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VOLUME 2
TECHNICAL ANALYSES OF EURASIAN COMMUNIST FIELD AND ANTITANK ARTILLERY CANNON SYSTEMS WITH APPENDIXES

PREPARED BY
US ARMY
ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
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GUN AND HOWITZER SYSTEMS (CURRENT AND PROJECTED)-- EURASIAN COMMUNIST COUNTRIES (U)

Volume 2

Technical Analyses of Eurasian Communist Field and Antitank Artillery Cannon Systems with Appendixes (U)

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Volume 2

Technical Analyses of Eurasian Communist Field and Antitank Artillery Cannon Systems with Appendixes (U)

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FOREWORD

This document, Volume II, contains the technical analyses and the trends and forecasts sections of subject study. Also included are five appendixes, plus list of abbreviations, units of measure, glossary, symbols, and US vs. Soviet terminology. See Volume I for the evolution and construction of cannon systems and the employment of Eurasian Communist field and antitank cannon artillery.

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Section II.

ANALYSIS OF CURRENTLY STANDARD ECC FIELD ARTILLERY CANNON SYSTEMS

A. SUMMARY OF OPERATIONAL AND TECHNICAL CHARACTERISTICS

1. (U) Analysis of Operational and Technical Characteristics

The analysis of ECC field artillery cannon systems known to be standard within ECC is set forth in the following subsections. The term "standard" as used in this compilation is intended to mean that the systems are currently deployed by the nation that developed the weapon to units in its active establishment, albeit in some instances in limited quantities to specialized formations such as airborne or mountain troops. The systems are those that will most frequently be encountered in a given country, geopolitical area, or hegemony. The subsections vary in the amount of material presented; however, this is not to be interpreted as a sole indication of the amount of data held on a specific system. Rather, the detail of the treatises presented result from the following considerations: The current deployment status of the system, the proliferation of the system, particularly interesting technical features, unique and revolutionary system developments, and the availability of information. The analysis of ECC field artillery cannon does not include all of the cannon systems in the possession of a particular country. Specifically excluded are unmodified free world systems. Those outmoded systems that are deployed but are relegated to home defense and cannot be accommodated in the considerations above also are excluded from this analysis.

2. ~~(C)~~ Tables Portraying Operational and Technical Characteristics

Tables II-A-2a through II-A-2d summarize the operational, technical, and tactical capabilities of the cannon systems addressed in section II of this study. These tables were provided to furnish a ready and comparative reference. The categories of information in each table are those most frequently the subject of inquiry and interest by US developers, users, staff officers, and field commanders. Tables II-A-2e through II-A-2h present additional data on selected systems. These data should be of interest to developers and others concerned with the engineering and design of new cannon systems. Also included in these latter tables are representative US cannon systems; these are intended to serve as a point of reference in evaluation of the ECC systems.

(b)(1),1.4 (c)

Table II-A-2a. General Characteristics (U)

Nomenclature	Year introduced / Status	Maximum range (m)	Measurement in travel position: Weight (kg)	Length (mm)	Width (mm)	Height (mm)	Laying capabilities: Total traverse	Elevation limits	Crew/w driver	Time: emplace (min) / displace (min)	Weight of fuzed HE projectile (kg)	Rate of fire full-charge rounds: 1 min	15 min	30 min
Soviet 76-mm mountain gun M1966 (?)	1966 standard	10 500 to 11 500 (est)	700 (est)	4850 (est)	1550 (est)	1450 (est)	45° to 50° (est)	-5° to +65° (est)	7	1 (est) / 1 (est)	6.20 (est)	15 (est)	85 (est)	115 (est)
Soviet 85-mm APAT gun SD-44	1953 standard	15 650 (18 970 w/trails dug in)	2270 (est)	8340	1730	1420	54°	-7° to +35°	5	1 / 1	9.54	10	60	90
Soviet 100-mm field gun M-1955	1955 standard	21 000 (est)	3360 (est)	9080 (est)	1580 (est)	1900 (est)	45° (est)	-5° to +20° (est)	6	3 / 2	15.6	7 (est)	60 (est)	75 (est)
Soviet 100-mm antitank gun T-12/12A	1965 standard	18 000 @20° (est) 19 500 dug in @30° (est)	2800 (est) T-12 / T-12A 3300 (est)	8900 (est) T-12 / T-12A 9190 (est)	1810 (est) T-12 / T-12A 2260 (est)	1450 (est)	54°	-10° to +20°	7	3 (est) / 3 (est)	9.5 (HEAT-FS) (est)	10 (est)	50 (est)	70 (est)
Soviet 122-mm howitzer M-30 (M-1938)	1938 limited-standard	11 800	2500	5930	1976	1803	49°	-3° to +63.5°	8	1 to 1.5 / 1 to 1.5	21.76	6	55	75
Soviet 122-mm howitzer D-30	1963 standard	15 300	3150	5400	1950	1660	360°	-7° to +70° (7° to +18° over trails)	8	1.5 to 2.5 / 1.5 to 2.5	21.76	6	55	75
Soviet 122-mm field gun D-74	1955 limited-standard	23 900	5570	9980	2500	2750	58°	-5° to +45°	9	3 to 5 / 3 to 5	27.5	5	50	75
Soviet 122-mm SP gun M1974	1974 standard	15 300	17 000 to 17 500 (est)	7410 (est)	2950 (est)	2400 (est)	360°	-4° to +65° (est)	4 (on board)	0.25 to 0.75 (est)* / 0.25 to 0.75 (est)*	21.76	10 to 12 (est)	55 (est)	70 (est)
Soviet 130-mm field gun M-46	1954 standard	27 490	8450	11 730	2450	2550	50°	-2.5° to +45°	8	4 / 4	33.4	5	45	70

*Elapsed time from coming to a halt and ready to accept lay or to fire first round in direct fire.

Table II-A-2a. General Characteristics (U) (Continued)

Nomenclature	Year introduced / Status	Maximum range (m)	Measurement in travel position: Weight (kg)	Length (mm)	Width (mm)	Height (mm)	Laying capabilities: Total traverse	Elevation limits	Crew/w driver	Time: emplace (min) / displace (min)	Weight of fuzed HE projectile (kg)	Rate of fire full-charge rounds: 1 min	15 min	30 min
Soviet 152-mm gun M-47	Unk	20 470	8450	11 320	2450	2550	50°	-2.5° to +45°	8	4 / 4	43.56	4	40	70
Soviet 152-mm SP gun M1973	1973 standard	17 230 (est)	27 000 (est)	8400 (est)	3200 (est)	2880 (est)	360°	-5° to +60° (est)	4 (on board)	0.25 to 0.75 (est)* / 0.25 to 0.75 (est)*	43.56 (est)	8 (est)	40 (est)	55 (est)
Soviet 152-mm gun-howitzer ML-20 (M-1937)	1937 obsolescent/ limited-standard	17 230	8070	8175	2345	2270	58°	-2° to +65°	9	8 to 10 / 10	43.56	4	40	60
Soviet 152-mm gun-howitzer D-20	1955 standard	17 230 (est)	5900	8140	2030	2470	58°	-5° to +63°	10	5 / 5	43.56	4	40	65
Soviet 152-mm howitzer D-1 (M-1943)	1943 standard	12 390	3640	5930	1900 (est)	1840 (est)	35°	-3° to +63.5°	9	2 / 2	40.0	4	40	65
Soviet 180-mm gun S-23	1955 war reserve	43 800 (RAP) 30 390 (conv)	21 500	13 000	3000	2700	40°	-2° to +55°	13	25 to 35 / 25 to 35	88.0	1	9	18
Soviet 203-mm howitzer B-4 (M-1931)	1931 limited-standard	18 025	11 900** 12 900	8500** 8950	2500** 2500	2500** 1950	8°	0° to +60°	14 (est)	60 to 120 / 60 to 120	98.75	1	9	18
Czechoslovak 85-mm field guns M-52 & M52/55	1952? obsolescent	16 160	2130	7520	1980	1140	60°	-6° to +38°	7	1 to 1.5 / 1 to 1.5	9.5	10 (est)	60 (est)	90 (est)
Czechoslovak 100-mm field gun M-53	1953? standard	21 000	4390	9100	2360	2600	60°	-6° to +42°	6	3 / 3	15.6	10 (est)	65 (est)	80 (est)
Yugoslav 76-mm mountain gun M-48	1950 limited-standard	8600	705	2420	2000 (est)	1500 (est)	50°	-15° to +45° (+12° to +65° w/short trails)	6	2.5 / 2.5	6.2	20	75 (est)	110
Yugoslav 105-mm howitzer M-56	1961 limited-standard	13 000	2100	5460	2000 (est)	1560	52°	-12° to +68°	8	3 / 3	15.0	16	?	?
Yugoslav 155-mm howitzer M-65	NA limited-standard	14 600 (est)	5700 (aprx)	7315	2474	1842	48.7°	-2° to +63°	7	5 / 5	43.09	4	24	30
PRC 130-mm field gun type 59-1	1969 standard	27 500 (est)	5630	10 980	2400	1880	58°	-6° to +44.5°	7	3 / 3	33.4	5 (est)	47 (est)	70 (est)

*Elapsed time from coming to a halt and ready to accept lay or to fire first round in direct fire.

**Note: Weapon transported in two loads. First entry is for carriage and second entry is for cannon.

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Table II-A-2b. Tactical Considerations (U)

Nomenclature	Maximum range	Principal task	Deployment		Firing position-rear of FEBA		Principal primemover	
			Assignment level	Operational level	Offense (km)	Defense (km)	Wheeled	Tracked
Soviet 76-mm mountain gun M1966 (?)	10 500 to 11 500 (est)	Direct support	Mountain division (USSR)	Maneuver bn, regt	1 to 2	2 to 4	GAZ-69 truck, animal pack	None
Soviet 85-mm APAT gun SD-44	15 650 (18 970 with trails dug in)	AT, direct support	Airborne division (USSR, E. Germany)	Division, regt maneuver	0.1 to 3	0.1 to 5	Aux-propelled, light trucks	AT-P
Soviet 100-mm field gun M-1955	21 000 (est)	AT	MRD (Warsaw Pact)	Antitank bn	0.2 to 0.4	0.1 to 5	ZIL-157	AT-P arty tractor
Soviet 100-mm antitank gun T-12/12A	18 000 @ 20° (est) 19 500 @ 30° (est)	AT	Division (Warsaw Pact, Vietnam), also front in USSR	Antitank bn	0.2 to 0.5	0.2 to 5	URAL-375 ZIL-151	MTLB (M1970 APC)
Soviet 122-mm howitzer M-30 (M1938)	11 800	Direct support	Division (W. Pact, N. Korea, PRC, Vietnam) MRR (W. Pact)	Maneuver co, bn, regt	1 to 3	2 to 6	ZIL-151 or 157	Indigenous light-to-medium arty tractors
Soviet 122-mm howitzer D-30	15 300	Direct support	Division (Warsaw Pact, Vietnam, Syria Finland, Egypt, Peru) MRR (W. Pact)	Maneuver co, bn, regt	1 to 2 (MRR) 2.5 to 4 (arty regt)	2 to 4 (MRR) 3 to 7 (arty regt)	URAL-375 ZIL-131	AT-L light arty tractor
Soviet 122-mm field gun D-74	23 900	General support	Front, Army (Warsaw Pact, N. Korea, Vietnam, Egypt, Syria, Sudan, PRC)	Army or div arty gp	4 to 7	5 to 10	ZIL-135 KrAZ-214	AT-S medium arty tractor
Soviet 122-mm SP gun M1974	15 300	Direct support	MRR (USSR, Poland, Czechoslovakia)	Maneuver co, bn, regt	1 to 2 [MRR (BMP equipped)]	1.5 to 5 [MRR (BMP equipped)]	Self-propelled	Self-propelled
Soviet 130-mm field gun M-46	27 490	General support	Arty bde, arty div (Warsaw Pact, PRC, N. Korea, Vietnam)	Army or div arty gp	4 to 8	5 to 10	ZIL-135 TATRA 813 KrAZ-255B	ATS-59 medium arty tractor
Soviet 152-mm gun, M-47	20 470	General support	Front or RVGK (est)	Army or front arty OP (est)	3 to 6 (est)	4 to 9 (est)	ZIL-135 TATRA 813 (est)	AT-S medium arty tractor (est)
Soviet 152-mm SP gun M1973	17 230	General support	Division and front (USSR)	Div arty gp regt arty gp	3 to 5 2 to 4	4 to 8 3 to 6	Self-propelled	Self-propelled

Table II-A-2b. Tactical Considerations (U) (Continued)

Nomenclature	Maximum range	Principal task	Deployment		Firing position-rear of FEBA		Principal primemover	
			Assignment level	Operational level	Offense (km)	Defense (km)	Wheeled	Tracked
Soviet 152-mm gun-howitzer ML-20 (M-1937)	17 230	General support or GS-reinforcing	Army, front	Div or army arty gp	3 to 6	4 to 9	ZIL-135 TATRA 813	AT-S medium, AT-T heavy arty tractors
Soviet 152-mm gun-howitzer D-20	18 400 (est) 17 230	General support or GS-reinforcing	Arty bde (Warsaw Pact, PRC)	Army or div arty gp	3 to 5	4 to 8	ZIL-135 TATRA 813	AT-S medium arty tractor
Soviet 152-mm howitzer D-1 (M-1943)	12 390	General support and reinforcing	Division and front (Warsaw Pact, N. Korea, PRC)	Div or regt arty gp	2 to 3	3 to 6	ZIL-151 ZIL-157	ATS-59 medium arty tractor
Soviet 180-mm gun S-23	43 800 (RAP) 30 390 (Conv)	General support	Front, (Syria, N. Korea, Vietnam, Egypt, Czecho-slovakia)	Army arty gp	7 to 12	10 to 16	KrAZ-219	AT-T heavy duty tractor
Soviet 203-mm howitzer B-4 (M-1931)	18 025	General support	Front	Army arty gp	4 to 6 (est)	5 to 9 (est)	---	AT-T
Czechoslovak 85-mm field gun M-52 & M-52/55	16 160	AT	Arty bn or regt (East Ger, Austria)	Arty btry or bn	0.1 to 0.5	0.1 to 0.5	Praga V3S truck	
Czechoslovak 100-mm field gun M-53	21 000	AT, general support	Front, army, division (Yugoslavia)	Division	0.2 to 3	0.1 to 5	TATRA 111, med Czechoslovak trucks	?
Yugoslav 76-mm mountain gun M-48	8600	Direct support	Special purpose divisions (Yugo)	Maneuver bn, regt	1 to 2	2 to 4	Light trucks, animal pack	?
Yugoslav 105-mm howitzer M-56	13 000	Direct support or GS-reinforcing	Home guard	Maneuver bn, regt; or div arty	2 to 4	4 to 7	TAM-4500-D	?
Yugoslav 155-mm howitzer M-65	14 600	General support	Unk	Unk	3 to 5	4 to 8	Med truck	Med arty tractor
PRC 130-mm field gun type 59-1	27 500	General support	Army	Army and div arty	4 to 8	5 to 10	?	ATS-59 or equal

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Table II-A-2c. Performance in Indirect Fire (U)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Nomenclature	Types of ammo available (indirect fire)	HE projectile designation	Probable errors in range and deflection at selected percentages of max range (m)						Remarks
			90%		70%		30%		
			range	PE_r/PE_d	range	PE_r/PE_d	range	PE_r/PE_d	
Soviet 76-mm mountain gun M1966 (?)	HE Smoke (WP)	OF-350 D-350	? ?	? ?	? ?	? ?	? ?	? ?	[1]based on performance of 76-mm ZIS-3's projectile
Soviet 85-mm APAT gun SD-44	HE, smoke (WP), chem	O-365K	14 100	52 / 7.6	11 000	40 / 4.5	4700	22 / 1.5	
Soviet 100-mm field gun M-1955	HE, smoke (WP)	OF-412	18 900	71 / 11	14 700	55 / 8.1	6300	28 / 2.1	[2]based on performance of 100-mm M-53's projectile
Soviet 100-mm[3] antitank gun T-12/12A	HE (?)	?	?	?	?	?	?	?	[3]normally used only in a direct fire role
Soviet 122-mm howitzer M-30 (M-1938)	Frag-HE, WP, illum, pgnd ?	OF-462 or OF-462A	10 600	35 / 7.5	8300	26 / 5.6	3500	22 / 2.3	
Soviet 122-mm howitzer D-30	Frag-HE, WP, illum, pgnd, chem	OF-462 or OF-462 Zh	13 800	23 / 7.6	10 700	23 / 5.6	4600	25 / 3.8	
Soviet 122-mm field gun D-74	Frag-HE	OF-477	21 510	91 / 16	16 730	60 / 10	7170	22 / 3.1	
Soviet 122-mm[4] SP gun M1974	Frag-HE, WP, illum, pgnd, chem	OF-462	13 800	23 / 7.6	10 700	23 / 5.6	4600	25 / 3.8	[4]performance estimated to be equal to or greater than shown for D-30
Soviet 130-mm field gun M-46	Frag-HE, illum, chem	OF-482M	24 740	62 / 12	19 240	44 / 8.4	8250	21 / 2.9	
Soviet 152-mm gun M-47	HE	OF-547	?	?	?	?	?	?	
Soviet 152-mm SP gun M1973[5]	Frag-HE CP ? WP ? nuc ?	OF-540 G-530	15 500	⩽64 / ⩽11	12 100	⩽46 / ⩽8.5	5200	⩽26 / ⩽5.2	[5]performance estimated to equal or exceed that of 152-mm D-20

*See remarks column for explanation of superscript figures.

Table II-A-2c. Performance in Indirect Fire (U) (Continued)

Nomenclature	Types of ammo available (indirect fire)	HE projectile designation	Probable errors in range and deflection at selected percentages of max range (m)						Remarks
			90%		70%		30%		
			range	PE_r/PE_d	range	PE_r/PE_d	range	PE_r/PE_d	
Soviet 152-mm gun-howitzer ML-20 (M-1937)	Frag-HE, CP nuc (?)	OF-540	15 500	64 / 11	12 100	46 / 8.5	5200	26 / 5.2	
Soviet 152-mm gun-howitzer D-20	Frag-HE, CP nuc (?)	OF-540(?)	15 500	≤64 / 11	12 100	≤46 / 8.5	5500	≤26 / 5.2	estimated
Soviet 152-mm howitzer D-1 (M-1943)	Frag-HE, CP, naval SAP, chem	OF-530 OF-530A	11 200	47 / 6.0	8700	32 / 4.6	3700	20 / 1.9	
Soviet 180-mm gun S-23	HE, CP, incd-frag-HE, RAP, nuc (?)	F-572	27 360 (conv)	94 / 8.8	21 280	63 / 6.7	9120	29 / 2.5	
		ZOF-23 (RAP)	39 330 (RAP)	220 / 25	30 590	150 / 15	NA	NA	
Soviet 203-mm howitzer B-4 (M-1931)	HE, CP	F-620	16 200	48 / 10	12 620	36 / 6	5410	19 / 2	dispersion data are from a 1943 range table
Czechoslovak 85-mm field guns M-52 & M-52/55	HE, AP-T	O	14 550	53 / 7.3	11 310	44 / 4.8	4850	11 / 1.4	
		O-365K	18 900	71 / 11	14 700	55 / 8.1	6300	28 / 2.1	
Czechoslovak 100-mm field gun M-53	Frag-HE	OF-412	7700	31 / 5.2	6000	22 / 3.5	2600	19 / 2.0	
Yugoslav 76-mm mountain gun M-48	HE	M-55 or OF-350	9900[6]	20 / 7.0	7700[6]	15 / 5.0	3300[6]	11 / 2.0	[5]performance based on US 105-mm M101
Yugoslav 105-mm howitzer M-56	HE, WP, illum	?	13 140[7]	48 / 4.0	10 220[7]	37 / 3.0	4380[7]	13 / 1.0	[7]performance based on US 155-mm M114A1
Yugoslav 155-mm howitzer M-65	HE, WP, illum	US M107 US M110 US M485	24 740[8]	62 / 12	19 240[8]	44 / 8.4	8250[8]	21 / 3.9	[8]performance based on Soviet 130-mm field gun, M-46
PRC 130-mm field gun type 59-1	HE, illum (?)	OF-482 (Soviet)							

*See remarks column for explanation of superscript figures.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

II-8 is denied in full



Table II-A-2e. Summary of Cannon Assembly and Recoil Mechanism Parameters (U)

Weapon	Breech mechanism			Cannon				Muzzle brake				Recoil system		
(nomenclature) (year) (country)	Type	Weight (kg)	Load (kg)	Construction	Length (cal)	Gun weight/ system weight (%)	Wear life (EFC rd)	Weight (kg)	Type	Efficiency (%)	Usual max overpressure at crew sta (kg/cm^2)	Type	Initial recuperator pressure (kg/cm^2)	Maximum pressure (kg/cm^2)
105-mm howitzer M102 (M137 E1) (1965) (US)	manual vertical wedge	149.8	288 225	auto-frettaged monobloc	30.0	28.3	5000	none	none	none	?	Puteaux variable length	93.5	527.3
122-mm howitzer M-30 (1938) (USSR)	manual interrupted screw	?	?	monobloc	22.7	33.7	7500	none	none	none	?	Schneider constant length	39.27	?
122-mm howitzer D-30 (1963) (USSR)	semi-automatic vertical wedge	302.8	503 493	monobloc	32.8	35.3	6800 (US est)	104.4	multi-baffle	49	0.43	Schneider constant length	47.43	105.4
122-mm gun D-74 (1955) (USSR)	semi-automatic vertical wedge	533.9	534 337	monobloc	46.5	40.3	1600 (est)	90.8	double-baffle	48	0.40	Schneider constant length	63.0	105.0
130-mm gun M-46 (1954) (USSR)	manual horizontal wedge	582.0	848 226	monobloc	52.7	35.0	800 (est)	80.5	multi-perfo-rated	35	0.32	modified Schneider variable length	57.87	342.0
130-mm field gun type 59-1 (1969) (PRC)	semi-automatic vertical wedge	717.3	?	monobloc	52.0	44.2	800 (est)	81.7	double-baffle	48 (est)	?	Schneider constant length	63.03	?
152-mm howitzer D-1 (1943) (USSR)	manual interrupted screw	?	?	monobloc	23.3	43.6	5000 (est)	?	double-baffle	40	?	Schneider constant length	53.73	?
152-mm gun-howitzer ML-20 (1937) (USSR)	manual interrupted screw	?	?	monobloc	25.0	31.6	2500 (est)	?	multi-baffle	35-40	?	Schneider variable length	45.0	?
155-mm howitzer M114A1 (1943) (US)	manual interrupted screw	379.1	583 017	monobloc	23.4	30.0	7500	none	none	none	?	Filloux variable length	105.45	457.0
155-mm howitzer XM198 (?) (US)	manual interrupted screw	309.0	1 095 437	auto-frettaged monobloc	39.0	35.4	2500	113.5	winged single-baffle	35	?	Puteaux variable length	79.09	562.4

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Table II-A-2f. Summary of Selected System Ratios, Projectile, and Propellant Data (U)

Weapon and year introduced	System wt/ momentum (t/s)	KE/ system wt (m)	HE projectile		Propellant for (full charge) HE round											Propellant geometry: perforation, shape, and dimensions (diameter and length) (in mm)
			weight (kg)	muzzle velocity (m/s)	charge selection available	type & chemical composition	model no. & configuration	weight (kg)	Additives: wear reducer (g)	Additives: decoppering agent (g)	Additives: flash reducer (g)	Flame temp (K)	gas volume (mol/g)	heat of explosion (cal/g)	chamber pressure (kg/cm^2)	
US 105-mm howitzer, M102 (M37E1), 1963	1.64	205	14.98	671	7	single base, MI (1)	M67, single & multi perforated	1.28	None	9.35 (2)	None	2417	0.04533	700	2741	SP[3] and MP[3] cylinders (both 3x20)
Soviet 122-mm M-30 howitzer, 1938	1.98	130	21.76	515	9	single base, NC (5)	Zh 463, single & multi-perforated	2.13	None	21.28 (6)	None	?	?	929	2458	MP[2] cylinders (5.5x13) and SP[3] cylinders (1.0x8)
Soviet 122-mm D-30 howitzer, 1963	2.86	167	21.76	690	6	single base, NC (full charge) (7)	Zh 9, single & multi-perforated	3.83	None	10 (6)	90	3102 (8)	0.0403	956 (8)	3234	MP[4] cylinder (n.5x13) and SP[3] cylinder (3x18)
Soviet 122-mm D-74 gun, 1955	2.24	148	27.5	885	4	double base, NDT-2 (9)	ZhN-472, single & multi-perforated	10.7	249 (10)	74 (6)	252	2700	?	?	4393	SP[3] tubular (6x324) and cylindrical (3x10.5)
Soviet 130-mm M-46 gun, 1954	2.43	191	33.55	930	5	double base, NDT-3 (11)	ZhN-482, single & multi-perforated	13.2	440 (10)	120 (6)	90	2700	?	930	3222 (8)	SP[3] tubular (5x393) and MP[4] cylindrical (5x123)
PRC 130-mm type 59-1 field gun, 1969	2.07	196	33.60	930 (12)	?	double base, composition unknown	model ?, single perforated	13.66	Yes quantity unknown (10)	120 (6)	?	?	?	?	?	SP[3] tubular (7.5x370)
Soviet 152-mm D-1 howitzer, 1943	1.26	144	40.00	508	9	single base, composition unknown	Zh 536, single & multi-perforated	3.48	?	?	250	?	?	?	?	No data available
Soviet 152-mm ML-20 gun-howitzer, 1937	2.71	121	43.56	655	13	double base, NG-3 (13)	ZhD 565, single perforated	8.29	?	Yes quantity unknown	250	?	?	?	2350	SP[3] tubular (4.75x175) and (6.75x287)
US 155-mm M114 howitzer	2.33	121	43.11	562	7	single base, MI (14)	M682, multi-perforated	6.02	None	None	28 (15)	2417	0.04533	700	2700	Cylindrical (3x20)
US 155-mm XM198 howitzer	1.80	229	43.11	827	8	triple base, M30A1 (16)	XM203, multi-perforated	11.85 (17)	539 (18)	255	714 (19)	3040	0.04308	974	3304	Cylindrical (8x20)

(1) Nitrocellulose and dinitrotoluene w/phthalate and diphenylamine additives.
(2) Lead foil.
(3) SP = single perforated.
(4) MP = multi-perforated.
(5) Nitrocellulose with diphenylamine additive.
(6) Lead wire.
(7) Nitrocellulose and diphenylamine with phthalate additive.
(8) Calculated.
(9) Nitrocellulose, trinitrotoluene, and diethyleneglycoldinitrate with centralite and phthalate additives.
(10) Paraffin sheets.
(11) Nitrocellulose, nitroglycerine, and trinitrotoluene with centralite and phthalate additives.
(12) Based on Soviet 130-mm M-46 gun.
(13) Nitrocellulose, nitroglycerine, and dinitrotoluene w/centralite and phthalate additives.
(14) Nitrocellulose and dinitrotoluene w/phthalate and diphenylamine additives.
(15) Potassium nitrate.
(16) Nitroguanidine, nitrocellulose, and nitroglycerine with centralite additive.
(17) Used with RAP only.
(18) Titanium dioxide (53%) and paraffin (47%).
(19) Potassium sulfate (80%) and black powder (20%).
(20) Actual weights based on exploitation rather than standard design weights.

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Table II-A-2g. Comparative Properties of Selected Cannon Tubes (U)

Weapon	Chemical composition (%)*									Micro-structure	Yield strength (0.1% offset) (kg/cm^2)	Tensile strength (kg/cm^2)	K_{1c} ($MPaxm^{1/2}$)	Elonga-tion	Impact values at -40°C (Nxm)	Reduc-tion in area (%)	Tempering temperature (°C)
	C	Mn	P	S	Si	Ni	Cr	Mo	V								
122-mm howitzer D-30 (1963) (USSR)	0.04	0.33	0.008	0.005	0.37	2.91	1.02	0.35	0.147	Bainite	8858-9069	10 060-10 292	175	17.9-21.1	59.9-63.7	58.0-60.5	?
122-mm gun D-74 (1955) (USSR)	0.33	0.46	0.32	0.026	0.24	2.87	1.47	---	0.14	Bainite (+ Pearlite)	8773-9280	9835-10 137	?	15.7-16.8	8.8-10.2	38.1-49.3	632
130-mm gun M-46 (1954) (USSR)	0.33	0.37	0.012	0.012	0.28	3.03	1.20	0.35	0.13	Bainite	10 070-10 239	10 973-11 096	143	14.0-16.0	24.1-26.4	38.5-47.0	?
Typical US gun steel (1957-1972)	0.36	0.45	0.010	0.010	0.35	3.20	0.90	0.65	0.10	Martensite	11 248-11 600	12 303-12 654	126	13.0-16.0	27.1-33.9	25.0-40.0	582
Typical US gun steel (1973-)	0.37	0.75	0.010	0.010	0.25	2.85	1.0	0.45	0.10	Martensite	11 248-12 654	12 795-14 060	126	13.0-16.0	27.1-40.7	25.0-50.0	560 577

*Remainder of material is Fe and traces.

