21'. Length of retarded recoil at the moment of the maximum velocity of recoil:

$$X_R = X_0 + V_0\theta_1 + \frac{1}{M_0}\left[P_0 b(\theta_1 - b) + R\left(b^2 - \frac{\theta_1^2}{2}\right)\right].$$

22'. Velocity of retarded recoil at the end of the first period:

$$V_k = V_0 + \frac{1}{M_0}\left[b(P_0 - sP_k) - Rt'\right].$$

23'. The length of retarded recoil at the end of the first period:

$$X_k = X_0 + V_0 t' + \frac{1}{M_0}\left\{b\left[P_0 t' - b(P_0 - sP_k)\right] - R\frac{t'^2}{2}\right\}.$$

The intermediate values of the velocities and lengths of retarded recoil in the period of the movement of the projectile along the bore for the moments of time $t_i < t_0$ may be calculated from the formulas:

$$V_i = W_i - \frac{1}{M_0}Rt_i; \quad X_i = L_i - \frac{1}{M_0}R\frac{t_i^2}{2},$$

and in the period of the secondary action for the moments of time $t_i < t'$, by the formulas:

$$V_i = V_0 + \frac{1}{M_0}\left[P_0 b\left(1 - e^{-\frac{t_i}{b}}\right) - Rt_i\right];$$

$$X_i = X_0 + V_0 t_i + \frac{1}{M_0}\left\{P_0 b\left[t_i - b\left(1 - e^{-\frac{t_i}{b}}\right)\right] - R\frac{t_i^2}{2}\right\}.$$

The first period. Case of braking with a constant force over all the length of the recoil.

15". The force of resistance in braking with a constant force over all

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the length of the recoil:

$$R = \frac{-B + \sqrt{B^2 + 4AC}}{2A},$$

where

$$A = \frac{1}{M_0'} \frac{t_\partial^2}{2} \left(1 - \frac{M_0}{M_0'}\right);$$

$$B = W_{max} \left(\frac{M_0}{M_0'} t_\partial + t'\right) + \lambda - L_K;$$

$$C = \frac{M_0}{2} W_{max}^2.$$

If the magnitudes g and ω may be disregarded in comparison with Q_0, then

$$R = \frac{\frac{M_0}{2} W_{max}^2}{\lambda - L_K + W_{max} t_K}.$$

The further calculation for the first period is carried out in accordance with points 14' ÷ 23'.

The second period of recoil. Braking with a variable force of resistance.

24. Length of recoil:

$$\lambda = \frac{B - \sqrt{B^2 - 4AC}}{2A},$$

where

$$A = Q_0 \cos \varphi_{np};$$

$$B = 2Q_6 D_{np};$$

$$C = \frac{h_{np}}{0.9} M_0 V_K^2 + 2Q_6 D_{np} X_K - Q_0 \cos \varphi_{np} X_K^2.$$

25. Resistance to recoil at the end of recoil:

$$R_\lambda = 0.9 \frac{Q_6 D_{np} - Q_0 \lambda \cos \varphi_{np}}{h_{np}}.$$

26. The force of resistance to recoil in the second period corresponding to the different values of the length of recoil:

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$$R = R_\lambda + \frac{R_K - R_\lambda}{\lambda - X_K}(\lambda - X).$$

27. Square of the velocity in the second period of recoil:

$$V^2 = \frac{(R + R_\lambda)(\lambda - X)}{M_0}$$

The calculation on the basis of point 27 is carried out for values of R calculated on the basis of point 26.

The calculation on the basis of points 26 and 27 is carried out for the same values of X at intervals of 50-100 mm.

28. The duration of the second period of recoil.

$$\theta_2 = \sqrt{\frac{M_0(\lambda - X_K)}{R_K - R_\lambda}} \ln \frac{R_K + \sqrt{R_K^2 - R_\lambda^2}}{R_\lambda}$$

or, approximately

$$\theta_2 = \frac{2M_0 V_K}{R_K + R_\lambda}.$$

29. Full time of recoil:

$$t_{oT} = t_K + \theta_2.$$

Second period. Braking with a constant force of resistance.

27'. Square of the velocity in the second period of recoil:

$$V^2 = \frac{2R}{M_0}(\lambda - X).$$

28'. Duration of the second period of recoil:

$$\theta_2 = \frac{M_0 V_K}{R}.$$

29'. Full time of recoil:

$$t_{oT} = t_K + \theta_2.$$

CHAPTER III

CLASSIFICATION AND BASIC SCHEMES FOR RECOIL MECHANISMS

1. Purpose of Recoil Mechanisms and General Requirements to be Met by Them

Recoil mechanisms are intended for lessening the destructive effect of the

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shot upon the carriage. In keeping with their purpose, recoil mechanisms include the recoil brake, counterrecoil brake, and counterrecoil mechaniam. In addition to these basic assemblies, the recoil mechanisms include hydraulic compensators, counterrecoil buffers, mechanisms for automatic regulation of the change in length of the recoil with a change in the angle of elevation, devices for filling them with liquid and gas (or air), packing devices, etc.

The following demands are made of recoil mechanisms:

1. They are to brake the recoil of the barrel at a certain length of recoil and then, after the stopping of the barrel, bring about the counterrecoil of the latter into the initial position it occupied before the shot; end, both recoil and counterrecoil should take place smoothly and without shocks (impacts).

2. In field carriages the resistance to recoil and counterrecoil by the recoil mechanisms should be such as to assure stability and immobility of the artillery weapon during the time of the shot under the same conditions of fire; their action should be uniform, and the rate of operation should not depend upon the atmospheric and temperature conditions of the surrounding air.

3. On the basis of their construction they should be simple and cheap to manufacture. Their parts should be interchangeable.

4. They should be simple and reliable to regulate and the replacement of worn out or damaged parts should be easy.

5. They should not be subject to fouling during operation under field conditions.

2. CLASSIFICATION AND CONSTRUCTION OF COUNTERRECOIL MECHANISMS

In artillery practice we may encounter counterrecoil mechanisms of the most varied construction. However, in the construction of each of them there are certain general principles inherent in all the counterrecoil mechanisms or groups of them.

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The basic elements of a counterrecoil mechanism are: springs or compressed gas (or air). On this basis there are two types of counterrecoil mechanisms: the spring counterrecoil and the hydropneumatic counterrecoil. Pneumatic counterrecoil mechanisms are also used.

In the recoil of the barrel the spring (or gas) is compressed. As a result of this a certain amount of energy is accumulated in the counterrecoil mechanism, energy which is then used for the return of the barrel to its ititial position.

For convenience in theoretical investigation and study of the construction of the above-mentioned types of counterrecoil mechanisms of present-day artillery weapons, they may be classified in the following manner on the basis of the method of construction:

TABLE 10 (Page 185)

Springs			Hydropneumatic				Pneumatic
With cylindrical helical springs		With Belleville springs	Without "throttling" of the liquid during the counterrecoil		With "throttling" of the liquid during counterrecoil		
With the springs placed in the form of a single column	With telescopic placing of the springs		With direct contact of the gas with the liquid	With a floating piston	With direct contact of the gas with the liquid	With a floating piston	

The spring counterrecoil mechanisms are constructed in the following manner. The spring, one or a column of several springs (the latter occurs most often in practice), rests with one end on the cradle, regidly connected with the carriage, and the other is connected by some means with the barrel. In this

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case the working compression of the column of the springs during the time of recoil will be equal to the length of recoil.

Figure 63 shows the simplest scheme of a spring counterrecoil mechanism with the placing of the cylindrical helical spring 1 in the form of a single column, placed on the barrel 2. With one end the column of the springs rests on the bottom 5 of the stationary "cradle" 3, and with the other end it rests in a ring casing 4 of the barrel. During the time of the recoil of the barrel the spring is compressed between the ring and the bottom of the "cradle" (1). After the cessation of the recoil, the spring expands and forces the barrel back into the initial position.

With such a constructional arrangement the spring has rather large clearances and heats up quickly. Such a design is rarely used.

Figure 63 (Page 186)

Most often the construction of the spring counterrecoil mechanism is executed in accordance with the scheme represented in Figure 64. In this case one end of the column of spring 1 rests on the bottom of a stationary "cradle" 3, and the other end rests on flange 4 of the cylinder 2 of the recoil brake, connected with lug 5 of the barrel. During the time of the recoil of the barrel the spring is compressed between the flange of the brake cylinder and the bottom of the "cradle". After the stopping of the recoil,

(1) Trans. note: From the drawings this would seem to be a tubular arrangement.

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the spring is released, acts through the flange of the brake cylinder on the barrel, returning it to the position it occupied before the shot.

Figure 64 (Page 186)

The use of several springs for making the column is called for by the following considerations:

1) to make a long spring it is necessary to use long wires and this complicates the process of manufacture;

2) a long spring is in convenient to transport as a spare part (greater weight, inconvenience in packing, cumbersomeness, etc);

3) helical springs when compressed, are subjected to torsional stresses, and when released they return to their former state, thus creating moments which cause the rotation of the support or bearing; the longer the spring, the stronger its action; so in order to avoid this we place in the supports some roller bearings or a core for the springs and make of the springs a composite of right and left winding; the assembly of the core in the latter case is done alternately: right, left, right, left, etc.

With such an assembly the twisting of one spring is counteracted by the twisting of another in the opposite direction.

Figure 65 shows the scheme of a spring counterrecoil mechanism in which the cores of the springs are placed one within the other. The front end of the outer spring 1 is pressed by flange 4 of the movable cylinder 3, and the back one rests in the bottom of a stationary "cradle" 5. The front end of

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the inner spring 2 is pressed by flange 7 of cylinder 6 of the recoil brake, connected with the barrel, and the rear end rests on the bottom of the movable cylinder 3.

Figure 65 (Page 187)

When the barrel recoils the cylinder of the recoil brake, which recoils with it, presses the inside spring. As a result of the action of the compressed inside spring the movable cylinder goes back and compresses the outside spring between the bottom of the stationary "cradle" and the flange of the movable cylinder. Hence, both cores of the springs are compressed simultaneously. A counterrecoil mechanism of such construction is called a telescopic counterrecoil.

The basic advantage of a telescopic counterrecoil mechanism over the usual ones consists in the fact that its total length is much shorter. With a telescopic arrangement of the springs the working arm of compression of each core of the springs will be shorter than with the employment of a single core for the springs, and, hence, the total length of the counterrecoil mechanism may be made shorter in comparison with the first case.

Among the defects of the telescopic counterrecoil mechanisms we should mention theincrease in the diameter and a somewhat complicated construction.

Figure 66 gives a diagramatic representation of a counterrecoil mechanism consisting of Belleville springs, used in the 152 mm coastal gun of Kane. The counterrecoil mechanism consists of two cores of similar construction.

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The core of the Belleville spring is placed on guide pin 7, on which it is divided into two parts. One end of the right part (in the drawing) of the core rests in the circular collar of guide pin 7, and theother rests on the movable bottom 4; one end of the left part of the core rests against the flange of the cylinder of the brake 1, and the other rests on the collar of guide pin 7. The guide pin can move along its axis.

The action of the counterrecoil mechanism is linked up with the action of the recoil brake and consists of the following.

Figure 66 (Page 188)
Legend: 1 - recoil

During the time of the recoil of the barrel the piston rod 2 with the piston is stationary, and the cylinder of the brake 1, with the spindle 3 fastened to it, the movable bottom 4, and the Belleville springs 5 execute a recoil movement. The liquid in cavity A is forced through the variable regulating openings formed by the regulating ring of the piston and the spindle. Besides, valve 6 moves to the right and does not interfere with the flow of the liquid through the opening C into the cavity B. As a result of the fact that during recoil the piston rod with the piston goes inside the cylinder of the brake, there issues from cavity A a volume of liquid greater

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than the volume made available in cavity B. These volumes are equalized by the shifting of the movable bottom 4. When the movable bottom is shifted, the spring of the counterrecoil mechanism is compressed between the collars of the guide pin on the one side and the flange of the brake cylinder and movable bottom on the other. Hence, there is created a "hydro-spring" relationship between the movable and stationary parts of the gun, an arrangement which provides for the counterrecoil of the barrel.

During the time of the counterrecoil of the barrel, the pressure of the liquid forces valve 6 against the piston and the liquid is forced in the reverse direction only through the small openings in the valve itself, due to which the counterrecoil is braked.

The advantage of such counterrecoil mechanisms lies in their compactness (great rigidity). They are employed in systems of large caliber with short recoil.

Figure 67 (Page 189)
Legend: 1 - recoil

Figures 67 and 68 show schemes of hydropneumatic counterrecoil mechanisms with the gas (or air) in direct contact with the liquid. In the first, the piston rod recoils, and in the second the cylinders (or the packing).

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Figure 68 (Page 189)
Legend: 1 - recoil

From the drawing we can see that each of the counterrecoil mechanisms represented consists of an air container 1 and a hydraulic cylinder 2, having within it a piston rod 3 with a piston 4. In the counterrecoil mechanism with recoiling cylinders there is placed an intermediate cylinder 5. A part of the air container is filled with gas (or air), and a part with liquid. The hydraulic and intermediate cylinders are filled completely with liquid. The cylinders communicate with each other through openings α and β.

In counterrecoil mechanisms of this type the liquid serves as a means for obturating the gas, holding it for a long time under pressure, and simultaneously performing the function of transmitting the pressure of the gas to the piston. Hence, they are called hydropneumatic counterrecoil mechanisms. The intermediate cylinder 5 in the scheme of Figure 68 of the counterrecoil mechanism with recoil of the cylinders is used for the purpose of covering with liquid the connecting ducts and in this manner preventing the penetration of gas into the hydraulic cylinder during fire under high angles of elevation.

During recoil the piston rod with the piston moves relative to the cylinders and the piston drives the liquid from the hydraulic cylinder into the air container, compressing the air. After the end of the recoil, the compressed air presses against the liquid, forcing the latter from the air container into the hydraulic cylinder of the counterrecoil mechanism, as a result of which the pressure of the gas is transmitted to the piston, causing the counterrecoil of the barrel.

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Figure 69 shows one of the schemes of a hydropneumatic counterrecoil mechanism with a floating piston. It differs from the preceding in that it has a complete piston rod, in the cavity of which the gas is separated from the liquid by a floating piston 1.

Figure 69 (Page 190)
Legend: 1 - air 2 - liquid

The pressure of the liquid against the air (and vice versa) is transmitted through the floating piston. The advantage of this scheme consists in the great compactness of the construction.

A weakness of the scheme is the complicated construction of the packing of the floating piston.

During the time of the recoil of piston rod 3 or of the cylinder 2, the liquid, under the action of piston 4, is forced through opening α into the cavity of the piston rod and displaces the floating piston 1 (on the drawing, to the left), which compresses the air. During counterrecoil, the compressed air, acting on the floating piston, moves it in the reverse direction and forces the liquid from the cavity of the piston rod into cylinder 2. The barrel counterrecoils.

The floating piston was introduced in an effort to separate the liquid from the air, the oxygen of which, dissolving in the liquid, creates favorable conditions for the corrosion of the hydraulic cylinder and the packing arrangements.

With the employment in counterrecoil mechanisms of inert gases (for example,

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nitrogen) and liquids having little corrosive effect, the necessity of employing floating pistons no longer exists.

The scheme of a hydropneumatic counterrecoil mechanism with direct contact between the gas and the liquid and with throttling of the liquid during the counterrecoil is shown in Figure 70. The difference between this scheme and the first two consists in the placing of the valve 6 with the spring 5. During recoil, under the pressure of the liquid, the valve moves away from its seat and compresses the spring. The liquid moves freely around the head of the valve and is driven through the opening α into the air cylinder, compressing the gas in it. During counterrecoil, as a result of the pressure of the liquid and of the spring, the valve goes into its seat. Then too the liquid is forced into the hydraulic cylinder only through the narrow openings δ in the valve. This creates the hydraulic resistance to counterrecoil, the counterrecoil is braked, and a part of the superfluous energy of the counterrecoil mechanism is absorbed.

Figure 70 (Page 191)
Legend: 1 - recoil

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Figure 71 (Page 191)

There are constructions (Figure 71) making it possible to change (automatically or by hand) the size of the openings in the valve and in this way to regulate the resistance to counterrecoil depending upon the angle of elevation. Most often this is brought about by turning a special cock A by a certain amount.

In weapons of large calibers we sue counterrecoil mechanisms in which the compression of the air is effected directly by the action of the piston on the air. Such counterrecoil mechanisms are called pneumatic.

In actual practice we find two types of pneumatic counterrecoil mechanisms: the type with a piston connected with the breech ring by means of a transverse piece and a tie rod counterrecoiling during the recoil, and the type with a piston connected with the breech ring through the piston rod (Figure 72).

The counterrecoil mechanism consists of an air container, a piston rod with a piston, and the packing. For increasing the volume of air the piston is made hollow.

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Figure 72 (Page 192)
Legend: 1 - air 2 - full or complete piston; 3 - air container; 4 - piston rod; 5 - oil line; 6 - air line; 7 - "intensifier"

The counterrecoil mechanism operates as follows: during the recoil of the piston rod with the piston the latter compresses the air; during the counterrecoil the air, acting on the piston, returns the barrel into its initial position.

The obturation of the air in the cylinders is effected by the liquid compressed in the packing devices of the counterrecoil mechanism to a pressure exceeding somewhat the pressure up to which the air is compressed in the counterrecoil mechanism. This is realized by means of an intensifier.

The intensifier (Figure 73) consists of a space (container) 1 and a piston rod 2 with piston 3. There is air in the cylinder on one side of the piston; on the other side there is liquid; the cavities are connected by an air line and by an oil line with the air container and thepacking devices of the counterrecoil mecha ism respectively.

As a result of the fact that the pressure of the air, equal in value to the pressure in the counterrecoil mechanism, acts over a greater area than the front surface of the piston, and that the cross section (profile) of the latter transmitting the pressure to the liquid has a smaller area, the pressure within the liquid will be greater than the pressure of the air. Hence, the

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collars of the piston and of the piston rod of the counterrecoil mechanism will be pressed against the adjacent surfaces by a greater pressure than the pressure within the air cylinders.

As we can see, liquid is used for obturating the air in the hydropneumatic and pneumatic counterrecoil mechanisms.

The merit of pneumatic counterrecoil mechanisms in comparison with hydropneumatic ones consists in a greater compactness. However, the complexity of construction of the packing is the main reason for their limited employment.

Figure 73 (Page 193)
Legend: 1 - air line to the air container of the counterrecoil mechanism 2 - liquid 3 - oil line to the packing of the piston rod (or piston) of the counterrecoil mechanism.

Finally, in connecti n with counterrecoil mechanisms it is necessary to bear in mind that in construction and functioning they may be independent of the recoil brakes or united with the latter in a single mechanism (for example, the 90 mm American antiaircraft gun, model 200). In actual practice we use, in the main, counterrecoil mechanisms the action of which does not depend on the action of the recoil brake.

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3. CLASSIFICATION AND CONSTRUCTION OF HYDRAULIC RECOIL BRAKES AND COUNTERRECOIL BRAKES.

The recoil brake and the counterrecoil brake of the present day artillery weapon are generally combined from a construction standpoint into a single mechanism. Their classification, depending upon the constructional characteristics, is given in Tables 11 and 12 below.

We shall consider the most typical schemes of construction of recoil brakes and counterrecoil brakes in the given classification.

Figure 74 shows the scheme of the recoil brake of the canal type and the counterrecoil brake of the needle type. The brake for recoil and counterrecoil consists of brake cylinder 1, piston rod 2 with piston 3, and needle 4. The piston rod is connected with the lug 5 of the barrel and recoils with the latter.

On the inside surface of the brake cylinder there are several canals, generally of constant width and variable depth. During the time of the movement of the piston rod with the piston, openings of variable cross section are formed between the surface of the piston and the surface of the canals. During recoil, the liquid from the working barrel (cavity) A in front of the piston is forced out, and through the openings α is forced into the idle cavity δ behind the piston, as a result of which there takes place the braking of the recoil. The variable discharge openings are determined with a view to assuring the braking of the recoil in accordance with the law accepted for the resistance to recoil.

Since during recoil the piston rod moves from the brake cylinder to the outside, the space in cavity δ freed by the piston will be greater than the volume of liquid forced from cavity A. As a result of this there will be formed in the cavity δ in the time of the recoil a "free space" -- a vacuum, equal to the space occupied by the part of the piston rod which moves outside.

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(Classification Stamp)

CLASSIFICATION OF RECOIL BRAKES TABLE 11

On the basis of the length of the recoil		On the basis of the constructional coordination of the action of the brake with the counterrecoil mechanism	On the basis of the way the flow openings are made					Relative movement of piston rod	
With a "constant" length of recoil, the length of recoil varies within insignificant limits, depending upon the change in the character of the acting force.	With a variable length of recoil. The length of the recoil decreases as a result of a change in the flow openings with a change in the angle of elevation.	Separate from the counterrecoil mechanism	Spindle	Canal (channel, pipe)	Tongue (cotter)	Slide valve	Valve	Combined: spindle-tongue, spindle-conal etc.	Piston moves outside during counter-recoil	Piston moves inside the cylinder during recoil

CLASSIFICATION OF COUNTERRECOIL BRAKES TABLE 12

On the basis of length of travel of braking		On the basis of the constructional coordination of the action of the brake with the counterrecoil mechanism		On the basis of the constructional coordination of the action of the recoil brake		On the basis of making the flow openings				
Braking over all the length of counterrecoil	Not braking over all the length of counterrecoil	Constructional connection with the counterrecoil mechanism	Separate from the counterrecoil mechanism	Recoil brake participates in the braking of the counterrecoil	Recoil brake does not participate in the braking of the counterrecoil	Needle (spindle)	Tongue	Canal	Slide valve	Valve	Combined: valve - conal etc. slide

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During the time of the counterrecoil, after the elimination of the vacuum the liquid is forced by the piston through the discharge openings G from the cavity B into cavity A, as a result of which there is braking of the counterrecoil by the recoil brake. During the recoil the needle moves out from the cavity of the piston rod, and during the counterrecoil moves into it and forces the liquid from it, thus bringing about the braking of the counterrecoil by a needle, which is with the counterrecoil brake. The counterrecoil brake, depending upon the length of the needle, will come into play at different periods of the counterrecoil and this is determined by the selection of the scheme for braking the counterrecoil, a matter about which we shall give further details below.

The advantage of the construction is its simplicity. Such a scheme for a recoil-counterrecoil brake may be recommended for guns with a short length of recoil, for example, in stationary and semi-stationary carriages (tanks, self-propelled guns, etc).

Figure 75 (Page 196)

In the recoil brake of the key (tongue) type with the needle counterrecoil brake (Figure 75) the discharge openings of the recoil brake are made by means of key 5 of variable height and the key cutout G on thepiston. In other respects the action of this type of brake is analogous to the preceding.

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Figure 76 (Page 196)

The essential characteristic of the construction of the recoil brake and counterrecoil brake of the slide valve type (Figure 76) consists in the following: within the brake cylinder 1 there is a piston rod 2 with a piston 3. The piston has projections a, which go into the helical slot (recess), made on the inside surface of the cylinder, and the openings l of constant section. The piston may turn around the piston rod, but it cannot be moved along it. On both sides of the piston there are slide valves (discs): recoil brake 4 and counterrecoil brake 5. The slide valves have recess-openings of corresponding profiles. During the time of the recoil the slide valves are moved over a certain sector in a progressive manner. They are kept from turning by keys 6.

During recoil and counterrecoil the piston, owing to the helical grooves on the surface of the cylinder, rotate on the piston rod and, consequently, also relative to the slide valves fixed on the piston rod, gradually closing the openings of the valves. During recoil the slide valve 4, under the action of the liquid, will be pressed to the piston, and slide valve 5 will move away from the piston (see Figure 76). Besides, the liquid is forced through the openings C of slide valve 4 behind the piston and brakes the recoil. Slide valve 5 does not obstruct the forcing of the liquid. During counterrecoil the process of flow of the liquid will take place in the reverse order.

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Figure 77 (Page 197)

The ports in the piston and the cutouts in the slide valves are designed in such a way that the turning of the piston provides in the latter discharge openings in realizing the law adopted for the braking of the recoil and counterrecoil. The braking of the counterrecoil begins from the moment of the elimination of the vacuum, and the recoil brake does not work during the counterrecoil (in the given construction).

The decrease in the length of the recoil may be effected by a previous turn of the piston rod with the piston relative to the cylinder, bringing about a previous partial closing of the discharge openings in the slide valve.

The construction of the recoil brake of the spindle type and of the counterrecoil brake of the canal type (Figure 77) is as follows. The brake cylinder 1 with the spindle 2 are stationary during the time of the recoil and the counterrecoil. The piston rod 3 with the piston 4 is fastened to lug 5 of the barrel and recoils together with the latter. At the end of the spindle there is fastened a valve-moderator 6 of the counterrecoil brake. On the inside surface of the cavity of thepiston rod there are canals α of variable depth.

During the time of the recoil of the barrel the liquid from the working cavity A of the brake cylinder is forced by the piston into the cavity B, where it flows in two directions: one stream I flows into the idle cavity δ of the brake cylinder, and the second II -- into the "trans-moderator" space C.

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The first stream of liquid is forced through the ring clearance between the surface of the spindle and the regulating eye 2 and is the basic one braking the recoil. The second stream of liquid, which is directed along the canal of the piston rod, pushes the valve-moderator of the recoil brake and through the opening 4 passes into the space made free behind the moderator. The construction of the brake should be such that the space behind the moderator is completely filled with liquid at any moment of the recoil.