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Table II-A-2h. Summary of Selected Rifling Data (U)

Weapon	Forcing cone diametral taper (in/in)	Number of grooves	Type of twist	Degree of twist (calibers/turn)	Tube diameter		Land width (mm)	Groove width (mm)	Wear factor [J/cm^3 (ft-lb/in^3)]	Band pressure (P_b/Y)	Equivalent band length (mm)	Final band length* (mm)	Interference ratio	Groove width ÷ groove depth	Groove radii** (mm)	Maximum band diameter*** (mm)
					Land to land (mm)	Groove to groove (mm)										
122-mm howitzer M-30 (1938) (USSR)	---	36	increasing right hand	36 to 20	121.92	126.06	3.04	7.60	8 143 (98 426)	2.42	11.30	33.60	0.0098	3.74		
122-mm howitzer D-30 (1963) (USSR)	0.090	36	increasing right hand	45 to 25	121.92	124.03	4.0	6.60	12 413 (150 047)	2.86	15.06	29.97	0.0098	6.60	0.863	124.39
122-mm gun D-74 (1955) (USSR)	0.100	28	uniform right hand	25	121.92	126.83	6.50	7.92	6 980 (84 370)	3.59	25.65	46.74	0.0170	3.28	1.324	133.30
130-mm gun M-46 (1954) (USSR)	0.101	40	uniform right hand	30	130.00	133.43	4.20	5.99	5 847 (70 670)	2.84	22.25	38.86	0.0180	2.21	1.981	139.62
130-mm field gun type 59-I (1969) (PRC)	---	40	uniform right hand	30	130.00	135.50	3.96	6.20	?	?	?	?	?	2.25	?	?
152-mm gun-howitzer ML-20 (1937) (USSR)	---	48	uniform right hand	25	152.40	155.40	3.00	6.98	?	?	?	?	?	4.65	?	?

(b) (1), (b) (3):10 USC 130c, 1.4 (a), 1.4 (c), 1.4 (e)

*Theoretical band length if all engraved material were stacked behind band at thickness of engraving.
**Curvature radii at juncture of land and base of groove.
***Maximum diameter of rotating band, including its obturator.

~~(CONFIDENTIAL)~~

B. SOVIET 76-MM MOUNTAIN GUN M1966(?)

3. ~~(C)~~ Description and Performance

The 76-mm mountain gun M1966(?) (fig II-B-1) was first sighted in April 1966 in a rehersal for the May Day Parade in Baku, USSR. This weapon possibly is intended to replace the 76-mm mountain gun M1938; it appears to offer improved performance characteristics as compared with the older weapon. The M1966(?) has split box section trails and a lunette is mounted on the trail ends. It has a relatively small, two-piece, flat-sloped shield with winged sides and a scalloped top. The shield has large wheel well cutouts and a direct fire sight aperture in the left shield section. The individual swing axles are probably associated with torsion-bar suspension and, because of the shield cutouts, appear to be rotatable to swing the wheels upward when the weapon is emplaced; this is similar to the operation of the 122-mm howitzer D-30. Unlike many Soviet weapons,

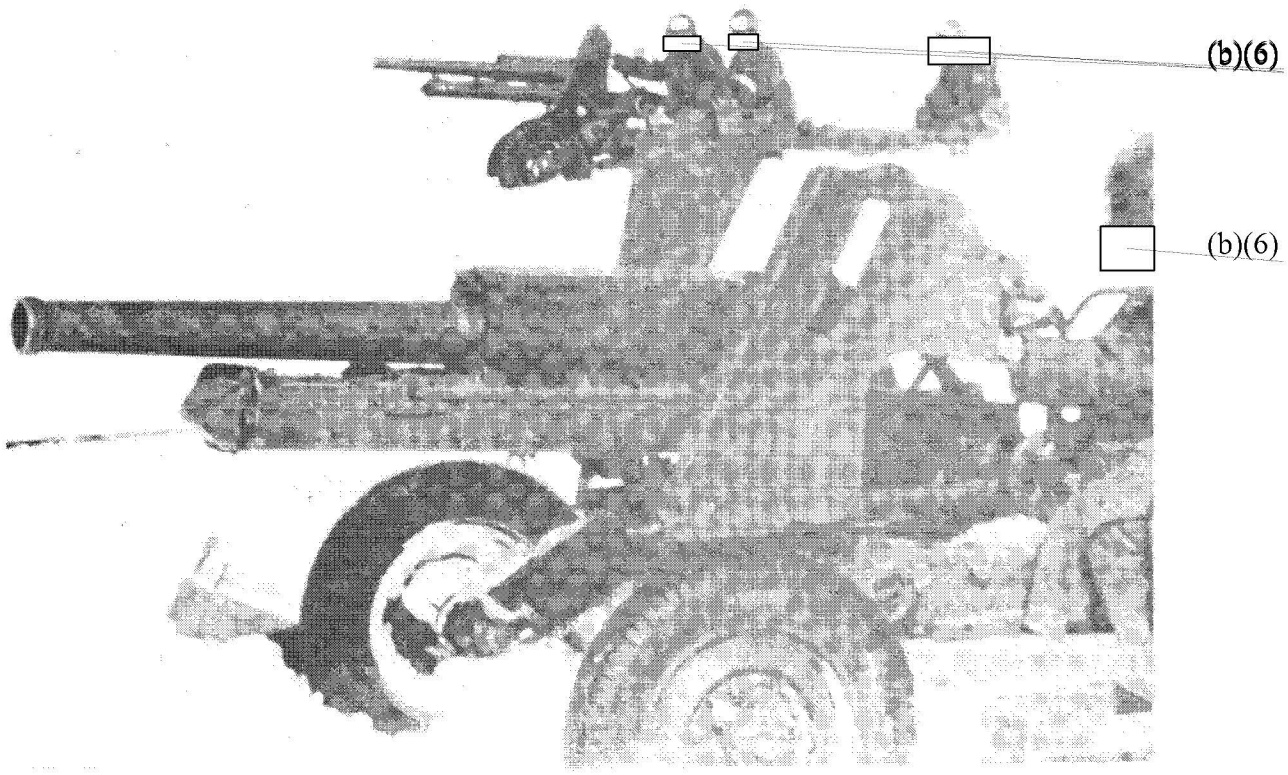

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Figure II-B-1. Soviet 76-mm mountain gun M1966(?) (U).

the M1966(?) does not have a central sliding section in the upper shield. Photography shows what appears to be a long, riveted, U-shaped, trough-type, cradle-like structure which may incorporate two rather long rails (fig II-B-2). A component of the tipping parts, this assembly may contain the entire recoil mechanism and probably includes, as a minimum, the recuperator and buffer. Another structure, which gives the appearance of either a sleeve-type cradle or a sleigh, encloses approximately the rear one-half of the tube, and is attached to the U-shaped cradle-like structure. Weight of the M1966(?) mountain gun in an unlimbered travel configuration is estimated to be somewhat less than the weight of the 76-mm M1938 mountain gun in a similar configuration, which is 785 kg. The 76-mm M1966(?) can be manhandled into firing position by its six-member guncrew. Estimated dimensions of the M1966(?) in travel configuration (minus limber, if any) are: Length, 4.85 meters; height, 1.45 meters; and width, 1.55 meters. Estimated length of the tube with breechring is 1.72 meters. Because of the specialized nature of this weapon, it can probably be broken down into component loads for transport by pack animals. Additionally, in the assembled mode, it has a lunette attached to the trail ends, and has been observed being towed by a GAZ-69 light truck. If provided with a limber, the weapon can probably also be moved by draft animals or, for short distances, by manpower. No performance information is available concerning the 76-mm mountain gun M1966(?). Nevertheless, being a relatively new--and thereby supposedly improved--weapon, it is estimated that maximum range of the M1966(?) is 10.5 to 11.5 km. A selection of charges and projectiles, including HEAT, are postulated to be available for this special-purpose weapon. It is probable that some projectiles used are those employed with the ZIS-3 gun.

4. ~~(C)~~ Component Analysis

The split box trails on the M1966(?) offer an improved on-carriage traverse capability over the single, open box trail of the M-1938. On-carriage traverse is estimated to have been increased from the 10° total on-carriage traverse available on the M-1938 to between 45° and 50° total on the M1966(?). Since the M1966(?) apparently is designed for use in mountainous terrain, it is assumed that a high angle capability has been incorporated and that elevation limits are approximately the -5° to +63° or +65° found in other Soviet weapons having a high angle capability. A sleeve-type sleigh encompasses the barrel. The sleigh is attached to the U-shaped cradle by legs that may be affixed to the cradle or may slide upon rails located thereon. The weapon's barrel configuration indicates that if it recoils through the sleigh, it may contain two small recoil brakes. The individual swing axles provide a high road clearance under the center carriage. The configuration of the small two-piece shield indicates that the wheels probably are swung into the wheel well cutouts to drop the base

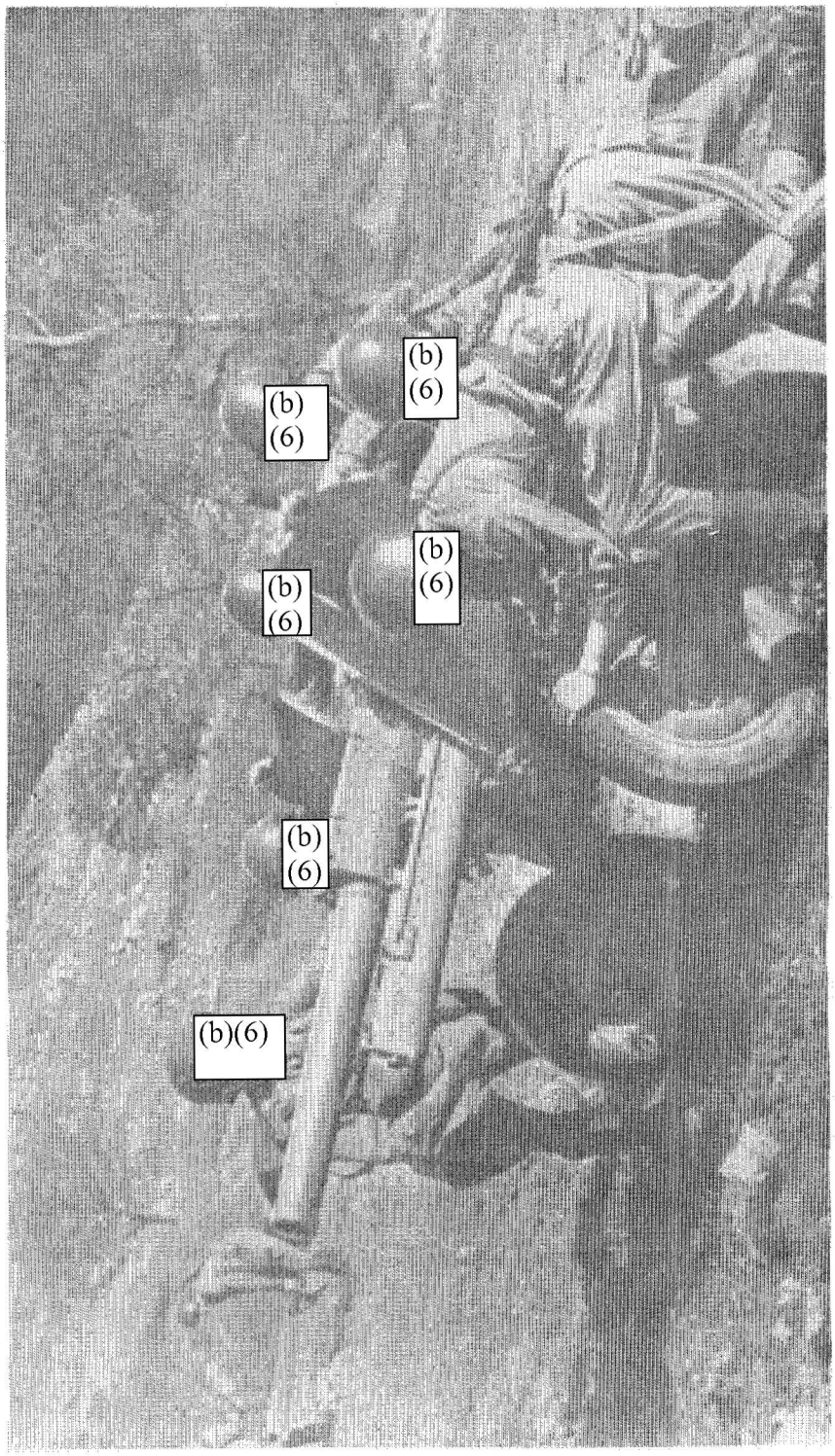

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Figure II-B-2. 76-mm M-1966(?) mountain gun (U).

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of the bottom carriage into ground contact for high angle fire; however, no firing pedestal or on-carriage jacking device is visible to assist in performing this action, which may depend upon the use of levers. The M-1966(?) probably can be fired from the wheels in low angle fire when necessary. Because of the angular positioning of the wheel struts-swing axle assemblies, and the probable incorporation of torsion-bar suspensions therein, it appears improbable that high angle fire would be conducted from the on-wheel posture. It is therefore postulated that a firing pedestal is utilized to raise the weapon until little, if any, weight remains upon the tires; the considerably greater distances between the top of the tire and the lower edge of the cutout section of the shield, as shown in figure II-B-1, as opposed to that distance shown in figure III-B-2, tends to substantiate this assumption. Since no muzzle brake is provided, the weapon probably does not develop a particularly high muzzle energy. Muzzle velocity therefore is postulated to be about 475 m/s.

C. SOVIET 85-MM AUXILIARY-PROPELLED FIELD (ANTITANK) GUN SD-44

5. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 85-mm Auxiliary Propelled Field (Antitank) Gun SD-44 (fig II-C-1) principally is a direct fire weapon. This weapon was adopted in 1953. First sighted in July 1961, it then was designated as the 85-mm Auxiliary Propelled Antitank Gun D-48. Currently standard for Soviet airborne troops, it also is deployed in the East German Army. This weapon is very effective against lightly armored vehicles, and poses more than a casual threat to medium tanks. Though the SD-44 primarily is used as a direct fire weapon, its maximum range in indirect fire (with trails dug in to attain 45° of elevation) reportedly is 18 970 meters. Maximum range, using full charge with maximum on-carriage elevation of 35°, is 15 650 meters. The SD-44 is essentially a modified version of the obsolescent 85-mm Field (Antitank) Gun D-44 (fig III-B-4a); however, the axle and suspension assemblies of the SD-44 have been considerably revised to accommodate the power train and related requirements. The tubular split trails also serve as fuel tanks having a combined capacity of approximately 58 liters (15 gallons). An M-72, two-cylinder, four-cycle, 14-horsepower motorcycle engine is mounted on the left trail. Ten rounds of ammunition are carried in two ready boxes on the right trail. A retractable third wheel, with associated steering wheel and controls, is attached to the left trail, and is positioned between the trails for use in the auxiliary powered mode. The wheel retracts when the weapon is to be towed by a prime mover. A double-baffle muzzle brake is provided. The moderately winged shield has a scalloped top. In the travel configuration, this weapon is approximately 2270 kg (5005 lb) in weight, and is 8340 mm (27.36 ft) long, 1730 mm (5.68 ft) wide, and 1420 mm (4.66 ft) high. The SD-44 normally is deployed in six-gun batteries.

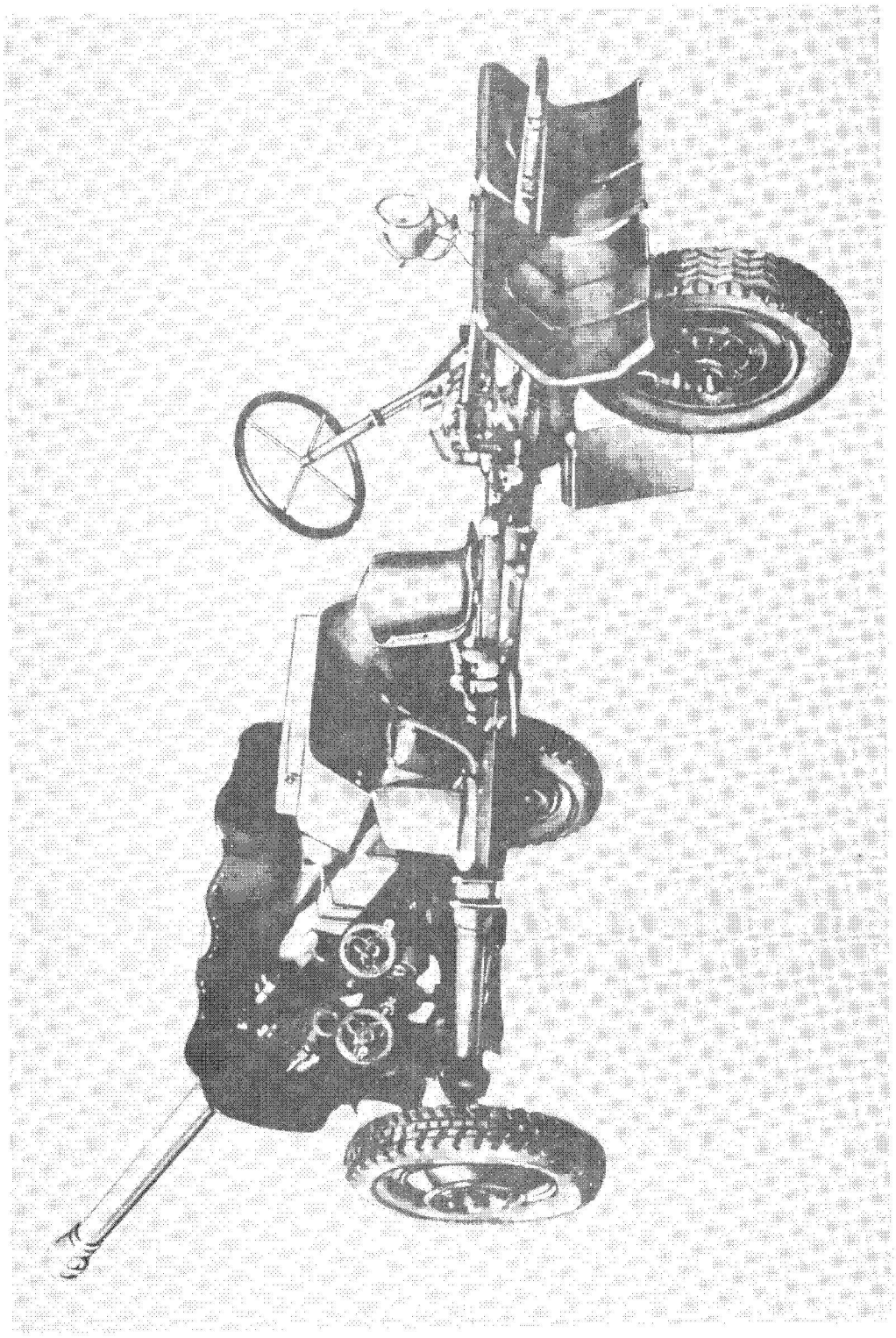

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Figure II-C-1. Soviet 85-mm auxiliary propelled field (antitank) gun SD-44 (U).

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b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The SD-44 has an elevation capability of -7° to +35° and a total on-carriage traverse capability of 54°. This weapon fires a 9.54 kg (21.0 lb) high explosive projectile to a maximum range of 15 650 meters using all of its on-carriage elevation capability. AP-T, HVAP-T, and HEAT-FS ammunition are available. Smoke projectiles also are provided. Ammunition, which is fixed, is issued in both full charge and reduced charge configurations. The prescribed rates of fire at 1, 3, 5, 15, 30, and 60 minutes for this weapon are 10, 25, 40, 60, 90, and 140 full-charge rounds, respectively. The rate for precisely aimed fire probably is about 8 rd/min. The unit of fire for this weapon is estimated to be 80 rounds per weapon. Under auxiliary power (fig II-C-2), the SD-44 can achieve 25 km/h on good roads, 12 km/h on country roads, and 5 to 10 km/h off-road; it can negotiate slopes of up to 27°. The weapon can be towed (fig II-C-3) by a wide variety of vehicles at maximum speeds up to 60 km/h on hard-surfaced roads or 35 km/h on country roads. Emplacement or displacement of this weapon can be accomplished in less than 1 minute by the normal five-man crew. Characteristics of projectiles commonly used with this weapon are shown in table II-C-1.

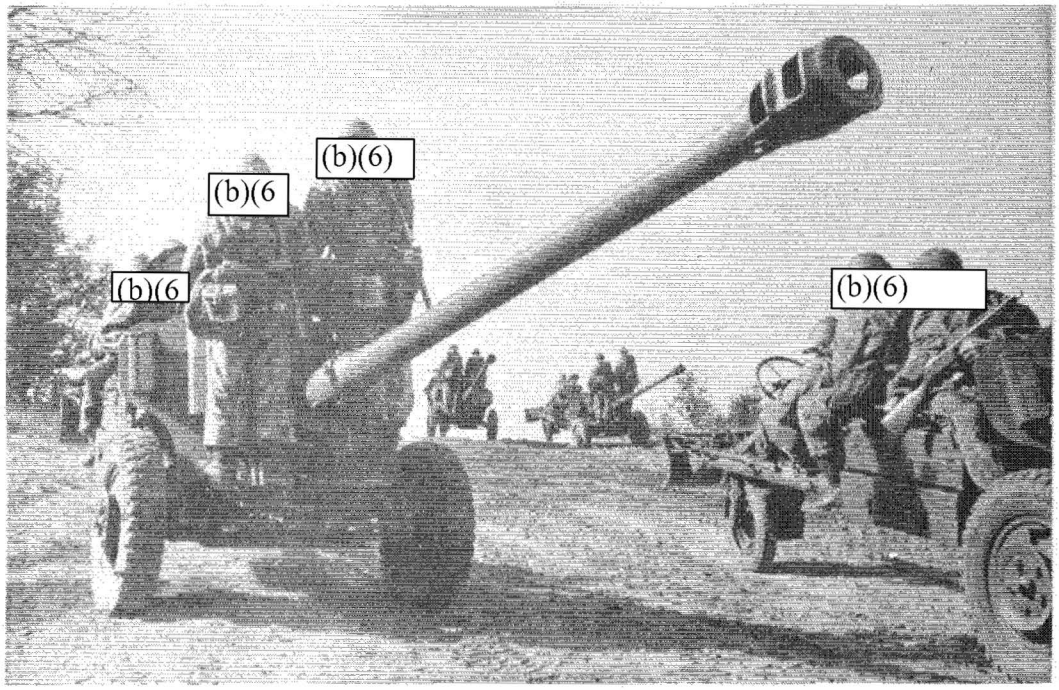

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Figure II-C-2. 85-mm SD-44 battery entering position area (U).

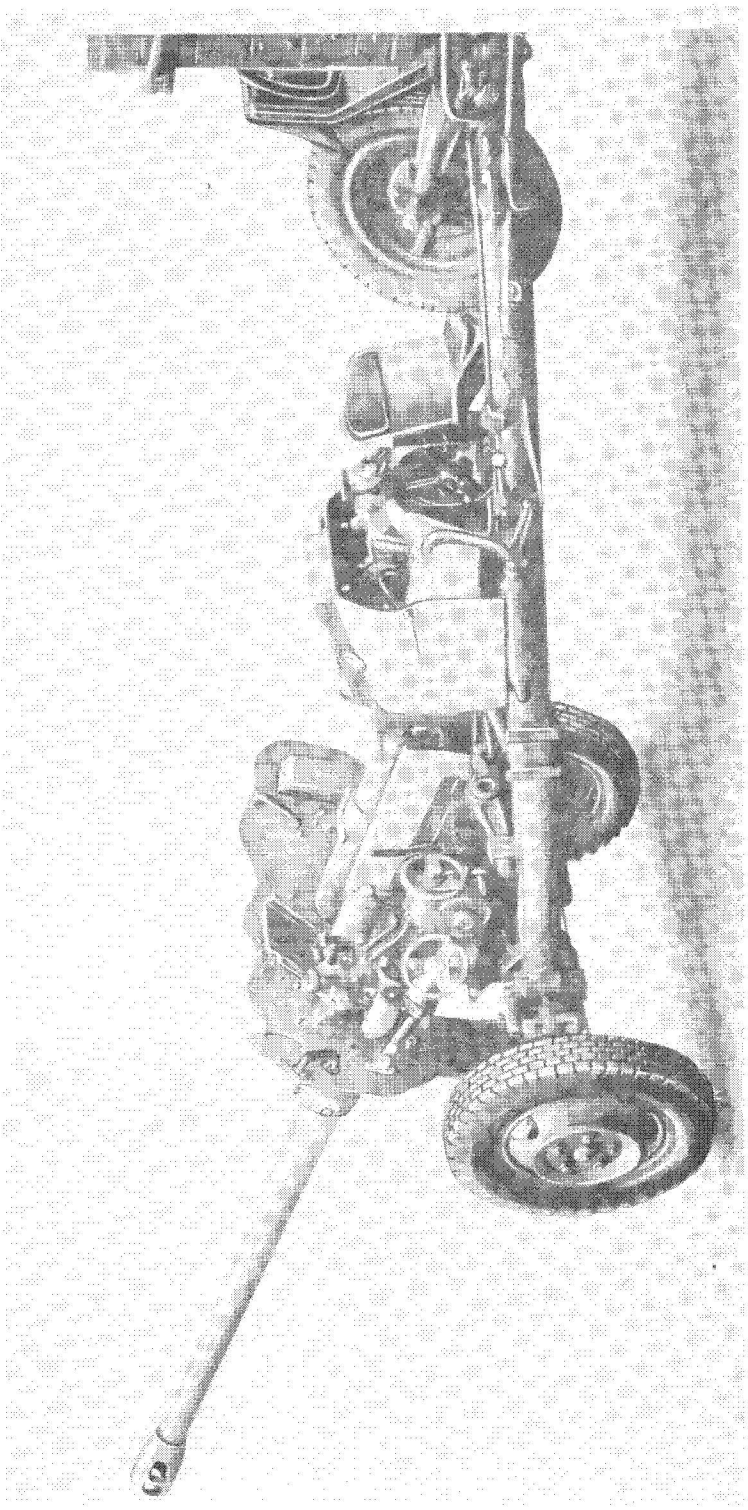

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Figure II-C-3. 85-mm SD-44 in towed configuration (U).

(UNCLASSIFIED)

Table II-C-1. Projectiles, 85-mm SD-44 Field Gun (U)

Type	Designation	In-flight weight (kg)	Muzzle velocity (m/s)	Armor penetration at 0° obliquity (mm)		
				1000	1500	2000
HE	O-365K	9.54	800	NA	---	---
HE	O-367A	9.54	800	NA	---	---
Smoke	D-367	10.07	655	NA	---	---
Chem	?	?	?	NA	---	---
APC-T	BR-365	9.20	800	100	92	83
AP-T	BR-365K	9.38	793 (est)	96	82	69
AP-T	BR-367	9.20	805	122	109	98
HVAP-T	BR-365P	4.99	1050	108	83	---
HVAP-T	BR-367P	3.35	1020	178	148	121
HEAT-FS	BK-2M	7.35	≈910	≈200*	at all ranges	

*Penetrated average 326 mm in US tests. ~~(CONFIDENTIAL)~~

(2) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data for indirect fire is provided in table II-C-2.

Table II-C-2. Probable Errors, 85-mm SD-44 Gun; Indirect Fire, Shell HE, O-365K (U)

Percent of maximum range (measurements in meters for various percentages)	PE_r (m)	PE_d (m)	PE_v (m)
90 (14 100 m)	52	7.6	49
70 (11 000 m)	40	4.5	20
50 (7800 m)	30	2.6	7.7
30 (4700 m)	22	1.5	2.0

~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Effectiveness. This weapon is not as effective in the indirect fire role as are howitzers and guns of heavier caliber; however, a 6-gun battery could deliver approximately 0.229 tonne of projectiles on an 8-PE_r deep target in the first 20 seconds of firing, or 0.572 tonne in the first minute.