Figure 78 (Page 198)

During counterrecoil the spindle goes into the cavity of the piston rod and the valve-moderator, under the pressure of the liquid, is forced against the face of the spindle and covers the opening 4. The liquid from the space behind the moderator (from the cavity C) moves out only along canals α on the surface of the cavity of the piston rod, and farther on into cavity A through the opening 6. Hence, the counterrecoil brake goes into action immediately upon the beginning of the counterrecoil and acts over the whole length of the counterrecoil.

From the moment of the elimination of the vacuum, the recoil brake also goes into action. Besides, the liquid from the cavity 5 is forced into cavity A through the openings 2 and 6.

In a number of present day artillery weapons, instead of a spindle there is a counter-piston rod with canals on the surface of the latter. However,

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the principle of operation of the brake is not changed by this.

The type of brake mentioned is widely employed in field artillery.

The scheme of the recoil brake of the combined type is shown in Figure 78. Its action consists of the following. Piston rod 2 with piston 3 recoils with the barrel. The brake cylinder 1 and the spindle 4 remain stationary. On the inside surface of the cylinder there are canals α_K of variable depth.

During recoil the liquid, filling all the cylinder of the brake, presses against the movable piston rod 5, forcing it up against the circular projection of the head of the piston, as a result of which the oblique openings 6 are uncovered. The liquid forced from cavity A forms two streams. One stream passes through the oblique openings 6 into the head of the piston and on through the openings α_B between the regulating eye and the spindle (or counter-piston rod) into the space Б ; the second stream passes through the opening α_K , formed by the surface of piston 5 and the canals, is also directed into the cavity Б . Both streams brake the recoil.

During counterrecoil, up to the moment of the elimination of the vacuum, the braking of the counterrecoil by the brake will be absent. After the eliminahion of the vacuum, the movable piston 5, by the pressure of the liquid is moved in the direction of the recoil and closes completely (or partially) the openings 6 . With complete closing of openings 6 , the liquid cannot flow through openings α_B , and hence the braking of the counterrecoil will be realized only by the forcing of the liquid along the canals (openings α_K). In addition to this, an insignificant part of the liquid will pass through the longitudinal openings 8 into the piston (Figure 78). With partial closing of the openings 6 , the forcing of the liquid will take place both along the canals and through the remaining part of openings 6 . The canal in the spindle provides a free exit for the liquid from the cavity of the piston rod into the brake cylinder, thus obviating the possibility of a hydraulic shock. As we can see from the scheme considered, the actions of the recoil brake and

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of the counterrecoil brake during the time of the recoil are mutually connected, because the section of the opening through which the flow of liquid takes place during recoil is equal to the sum of the sections of the openings α_B and α_K.

Figure 79 shows the scheme of the valve brake for recoil and counterrecoil, the action of which is organically connected with the action of the counter-recoil mechanism. The recoil-counterrecoil brake and the counterrecoil mechanism consist of a brake cylinder 1, piston rod 2 with a piston 3, regulating valve 4 of the recoil brake, a regulating valve-ball 5 of the counterrecoil brake, floating piston 6, placed in the air container 7.

During the time of the shot the piston rod with the piston recoils with the barrel. The liquid from the brake cylinder 1, forced out by the regulating valve 4, through the discharge openings formed around the head of the valve, is forced into cavity A and on through canal α into the air container, where it displaces the floating piston. The piston, being moved, compresses the air, as a result of which the pressure in the air reservoir increases.

Figure 79 (Page 200)
Legend: 1-recoil 2-liquid 3-air

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The size of the discharge opening is self-regulated by the preasure of the liquid on the one hand and by the force of the spring 8 on theother. The maximum opening of the regulating valve 4 is limited by the resting of its tail part on the regulating rod 9.

During counterrecoil, under the pressure of the air, the floating piston is moved in the reverse direction. The liquid from the air reservoir is forced out through a special canal and, pressing away valve 5, moves into cavity B and then through the opening *b* into cylinder 1. Counterrecoil is produced by the pressure of the liquid on the piston. The braking of the counterrecoil is realized only by the forcing of the liquid through the openings formed around the valve-ball 5, because valve 4 by the pressure of the spring and by the pressure of the liquid is closed.

The advantageous feature of such a scheme for counterrecoil mechanisms is its compactness, and also the fact that there is no need of a liquid compensator. Among its weaknesses should be mentioned the complexity of the construction of the valves and the packing of pistons 6, and also the comparatively rapid heating of the air in the counterrecoil mechanism.

A variation in the length of the recoil depending on the angles of elevation may be realized by changing the position of the regulating rod 9.

CHAPTER IV

CALCULATION OF THE COUNTERRECOILS

1. Determination of the Stress of the Spring Counterrecoil

In the determination of the stress of the spring counterrecoil we shall assume that the compression of the spring of the counterrecoil takes place statically. In this case the stresses developed by the spring of the counterrecoil are proportional to the deformations and represent a linear function of the length of recoil (Figure 80).

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We shall adopt the following notation:

II_0, II, II_λ -- the initial, "current" (at any given moment), and final strength (force) of the counterrecoil in kilograms respectively;

II_{max} -- the force of the counterrecoil with compression of the spring until the coils make contact, in kilograms;

λ --the total length of the recoil in meters;

X --length of the recoil at the moment considered, in meters.

Figure 80 (Page 202)

The counterrecoil should meet two basic requirements: in the first place, it should counterrecoil the barrel into the initial position at any angle of elevation; in the second place, it should hold the barrel in its initial position at the maximum angle of elevation, that is, it should prevent the slipping of the barrel backwards during the time of laying and also during movement. Hence, the initial force II_0 of the counterrecoil, taking as our basis the purpose of the latter, should be selected in such a way that after the recoil there will be a complete counterrecoil of the barrel and a holding of it in this position under all angles of elevation. At any moment of the counterrecoil, the counterrecoil mechanism should overcome the component of the weight of the recoiling parts $Q_0 \sin \varphi$, the forces of friction on the guide "cradles" T and in the packing devices F. Taking this as our basis, we shall have the following condition for the determination of the initial force of the counterrecoil mechanism with the maximum angle of elevation φ_{max}.

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$$\Pi_0 \geqslant Q_0 \sin \varphi_{max} + T + F. \qquad (449)\ 202$$

The forces of friction in the guide "cradle" T may, with a sufficient degree of accuracy for practical purposes, especially in the initial calculations, be taken as equal to the following:

$$T = fQ_0 \cos \varphi_{max}, \qquad (450)\ 203$$

where f is the coefficient of the friction of sliding. Inasmuch as the grips (holding devices) are lined with bronze, then with the average quality of lubricant the coefficient f may be taken as equal to $0.16 \div 0.20$.

The value of the force of friction F in the packing devices (stuffing boxes, collars), depends a great deal on the pressure in the counterrecoil mechanism P_H and on the pressure in the recoil brake P_T. We shall say something below concerning the determination of the value of the force F. If, however, P_H and P_T are unknown, the force of friction in the packing devices is taken proportional to the weight of the recoiling parts Q_0, that is,

$$F = \nu Q_0, \qquad (451)\ 203$$

The coefficient $\nu = 0.3 \div 0.5$. The smaller value should be taken in calcualtion of spring counterrecoils; the average and the larger should be taken in the calculation of the hydropneumatic and pneumatic counterrecoil mechanisms.

By substituting the values of T and F obtained, in formula (449), we get the expression for the initial force of the counterrecoil mechanism in the following form:

$$\Pi_0 \geqslant Q_0 (\sin \varphi_{max} + f \cos \varphi_{max} + \nu) \qquad (452)\ 203$$

or

$$\Pi_0 \geqslant \beta Q_0, \qquad (452a)\ 203$$

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where for brevity we use the notation

$$\beta = \sin \varphi_{max} + f \cos \varphi_{max} + \nu. \qquad (453)\ 203$$

From formula (452) we can see that with the assigned values Q_0, f and ν, the value of the initial force of the counterrecoil mechanism depends only on the angle of elevation φ. With $f = 0.20$ and $\nu = 0.40$ the average value of the coefficient β will vary; for angles of elevation 20—30° — 0.90 ÷ 1.10; for 40—45° — 1.20 ÷ 1.25; above 60° — 1.40. For weapons having a maximum angle of elevation 45° and above, we may take $\beta = 1.40$. In this case we obtain a somewhat elevated value for Π_0, which will assure reliability in the functioning of the counterrecoil mechanism.

Having the initial force of the counterrecoil Π_0, we obtain directly from the work graph of the spring the expression for the determination of the "current" value of the force of the counterrecoil mechanism:

$$\Pi = \Pi_0 \frac{s_0 + X}{s_0} \qquad (454)\ 203$$

or

$$\Pi = \Pi_0 + \eta X, \qquad (454a)\ 203$$

where s_0 is the amount of the preliminary compression;

$\eta = tg\, \alpha = \frac{\Pi_0}{s_0}$ —the coefficient of rigidity of the spring of the counterrecoil mechanism, characterizing the rapidity of the increase in the force of the counterrecoil mechanism

With $X = \lambda$ we obtain the final force of the counterrecoil mechanism.

$$\Pi_\lambda = \Pi_0 + \eta\lambda. \qquad (455)\ 204$$

With normal work of the recoil devices, the spring of the counterrecoil is not compressed until the coils touch. However, for a number of reasons (insufficient filling of the recoil brake with liquid, wear of the lining of the piston of the brake, etc), it is possible in practice to have cases of

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deviation in the length of the recoil downward or upward. Deviation downward is not dangerous for the spring. In deviations of the length of recoil upward, it is possible for the spring to be compressed until the coils touch, something which is not desirable. Usually, a deviation in length upward by 5 to 10% of the full length ($\Delta\lambda = 0.05\lambda \div 0.10\lambda$) is permissible. On this basis the maximum amount of compression of the springs should be expressed by the equality:

$$f_{max} = s_0 + \lambda + \Delta\lambda, \qquad (456)\ 204$$

where $\Delta\lambda$ is the assumed deviation in the length of the recoil.

The load necessary for compressing the spring until the coils touch is determined by the formula

$$P_{max} = P_0 \frac{f_{max}}{s_0}. \qquad (457)\ 204$$

The ratio of the final force of the counterrecoil to the initial force

$$m = \frac{P_\lambda}{P_0} = \frac{s_0 + \lambda}{s_0} \qquad (458)\ 204$$

is called the compression ration of the counterrecoil mechanism.

From this ratio we can determine the force (strength) of the counterrecoil mechanism at the end of the recoil by the formula

$$P_\lambda = mP_0. \qquad (459)\ 204$$

The compression ratio at which the spring -- all other conditions remaining the same -- has a minimum weight is called the most favorable one. The value of it is obtained on the basis of the following considerations.

At the end of the recoil the full potential energy of the spring is expressed by the equality:

$$E = \frac{P_\lambda}{2}(\lambda + s_0).$$

By replacing P_λ with the value (459) and bearing in mind that $m = \frac{s_0 + \lambda}{s_0}$, we obtain after the substitution:

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$$E = \frac{\Pi_0}{2}\left(\frac{s_0+\lambda}{s_0}\right)(s_0+\lambda) = \frac{\Pi_0}{2}\left(\frac{s_0}{\lambda}+2+\frac{\lambda}{s_0}\right)\lambda. \qquad (460)\ 205$$

Since the initial strength of counterrecoil Π_0 and the length of recoil λ in this expression are constants, the energy of the spring is a function of the amount of preliminary compression s_0, which is shown graphically in figure 81. From Figure 81 it follows that with a change in the value s_0 there is also a change in the relationship between the amount of energy accumulated by the counterrecoil during the time of the recoil on path λ (length of travel) and the amount of potential energy which it possesses in the position before the shot, and with a decrease of s_0 the amount of energy accumulated during the time of the recoil increases (sic). An increase in s_0 is favorable from the point of view of decreasing the surplus energy of the counterrecoil mechanism (see for further details "counterrecoil"), but is unfavorable from the point of view of dimensions of the counterrecoil mechanism and, consequently, also its weight. Since the total energy of the spring isproportional to its volume, and, consequently, to the weight, it is necessary to investigate expression (460) in an effort to find the minimum.

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Figure 81 (Page 205)

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By drawing up the derivative from E and s_0 and equating it with 0:

$$\frac{dE}{ds_0} = \frac{\Pi_0 \lambda}{2}\left(\frac{1}{\lambda} - \frac{\lambda}{s_0^2}\right) = 0,$$

we have:

$$\frac{1}{\lambda} - \frac{\lambda}{s_0^2} = 0,$$

whence

$$s_0 = \lambda.$$

Taking the second derivative

$$\frac{d^2E}{ds_0^2} = \frac{\Pi_0}{s_0^3}\lambda 2$$

and substituting the value $s_0 = \lambda$, we obtain:

$$\frac{\Pi_0}{s_0^3}\lambda 2 = \frac{\Pi_0}{s_0} > 0,$$

that is, with $s_0 = \lambda$ we have the minimum function $E = f(s_0)$.

By substituting in formula (458), instead of s_0, its value λ, we obtain

$$m = \frac{2\lambda}{\lambda} = 2.$$

Consequently, the compression ratio "2" is the most favorable.

Figure 82 (Page 206)

In spring counterrecoil mechanisms we cannot always obtain $m = 2$. However, if it is impossible to have $m = 2$, we must take the value of m as close to 2 as possible, remembering that with an increase in m the rigidity of the spring of the counterrecoil mechanism also increases. In the spring counterrecoil mechanisms of a number of existing systems, the value m varies between the limits 1.7 --- 2.3.

With the compression ratio m which we have adopted, we obtain the value

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of S_0 from the formula (458):

$$S_0 = \frac{\lambda}{m-1} . \qquad (461)\ 206$$

Finally, in the selection of the compression ratio it is also necessary to bear in mind that the force of the counterrecoil mechanism at the end of recoil II_λ was not greater than the force of resistance to recoil R_λ.

Let us suppose that we took a compression ratio of such a magnitude that II_λ is greater than R_λ (Figure 82). Then, on the sector of the path from the point α to the end of the recoil, the force of the counterrecoil mechanism II will be greater than our resistance to recoil R, thus heading to an interference with the stability of the gun. Finally, as a result of the elastic qualities of the counterrecoil mechanism, we would not obtain a precise limitation of the length of recoil. Hence, in selecting a compression ratio it is necessary to see that

$$II_\lambda \leq 0.9 R_\lambda .$$

2. Determination of the Strength of the Pneumatic and the Hydraulic Counterrecoil Mechanisms

The variety found in the construction of pneumatic and hydraulic counterrecoil mechanisms do not exert, in principle, any essential influence upon the calculation of the strength of the latter. Hence, we shall consider the problem with a scheme such as that represented in Figure 83.

Figure 83 (Page 207)

We shall use the following notation:

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P_0, P, P_λ —pressures in the counterrecoil mechanism: initial, "current", and end of the recoil respectively;

II_0, II, II_λ —forces of the counterrecoil mechanism: initial, "current", and final respectively;

W_0, W, W_λ —the volumes of gas in the counterrecoil mechanism: initial, "current", and end of the recoil respectively;

A_H —the working area of the piston;

X —the length of the recoil at any given moment;

λ —the total length of recoil.

The initial force (strength) of the counterrecoil mechanism is determined by formula (452) from the considerations expressed in the discussion of spring counterrecoil mechanisms. The necessary value of II_0 in the counterrecoil mechanism is created by the appropriate selection of the initial pressure in the counterrecoil mechanism p_0 and the working area of the piston A_H, since

$$II_0 = A_H p_0 .$$

During the time of the recoil, as a result of the displacement of the piston, a part of the liquid from the hydraulic cylinder of the counterrecoil mechanism will be forced into the air container, in which the gas is compressed; during the time of the counterrecoil the process will be just the reverse. As a result, the temperature of the gas in the counterrecoil mechanism will increase with each shot. As a result of the radiation of a part of the heat into the atmosphere, the law of the change of the condition of the gas in the counterrecoil mechanism is neither adiabatic nor isothermic. Many years of experience shows that there takes place in the condition of the gas of the counterrecoil mechanism a polytropic change characterized by the equation

$$p_0 W_0^x = p W^x ,$$

whence, the pressure in the counterrecoil mechanism is

$$p = p_0 \left(\frac{W_0}{W}\right)^x , \qquad (462)\ 208$$

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where $\varkappa$ is the index of the polytrope taken as equal to 1.20 ÷ 1.33.

At the moment of the passing of the recoiling parts over the path X the volume of the liquid forced from the hydraulic cylinder into the air cylinder will be equal to $A_H X$. The initial volume of the gas is decreased by this same magnitude. As a result of this the "current" volume, occupied by the air at the given moment, will be expressed by the equality:

$$W = W_0 - A_H X. \qquad (463)\ 208$$

By substituting this value of W in (462), we obtain

$$p = p_0 \left(\frac{W_0}{W_0 - A_H X} \right)^{\varkappa}. \qquad (464)\ 208$$

Since the product $A_H p$ represents the force of the counterrecoil mechanism, by multiplying the left and the right sides of the equation (464) by A_H we shall have:

$$II = II_0 \left(\frac{W_0}{W_0 - A_H X} \right)^{\varkappa}. \qquad (465)\ 208$$

With $X = \lambda$ we obtain the expression for the determination of the final force of the counterrecoil:

$$II_\lambda = II_0 \left(\frac{W_0}{W_0 - A_H \lambda} \right)^{\varkappa}. \qquad (466)\ 208$$

For convenience of use we transform the formula obtained.

Above we pointed out that the ratio of the force of the counterrecoil mechanism at the end of the recoil II_λ to its initial force II_0 is the compression ratio m. Consequently,

$$m = \frac{II_\lambda}{II_0} = \left(\frac{W_0}{W_0 - A_H \lambda} \right)^{\varkappa}. \qquad (467)\ 208$$

By solving the latter for W_0 we obtain the expression for the determination of the initial volume of air depending upon the compression ratio:

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$$W_0 = \frac{A_H \lambda}{1-\left(\frac{1}{m}\right)^{\frac{1}{\chi}}} . \qquad (468)\ 209$$

For brevity we make use of the following notation

$$\nabla = \frac{1}{1-\left(\frac{1}{m}\right)^{\frac{1}{\chi}}} , \qquad (469)\ 209$$

after which the formula (468) takes the form:

$$W_0 = \nabla A_H \lambda . \qquad (470)\ 209$$

It is convenient to express the initial volume of the air W_0 in the containers of the counterrecoil mechanism in liters (dm^3); the length of the recoil λ in meters; and the working area of the piston A_H in square centimeters. Taking this into account formula (470) for the determination of the initial volume of air in the counterrecoil mechanism should be rewritten in the following form:

$$\boxed{W_0 = 0.1 \nabla A_H \lambda} \ (dm^3). \qquad (471)\ 209$$

Substituting the value of W_0 obtained in formula (465), we rewrite it as follows:

$$II = II_0 \left(\frac{0.1 \nabla A_H \lambda}{0.1 \nabla A_H \lambda - 0.1 A_H X}\right)^{\chi}$$

or

$$II = II_0 \left(\frac{\nabla \lambda}{\nabla \lambda - X}\right)^{\chi} . \qquad (472)\ 209$$

After determining the length of recoil λ and having assigned the compression ratio m we can calculate ∇ with formula (469) and then, on the basis of formula (472), calculate the strength of the counterrecoil mechanism.

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Figure 84 (Page 209)

The values of ∇ are given in Table 13, for different compression ratios and indexes of the polytrope. By plotting on a graph the values of II obtained, we get the curve (Figure 84), characterizing the increase in the strength of II of the counterrecoil mechanism depending on the length of travel of the recoil.

TABLE 13 (Page 120)

THE VALUES OF FOR DIFFERENT COMPRESSION RATIOS AND INDEXES OF THE POLYTROPE

m \ $\varkappa$	1.05	1.10	1.15	1.20	1.25	1.30	1.33	1.35	1.40
1.5	3.12	3.24	3.37	3.49	3.61	3.74	3.80	3.86	3.98
1.6	2.77	2.88	2.98	3.09	3.19	3.30	3.36	3.41	3.51
1.7	2.52	2.61	2.70	2.80	2.89	2.92	3.04	3.08	3.17
1.8	2.33	2.42	2.50	2.58	2.67	2.76	2.81	2.84	2.79
1.9	2.19	2.27	2.34	2.42	2.49	2.57	2.61	2.65	2.72
2.0	2.07	2.14	2.21	2.29	2.35	2.43	2.46	2.49	2.56
2.1	1.97	2.04	2.10	2.17	2.23	2.31	2.34	2.37	2.43
2.2	1.90	1.96	2.02	2.08	2.14	2.20	2.24	2.27	2.32
2.3	1.83	1.88	1.94	2.00	2.06	2.12	2.15	2.17	2.23
2.4	1.77	1.82	1.88	1.90	1.99	2.05	2.08	2.10	2.15
2.5	1.72	1.77	1.82	1.87	1.93	1.98	2.01	2.03	2.08
2.6	1.67	1.72	1.77	1.82	1.87	1.93	1.95	1.97	2.01
2.7	1.64	1.68	1.73	1.78	1.82	1.88	1.90	1.92	2.00
2.8	1.60	1.65	1.69	1.74	1.78	1.83	1.86	1.88	1.92
2.9	1.57	1.61	1.66	1.70	1.74	1.79	1.82	1.83	1.88
3.0	1.54	1.58	1.63	1.67	1.71	1.76	1.78	1.80	1.84
3.1	1.52	1.56	1.60	1.64	1.68	1.72	1.75	1.76	1.80
3.2	1.49	1.53	1.57	1.61	1.65	1.69	1.72	1.73	1.77
3.3	1.47	1.51	1.55	1.59	1.63	1.67	1.69	1.70	1.74
3.4	1.45	1.49	1.53	1.56	1.60	1.64	1.66	1.68	1.72
3.5	1.44	1.47	1.51	1.54	1.58	1.62	1.64	1.66	1.69
3.6	1.42	1.45	1.49	1.52	1.56	1.60	1.62	1.63	1.67
3.7	1.40	1.44	1.47	1.51	1.54	1.58	1.60	1.61	1.65
3.8	1.39	1.42	1.46	1.49	1.52	1.56	1.58	1.59	1.63
3.9	1.38	1.41	1.44	1.48	1.51	1.54	1.56	1.58	1.61
4.0	1.37	1.40	1.43	1.46	1.49	1.53	1.55	1.56	1.59

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By dividing the numerator and denominator of formula (472) by the total length of recoil λ we shall have:

$$II = II_0 \left(\frac{\nabla}{\nabla - L}\right)^{\varkappa}. \qquad (473)\ 210$$

With $II_0 = 1$, we obtain:

$$II_1 = \left(\frac{\nabla}{\nabla - L}\right)^{\varkappa}. \qquad (474)\ 210$$

Bearing this in mind we may represent formula (472) in this form:

$$II = II_0 \cdot II_1, \qquad (475)\ 210$$

where $L = \frac{x}{\lambda}$ —the relative length of recoil; it changes from 0 to 1;

II_1 —the value of the strength of the counterrecoil depending upon L with ∇ given and with $II_0 = 1$.

Since L changes in the interval from 0 to 1, we may take for L in this interval the fixed values: 0.001; 0.002; 0.004...0.100 etc and carry out the previous calculation for a number of values of m and place the findings of the calculation in an appropriate table. In appendix 2 we give a table for values of II_1 depedning upon L for the given compression ratio (with $\varkappa = 1.33$).

The use of the above table is simple. The base figures ("entering" figures) in the table are the compression ratio and the relative length of the path of recoil L. Having assigned the compression ratio m, we find in the vertical column of the table values of II_1 for a number of values of L. Then, by simple multiplication of II_0 — the initial strength of the counterrecoil mechanism (which we suppose to be known) — by II_1, we determine the strength of the counterrecoil mechanism.

The absolute value of the length of recoil is determined by the formula $X = L\lambda$; with this length of recoil λ should be known.

It is clearly evident that the values of L in the table may not be taken one after the other, but at intervals of 1 to 2 lines, depending upon the

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desired value of the interval of distance between the successive points of recoil. By interpolation we can determine the value of Π_1 for any value of L not contained in the table. The latter is particularly important for the case when it is necessary to determine the value of Π_1 for a given length of the path of recoil X. In this case we find the precise value of $L = \frac{X}{\lambda}$ (if the L obtained is not in the table) and then by interpolation we determine Π_1.

As we can see, the table mentioned enables us to calculate the force of the counterrecoil in a very short time.

In the utilization of formulas (472) or (474) it is necessary to determine the value of m. Consequently, it is necessary to know to what results an increase or decrease in the compression ratio will lead.

From formula (469) and Table 13 which we have calculated we can see that with an increase in the compression ratio the value of ∇ drops, a fact which is shown in Figure (85). Consequently, with the predetermined (assigned) lengths of recoil λ and the working area of the piston A_H, with an increase in the compression ratio m the initial volume of the air W_0 decreases, something which leads to a decrease in the dimensions of the counterrecoil mechanism.

For example, if the initial volume of air with a compression ratio $m = 1.5$ is taken as unity, then, with an increase in the compression ratio, we obtain the values for the initial volumes of air given in Table 14.

From the data of Table 14 we see that the initial volume of air decreases perceptibly only with an increase in the compression ratio up to $2 \div 2.5$. A further increase in the compression ratio exerts relatively little influence upon the change of the initial volume.

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TABLE 14 (Page 212)

THE VALUE W_o DEPENDING UPON THE COMPRESSION RATIO m

m	1.5	2.0	2.5	3.0	3.5	4.0
W_o	1.00	0.647	0.529	0.468	0.432	0.408
Decrease in volume in comparison with the preceeding in %.....		35.3	11.8	6.1	3.6	2.4

Figure 85 (Page 212)

In addition to this, the intensity of the heating of the gas in the counter-recoil mechanism during the time of the recoil depends upon the compression ratio, as we can see from the following. For thepolytropic condition of the gas the following relationship exists between its volume and absolute temperature

$$T_o W_o^{x-1} = T W^{x-1},$$

whence

$$T = T_o \left(\frac{W_o}{W}\right)^{x-1},$$

where T_o and T --are the absolute temperatures (of the air at the beginning and during the time of the recoil;

W_o and W --the corresponding volumes of the air. By replacing the ratio $\frac{W_o}{W}$ by the ratio of pressures

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$$\frac{p}{p_0} = \left(\frac{W_0}{W}\right)^{\varkappa},$$

we obtain

$$T = T_0 \left(\frac{p}{p_0}\right)^{\frac{\varkappa-1}{\varkappa}}$$

On the basis of this formula we can determine the absolute temperature of the compressed air at any moment of the recoil.

Figure 86 (Page 213)

For the end of the recoil this expression takes the following form:

$$T_\lambda = T_0 \left(\frac{p_\lambda}{p_0}\right)^{\frac{\varkappa-1}{\varkappa}}.$$

or, since $\frac{p_\lambda}{p_0}$ is the compression ratio,

$$T_\lambda = T_0 (m)^{\frac{\varkappa-1}{\varkappa}}.$$

The latter expression confirms the statement made above concerning the dependence of the heating of the gas on the compression ratio. If we take $T = 288^\circ$ (normal 15° C) and $\varkappa = 1.33$, then with an increase in the compression ratio we obtain the values of the increment (increase) of the temperature of the gas in the counterrecoil mechanism at the end of the recoil, given in the graph (Figure 86) and in Table 15.

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TABLE 15 (Page 213)

VALUE OF T_λ AND ΔT DEPENDING UPON THE COMPRESSION RATIO m

m	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
T_λ	318	342	361	378	393	406	418	429
$\Delta T = T_\lambda - T$	30	54	73	90	105	118	130	141

What is explained above shows that special attention should be given to the selection of the compression ratio. For present-day field guns, oftentimes having a comparatively high rate of fire, the compression ratio is taken at $1.5 \div 2.5$. For large calibers of guns, whose rate of fire is relatively low, the compression ratio may be taken somewhat larger. Finally, the smaller compression ratios m should also be selected in order to avoid the accumulation of an excessively large reserve of potential energy in the counterrecoil mechanism during the time of the recoil.

The selection of the initial pressure p_0 is also very important in the designing of a counterrecoil mechanism. A high initial pressure leads to an increase in p_{max}, which renders difficult the obtaining of reliable obturation of the air and the holding of the liquid, especially with strong heating of the latter. In addition to this, in the selection of p_0 it is necessary to take into account the problem of caring for the counterrecoil mechanism. If the weapon is stationary (coast, ship, railroad, etc), when we can use a high pressure pump, the initial pressure may be taken within the limits of 50 — 100 kg/cm^2. Such initial pressures may also be selected in those cases when the filling of the counterrecoil mechanism with air is done by means of a cylinder. For field guns it is recommended that we take an initial pressure of 25 — 50 kg/cm^2, being guided by the possibility of using hand pumps under field conditions.

3. Calculation of the Constructional Dimensions of Hydropneumatic Counterrecoil Mechanisms

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In the calculation of a counterrecoil mechanism there can be no set pattern. Hence, it is impossible go give a set recipe for all possible cases encountered in practice. As a result of this we should consider the method of calculation proposed below only as one of the possible variants.

Before proceeding to calculate the constructional dimensions of a counterrecoil mechanism, it is necessary to determine II_0 and II_λ. After this, the subsequent calculation may be carried out in the following manner.

Since the piston rod generally works under tension, then, from the conditions of stability, we determine the diameter of the piston rod of the counterrecoil mechanism on the basis of a formula (supposing that the piston rod recoils):

a) In the case of a solid piston rod

$$d'_w = 2\sqrt{\frac{II_\lambda + I_w}{\pi R_z}}\ ; \qquad (476)\ 214$$

b) In the case of a hollow piston rod

$$d'_w = \sqrt{4\frac{II_\lambda + I_w}{\pi R_z} + d_1^2}\ , \qquad (477)\ 214$$

where R_z is the permissible stress under tension, taken equal to about ;

I_w — the force of inertia of the piston rod with the piston;

d_1 — the diamster of the canal of the piston rod;

d'_w — the diameter of the dangerous section of the piston rod (where the threads are).

The diameter d_H of the cylindrical part of the piston rod will depend upon the calculated value of d'_w, namely:

$$d_H = 1.13\, d'_w\ . \qquad (478)\ 215$$

Having predetermined (assigned) the initial pressure in the counterrecoil mechanism p_0 and having the initial strength of the counterrecoil mechanism II_0, we may determine the working area of the piston:

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$$A_H = \frac{\Pi_0}{p_0}. \qquad (479)\ 215$$

The inside diameter of the hydraulic cylinder of the counterrecoil mechanism is determined by the formula

$$D_H = \sqrt{d_H^2 + \frac{4}{\pi} A_H} = \sqrt{d_H^2 + 1.27 A_H}. \qquad (480)\ 215$$

Having predetermined in a definitive manner the construction of the end part of the piston rod and/or the piston, we should choose the construction of the collars of the piston rod and piston (diameters, length) and the stuffing boxes, taking into account questions of unification and standards. On the basis of the collars selected we determine the final values of the diameters D_H and d_H. After this we can determine the precise value of the working area of the piston:

$$A_H = \frac{\pi}{4}\left(D_H^2 - d_H^2\right). \qquad (481)\ 215$$

On the basis of the precise value of A_H obtained, we then determine the exact value of the initial pressure p_0:

$$p_0 = \frac{\Pi_0}{A_H}$$

The final pressure in the counterrecoil mechanism P_λ with the compression ratio m selected is determined by the formula

$$P_\lambda = m p_0 \qquad (482)\ 215$$

or

$$p_\lambda = \frac{\Pi_\lambda}{A_H} \qquad (483)\ 215$$

The cylinders of the counterrecoil mechanism are designed for solidity on the basis of formulas for cylindrical vessels in accordance with the theory of maximum deformations:

a) If cylinders with bottoms are subjected to a single internal pressure (Figure 87):

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$$D'_H = D_H \sqrt{\frac{R_z + 0.4\,p_\lambda}{R_z - 1.3\,p_\lambda}} \qquad (484)\ 215$$

or

$$\delta = 0.5\,D_H \left[\sqrt{\frac{R_z + 0.4\,p_\lambda}{R_z - 1.3\,p_\lambda}} - 1 \right]. \qquad (485)\ 216$$

b) If a cylinder is subject only to external pressure (Figure 88):

$$D'_H = D_H \sqrt{\frac{R_d}{R_d - 2p_\lambda}} \qquad (486)\ 216$$

Figure 87 (Page 216)

Figure 88 (Page 216)

or

$$\delta = 0.5\,D_H \left[\sqrt{\frac{R_d}{R_d - 2p_\lambda}} - 1 \right] \qquad (487)\ 216$$

where D'_H and D_H are the diameters of the external and internal surfaces of the cylinder respectively;

R_z —the permissible stress under the tension taken is $R_z = 1/3\ \sigma_e$;

R_d —the permissible stress of compression, taken as $(1.5 \div 2.0)\ R_z$;

δ —thickness of the walls of the cylinder.

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With action on a cylinder with length $L_ц > 4.9\rho\sqrt{\frac{\rho}{\delta}}$ of the external pressure it is also necessary to check the stability of the walls of the cylinder. The critical pressure at which the flattening (collapse) of the cylinder may take place is expressed by the formula

$$P_{кр} = \frac{E\delta^3}{4\rho^3(1-\mu^2)}, \qquad (488)\ 216$$

where δ is the thickness of the walls;

ρ —the radius of the average (internal) surface of the cylinder;

μ —coefficient of Poisson;

E —the modulus of elasticity.

Taking the margin of safety as equal to 5, we find that for maintaining the stability of the cylinder it is necessary that

$$P_л \leqslant \frac{1}{5} P_{кр}.$$

The constructional dimensions of the air container are determined on the basis of the initial volume of air W_0 and the quantity of liquid $W_ж$ in it necessary for reliable obturation of the air in the counterrecoil mechanism. In this case we should observe the following conditions:

$$\frac{\pi}{4} D_в^2 L_ц n = W_0 + W_ж,$$

whence

$$D_в = \sqrt{\frac{4(W_0 + W_ж)}{\pi n L_ц}}, \qquad (489)\ 217$$

where $D_в$ is the inside diameter of the air cylinder;

W_0 —the initial volume of the air;

$W_ж$ —the volume of liquid in the air container;

$L_ц$ —the length of the air cylinder; it is selected on the basis of the construction;

n —number of cylinders.

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Figure 89 (Page 217)

Figure 90 (Page 217)
Legend: 1. level of the liquid.

The volume of the liquid is selected so that the flanges, packing arrangements and connecting holes will be covered with liquid at any angle of elevation. With arrangement of the air cylinder separate from the hydraulic cylinder, the liquid, in the position before the shot, should occupy about one-half of its space (Figure 89). In this case the diameter of the air container $D_в$ is determined by the formula

$$D_в = \sqrt{\frac{8 W_0}{\pi n L_ц}} . \qquad (490)\ 217$$

If, however, the air container is placed excentrically with respect to the hydraulic container (Figure 90), the liquid should cover the hydraulic cylinder completely in the horizontal position of the latter. In this case we find from the equality

$$W_0 = F n L_ц$$

the area of the circular segment

$$F = \frac{W_0}{n L_ц} \qquad (491)\ 218$$

On the other hand, the following relationship exists between the area F of the circular segment, the radius r of the cylinder and the central angle α:

$$F = \frac{r^2}{2}\left(\frac{\pi}{180}\alpha - \sin\alpha\right), \qquad (492)\ 218$$

where r is the radius of the inside surface of the air cylinder;

α --is the central angle (in degrees).

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In formula (492) the value of the area F is a function of two variables (Υ, α). Knowing F and assigning a value to α, we can find Υ and vice versa. In practice we generally determine Υ. It is fully evident that in accordance with formula (492) we can obtain the required radius of the air cylinder only by a number of tests. In order to avoid this in the designing, it is most convenient to predetermine (assign) constructionally the magnitude Δh of the shifting of the air of the container with respect to the hydraulic cylinder (Figure 90).

The diameter of the hydraulic cylinder is known from the preceding calculation. Hence, we shall have the required value of the height of the level of the liquid H:

$$H = D'_H + \Delta h. \qquad (493)$$ 218

On the other hand, we have the following equality:

$$2r = H + h = H + \left(r - r\frac{\cos\alpha}{2}\right),$$

whence

$$H = r\left(1 + \cos\frac{\alpha}{2}\right). \qquad (494)$$ 218

Since the height of the level of the liquid H is supposed to be known, then by solving (494) for Υ we obtain:

$$\Upsilon = \frac{H}{1 + \cos\frac{\alpha}{2}}. \qquad (495)$$ 28

By substituting in formula (492), instead of radius r, its value (495), we shall have:

$$F = \frac{H^2\left(\frac{\pi}{180}\alpha - \sin\alpha\right)}{2\left(1 + \cos\frac{\alpha}{2}\right)^2}$$

or

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$$\frac{F}{H^2} = \frac{\frac{\pi}{180}\alpha - \sin\alpha}{2\left(1+\cos\frac{\alpha}{2}\right)^2}. \qquad (496)\ 219$$

For brevity we sue the notation

$$\varphi(\alpha) = \frac{\frac{\pi}{180}\alpha - \sin\alpha}{2\left(1+\cos\frac{\alpha}{2}\right)^2} \qquad (497)\ 219$$

and by rewriting the expression (496) in the following form:

$$\frac{F}{H^2} = \varphi(\alpha). \qquad (498)\ 219$$

As we can see, function $\varphi(\alpha)$ represents the ratio of the area of the circular segment F to the square of the height of the level of the liquid H^2. Its value, for the angle α, may be calculated beforehand with formula (497) and applied in Table 16, given on Page 220.

Hence, knowing F and predetermining H, we ascertain by formula (498) the value of the function $\varphi(\alpha)$, and on the basis of $\varphi(\alpha)$ we find in Table 16 the angle α. Then on the basis of formula (495) we determine the radius r which satisfies the required conditions. If necessary, the rest of the dimensions of the circular segment may be determined by the following formulas: length of the arc

$$b = r \cdot \frac{\pi}{180}\alpha, \qquad (499)\ 219$$

length of the chord

$$s = 2r\sin\frac{\alpha}{2}, \qquad (500)\ 219$$

the height (camber) of segment

$$h = 2r\sin^2\frac{\alpha}{4}. \qquad (501)\ 219$$

With the radius of the arcs equal to unity ($r=1$), the aforementioned values of H, F, b, s, h are calculated as functions of the angle α and given in Table 16. Table 16 is used as follows:

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TABLE 16 (Page 220)

THE TABLE OF THE LENGTH OF ARC b_1, CAMBER h_1, CHORD s_1, HEIGHT H_1, AREA F_1, OF THE CIRCULAR SEGMENT FOR $r=1$ AND FUNCTIONS OF $\varphi(\alpha)$.

$\varphi(\alpha)$	α	b_1	h_1	s_1	F_1	H_1
0	0	0	0	0	0	2,000
0.000016	5	0.0873	0.0010	0.0872	0.00006	1.999
1.00011	10	0.1745	0.0038	0.1743	0.00044	1.996
0.00038	15	0.2618	0.0086	0.2611	0.00149	1.991
0.00089	20	0.3491	0.0152	0.3473	0.00352	1.985
0.0018	25	0.4363	0.0237	0.4329	0.00686	1.976
0.0035	30	0.5236	0.0341	0.5176	0.01180	1.965
0.0049	35	0.6109	0.0463	0.6014	0.01864	1.954
0.0073	40	0.6981	0.0603	0.6840	0.02767	1.940
0.0106	45	0.7854	0.0761	0.7654	0.03915	1.924
0.0146	50	0.8727	0.0937	0.8452	0.05331	1.906
0.0197	55	0.9599	0.1130	0.0235	0.07039	1.887
0.0260	60	0.0472	0.1340	1.0000	0.09059	1.866
0.0336	65	1.1345	0.1566	1.0746	0.11408	1.843
0.0426	70	1.2217	0.1808	1.1472	0.14102	1.819
0.0534	75	1.3090	0.2066	1.2175	0.17154	1.793
0.0660	80	1.3963	0.2340	1.2856	0.20573	1.766
0.0808	85	1.4835	0.2627	1.3512	0.24367	1.737
0.0980	90	1.5708	0.2929	1.4142	0.28540	1.707
0.1178	95	1.6581	0.3244	1.4746	0.33093	1.676
0.1409	100	1.7453	0.3572	1.5321	0.38026	1.643
0.1674	105	1.8526	0.3912	1.5867	0.43333	1.609
0.1982	110	1.9199	0.4264	1.6383	0.49008	1.574
0.2330	115	2.0071	0.4627	1.6868	0.55041	1.537
0.2729	120	2.0944	0.5000	1.7321	0.61418	1.500
0.3188	125	2.1817	0.5383	1.7740	0.68125	1.462
0.3712	130	2.2689	0.5774	1.8126	0.75144	1.423
0.4319	135	2.3562	0.6143	1.8478	0.82454	1.382
0.4999	140	2.4435	0.6580	1.8794	0.90034	1.342
0.5814	145	2.5307	0.6993	1.9074	0.97858	1.301
0.6678	150	2.6180	0.7412	1.9319	1.05900	1.259
0.7717	155	2.7053	0.7836	1.9576	1.14132	1.216
0.8891	160	2.7925	0.8264	1.9696	1.22525	1.174
1.0246	165	2.8798	0.8695	1.9829	1.31049	1.131
1.1816	170	2.9671	0.9128	1.9924	1.39671	1.087
1.3609	175	3.0543	0.9564	1.9981	1.48359	1.044
1.5708	180	3.1416	1.0000	2.0000	1.57080	1.000

Having F and H, we determine the ratio $\frac{F}{H^2} = \varphi(\alpha)$; on the basis of function $\varphi(\alpha)$ in Table 16, we find the central angle α and F_1, and also, if necessary, the corresponding values of H_1, b_1, S_1, and h_1. After this we determine the radius of the cylinder on the basis of formula:

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$$r = \sqrt{\frac{F}{F_1}}.$$ (502) 221

By multiplying H_1, b_1, s_1, h_1, by the radius r we obtain the height H, the length of the arc b, the length of the chord s, the height of the segment h; in order to obtain the area F (if it is unknown, and r is given), it is necessary to multiply F_1 by r^2.

Figure 91 (Page 221)

It is obvious that the basic number ("entering" number) in the table may be not only the function $\varphi(\alpha)$ but also other values.

For the purpose of facilitating the finding of the necessary values we also give, along with the tables, the graph of Figure 19. No special explanation is needed for the use of the graph.

The thickness of the walls of the air cylinder is calculated in all cases for the inside pressure P_λ on the basis of formula (484) or on the basis of formula (485). The rest of the dimensions (openings etc) are selected constructionally.

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As liquid for filling the counterrecoil mechanism we sue steel M and spindle oil.

4. Methods of Checking the Amount of Liquid in the Counterrecoil Mechanism

The design values of the force of the hydropneumatic counterrecoil mechanism during the time of recoil, with the selected initial pressure, are to be obtained only with the normal quantity of liquid in it. With a change in the quantity of liquid, the initial volume of the air also changes, thus leading to a change in the rate of operation of the counterrecoil mechanisms, as a result of which the rate of operation of the recoil mechanisms as a whole also changes. Hence, in employing the device it is necessary to have a systematic checking both of the quantity of liquid in the counterrecoil mechanism and the initial pressure P_0.

The checking of the initial pressure is done by means of a manometer. The checking, however, of the quantity of liquid in the counterrecoil mechanism may be done in two ways: on the basis of the level of the liquid in the cylinder of the counterrecoil mechanism and by means of a special graph.

The essence of the checking by the level of the liquid consists in the following.

On the cover of the air cylinder of the counterrecoil mechanism we bore a control opening, the axis of which, with the cylinder of the counterrecoil mechanism in a horizontal position, coincides with the level of the normal quantity of liquid. The opening is closed by a plug.

In checking the quantity of liquid, we give to the barrel an angle of elevation equal to 0, unscrew the plug by two or three turns and observe the character of the liquid forced out through the control opening. If the counterrecoil mechanism contains the normal quantity of liquid, air with splashes of liquid should be forced from the opening. With the previously determined angle of depression ($\varphi <$ [RESTRICTED] come from the opening, and with

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an angle of elevation $\varphi > 0$ —only air.

By the preliminary calculation we can determine the functional relationship between the value of the angle of depression (or elevation) and the quantity of liquid lacking (or the superfluous liquid). For example, in our Russian 85mm antiaircraft gun model 1939 the escape of nitrogen with an angle of depression of 5 mils shows a lack of liquid of 0.5 liters; with 10 mils — 1.25 liters; with 15 mils — 1.8 liters.

As we can see, this method is simple and convenient. It makes possible a sufficiently precise determination of the quantity of liquid in the counterrecoil mechanism! Itsdefect consists in the fact that the evaluation of the results of the check is rather subjective.

Figure 92 (Page 223)

Legend: 1 - pressure in the counterrecoil mechanism with the barrel moved backward by 600mm; 2 - liquid greater than the normal; 3 - liquid less than the normal; 4 - initial pressure in the counterrecoil mechanism; 5 - 22.8 liters, 22 liters, 212 liters; 6 - liquid in liters.

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The essence of the checking by means of the graph consists in measuring the pressure in the counterrecoil mechanism twice: the initial p_0 and the pressure p with the piston displaced by a previously determined length, after which, on the basis of the pressures obtained, we refer to the graph (Figure 92). Supposing that the use of the graph is known to the reader, we shall explain the problem of constructing such a graph.

Since the drawing out of the piston rod to the length l (up to the second mark) takes places slowly, we may suppose that in the counterrecoil mechanism we shall observe during this time the operation of the isothermic law of the condition of the gas, the equation of which has the form

$$p_0 W_0 = p W, \qquad (503)\ 224$$

where p_0 and p are the initial and variable pressures;

W_0 and W — the volumes of the gas (or air) corresponding to the given p_0 and p.

We shall use the following notation:

$W_{ж}$ —the normal volume of liquid in the counterrecoil mechanism;

W_H —the volume of the cylinders of the counterrecoil mechanism occupied by the air and liquid before the recoil.

Since

$$W_H = W_0 + W_{ж},$$

then

$$W_0 = W_H - W_{ж}.$$

If we move the piston by the length l, the volume of the air at this moment will be expressed by the equality:

$$W = W_0 - A_H l = W_H - W_{ж} - A_H l.$$

By substituting the values of W_0 and W in formula (503) we obtain:

$$p_0 (W_H - W_{ж}) = p (W_H - W_{ж} - A_H l),$$

whence

$$p = \frac{W_H - W_{ж}}{W_H - W_{ж} - A_H l} p_0. \qquad (504)\ 224$$

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Using the designation

$$K = \frac{W_H - W_{ж}}{W_H - W_{ж_1} - A_H l},$$

we rewrite equation (504) in the following form:

$$p = K p_0. \qquad (504a)224$$

The path l (the distance between the marks), the values W_H and A_H are constants. Hence, the value K for the given counterrecoil mechanism, with a normal, strictly determined, quantity of liquid, is also constant when the check is made. Consequently, the expression (504) is the equation of a straight line with an angular coefficient K (Figure 93). The angular coefficient K is the tangent of the angle α

$$K = tg\,\alpha = \frac{p}{p_0}$$

of the slope of the straight line to the positive direction of the axis Op_0 passing through the origin of the coordinates. By laying off on the axis of the abscissas the values of p_0 and upon the axis of the ordinates the values of p, we obtain the graphic representation of the equation (504a) in the form of a straight line OO_1.

If in the counterrecoil mechanism there is less liquid than the normal ($W_{ж_1} < W_{ж}$), the angular coefficient will have a new balue:

$$K_1 = \frac{W_H - W_{ж_1}}{W_H - W_{ж_1} - A_H l},$$

less than K in value.

On the other hand the volume of liquid in the counterrecoil mechanism is greater than the normal, then $K_2 > K$.

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By plotting on the graph the values of p and p_0 of equation (50a) with the new values of the angular coefficient, we obtain: in the first case, the straight line 00_2, and in the second case the straight line 00_3.

By assigning a different quantity of liquid we can also make the calculation and as we have explained we can plot on the graph as many straight lines as we please representing the law of the change of pressure in the counterrecoil mechanism depending on p_0 with the given values W_k and l_0. For practical work it is entirely sufficient to have three of such lines: for the normal quantity of liquid (00_1), for the permissible excess (00_3), and for the permissible shortage of liquid (00_2).

For convenience in using the graph we shall take only that part of it which must be used in practical work, forming the graph in a corresponding manner (see figure 92).

This method of checking the quantity of liquid by means of a graph, though sufficiently precise, reliable, and objective, is tedious. It requires a great deal of time, and for this purpose it is necessary to have special devices for carrying out the process of verification (a screw with a "matrix" wrenches, etc). Without these devices we cannot make the check, and this constitutes the basic weakness of this method.

Hence, it will be advantageous to work out and employ simpler, more convenient and at the same time more precise methods of checking the quantity of liquid in the counterrecoil mechanism by the use of special indicators. As an example we might mention the indicator of the hydropneumatic counterrecoil mechanism with a floating piston used in a model of one of our own guns. Figure 94 gives a diagrammatic representation of the indicator of the position of a floating piston.

The floating piston 1, placed in a hollow piston rod 3, is a diaphragm separating the compressed air from the liquid (see Figure 69). Hence, a given position of the piston indicates a certain relationship between the volumes of

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air and liquid. Consequently, from the position of the floating piston we may judge the quantity of liquid in the counterrecoil mechanism. This problem is solved with the help of indicator 4, the principle of whose construction is essentially the following.

Figure 94 (Page 226)
Legend: 1-air; 2-liquid

Indicator 4 of the position of the floating piston is placed in the sleeve of cover 5 of piston rod 3. Under the action of spring 6, one end of which rests in the circular groove of the sleeve of the cover, and the other, in the collar, on the indicator, the latter always pressing against the floating piston. The cylindrical end of the indicator passes through the packing 7 and its face rests in the valve 9 of the indicator. The valve is placed in the cover 10 of the cylinder of the counterrecoil mechanism, and its end protrudes to the outside (for observation). By the action of spring 8, one end of which rests against the collar of the valve and the other end against the cover, the valve is pressed to the indicator 4. The canals in the indicator serve for the free flow of liquid.

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With a normal quantity of liquid in the counterrecoil mechanism, the indicator, with its face resting in the valve, gives to the latter a definite position. This position may be noted (marked), for example by agreement of a special line on the cylindrical end of the valve with a section of the cover (see arrow in figure 94). A change in the quantity of liquid causes a change in the position of the piston, and, consequently, also in the position of the indicator: with a surplus of liquid the indicator moves inward; with a lack of liquid, it moves farther beyond the face of the cover. It is obvious that the permissible surplus and the lack of liquid may be marked also by lines on the cylindrical end of the valve.