(c) ~~(C)~~ Fragmentation. The O-365K HE projectile is fabricated of steel, whereas the O-367A is a combination cast iron and steel projectile. Both projectiles are used primarily against personnel and light materiel targets. The O-365K projectile has a charge-to-mass ratio of 0.088:1.0 and the O-367A has a ratio of 0.076:1.0. The O-365K bursts into an average of 3820 fragments having a mean mass of 2.333 grams and an average initial fragment velocity of 698 m/s (2288 ft/s).

(d)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(3) ~~(C)~~ Direct fire.

(a) ~~(C)~~ Precision. Probable errors in direct fire for the SD-44 auxiliary propelled field gun are shown in table II-C-3.

Table II-C-3. Probable Errors; 85-mm SD-44 Gun, Direct Fire (U)

Range (m)	PE_d (m)		PE_v (m)		PE_d (m)	PE_v (m)
	AP-T proj (BR-367)	HVAP-T proj (BR-367P)	AP-T proj (BR-367)	HVAP-T proj (BR-367P)	HE projectile, full charge (O-365K)	
500	0.1	0.1	0.1	0.1	0.1	0.1
1000	0.2	0.2	0.2	0.2	0.3	0.3
1500	0.35	0.3	0.35	0.3	0.4	0.4
2000	0.5	0.4	0.5	0.4	0.5	0.5
3000	0.7	---	0.8	---	0.9	0.9
4000	0.9	---	1.3	---	1.2	1.4

~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Grazing range. Soviet firing tables state that grazing ranges for the AP-T and HVAP-T projectiles versus targets of various size are as set forth in table II-C-4.

Table II-C-4. Grazing Ranges, 85-mm SD-44 Gun (U)

Target height (m)	AP-T (BR-367) (m)	HVAP-T (BR-367P) (m)
2.0	970	1120
2.5	1070	1240
3.0	1165	1330

~~(CONFIDENTIAL)~~

(c) ~~(C)~~ Effective range. Table II-C-5 presents hit probabilities against the standard NATO 2.3-meter x 2.3-meter target as calculated for the 85-mm SD-44 gun firing the BR-365P (1050 m/s) HVAP-T projectile. Calculated effective range (50% hit probability) is 914 meters.

Table II-C-5. Probabilities of First Round Hit; 85-mm SD-44 Gun Firing HVAP-T (BR-365P) Versus Standard NATO Target (U)

Range (m)	Hit probability (%)
500	0.88
913	0.50
1000	0.42
1500	0.14
2000	0.04

~~(CONFIDENTIAL)~~

(d) ~~(C)~~ Engagement range. Soviet firing tables state that the HVAP-T projectiles are used against tanks and self-propelled guns. The BR-365P is employed to 1000 meters and the BR-367P to 2000 meters although the Soviets admit that the tracer signature of the latter projectile is poor at ranges much greater than 1000 meters. It is probable that fire is opened at about 1500 meters.

(e) ~~(C)~~ Armor penetration. Table II-C-6 provides armor penetration data (b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Table II-C-6. Armor Penetration, 85-mm SD-44 Gun (U)

Range (m)	At 0° obliquity (mm)		At 30° obliquity (mm)	
	AP-T (BR-367) (805 m/s)	HVAP-T (BR-367P) (1020 m/s)	AP-T (BR-367) (805 m/s)	HVAP-T (BR-367P) (1020 m/s)
500	135	213	110	155
1000	122	178	99	130
1500	109	148	89	108
2000	98	121	80	88
3000	78	NA	64	NA

~~(CONFIDENTIAL)~~

c. ~~(C)~~ Configuration. The SD-44 is equipped with split tubular trails. A lunette is attached to the right trail for use when this weapon is towed by a prime mover. A retractable wheel with associated steering gear and controls is mounted on the left trail near the trail end. When lowered, this steerable wheel and related controls provide the means for auxiliary powered mobility. This gun is equipped with a hydropneumatic, independent, constant length recoil system. The cradle is a two-part cylindrical casting having internally mounted bronze bushing pads upon which the tube rides during recoil and counterrecoil. The breech is a semiautomatic, vertical sliding-wedge mechanism. On-carriage fire control equipment consists of a dependent-type quadrant mount with associated elevation and site scales and a range drum; a

panoramic telescope model PG-1 or PG-1M; and a direct fire telescope, model OP 1-7 or OP 2-7. Infrared sighting equipment is available for use with this weapon, and it is very possible those SD-44's issued to airborne divisions are equipped with passive night sights similar to those used on the 100-mm T-12 antitank gun.

d. (U) Summary. The SD-44 (fig II-C-4) primarily is a dual-purpose weapon employed by airborne troops. It can deliver direct fire against lightly armored combat vehicles at ranges of 2000 meters with HVAP-T projectiles and 3000 meters with AP-T projectiles; however, the effectiveness of this weapon in the dual role of indirect fire is diminished by the low charge-to-mass ratio and light weight of its high explosive projectiles. The weapon is fully mobile using auxiliary power, can be emplaced or displaced rapidly, and can achieve a relatively high rate of fire. Additionally, the SD-44 is easily air or helicopter transportable, and can be towed by a wide variety of prime movers when moving over distances not suitable to the use of the auxiliary power unit.

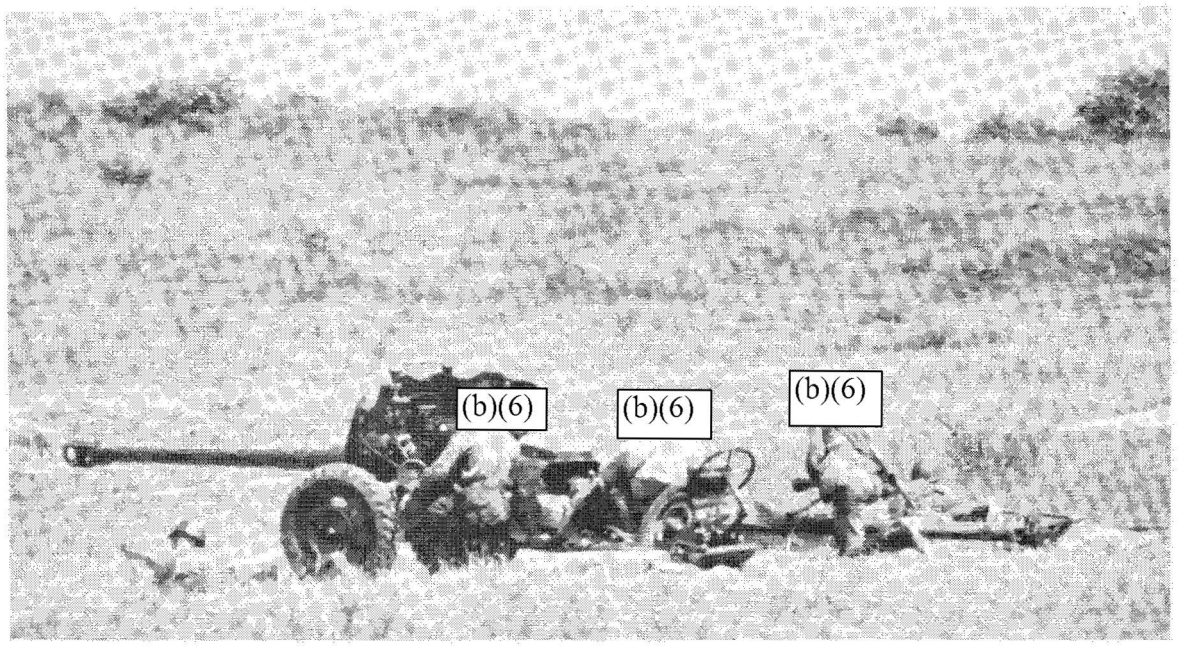

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Figure II-C-4. 85-mm SD-44 in direct fire position (U).

6. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) ~~(C)~~ Gun tube. The tube, estimated to be identical to the model used on the D-44, is of monobloc construction. If it is the same model tube used on the D-44, it is fabricated from material comparable to a high chromium modification of AISI-9830 steel. The 4685-mm long (48.8-caliber tube) barrel assembly weighs 718 kg. Approximately the rear third of the exterior of the tube is machined and, in conjunction with the bearing pads in the cradle, serves as the surface on which the tube rides in recoil and counterrecoil (fig II-C-5). An unthreaded shoulder provided on the breech end of the tube is the means through which the tube and the breechring are joined by use of an externally threaded collar. The muzzle end of the tube has external, left-hand threads on which the muzzle brake is mounted. Rifling is of uniform right-hand twist, having one turn in 26.9 calibers (7°9'45" inclination). There are 24 lands and grooves. Lands are 3.62 mm wide and grooves are 7.6 mm wide and 0.85 mm deep. Maximum gas pressure at the base of the projectile is 2550 kg/cm^2. Tube life of this weapon is estimated to be 1000 EFC rounds.

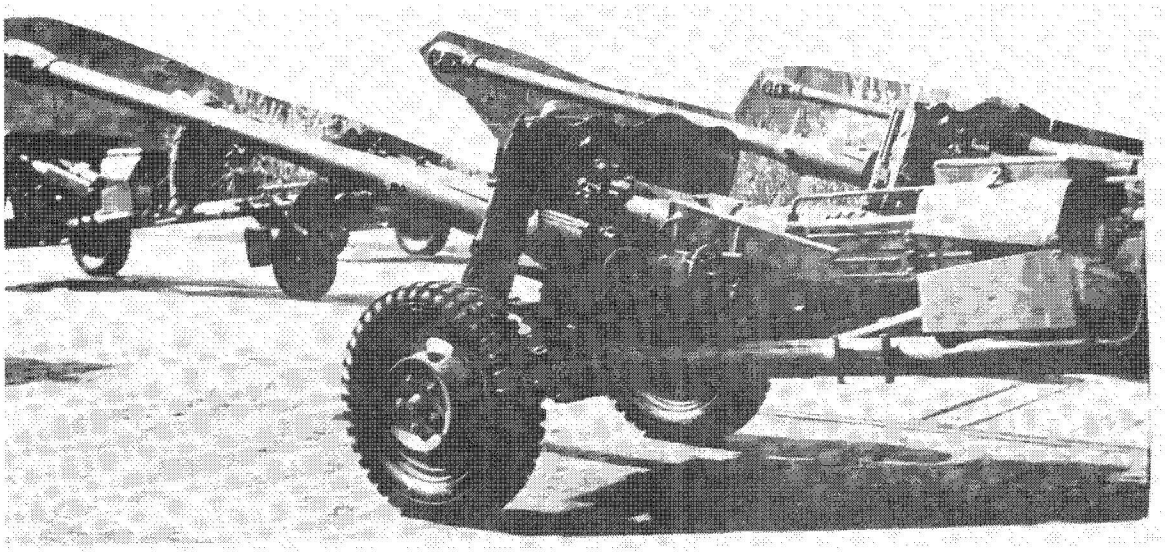

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Figure II-C-5. 85-mm SD-44 field gun (U).

(2) ~~(C)~~ Breechring. This component is a conventional fixture which houses the cam-operated, semiautomatic, vertical sliding-wedge breech mechanism. The breechring, a steel casting, has internal threads for mating the tube with a threaded sleeve. A yoke through which the two recoil system cylinders are attached is bolted and spotwelded to the breechring. The initial opening of the semiautomatic breechblock, like similar Soviet breech mechanisms, is accomplished manually. After the weapon is fired, the breechblock is opened, the spent cartridge case ejected, and the block latched open during counterrecoil.

(3) ~~(C)~~ Muzzle brake. The muzzle brake is a double-baffle fixture. It is threaded to the muzzle with left-hand threads and fixed with locking nuts. The brake, of cast construction, is composed of comparatively low-quality steel. The brake absorbs approximately 64% of the recoil energy.

b. ~~(C)~~ Top Carriage.

(1) (U) General. The top carriage, which supports the gun assembly, includes the cradle and trunnions, the elevating mechanism, the gear train portions of the traversing mechanism, the on-carriage fire control equipment, the upper shield, and the equilibrator assembly. The top carriage yoke, of cast construction, has a lower forward extension on the right side to which the equilibrator assembly and upper shield are mounted. The top carriage appears identical to that of the 85-mm Field (Antitank) Gun D-44.

(2) ~~(C)~~ Cradle. This component is a two-piece cylindrical casting with installed bronze bushing pads on which the gun tube slides during recoil and counterrecoil. Trunnions, which are integral to the cradle, mount in capped trunnion seats on the top carriage. Attachment points are provided on the cradle both for the recoil and recuperator piston rods and the equilibrator. A slide-type recoil index gage is provided in the top of the cradle.

(3) ~~(C)~~ Elevating mechanism. This mechanism is a handwheel-operated, worm gear-driven pinion that operates against an elevating rack mounted on the left rear of the cradle. The gearbox and pinion gear are both short shaft devices. Additionally, a plunger-type firing lever, mounted through the elevating handwheel shaft, functions mechanically against a firing lever on the forward side of the gearbox. Elevation limits are from -7° to +35°. Muzzle weight preponderance is counteracted by a push-type pneumatic equilibrator located on the right forward side of the top carriage.

(4) ~~(C)~~ Traversing mechanism. The traversing mechanism is a simple screw and sleeve-nut arrangement. One end of the screw shaft is attached to a pivot fitting on the bottom carriage. The screw shaft is held in a long nut, which is an extension of the traversing handwheel shaft, and is mounted to a bracket on the left side of the top carriage. A flexible canvas dust cover protects the traversing worm. The weapon has a total on-carriage traverse capability of 54°.

(5) ~~(C)~~ Recoil mechanism. This cannon has a Schneider-type hydropneumatic, independent, constant-length recoil system. The recoil system cylinders are located above the tube, with the recoil brake cylinder on the left and the recuperator cylinder on the right. No replenisher is provided. The replenisher and the counterrecoil buffering functions are accomplished through a valve and throttling groove arrangement in the recoil brake. The hydraulic recoil brake, filled with 4.75 liters of Steol-M fluid at atmospheric pressure, is a conventional tapered rod and piston device. The recuperator is charged with 3.75 liters of Steol M and is pressurized with dry air at 49.6 kg/cm^2 ±2.1 kg/cm^2 (48 ±2 atm). Maximum gas pressure in the recuperator during the recoil cycle is 103.8 kg/cm^2. Recoil and recuperator piston rods have a dull, smoke-colored, chromium finish. Weight of the recoiling parts of the recoil system is approximately 781 kg. Length of the recoil stroke is from 580 to 660 mm; maximum length of stroke is 675 mm.

(6) ~~(C)~~ On-carriage fire control. This mechanism is a dependent-type system consisting of the following equipment:

- An S71-7 quadrant mount has associated-primary and micrometer mil scales for elevation and site, plus a range drum. Integral telescope mounts are included.
- A model PG-1 or PG-1M panoramic telescope. This standard Soviet sight is used for indirect fire and as a backup means for direct fire.
- A model OP-1-7 or OP 2-7 direct fire telescope is used with this weapon. Three range scales, associated with HE, AP-T, and HVAP-T ammunition, are provided.
- Infrared night viewing equipment such as the APN-3 system is postulated as being available for use with this weapon. This equipment is composed of an IR light source, a viewer, and a power source composed of two 24-V batteries. Maximum range of the APN-3 system is estimated to be approximately 1200 meters. It is very possible that those SD-44's issued to airborne divisions are equipped with passive night sights such as are on the 100-mm T12A antitank gun.

(7) (U) Crew protection. Protection is provided by an armor plate shield. The shield is moderately winged, has a scalloped top and a flat center portion with a curved traveling center section mounted on the cradle aft of the main shield, and has right and left sections angled rearward. The front of the shield is equipped with steps on the lower right and left, on which two crew members stand when traveling in the auxiliary powered mode. Four rammer staff sections, two stowage boxes, and a towing cable are mounted on the front of the shield. Two hinged apertures are provided in the left upper shield to facilitate use of the panoramic and direct fire telescopes. A "D-ring-type" handhold fixture is provided on the bottom outside edges of the upper shield. A hinged skirt shield is provided on the bottom carriage.

(8) ~~(C)~~ Equilibration. This capability is provided by a pneumatic, push-type equilibrator located on the right forward side of the top carriage behind the shield. The equilibrator, charged with 0.6 liter of Steol and dry air to a pressure of 63.27 kg/cm^2 (61.19 atm), applies the force required to overcome the muzzle weight preponderance. Operating pressure usually varies in the range of 56.8 to 62.0 kg/cm^2. The lower equilibrator piston end is fitted with a ball fixture that engages a socket mounted on a forward extending bracket affixed to the bottom of the top carriage. The top of the equilibrator is attached to the cradle by a pivot fixture located on a lateral protrusion of the cradle casting. Equilibrators on guns of recent manufacture are pneumatic plus fluid and contain 0.6 liter of Steol under a pressure of 50 to 60 kg/cm^2 at maximum elevation.

c. ~~(C)~~ Bottom Carriage.

(1) (U) General. This component provides the base on which the top carriage is mounted through the use of a conventional pintle. The bottom carriage appears to have been modified in comparison with that of the 85-mm Field (Antitank) Gun D-44; this was done to incorporate the power train associated with the auxiliary propelled SD-44. The bottom carriage includes: The pintle pin housing and associated parts on which the top carriage is traversed; the axle assembly, including a differential; the suspension system, wheels, and split tubular trails with their mounted accessories, including ready ammunition cases; and the propulsion engine and driving controls. A retractable steerable wheel is positioned between the trails near the trail ends.

(2) ~~(C)~~ Axle housing. This housing is estimated to be of cast design. The drive shaft from the engine runs along the left trail and beneath the breech locking bar. What appears to be a differential is located in the center of the axle housing. A lever on this housing reportedly permits removal of all power to the wheels. In the towed 85-mm D-44 Field

(Antitank) Gun, a similar but somewhat different appearing appurtenance houses an axle equalizer. Ground clearance is approximately 350 mm.

(3) ~~(C)~~ Wheels. The wheels are steel disk type having additional narrow steel drums mounted on the outer sides for use with cables for self-extractions should the weapon become mired. Steel rim-locking rings secure foam rubber-filled nondirectional tires to the wheel disks. The wheels appear to be driven by separate, open, universal-jointed drive shafts originating at the centrally located differential; these drive shafts attach to fixtures at the wheels that are not coaxially aligned with the wheel spindles. The weapon does not appear to have hand brakes.

(4) (U) Trails. The trails, of welded cylindrical design, serve the additional purpose of fuel tanks having a combined capacity of approximately 58 liters (15.3 gallons). The weapon is of split trail design, having conventional hinge fittings. The auxiliary propulsion engine is mounted on the left trail, and a driver's seat is located between the engine and the trail ends (fig II-C-6). A steering wheel and associated clutch, brake, throttle, gearshift, and transfer case controls are appropriately located. The retractable third wheel, located between the trails near the trail ends, has an associated mud guard. Ready ammunition is carried in metal cases on the right trail. In the travel mode, the top of the case serves as a seat for two crew members. The trails are latched together for travel. A lunette is attached to the right trail for use when the third wheel is raised and the weapon is towed by a prime mover.

(5) (U) Mobility. When this weapon is being moved under its own (auxiliary) power, carrying its crew of five men, it can achieve approximately 25 km/h on country roads or 5 to 10 km/h off-road; it can negotiate slopes of up to 27°. It can be towed by a prime mover at maximum speeds of approximately 60 km/h on hard-surfaced roads or 35 km/h on country roads. The auxiliary propulsion engine is reported to overheat after about 1 hour of operation; however, the SD-44 can be towed by a wide variety of prime movers, and the operating limitations posed by potential overheating therefore should not be critical. The SD-44 is air and helicopter transportable and airdroppable.

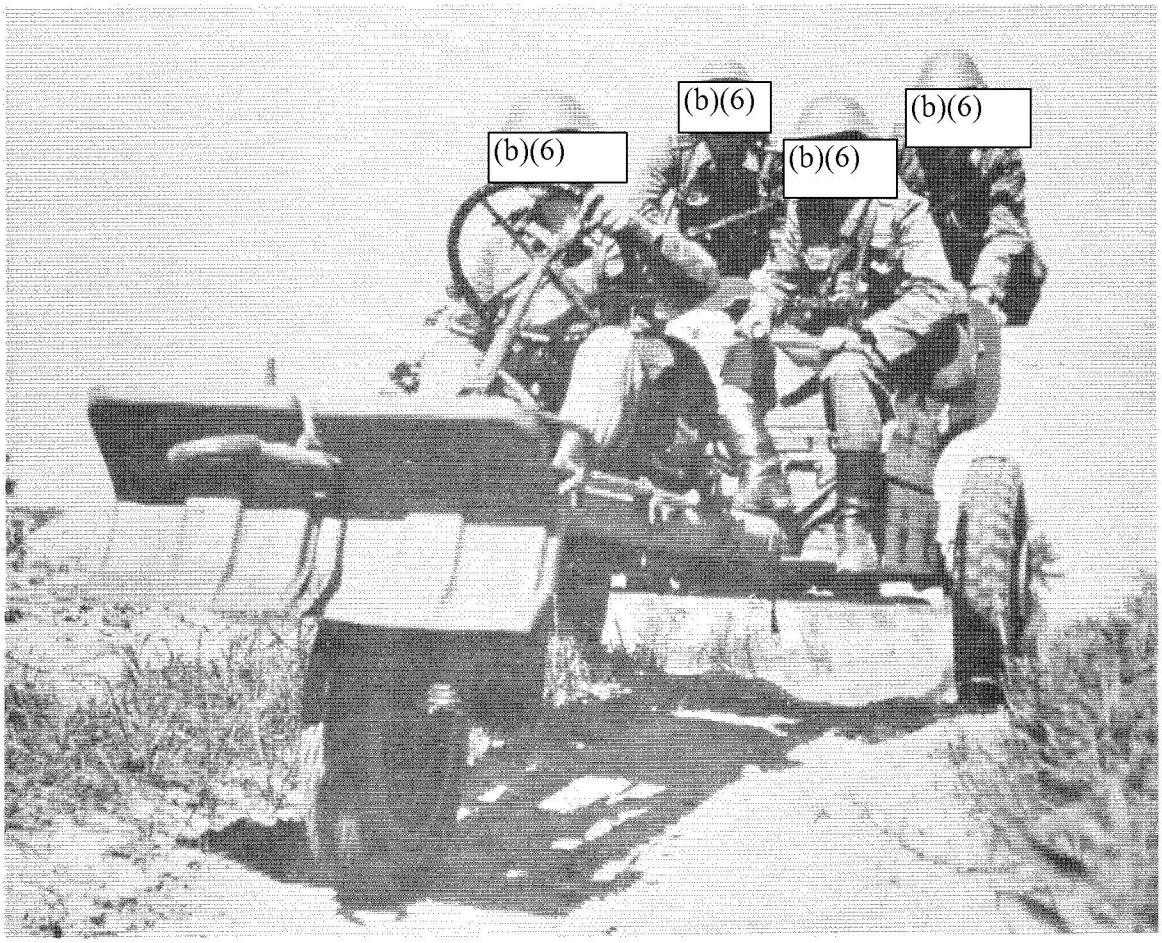

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Figure II-C-6. 85-mm SD-44 gun, on-march with crew (U).

D. SOVIET 100-MM FIELD (ANTITANK) GUN M-1955

7. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 100-mm Field Gun M-1955 (fig II-D-1) was first observed in a 1955 Moscow parade. Since 1955, it has been deployed in first-echelon Soviet divisional and nondivisional units, as a replacement for the Soviet 100-mm Field Gun BS-3 (M-1944). Subsequent to 1965, the M-1955 began to be replaced in the antitank battalions of Soviet motorized rifle divisions by the Soviet 100-mm Antitank Guns T-12 and T-12A. Since the M-1955 was produced in considerable quantities, however, and the T-12 has not been issued to all Soviet antitank battalions, the M-1955 is still

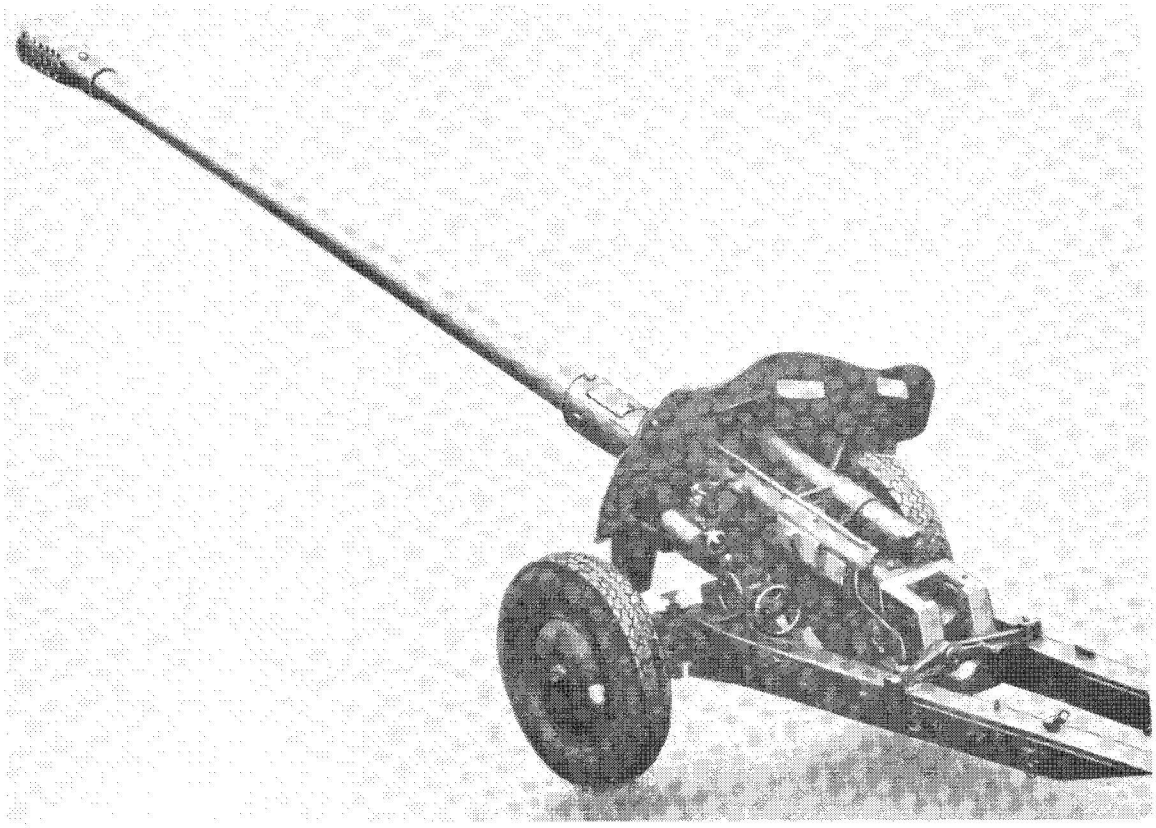

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Figure II-D-1. Soviet 100-mm field gun M-1955 (U).

very prevalent in the Soviet and other Warsaw Pact armies. The M-1955 (fig II-D-2) is characterized by its long tube; multiperforated muzzle brake; a recoil mechanism mounted above the gun tube, between the shield and the breechring; a single trail-mounted caster; single carriage wheels; box-section trails; and a shield that is scalloped along the top edge. In general appearance, the M-1955 closely resembles the Soviet 85-mm Field Gun D-44. The D-44, however, has tubular trails and a double-baffle muzzle brake. The Soviet 100-mm T-12 antitank gun also presents a close similarity to the M-1955 in overall appearance. The M-1955 is estimated to weigh 3.36 tonne (7400 lb). In travel position, the weapon's overall length, width, and height are estimated to be 9.08 meters (29.8 ft), 1.58 meters (5.2 ft), and 1.90 meters (6.2 ft), respectively. The M-1955 normally is deployed in 6-gun batteries.

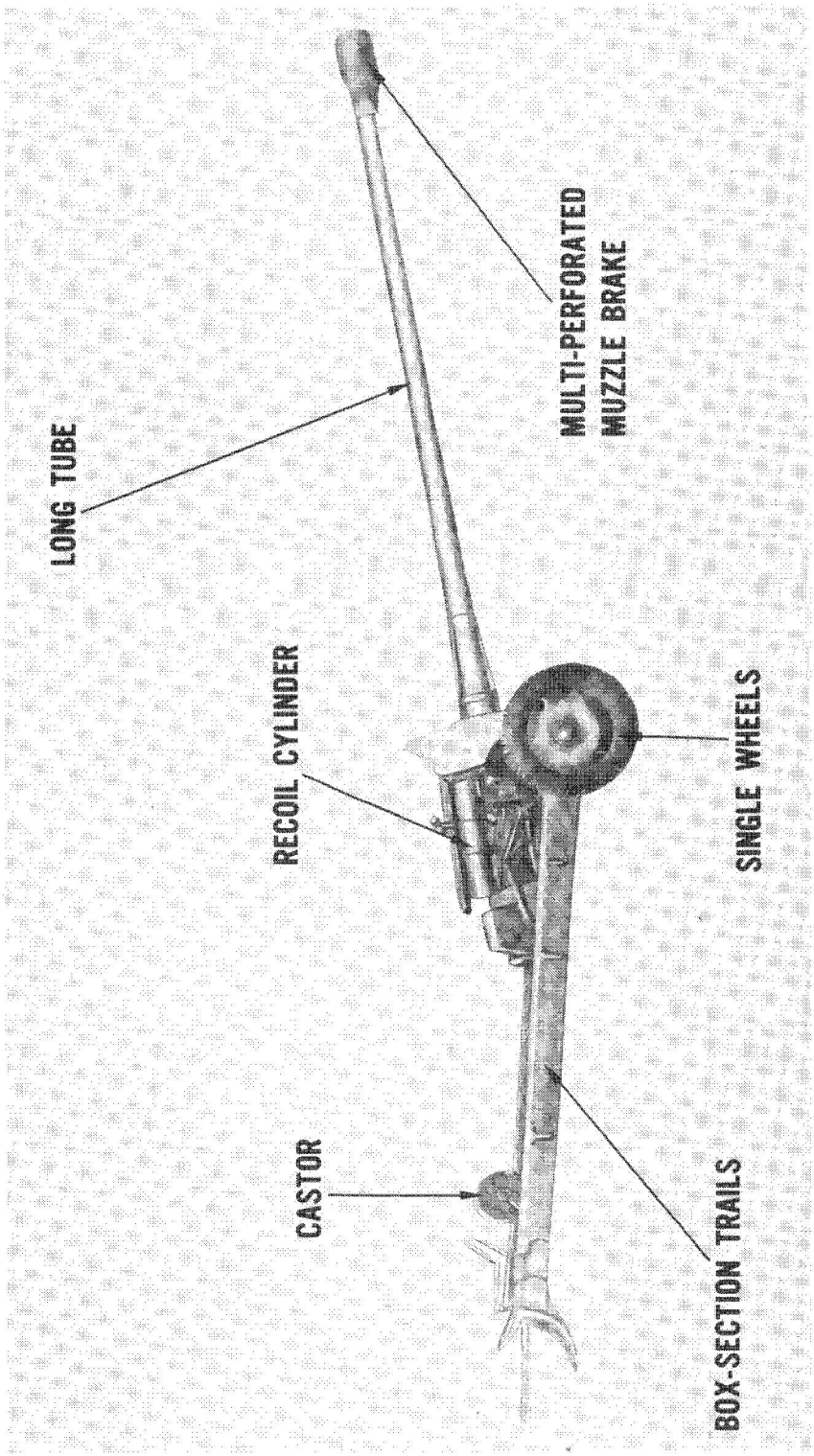

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Figure II-D-2. Recognition features; Soviet 100-mm field gun M-1955 (U).

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. Empirical data on the performance capabilities for the M-1955 are not available. Reliable estimates may be made, however, based on the postulation that the M-1955 is ballistically similar to the 100-mm gun in the Soviet T-55 tank, plus the fact that the M-1955 fires the same Soviet ammunition as the Czechoslovak 100-mm M-53 field gun, and may fire the Czechoslovak ammunition as well. The M-1955 fires a 15.6-kg (34.40-lb) HE projectile to an estimated maximum range of 21 000 meters at 45° of elevation; should elevation limits preclude the tube's attaining 45°, range would be reduced to about 16 200 meters. Prescribed rates of fire at 1, 3, 5, 15, 30, and 60 minutes probably are 7, 18, 30, 60, 75, and 95 full-charge rounds, respectively. The UOF for this weapon is estimated to be 60 rd. The M-1955 normally is towed by either the Soviet ZIL-157 truck or the AT-P tracked artillery tractor. The six-man crew is estimated to require 3 minutes to emplace, and perhaps 2 minutes to displace, this weapon. The M-1955 fires fixed ammunition. Characteristics of projectiles fired from this weapon are assumed to be the same as those of Soviet rounds employed with the Czechoslovak 100-mm M-53 field gun; see table II-S-1. Tube wear life is estimated to be 1500 AP-T rounds.

(2) (U) Indirect fire. Data pertaining to the performance of this weapon in indirect fire are believed to be the same as those presented in table II-S-2.

(3) (U) Direct fire. Precision errors for the M-1955 in direct fire are assumed to be the same as those shown in table II-S-3.

c. ~~(C)~~ Configuration. The gun tube is of monobloc construction, the rifling having an increasing right-hand twist. The vertical sliding-wedge breechblock is opened manually by means of the breech-operating lever; it opens automatically after a round is fired. Technical details of the top and bottom carriage are unknown; however, a study of available photographs and the basic similarity to other Soviet artillery weapons provide a basis for the following analysis. The top carriage consists of the cannon assembly, cradle, recoil mechanism, sights, protective shields, and the equilibrator. The top carriage is similar to the Soviet 85-mm D-44 field gun, except the M-1955 components are somewhat larger. The entire recoil mechanism is positioned above the gun tube between the shield and the breechring, supporting the hypothesis that the gun is similar to that used in the Soviet T-55 tank. The gun is equipped with a moderately rearward-slanted protective shield to protect the crew from fragments, small arms fire, and muzzle blast (fig II-D-2). The center portion of the shield, perpendicular to the gun axis, is sectioned to allow movement of the tube in the vertical plane. An auxiliary curved

shield is attached to the cradle to cover the gaps in the sectioned portion of the primary shield. Manually operated elevating and traversing handwheels are located on the left side of the top carriage. The equilibrator compensates for muzzle preponderance, thereby facilitating the elevation and depression of the tube. Though specific details are not known, it is assumed the Soviet preference for hydropneumatic, pusher-type equilibrators is continued in the M-1955.

8. ~~(C)~~ Summary

The Soviet 100-mm M-1955 field gun is a high performance cannon whose primary mission is the destruction of enemy tanks. This weapon has an indirect fire capability. Although being replaced with the 100-mm T-12A, the M-1955 still is widely used by Warsaw Pact forces. It represents a formidable threat to opposing armor units. Positive information is not available regarding the full complement of projectiles the M-1955 is capable of firing. Assuming that the weapon is capable of firing ammunition designed for the Soviet 100-mm M-1944, and knowing that Soviet 100-mm gun ammunition is used in the Czechoslovak 100-mm M-53 and in the Soviet T-55 tank, the M-1955 should demonstrate considerable flexibility on the battlefield. Among the countries using the M-1955 are: Bulgaria, Poland, East Germany, and Romania.

E. SOVIET 100-MM ANTITANK GUNS T-12 (2A 19) AND T-12A (2A 19-1)

9. ~~(C)~~ Description and Performance

a. General. The 100-mm Antitank Gun T-12 (2A 19) (fig II-E-1) was first sighted in 1965. The T-12 and the more recently introduced modified version of that weapon, the T-12A (2A 19-1) (fig II-E-2), are the latest known antitank cannon to be introduced into the Soviet inventory. They are carried in the TOE of the three 6-gun firing batteries assigned to the antitank battalion of the Soviet motorized rifle division. The weapon we are calling the T-12 is designated the "T-12" in the East German and Yugoslav armies. The designation "T-12A" for the modified version is a Quadripartite designation, the "A" having been added to distinguish between the T-12 and its improved variant. Recent observation of the lubrication and sight alignment plate (located in the space on the weapon normally reserved for weapon model numbers; e.g., D-20, D-30, M-46, etc.) on a T-12A reads "2A 19-1." It is, therefore, probable that the Soviet model designations of these guns, or possibly of their cannon assemblies only, are 2A 19 and 2A 19-1, respectively. The T-12 and the T-12A are similar in appearance to the 100-mm M-1955 field (antitank) gun, which they are replacing. Both the T-12 and T-12A are smoothbore, rather than rifled, guns. The T-12 (and T-12A) tube is the second known

II-35 and II-36 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

smoothbore high performance gun to be adopted by the Soviets, the first being the gun mounted on the T-62 tank. The T-62 and T-12A also have larger breechrings, and somewhat different muzzle brake and shield configurations, than does the M-1955. Additionally, the T-12A has a distinctive cylinder to the right of, and above, the recoil cylinders. Although their on-carriage fire control equipment permits their use in indirect fire, the T-12 and T-12A appear to have only a limited capability in that mode. The T-12 and the T-12A primarily are intended for use in direct fire, principally in the antitank role. The main recognition features of the T-12 (and T-12A) are their distinctively long tubes mounting multiperforated (pepperpot) muzzle brakes (fig II-E-3), the sleeve-type cradle extending forward of the shield (fig II-E-4), two visible recoil cylinders mounted above the tube between the shield and breechring (except that the T-12A has an additional large cylinder positioned to the right, above, and extending forward of, the breechring), a large breechring that is latched to the trails for travel, and a single caster wheel positioned above and between the trails near the trail ends when the weapon is march ordered. The shield, of winged design, has hinged sight apertures for use with the on-carriage fire control equipment. Estimated dimensions and weights of the T-12 and T-12A are shown in table II-E-1.

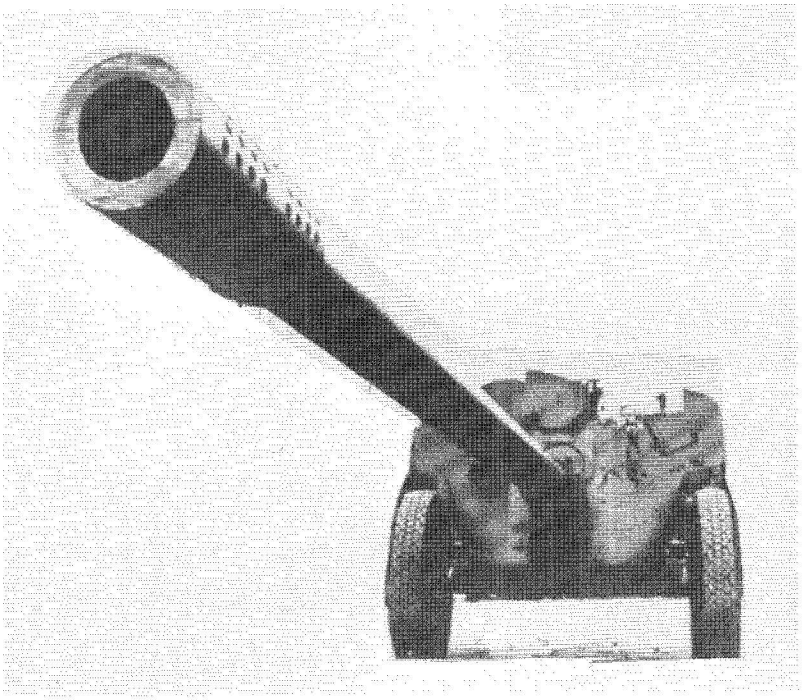

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Figure II-E-3. 100-mm T-12 antitank gun, front view (U).

II-38 is denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Table II-E-1. Estimated General Dimensions and Weights, T-12 and T-12A 100-mm Antitank Guns (U)

Item	T-12	T-12A
Overall length (on march)	8.90 m (29.2 ft)	9.19 m (30.2 ft)
Overall barrel length, rear of breechring to front of muzzle brake	6.64 m* (21.8 ft)	6.93 m (22.7 ft)
Width of breechring	295 mm	375 mm
Width to outside of tires	1.81 m (5.94 ft)	2.26 m (7.41 ft)
Track width	1.58 m	2.00 m
Tire diameter	935 mm (7.50x20)	1025 mm (9.00x20)
Total weight	2800 kg (6170 lb)	3300 kg (7280 lb)

*Some T-12's mount the T-12A's gun tube.

~~(CONFIDENTIAL)~~

Compared with the T-12, the T-12A has a cannon assembly about 0.3 meter longer; a wider breechring; a larger shield; larger tires; a longer axle, which results in wider spaced wheels and a wider weapon stance (fig II-E-5); a different suspension system; and an added cylinder approximately 940 mm long and 150 mm in diameter (fig II-E-6); it also is heavier than the T-12. These extensive modifications provide improved stability for the T-12A; ballistic performance may or may not be enhanced by the longer tube on the T-12A. The Soviet Union has provided the T-12 to Czechoslovakia, East Germany, Poland, Yugoslavia, and North Vietnam; East Germany also has the T-12A, and it is probable that some other non-Soviet Warsaw Pact armies also possess this newer weapon.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-E-5. 100-mm T-12A, right front view of top and bottom carriage (U).

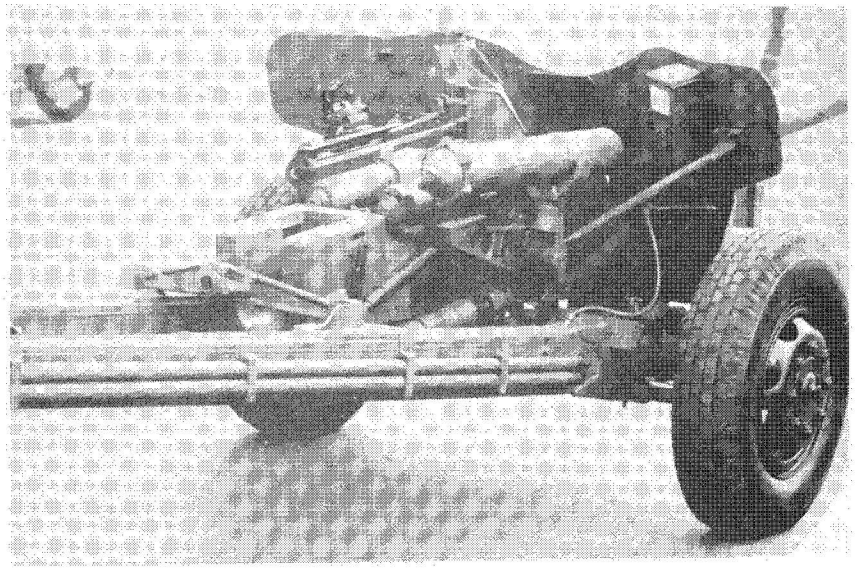

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Figure II-E-6. 100-mm T-12A, right rear view (U).

b. Capabilities.

(1) General. The T-12 (T-12A) fires fixed ammunition. Two types of rounds are available for direct fire application, one having an estimated 9.5-kg HEAT-FS projectile and the other an estimated 3.82-kg in-flight weight HVAP-DS-FS projectile. Since HEAT ammunition would be less effective than HE in the indirect fire role that may be assigned as a secondary mission for these weapons, and the HVAP almost totally ineffective, an HE round also may be available. Training in indirect fire procedure reportedly is limited. Maximum range of this weapon in the indirect fire role is estimated to be 18 000 meters at 20° elevation or 19 500 meters if the trails are dug in to enable the attainment of 30° of elevation and a recoil pit is provided. In the latter configuration, however, fulfillment of the primary (direct fire) role will be severely degraded. Theoretical maximum rate of fire for the T-12 reportedly is 14 rd/min. The estimated prescribed rates at 1, 3, 5, 15, and 30 min are 10, 20, 30, 50, and 70 rounds, respectively. A maximum rate of only 6 rd/min of precisely aimed fire probably is achieved by well-trained crews since the T-12 exhibits excessive muzzle whip. It also is probable the equilibrator-like cylinder on the T-12A attenuates this excessive muzzle whip; this attenuation may permit a rate of 10 rd/min of aimed fire with the T-12A. The UOF for these weapons is believed to be 60 rd. The tube of the T-12 is reported to heat up quickly and becomes too hot to continue firing without a period for cooling after 30 rd are fired at the permissible sustained rate. The T-12 is also reported to have had recoil system failures during sustained periods of fire. This condition probably has been corrected in the T-12A. In the Soviet Army, the normal prime mover for the T-12 (T-12A) has been the armored tracked artillery tractor AT-P. More recently, the weapon has been observed being towed by the newer M-1970 APC. The AT-P achieves a maximum speed of approximately 50 km/h (31 mi/h) on hard-surfaced roads and 25 km/h (16 mi/h) off improved roads. The M-1970 should equal or exceed the performance of the AT-P since, otherwise, there is no apparent reason for deploying the M-1970 as the prime mover for the T-12 gun. Other countries are observed to have been using the URAL-375D or equivalent indigenous vehicles as prime movers. Wheeled prime movers used with this weapon (such as the URAL-375D, the ZIS/ZIL-151, or equivalent indigenous vehicles) provide increased mobility on improved roads but a decreased capability elsewhere. The T-12 (T-12A) can be emplaced/displaced by a six-man crew, plus driver, in approximately 3 minutes. The crew can manually move this weapon over comparatively short distances; the caster wheel, which is mounted near the trail ends, facilitates such movement. Large deflection changes, those beyond on-carriage traverse limits, can be accomplished quickly by the crew shifting the trails. Elevation limits are approximately -10° to +20°. Total on-carriage traverse is approximately 54°. Estimated characteristics of projectiles associated with the T-12 (T-12A) are provided in table II-E-2.

Table II-E-2. Projectiles, 100-mm Antitank Gun, T-12 (T-12A) (U)

Type	Designation	Estimated in-flight weight (kg)	Estimated muzzle velocity (m/s)	Armor penetration at 0° obliquity (est) (mm)
HEAT-FS	?	9.5	900	400 at all ranges
HVAP-DS-FS	?	3.8	1500-1550	225 at 1000 m
HE ?	?	?	?	------

(CONFIDENTIAL)

(2) Indirect fire. Delivery of indirect fire definitely is but a secondary mission for units armed with the T-12 (T-12A). In view of the considerable quantity and variety of field artillery weapons available to Soviet field commanders, plus the estimated marginal performance of the T-12 (T-12A) in the indirect fire role, except in extraordinary circumstances, it appears unlikely that this weapon will be used routinely in other than a direct fire application.

(3) Direct fire.

(a) Precision. The precision (round-to-round dispersion) of these weapons is unknown.

(b) Grazing range. Some indication of grazing range when using the HVAP-DS-FS projectile may be gained from table II-E-3. Grazing range when firing upon a US M60A1 tank should approximate 2250 meters; against the standard NATO target, grazing range should be about 1920 meters.

(c) Effective range. Table II-E-3 presents calculated effective range, presented in terms of 50% probability of a first round hit, for the T-12 and T-12A antitank guns versus the standard NATO target and the US M60A1 tank. Also shown for comparison are the 85-mm SD-44 and the 100-mm M-1955 field (antitank) guns, the 122-mm D-74 and 130-mm M-46 field guns, and the 122-mm D-30 howitzer. Note the enhanced performance of the T-12 over that of the 100-mm M-1955 gun. Further comparisons of probability of first round hit for the T-12 versus the standard NATO target and the US M60A1 tank are presented in appendix III.

Table II-E-3. Calculated Ranges for 50% Probability of a First Round Hit of Various Soviet Cannon (U)

Cannon	Round	Range at which 50% probability is attained (m)	
		M60A1 tank	Standard NATO target
SD-44 (85-mm gun)	AP-T	1125	900
T-12/T-12A (100-mm gun)	APDS	2000	1625
M-1955 (100-mm gun)	AP-T	1450	1250
D-74 (122-mm gun)	AP-T	1325	1150
D-30 (122-mm how)	HEAT	950	775
M-46 (130-mm gun)	AP-T	1450	1250

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(d) Engagement range. It is estimated that the gun commander of a T-12A will open fire upon a US M60A1 tank at ranges up to about 2500 meters. The reticle in the direct fire telescope allegedly provides range indices up to 3000 meters for the HEAT-FS projectile. Target lead indices, each interval equating to 20 km/h, are said to extend right and left of the reticle's vertical axis to provide a total lead in either direction to accommodate a target speed of 80 km/h. Although it is unlikely that fire would be opened at 3000-meter ranges against a moving tank, it is probable that closely grouped armored vehicles or strongpoints and weapons being fired from lightly constructed buildings may, on occasion, be engaged at this range.

(e) Armor penetration. Estimated penetration data are shown in table II-E-2.

c. Configuration. The carriage of the T-12 is of split trail design. The trails are of welded box-section construction with conventional trail spades and hinge components. A lunette is attached to the right trail and the trails are latched together for travel. A single caster wheel, which is attached to the left trail on a pivot fitting, is latched in a position above and between the trails for travel. This caster wheel may be lowered between and near the ends of the closed trails to facilitate the crew moving the weapon manually over short distances. Each trail end has a hinge-mounted handspike that folds along the trails for travel. This handspike latches in an upward posture when the weapon is in firing position as an aid in effecting gross movements in traverse. A heavy cast bar, positioned between the trails at the rear face of the breechring, contains a latching bolt, by means of which the breechring and the trails are locked together for travel. The tube is positioned at near the maximum on-carriage elevation limit when the weapon is in the travel configuration. The recoil mechanism is an independent-type hydropneumatic system. The recoil brake and recuperator cylinders are attached to the tube, rather than to the breechring, by means of a yoke (fig II-E-7) which encompasses both of these cylinders. This method of attachment is a deviation from usual practice. Further, the location of the yoke being at a point about one-third of the way forward from the rear ends of the cylinders, the alignment of the piston rods with the longitudinal axis of the base may not be as precise as could otherwise be obtained. Maximum permissible length of recoil is approximately 760 mm. The cylinders travel in recoil and the recoil mechanism's piston rod ends are attached, at the forward ends of the cylinders, to the cradle sleeve at a point behind the shield. The forward portion of the cradle is cylindrical. A rearward extension is provided below the breechring, and two puller-type equilibrators are attached thereto. The T-12A has been modified by the addition of a cylinder to the right of, and slightly above, the cylinders of the recoil mechanism. This third cylinder is attached by means of a gimbal fitting to a fixed bracket on the upper carriage. The piston rod from this cylinder is attached with a slot-and-pin fitting to a bracket fixed to the cradle forward of the trunnions. The purpose of this third cylinder on the T-12A is estimated to be for the attenuation, by damping, of some of the excessive muzzle whip that has been observed in firings of the T-12; it also may serve to augment the equilibration force available on the T-12. The wider, and therefore heavier, breechring on the T-12A also serves to reduce muzzle preponderance. On-carriage fire control equipment includes an S-71-40 mount with a range drum having associated scales for available ammunition and mil scales for angles of elevation and site; a PG-1M

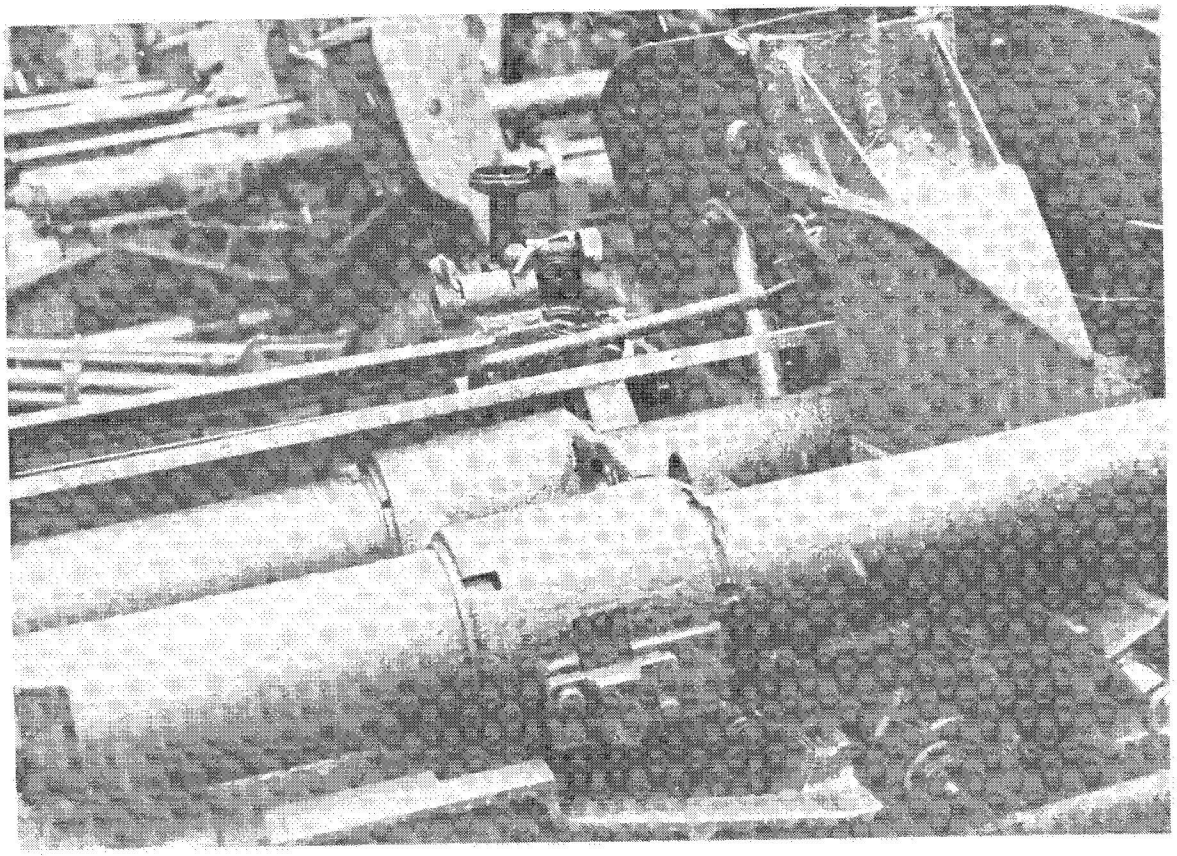

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Figure II-E-7. T-12 yoke encompassing and attaching cylinders of the recoil mechanism to the tube (U).

panoramic telescope; an OP-4M-40 direct fire telescope; and a night observation device, APN-5-40, which may be a modification of the Soviet NNP-20M tripod-mounted equipment that has a 500- to 1500-meters range on a clear moonless night.

d. Summary. The T-12 (2A 19) (fig II-E-1) and the T-12A (2A 19-1) modified version (fig II-E-2) primarily are direct fire weapons. These relatively mobile, high energy-high velocity, smoothbore antitank, weapons exhibit a high probability of a first-round hit from their fin-stabilized armor defeating ammunition. The T-12A should provide substantially improved firing stability compared with that of the T-12. The design and construction of the T-12 (T-12A) is consistent with other Soviet weapons except for the mounting of the recoil mechanism and the

fact that the tube is a smoothbore. The T-12 (T-12A) is assessed as being highly effective in the direct fire role. The weapon, although capable of indirect fire, is limited to approximately -10° to +20° of on-carriage elevation. Digging in the trails to increase the maximum elevation capability in indirect fire will decrease the on-carriage depression capability (-10°) and increase the time and effort required to shift trails; such practice will seriously degrade the capability of the T-12 and T-12A in performing their primary direct fire role. Grazing range for the T-12 (T-12A) using the HVAP-DS-FS round versus a 2-meter high target is estimated to be 1840 meters, and against a 3-meter high target grazing range is estimated to be 2230 meters. First-round hit probability at these ranges is considered to be 35% or higher. The direct fire telescope is graduated to 3000 meters for the HEAT-FS round and to 6000 meters for the HVAP-DS-FS round. The T-12 (T-12A) tube reportedly must be cooled after no more than 30 rounds of sustained fire. Reported types of ammunition available are limited to those effective in direct fire applications. The tube wear life of this weapon should approximate 1000 APDS or 7000 HEAT rounds by US criteria. Unless HE ammunition is available, these weapons are unlikely to be utilized in an indirect fire mode except under unusual conditions.

10. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon Assembly. The tubes of the T-12 and T-12A are smoothbores of monobloc construction. The tube of the T-12 is about 58 calibers in length and that of the T-12A is about 61 calibers in length. Overall length, including the breechring and muzzle brake, is about 6.6 meters and 6.9 meters respectively. The tube, adapted to the carriage with a sleeve-type cradle, is attached to the recoil mechanism through a rear yoke. The recoil mechanism's piston rods are attached to cradle brackets located in rear of the shield, thus completing the gun-to-carriage accommodation. Tube life is estimated to be limited to fatigue life, which is estimated to be no more than approximately 1200 rounds. The T-12 (T-12A) breechring, considerably enlarged compared with that of the 100-mm M-1955 field gun, houses a semiautomatic vertical sliding-wedge type breechblock. The breech is opened automatically by a cam path and follower arrangement mechanism as the tube returns to battery in the counterrecoil phase of the recoil cycle. The breechring of the T-12A is wider and heavier than that of the T-12. The muzzle brake is a multiport (pepperpot)-type fixture that also serves as a partial flash hiding device. There are two groupings of 20 holes each on either side of the fixture for a total of 80 ports.

b. ~~(C)~~ Top Carriage. The top carriage supports the tube, the recoil mechanism, the cradle through its trunnions, the elevating mechanism, the gear train side of the traversing mechanism, the gun shield (except for the lower skirt-type shield between the wheels and below the axle), and the two bottom-located equilibrators of the T-12/T-12A plus the upper

damper/equilibrator cylinder on the T-12A. Interface of the top carriage with the bottom carriage is effected through a pintle-type arrangement.

(1) ~~(C)~~ Cradle. This fixture consists of a cylindrical casting composed of two or more parts. It extends from forward of the shield to a position somewhat forward of the leading edge of the breechring. The top of the cradle forward of the shield has a covered port that provides access through which lubricant may be applied to the bearing surfaces of the tube-cradle interface. The rear of the cradle has a lower bracket to which are attached the puller-type equilibrators. A lug, apparently associated with the semiautomatic breech opening device, appears on the right rear of this bracket.

(2) ~~(C)~~ Elevating mechanism. This is a conventional handwheel operated, worm-driven, rack-and-pinion device. On-carriage elevation limits are -10° and +20°, with trail spades reportedly seated to a depth of approximately 400 mm. Additional positive elevation can be achieved by further digging in of the trails; however, in this posture, the capability for depressing the tube is diminished by an equivalent amount and the capability of the weapon to perform its primary mission of direct fire is similarly degraded.

(3) ~~(C)~~ Traversing mechanism. This is a worm-driven, handwheel-operated, traveling nut-type device that is protected by a soft dust cover. The capability for on-carriage traverse is 27° right and left of center, for a total of 54°.

(4) ~~(C)~~ Recoil mechanism. This is a hydropneumatic, independent-type, constant length system. Maximum permissible length of recoil is 760 mm (29.9 inches). This mechanism consists of a recoil brake and a recuperator located above the tube. This mechanism, as do other similar Soviet systems, probably incorporates a replenisher and a buffer. The recoil brake and recuperator cylinders are attached to the tube, rather than to the breechring, through a yoke. The piston rods are affixed to the cradle sleeve at a point behind the shield.

(5) ~~(C)~~ On-carriage fire control. These equipments consist of:

- An S-71-40 sight mount.
- A Model PG-1M panoramic telescope.
- A Model OP-4M-40 direct fire telescope.
- A Model APN-5-40 night viewing device.

The S-71-40 sight mount (fig II-E-8) is a dependent-type mount that incorporates a range drum, which has graphical range scales inscribed for the HEAT-FS and HVAP-DS-FS rounds fired by this weapon. The fixture also has primary and micrometer mil scales for application of elevation and site settings. The PG-1 or PG-1M panoramic telescope, standard for all Soviet field artillery weapons, is used principally in the indirect fire mode. The OP-4M-40 direct fire telescope has reticle indices graduated in hundreds of meters of range (0-30), reflecting a maximum sighting capability of 3000 meters, for the HEAT-FS projectile, and similarly graduated (0-60), reflecting a range of 6000 meters, for the HVAP-DS-FS projectile. Lead indices graduated in four 20-km/h increments right and left of center are provided for direct fire applications upon moving targets. A night vision device, model APN-5-40, is mounted on a bracket above the tube. This device is estimated to have a maximum effective range of approximately 1500 meters on a clear moonless night.

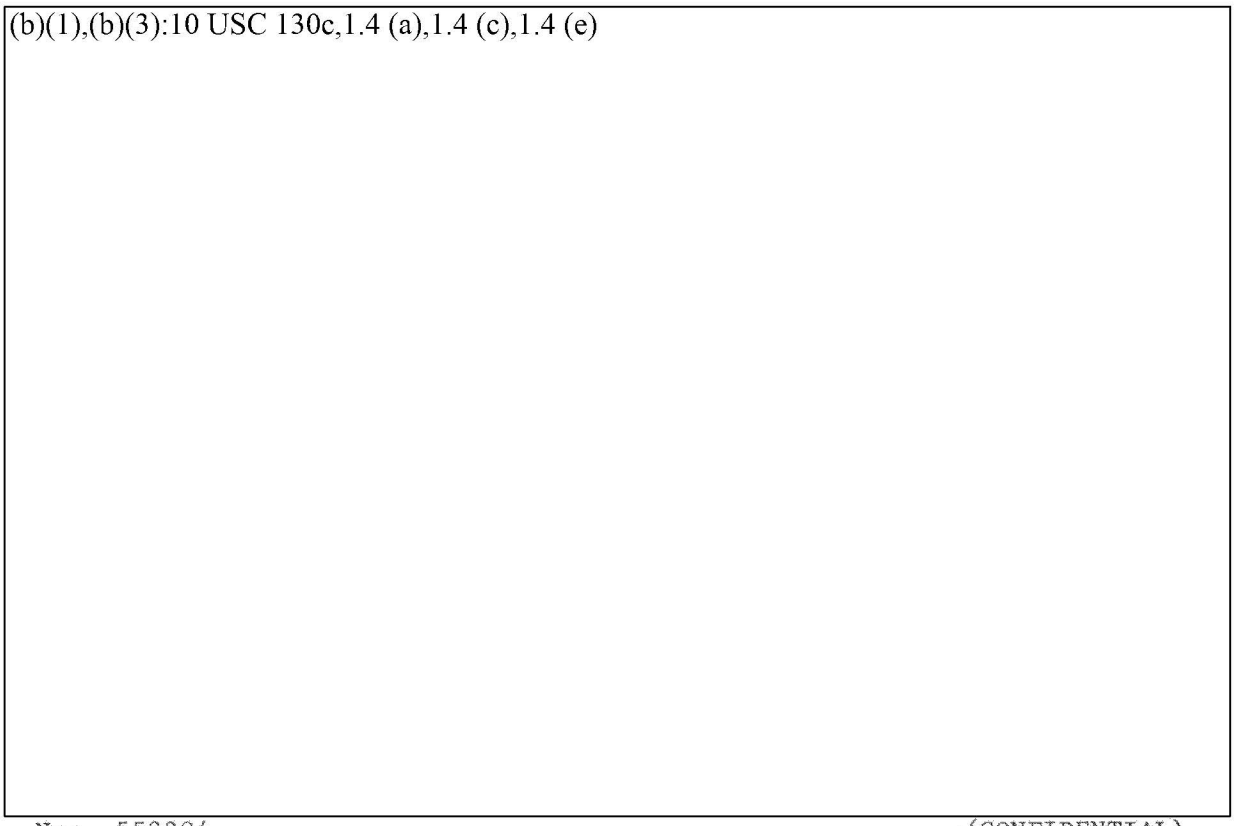

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Figure II-E-8. 100-mm T-12A, left side view of top and bottom carriages (U).

(6) ~~(C)~~ Crew protection. The primary shield on the T-12 (T-12A) consists of a winged-type shield that is moderately scalloped on the top. This shield is attached to the top carriage. A 300-mm high skirt shield is attached to the bottom carriage. This skirt provides protection both below the axle and between the wheels when it is lowered on its hinged fittings to its firing position posture. The shields are fabricated from armor plate having a 5-mm to 6-mm thickness. A travel light is mounted on the right forward face of the shield. There are two hinged apertures in the left side of the primary shield to provide forward visibility for the panoramic and direct fire telescopes. An accessory case is mounted on the right rear face of the primary shield. This shield also has a double hinged (collapsible) section located below the tube to provide continuous shielding during elevation and depression of the cannon assembly.

(7) ~~(C)~~ Equilibration. Compensation for muzzle preponderance on the T-12 consists of two puller-type pneumatic equilibrators, mounted below the rear of the weapon, that are attached to a lower rearward extension of the cradle assembly and to the base of the top carriage. The T-12A has an added, probably pneumatic, cylinder mounted on the upper right side of the top carriage; this cylinder is attached, by means of a bracket, to the cradle. The fixture is estimated to provide both damping to the tube to attenuate muzzle whip and to augment the equilibration force available from the original two equilibrators.

c. (U) Bottom Carriage. This assembly provides the fixed base on which the top carriage is traversed. It includes the carriage base, the traveling nut end of the traversing mechanism, the axle and suspension system, the hinged split trails with associated trail spades and a lunette, the wheels, and a hinged (lowerable) skirt-type shield that is located between the wheels. The axle is of cast construction. The T-12A has a modified axle that is longer and heavier than that of the T-12, thereby broadening the firing base and improving stability both when firing and during travel. The suspension system of the T-12A has also been modified to include heavier construction, leaf springs, and shock absorbers. The suspension system is locked out as the trails are spread when the weapon is being emplaced. The wheels, which are of steel disk design, are mounted on axle spindles. There are no brakes. The 9.00x20, Ya-37 tires are foam rubber-filled, and are, like other similar tires, mounted on the rim by means of a locking expansion ring. The trails are of welded box-section construction. When the trails are spread and locked in the firing position by means of pin-type latches, the axle is disengaged from its travel position and the suspension system is locked out. A heavy cast bar, mounted between the trails, fixes the weapon in the travel position by the employment of a locking pin engaged in the rear face of the breechring.

Each trail end mounts a conventional fixed-type trail spade. The lunette is mounted on the right trail and a retractable caster wheel is mounted on the left trail. In the travel configuration, the caster wheel is raised between the trails. Each trail has a hinged trail handspike to facilitate gross shifts in deflection when the weapon is in the firing position. The handspikes are folded down along the trails for travel. Two shovels, a crowbar, and a staff section are mounted on the outside of the left trail, and two long staff sections are mounted along the outside of the right trail.

d. ~~(C)~~ Mobility. The T-12A has been widened so that its wheelbase now approximates that of the URAL-375D truck, and the suspension system has been modified. The T-12A obviously is considerably heavier than the T-12. Nevertheless, the T-12A is estimated to have excellent tracking and good on- and off-road mobility characteristics. The mobility characteristics of the T-12 are not as good as those of the T-12A. Its narrower wheelbase and less sophisticated suspension system impair its ability to track with its prime mover and its stability during travel.

F. SOVIET 122-MM HOWITZER M-30 (M1938)

11. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 122-mm howitzer M-30 (M-1938) (fig II-F-1) was developed by the USSR during the early thirties. It was produced in large quantities during the period 1937 through 1955. This weapon was used by the Soviets during World War II to reinforce the fires of their 76-mm ZIS-3 divisional guns and as general support artillery in artillery brigades, division, and corps. The M-30 is one of the most successful artillery weapons to have been developed by the USSR. It has been replaced in most first- and some second-line active Soviet Army artillery units by the newer (1963) and more versatile 122-mm D-30 howitzer. In US parlance, the 122-mm D-30 is standard, and the M-30 is limited standard or standard B, but remains widely deployed in the Warsaw Pact, the PRC, and other ECC armies. This weapon usually is employed in 6-gun batteries, 18-gun battalions; nevertheless, the PRC deploys it in 4-gun batteries. In accordance with normal Soviet field artillery doctrine, the M-30 is employed in both the direct and indirect fire roles. The M-30 and its companion weapon, the 152-mm Howitzer D-1 (M1943) (sec II, subsec O), present the same general appearance since they are mounted on the same carriage. The D-1 carriage has been reinforced to provide the added strength necessary to accommodate the heavier 152-mm howitzer. In addition to the difference in tube size, the most easily detectable variation between the M-30 and the D-1 is the presence of a double-baffle muzzle brake on the 152-mm D-1, whereas the 122-mm M-30 has no muzzle device.

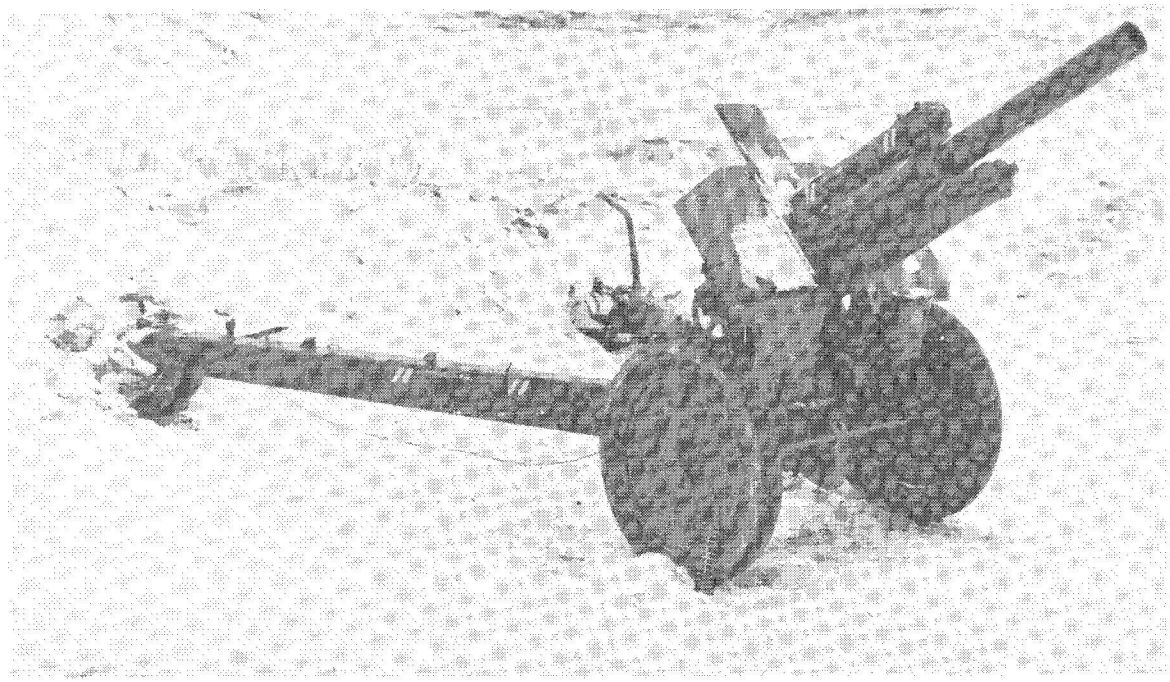

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Figure II-F-1. 122-mm howitzer M-30 (M-1938), right front view (U).

b. ~~(C)~~ Capabilities.

(1) (U) General. The 122-mm M-30 howitzer fires a 21.76-kg (47.97-lb) projectile to a maximum range of 11 800 meters. Its prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are 6, 16, 25, 55, 75, and 100 full charge rounds, respectively. The M-30, in travel position, is 5.93 meters (19.46 ft) long. The ZIL-151 (now replaced by the ZIL-157), 6x6, 2.5-ton truck or its equivalent is the normal Soviet prime mover for the unlimbered 2500-kg (5510-lb) M-30. The howitzer may be towed by a variety of prime movers and it is readily adaptable to indigenous vehicles. Soviet prescribed towing speeds are 50 km/h (31 mi/h) over improved roads and 35 km/h (22 mi/h) off improved roads. The howitzer can be emplaced and prepared for firing by a crew of nine men, including driver, in 1 to 1.5 min. The M-30 utilizes cased, separate loading ammunition. Nine propellant charges are available, including full charge and 7 numbered charges, In exceptional cases, older ammunition, associated with the obsolete 122-mm 1910/1930 howitzer and identified as VOF-462, VOF-462G, VOF-462AG, VOF-462A, and VD-462, can be fired by the M-30. This older ammunition, stocks of which may by now have been depleted, had four

propellant charges and achieves a maximum range of 9000 meters when used in the M-30. The unit of fire at battery level is estimated to be 80 rounds per weapon (480 rd/per 6-gun battery). The on-vehicle load carried by each prime mover (ZIL-151/157 or equivalent) is estimated to be 40 rounds. Characteristics of projectiles commonly employed with the M-30 are set forth in table II-F-1.

Table II-F-1. Projectiles, 122-mm M-30 Howitzer (U)

Type	Designation	In-flight weight (kg)	Muzzle velocity (m/s)	Penetration, 0° obliquity at any range (mm)
HE	OF-462 or 462A	21.76	515	NA
HEAT	BP-460A	13.24	570	203
Smoke	D-462	22.32	?	NA
Illum	S-462	21.0	?	NA
Pgnd	A-462	21.5	?	NA

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Point detonating quick and delay fuzes, GVMZ, RGM, RGM-2, and RG-6, and time fuze D-1 are used with all projectiles, except smoke and HEAT. Fuzes KTM and KT-2 are used with the smoke projectile. Complete round weight, except HEAT, approximates 27 kg (59.5 lb).

(2) ~~(c)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data are depicted in table II-F-2.

(b) ~~(c)~~ Effectiveness. An 18-howitzer battalion of M-30's can deliver 1.175 tonne (54 rounds) of projectiles on an area target 8 PE_r, or more, in depth in 20 seconds of fire. When firing upon a 250x200-meter counterbattery-sized target at a range of 10 000 meters, the M-30 battalion can place 1.094 tonne (96.5% of the 1.175 tonne delivered) within the target area.

Table II-F-2. Probable Errors in Indirect Fire; 122-mm M-30 Howitzer; Shell HE (OF-462 or OF-462A) (U)

Percent of maximum range (11 800 m) (measurement in meters at various percentages)	PE_r (m)	PE_d (m)
90 (10 600, chg full)	35.4	7.5
70 (8300, 2d chg)	26.2	5.6
50 (5900, 4th chg)	24.6	4.0
30 (3500, 7th chg)	21.5	2.3

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(c) ~~(C)~~ Fragmentation. The OF-462 high explosive projectile (VOF-463G round) fired by the M-30 has a steel body. The OF-462A high explosive projectile (VOF-463 round) has a cast iron body. See paragraph 13b(3)(c) for fragmentation data.

(d) ~~(C)~~ Lethality. These data for the OF-462 HE projectile are presented in paragraph 13b(3)(d).

(3) ~~(C)~~ Direct fire.

(a) (U) Precision. Probable errors in direct fire of the 122-mm M-30 howitzer are shown in table II-F-3.

(b) ~~(C)~~ Grazing range. The PRC states that its 122-mm type 54 howitzer, a copy of the Soviet M-30, has a grazing range of 630 meters against a 2-meter-high target. Normal range for opening fire against tanks, except during a mass tank attack, is 700 meters. Prior to the HEAT round being fired, the sight (range scales) is set on the "DG-3" scale on either the range drum or the elevation scale using, in either case, data obtained from the firing tables. Recently acquired range table information states the grazing range for the M-30, when firing VP-463 HEAT, V_o=570 m/s, is: 660 meters vs. a 2-meter-high target, 760 meters vs. a 2.7-meter-high target, and 800 meters vs. a 3.0-meter-high target.

Table II-F-3. Probable Errors* in Direct Fire, 122-mm M-30 Howitzer HEAT Projectile (BP-460A) (U)

Range (m)	PE_d (m)	PE_v (m)	PE_r (m)
500	Not available	Not available	Not available
1000	0.6	0.6	11
1500	0.9	1.0	11.5
2000	1.2	1.3	12
3000	1.8	2.4	14
4000	2.4	3.9	15

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*Note: Although the propellant for the HEAT round is a nonadjustable 4th charge, the difference of the projectile weight changes the ballistic characteristics of the shell to correspond closely to those of an HE shell fired with the 3d charge. The data in this table therefore have been extracted from the firing table values for 3d charge firing the OF-462 HE projectile.

(c) ~~(C)~~ Effective range. Hit probabilities have not been calculated for this weapon; a good estimate probably would be a 50% probability of a first round hit upon an M60A1 tank at 700 meters.

(d) ~~(C)~~ Engagement range. This weapon probably would open fire on a US M60A1 tank at about 800 meters.

(e) ~~(C)~~ Armor penetration. Armor penetration of the BP-460A HEAT projectile is 203 mm (7.99 in) at 0° obliquity. Another HEAT projectile, the fin-stabilized BK-463UM, probably has equal or greater penetration and, allegedly, produces fragmentation effects equal to those of the OF-462 HE projectile.

c. (U) Configuration. The carriage of the M-30 is of split trail design. The trails are of riveted box construction. The howitzer has a solid, rectangular, axle and a single, seven-leaf, suspension spring running longitudinally along the axle. The spring suspension is locked out when the trails are spread, as the howitzer is prepared for firing. The lunette, a separate fixture attached to the trail ends, secures the trails together through a turnbuckle arrangement. The howitzer has 49° of on-carriage traverse (24°30' right and left of center); the trails must be shifted manually if larger changes in direction are required. On-carriage traverse using the handwheel, which is located on the left side of the howitzer, is accomplished at the rate of 1.5° per revolution. Positioning limits in elevation are -3° (50 M) and +63°30' (1058M). The elevation handwheel, located on the right side of the howitzer, achieves 1.1° in elevation for each revolution. The recoil mechanism of the M-30 is an independent-type, hydropneumatic system having a constant (non-variable) hydraulic recoil brake and a hydropneumatic recuperator. The cradle is of semicylindrical, riveted, construction with forward and aft yokes. The trunnions and the elevating rack are integrated into the rear yoke component. On-carriage fire control is an independent (semi-independent on more recently produced weapons) system, Model 1930, consisting of an elevation quadrant mount with range drum and a model PG-1 or PG-1M panoramic telescope. This fire control system is used for both direct and indirect fire.

d. ~~(C)~~ Summary. The M-30 is being replaced in active Soviet Army field artillery units by the modern (1963) and improved 122-mm D-30 howitzer. The M-30 remains deployed to a number of Soviet divisions, however, and is the standard direct support artillery weapon in some Warsaw Pact nations and in various other countries, including the PRC, which has been equipped from Soviet resources. The PRC 122-mm type 54 howitzer is identical to the M-30 except for tire sizes, 1180x165 on the M-30 versus 1150x165 on the PRC type 54. In view of the wide distribution of this simple, durable, and still reasonably effective weapon, Soviet war reserves appear likely to continue to reflect a considerable inventory of M-30's and associated items. Although this weapon is more limited in range (11 800 meters) than the D-30 (15 300 meters), it is comparatively simple to operate and to maintain under field conditions; it has proven to be a reliable weapon. Additionally, it has been made available in large quantities to numerous beneficiaries. Using full charge at 70% (8300 meters) of maximum range, the probable error, expressed as a percentage of range, is 0.313%. This error increases to 0.334% at 90% (10 600 meters) of maximum range and to 0.347% at maximum range (11 800 meters). For comparison, the US 105-mm M102 howitzer at equivalent ranges using charge 7 has comparable errors of 0.174% of range at 70% (8100 meters) and 0.160% at 90% (10 400 meters) of maximum range and 0.434% (charge 6) at maximum range (11 500 meters).

The charge-to-mass ratio for the M-30's HE projectile is 0.158:1 compared with the US 105-mm M1 HE projectile, with a charge-to-mass ratio of 0.129:1. Because the M-30 has endured and continues in wide use after more than 35 years it attests to the satisfaction of the Soviets and others with the results attained when employing this system.

12. ~~(C)~~ Component Analysis

a. (U) Cannon.

(1) (U) Tube. The rear half of the monobloc gun tube is encased by a welded adapter jacket (fig II-F-2), which, although reinforcing the tube to a minor extent, has the principal functions of providing the means for mounting the screw-on-type breechring and securing the tube and breechring together. Additionally, the jacket houses the recoil rollers that engage the recoil rails incorporated in the rear cradle yoke. The jacket also contains the means of supporting the recoil brake, which is attached to the lower portion of the breechring. The recoil brake cylinder moves in recoil, having the piston rod attached to the forward end of the cradle. The recuperator cylinder is mounted on the upper yoke, and only the recuperator piston and piston rod, which is attached to the upper part of the breechring, moves in recoil. Tube length is 23 calibers (2804 mm, 110.4 in). The rifling is of increasing right-hand twist, initiating at the origin of the lands at the rate of one turn in 36 calibers (4°59'14") and terminating at the muzzle at the rate of one turn in 20 calibers (9°41'23"). There are 36 lands and grooves. Design land width is 3.04 mm, groove width 7.6 mm, and groove depth 2.03 mm. Design length of the propellant chamber to the origin of the rifling is 392 mm (15.4 in). Weight of the cannon assembly is 725 kg. Tube life is 7500 EFC rounds. The fatigue life of the tube and of the breech are not known.

(2) (U) Breechring. This fixture houses a manually operated, interrupted screw-type breechblock that operates on a hinged carrier by use of a conventional lever. The breechblock, which contains a percussion-type firing device operated by means of a lanyard, has normal extracting and firing safety mechanisms for this type equipment. Obturation principally is attained by the cartridge case.

b. (U) Top Carriage. The top carriage supports the cannon assembly and associated items, the recoil mechanism, the cradle with its trunnions, the elevating mechanism, the on-carriage fire control equipment, the gun shield, the equilibrators, and the drive train portion of the traversing mechanism.

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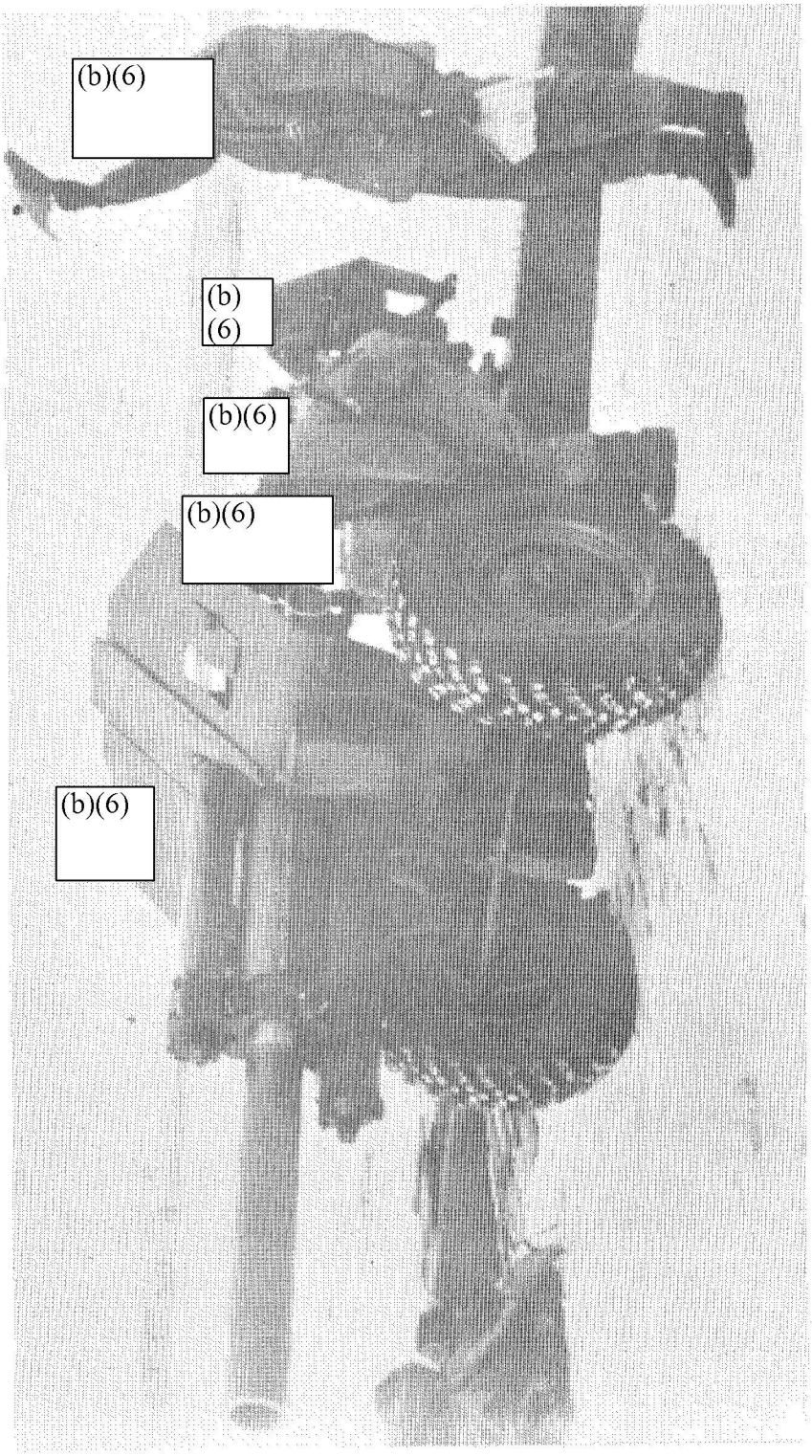

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Figure II-F-2. 122-mm howitzer M-30 (M-1938), left front view (U).