As a result of this, the permissible deviation of the valve from the normal position is determined by the distance between the ends of the lines. The section of the cover (or any other devices--arrows, etc) should always be within the limits of the aforementioned length.

As we can see, this method of checking is extremely simple and convenient. It enables us to judge the quantity of liquid in the counterrecoil mechanism at any moment, directly in the process of fire.

CHAPTER V

THE THEORY OF HYDRAULIC RECOIL BRAKES

1. The Essence of the Operation of a Hydraulic Brake

The idea of the employment of a hydraulic brake for braking the recoil of field artillery weapons was first put into practice in the 2.5-inch gun by the talented Russian inventer, V.S. Baranovsky in 1872. Up until this time the recoil brakes used were based on friction.

By employing springs or air for braking the recoil, as we do in counterrecoil mechanisms, it was possible to limit the recoil. However, springs and air, in absorbing the energy of recoil, convert it into a reversible form which acts upon the recoiling parts in the opposite direction. Springs (or air) during the time of the recoil accumulate and conserve in a potential form all the energy of the recoil absorbed by them. During counterrecoil this energy is given off in the

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reverse direction to the moving parts. As a result of this, during the time of the cyle of the recoil--counterrecoil only a part of the energy of recoil, equal to the work of the force of friction, is converted into heat, which is not a reversible form of energy.

During the time of the recoil and counterrecoil the hydraulic brake converts the energy of the recoil into thermic energy. For an explanation of this phenomenon we shall consider the process taking place in the movement of a liquid along a tube and the forcing of it through holes.

Let us suppose that under the action of force P a piston forces an ideal liquid from a vessel with a nozzle, having over its length cross sections of various areas (Figure 95); in this case there takes place a steady movement of the latter. During this steady movement, at any given cross sections of the flow, for example I, II, and III, the pressure in the liquid and the velocity of movement of the liquid W_1, W_2 and W_3 do not change with the time; the movement of the liquid along the tube takes place without an interruption of the flow.

Figure 95 (Page 228)
Legend: 1--piston

Under such conditions, during the same interval of time, the same volume Q of liquid should flow through the aforementioned sections I, II, III with an area of cross section A_1, A_2, A_3. In the contrary case, the quantity of liquid in a segment of the tube, limited by sections (for example II and III), would

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change and the flow would not be steady. Hence, we have the following equality:

$$Q = A_1 w_1 = A_2 w_2 = A_3 w_3 . \qquad (505)\ 229$$

The expression (505) is called the equation of continuity of the stream (jet).

Starting from this equation for two adjacent sections, for example I and II, we may write the following relationship:

$$\frac{w_2}{w_1} = \frac{A_1}{A_2},$$

whence

$$w_2 = \frac{A_1}{A_2} w_1 . \qquad (506)\ 229$$

From these equations it follows that the velocities of flow of the liquid are inversely proportional to the cross sections of the flow (of the tube). Where the section decreases, the velocity of flow increases and vice versa.

Figure 96 (Page 229)

Legend: 1—cylinder of the brake; 2—piston; 3—piston rod; 4—hole for the flow; 5—recoil.

We have an analogous picture in the hydraulic recoil brake, a simple scheme of which is given in Figure 96. In the hydraulic brake the liquid is driven from the space in front of the piston, usually called the working space (barrel) into the space behind the piston, called the non-working space. In the working barrel the liquid moves along a circular canal of the transversal section $A_0 = \frac{\pi}{4}(D^2 - d^2)$ with a velocity V, equal to the velocity of the recoil. During this same interval of time the liquid driven from the working barrel should pass through the escape openings (in Figure 96 in the piston), the area of whose cross section α is considerably less than A_0. By applying to the flow of the liquid in the recoil brake the equation of continuity of the stream (505) we obtain:

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$$w = \frac{A_0}{a} V, \qquad (507)\ 230$$

where w is the velocity of the liquid forced through the hole in meters per second;

a --the total area of the escape holes for the liquid in square centimeters;

V --velocity of the movement of the piston, which corresponds to the velocity of the recoil, in meters per second;

A_0 --the working area of the piston in square centimeters.

From formula (507) it follows that with a given velocity of recoil V the value of the velocity of the flow of the liquid w depends upon the magnitude of the ratio $\frac{A_0}{a}$. In recoil brakes the ratio $\frac{A_0}{a}$ is rather large. At the moment of the maximum velocity of the recoil it varies within limits from 50 to 150; the maximum velocity of recoil V, however, in present day guns varies from 8 to 15 m/sec. With such values of the ratio $\frac{A_0}{a}$ and the velocity of recoil V, the velocity of the flow of the liquid reaches hundreds of meters per second.

Before the beginning of the displacement of the piston the liquid is in a state of rest; hence, it is evident that in order to communicate to the particles of liquid the aforementioned velocities during a very short interval of time (in the course of hundredths or thousandths parts of seconds), it is necessary to impart to them a very great acceleration. As a result of this, the particles of liquid show a great resistance of inertia to the displacement of the piston. In order to overcome this resistance we must apply through the piston a force F_1.

In the movement of the piston the force F_1 acting on it performs work over path X equal to $\int_0^X F_1\,dX$. Of course, the recoiling masses lose this same amount of energy, and the particles of liquid, passing through the discharge openings, gain an equal amount. As a result of this, the particles of liquid, in coming out of the discharge openings, have a great velocity. With these velocity the particles of liquid move behind the piston into the cavity limited by the walls of the cylinder and the liquid contained in it and exert their

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pressure against these obstacles. Owing to these impacts the kinetic energy of the particles of liquid is converted into heat, warming the liquid and the particles surrounding it.

From what we have said it follows that the liquid, passing through the discharge openings, acquires the energy of the recoiling masses and, passing through the openings, by means of the impacts, converts this energy into heat.

In addition to this, under actual conditions we have to deal not with an ideal liquid but with a real one. When the real liquid, which possesses a characteristic viscosity, moves along the passageway and in the escape openings, there will be different kinds of resistance to movement: internal friction of the particles of the liquid, friction against the walls, etc. In order to overcome this resistance (we shall call it the resistance of the liquid to the force of friction there is applied a force F_2 through the piston. On the path X the force F_2 performs work $\int_0^X F_2\,dX$. The recoiling parts lose the same amount of energy. This energy will be used in heating the liquid and its surrounding parts.

Finally, we note that a part of the energy of the recoil (20 - 25%) is absorbed by the forces of friction on the "guide cradles" and in the packing devices. As a result of this; the complete absorption of the kinetic energy of recoil and its conversion into heat takes place during the time of the recoil and the counterrecoil.

From what we have said it is evident that the essential work of the hydraulic recoil brake consists in converting a considerable part of the kinetic energy of recoil into thermic energy.

Hence, the hydraulic resistance of the recoil brake is a resistance to the movement of the piston by the liquid, which is the result of the inertia of the resisting particles of the liquid and the resistance of the force of friction of the liquid ($\Phi_0 = F_1 + F_2$). We suppose the force Φ_0 to be distributed uniformly over all the surface in front of the piston. By the assumption of a definite law for the change of the force Φ_0 we can bring about a regulation

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of the character of the recoil.

The purpose of the hydraulic counterrecoil brake is to absorb the excess energy of counterrecoil by converting it into thermic energy and regulation of the velocity of counterrecoil.

2. The Hydraulic Resistance of a Recoil Brake of the Simplest Type

By a recoil brake of the simplest type we mean a brake in which the forcing of the liquid through the regulating openings takes place in only one direction and without counterpressure. For a consideration of the problem we shall take the scheme of the brake with small canals on the inside surface of the brake cylinder (see Figure 74). The action of such a brake was considered above.

We shall now derive the expression for the determination of the pressure in the cylinder and the hydraulic resistance to recoil of such a type of recoil brake. In the explanation of the problem we shall employ the following notations:

A_0 --the area of the piston subjected to the action of hydraulic pressure on one side and called the working surface of the piston of the recoil brake:

$$A_0 = \frac{\pi}{4}\left(D_T^2 - d_T^2\right);$$

D_T --the diameter of the piston (cylinder of the recoil brake);

d_T --diameter of the piston rod;

α_χ --total area of the cross sections of the openings for the flow of the liquid;

V --the velocity of retarded recoil;

X --the length of retarded recoil;

w_1 --the average velocity of the movement of the liquid as it enters the regulating openings α_χ; it is usually taken as equal to the velocity of retarded recoil;

w_2 --the average velocity of the movement of the liquid as it leaves the regulating openings α_χ;

p_1 --pressure of the liquid in the working space of the cylinder of the brake;

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p_2 --the same in the non working cavity (barrel) of the cylinder;

α --the coefficient of compression of the stream, by which we understand the ratio of the area of the section of the stream at maximum compression to the area of the section of the discharge openings.

We shall suppose that the brake cylinder is filled completely with non-compressed liquid and that the piston rod with the piston recils with the barrel, and also that the cylinder is stationary; the action of the brake does not change if we assume the cylinder of the brake to be movable and the piston to be stationary.

If at a certain moment of time the piston occupies the position 1, then, the piston, passing over the path dX during the interval of time dt, occupies the position 2 (Figure 97). During this time the liquid in the space $(A_0 + a_x)\,dX$, opposite the working area of the piston and opposite the regulating escape openings (crosshatched), will be behind the piston. Since the escape of liquid of volume $(A_0 + a_x)dX$ during the time dt takes place only through the regulation openings of area a_x, the equation of continuity (505) of the flow may be written in the following form:

$$\alpha a_x w_2 dt = (A_0 + a_x)dX, \qquad (508)233$$

whence the velocity of the liquid forces through the regulating openings is determined by the formula

$$w_2 = \frac{A_0 + a_x}{\alpha a_x} \cdot \frac{dX}{dt} = \frac{1}{\alpha} \cdot \frac{A_0 + a_x}{a_x} V. \qquad (509)233$$

The regulating openings are generally made with rounded edges; as a result of this the coefficient of compression of the stream α is close to unity. If we take $\alpha = 1$, formula (509) for w_2 takes the following form:

$$w_2 = \frac{A_0 + a_x}{a_x} V. \qquad (510)233$$

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Figure 97 (Page 233)

Legend: 1---recoil

By multiplying the right side of equality (508) by the specific weight γ and dividing by the acceleration of the force of gravity g, we obtain the elementary mass of the liquid forced through the openings a_x during the time dt:

$$dM = \frac{\gamma}{g}(A_0 + a_x)\,dX. \qquad (511)233$$

The kinetic energy of this mass of liquid in leaving the openings will be:

$$\frac{1}{2}w_2^2\,dM = \frac{\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2 (A_0 + a_x)\,dX. \qquad (512)233$$

The kinetic energy obtained for the liquid is the result of the work of forces. Such forces will be:

In section / with an area of $(A_0 + a_x)$ the resultant force of pressures p_1 will be equal to $p_1(A_0 + a_x)$. By multiplying the force obtained by the length dX we obtain the work of this force.

During the time of recoil, as a result of the exit of the piston rod from the cylinder of the brake into the non-working cavity, that is, behind the piston, there will be formed a vacuum.

Hence, the pressure p_2 is equal to 0, and consequently the work of the force of pressures p_2 will also be equal to 0.

In addition to this, as a result of the very small difference in the heights of the particles of liquid in front of the piston at the entrance to the openings and behind the piston at the exit from the openings, the work of the force of the weight of the particles of liquid may be neglected.

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Hence, this kinetic energy of the elementary mass dM of ideal liquid is obtained by the work of force $p_1 (A_0 + a_x)$ over the distance dX. On this basis we write the equality:

$$\frac{\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2 (A_0 + a_x)\, dX = p_1 (A_0 + a_x)\, dX, \qquad (513)234$$

whence

$$p_1 = \frac{\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2. \qquad (514)234$$

Formula (514) enables us to determine the pressure in the ideal liquid in the barrel (working cavity) of the cylinder of the recoil brake of the simplest type.

Under actual conditions we deal with a real liquid, in the movement of which, along the passageway, different kinds of resistance are encountered: the friction against the walls, the internal friction of the particles of liquid, the whirling movement, etc. As a result of this a part of the kinetic energy of the liquid will be lost or dissipated. In determining the values of the energy losses with the displacement of the real liquid from one section to the other, we take in hydraulics the separate losses as proportional to the square of the velocity which the real liquid has in the second section, that is, the value of the loss is determined as a part of the kinetic energy in the given section.

In this case the expression (513) for the real liquid assumes the following form:

$$p_1 (A_0 + a_x)\, dX = \frac{\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2 (A_0 + a_x)\, dX +$$

$$+ \xi_c \frac{\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2 (A_0 + a_x)\, dX = \frac{k\gamma}{2g}\frac{(A_0 + a_x)^3}{a_x^3} V^2\, dX,$$

from which we find the pressure p_1 in the real liquid:

$$p_1 = \frac{k\gamma}{2g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2, \qquad (515)234$$

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where k is the general coefficient of the resistance of the stream:

$$k = 1 + \xi_c, \qquad (516)234$$

ξ_c --the coefficient characterizing the loss of energy; in hydraulics it is called the coefficient of resistance of the system; below we shall call it the coefficient of resistance of the hydraulic system of the recoil brake.

In formula (515) the values going to make up its magnitudes are expressed in the system kilogram-meter-second. In practice, however, it is convenient to express A_0 and a_x in square centimeters; p_1 in kilograms to the square centimeter; γ -- in cubic decimeters (killogram-liters); g -- in meters per second square and V in meters per second, that is, to utilize a mixed dimension nomenclature. Besides, we write the formula (515) in the following form:

$$p_1 = \frac{k\gamma}{20g}\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2. \qquad (517)235$$

If for sake of brevity we use the notation

$$C = \frac{k\gamma}{20g}, \qquad (518)235$$

then the formula for the determination of the pressure in real liquid in the working space of the cylinder of the recoil brake will take the final form:

$$p_1 = C\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2. \qquad (519)235$$

The pressure p_1, acting on the working surface of the piston A_0, creates the hydraulic resistance ϕ_0 of the recoil brake:

$$\phi_0 = CA_0\left(\frac{A_0 + a_x}{a_x}\right)^2 V^2. \qquad (520)235$$

This is also the final form of the formula for determination of the magnitude of the hydraulic resistance of the recoil brake of the simplest type.

From formula (520) it follows that with C and A_0 having assigned values, taken as constant over all the length of the recoil, the hydraulic resistance will depend on a_x and V^2, which are generally variables. Bearing this in

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mind, formula (520) may be given the following form:

$$\Phi_0 = f(a_x) V^2, \qquad (520a)235$$

where

$$f(a_x) = C_1 + \frac{C_2}{a_x} + \frac{C_3}{a_x^2},$$

$$C_1 = CA_0,$$

$$C_2 = 2CA_0^2 = 2C_1 A_0,$$

$$C_3 = CA_0^3 = 0.5 C_2 A_0.$$

If we suppose that the liquid in the escape openings and opposite them remains at rest during the time of the recoil, we obtain by an analogous manner the formula of Kane:

$$\Phi_0' = C \frac{A_0^3}{a_x^2} V^2. \qquad (520b)235$$

From a comparison of formulas (520) and (520b) it is evident that they are distinguished by the factor in the numerator. The factor A_0^3 in the numerator of formula of Kane is replaced by the factor $A_0 (A_0 + a_x)^2$ in formula (520). This is explained by the following. The formula of Kane does not take into account the fact that the liquid opposite the escape opening of the flow does not remain at rest during the time of the recoil, but is set in movement during the displacement of the piston.

The required value of the hydraulic resistance of the recoil brake is determined beforehand by the formula: $\Phi_0 = R + Q_0 \sin\varphi - \Pi - T - F.$

This formula expresses the law of hydraulic resistance of the recoil brake which we must realize in construction by meansof regulating devices. As we can see, the force Φ_0 on the whole is a function of the length of recoil and the angle of elevation, that is, it is a variable magnitude $[\Phi_0 = f(X, \varphi)]$. With a given angle of elevation the force Φ_0 is a function only of the length of recoil.

Taking a specified liquid and having the law of variation of the force

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Φ_0, the velocities of the recoil V, the working area of the piston A_0 and solving (520) for a_χ, we obtain for determination of the escape openings of the following expression:

$$a_\chi = \frac{A_0}{\sqrt{\frac{1}{CA_0}}\sqrt{\frac{\Phi_0}{V^2}-1}} \qquad (521)236$$

or

$$a_\chi = \frac{A_0\sqrt{CA_0}}{\sqrt{\frac{\Phi_0}{V^2}}-\sqrt{CA_0}}. \qquad (521a)236$$

Since $\Phi_0 = A_0 p_1$, the formula (521) may be given in the following form:

$$a_\chi = \frac{A_0\sqrt{C}}{\sqrt{\frac{p_1}{V^2}}-\sqrt{C}}.$$

If in formula (521) we reject the unit with the sign minus in the denominator, we get the formula in this form:

$$a'_\chi = \sqrt{CA_0^3}\sqrt{\frac{V^2}{\Phi_0}}, \qquad (521b)236$$

which, up until recently, was used in practice.

From a comparison of formulas (521) and (521b) it can be seen that the results of calculations based on them will be different. Formula (521) gives a more precise result, because it takes into account the movement of the liquid that is present opposite the escape openings. Actual practice shows that when the working pressure p_1 in the recoil brake is relatively small, and the velocities of recoil are larger, the formula (521b) gives a relatively large error. Hence, it is necessary to use formula (521).

On the basis of experimental data it is recommended that we take the coefficient k for the given type of brake equal to 1.4 plus 1.6 ; if, however, the constructional dimensions of the brake are fixed, the coefficient is calculated by the method given in section 7.

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3. Certain Improvements in the Accuracy of the Theory of Hydraulic Recoil Brakes.

Above we considered problems connected with the calculation of the hydraulic recoil brake of the simplest type. The functional relationship for the determination of the pressure in the cylinder of the brake and its hydraulic resistance with certain assumptions were derived on the basis of the equation of kinetic energy. Even though it is rather seldom that we find hydraulic brakes of such a type, still, due attention is always paid to calculating them. This is explained by the fact that the theoretical relationships obtained for an elementary brake also find application for the derivation of formulas for calculating hydraulic brakes of a more complicated structure, used in present day artillery weapons. As a result of this, the precision of the mathematical formulas of the latter depend upon the precision of the formula for the elementary brake. Our Russian artillerymen - scientists, Shiff, Durlyakhov, Grodsky and others of the Professor Mikhailovsky Artillery Academy, have examined many times and improved the theoretical basis of the calculation of hydraulic recoil brakes. Thus, Rear Admiral Bravin (engineer), (Bravin E. L., "A new method of calculating hydraulic brakes of artillery systems," edition of Artillery Academy 1944) has also considered just recently the theory of the calculation of hydraulic recoil brakes. Even though the method of hydraulic recoil brakes proposed by Professor Bravin still has not been widely used among constructors of artillery weapons, it still merits the attention of the latter, because at the present time it may help to explain the causes of the lack of agreement between theoretical calculations and our experimental data. Some of the theses of Professor Bravin are given below.

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We shall consider the hydraulic brake of the simplest type with constant escape openings. If the area of the piston, after the deduction of the area of the piston rod is equal to $A = \frac{\pi}{4}(D^2 - d^2)$, and the area of the escape openings is $a_\chi = \frac{\pi}{4} d_0^2$, then by the working surface of the piston we generally understand the area.

$$A_0 = A - a_\chi .$$

If in the flow of the liquid through the openings there takes place a constriction of the stream, and the coefficient of constriction is equal to α, the minimum area of the cross section of the latter will be αa_χ. Then the circular area $a_\chi - \alpha a_\chi = (1 - \alpha) a_\chi = \varepsilon a_\chi$. (double hatched, Figure 98) will evidently be Λ. In order to obtain the effective surface A_e of the piston, it is necessary to add to the surface A_0 the area εa_χ, that is, $A_e = A_0 + \varepsilon a_\chi$.

From the physical side such a determination of the working area of the piston is absolutely correct and may be grounded by the elementary considerations given below. If there were no constriction of the stream, then, through the opening with area a_χ, with uniform displacement of the piston during a certain interval of time, there would pass a mass of liquid m with a velocity w_0 and this mass would possess a kinetic energy of $\frac{m w_0^2}{2}$.

In case, however, of a constriction of the stream during this same interval of time the same mass should pass but with a velocity of $w_\alpha > w_0$ and, consequently, $\frac{m w_\alpha^2}{2} > \frac{m w_0^2}{2}$. Inasmuch as the kinetic energy of the mass of liquid should be equal to the work done, it is evident that in the latter case there will be more work, the increase of which, other equal conditions being equal, may be obtained only by an increase in the working surface of the piston by the magnitude $\varepsilon a_\chi = (1 - \alpha) a_\chi$. Since in recoil brakes rounded angles are made at the escape openings, the coefficient of constriction α is close to unity, about 0.98 — 0.96, as a result of which the value of the area εa_χ in comparison with the area A_0 is very small and, hence, the indicated correction

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taken by itself, separately, rarely shows any perceptible results in calculations.

Having stated in a precise manner the problem of the working surface of the piston, we shall now pass to the derivation of the formulas for the elementary brake, and to begin with all of our reasoning will apply to an ideal liquid and assuming that its movement has been determined.

There is no doubt that the hydraulic resistance of the brake is chiefly the result of the communication of kinetic energy to the particles of liquid as they are forced with a great velocity through the escape openings. We shall assume that the piston moves with a velocity V in the direction indicated by the arrow in Figure 98. Then the amount of liquid passing from the "working space" of the cylinder into the "non-working space" through the smallest section of the constricted part of the stream αa_x will be determined by the velocity w_r relative to the edge of the escape (discharge) openings moving in its turn with the "moving" velocity V, and the equation of continuity will be written in the following form:

$$(A_0 + a_x) V = \alpha a_x w_r \qquad (522)239$$

or

$$(A_0 + a_x) V = \alpha a_x (V + w_\alpha), \qquad (523)239$$

whence the relative velocity

$$w_r = \frac{A_0 + a_x}{\alpha a_x} V. \qquad (524)239$$

The absolute velocity of the discharge is determined from the expression

$$w_\alpha = w_r - V = \frac{A_0 + \varepsilon a_x}{\alpha a_x} V. \qquad (525)239$$

In the course of the interval of time dt, corresponding to the length of travel of the piston dX, an elementary mass of liquid equal to the following will pass through the discharge openings:

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$$dM = \frac{\gamma}{g}(A_0 + a_x)V\,dt = \frac{\gamma}{g}(A_0 + a_x)dX. \qquad (525a)239$$

Taking the pressure in the part close to the piston as equal to p_1 and equating the absolute work performed by the piston of the brake, the absolute kinetic energy of the elementary mass dM may be written:

$$P_1(A_0 + \varepsilon a_x)dX = \frac{1}{2}dMU_a^2 = \frac{\gamma}{2g}(A_0 + a_x)\left(\frac{A_0 + \varepsilon a_x}{a a_x}\right)^2 V^2,$$

whence

$$P_1 = \frac{\gamma}{2g}\frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{(a a_x)^2}V^2 \qquad (526)240$$

or disregarding the magnitude εa_x

$$P_1 = \frac{\gamma}{2g}\frac{(A_0 + a_x)A_0}{(a a_x)^2}V^2. \qquad (527)240$$

The hydraulic resistance of the brake in the case of an ideal liquid is determined by the formula

$$\Phi_0 = p_1(A_0 + \varepsilon a_x) = \frac{\gamma}{2g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a)^2}{(a a_x)^2} \cdot V^2 \approx$$

$$\approx \frac{\gamma}{2g} \cdot \frac{(A_0 + a_x)A_0^2}{(a a_x)^2}V^2. \qquad (528)240$$

For a real liquid the expression for the pressure is written in the following form:

$$p_1 = \frac{k_1\gamma}{2g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{a_x^2} \cdot V^2 \qquad (529)240$$

or

$$p_1 = \frac{k_1\gamma}{2g} \cdot \frac{(A_0 + a_x)A_0}{a_x^2} \cdot V^2, \qquad (530)240$$

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where $k_1 = \frac{1+\varepsilon_1}{a^2}$ is the correction coefficient of the calculation of the hydraulic losses and the constriction of the stream. The problem of the hydraulic resistance of the elementary brake for a real liquid will be considered below. By comparing our formulas (529) and (530) for pressures p_1 with formula (515), we can see that they differ only in the case of one factor in the numerator. Consequently, pressures calculated with formula (530) turn out to be less than pressures calculated with formula (515).

The difference in the values of the pressures calculated by this and the other formula will depend upon the relationship between A_0 and a_x.

Formulas (526) and (529) may be obtained in a coordinate system connected with the cylinder.

We draw a control surface as shown in Figure 99 by the dotted line and employ the principle of the "freezing" of the stream. Supposing also that the pressure in front of the cylinder is equal to p_1 and behind it zero, we draw up the equation of the energy which we formulate as follows: the work of all the forces applied to the piston during the time dt is equal to the sum of the kinetic energy of the liquid flowing from the volume limited by the control surface and the kinetic energy acquired by the liquid within the aforementioned volume. Bearing in mind that the work of the piston is done by the force

$$\Phi_0 = p_1 (A_0 + \varepsilon a_x),$$

the mathematical expression of the aforementioned statement may be written in the following form:

$$\Phi_0 V dt = \alpha a_x w_a dt \frac{\gamma}{2g} \cdot w_1^2 + \alpha a_x V dt \frac{\gamma}{2g} w_a^2 \qquad (531)241$$

The kinetic energy of the liquid flowing from the volume

The kinetic energy acquired by the liquid in the volume.

We shall carry out the transformation of the expression on the right side of the equation (531), taking into account the equation of continuity

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$$a a_x w_a dt \frac{\gamma}{20g} w_a^2 + a a_x V dt \frac{\gamma}{20g} w_a^2 = a a_x \frac{\gamma}{20g} w_a^2 (w_a + V) dt =$$
$$= \frac{\gamma}{20g} (A_0 + a_x) V dt \, w_a^2 ;$$

consequently

$$\Phi_0 V dt = \frac{\gamma}{20g} (A_0 + a_x) V dt \, w_a^2$$

or

$$P_1 (A_0 + \varepsilon a_x) = \frac{\gamma}{20g} (A_0 + a_x) w_a^2 .$$

Since

$$w_a = \frac{A_0 + \varepsilon a_x}{a a_x} V_1$$

then

$$P_1 (A_0 + \varepsilon a_x) = \frac{\gamma}{20g} (A_0 + a_x) \frac{(A_0 + \varepsilon a_x)^2}{(a a_x)^2} \cdot V_1^2 ,$$

whence

$$P_1 = \frac{\gamma}{20g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{(a a_x)^2} \cdot V^2 \approx \quad (532)241$$

$$\approx \frac{\gamma}{20g} \cdot \frac{(A_0 + a_x) A_0}{(a a_x)^2} \cdot V^2$$

or

$$P_1 = \frac{k_1 \gamma}{20g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{a_x^2} \cdot V^2 \approx \quad (533)241$$

$$\approx \frac{k_1 \gamma}{20g} \cdot \frac{(A_0 + a_x) A_0}{a_x^2} \cdot V^2 ,$$

that is, the same expression which Professor Bravin obtained by drawing up the expressions for absolute work.

Professor Bravin rendered the theory of hydraulic brakes more precise by determining the relationship between the pressure p_1 on the piston and the pressure p on the bottom of the cylinder of the working part of the brake. These pressures are not equal to each other because of the fact that with the movement of the liquid there arises a resistance to the flow of the liquid, which is directly proportional to the square of the velocity of flow and which is directed in the form of a

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reaction coming from the liquid (Figure 99).

This problem is of practical interest, because in the investigation of the recoil brake there is made a recording of the pressure by the "Maihak" indicator (or by other devices), exerted on the bottom of the working cavity of the cylinder.

Figure 99 (Page 242)

The pressure recorded in this way is used as the pressure on the piston.

We shall consider this problem first for the ideal liquid and suppose that

$$p = p_1 + \Delta p .$$

Designating by R_1 the reaction of the bottom of the working part of the cylinder and by ϕ_0 the reaction of the piston, we write the expression for the total impulse.

$$I = (R_1 - \phi_0)\,dt = [p\,(A_0 + a_x) - p_1\,(A_0 + \varepsilon a_x)]\,dt =$$

$$= [(p_1 + \Delta p)(A_0 + a_x) - p_1\,(A_0 + \varepsilon a_x)]\,dt = \qquad (534)242$$

$$= p_1\,\alpha a_x \left[\frac{\Delta p}{p_1} \cdot \frac{A_0 + a_x}{\alpha a_x} + 1\right] dt .$$

The increment, however, of the amount of movement, taking into account the expressions (525) and (526), is written in the following form:

$$dM\,w_a = \frac{\gamma}{10g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{\alpha a_x} \cdot V^2 dt = 2p_1\,\alpha a_x\,dt, \qquad (535)242$$

where dM is the elementary mass of the liquid.

Since

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$$I = dM w_a,$$

then

$$2p_1 \alpha a_x dt = p_1 \alpha a_x \left[\frac{\Delta p}{p_1} \cdot \frac{A_0 + a_x}{\alpha a_x} + 1\right] dt,$$

whence

$$\frac{\Delta p}{p_1} \cdot \frac{A_0 + a_x}{\alpha a_x} = 1 \quad \text{and} \quad \Delta p = \frac{\alpha a_x}{A_0 + a_x} p_1.$$

Consequently,

$$p = p_1 + \Delta p = \left(1 + \frac{\alpha a_x}{A_0 + a_x}\right) p_1. \qquad (536)243$$

From a juxtaposition of formulas (534) and (535) it is easy to see that

$$R_1 - \Phi_0 = 2p_1 \alpha a_x, \qquad (537)243$$

that is, the force of the dynamic reaction of the escaping stream of liquid is equal to twice the force of the static pressure on the area of the cross section of the stream. This assumption is found to be in keeping with the derivations of hydrodynamics for the reaction of a stream of liquid flowing from a vessel through an opening.

Such a stream will exert an active effect upon the bottom of the non-working cavity of the cylinder in the form of an impact against the wall with a loss of a part of its movement, and hence the reaction on this area will be expressed by the following equality:

$$R_2 = \frac{\gamma}{10g} \cdot \frac{(A_0 + a_x)(A_0 + \varepsilon a_x)}{\alpha a_x} V^2 = 2p_1 \alpha a_x. \qquad (538)243$$

Since R_2 is opposite the reaction R_1, then

$$(R_1 - R_2) = \Phi_0 = 0. \qquad (539)243$$

The latter equality shows that the total reaction on the wall of the cylinder in the direction of its axis, which is the action imparted by the

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piston to the cylinder through the liquid, is equal to the counteraction of the piston and, hence, represents nothing else except the third law of Newton dealing with the equality of action and counteraction.

We determine the relationship between p_1 and p for the case of the real liquid by making use of the relationships obtained above.

We suppose, as we did previously that $p = p_1 + \Delta p$.

From the juxtaposition of formulas (526) and (529) it is easy to see that the pressure p for the ideal liquid is obtained by multiplying the values of the pressure for the real liquid by $\frac{1}{1+\xi_1}$. Taking this into account, the expression for Δp in the case of a real liquid may be written in the following form:

$$\Delta p = \frac{1}{1+\xi_1} \cdot \frac{\alpha a_x}{A_0 + a_x} \cdot p_1 . \qquad (540)243$$

Consequently

$$p = p_1 + \Delta p = \left[1 + \frac{1}{1+\xi_1} \cdot \frac{\alpha a_x}{A_0 + a_x} \right] p_1 . \qquad (541)244$$

Above we obtained the following expression for the ideal liquid:

$$R_1 - \Phi_0 = 2 p_1 \alpha a_x .$$

For a real liquid this expression is written as follows:

$$R_1 - \Phi_0 = \frac{2 p_1}{1+\xi_1} \alpha a_x ,$$

whence

$$\Phi_0 = R_1 - \frac{2 p_1}{1+\xi_1} \alpha a_x . \qquad (542)244$$

Since the reaction of the bottom of the working part of the cylinder is

$$R_1 = p (A_0 + a_x) = (A_0 + a_x) \left[1 + \frac{1}{1+\xi_1} \cdot \frac{\alpha a_x}{A_0 + a_x} \right] p_1 ,$$

then

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$$\Phi_0 = (A_0 + a_x)\left[1 + \frac{1}{1+\xi_1}\cdot\frac{\alpha a_x}{A_0 + a_x}\right]p_1 - \frac{2p_1}{1+\xi_1}\alpha a_x =$$
$$= \left[A_0 + \left(1 - \frac{1}{1+\xi_1}\alpha\right)a_x\right]p_1$$

or

$$\Phi_0 = (A_0 + \varkappa a_x)p_1, \qquad (543)\,244$$

where

$$\varkappa = 1 - \frac{1}{1+\xi_1}\alpha = \frac{\xi_1}{1+\xi_1}\alpha.$$

The latter expression serves for determining the hydraulic resistance of the brake of the type considered in the case of a real liquid.

The value of the correction $\varkappa a_x$ does not exceed 1% of A_0, however, in making precise calculations it should be taken into account.

4. Hydraulic Resistance of Recoil Brakes with Movement of a Part of the Liquid Behind the Moderator.

In recoil brakes of such a type, the liquid forced out during the time of the recoil from the working cavity of the cylinder into the cavity of the piston is separated into two streams moving in contrary directions. The first stream, which is the basic one, flows through the regulating openings into the non-working cavity and is for the purpose of braking the recoil; the second stream is forced along the circular canal into the moderator space of the piston rod for the purpose of subsequent braking of the counterrecoil from the very beginning of the counterrecoil of the barrel, and the cavity of the piston rod should be entirely filled with liquid at any moment of the recoil. The most widely used of this type of brake is the spindle brake (see Figure 77), the action of which was considered above.

In the discussion of the problem we shall take the scheme of brake represented in Figure 100.

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Figure 100 (Page 245)
Legend: 1--recoil

We shall adopt the following definitions and notations:

A_0 --the working area of the surface of the brake piston during recoil in square centimeters:

$$A_0 = \frac{\pi}{4}\left(D_T^2 - d_T^2\right);$$

(544)245

D_T --the diameter of the piston of the recoil brake in centimeters;

d_T --the diameter of the piston rod in centimeters;

A_{TH} --area of the cross section of the canal of the cavity of the piston rod or the working area of the counter recoil brake in square centimeters:

$$A_{TH} = \frac{\pi}{4} d_1^2;$$

d_1 --diameter of the cavity of the piston rod in centimeters;

A_P --area of the section of the eye of the regulating ring in square centimeters;

d_P --diameter of the eye in centimeters;

A_M --area of the cross section of the spindle (counter piston rod) in square centimeters;

δ --variable diameter of the spindle (counter piston rod) on its profile part in centimeters;

δ_{max} --the maximum diameter of the spindle in centimeters;

Ω --the area of the cross section of the circular canal formed by the

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surface of the spindle (counter piston rod) and the surface of the cavity of the piston rod; it is calculated by the formula

$$\Omega = \frac{\pi}{4}\left(d_1^2 - \delta^2\right) = A_{TH} - A_H \text{ i} \qquad (545)246$$

Ω_1 --the minimum area of the cross section of this same canal in square centimeters;

$$\Omega_1 = \frac{\pi}{4}\left(d_1^2 - \delta^2_{max}\right); \qquad (546)246$$

$a_{.x}$ --the area of the flow openings of the recoil brake representing the circular clearance between the regulating ring and the spindle in square centimeters; it changes during the time of the recoil:

$$a_x = f_p - A_H = \frac{\pi}{4}\left(d_p^2 - \delta^2\right); \qquad (547)246$$

V --velocity of retarded recoil in meters per second;

w_1 --average velocity of the movement of the liquid through the section during movement into the regulating openings in meters per second;

w_2 --average velocity of the forcing of the liquid through the given section of the regulating openings a_x in meters per second;

w_3 --average velocity of the movement of the liquid through the smallest Ω_1 section of the circular canal of the cavity of the piston rod, leading the liquid behind the moderator, in meters per second;

p_1 --pressure of the liquid in the working cavity of the brake cylinder, that is, in front of the piston, in kilograms to the square centimeter;

p_2 --pressure in the non-working cavity of the brake cylinder, that is behind the piston, in kilograms to the square centimeter;

p_3 --pressure in the moderator (behind moderator) space in kilograms to the square centimeter;

α --coefficient of compression of the stream in the flow openings;

α_1 --coefficient of compression of the stream, flowing behind the moderator.

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In the consideration of the problem we shall make the following assumptions:

1. The cylinder of the recoil brake is completely filled with non-compressible liquid.

2. The drop in pressure during the passage of the liquid from the working cavity of the cylinder into the cavity of the piston is equal to 0. Hence, in front of the working area of the piston and within the cavity of the piston the pressures are equal to p_1. In actual practice this is achieved by having in the piston a sufficiently large total area of openings leading the liquid into the cavity of the piston.

3. The movement of the liquid behind the piston and behind the moderator is steady (fixed).

We shall assume that the piston rod recoils and that the cylinder of the brake is stationary (the action of the brake is not changed if we assume the brake cylinder to be immovable and the piston rod with the piston to be stationary).

Let us suppose that at a certain moment the piston occupies the position 1. after the interval of time dt and having traveled the distance dX, the piston comes to occupy the position 2. The liquid in front of the working surface of the piston and also in the cavity of the piston rod (in Figure 100 cross-hatched), with a total volume $(A_0 + A_{TH} - A_g)\,dX$, is in the cavity behind the piston and in the cavity behind the moderator.

The equation of continuity of the streams is written as follows:

$$(A_0 + A_{TH} - A_g)\,dX = \alpha\,\omega_2\,a_x\,dt + \alpha_1\,\omega_3\,\Omega_1\,dt. \qquad (548)247$$

In the same interval of time the volume of the space behind the moderator is increased by the amount $A_{TH}\,dX$. Depending upon the working conditions of the brake, this space which is made available should at the same time be filled with liquid. Hence, during the time dt a volume of liquid $A_{TH}\,dX$, passes into the space behind the moderator and we may write the equation of the continuity of the stream flowing behind the moderator in the following form:

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$$A_{TH}\,dX = \alpha_1 \Omega_1 w_3\,dt,$$

whence

$$w_3 = \frac{A_{TH}}{\alpha_1 \Omega_1} \cdot \frac{dX}{dt} = \frac{A_{TH}}{\alpha_1 \Omega_1} V \qquad (549)247$$

Into the cavity behind the piston there flows a volume of liquid equal to

$$(A_0 + A_{TH} - A_B)\,dX - A_{TH}\,dX = (A_0 - A_B)\,dX. \qquad (550)247$$

Consequently, the equation of continuity of the stream passing behind the piston may be written as follows:

$$(A_0 - A_B)\,dX = \alpha w_2 a_x\,dt,$$

whence

$$w_2 = \frac{A_0 - A_B}{\alpha a_x} V. \qquad (551)247$$

Hence, the total displaced volume of liquid with an area of active section $(A_0 + A_{TH} - A_B)$ may be represented as consisting of two volumes: one the area of the active section $(A_0 - A_B)$, and the other the area of the active section A_{TH}. The first under the pressure of liquid p_1 flows behind the piston, and the second, under the action of the resultant of pressure $(p_1 - p_2)$ moves behind the moderator.

The kinetic energy of the mass of liquid moving behind the piston is equal to the work of the force of pressure p_1 over the distance dX. On this basis we write the equality (with noted dimensions):

$$p_1 (A_0 - A_B)\,dX = \frac{\gamma}{2g} w_2^2 (A_0 - A_B)\,dX =$$

$$= \frac{\gamma}{2g} \cdot \frac{(A_0 - A_B)^3}{\alpha^2 a_x^2} \cdot V^2\,dX,$$

whence

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$$P_1 = \frac{\gamma}{2\alpha^2 g} \cdot \left(\frac{A_0 - A_B}{a_x}\right)^2 V^2. \qquad (552)248$$

Assuming on the basis of the considerations given above that $\alpha = 1$, we shall have the following formula for real liquid:

$$P_1 = \frac{k\gamma}{2g}\left(\frac{A_0 - A_B}{a_x}\right)^2 V^2. \qquad (553)248$$

Or, since

$$A_B = A_p - a_x; \quad C = \frac{k\gamma}{2g},$$

then

$$P_1 = C\left(\frac{A_0 - A_p + a_x}{a_x}\right)^2 V^2. \qquad (554)248$$

On the basis of formula (554) we can determine the pressure of the liquid in the working cavity of the brake cylinder.

The kinetic energy of the mass of liquid moving behind the moderator is equal to the work of the force of the resultant pressure $(P_1 - P_3)$ over the length dX. Hence, the following equality is correct

$$(P_1 - P_3) A_{TH}\, dX = \frac{\gamma}{2g} w_3^2 A_{TH}\, dX =$$

$$= \frac{\gamma}{2\alpha_1^2 g} \cdot \frac{A_{TH}^3}{\Omega_1^2} V^2 dX, \qquad (555)248$$

whence

$$P_3 = P_1 - \frac{\gamma}{2\alpha_1^2 g} \cdot \frac{A_{TH}^2}{\Omega_1^2} V^2. \qquad (556)248$$

Assuming that $\alpha_1 = 1$ and considering real liquid, we obtain the formula for the determination of the pressure in the cavity of the piston rod behind the moderator in the following form:

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$$P_3 = P_1 - \frac{k_1 \gamma}{2g} \cdot \frac{A_{TH}^2}{\Omega_1^2} V^2.$$

or

$$P_3 = P_1 \left[1 - \frac{k_1 \gamma}{2g} \cdot \frac{A_{TH}^2}{P_1 \Omega_1^2} V^2 \right], \qquad (557)249$$

where k_1 is the coefficient of resistance of the stream flowing behind the moderator.

If we substitute in expression (557) instead of P_1 its value (554), the formula finally assumes the following form:

$$P_3 = C \left(\frac{A_0 - A_p + a_x}{a_x} \right)^2 \left[1 - \frac{k_1}{k} \cdot \frac{A_{TH}^2 a_x^2}{\Omega_1^2 (A_0 - A_p + a_x^2)^2} \right] V^2. \qquad (557a)249$$

By multiplying the pressure P_1 by the area of the piston upon which this pressure acts, we obtain the force of the hydraulic resistance to recoil:

$$\Phi_1 = P_1 (A_0 + A_{TH} - A_p)$$

or

$$\Phi_1 = C (A_0 + A_{TH} - A_p) \left(\frac{A_0 - A_p + a_x}{a_x} \right)^2 V^2. \qquad (558)249$$

With this formula we do not take into account the influence of the pressure P_3 in the cavity of the piston rod. By taking into account this influence we obtain an additional force acting on the piston rod of the recoil brake in a direction contrary to the force Φ_1. The additional force $\Delta\Phi$ will be expressed by the equality:

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$$\Delta\Phi = p_3 A_{TH} = CA_{TH}\left(\frac{A_0 - A_p + a_x}{a_x}\right)^2\left[1 - \frac{k_1}{k}\cdot\frac{A_{TH}^2 a_x^2}{\Omega_1^2 (A_0 - A_p + a_x)^2}\right]V^2. \quad (559)249$$

Bearing this in mind, the resultant force of the complete hydraulic resistance of the recoil brake may be expressed by the formula

$$\Phi_0 = \Phi_1 - \Delta\Phi. \quad (560)249$$

By substituting formulas (558) and (559) in formula (560) we obtain:

$$\Phi_0 = C(A_0 + A_{TH} - A_p)\left(\frac{A_0 - A_p + a_x}{a_x}\right)^2 V^2 - CA_{TH}\left(\frac{A_0 - A_p + a_x}{a_x}\right)^2\left[1 - \frac{k_1}{k}\cdot\frac{(A_{TH} a_x)^2}{\Omega_1^2 (A_0 - A_p + a_x)^2}\right]V^2.$$

After transformation of the latter we obtain in the following form the formula for the calculation of the hydraulic resistance of the recoil brake of the type considered:

$$\Phi_0 = C\left[(A_0 - A_p)\left(\frac{A_0 - A_p + a_x}{a_x}\right)^2 + \frac{k_1}{k}\cdot\frac{A_{TH}^3}{\Omega_1^3}\right]V^2, \quad (561)250$$

or

$$\Phi_0 = f(a_x)V^2, \quad (561a)250$$

where

$$f(a_x) = C_1 + \frac{C_2}{a_x} + \frac{C_3}{a_x^2};$$

$$C_1 = C\left[(A_0 - A_p) + \frac{k_1}{k}\cdot\frac{A_{TH}^2}{\Omega_1^2}\right];$$

$$C_2 = 2C(A_0 - A_p)^2;$$

$$C_3 = C(A_0 - A_p)^3.$$

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Solving the expression (561) for a_x, we obtain:

$$a_x = \frac{A_0 - A_p}{\sqrt{\frac{1}{C(A_0 - A_p)} \cdot \frac{\Phi_0}{V^2} - \frac{k_1}{k} \cdot \frac{A_{TH}^3}{\Omega_1^2 (A_0 - A_p)}} - 1} \qquad (562)250$$

$$a_x = \frac{(A_0 - A_p)\sqrt{C(A_0 - A_p)}}{\sqrt{\frac{\Phi_0}{V^2} - \frac{k_1}{k} \cdot \frac{CA_{TH}^3}{\Omega_1^2}} - \sqrt{C(A_0 - A_p)}} . \qquad (562a)250$$

By introducing the notation

$$B_0 = (A_0 - A_p)\sqrt{C(A_0 - A_p)} ;$$

$$B_1 = \frac{k_1 C A_{TH}^3}{k \Omega_1^2} ;$$

$$B_2 = \sqrt{C(A_0 - A_p)} ,$$

formula (562a) may be written in the following form:

$$a_x = \frac{B_0}{\sqrt{\frac{\Phi_0}{V^2} - B_1} - B_2} . \qquad (562b)250$$

The formula obtained enables us to calculate the flow openings of the recoil brake with the drawing away of a part of the liquid into the moderator space.

If in formula (562) we discard in the denominator the unit with the minus sign and disregard $\frac{k_1}{k} \cdot \frac{A_{TH}^3}{\Omega_1^2 (A_0 - A_p)}$, we obtain:

$$a_x = \frac{B_0}{\sqrt{\frac{1}{\ }}} \cdot V$$

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The formula given maybe used in practice, depending upon the accuracy required. The final calculation should be made with formula (562) because it is more precise.

For convenience in carrying out the calculations and employing them it is recommended that the data be placed in a table of the form given below (Table 17):

Table 17 (Page 251.)

Serial No.	X m	R kg	Π kg	T kg	F kg	ϕ_0 kg	V m/sec.	V^2	$\frac{\phi_0}{V^2}$	a_x cm²	δ mm	h mm

5. Requirements to be Met by the Moderator Space During the Time of the Recoil.

In order to assure smooth counterrecoil of the barrel into the position it occupied before the shot and at the same time to remove the possibility of an abrupt blow during the last moments of counterrecoil, we have special devices called counterrecoil brakes. In brakes constructions with a leading off of a part of the liquid into the moderator space, the counterrecoil brake works over all the length of the counterrecoil. For making this possible it is necessary that at any moment of the recoil all of the space in front of the moderator be filled with liquid.

For uninterrupted filling of the moderator space at any moment of the recoil, there must be free passage for the liquid along the long circular canal, for which purpose its minimum cross section area should not be less than a definite value which should be determined. Since for continuity in filling we should have the inequality, $P_3 \geqq 0$, then, on the basis of formula (557a), we may write the inequality in the following form:

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$$1-\frac{k_1}{k}\cdot\frac{A_{TH}^2 a_x^2}{\Omega_1^2 (A_0-A_p+a_x)^2}\geq 0.$$

By solving the latter for Ω_1 we obtain the expression for the determination of the minimum value of the area of the cross section of the canal leading the liquid behind the moderator:

$$\Omega_1 \geq \sqrt{\frac{k_1}{k}}\cdot\frac{A_{TH}\, a_x}{A_0-A_p+a_x}. \qquad (563)252$$

With definite values for k, k_1, A_0, A_p and A_{TH} we shall have the maximum value of the right side of the inequality with values $a_x = a_{max}$. Evidently Ω_1 should not be less than the maximum value of the right side. Hence, the condition obtained, assuring during recoil the continuous filling of the cavity of the piston rod with liquid, should be written as follows:

$$\Omega_1 \geq \sqrt{\frac{k_1}{k}}\cdot\frac{A_{TH}\, a_{max}}{A_0-A_p+a_{max}} \qquad (564)252$$

The value a_{max} corresponds to the minimum ratio of ϕ_0 to V^2. Bearing this in mind and substituting in formula (564), instead of a_{max} its expression on the basis of formula (562), we obtain the following after transformations:

$$\Omega_1 \geq C_2\left(\frac{V}{\sqrt{\phi_0}}\right)_{max}, \qquad (565)252$$

where

$$C_2=\sqrt{\frac{k_1 T (A_0-A_p+A_{TH})A_{TH}^2}{2g}}$$

The values of the coefficients k and k_1 in formula (565) are determined by calculation (see section 7, page 255) or it applied on the basis of experimental data: $k = 1.4 \div 1.6$; $k_1 = 3 \div 5$.

6. The Hydraulic Resistance of the Recoil Brake with Calculation of the Variable Force of Friction in the Packing Devices

In the determination of the necessary and permissible construction of a

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weapon using hydraulic resistance in the recoil brake we used above the formula

$$\phi_0 = R + Q_0 \sin \varphi_{\text{пр}} - \text{II} - T - F, \qquad (566)252$$

in which the force of friction in the packing devices is taken proportional to the weight of the recoiling parts and determined on the basis of the formula $F = \nu Q_0$. In reality, the force of friction in the collars and stuffing boxes of the recoil brake and the counterrecoil mechanism depends also on a number of other values, first of all on the dimensions of the stuffing boxes and collars and on the pressure in the cylinders and the recoil mechanisms. Hence, the preceding formula may be used only for the first approximation, for the determination of the constructional dimensions of the recoil devices, after which it is necessary to determine the force of friction F more precisely.

Figure 101 (Page 253)

During the time of work, the collars press against the corresponding surfaces (Figure 101) with a pressure equal to that of the liquid which they lock up in the recoil brake and the counterrecoil mechanism. The first collar 1 is subjected directly to the pressure of the liquid which pushes and presses it against the obturating surface: against piston rod 3 and against the walls of the cylinder 4. The second collar 2, in normal operation, at first is not subjected to any direct hydraulic pressure of the liquid, and receives only the pressure of the sub-collar ring 5 on the inside and of the outer collar ring 6 on the outside.

As a result of this the wings of the collars will be pressed against the obturating surface by unequal pressures. However, since the difference in the

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magnitude of the pressure will be very small, we may assume the pressure of the first collar and the second collar on the corresponding surfaces to be the same and equal to p_H (in the counterrecoil mechanism) and p_T (in the brake).