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(1) (U) Cradle. This fixture is the principal tipping part of the howitzer. The main components of the cradle are the semicylindrical casting, the trunnion yoke, the forward bracket (yoke), and the travel latch bracket. The trunnion (rear) yoke, which is riveted to the casing, includes the elevating rack, the trunnions, and a double clamp for fixing the rear of the recuperator cylinder to the rear yoke. Additionally, the rear yoke contains internal rollers, one on either side, on which the rails on the tube jacket ride in recoil and counterrecoil. The on-carriage fire control equipment is mounted at the left trunnion. The travel latch bracket is riveted to the bottom of the cradle casting. The forward bracket (yoke) also is riveted to the cradle casting. The forward bracket contains six rollers, which guide the tube in recoil and counterrecoil, and a fixture that clamps the forward end of the recuperator cylinder to the forward end of the cradle. The cradle casting itself has an integral forward plate through which the piston rod of the recoil brake passes and is secured with a nut. Weight of the cradle is 135 kg.

(2) (U) Elevating mechanism. This assembly is a conventional handwheel-operated rack-and-pinion device having an integral worm-and-gear arrangement to achieve movement and to maintain stability of the cannon assembly in the vertical plane. Elevation limits are -3° and +63°30'. Positioning in elevating is facilitated by the employment of two adjustable push-type spring-loaded equilibrators attached by trunnions to the right and left sides of the cradle and to the top carriage, respectively.

(3) (U) Traversing mechanism. This mechanism consists of a push-pull type of telescoping worm shaft with a housing and a jacket (worm and acme screw). On-carriage traverse is limited to 24°30' right or left of center, a total on-carriage traverse capability of 49°.

(4) (U) Recoil mechanism. A Schneider-type hydropneumatic, independent, constant-length [1100 mm (43.3 in) maximum] mechanism is employed. The recoil mechanism consists of the recoil brake and the recuperator. The recoil brake is filled with 10 liters of Steol M. The recoil brake includes a spring-loaded replenisher with filling valve located in the aft section of the brake. The recuperator is filled with 7.1 to 7.21 liters of Steol M fluid and compressed air under a pressure of 38 ±1 atmospheres (39.3 kg/cm^2, 559 lb/in^2). During the recoil cycle, air pressure in the recuperator increases to a maximum of 104 atmospheres (107.5 kg/cm^2, 1529 lb/in^2). In counterrecoil, buffering action is attained by means of a throttling valve in the recuperator; this valve operates in conjunction with a small amount of recoil fluid that bypasses the recuperator piston in recoil. This recoil system is simple, rugged, and reliable. Battery-level personnel can service this system. A plate having a graph, which indicates the appropriate fluid level for the recuperator under varying conditions of ambient temperature, is attached to the left side of the breechring.

(5) (U) On-carriage fire control. These equipments, located on the left side of the howitzer, consist of the standardized M1930 sighting system (sight and mount). Depending on the vintage of the weapon, on-carriage fire control is of either the independent or the semi-independent variety. Figure II-F-2 illustrates the semi-independent-type system mounting a PG-1 panoramic telescope. The major components of this equipment are the sight mount and the panoramic telescope. The mount includes a matching index-type elevating indicator, elevating and site mechanisms and scales, and longitudinal and cross-level vials. The range drum utilized with this weapon is inscribed "TS" No. 146 ("TS" is the abbreviation for firing or range table). The outer face of the drum is an elevation scale inscribed in mils (M). The six range scales on the drum are inscribed "DG full," "DG 1," "DG 2," "DG 3," "DG 4," and "DG 7." When the 5th charge is fired, the range drum scale marked "DG-4" is used to enter drum settings obtained from the tabular range tables. When the 6th charge is fired, the "DG-7" scale is employed to insert the tabular data. The angle of site scale, which reads from zero to ±250 M, has graduations every 2 M with numerical designations every 10 M.

(6) (U) Crew protection. A winged shield, moderately sloped in the upper half and essentially vertical in the lower half, is positioned forward of the trunnions and equilibrators and extends laterally over the tops of the wheels. The steel plate from which the shield is made is approximately 4 mm (0.16 in) thick. The center portion of the upper shield, similar to that area on other Soviet artillery weapons, is a moving scab section which, when the barrel assembly is elevated, rides channels on the primary shield to provide continuing protection to the crew. An aperture is located on the left side of the shield forward of the panoramic telescope to provide a line of sight for use in the conduct of direct fire.

(7) (U) Equilibration. Compensation for muzzle preponderance is provided by two pusher-type, adjustable, spring-loaded equilibrators located on the right and left sides of the top carriage behind the shield. Attachments are to two associated trunnions on the cradle and to the lower top carriage.

c. ~~(C)~~ Bottom Carriage. This assembly consists of a hollow steel casting that provides the base upon which the top carriage is mounted. The upper face of the bottom carriage is machined. The machined surface on the lower face of the top carriage comes in contact with this surface. Bronze bushings are fitted inside the bottom carriage to center the pintle of the top carriage. Wings in the casting contain hinge pin holes for attaching the trails. Lugs are included to house trail locking pins, which secure the spread trails in the firing position. A slot is provided in the casting to accommodate the axle and spring. A locking pin and

associated mechanisms are installed to lock or release the spring suspension when the howitzer is put into firing or travel configuration. A bracket in the casting provides the means through which the cradle and the lower carriage may be locked together for travel.

(1) (U) Axle. Rectangular, the steel axle incorporates conventional arrangements for mounting the wheels. Suspension of the howitzer in the travel mode is achieved through double slides (fore and aft) on the bottom carriage. These slides ride in vertical slots in the center of the axle assembly and place the weight of the carriage on the center of a leaf spring running along the underside of the axle. The leaf spring is attached by shackles to the right and left sides of the axle near the wheels. A lever withdraws the locking dowel associated with the suspension system when the left trail is opened in preparation for firing; this action causes the spring to be "locked out" of the suspension system.

(2) (U) Wheels. The steel disk wheels are equipped with 1180x165 sponge rubber-filled tires. The wheels are equipped with mechanical parking brakes that are operated by a single hand lever. The M-30 howitzer does not have a primary brake system operated by the prime mover driver. There is a provision, however, for two ropes or cables to be attached to the hand brake lever and run through the shield either to the limber or to the rear of the prime mover bed. These ropes may be manipulated by a crew member to apply or release the hand brakes in situations requiring augmented braking of the prime mover-howitzer combination.

(3) (U) Trails. These members are of riveted box-type construction, with internal angle iron reinforcements. They are connected to the bottom carriage by a hinge pin through the upper and lower hinge pin fittings. The trails, which engage stops on the lower carriage, are locked in the spread configuration by the locking pins located on the bottom carriage. A bracket on the left trail operates the mechanism to release the suspension spring when that trail is spread, thus locking-out the suspension while the weapon is in the firing configuration. "Winter" (small) trail spades are rigidly mounted on each trail end. "Summer" spades (larger spades for use in soft earth) are attached to each trail with an eccentric shaft arrangement that facilitates their being positioned and locked in place. The lunette is a separate fixture that is aligned with each trail end by lugs. The lunette, which ties the trail ends together with a turnbuckle attachment, provides the connection between the prime mover's pintle and the howitzer. Handspikes are secured to each trail end with a slip hinge and sleeve arrangement that permits their being folded down along the trail and latched for travel. A rammer staff and two shovels are latched onto the left trail.

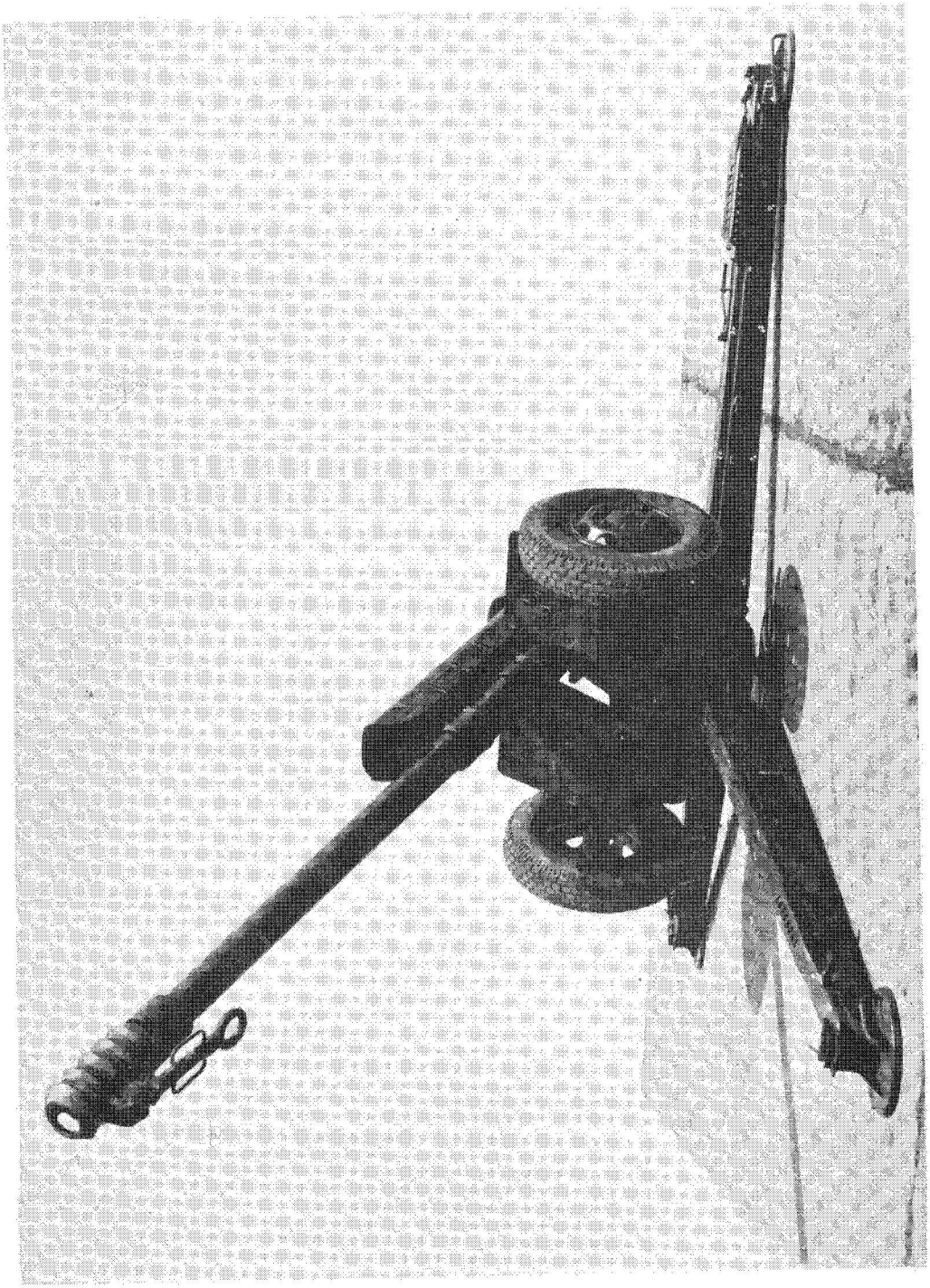
A crowbar and aiming stakes are mounted on the right trail. Mounting plates for a "Wickers" (air) pump are riveted to the tops of the trails.

(4) ~~(C)~~ Mobility. This howitzer is not nearly so roadable as is the torsion bar-suspended 122-mm D-74 gun nor the torsion bar-suspended 122-mm D-30 howitzer, which, towed by the muzzle, has outstanding roadability. The roadability of the leaf-spring sprung M-30 should equal or exceed that of the US 105-mm M-101 howitzer.

G. SOVIET 122-MM HOWITZER D-30

13. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 122-mm Howitzer D-30 (fig II-G-1) was first sighted in 1963. This howitzer continues to be produced and has replaced the 122-mm Howitzer M-30 (M-1938) as the direct support artillery weapon in most Soviet first-echelon units and in some lesser priority Soviet units. It also has been provided to the armies of several Warsaw Pact nations and limited numbers have been furnished to other countries, including North Vietnam, Finland, Egypt, Peru, and Syria. The D-30 is not believed to have been provided to the People's Republic of China (PRC) by the Soviets. It is a relatively lightweight, towed artillery weapon that reflects a number of design changes when compared with its predecessor, the 122-mm M-30 howitzer. The D-30 is readily recognizable in the travel configuration (fig II-G-2). The two movable trails are joined to the fixed trail and the fixed trail is attached to the tube for travel. The howitzer is towed through a folding lunette-drawbar fixture that is attached to the muzzle brake (fig II-G-3). The weapon has a noticeably short overall length in the travel mode, an inverted cradle that shields the top mounted recoil system, and torsion bar suspension. The bulk of the weapon's mass is centered astride the wheel assembly. The three-piece shield on this piece, unlike that on most Soviet weapons, is essentially square (fig II-G-4), presenting an appearance of straight lines with small wings. This shield is open in its upper center section; it does not have the sliding shield (scab) section that is common to some other Soviet weapons such as the 122-mm M-30 howitzer. In its firing configuration, the D-30 exhibits a trifurcate posture. An eccentric shaft device on the traversing mechanism serves as a "throwout" that, disconnecting that mechanism, permits the weapon to be rapidly slewed in traverse. Although elevation is limited by a lockout device when the breechring is aligned with any one of the trails, this limitation does not adversely affect the capability of this weapon in the direct fire or antitank roles nor at elevations between -7° and +18°. At +18° of elevation the maximum range of the D-30 is reduced from 15 300 to 11 000 meters. Acceptance of this limitation is a trade-off for the stability



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Neg. 517584

Figure II-G-1. 122-mm howitzer D-30 in firing configuration, left front view (U).

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-G-2. 122-mm D-30 howitzer towed by GAZ-63 truck (U).

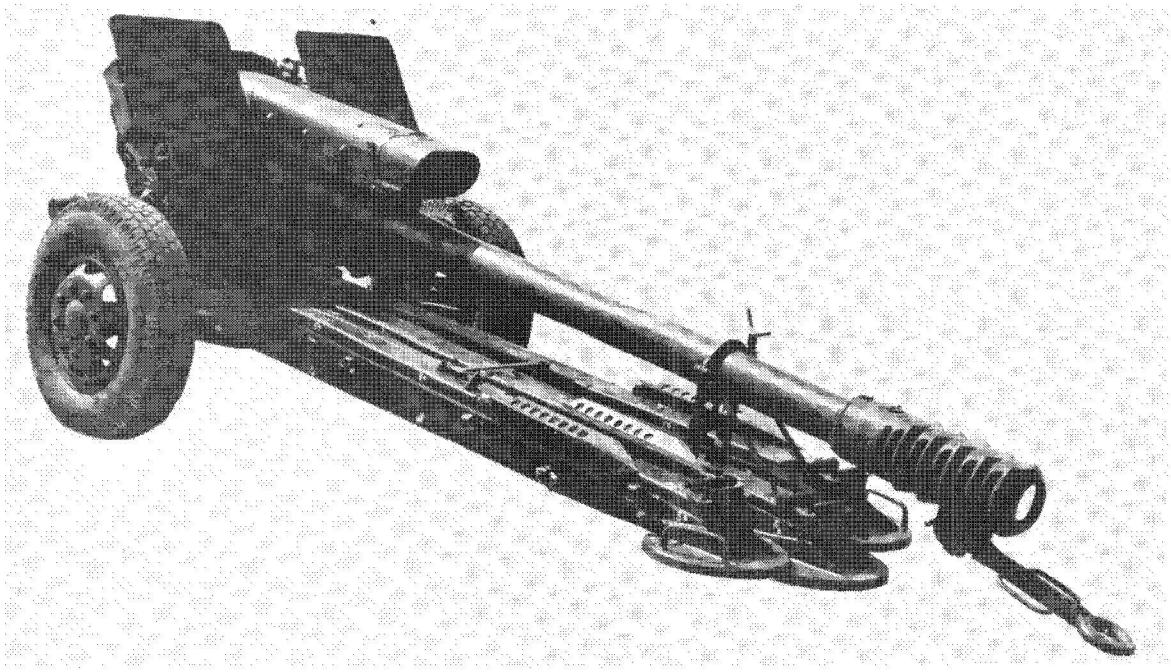

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Figure II-G-3. 122-mm D-30 in travel configuration, right front view (U).

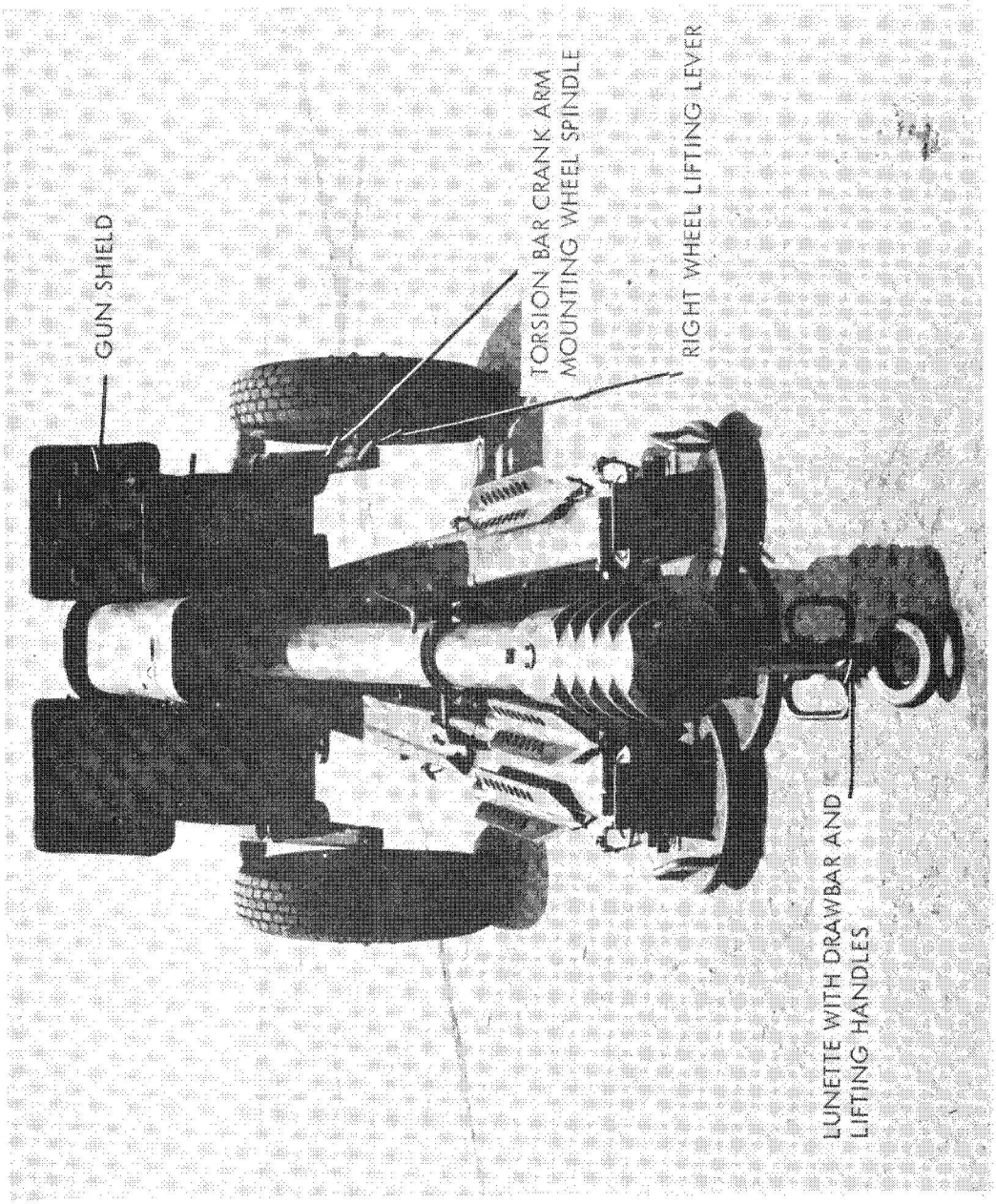

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Figure II-G-4. 122-mm D-30 in travel configuration, front view (U).

afforded by the trifurcate trails. Elevation limits, other than when over a trail, are -7° and +70°. Note that in figure II-G-5, which shows the D-30 maximum elevation, the jack is fully retracted, as is proper, whereas in figure II-G-1 the jack shaft remains partly extended, which is improper when the weapon is in the firing position. The D-30 weighs 3.15 tonne (3.52 tons) in the travel mode. In the travel configuration, the howitzer is 5.4 meters (17.7 ft) long, 1.95 meters (6.40 ft) wide, and 1.66 meters (5.45 ft) high. Height to the top of the shield in the firing position is 1.42 meters (4.66 ft). The D-30 is deployed to the division level as the direct support artillery weapon. Additional D-30 battalions are available from RVGK artillery to augment battalions assigned to tank airborne and MR divisions. Usual deployment of D-30 units is in 6-gun batteries and 18-gun battalions.

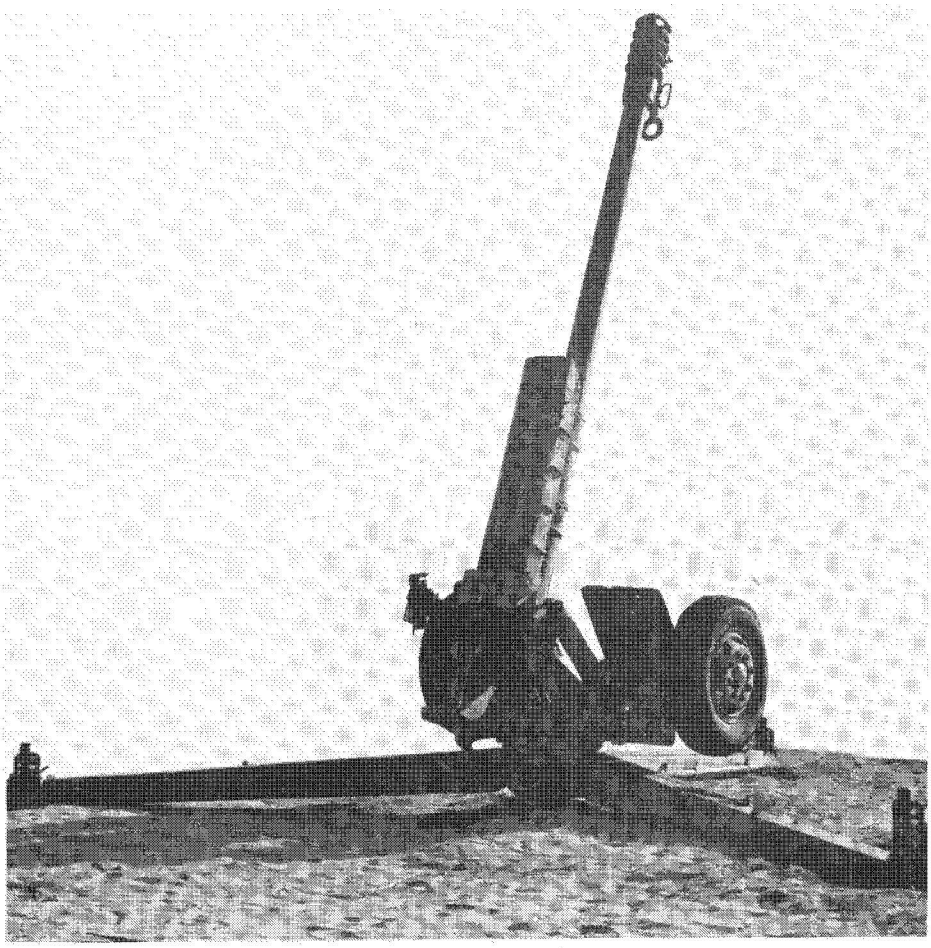

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Figure II-G-5. 122-mm D-30 in firing configuration at maximum elevation (U).

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The 122-mm D-30 fires a 21.76-kg (47.97-lb) HE projectile (OF-462 or OF-462 Zh) to a maximum range of 15 300 meters. Maximum prescribed rate of fire is 6 rd/min; nevertheless, 8 to a possible 10 rd/min is attainable by the gun crew. The prescribed rates of fire for 1, 3, 5, 15, 30, and 60 min are 6, 16, 25, 55, 75, and 100 full-charge rounds, respectively. The D-30 can be towed by a variety of wheeled or tracked prime movers. It usually has been observed being towed by the ZIL-131 and URAL-375, or equivalent, trucks, or the AT-L, or equivalent, tractors. The prime mover used must be capable of supporting the D-30's pintle weight of 150 kg (331 lb) and of controlling the 3.2-ton unbraked towed-load weight of the howitzer. The Soviets state that this weapon may be towed at a maximum speed of 60 km/h (37 mi/h) over improved roads. This is believed to be a speed limit imposed due to overheating of the sponge rubber-filled tires during long distance road marches at high speed; the D-30 has been towed at more than 80 km/h over secondary roads without exhibiting instability. A special truck (dolly) is provided, either as a component attached to the fixed trail or, separately, as section equipment (depending on the model of the D-30), that enables the howitzer crew to manually move the weapon over short distances. The D-30 can be emplaced/displaced by its six-man crew (plus driver) in from 1.5 to 2.5 min, depending upon the crew and the terrain. Although standard crew size is six men, three men can emplace, service, and displace this weapon. Similar to other Soviet weapons, the D-30 uses separated loading ammunition, the propellant being contained in a brass cartridge case (fig II-G-6). Cased propellant options are: Full charge (nonreducible) or a multisectional reduced charge that provides five selectable charge options. A special cased charge is used with the spin-stabilized HEAT projectile. As with most other Soviet weapons, the projectile must be inserted and rammed separately, after which the cartridge case is loaded. The projectile must not be permitted to ride in the propellant case for seating, because, upon firing, this practice may result in a detonation of the propellant charge. Characteristics of the projectiles commonly employed with the D-30 are set forth in table II-G-1.

(2) ~~(C)~~ Ammunition quantities. The unit of fire is estimated to be 80 rounds per weapon. The average on-vehicle load carried by each prime mover of the ZIL-131 type, or equivalent, is estimated to be approximately 40 rounds.

(3) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data are depicted in table II-G-2.