The packing against the obturated surfaces is compressed by a nut, generally through the intermediary of a spring (see Figure 129). The forces of compression on the nut of the "stuffing box" (washers, gaskets) are calculated so that the packing is pressed against the obturated surface under a pressure of

$$p_c \cong 10 \div 15 \text{ kg/cm}^2.$$

From what we have said it follows that the value of the full force of friction in the packing arrangements can be determined more precisely by adding the forces of friction in each tightening in accordance with the general formula:

$$F = F_{BH} + F_{BT} + F_{CH} + F_{CT}, \qquad (567)254$$

where F_{BH} is the force of friction in the collars of the counterrecoil mechanism;

F_{BT} —the force of friction in the collars of the recoil brake;

F_{CH} —the force of friction in the packing devices of the counterrecoil brake;

F_{CT} —the force of friction in the packing devices of the recoil brake;

In this case the forces of friction F_{BH}, F_{BT}, F_{CH}, F_{CT} are determined on the basis of formulas:

$$F_{BH} = \mu_1 \omega_1 p_H,$$
$$F_{BT} = \mu_1 \omega_2 p_T,$$
$$F_{CH} = \mu_2 \omega_3 p_c,$$
$$F_{CT} = \mu_2 \omega_4 p_c,$$

where μ_1 is the coefficient of the friction of the collars against steel; it is usually taken equal to 0.05 — 0.07; for sovprene collars we take 0.07;

μ_2—the coefficient of friction of the packing against the steel; it is taken equal to 0.07 — 0.10;

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ω_1 —the working surface of the collars of the counterrecoil mechanism at the place of contact with the piston rod and at the place of contact of the piston with the cylinder is:

$$\omega_1 = n\pi d_H \ell_{B_1} + n\pi D_H \ell_{B_2} = n\pi(d_H \ell_{B_1} + D_H \ell_{B_2});$$

ω_2 —the working surface of the collars of the recoil brake;

$$\omega_2 = n\pi d_T \ell_B;$$

ω_3 —the working surface of the packing material in the counterrecoil mechanism.

$$\omega_3 = \pi d_B \ell_c;$$

ω_4 —the working surface of the packing in the recoil brake;

$$\omega_4 = \pi d_T \ell_c;$$

n —the number of collars;

ℓ_B —the working length of the collars;

ℓ_c —the working length of the packing;

D_H and d_H —diameters of the piston and piston rod of the counterrecoil mechanism;

d_T —the diameter of the piston rod of the recoil brake;

p_H —the pressure in the counterrecoil mechanism — equal to $\frac{\Pi}{A_H}$;

p_T —the pressure in the recoil brake, equal to $\frac{\Phi_0}{A_0}$;

p_c —the pressure from the packing on the surface of the piston rod.

The working length of the leather collars of the recoil brake may be determined approximately on the basis of the following formula:

$$\ell_B \approx 0.50\sqrt{d_T} \quad (cm),$$

and the hemp packing on the basis of:

$$\ell_c \approx 0.85\sqrt{d_T} \quad (cm).$$

After calculating on the basis of the formulas given the values F_{BH}, F_{BT}, F_{CH} and F_{CT}, we can, on the basis of formula (567), find the precise value

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of the force F and after this, on the basis of formula (566), determine ϕ_0 .

All the calculations are carried out for those same values of X for which one calculated the velocity of recoil V .

We note that the value of the force of friction T on the "directing cradles" (guide tubes) is determined as before by the formula

$$T = f Q_0 \cos \varphi.$$

7. Determination of the Value of the Coefficient of Resistance of the Stream k.

In the formulas for the determination of the hydraulic resistance of recoil brakes we have the coefficient k of the resistance to forcing of the stream. Consequently, on the precision of the determination of this coefficient, will depend the precision of the calculations and their agreement with experimental data. In this section we give the general method for calculating the coefficient k.

Since $k = 1 + \xi_c$, the determination of the value of k amounts essentially to the determination of the precise value of the "coefficient of resistance of the hydraulic system of the recoil brake". With the help of the coefficient ξ_c in hydraulics we take into account all the losses of pressure in the stream resulting from the influence of the different factors. In the calculations we distinguish two kinds of losses:

a) losses in pressure resulting from any local causes obstructing the movement of the liquid, for example: construction or widening of the flow, turn, stop cock, etc, are the so-called local losses;

b) losses in pressure during the movement of the liquid along the straight sectors of the flow, which depend upon the dimensions of the cross section, the length of the canal, roughness of the walls, etc. In the main these are losses due to friction, which are uniformly and continuously distributed over all the length of the given flow and are called linear losses.

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In the calculation of the sum of the local losses, we have the "principle of the superposition of losses", that is, the separate losses, which have different causes, are added arithmetically:

$$\sum_{i=1}^{i=n} \eta_i = \eta_1 + \eta_2 + \ldots + \eta_i + \ldots + \eta_n = \xi_1 \frac{u_1^2}{2g} + \xi_2 \frac{u_2^2}{2g} + \ldots + \xi_i \frac{u_i^2}{2g} + \ldots + \xi_n \frac{u_n^2}{2g}. \quad (568)256$$

In practice we generally refer all of the separate local losses to some one of the average velocities u_{cp}; in this case the expression (568) takes the following form:

$$\sum_{i=1}^{i=n} \eta_i = (\xi_1 + \xi_2 + \ldots + \xi_i \ldots + \xi_n) \frac{u_{cp}^2}{2g} = \xi_M \frac{u_{cp}^2}{2g}, \quad (569)256$$

where ξ_M is the coefficient of resistance from the local losses, equal to

$$\xi_M = \xi_1 + \xi_2 + \ldots + \xi_i + \ldots + \xi_n. \quad (570)256$$

The value of the coefficients of resistance will depend upon the character of the local obstacle. The formulas and tables for the calculation of the most typical cases applicable to the recoil brake may be found in hydraulic courses or suitable handbooks, to which we refer the reader.

The linear losses depend to a great extent upon the character of the movement of the liquid. Hence, before we determine the linear losses of the pressure, we shall consider the problem of the character of the movement of the liquid on the straight sectors of the flow.

Numberous investigations have shown that even on the straight sectors of the flow there exist in principle two different forms of flow for the liquid. With low velocities of movement the small streams of liquid do not mix with each other and remain parallel to the axis of the tube. Such movement of the liquid is called "stratified" or "laminar".

If, however, we increase the velocity of the movement of the liquid along

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the tube, it is found that with velocities greater than (V_{kp}) determined for each given case, the laminar flow becomes unsteady. The particles of liquid move in all directions, including directions perpendicular to the axis of the tube. In this case the trajectories of the particles of liquid are found to be very complicated and entangled. At each point within the tube the velocity changes constantly and consequently the flow of the liquid is not stationary; such movement is called turbulent. The appearance of a turbulent flow depends a great deal upon whether or not the entrance into the tube is smooth or abrupt, on the roughness of the walls of the tube, on the presence of jolts, shaking the tube, and on many other factors.

A turbulent flow is observed during the time of the cycle recoil-counterrecoil and in the recoil mechanisms of artillery weapons.

Assuming the flow of the liquid in the recoil brake to be turbulent, the expression for the determination of the value of the coefficient of the linear losses ξ_{ai} is obtained on the basis of the following considerations.

Above we pointed out that during the flow of the liquid along the straight sectors of the course the chief resistance to movement will be friction against the walls of the tube (canal). In this case, for the determination of the resistance of the force of friction to to the flow of the liquid along the tube the following functional relationship of Frud is applicable:

$$R = \zeta F w^2, \qquad (571)257$$

where R is the force of resistance of friction in kilograms;

ζ —the coefficient of the resistance of friction determined by experiment; it is measured in kilograms to 1 square meter of surface with a velocity of 1 meter per second;

F —the area of contact with the walls of the canal (tube);

w —the velocity of movement of the stream of liquid in meters per second.

From the functional relationship of Frud, obtained by experiment, we can

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see that the resistance of the force of friction is directly proportional to the square of the velocity w, to the area of contact F and to the coefficient ζ.

In the recoil brake the straight sectors of the flow of liquid are usually cylindrical canals. Hence, we employ the formula of Frud for determination of the coefficient of the linear losses $\xi_{w} i$ for the case of the movement of liquid along a tube of constant diameter d, with a length L (Figure 102). In this case each kilogram of moving liquid represents a cylinder with a cross section of $S = \frac{\pi}{4} d^2$ and a length ΔL, the force of resistance of which will be equal to:

$$R_1 = \zeta \pi d \cdot \Delta L \cdot w^2. \qquad (572)257$$

The expression for the unit of weight of the liquid is written in the following form:

$$1\ kg = S \cdot \Delta L \cdot \gamma = \frac{\pi}{4} d^2 \cdot \Delta L \cdot \gamma$$

whence

$$\Delta L = \frac{4}{\pi \gamma d^2}, \qquad (573)258$$

where γ is the specific weight of the liquid;

S —the area of the cross section of the canal.

Substituting in expression (572) its value (573) instead of ΔL, we obtain:

$$R_1 = \zeta \frac{4 \pi d}{\gamma \pi d^2} w^2 = \zeta \frac{4}{\gamma d} w^2. \qquad (574)258$$

Figure 102 (Page 258)

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The expression for the determination of the work of the force of friction with the movement of 1 kg of liquid over all the length L may be written as follows:

$$R_1 L = \zeta \frac{4L}{\gamma d} w^2. \qquad (575)258$$

After multiplying and dividing the right side of the latter equality by 2g, we rewrite it in the following form:

$$R_1 L = \frac{2g\zeta}{\gamma} \cdot \left(\frac{L}{d}\right) \cdot \frac{w^2}{2g}. \qquad (576)258$$

In the right side of this expression the factor $\frac{2g\zeta}{\gamma}$ is an abstract number. We designate it by φ and rewrite the formula (576) as follows:

$$R_1 L = \varphi\left(\frac{L}{d}\right)\frac{w^2}{2g}. \qquad (577)258$$

On the basis of the physical meaning this work of the force of resistance of friction should be set equal to the loss in pressure head of the liquid over the length of the sector L, that is, equal to $\xi_{cn} \frac{w^2}{2g}$. On the basis of what we said, we write the equality

$$\xi_{cn} \frac{w^2}{2g} = \varphi\left(\frac{L}{d}\right)\frac{w^2}{2g}$$

or

$$\xi_{cn} = \varphi\left(\frac{L}{d}\right), \qquad (578)259$$

where L is the length of the sector of the tube (canal) considered;

d —diameter of the tube;

φ —a certain coefficient.

Hence, the formula obtained for determination of the coefficient of the linear losses ξ_{cn} depending upon the ratio of the length of the straight sector of the tube considered to the diameter d of the tube and upon a certain new

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coefficient φ.

By multiplying and dividing the right part of the expression (578) by $\frac{\pi}{4} d^2$, we obtain the formula:

$$\xi_{\pi} = \varphi \frac{L \frac{\pi}{4} d^2}{\pi d \left(\frac{d}{2}\right)^2} = \varphi \frac{L}{4r'} \qquad (579)259$$

where r' is the hydraulic radius representing the relationship of the area of the cross section of the tube to the moistened perimeter:

$$r' = \frac{\frac{\pi}{4} d^2}{\pi d} = \frac{r}{2}. \qquad (580)259$$

Owing to the introduction into the formula of the hydraulic radius, formula (580) is applicable for flows of liquid of any cross section (small canals, etc).

For determination of the value of the coefficient φ various investigators have given a number of formulas. From the expression $\varphi = 8 \frac{g}{\gamma} \zeta$ we can see that the coefficient φ in its turn depends upon a certain coefficient ζ and upon the specific weight of the liquid γ.

In accordance with the statements of some authors with reference to experimental data, the coefficient ζ for pure water moving with a velocity of 20 - 40 m/sec is equal to 0.0002. Liquid steol, steol M, and spindle oil, used for filling recoil brakes, should not differ very much from pure water as regards the coefficient ζ. Taking for the above mentioned liquids a coefficient $\zeta = 0.0002$, we obtain the following value for φ :

for steol with $\gamma = 1.17$

$$\varphi_c = 8 \frac{g}{\gamma} \cdot \zeta = 8 \cdot 9.81 \frac{0.0002}{1.17} = 0.0133;$$

for steol M with $\gamma = 1.11$

$$\varphi_c = 8 \cdot \frac{g}{\gamma} \cdot \zeta = 8 \cdot \frac{9.81}{1.11} \cdot 0.0002 = 0.0141:$$

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for spindle oil, in the case of which $\gamma = 0.89$

$$\varphi_B = 8g\frac{\xi}{\gamma} = 8 \cdot 9.81 \frac{0.0002}{0.89} = 0.0176.$$

Since the friction of the liquid against the walls of the canal is not the only cause of the loss of pressure head, the real value of the coefficient φ will be somewhat different from that obtained. On an average, for practical calculations we may recommend the taking of $\varphi = 0.015$ for steel M; and for spindle coil $\varphi = 0.020$. Then formula (579) may be given the definitive form:

$$\xi_{MC} = 0.015\frac{l}{d} = 0.015\frac{l}{4r} = 0.0037\frac{l}{r}; \quad (581)260$$

$$\xi_{MB} = 0.020\frac{l}{d} = 0.020\frac{l}{4r} = 0.0050\frac{l}{r}. \quad (582)260$$

In conclusion, we also give the most widely used formula of hydraulics, on the basis of which we calculate the coefficient φ :

Formula of Darcy:

$$\varphi = 0.02\left(1 + \frac{l}{40d}\right). \quad (583)260$$

Here the diameter d is taken in meters. The formula itself is accurate and valid for clean tubes having a diameter up to 0.5 m.

The formula of Blyazius:

$$\varphi = \frac{0.3164}{\sqrt[4]{R_e}} \quad (584)260$$

The Reynold's number R_e, entering formula (584), in application to hydraulic recoil brakes may be determined by the formula

$$R_e = \frac{2vr}{\nu} \quad \frac{2vr\rho}{\mu} \quad (585)260$$

where v is the average velocity of the flow of the liquid in the tube in meters per second;

r —the radius of the tube in meters;

μ —the coefficient of viscosity of the liquid;

ρ —the density of the liquid;

ν —the kinematic coefficient of the viscosity in square meters per second.

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The kinematic viscosity ν is a function of the qualities of the liquid and its temperature. The graphs of the change of ν depending upon the temperature for spindle oil AU and steel are given in Figure 103. In calculation of the discharge openings we must take as our basis the conditions of operation of the recoil brake with liquid heated up to a temperature of 50° — 100°.

Figure 103 (Page 261).
Legend: 1. Steel; 2. spindle oil

In the determination of the general coefficient of resistance from linear losses we also use the principle of the "superposition of losses". Hence, the separate coefficients of linear losses are added arithmetically:

$$\xi_{л} = \xi_{л1} + \xi_{л2} + \ldots + \xi_{лi} + \ldots + \xi_{лn}. \quad (586)261$$

Having $\xi_{м}$ and $\xi_{л}$, the coefficient $\xi_{с}$ is determined on the basis of the formula

$$\xi = \xi + \xi_{м}, \quad (587)261$$

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after which we can determine k by the formula

$$k = 1 + \xi_c .$$

The value of coefficient k is a variable depending upon the length of recoil. For the final calculation of the coefficient k we must take the average value.

Below, in Table 18, we have given the schematic steps in the calculation of coefficient k.

Table 18

Schematic steps in the calculation of coefficient .

Serial No.	Values to be determined
1	Determine in the direction of the flow of the liquid the sectors of possible local losses.
2	Making use of the corresponding formulas of the handbook on hydraulics, determine the coefficients $\xi_1, \xi_2, \ldots, \xi_n$ of the resistance of the local losses on the sectors.
3	Determine the coefficient of resistance of the local losses: a) taking into the losses on the basis of the mean velocity in accordance with the formula: $\xi_M = \xi_1 + \xi_2 + \cdots + \xi_n ;$ b) taking into account the losses on the basis of the value of the velocity in each given section of flow $\xi_M = \frac{\sum_{i=1}^{i=n} \xi_i u_i^2}{u_{cp}^2} ; \quad u_{cp} = \frac{u_1 + u_2 + \cdots + u_n}{n} .$
4	Determine in the direction of the movement of the liquid the straight sectors of flow.
5	For each given straight sector of flow determine the coefficient of linear losses $\xi_{l1}\ \xi_{l2} \cdots \xi_{ln}$

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6 Determine the general coefficient of resistance from linear losses

$$\xi_{\text{л}} = \xi_{\text{л}1} + \xi_{\text{л}2} + \cdots + \xi_{\text{л}n}.$$

7 Determine the coefficient k:

$$k = 1 + \xi_{\text{м}} + \xi_{\text{л}} = 1 + \xi_{\text{с}}.$$

By experiment it has been found that the value of k varies within the following limits: for slow moving behind the piston $k = 1.4 \div 1.6$; for flow directed behind the moderator $k = k_1 = 3 \div 5$. Taking into account the losses in the counterrecoil mechanism the value of k may be taken equal to $1.10 \div 1.20$.

8. Approximation method of determining the coefficient k_1.

In the case of the recoil brake of the spindle type the movement of the liquid behind the moderator takes place over a long circular canal which generally contracts and changes direction. The coefficient of resistance for this flow is k_1.

For determination of the value of the coefficient k_1 of the resistance to the flow of the liquid behind the moderator we sue the functional relationship of Frud (471). Also we shall suppose that the flow of the liquid takes place along a circular canal of length L with constant diameters d_1 and $\delta_{\text{ср}}$ (Figure 104). Under these conditions the force of resistance of a unit weight of liquid will be equal to:

$$R_1 = \zeta F_1 w^2 = \zeta \Delta L \cdot \pi (d_1 + \delta_{\text{ср}}) w^2. \quad (588)263$$

From the expression for a unit weight of liquid

$$1\ \text{kg} = \frac{\pi}{4}\left(d_1^2 - \delta_{\text{ср}}^2\right)\Delta L \cdot \gamma$$

Figure 104 (Page 263)

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we find:

$$\Delta L = \frac{4}{\pi\gamma\left(d_1^2 - \delta_{cp}^2\right)}, \qquad (589)263$$

where ΔL is the length of the circular canal, corresponding to the unit weight of liquid;

γ —the specific weight of the liquid.

By substituting in formula (588) its value (589), instead of Δ L, we obtain:

$$R_1 = \zeta \frac{4}{\gamma\left(d_1 - \delta_{cp}\right)} w^2. \qquad (590)263$$

We multiply and divide the right side of the last equality by 4g and rewrite the expression in this form:

$$R_1 = 8\frac{g}{\gamma}\zeta \cdot \frac{1}{2\left(\frac{d_1 - \delta_{cp}}{2}\right)} \cdot \frac{w^2}{2g}. \qquad (591)263$$

We use the following notation:

$e = \frac{d_1 - \delta_{cp}}{2}$ —the radial clearance;

$\varphi = 8\frac{g}{\gamma}\zeta$ —a certain coefficient (an abstract number).

The value of the coefficient φ is deterrined on the basis of one of the formulas (581), (582), or it may be taken equal to the following: for steol and steol M 0.015, and for spindle oil 0.020 (see page 260).

In this case the expression (591) for the force of resistance to the flow of a unit weight of liquid may be definitively rewritten in the following form:

$$R_1 = \varphi \frac{1}{2e} \cdot \frac{w^2}{2g}. \qquad (592)264$$

The total work of the force of friction R_1 over all the path of movement L will be:

$$R_1 L = \varphi \frac{L}{2e} \cdot \frac{w^2}{2g}$$

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On the basis of the physical meaning this work of resistance should be equal to the loss of pressure head of the liquid resulting from linear losses; hence, we may write the equality:

$$\xi_л \frac{w^2}{2g} = \varphi \frac{L}{2e} \cdot \frac{w^2}{2g}, \qquad (594)264$$

whence

$$\xi_л = \varphi \frac{L}{2e}, \qquad (595)264$$

where $\xi_л$ is the coefficient of linear losses.

By adding 1 to the right and to left sides of the latter equality, we obtain for k_1 the following expression:

$$k_1 = 1 + \xi_л = 1 + \varphi \frac{L}{2e}. \qquad (596)264$$

As a result of the variable value of L the coefficient k_1 is also a variable value. At the beginning of the recoil the length of the path of forcing of the stream of liquid is the maximum. Consequently, the value of k_1 should also be the maximum. At the end of recoil the travel length of the stream of liquid is small and hence the value of k_1 will be much less.

From the functional relationship of Frud (571) we can see that the resistance to the flow of the liquid depends to a great extent upon the velocity of flow W of the latter. It is entirely evident that the maximum value of resistance k_1 will be the maximum velocity of recoil.

With the existing types of brakes the maximum velocity of recoil starts after the recoiling parts have travelled about 20 - 25% of the total length of recoil. Taking the length of the circular canal L as equal to the remaining length of the path of recoil, that is supposing that

$$L \cong 0.75 \lambda_1, \qquad (597)264$$

we obtain the formula for the determination of k_1 in the following form:

$$k_1 = 1 + \varphi \frac{0.75\lambda}{2e} = 1 + 0.375 \varphi \frac{\lambda}{e}. \qquad (598)265$$

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With $\varphi = 0.015$ (for steel M) and $\varphi = 0.020$ (for spindle oil), we obtain:

$$k_{ic} = 1 + 0.0056 \frac{\lambda}{e}; \qquad (599)265$$

$$k_{ie} = 1 + 0.0075 \frac{\lambda}{e}. \qquad (600)265$$

On the basis of these formulas we can determine the approximate value of k_1 with a given length of recoil λ and with a minimum value of the average radial clearance e.

On the other hand, with a selected value of coefficient k_1, after solving the expressions (599) and (600) for e we obtain the conditions for the selection of the value of the radial clearance:

$$e \geqslant \frac{0.0056\ \lambda}{(k_{ic} - 1)}; \qquad (601)265$$

$$e \geqslant \frac{0.0075\ \lambda}{(k_{ie} - 1)}. \qquad (602)265$$

Since for the maximum assurance of providing for the filling of the space behind the moderator it is advisable to take the value of the radial clearance somewhat larger than the minimum, we have placed the sign of inequality in the latter expressions.

9. Calculation of the Constructional (Design) Dimensions of the Main Types of Recoil Brakes

Before we start to calculate the constructional dimensions of the recoil brake, we should select the type of the latter and make the necessary calculations of the values of hydraulic resistance Φ_0 of the brake for a number of points.

Then, starting from the thermic regimen of operation of the recoil brake, we determine (see page 288) the quantity of liquid necessary for filling the recoil brake. This is approximately the minimum volume of the cylinder.

Below, in determining the constructional dimensions, it is necessary to

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assign the maximum pressure p_{max} in the cylinder of the recoil brake and determine the maximum resistance of the hydraulic recoil brake on the basis of formula:

a) for field guns:

$$\Phi_{0\,max} = R_k - \Pi_k - T - F + Q_0 \sin \varphi_{max}; \quad (603)265$$

b) for stationary guns:

$$\Phi_{max} = R_K - \Pi_K - T - F + Q_0 \sin \varphi_{max}, \quad (604)266$$

where R_K and Π_K are the force of resistance to recoil and the force of the counterrecoil mechanism at the moment of the end of the action of the powder gases.

Usually, the maximum pressure p_{max} for field artillery weapons is assumed to be from 100 - 200 kg/cm^2. In large caliber (stationary and mobile) carriages (mounts) the maximum pressure may be increased up to 300 kg/cm^2.

Having p_{max} and Φ_{max}, it is necessary to proceed to determine the design dimensions of the brake. The method of calculation should be suitable for the type of brake.

The recoil brake of the simplest type with canals on the inside surface of the cylinder. The construction of such a type of brake is represented diagrammatically in Figure 74. We employ the following notation:

b --the width of the canals;

h --the variable depth of the canals;

h_{max} --the maximum depth of the canals;

n --the number of canals.

We determine the working area A of the piston of the recoil brake by the formula

$$A_0 = \frac{\Phi_{max}}{p_{max}} \quad (604)266$$

On the other hand, the working area of the piston is equal to:

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$$A_0 = \frac{\pi}{4}\left(D_T^2 - d_T^2\right). \qquad (606)266$$

In this expression the diameters D_T and d_T are unknown. Having assigned constructional ratio of the diameter of the piston D_T to the diameter of the piston, rod d_T, that is. $y = \frac{D_T}{d_T}$, we obtain an expression of the form:

$$A_0 = \frac{\pi}{4}\left(D_T^2 - \frac{D_T^2}{y^2}\right). \qquad (607)266$$

Solving the latter for the diameter of the piston of the recoil brake, we obtain:

$$D_T = 2y\sqrt{\frac{A_0}{\pi(y^2-1)}} \qquad (608)266$$

and also the diameter of the piston rod.

$$d_T = \frac{D_T}{y}. \qquad (609)266$$

If we take not one cylinder but m cylinders of the same kind, the formula (608) assumes the following form:

$$D_T = 2y\sqrt{\frac{A_0}{\pi m(y^2-1)}}. \qquad (610)267$$

In the recoil brakes of present day artillery weapons, the value y varies in limits from 0.7 to 2.2.

The diameters D_T and d_T obtained are rounded to normal values (on the basis of OST - All-Union Standard), taking into account the selected dimensions of the collars, after which we determine the precise value of the working area of the piston by the formula (606), and the specific pressure by the formula

$$p_{max} = \frac{\Phi_{0\,max}}{A_0}. \qquad (611)267$$

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Having the final value A_0 we can, on the basis of formula (521), determine the value of the discharge openings for those points for which we determined the velocity of recoil V and the hydraulic resistance of the brake ϕ_0. Knowing a_x, D_T and d_T, we can calculate the small canals.