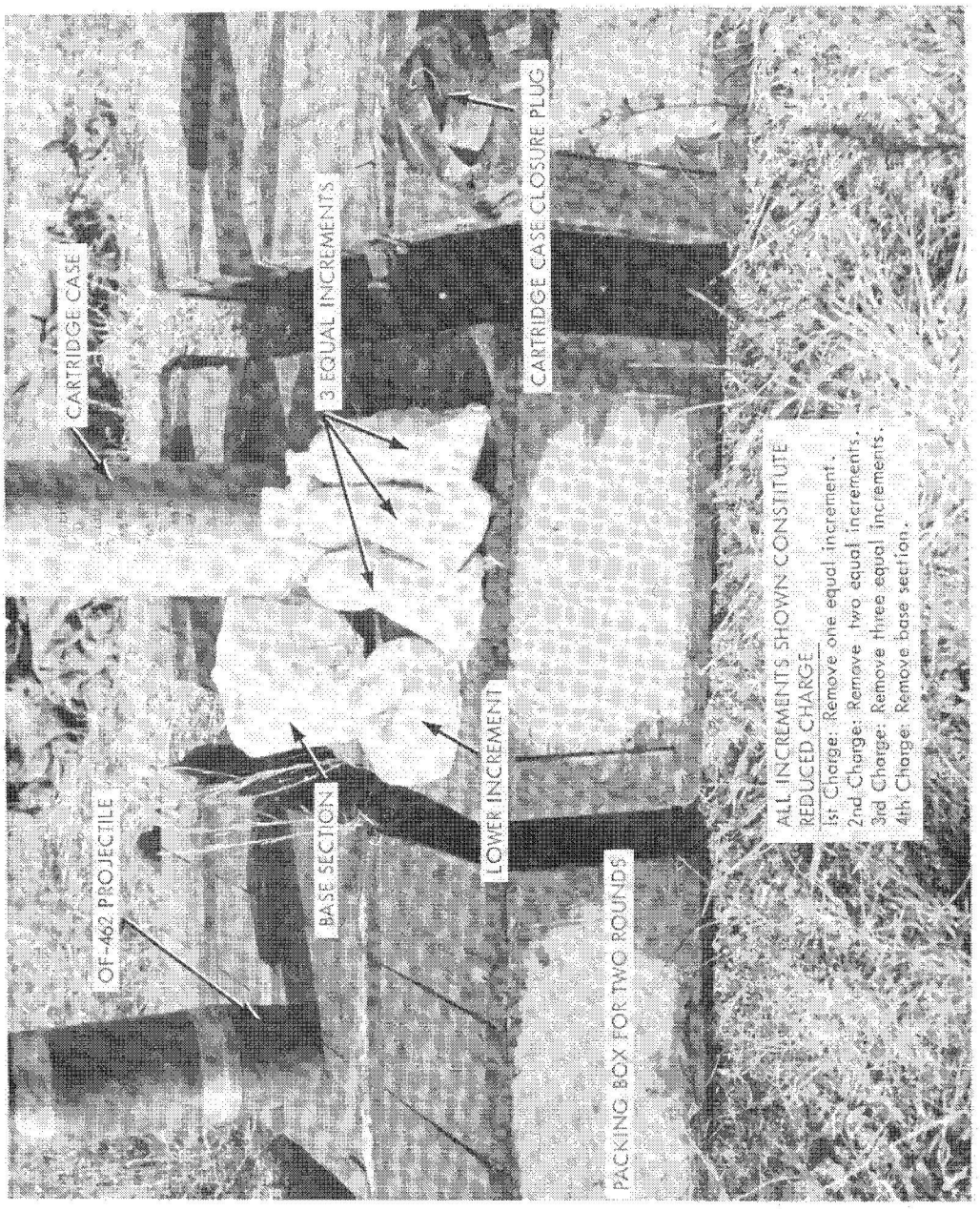

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Figure II-G-6. Reduced charge (VOF-5) fragmentation-HE round for 122-mm D-30 howitzer (U).

Table II-G-1. Projectiles, 122-mm D-30 Howitzer (U)

Type	Projectile designation	In-flight weight (kg)	Muzzle velocity (m/s)	Penetration at 0° obliquity at any range (mm)
Frag-HE (steel)	OF-462	21.76	690	NA
Frag-HE (steel)	OF-462 Zh	21.76	690	NA
Smoke	D4	21.76	690	NA
Illum	S463, S463Zh	21.96	?	NA
Pgnd	A1,A1D	21.76	690	NA
Chem	?	?	?	NA
HEAT (FS)	BK-6	21.58	680	350*
HEAT (FS)	BK-6M	21.58	680	400
HEAT (SS)	BP-1	14.08	740	180

*Note. Under US criteria, penetration capability is 579 mm.

~~(CONFIDENTIAL)~~

Table II-G-2. Probable Errors in Indirect Fire; 122-mm D-30 Howitzer, Shell Fragmentation-HE (OF-462) (U)

Percent of maximum range (15 300 m) (measured in meters at various percentages)	PE_r (m)	PE_d (m)	PE_r (%)
90 (13 800, full chg)	23	7.6	0.167
70 (10 700, reduced chg)	23	5.6	0.220
50 (7700, 2d chg)	17	4.6	0.227
30 (4600, 4th chg)	25	3.8	0.543

~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Effectiveness. One measure of effectiveness is the amount of warhead weight that can be delivered on a target within a given span of time. An 18-howitzer D-30 battalion can deliver approximately 1.18 tonnes (3 volleys) of projectiles on an 8-PE_r-deep target area in the first 20 seconds of firing. When firing on a 250x200-meter area-type target at a range of 14 000 meters (PE_r, full chg = 27 meters), and considering errors in precision only, 1.12 tonnes of projectiles can be delivered into the target area within 20 seconds. Upon these same targets, a US 155-mm M-109 howitzer battalion can deliver 1.55 tonnes and 1.35 tonnes, respectively. In sustained fire at 14 000-meter range, which both weapons can reach, the D-30 battalion (PE_r = 27 meters) will deliver 8.22 tonnes in 4 minutes versus the 8.79 tonnes delivered by the M-109 battalion (PE_r = 36 meters); under the same criteria, however, in 18 minutes the D-30 battalion will deliver 22.05 tonnes, while the M-109 begins to fall behind by delivering only 16.91 tonnes.

(c) ~~(C)~~ Fragmentation. The standard OF-462 and OF-462 Zh high explosive projectiles fired by the D-30 howitzer have steel bodies. The OF-462 has a copper rotating band and the OF-462 Zh has a ceramet rotating band (sintered iron impregnated with oil, paraffin and graphite); otherwise, these projectiles are the same.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(4) ~~(C)~~ Direct fire.

(a) (U) Precision. Probable errors in direct fire for the 122-mm D-30 howitzer are shown in table II-G-3.

(b) (U) Grazing range. Soviet data state that the grazing range both for the D-30 HEAT projectiles BK-6, BK-6M, and BP-1 and for the fragmentation-HE projectile OF-462 versus targets of various heights are as shown in table II-G-4.

II-70 and II-71 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Table II-G-3. Precision in Direct Fire, 122-mm D-30 Howitzer (U)

Range	HEAT projectile, BK-6 or BK-6M (fin-stabilized) v_o = 680 m/s			HEAT projectile, BP-1 (spin-stabilized) v_o = 740 m/s			HE projectile, OF-462 or 462 Zh v_o = 680 m/s			
	Max ordinate	PE_d	PE_v	Max ordinate	PE_d	PE_v	Max ordinate	PE_d	PE_v	PE_r
(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
500	0.8	0.2	0.2	0.6	0.1	0.1	1.0	0.1	0.1	18.0
1000	3.5	0.4	0.4	2.8	0.2	0.2	2.9	0.2	0.2	17.0
1500	9.1	0.6	0.8	7.4	0.2	0.2	7.2	0.4	0.3	16.5
2000	19.0	0.8	1.2	15.0	0.4	0.4	14.0	0.6	0.4	15.0
3000	NA	--	--	NA	--	--	35.0	1.3	0.7	14.0
4000	NA	--	--	NA	--	--	70.0	2.4	1.1	13.0

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Table II-G-4. Grazing Range, 122-mm D-30 Firing Various Projectiles (U)

Target height (m)	Grazing range in meters for projectile		
	BK-6 or BK-6M HEAT	BP-1 HEAT	OF-462 frag-HE
2.0	800	860	830
2.7	900	980	--
3.0	940	1030	1010

~~(CONFIDENTIAL)~~

(c) ~~(C)~~ Effective range. Calculated effective ranges (50% probability of a first round hit for the 122-mm D-30 firing the BP-1 HEAT projectile vs. a frontally presented US M60A1 tank and the standard 2.3x2.3-meter NATO target are 950 meters and 775 meters, respectively). See appendix III for comparative data on D-30 vs. other weapons.

(d) ~~(C)~~ Engagement range. A D-30 gun commander probably will commence firing against the US M60A1 tank with BP-1 HEAT projectiles at a range of about 1050 to 1100 meters. Note that in figure II-G-9 the lunette-draw bar has not been folded back, nor have trail stakes been used; this is probably to reduce the time required to get into action. Direct fire against stationary point targets such as field positions containing antitank missiles or an observation post probably would be undertaken up to a range of about 3500 m with the OF-462 (frag-HE) projectile.

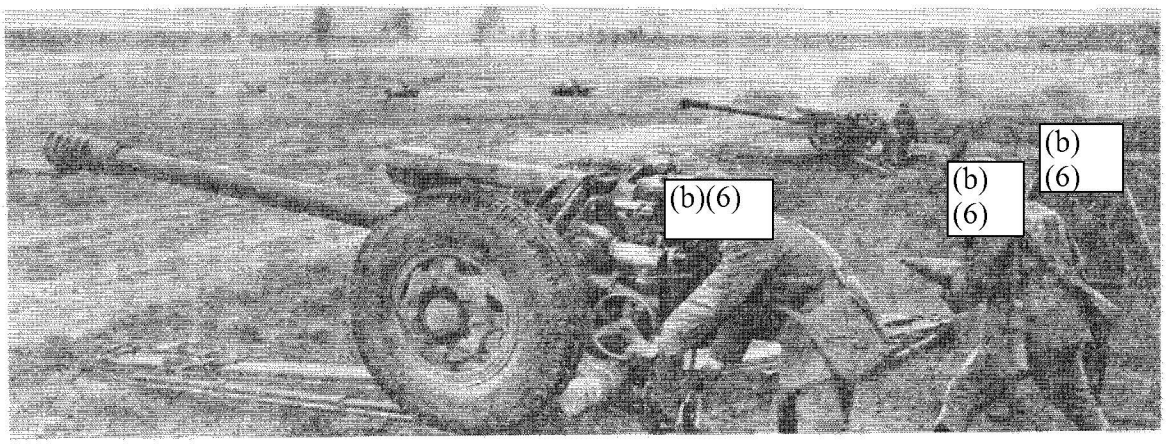

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Figure II-G-9. 122-mm D-30's in a direct fire exercise (U).

(e) ~~(C)~~ Armor penetration. Table II-G-5 sets forth penetration data (b)(1),(b)(3):10 USC 130c,1.4 (c),1.4 (e)

Table II-G-5. Armor Penetration, 122-mm D-30 Howitzer Firing HEAT Projectiles BP-1 (Spin-Stabilized) and BK-6 and 6M (Fin-Stabilized) (U)

Round	Projectile	Velocity (m/s)	At 0° obliquity (mm)	At 30° obliquity (mm)
VBP-3	BP-1	740	180	150
VBK-3	BK-6	680	350*	250
VBK-3	BK-6M	680	400	330

~~(CONFIDENTIAL)~~

*Penetrated 579 mm of armor by US standards in exploitation test.

c. (U) Configuration. The carriage of the D-30 is unique in the Soviet inventory of field artillery cannon systems. It is a trifurcate design that has one fixed trail and two hinged trails, all of welded box-type construction. For travel, the tube is positioned over the

fixed trail, the movable trails are attached to the fixed trail, and the tube is attached by a gun stay (bracket) to the fixed trail (fig II-G-4). A two-position lunette with draw bar is affixed to the muzzle brake by a hinged fitting. This fixture is folded back and latched along the tube when the D-30 is placed in the firing configuration. Some models of the D-30 are equipped with a caster wheel attached to the end of the fixed trail to facilitate manual movement of the howitzer over short distances. Models that do not have this attachment have a similar attachable caster wheel (truck) as a part of their section equipment. To place the D-30 into the firing configuration, the carriage is jacked up on a pedestal-type, screw jack (not a firing jack) located under the carriage. The wheels are raised up manually, with assisting force being provided by the equilibrator. The trails are spread and locked into their normal 120° offset positions. When the weapon is in the jacked-up position, it is relatively unstable; the crew must exercise care to open the two movable trails simultaneously and at a relatively constant and equal rate to preclude toppling the weapon onto its side. When necessary, any slight elevations in the ground which prevent the trail ends from coming into firm contact with the ground are levelled with pick and/or shovel. The carriage is lowered so that the pad on each trail end comes into firm contact with the ground. The jack pad, having been withdrawn under the center of the bottom carriage, does not support the weapon. One trail stake is driven through each trail end. With the weapon in firing position, the retracted jack pad should not contact the ground. The circular pad and stake on each trail end of the trifurcate trails provide for support and stability over a wide area, and permit 360° of on-carriage traverse to be employed. Positioning limits in elevation are -7° and +70° between the trails and -7° and +18° to 22° when the breechring is positioned above any one of the three trails. A firing interlock device is activated at +18° when the tube is over the trails. The firing interlock precludes firing at some point within the span of 18° to 22° of elevation; it will not activate at less than 18°, and will always activate upon attainment of 22° of elevation (fig II-G-10). The D-30 has an independent-type hydropneumatic, constant length (nonvariable) recoil mechanism mounted within an inverted cradle. Unlike this component in most weapons, the tube rides as a weight suspended from the cradle's recoil slides (rails) rather than riding upon the slides from above (fig II-G-11). The inverted cradle is a reinforced "U"-shaped structure. It is fabricated from sheet and bar stock, with appurtenances welded to it. On-carriage fire control equipment consists of a dependent-type sight mount, model D726-45, that incorporates cross-level, elevation, and site mechanisms, plus a range drum. A standard PG-1M panoramic telescope is installed upon the mount for use in indirect fire. A PG-1M telescope or a model OP4-45 or OP4M-45 direct fire telescope is utilized for direct fire. The range scales in the reticle of this telescope

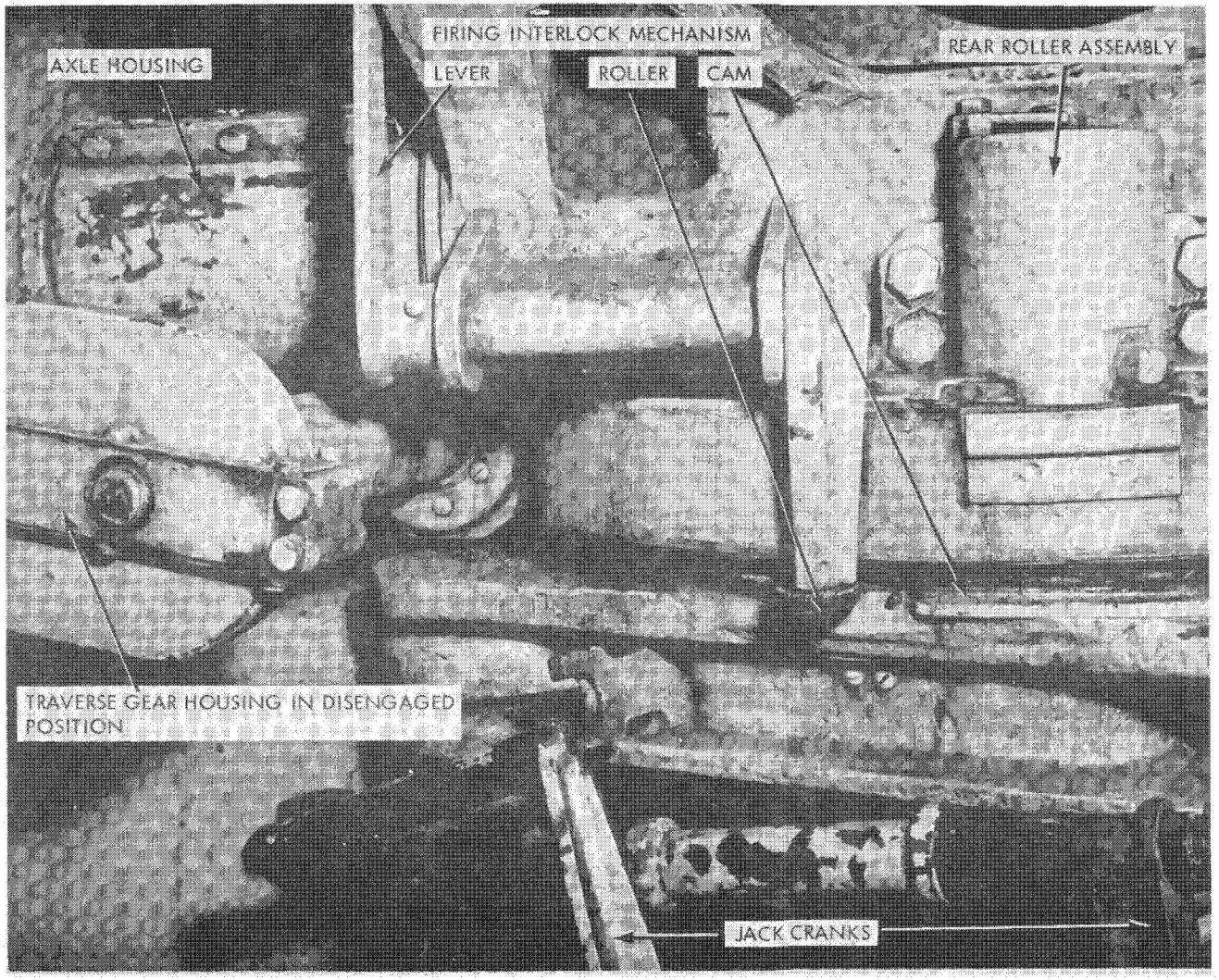

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Figure II-G-10. 122-mm D-30, rear view of interface of top and bottom carriages (U)

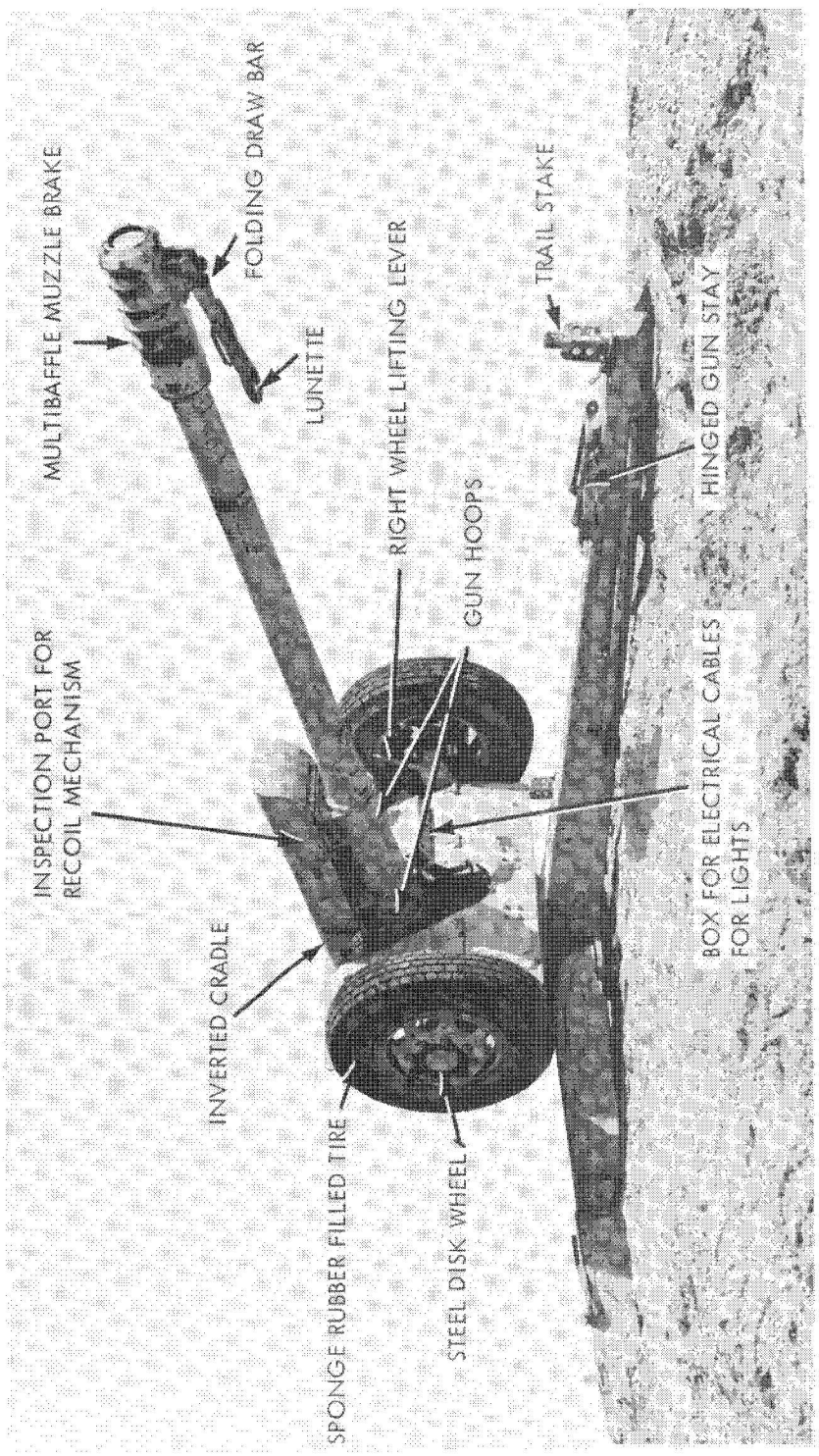

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Figure II-G-11. 122-mm D-30 in firing configuration, right front view (U).

generally are graduated in hundreds of meters (hectometers). Separate scales are incorporated for the full charge fragmentation-HE projectile (VOF-5 round with OF-462 or OF-462 Zh projectile) graduated from 0 to 40 (4000 meters); for the spin-stabilized HEAT projectile (VBP-3 round with BP-1 projectile) graduated from 0 to 20 (2000 meters); and for the fin-stabilized HEAT projectiles (VBK-3 round with BK-6 or BK-6M projectile) graduated from 0 to 20 (2000 meters).

d. ~~(C)~~ Summary. The D-30 reflects a considerable departure from earlier Soviet field artillery weapon design. Unique features of this weapon include: The inverted cradle, trifurcate trail design to provide a 360° on-carriage traverse capability and improved firing stability (fig II-G-11), compact loading over the wheels, towing of the weapon by the muzzle (fig II-G-4), and a throwout on the traversing mechanism to permit rapid manual slewing of the weapon. Among the good design features carried forward from earlier weapons are torsion bar suspension and a high efficiency (49%) multibaffle muzzle brake. The D-30 achieves a 30% increase in range capability (15 300 m vs. 11 800 m), 360° of on-carriage traverse, and much better stability over the 122-mm M-30 howitzer, at the cost of a 28% increase in weight in the travel configuration (3200 kg vs. 2500 kg). The 360° on-carriage traverse capability of the D-30, which compares with the 49° available on the M-30, contributes to the improved performance reflected by the D-30, particularly in regard to the direct fire role. The 122-mm D-30 howitzer is rugged, durable, and simple to operate and maintain. According to US crew members who operated this weapon, operational procedures for the weapon can be learned more quickly and easily than those for comparable US weapons on which they had been trained. Maintenance is relatively easy and, for the most part, can be accomplished at battery level. A lack of handbrakes for use when manhandling the weapon, plus the overpressure in the crew area caused by the high efficiency (49%) muzzle brake, have been cited as deficiencies, according to US standards; however, this weapon represents a highly effective and efficient addition to the Soviet arsenal of artillery weapons. The D-30 appears to have been more carefully manufactured than earlier Soviet artillery weapons, although nonessential finishing continues to be a secondary consideration. Emphasis continues to be placed on achieving all functional requirements without serious regard for the niceties of appearance. The trails of the D-30 are welded reinforced box design rather than the riveted reinforced design usually reflected in earlier weapons.

(b)(1),1.4 (c)

[redacted] To the authors' knowledge, the Soviets do not use the terms "wear" or "fatigue" life, per se, in published documents. They do publish data purporting to correct for loss in muzzle velocity due to advancement of the forcing cone, instructions for star gaging the weapon, instructions for inspection of the

tube for cracks, and, especially, after cleaning of the tube and breech, for crack growth. There is information that the Soviets consider the minimum "tube life" of the D-30 to be approximately 4000 EFC rounds. This alleged 4000 rounds probably is the "practical life" of the tube in the Soviet view. The tube of the D-30 is tough (160 $lb/in^{3/2}$ versus 130 $lb/in^{3/2}$ fracture toughness for the Soviet 130-mm M-46 gun, and 115 $lb/in^{3/2}$ for the martinsite steel used for US gun tubes), and the gun crew should have a considerable number of rounds within which the growing crack could be detected prior to catastrophic failure occurring. It is postulated, therefore, that both tube and "actual" fatigue life are in the neighborhood of 4000 EFC rounds. The precision of the D-30 in indirect fire is compared to that of the US 105-mm M102 and 155-mm M109A1 howitzers in table II-G-6.

Table II-G-6. Precision in Indirect Fire; Comparison of US 105-mm M102, Soviet 122-mm D-30, and US 155-mm M109A1 Howitzers (U)

Range (m)	US M102			Soviet D-30			US M109A1		
	PE_r	% range	charge	PE_r	% range	charge	PE_r	% range	charge
18 000	-	-	-	-	-	-	58	0.322	8
15 000	44	0.293	RAP	26	0.173	full	49	0.327	8
13 000	34	0.262	RAP	22	0.169	full	32	0.246	7 white
11 000	18	0.164	7	19	0.173	full	28	0.255	7 white
9 000	15	0.167	6	17	0.189	full	25	0.278	5 green
7 000	11	0.157	6	14	0.200	full	18	0.257	5 green
5 000	12	0.240	5	11	0.220	full	12	0.240	5 green
3 000	16	0.533	3	10	0.333	1st	9	0.300	5 green
1 000	6	0.600	3	7	0.700	3d	4	0.400	4 green

~~(CONFIDENTIAL)~~

The mobility, stability, precision, range, maximum prescribed rate of fire, and RAM-D characteristics of this weapon all combine to result in a simple, easy operable, towed weapons system that excellently fulfills the requirements for an artillery piece performing the direct support role (to include the delivery of direct fire). The D-30 provides numerous improvements over the Soviet M-30 howitzer. The M-30, however, continues in widespread use throughout countries within the Soviet hegemony.

14. ~~(C)~~ Component Analysis

a. Cannon.

(1) Tube. The D-30 tube is of monobloc construction; there is no evidence of its being autofrettaged. The tube has five major tapers and six major diameters; this is indicative of a more complex manufacturing process for this tube than for earlier Soviet howitzer tubes. Tube material properties exhibit a considerable improvement over that of the 122-mm D-74 field gun, which is about 10 years older than the D-30. The tube alloy is similar to AISI 4337 steel. Rockwell C hardness of the tube is 30. Tube yield strength (0.1% offset) is 8900 kg/cm^2 (126 600 lb/in^2) to 9069 kg/cm^2 (129 000 lb/in^2). As stated previously, fracture toughness (K_{1c}) is 160 $lb/in^{3/2}$. Tube tensile strength is 10 060 kg/cm^2 (143 100 lb/in^2) to 10 292 kg/cm^2 (146 400 lb/in^2). The tube has two hoops that mount the recoil slides. The hoops are mounted on the tube with threaded locking collars and keys. These collars engage the only threads used on the tube. The breechring and the muzzle brake are attached to the tube with adapters and threaded sleeves that engage the fixtures, thus obviating any requirement for incorporating major threads on the tube for these items. Tube length without the muzzle brake is 32.76 calibers (3994 mm or 157.24 in). Tube weight, without breechring or muzzle brake, is 688.6 kg (1518 lb). Tube length, including the muzzle brake, is 4785 mm (188.4 in). Length of rifling is 3400 mm and chamber length (as measured using a 124.29-mm-diameter ring) is 594 mm. Chamber volume is 6.85 dm^3 (liters). The muzzle end of the tube has a keyed shoulder which, in conjunction with a split sleeve and a threaded sleeve, provides the means for mounting the muzzle brake. A keyed, externally threaded, sleeve and shoulder arrangement also is used to mount the breechring to the breech end of the tube. The breechring weighs 303 kg (667 lb) and the breechblock weighs 36 kg (79 lb). The rifling is of progressive (increasing) right-hand twist, originating as one turn in 45 calibers (an inclination of about 3°57') and increasing to one turn in 25 calibers (an inclination of about 7°10') at the muzzle. The tube has 36 lands and grooves. Design land width is 4.0 mm, groove width is 6.6 mm, and groove depth is 1.0 mm; this is a shallow depth when compared with the 122-mm D-74 field gun's depth of 2.4 mm.

(2) Breechring. The breechring (fig II-G-12) houses a semiautomatic, vertical sliding-wedge breechblock. If closed in the unloaded posture for travel or other purposes, the breech mechanism must be manually operated to achieve initial opening. A fixed camplate on the right inner side of the cradle plus a crank attached to the breechring provide a mechanism that opens the breech and extracts and ejects the empty cartridge case during the counterrecoil phase of the recoil cycle. Loading a fresh cartridge case trips the extractors, which release a spring-loaded mechanism that closes the breech. Rockwell C hardness of the breech is 36. The estimated life of the D-30 breech is 12 000 EFC rounds; this enables at least one, and probably two, tube replacements to be effected during the life of the breech. The factors of safety of the breechring and breechblock of this Soviet cannon are considerably higher than US design standards.