Figure 105 (Page 267)

Assigning from design considerations the number of small canals (Figure 105) and their width (or depth) b, we find the maximum depth (or width) of the canals by the formula:

$$h_{max} = \frac{a_{max}}{bn} \qquad (612)267$$

Having the dimensions of the small canals it is necessary to check the piston rod and cylinder of the brake for strength by means of appropriate formulas: the cylinder for inside pressure p_{max}, the piston rod — for tensile strength. In the calculation of the brake cylinder for strength the inside radius should be taken equal to

$$r = \frac{D_T}{2} + h_{max}. \qquad (613)267$$

For all the other sections the depth (or width) of the small canals h is determined by the formula

$$h = \frac{1}{bn} \cdot a_x. \qquad (614)267$$

On the basis of formula (614) we make the calculation for the depth (or width) of the canals for all values of a_x determined previously for the different values of the length of recoil. For convenience in calculation the values of h

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are placed in the appropriate column of a table (see page 356 original) and we construct the profile of the small canals similar to what is shown in figure (106).

Figure 106 (Page 268)
Legend: 1 - profile of the canals.

In conclusion, we note that in case we assume the small canals to be of constant depth and variable width (as for example in the 76mm American tank gun UT-A2), the calculation of the small canals is carried out in a similar manner: assuming a constant depth, we calculate the width of the canals.

The recoil brake of the simplest type with "keys" of variable height on the inside surface of the cylinder. The construction of such a brake is represented diagrammatically in Figure 107.

Figure 107 (Page 268)

We adopt the following notation:

b --the width of the key;

h --the depth of the regulating openings or holes (variable);

h_{max} --the maximum depth of the regulating holes;

h' --rated (profile) height of the "key";

n --number of all the "keys".

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e --minimum height of the "keys" protruding above the inside surface of the cylinder;

C --depth of the key groove on the piston.

In this type of brake the discharge openings are made on the piston. We shall write the functional relationship between the working surface of piston A_0, the escape openings a_{max}, and the dimensions of the piston and the piston rod:

$$A_0 = \frac{\pi}{4}\left(D_T^2 - d_T^2\right) - a_{max} - nbe \qquad (615)\ 268$$

or

$$A_0 = \frac{\pi}{4}\left(D_T^2 - \frac{D_T^2}{y^2}\right) - nS, \qquad (616)269$$

where y is the ratio of the diameter of the piston to the diameter of the piston rod;

S --the area of the transversal section of the key groove on the piston, equal to

$$S = cb = \frac{1}{n}\, a_{max} + be = (e + h_{max})\, b. \qquad (617)269$$

Having determined beforehand the value A_0 by formula (605), then with formula (521) we find the value of a_{max}.

Assigning from considerations of design the values y, b, e, n and then solving the equality (617) for the depth of the key groove on the piston C, we shall have:

$$C = \frac{a_{max}}{nb} + e. \qquad (618)269$$

Solving the equality (616) for D_T, we obtain the formula for determination of the diameter of the piston:

$$D_T = 2y\sqrt{\frac{A_0 + nS}{\pi(y^2 - 1)}}. \qquad (619)269$$

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We then find the diameter of the piston by formula (609). The diameters obtained must be rounded to the normal ones, taking into account the dimensions of the collars selected. With the final values taken for A_0, a_{max}, D_T and d_T it is necessary to check to see if conditions (616) are met, doing this by determining the final value of S. For this purpose, having solved expression (616) for S, we obtain:

$$S = \frac{\pi(D_T^2 - d_T^2) - 4A_0}{4n}. \qquad (620)269$$

Having S, by a number of calculations we determine the final value of the dimensions c, b and e of the key groove, observing the conditions

$$S = cb = \frac{1}{n} a_{max} + be. \qquad (621)269$$

Since in the given type of brake the flow of the stream of liquid takes place without resistance, the calculation of the discharge openings for all the points for which we determined the velocities of recoil V and the hydraulic resistance to recoil ϕ_0 is done by formula (521).

The key groove in the piston remains constant in depth (c) and width (b) and, hence, we obtain a variable value for the discharge openings by varying the height of the key, which is determined by the formula

$$h' = h_{max} - h = \frac{1}{nb}(a_{max} - a_x). \qquad (622)270$$

Having calculated the variable height of the key, we can construct the profile of the key.

The simplest recoil brake of the gate valve type. The scheme (diagram) and action of such a recoil brake is given on page 196. The determination of the necessary discharge openings and the dimensions of the brake is done in the following manner.

In this type of brake the flow of the stream of liquid takes place without resistance. Hence, the escape openings are calculated by formula (521) and the

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diameter of the piston D_T and the diameter of the piston rod d_T by formula (615), assuming that nbe = 0.

If, during the time of the recoil, the recoiling parts travel the distances x_m, x_3, x_4, x_5, x_6, ... x_i etc, the values of the escape (discharge) openings for the liquid in the recoil brake should be a_m, a_3, a_4, a_5, a_6, ... a_i etc respectively. It is evident that with the passing of the recoiling parts from the point corresponding to the length of the recoil x_i to the point x_{i+1}, there should take place a change in the escape openings by the magnitude

$$\Delta a_i = a_{i+1} - a_i .$$

In obtaining Δa_i with a plus sign, the new value of the escape openings should be obtained by increasing the preceding opening in the gate valve; on the contrary, with the sign minus, the new value of the escape openings should be obtained by covering (partially) the preceding opening in the gate valve. In the first case the opening is increased in size and in the second it is decreased.

The calculation of the contour of the curve limiting the opening in the gate valve (slide valve) is generally done by a graphic method. In the construction of the aforementioned contour we take for the beginning the maximum escape opening, which is generally, as we have already stated above, at the momentof the greatest velocity of the recoil occuring somewhat previous to the termination of the action of the gases. For practical purposes it is entirely sufficient to assume $a_{max} = a_k$, that is, to assume that a_{max} corresponds to the termination of the secondary action of the gases.

Taking the latter for further estimates, we make the calculation for the differences in the escape openings for a number of successive points of recoil on the sector $(\lambda - x_k)$:

To the increment of the length of recoil $\Delta x_5 = x_5 - x_k$ there corresponds the increment of the value of the covering of theopening $\Delta a_5 = a_5 - a_k$.

To the increment of the length of recoil $\Delta x_6 = x_6 - x_5$ there corresponds the increment of the value of the covering of the opening $\Delta a_6 = a_6 - a_5$.

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To the increment of the length of recoil $\Delta x_7 = x_7 - x_6$ there corresponds an increment of the value of the covering of the openings $\Delta a_7 = a_7 - a_6$.

To the increment of the length of recoil $\Delta x_i = x_i - x_{i-1}$ there corresponds an increment of the value of the covering of the opening $\Delta a_i = a_i - a_{i-1}$.

To the increment of the length of recoil $\Delta x_n = x_n - x_{n-1}$ there corresponds an increment of the value of the covering of the openings $\Delta a_n = a_n - a_{n-1}$.

The data of the aforementioned calculation should be placed in the table given below.

Table 19 (Page 271)

CALCULATION OF THE ESCAPE OPENINGS IN THE GATE VALVE

Length of recoil	x_r	x_h	x_5	x_6	...	x_i	x_{i+1}	...	...	x_{n-1}	$x_n = \lambda$
Value of the escape openings	a_r	a_h	a_5	a_6	...	a_i	a_{i+1}	...	...	a_{n-1}	a_n
Increment of the length of recoil Δx			Δx_5	Δx_6	...	Δx_i	Δx_{i+1}	...	...	Δx_{n-1}	Δx_n
Increment of the value of the covering of the openings Δa.			Δa_5	Δa_6	...	Δa_i	Δa_{i+1}	...	...	Δa_{n-1}	Δa_n

We know that the escape opening, beginning with a_{max} decreases up to the end of the recoil. Hence, the differences in Δa shown in Table 19 represent the values of the covering of the escape openings for the liquid corresponding to the sectors Δx on the path of recoil.

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The sum of these differences is equal to:

$$\sum_{i=1}^{i=n} \Delta a_i = \Delta a_1 + \Delta a_2 + \ldots + \Delta a_n = (a_1 - a_k) + (a_2 - a_1) + \ldots + (a_n - a_{n-1}) = a_n - a_k .$$

At the end of the recoil the gauge openings are generally completely closed; hence, $a_n = 0$ and, consequently,

$$\sum_{i=1}^{i=n} \Delta a_i = [-a_k].$$

As we can see the absolute sum of the differences of the openings should constitute the area of the maximum gauge opening and, hence, the derived formula may serve as a check. On the basis of it we can check the accuracy of the calculations made.

Figure 106 (Page 272)

For proper functioning of the recoil brake there must be strict observance of the value of the closings Δa_i on the corresponding sectors of the path Δx_i of the recoil. The latter is obtained by the proper turning of the piston (or gate valve), which by the end of the recoil should be turned so much that it completely covers the maximum opening a_{max}. To assume the disc (gate valve), to be of the non-rotating type, and the piston (figure 108) to be of the rotating type. Let the diameter of the piston and gate valve be equal to D_r and let the

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openings made in the gate valve and in the piston be equal in value. At the instant when the recoiling parts travel the distance corresponding to the moment of the end of the action of the powder gases, the openings in the gate valve and piston will coincide, and the working face of the piston will occupy the position OA (Figure 108). On the remaining sector of the path of recoil $\lambda_1 = (\lambda - x_k)$ there should be complete closing of the opening α_k with a turn of the piston by an angle of α°, and in this case the working face of the piston will occupy the position OB. Taking the slope (inclination) of the guide groove as constant under an angle of α, we shall have:

$$\frac{\alpha^\circ}{\lambda_1} = \frac{\Delta\alpha^\circ}{\Delta x} \qquad (623)273$$

whence

$$\Delta\alpha^\circ = \frac{\alpha^\circ}{\lambda_1}\Delta x \qquad (624)273$$

Consequently, after the recoiling parts travel a distance of Δx_5 the piston will be turned by an angle equal to:

$$\Delta\alpha_5^\circ = \frac{\alpha^\circ}{\lambda_1}\Delta x_5 \qquad (625)273$$

and closes the opening α_k by the amount $\Delta\alpha_5$. The working face of the piston in this case will occupy the position OA_1. Let the value $\Delta\alpha_5$ on the drawing 108 correspond to the area $AA_1 n m$. It is necessary to find r_5 that is, the radius of the outline of the opening of the disc (or gate valve) on the sector of the turn. The area $\Delta\alpha_5$ is equal to:

$\Delta\alpha_5$ = area of $AA_1 n m$ = area sector AOA_1 — area sector $m\,0\,n$.

Since the area of the sector is equal to $\frac{\pi r^2}{360}\Delta\alpha^\circ$, then

$$\Delta\alpha_5 = \frac{\pi}{360}\left(R^2 - r_5^2\right)\Delta\alpha_5^\circ, \qquad (626)273$$

where

$$R = \frac{D_c}{2} = OA.$$

Substituting instead of $\Delta\alpha_5^\circ$ its value (625), we obtain:

$$\Delta\alpha_5 = \frac{\pi\alpha^\circ\Delta x_5}{360\,\lambda_1}\left(R^2 - r_5^2\right). \qquad (627)273$$

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Solving the latter for r_5, we have:

$$r_5 = \sqrt{R^2 - \frac{360\,\lambda_1\,\Delta\alpha_5}{\pi\,\alpha^\circ\,\Delta x_5}}\,. \qquad (628)273$$

By reasoning similar to the preceding, we see that after the recoiling parts pass over the sector of the path Δx_6, the piston is turned by

$$\Delta\alpha_6^\circ = \frac{\alpha^\circ}{\lambda_1}\,\Delta x_6,$$

and the necessary radius of the outline of theopening of the disc is determined by the formula

$$r_6 = \sqrt{R^2 - \frac{360\,\lambda_1\,\Delta\alpha_6}{\pi\,\alpha^\circ\,\Delta x_6}}\,. \qquad (629)273$$

Continuing to reason in a similar manner, we obtain the general formula for the determination of the radius r_i for a number of points in the following form:

$$r_i = \sqrt{R^2 - \frac{360\,\lambda_1\,\Delta\alpha_i}{\pi\,\alpha^\circ\,\Delta x_i}}\,. \qquad (630)274$$

Hence, assigning a value to α° and substituting from the table the different values of Δx_i and corresponding to them, we can by formula (630) calculate the necessary radii $\Delta\alpha_i$ and by drawing the arcs with these radii we obtain the broken line representing the profile of theopenings in the disc (figure 108). By smoothing it we finally obtain the curve of the profile of the opening in the disc (figure 109)

Figure 109 (Page 274)

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In order to avoid eccentricity in the application of the force, we make in the disc several symmetrically placed escape openings and then the formula (630) assumes the following form:

$$r_i = \sqrt{R^2 - \frac{360\,\lambda_1 \Delta\alpha_i}{\pi n \alpha^\circ \Delta\chi_i}}, \qquad (631)274$$

where n is the number of openings in the disc.

In brakes with a variable length of recoil, changing with the angle of elevation, the piston is first turned by a certain angle, closing ahead of time a part of the escape opening.

With recoil on the sector of the path from $\chi = 0$ to χ_k the opening is first enlarged to the value α_k and then gradually closed. The method of calculation itself is analogous to that explained for sector from $\chi = \chi_k$ on λ_1.

The recoil brake of the valve type. In a recoil brake of the valve type the variable escape opening is provided by appropriate adjustment of the position of the valve and by appropriate compression of the spring of the valve. Hence, in a valve brake the calculation of the diagram of the spring of the valve is the same as the calculation of the profile of the regulating parts in other types of brakes.

In regard to construction it is necessary to distinguish two types of valves: the closed (with counter-pressure) and the open (without counter-pressure).

A diagram showing the principle of the closed valve (with counter-pressure) is given in figure 110. At any given moment there acts on the valve a pressure p_1 opposed by a pressure p_2, in addition to the pressure of a spring. The pressure p_1 is created during the recoil by the pressure of the forcing of the liquid. The pressure p_2 is created, for example, by the resistance of the counterrecoil mechanism (see figure 78).

During recoil, as a result of the action of the pressure p_1 the spring begins to contract, the valve moves towards its seat by a certain value and the

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necessary escape opening is formed around the head of the valve.

(See figure 210 (Page 275)

Besides, at any given moment of the recoil, the force of the spring will be equal to:

$$P_n = p_1 \frac{\pi}{4} \delta_1^2 - p_a \frac{\pi}{4} \delta_1^2 = \frac{\pi}{4} (p_1 - p_a) \delta_1^2 ,$$

where p_a is the force of the seating of the valve;

p_1 --the pressure on the valve equal to the specific pressure in the cylinder of the recoil brake;

p_a --the resistance to the valve; relative to the scheme (Figure 79) it may be taken equal to

$$p_a = \frac{\Pi}{A_H} ;$$

δ_1 --diameter of the canal supplying the liquid.

It is evident that the maximum and the minimum force of the spring will be:

$$\left.\begin{aligned} P_{n\,max} &= \frac{\pi}{4} \delta_1^2 (p_1 - p_a)_{max} \\ P_{n\,min} &= \frac{\pi}{4} \delta_1^2 (p_1 - p_a)_{min} \end{aligned}\right\} \quad (632)275$$

For calculation of the design dimensions of the spring of the valve, we should know, in addition to $P_{n\,max}$ and $P_{n\,min}$, the value of the working

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stroke of the spring. In the diagram given the value of h will be the maximum working stroke of the spring of the valve, which it is necessary for us to determine.

With down movement of the valve by the value h the maximum escape opening f_{max} is formed around the head of the valve, the area of which is equal to the lateral surface of the truncated cone abcd (Figure 111) with an altitude h_1 and with diameters at the base of δ_1 and δ_2.

Since the lateral surface of the truncated cone is equal to the product of half the sum of the circumferences of the bases, we have the equality

$$f_{max} = \frac{\pi}{2}(\delta_1 + \delta_2)\sqrt{h_1^2 + \left(\frac{\delta_1 - \delta_2}{2}\right)^2}.$$

Solving the latter for h_1 we obtain:

$$h_1 = \frac{1}{2(\delta_1 + \delta_2)}\sqrt{\frac{16}{\pi^2} f_{max}^2 - (\delta_1^2 - \delta_2^2)^2}. \quad (633)\ 276$$

Figure 111 (Page 276)

Figure 111a (Page 276)

We have the following directly from the Figure 111a:

$$tg\,\alpha = \frac{\delta_1 - \delta_2}{2h_1},$$

whence

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$$h_2 = \frac{\delta_1 - \delta_2}{2 \operatorname{tg} \alpha} = \frac{\delta_1 - \delta_2}{2} \operatorname{ctg} \alpha. \qquad (634)276$$

Knowing h_1 and h_2, we find the working stroke of the spring:

$$h = h_1 + h_2.$$

By substituting h_1 and h_2 instead of their values (633) and (734), we obtain the formula for determination of the limit height of the down movement of the valve (or the working stroke of the spring of the valve) in the following form:

$$h = \frac{1}{2(\delta_1 + \delta_2)} \left[\sqrt{\frac{16}{\pi^2} a^2_{max} - (\delta_1^2 - \delta_2^2)^2} + (\delta_1^2 - \delta_2^2) \operatorname{ctg} \alpha \right] \qquad (635)276$$

Having $p_{n\,max}$, $p_{n\,min}$ and h, we can construct the diagram of the spring (Figure 112). The formula (636) is applicable only for the construction of the seat of the valve represented in Figure 111a. If the seat of the valve has a different form of construction, then as we have explained, it is necessary to derive a new calculation formula, taking design values for δ_1, δ_2 and α.

The open valve (without counter-pressure) is represented diagrammatically in Figure 113. For determination of $p_{n\,max}$ and $p_{n\,min}$ it is necessary to set $p_x = 0$, in formula (632). In other respects the calculation is the same.

With a variable length of recoil, the value (size) of theopen valve, except the spring, is further regulated by a special mechanism.

The calcualtion of the recoil brake with participation of the counterrecoil brake in the braking of the recoil. This type of brake includes, for example, the recoil brake and the counterrecoil brake, diagrammatically represented in Figure 78. Its functioning is considered on page 198.

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Figure 112 (Page 277)

A peculiarity of the calculation of the design dimensions of such a brake will consist in the following.

Before proceeding to calculate the design dimensions of the recoil brake it is necessary:

a) to determine the necessary escape openings for the recoil brake; the calculation carried out on the basis of formula (521);

b) to calculate the counterrecoil brake in a complete manner; the calculation of the escape openings of the counterrecoil brake should be made in accordance with formula (521), substituting in it the respective value of the working surface of the piston during counterrecoil.

Figure 113 (Page 277

From the values obtained for the escape openings of the recoil brake we must subtract the values of the escape openings of the counterrecoil brake, corresponding to the given sectors of the length of recoil:

$$\Delta a = a_T - a_H ,$$

where a_T is the necessary area of the section of theescape opening of the

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recoil brake;

a_H --the necessary area of the section of the escape opening of the counterrecoil brake.

On the basis of the difference obtained it is necessary to calculate the profile of the spindle by the formula

$$\delta = \sqrt{d_p^2 - \frac{4\Delta a}{\pi}} . \qquad (636)277$$

The rest of the design dimensions are calculated by the usual formulas applicable to this type of recoil brake.

The recoil brake in which a part of the liquid passes behind the moderator. Having determined the volume of liquid $\Phi_{o\,max}$ and assigning P_{max}, it is necessary to determine the value of the working area of the piston A_o by formula (606). Then, assigning the ratio of the diameters y, on the basis of formulas (608) and (609), it is necessary to determine D_T and d_T.

After the determination of A_o, D_T, d_T (taking into account the dimensions taken for the collars and P_{max}, and having predetermined the permissible stress of the piston rod under tension R, we can determine the diameter of the hollow cavity of the piston rod by the formula

$$d_1 = \sqrt{d_p^2 - \frac{4(\Phi_{o\,max} + I_w)'}{\pi R_z}} , \qquad (637)278$$

where I_w is the force of inertia of the piston rod:

$$I_w = m_w j ; \qquad (638)278$$

m_w --mass of the piston rod with the piston;

j --the maximum acceleration of the recoiling piston rod, taken equal to

$$j = \frac{P_{KH.\,max} - R_m}{M_o} \cong \frac{P_{KH.\,max}}{M_o} .$$

(1) Assuming that the piston rod moves and that the moments of the appearance of the maximum force $\Phi_{o\,max}$ and I_w coincide.

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Substituting the latter in expression (638), we obtain:

$$I_w = \frac{q_w}{Q_0} P_{KH.max}. \qquad (638a)278$$

In the latter expression we mean: q_w weight of the piston rod with the piston; Q_0 --weight of the recoiling parts.

If the recoil brake consists of n cylinders, formula (637) may be written in the following form:

$$d_1 = \sqrt{d_T^2 - \frac{4(\Phi_{0\,max} + I_w)}{\pi n R_z}}. \qquad (639)278$$

It is necessary to round to normal the value obtained for the diameter d_1. Having definitively selected the diameter d_1 of the cavity of the piston rod, it is necessary to check the piston rod for strength by the formula

$$R_z = \frac{4(\Phi_{0\,max} + I_w)}{\pi n (d_T^2 - d_1^2)}. \qquad (640)278$$

In case of recoiling cylinders it is necessary to drop the force of inertia of the piston rod in formulas (637) and (639).

Having the value of the diameter d_1 of the cavity of the piston rod, we find the value of the area of the cross section of the hollow part of the piston rod (working area of the counterrecoil brake):

$$A_{TH} = \frac{\pi}{4} d_1^2.$$

The maximum diameter of the spindle should be such that at the end of the recoil the escape opening for the liquid will be completely closed. Hence, the diameter of the spindle δ_{max} on the basis of the "nominal" should be equal to the diameter of the "eye" of the regulating ring ($\delta_{max} = d_p$). The diameter of the "eye" of the regulating ring is taken in construction at 4 ~ 6 mm less than d_1. Hence,

$$d_p = d_1 - (0.4 \div 0.6)\ cm. \qquad (641)279$$

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The area of the "eye" of the regulating ring is determined by the formula

$$A_p = \frac{\pi}{4} d_p^2 .$$

After this, having predetermined or calculated on the basis of appropriate formulas the value of coefficients k and k_1, we determine the minimum area of the cross section of the circular canal leading the liquid behind the moderator, doing so by means of formula (6.35):

$$\Omega_1 = C_d \left(\frac{V}{\sqrt{\Phi_0}}\right)_{max} .$$

On the other hand, the value obtained for Ω_1 is usually equal to:

$$\Omega_1 = \frac{\pi}{4}(d_1^2 - d_p^2) = \pi \left(\frac{d_1 - d_p}{2}\right)\left(\frac{d_1 + d_p}{2}\right) = 0.5\pi e (d_1 + d_p),$$

whence

$$e = \frac{\Omega_1}{0.5\pi (d_1 + d_p)} = 0.637 \frac{\Omega_1}{d_1 + d_p} ,$$

where $e = \frac{d_1 - d_p}{2}$ is the radial clearance of the canal leading the liquid behind the moderator.

For a greater assurance of filling of the cavity of the piston rod, the value e obtained should be checked by the formulas:

--in filling the recoil brake with steel K,

$$k_{1c} = 1 + 0.0056 \frac{\lambda}{e}$$

or in filling the recoil brake with spindle oil,

$$k_{1s} = 1 + 0.0075 \frac{\lambda}{e} .$$

As we can see from the expressions given, with the length of recoil λ, that we have taken and with the radial clearance e selected for construction the coefficients k_{1c} (for steel K) and k_{1s} (for spindle oil) assume a definite significance.

Remark. The maximum diameter of the spindle (diameter of the "eye" of the

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regulating ring) may also be determined by the formula

$$d_p = \delta_{max} = \sqrt{\frac{4}{\pi}(A_{TH} - \Omega_1)}. \qquad (642)280$$

After all those calculations, it is necessary to determine a_{max} by formula (563) and then determine from the equality

$$a_{max} = \frac{\pi}{4}(d_p^2 - \delta^2_{min})$$

the minimum value of the diameter of the spindle:

$$\delta_{min} = \sqrt{d_p^2 - \frac{4a_{max}}{\pi}}. \qquad (643)280$$

After having definitively determined the dimensions of the piston rod and the spindle (counter piston rod), it is necessary to check the piston rod for strength by formulas analogous to formulas (476) and (478).

During counterrecoil the piston rod and the spindle (counter piston rod) are subjected to compression, and it is possible to have lateral bending of the spindle. The maximum compressive force $\Phi_{H\,max}$ most often occurs at the moment of the filling (?) of the vacuum and we find it from the scheme of the counterrecoil or the table (see calculation of the counterrecoil brake).

The checking for lateral bending of the spindle or counter piston rod is done by the formula of Eiler:

(644)280

where P_{KP} is the critical load with lateral bending, with which it is possible to have a loss of rectilinearity of the axis of the spindle, in kilograms;

l --the length of the rod in centimeters;

I_{min}--the minimum equatorial moment of inertia of the section of the rod (cm^4), and it is assumed that the rod is of constant cross section;

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E --modulus of elasticity of the first degree;

K --the coefficient depending upon how the ends of the rod are built in.

The values of the coefficient K for various ways of attaching (Figure 114) are given in Table 20.

Table 20 (Page 281)

TABLE OF THE VALUES OF COEFFICIENT K

Serial number	Method of attaching the ends	Value of K
1	One end is fastened, while the other end is free.....	$\frac{1}{4}\pi^2=2.467$
2	Both ends on hinges.....	$\pi^2=9.860$
3	One end on a hinge and the other fastened	$2\pi^2=19.720$

In counterrecoil mechanism we most often encounter the 3d method of attaching: one end on a hinge, the other fastened.

Figure 114 (Page 281)
Legend: 1 - first method;
2 - second method;
3 - third method.

We should not load the spindle (counter piston) up to the critical tension; in calculation of the spindle for lateral bending it is necessary to have a certain margin of safety. Bearing in mind that in our case the force $\Phi'_{H\,max}$ acts on the counter piston rod, it is necessary that it represent only a part of the force P_{kp}, that is,

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$$\phi'_{H\,max} = \frac{1}{n} P_{KP} , \qquad (645)281$$

where n is the coefficient of reserve stability (margin of safety) of the counter piston rod (spindle).

Replacing P_{KP} and K by their values (we take K equal to $2\pi^2$), we rewrite the expression (644) in this form:

$$\phi'_{H\,max} = \frac{2\pi^2}{n} \cdot \frac{EI_{min}}{l^2} . \qquad (646)281$$

Solving the latter for n, we obtain:

$$n = \frac{2\pi^2 EI_{min}}{l^2 \phi'_{H\,max}} . \qquad (647)281$$

The design (rated) length l of the counter piston should be taken 10 - 15% greater than the length of the recoil λ, that is,

$$l = (1.10 \div 1.15)\lambda \text{ cm.}$$

The safety margin n for the counter piston, calculated with formula (647), should not be less than 5. Usually it lies within the limits 5 - 10.

Sometimes deformation from compression may be more dangerous than deformation from lateral bending. Hence, it is expedient to make a check for compression of the counter piston by the formula

$$\sigma_d = \frac{4\phi'_{H\,max}}{\pi \delta^2_{min}} . \qquad (648)282$$

In addition to this, the strength of the hollow piston rod is checked for internal pressure, equal to

$$p_H = \frac{\phi'_{H\,max}}{A_{TH}} ,$$

by the usual formula employed

$$\sigma_z = \frac{2}{3} p_H \frac{2d_T^2 + (d_1 + 2h_{max})^2}{d_T^2 - (d_1 + 2h_{max})^2} , \qquad (649)282$$

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where σ_z is the tensile stress, which should not be equal to more than one-third of the limit of elasticity of the metal;

h_{max} -- the maximum depth of the corrosion on the inside surface of the hollow piston rod (see calculation of the counterrecoil brake).

Having satisfied ourselves that the piston rod and the counter piston rod (spindle) are sufficiently strong, we can calculate the rest of the values of the escape openings α_x by formula (568). After this, from the equality

$$\alpha_x = \frac{\pi^2}{4}\left(\delta^2_{max} - \delta^2\right)$$

we find the variable diameter of the piston rod:

$$\delta = \sqrt{\delta^2_{max} - \frac{4\alpha_x}{\pi n}}. \qquad (650)282$$

The checking of the strength of the brake cylinder is done by formula

$$\sigma_z = \frac{2}{3} p_{max} \frac{2D_T' + D_T}{D_T' - D_T}, \qquad (651)282$$

where D_T and D_T' are the corresponding inside and outside diameters of the brake cylinder;

σ_z --the tensile stress in the cylinder.

For convenience in using the data of the calculation, the values found for δ and α_x should be placed in Table 17 (Page 251), and we should construct a profile of the spindle (Figure 116).

Figure 116 (Page 283).
Legend: 1 - profile of the spindle

Figure 116 (Page 283)

Figure 117 (Page 283)

a) Scheme I. In accordance with scheme I (Figure 116), in fire under an angle of elevation from $\varphi = 0$ to $\varphi = \varphi_1$, the length of recoil λ remains constant, equal to the maximum (λ_3). In the range of the angle of elevation from $\varphi = \varphi_1$ to $\varphi = \varphi_2$ the length of recoil changes and with $\varphi = \varphi_2$ reaches its minimum value. Then from $\varphi = \varphi_2$ to $\varphi = \varphi_3$ the length of recoil remains constant, short, equal to λ_4. In present day weapons this scheme has come to be widely used.

b) Scheme II. In accordance with scheme II (Figure 117), with a change in the angle of elevation, the length of recoil continuously decreases from λ_3

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The peculiarities of the calculation of the brake with variable length of recoil. The initial velocity of the projectile and the angle of elevation of present day guns have increased greatly. Fire under high angles of elevation requires short recoil, otherwise the breech may strike against the base (ground). In order that this may not take place and in order to satisfy at the same time the conditions of stability of the weapon in fire under small angles of elevation, many field guns have a variable length of recoil, changing with the angle of elevation. The change in the length of recoil is brought about by varying the force of resistance to recoil by altering the value of the openings through which the liquid escapes.

In principle there are many schemes for changing the length of the recoil on the basis of the angle of elevation φ. In actual practice, however, we encounter in the main only two schemes, namely the following two:

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with $\dot{\varphi} = 0$ to λ_{k} with $\varphi = \varphi_{max}$. This scheme is found most often in guns with relatively small lengths of recoil.

In the calculations it is necessary to be guided by the following, regardless of the scheme for changing the length λ.

The maximum length of recoil λ_{g} is determined from the conditions of stability of the weapon with a minimum angle of elevation (generally equal to 0°). The calculation of the escape openings of the recoil brake is also made with φ_{min}. The calculation of the other dimensions is made with φ_{max}.

The short length of recoil λ_{k} is determined constructively from the requirements as to dimensions (height of the line of fire, height of the axis of the trunnion, placing of the axis of the trunnion relative to the breech, maximum angle of elevation, etc). At the same time the law of resistance to recoil is generally employed, as in the stationary system, that is, $P = \text{const}$, and the calculation of the escape openings is made with φ_{max}.

Hence, the calculations of the long and short recoils are made independently of each other. The difference in the escape openings should be overlapped (covered, closed) on the transition sector from long to short recoil. The values of the overlaps $\Delta\alpha$ are determined by the method given in Table 21.

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Table 21 (Page 284)

CALCULATION OF THE OVERLAP OF THE ESCAPE OPENINGS

x m	$a_э$ cm²	$a_к$ cm²	$\Delta a = a_э - a_к$
0	0	0	0
x_1	$a_{э1}$	$a_{к1}$	Δa_1
x_2	$a_{э2}$	$a_{к2}$	Δa_2
⋮	⋮	⋮	⋮
x_i	$a_{эi}$	$a_{кi}$	Δa_i
⋮	⋮	⋮	⋮
$x = \lambda_к$	$a\lambda_{эк}$	$a_{к\lambda к}$	$\Delta a\lambda_к$
⋮	⋮	⋮	⋮
x_{n-1}	$a_{эn-1}$	—	$\Delta a_{n-1} = a_{эn-1}$
$x_n = \lambda_э$	$a_{эn}$	—	$\Delta a_n = a_{эn}$

Constructively the overlapping may be effected by different methods (long and short canals on the counter piston rod, gate valves, etc). It is best to have the long canals calculated for Δa, and the short ones for a_k, so that with the short recoil the openings Δa will be completely overlapped. The formulas for the calculation are the following:

$$h_к = \frac{1}{bn} a_k ; \qquad (652)285$$

$$h_э = \frac{1}{bn} \Delta a , \qquad (653)285$$

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where b is the width of the canals;

n --the number of canals;

h_k and h_d --the depth of the short and long canals respectively.

In recoil brakes of the gate valve type, the law of resistance to recoil is determined by the scheme of braking with long recoil. A decrease in the length of recoil with a change in the angle of elevation is effected by previous turning of the piston (or counter piston) by a certain angle, thus providing the initial overlap of the opening and in this way increasing the resistance to recoil.

10. Liquid for Filling the Recoil Mechanisms.

The selection of the liquid for recoil mechanisms of artillery weapons is exceptionally important. The liquid should assure normal operation of the artillery weapon during the time of fire under the most varied conditions of tactical employment. By means of the liquid we effect a conversion of the energy of recoil into heat; in hydraulic and pneumatic counterrecoil mechanisms it is a hydraulic means for shutting off the gas and the transmission of pressure to the piston.

Starting from this the following requirements are made of liquids for the recoiling mechanisms.

In the first place, the liquid should assure normal operation of the counter-recoil mechanisms under various temperature conditions: under freezing conditions, warm weather, etc. As a result of this the liquid should have a low solidification point and boiling point that is as high as possible.

In the second place, the liquid should not change its composition and qualities under various conditions of employment.

In the third place, the liquid should be strictly neutral from a chemical standpoint. It should not cause the corrosion of steel or other metals used for the manufacture of the recoil mechanisms, should not interfere with the packing devices (collars, stuffing boxes), and should not penetrate them.

In the fourth place, the possibility of manufacturing the liquid from home products, available in quantities and cheap to manufacture, should also be taken into account.

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At the present time we use the following liquids for filling the recoil mechanisms in our artillery:

Glycerinated liquid steol, the use of which was started in 1936. It was standard up to October 1942 and was used in the hydraulic brakes of the majority of guns and the hydropneumatic counterrecoil mechanisms of almost all systems.

Spirit-glycerinated liquid steol M. This is a mixture of liquid steol with ethyl spirits. It is prepared in plants and also in the artillery units themselves by the dilution of 2.5 volumes of liquid steol with 1 volume of ethyl spirits (more precisely, 71 parts by volume of steol and 29 parts by volume of spirits); or, 80 parts liquid steol and 20 parts of spirits, by weight (see Instructions of the Chief Artillery Administration, "Artillery lubricants and liquids". Memorandum dealing with employment).

It was adopted for use to replace liquid steol, which proved to have insufficient resistance to cold.

Spindle oil AU (spindle oil of the Artillery Administration) is prepared by distillation of petroleum. Earlier spindle oil was extensively employed and is still used for filling the recoil mechanisms in our artillery. The basic characteristics of the aforementioned liquids are given in Table 22.

Table 22 (Page 236)

TABLE OF THE BASIC CHARACTERISTICS OF THE LIQUIDS USED FOR FILLING THE RECOIL MECHANISMS

Serial No.	Name	Unit of Measurement	Composition and indexes of the liquid		
			Steol	Steol M	Spindle oil AU
	Composition on the basis of weight				
1	glycerine 100%	%	57.7	46.3	choice made from/ petroleum
2	ethyl spirits.....	%	-	20	

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3	potassium chromate.....	%	2.0	1.6	
4	sodium hydroxide.....	%	0.13	0.10	absent
5	water.....	%	rest	rest	
	Characteristics				
1	specific weight at 15° C	-	1.161 1.176	1.09 1.11	0.888 0.896
2	temperature of solidification.....	0°C	35	less than 57	45
3	boiling point.....	0°C	110-112	89-92	350
4	coefficient of volumetric expansion for 0° Centigrade..	-	0.00055	0.00065	0.00069
5	spedific thermic capacity....	-	0.76-0.79		0.45-0.46
6	absolute viscosity:				
	at - 30°C.....	puaz(1)	3.5	3.89	48.82
	" - 20°C.....	"	1.24	1.443	11.53
	" - 10°C.....	"	0.553	0.661	3.85
	" - 0°C.....	"	0.267	0.297	1.65
	" - 20°C.....	"	0.103	0.109	0.40
	" - 50°C.....	"	0.037	0.037	0.106
	" - 80°C.....	"	0.020	0.019	0.048

(1) unit of measure for viscosity

The data given in Table 22 show that steol and steol M, in comparison with spindle oil, have a smaller coefficient of volumetric expansion and greater thermic capacity, which constitute an advantageous factor, because with the absorption of the same quantity of thermic energy the volume of the liquid is increased by a smaller amount.

The antifreeze quality of steol and spindle oil "AU" is poorer than in the case of steol M. At low temperatures spindle oil becomes thick and crystals of ice appear in steol, as a result of which the resistance to recoil is greatly increased. In order to avoid this, in fire at low temperatures, it is necessary

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to fire the first shots with smaller charges or execute an artificial recoil. Steol M, having a lower temperature of solidification, is still liquid at a temperature of minus 57° Centigrade and solidifies at minus 65° without the formation of crystals. This characteristic of steol M gives it an advantage over the other liquids.

The greatest defect of liquid steol M and of steol, in comparison with spindle oil, is the relatively low boiling point: steol M simmers at plus 88°C and boils at plus 92°C. This disadvantage is moderated somewhat by the fact that steol M has a specific thermic capacity greater than spindle oil, and this means that the same quantity of heat communicated to steol M and to spindle oil causes a smaller increase in the temperature of the liquid.

The addition of potassium chromate to the glycerinated liquid (one may also use sodium chromate, potassium and sodium bichromate, the best kinds of commercial sodium hydroxide and potassium hydroxide) makes steol and steol M very stable and resistant to oxidation by oxygen of the air, even under pressure. Under the leather collars we do not observe any corrosion, with the exception of a little dullness and roughness (liquid steol M does not cause corrosion of steel if the surface of the metal is very clean before it is put in. In the contrary case there may be corrosion at the places where the object is fouled).

Spindle oil will not remain stable for a long time, especially at high temperatures and under the pressure of compressed air. In addition to this, by reason of its physical characteristics it penetrates leather (it filters through the leather), regardless of the quality of the latter. The chief advantage of a liquid of the type of steol, in comparison with spindle oil, consists in its excellent anit-corrosive qualities. Spindle oil is much cheaper than glycerinated liquids.

11. The Quantity of Liquid Necessary for Filling the Recoil Brake.

As we have already pointed out above, the kinetic energy of the recoiling masses, owing to the work performed by the recoil-counterrecoil brake and the forces of friction during the cycle recoil-counterrecoil, is completely converted

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into heat used in warming up the liquid and the parts surrounding it. Of course, during fire we must not allow the heating of the liquid up to the boiling point, because this would at the same time interfere with the proper functioning of the recoil brake. Hence, it is necessary to know how much the temperature of the liquid rises during the highest rate of fire for the given weapon.

We know that the functional relationship between heat generated and work is expressed by the formula

$$E = IQ, \qquad (654)288$$

where E is the work in kilogram-meters;

Q --the quantity of heat in kilogram-calories;

I --the mechanical equivalent of heat: I = 427 kgm/cal.

In our case the work E will correspond to the work of the force of hydraulic resistance of the brake during the time of the cycle recoil-counterrecoil, and, hence, we may write the equality in the form

$$E = \int_0^{\lambda} R\,dX - \int_0^{\lambda} (R_f + R_H)\,dX = \int_0^{\lambda} (\Phi_o + \Phi_H)\,dX. \qquad (655)289$$

where Φ_o is the hydraulic resistance to recoil;

Φ_H --the hydraulic resistance to counterrecoil;

R_f --the forces of friction acting during recoil;

R_H --the force of friction acting during counterrecoil.

The quantity of heat going into the liquid and the parts surrounding it is determined by the formula

$$Q = (Q_1 C_1 + Q_2 C_2)\Delta T, \qquad (656)289$$

where Q_1 is the weight of the liquid and Q_2 --the weight of the heated metallic parts of the recoil brake in kilograms;

C_1 and C_2 --the specific thermal capacities of the liquid and the steel respectively; the specific thermal capacity of steel is $C_2 = 0.115$;

ΔT --the increase in the temperature during one shot.

By replacing E and Q in formula (654) with their values in (655) and

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(656), we obtain the equality

$$\int_0^{\lambda} (\phi_o + \phi_H)\, dX = 427\,(Q_1 C_1 + Q_2 C_2)\,\Delta T. \quad (657)289$$

A part of the heat is radiated into the atmosphere, an amount which is taken into account by the coefficient of heat radiation η. Bearing this in mind and solving equality (657) for ΔT we obtain the formula for the determination of the increase in temperature of the liquid during one shot:

$$\Delta T = \frac{\eta \int_0^{\lambda} (\phi_o + \phi_H)\, dX}{427\,(Q_1 C_1 + Q_2 C_2)}, \quad (658)289$$

or, for n shots, following one after the other without interruption:

$$\Delta T_n = \frac{n \eta \phi_{cp} \lambda}{427\,(Q_1 C_1 + Q_2 C_2)}. \quad (659)289$$

The average hydraulic resistance may be estimated by the formula

$$\phi_{cp} = \frac{\sum_{i=1}^{i=n} \phi_{oi}}{n} + \frac{\sum_{i=1}^{i=n_1} \phi_{Hi}}{n_1}, \quad (660)289$$

where n and n_1 are the number of the values of ϕ_o and ϕ_H found in the calculation of the recoil brake and the counterrecoil brake respectively.

In calculations the coefficient of heat emission η is taken to be 0.9.

If the temperature of the liquid before firing was T_0, then after firing n shots it will be

$$T_n = T_0 - \Delta T_n, \quad (661)290$$

The maximum temperature to which the liquid is heated after n shots will serve as a criterion for determining whether or not the quantity of liquid in the recoil brake is sufficient. This temperature should be 20 - 30% lower than the boiling point.

As a result of the fact that the coefficient of the volumetric expansion of steel is much less (.000033) than the liquid, the volume of the liquid, as a

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result of the heating, will increase faster than the volume of the heated cylinders. Hence, in addition to the increase in the temperature of the liquid, it is necessary to determine the increase in the volume of the liquid as a result of heating.

This increment is determined by the formula

$$\Delta w = \beta w_0 (T_n - T_{\substack{c \\ (0°)}}) = \beta w_0 \Delta T_n, \qquad (662)290$$

where Δw is the increase in the volume of the liquid;

β --the coefficient of the volumetric expansion;

w_0 --the initial volume of the liquid in the recoil brake;

T_n --the temperature of the liquid after n shots;

T_0 --the initial temperature (15°C.)

The cylinders of the hydraulic recoil brakes are usually filled completely with liquid. A failure to fill the cylinders of the recoil brakes with liquid shows itself in the functioning of the recoil mechanisms. With an increase in the shortage of liquid, there is an increase in the maximum velocity of recoil; the maximum resistance to recoil increases with simultaneous shifting along the length in the direction of the recoil; the maximum velocity of counterrecoil increases, causing an abrupt counterrecoil. At the same time the full length of the recoil increases comparatively little. The duration of recoil is somewhat less. Hence, in view of technical conditions the cylinders of the recoil brake should be filled to at least 98% of their capacity. Consequently, the increase in the volume should not be greater than 2% of the initial volume of the liquid, that is, we must observe the conditions

$$\Delta w \leqslant 0.02\, w_0.$$

In the contrary case, it is necessary to insert a liquid compensator or increase the quantity of liquid in the cylinder of the recoil brake, changing the dimensions of the latter in a corresponding manner.

For automatic and rapid fire guns we use in actual practice an increased temperature of not greater than 1° Centigrade for one shot; for slow firing guns

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we may allow an increase in the temperature up to 2°C for one shot.

For making a preliminary estimate of the amount of liquid required for a recoil brake, we may use the ratio established by practice, taking one liter of liquid steel M for 1.5 tm of the energy of free recoil for non-automatic weapons. On the whole, however, in designing guns the thermic regimen of the recoil brake should be clarified by a special calculation, starting from the tactical-technical requirements made of the weapon.

12. Liquid Compensators.

Above we said that in brake devices the liquid is heated during the time of the shot, as a result of which it expands and increases in volume. Since at the same time the volume of the cylinders remains almost unchanged, we have as a result of this an excess of liquid in the cylinder, and with prolonged fire this leads to short recoils. In order to remedy this it is necessary to let out a certain quantity of liquid, and in the process of fire we must have recourse to this procedure repeatedly.

During the time of an interruption in fire the liquid cools and its volume decreases, as a result of which a vacuum is formed in the cylinders. In addition to this, a vacuum is also formed by the removal of a part of the liquid by the brake rod during recoil. It is necessary to put in additional liquid, otherwise we shall have abrupt recoils and counterrecoils.

At the present time this function is oftentimes performed by special replenishers, called compensators, with which the recoil brakes are equipped. The compensator is an additional reservoir from which the liquid flows into the cylinder of the recoil brake, when liquid is lacking, or into which liquid flows from the brake cylinder, when it expands. Hence, the basic purpose of the compensator is to regulate automatically the quantity (by volume) of liquid in the cylinder of the recoil brake.

In practice use has been made of two types of compensators: the hydropneumatic type and the spring type.

A diagram of the hydropneumatic compensator is given in Figure 118. It

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consists of a metallic box 1, usually placed with respect to the brake cylinder in such a way that it forms a continuation of the latter. The diaphragm 2 separates it from the brake cylinder. Reservoir 3 of the compensator is partially filled with liquid and is connected by tube 4 with the space behind the piston of the brake cylinder. In the part of the reservoir not filled with liquid there is air under a pressure of about 1 atmosphere or above.

During intense fire the volume of air is decreased as a result of the escape from the brake cylinder of the excess liquid forming during the temperature expansion. At the same time the pressure of the air in the container is increased in accordance with the law of the polytrope. After the cooling of the liquid, the pressure of the air forces the necessary quantity of it into the brake cylinder.

Figure 118 (Page 292)

The scheme of the spring compensator is represented in figure 119. In the reservoir of compensator 1 there is a piston 2, on one side of which is liquid and on the other side a spring 3. The excess of liquid passing through opening α in diaphragm 4 from the brake cylinder into the reservoir of the compensator moves the piston and compresses the spring. After the cooling of the liquid, the piston is moved in the reverse direction by the force of the spring pressing the liquid into the brake cylinder and filling it.

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Figure 119 (Page 292)

With such an arrangement of the compensators (Figures 118 and 119) the brake cylinder has the required amount of liquid at the beginning of the recoil. The basic weakness of such a scheme consists in the fact that however small the opening in the diaphragm, a part of the liquid still gets into the brake cylinder during the time of the recoil, and will be forced into the reservoir of the compensator during the counterrecoil. In other words, there is a reverse process of overfilling with liquid during the time of each cycle of recoil-counterrecoil.

By the placing of a special valve (Figure 120) the aforementioned defect is remedied, but the construction of the compensator is made more complex. The action of the valve consists in the following.

During recoil valve 1, under the action of spring 2 and compressed air, is shifted and pressed against its seat, closing the exit of the liquid into the brake cylinder. At the end of the counterrecoil the piston of the brake rod rests on the face of the valve and moves the valve within the reservoir. At the same time the valve moves from its seat and the excess volume of liquid can move from the brake cylinder into the reservoir of the compensator.

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After the cooling of the liquid its volume decreases, as a result of which a free space is formed behind the piston of the brake cylinder. The piston is able to move and open the valve for admission of the necessary quantity of liquid into the brake cylinder. Hence, the valve prevents the flow of excess liquid from the reservoir into the brake cylinder during recoil and in the reverse direction during counterrecoil.

13. Packing (Tightening) Devices.

As we know, the cylinders of recoil brakes are filled with liquid, and the cylinders of the counterrecoil mechanism are filled with liquid and gas (air). In order to assure tightness and prevent the leak of liquid and gas from the cavities which they occupy, we make use of tightening devices arranged in the places where the rods pass through the cylinder and on the piston itself.

On the basis of construction we distinguish the following methods for securing tightness:

1) Method of close (precise) fitting;

2) Collars and

3) Packing devices employed separately or in combination with collars.

In the method of precise fitting the parts to be obturated are made to fit comparatively "tight" (Figure 121). The piston 1 is covered by a bronze jacket 2, which serves as a slide during the movement of the piston in cylinder 3 and gives the proper tightening.

During fire there is "sticking" in such combinations, as a result of the repeated expansion due to the heating of the bronze lined parts and steel cylinders. In order that this may not happen it is necessary to have a minimum clearance of 0.20 - 0.25 mm, between the steel cylinder and the bronze jacket, and 0.08 - 0.12mm between the moderator and the piston rod. For assuring the necessary tightness under such conditions the surfaces in contact must be carefully machined, and several transversal canals (grooves) α made on the surface of the jacket. When the jacket of the piston wears too much, we can easily replace it.

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Figure 121 (Page 294)

This method is used when a slight loss of liquid does not have any substantial influence upon the character of the work and, when for this reason absolute tightness is not necessary. This method is used to make the piston of the recoil brake tight.

An advantage of this method consists in the fact that the tightening generates little friction and does not depend upon pressure in the cylinder and it does not require any special care.

Tightening by means of collars is always used for obturation of the piston of hydropneumatic counterrecoil mechanisms, and for the obturation of the rods of recoil brakes and counterrecoil mechanisms in certain cases. They may be of the single collar type (Figure 122) or the two-collar type (Figure 123). Regardless of the number of collars, the collar is placed on a sub-collar ring and rests either on the sub-collar ring alone or it may rest on a sub-collar which in its turn rests on a stuffing box pressed by a spring (Figure 124). The sub-collar ring serves as a support for the collars, and the sub-collar devices transmit and distribute the pressure.

On the whole the collar arrangements are constructed on the same pattern. By way of example Figure 123 shows one of the constructions of the two-collar piston of the counterrecoil mechanism. As we can see, the collar arrangement is assembled on the head 3 of the piston rod. The second collar 2 is placed on sub-collar ring 4 and rests on ring-piston 5, which serves at the same time as the super-collar ring of this same collar. Ring 5 has a babbit ring 6, for

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centering the piston rod.

Figure 122 (Page 295)

Figure 123 (Page 295)

Figure 124 (Page 295)

The first collar 1 is placed in its turn on the sub-collar ring 7 and rests on the super-collar ring 8, pressing against the sub-collar ring of the second