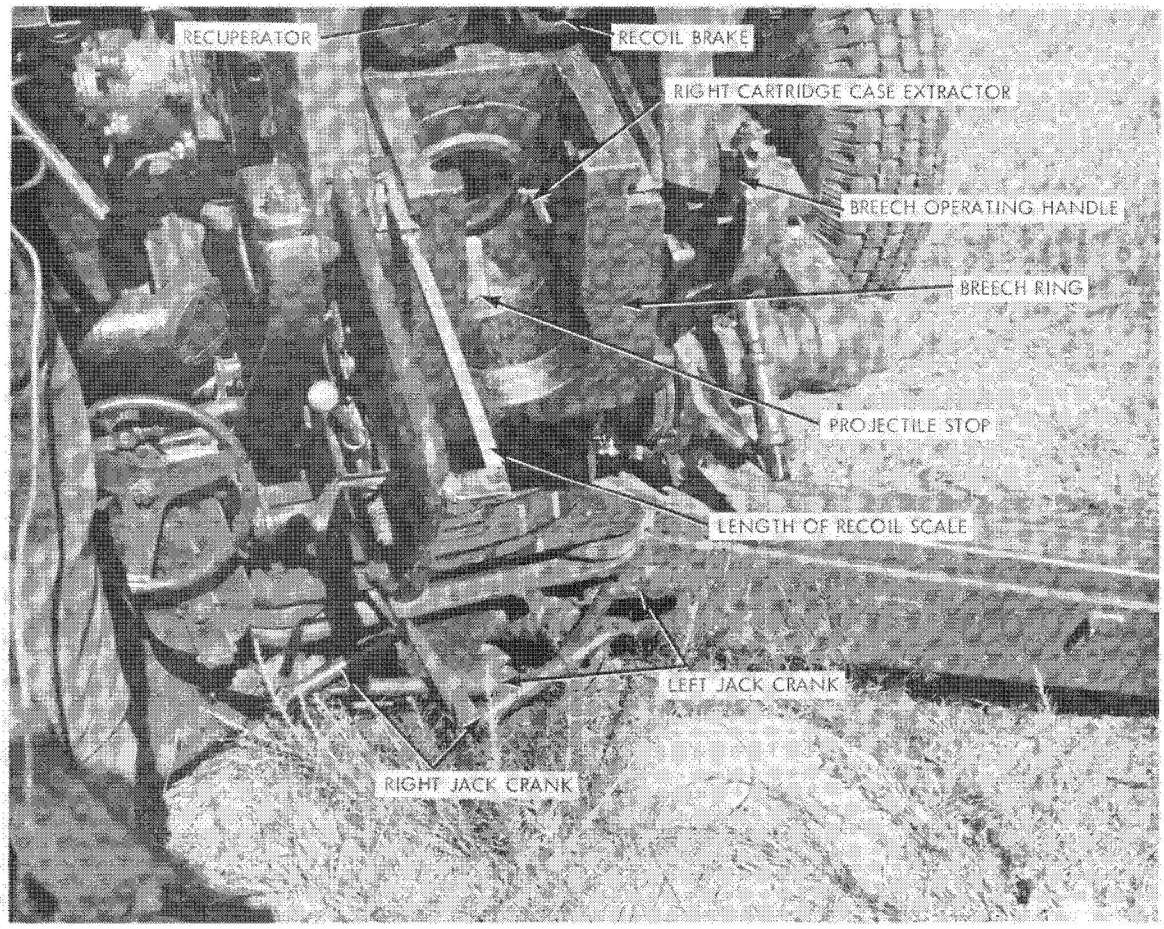

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Figure II-G-12. 122-mm D-30 in firing configuration, closeup rear view (U).

(3) Muzzle brake. This multibaffle (six-baffle), slotted, high efficiency brake (fig II-G-11) is of cast construction, and design efficiency is approximately 49% (measured in US tests as 48.1% vs. Soviet claim of 50%). The blast effects from the muzzle brake can create overpressures at the gunner's and the number-one man's stations of 0.43 kg/cm^2 (6.1 lb/in^2) in low angle (direct) fire when using maximum charge. Such overpressures considerably exceed US permissible limits (3.0 lb/in^2), and may result in ear damage unless protective devices are employed. The lunette, which is attached to the muzzle brake, is of welded construction, and includes lifting handles. It is adjustable to two positions to provide flexibility in adaption to available prime movers (tracked or wheeled). Design weight of the muzzle brake with lunette is 104.3 kg (230 lb).

b. Top Carriage. The top carriage supports the inverted cradle, the recoil mechanism, the cannon assembly, the trunnions, the on-carriage fire control equipment, the equilibrators, the shield, and the pinion side of the traversing mechanism. The top carriage is a casting that is attached to the bottom carriage by an arrangement of a sleeve, a bushing, the jack shaft, and a nut and locking collar. The jack screw shaft, in association with the bushing, acts as a pintle. The side frames of the top carriage incorporate trunnion seats and bearing caps to receive the cradle's trunnions. An elevation gear housing, attached to the left side of the cradle, incorporates an eccentric bushing to provide an adjustment for proper clearance between the pinion gear and the elevation arc (fig II-G-13). The lower left side frame of the top carriage also mounts the traversing mechanism fixture. Recess sleeves in the side frames of the top carriage mount the axle housing and the axle. A spline gear, welded to the right side of the axle housing in the right side frame, serves as the fixed increment of the axle engagement/disengagement (wheel positioning) and locking mechanism.

(1) The cradle. This fixture (fig II-G-11) consists of an inverted "U"-shaped cradle frame made of bar stock 3.6-mm (0.143-in) sheet steel having a Rockwell hardness of C-12. Castings are welded to the rear of the cradle at the most highly stressed areas. The cradle mounts the recoil rails, an access cover, the trunnions, an elevating arc, the sight and equilibrator mounting brackets, a firing guard assembly, its internally welded reinforcement ribs and castings, and a machined plate that serves as a quadrant seat for cross-leveling the howitzer. The inverted posture of the cradle provides shielding for the recoil mechanism, thereby reducing the vulnerability of the most vulnerable mechanism on a towed howitzer system. The forward portion of the cradle contains two seats for locking the recoil and recuperator piston rods to the cradle end and two spaces to accommodate the replenisher and the valve body. An access plate (fig II-G-14) in

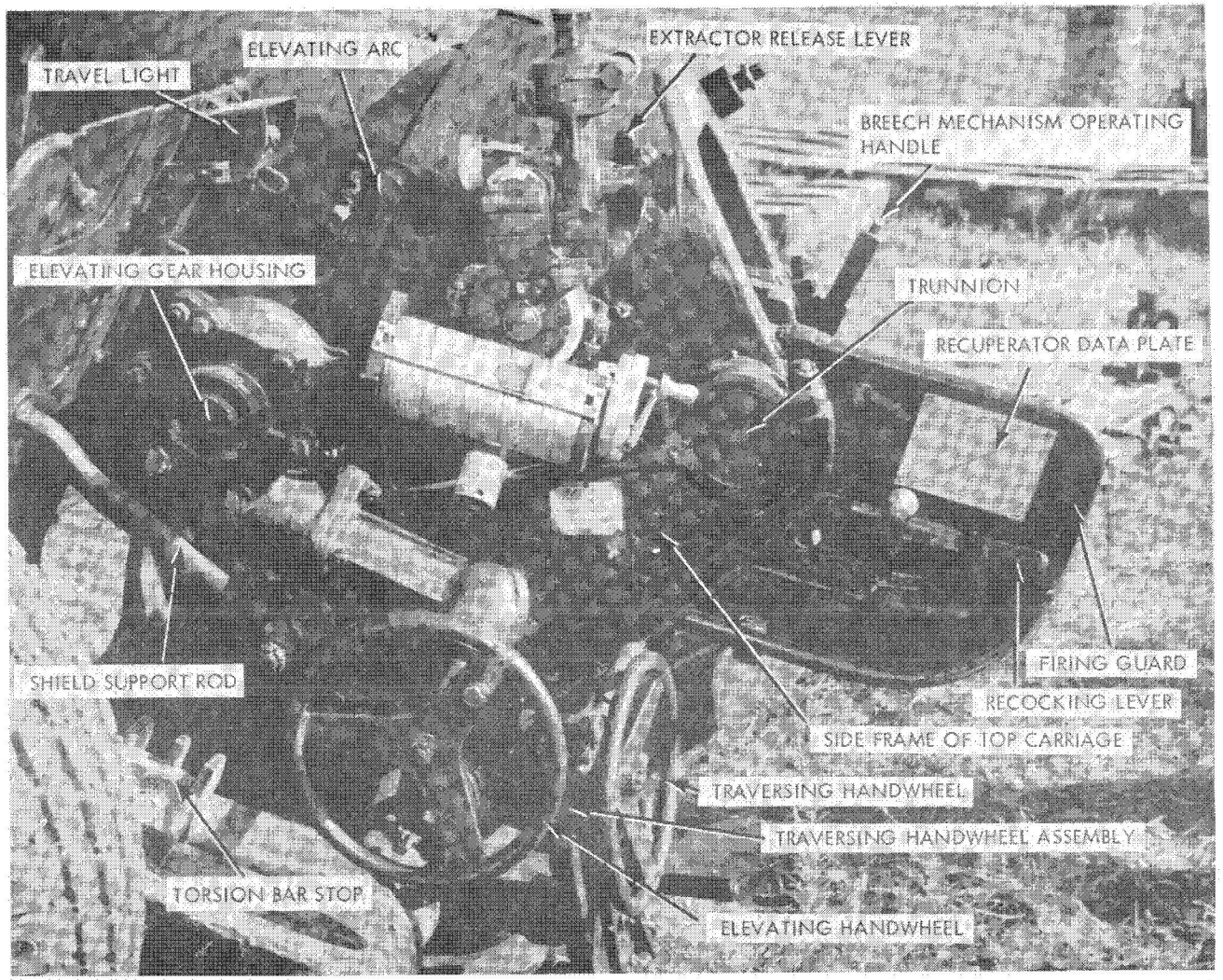

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Figure II-G-13. 122-mm D-30 in firing configuration, left side view of breech area (U).

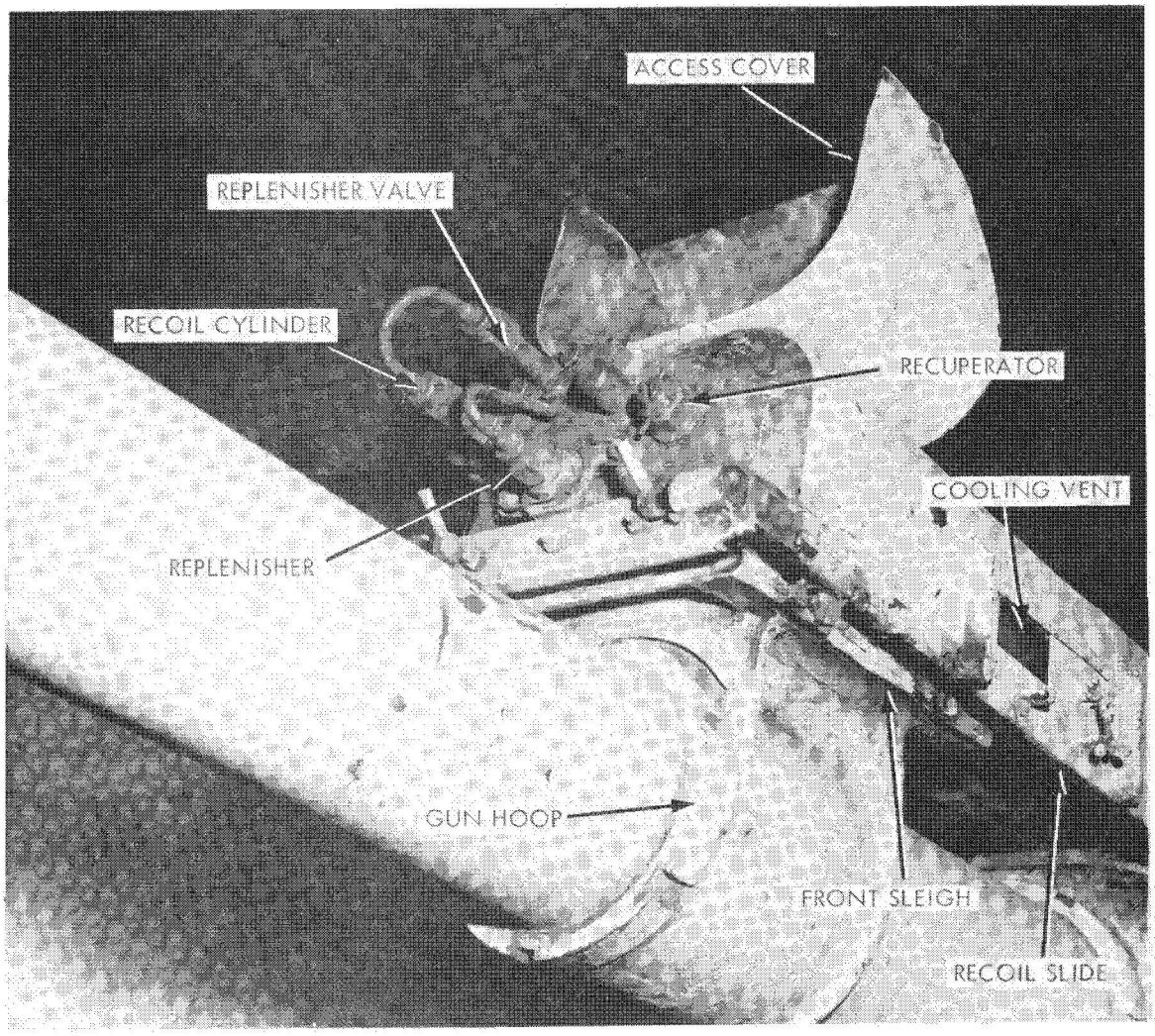

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Figure II-G-14. 122-mm D-30 cradle, left front view (U).

the forward end permits easy access to the recoil system's piston rod lock nuts and the replenisher. A vent and cover is provided in the right side of the cradle for servicing the recoil mechanism (fig II-G-11). A similar opening is provided on the left side near the front of the cradle for cooling the recoil cylinders. The trunnion seats are equipped with needle bearings and bearing caps. The guard assembly mounts the firing lever, the recocking mechanism, and one end of the length of recoil scale (fig II-G-12). The breech opening cam plate is attached to the lower right inner side of the cradle.

(2) Elevating mechanism. This rack-and-pinion-type mechanism consists of a handwheel, a drive box and shaft, drive gears, a universal joint, bearings, a housing that includes the pinion shaft, a worm wheel, and a worm shaft ending in a pinion. Brass bushings and a thrust bearing are provided to attenuate firing shock. The elevating arc (rack) is located on the left side of the weapon at the forward edge of the rear inverted "U"-shaped heavy casting. The pinion gear engages this arc and provides the means through which the cannon is positioned in elevation (fig II-G-13). Elevation limits are -7° and +70°. A single, pneumatic, pusher-type equilibrator, located on the right side of the top carriage, overcomes muzzle preponderance and assists in raising and lowering the wheels (fig II-G-15).

(3) Traversing mechanism. The traversing mechanism housing, which is attached to the top carriage, contains an eccentric shaft and a worm and shaft. The assembly, which mounts the traversing handwheel (fig II-G-13), contains a train of spur gears. This movable assembly is held in the vertical position by a lock attached to the top carriage. When the handwheel assembly is unlocked and rotated downward to the left (fig II-G-10), the traversing mechanism becomes disengaged, and the gunner, by pulling, or pushing, upon the rear of the left side frame of the top carriage, can rapidly slew the cannon in traverse to point it in any direction; the slew rate is limited only by the speed at which the gunner can run in a circle while hurdling the trails. This capability for slewing the weapon through 180° within about 5 seconds engenders a marked advantage in the conduct of direct fire. The traversing handwheel transmits motion through drive gears to the worm shaft, which operates against a full-circle worm gear that is fixed to the bottom carriage to provide an unlimited 360° traverse capability (fig II-G-16). The eccentric bushing that provides the means of disengaging the worm from the worm wheel for rapid traverse must be reengaged prior to firing; this is accomplished by rotating the handwheel assembly into the vertical position and locking it to the top carriage. Two front and one rear, Belleville spring-loaded, traversing roller assemblies provide for smooth traverse (fig II-G-17). The Belleville spring assemblies attenuate firing shock and maintain appropriate clearances between bearing surfaces. These roller assemblies are fixed, by means of threaded cap nuts, in vertical bores within the top carriage casting. Proper clearance between the top and bottom carriages is attained by adjusting the threaded cap nuts.

(4) Recoil mechanism. This mechanism is a hydropneumatic, independent, constant 790- to 930-mm length (940 mm or 37 inches maximum), Schneider-type recoil system. The system consists of a hydraulic

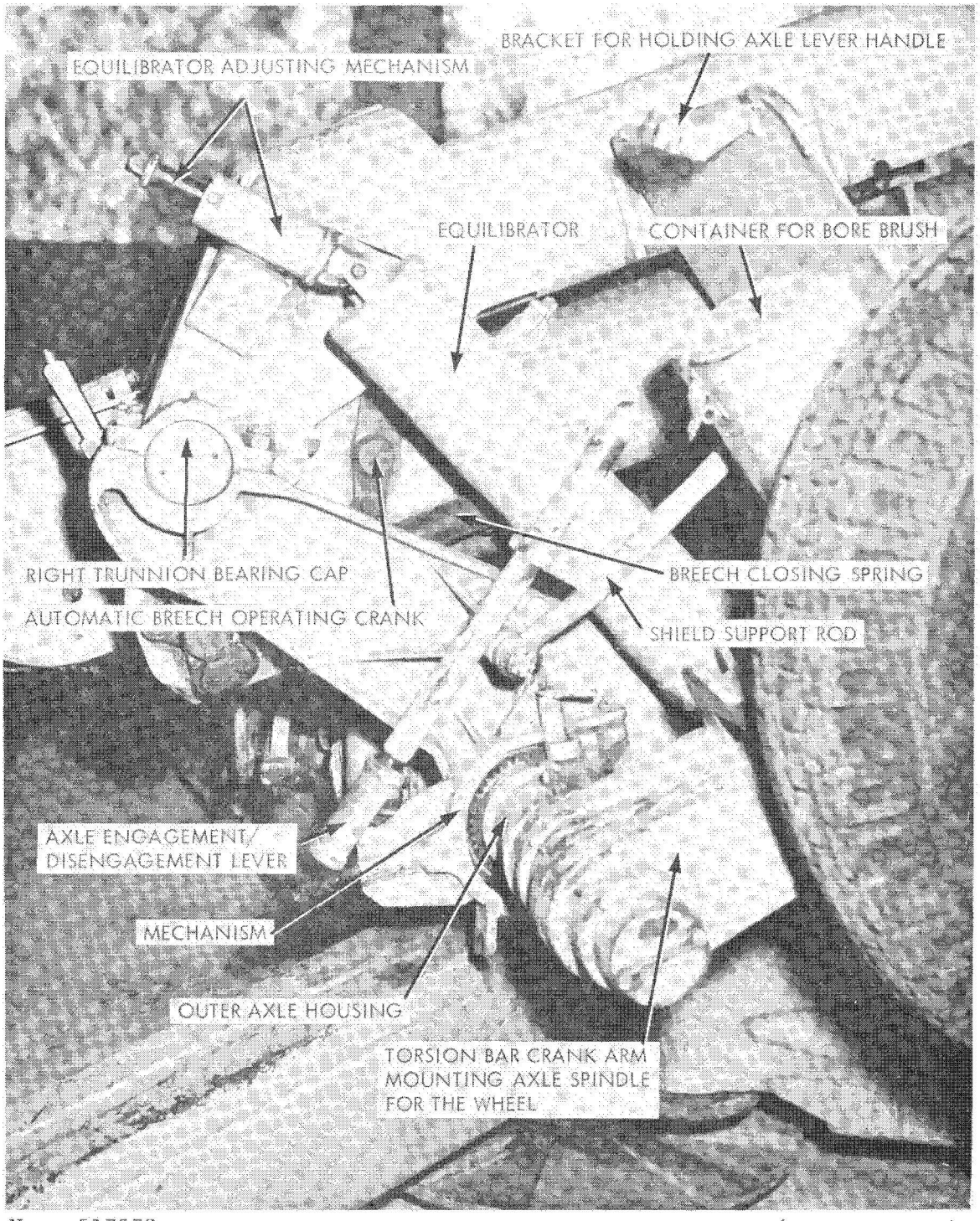

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Figure II-G-15. 122-mm D-30, right side view of top carriage (U).

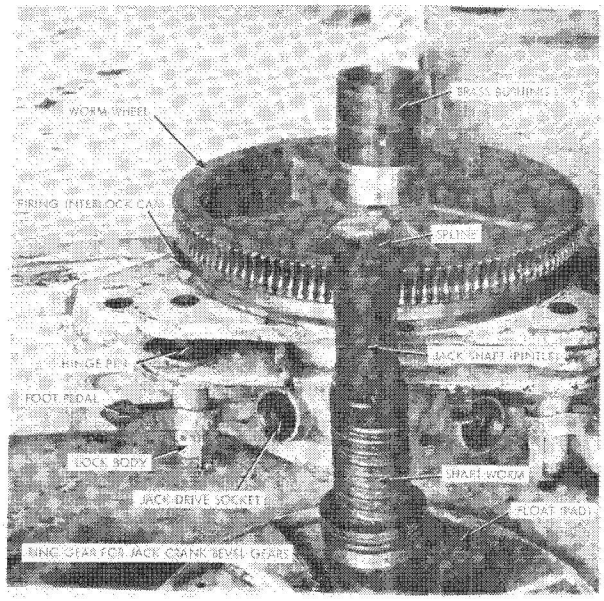

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Figure II-G-16. 122-mm D-30, bottom carriage (U).

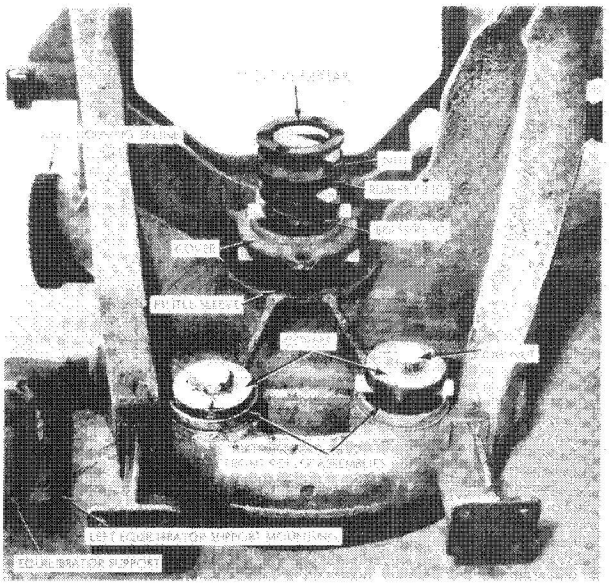

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Figure II-G-17. 122-mm D-30, front view of top carriage (U).

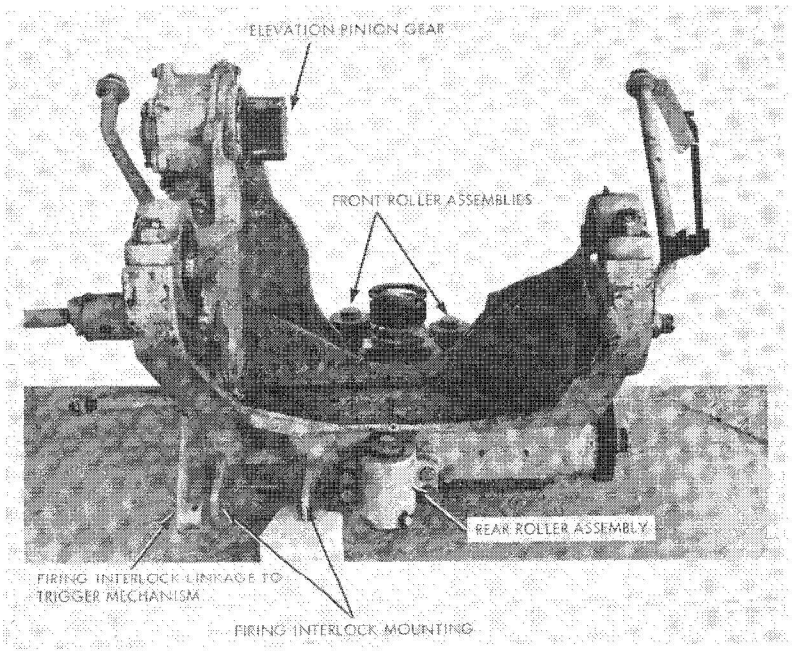

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Figure II-G-18. 122-mm D-30, rear view of top carriage (U).

recoil brake, a hydropneumatic recuperator, and a spring-loaded replenisher (fig II-G-14). The recoil brake and recuperator piston rods are attached to the forward end of the cradle and, along with their pistons, remain stationary relative to the cradle. Both cylinders, attached to the breechring, move in recoil. Counterrecoil buffering is accomplished through throttling of the recoil fluid, and, lastly, by a rubber buffer mounted in the lower forward section of the cradle. The spring-loaded replenisher accepts Steol M recoil fluid from the recoil brake as the brake is heated during firing, and, by its spring-loaded action, maintains the proper oil level by reinjecting the fluid into the recoil brake as the brake cools. A plunger valve causes the replenisher to accept or dispense recoil fluid during the last 9 to 11 mm of tube travel in counterrecoil. The recoil system operates at a maximum pressure of 105.4 kg/cm^2 (1500 lb/in^2). The recoil piston rod is a hollow unit with a chrome-plated outer surface. The piston rod head has six slanted holes, and the rod has three variable-depth grooves positioned at 120° intervals. The recoil brake is charged with 10.3 liters of Steol M. The recuperator is filled with 9.77 ±0.2 liters of Steol M and charged with dry air to a pressure of 47.5 to 49.6 kg/cm^2 (46 +2 atm).

(5) On-carriage fire control. A D726-45 sight mount, which incorporates elevation and angle of site mechanisms and a 6° cross-leveling capability, is employed for indirect fire (fig II-G-19). This system provides a dependent-type line of sight. Mountings are provided for both the standard Model PG-1M panoramic telescope and Model OP4-45 or OP4M-45 direct fire telescope. In emergencies, the panoramic telescope can be employed in the direct fire role in conjunction with the mils elevation scale and tabular values or the BP-1 scale on the range drum. The D726-45 sight mount incorporates primary and micrometer elevation and site scales for use in indirect fire. The elevation scale provides settings from 0-00 M to 12-00 M. The site scale is graduated from 28-00 (-200 M) to 34-00 (+400 M), with 30-00 M corresponding to the level line (zero angle of site). The range drum is designated either "D-30 R.T. No. 0.45" or "Howitzer D-30 R.T. No. 0145B." Scales on the drum are graduated in 50-meter increments. The range drum incorporates six scales (one elevation scale and five range scales). These are: A mils scale; a range scale for firing the spin-stabilized BP-1 HEAT projectile (marked "BP"); and four range scales for fragmentation-high explosive shell (OF-462 or OF-462 Zh), which are marked "OF-Full," "OF-Reduced," "OF-2," and "OF-4," respectively. No scales are provided on the range drum for the 1st and 3d charges; however, tabular settings are provided to fire 1st charge using the "OF-Reduced" scale and 3d charge using the "OF-4" scale. The direct fire telescope OP4-45 (or OP4M-45) is sometimes designated the OP-4-45A. This model sight is standard for a number of Soviet artillery weapons, but incorporates an appropriate reticle for the particular weapon on which it is to be used. The direct fire sight designated for use with the D-30 is marked "OP4-45 (OP4M-45), K D-30 No. 0000." The reticle of the OP4-45 largely is graduated for range in 100-m increments. Eight scales are provided. These consist of: A scale marked "BP" for firing the spin-stabilized BP-1 projectile with its special charge (this scale is graduated 0-400 meters and from 400 to 2000 meters in 100-meter increments), a scale marked $\frac{\text{"OF"}}{\text{PODN}}$ for firing fragmentation-HE shells OF-462 or OF-462 Zh using full charge (this scale is graduated 0-600 meters and from 600 to 4000 meters in 100-meter increments), a scale marked "BK" (this scale is graduated 0-500 meters and from 500 to 2000 meters in 100-meter increments) for firing the BK-6 (or BK-6M) fin-stabilized HEAT projectile [alternately, the BK-6 (or BK-6M) projectile can be fired using the $\frac{\text{"OF"}}{\text{PODN}}$ scale with tabular settings provided in the range tables], a scale graduated in mils from 0° to 7° for angle of elevation or other applications in the vertical plane, a stadia ranging scale, two pairs of tickmarks for firing at targets 2.7 meters and 1.5 meters high that are within grazing range, a target

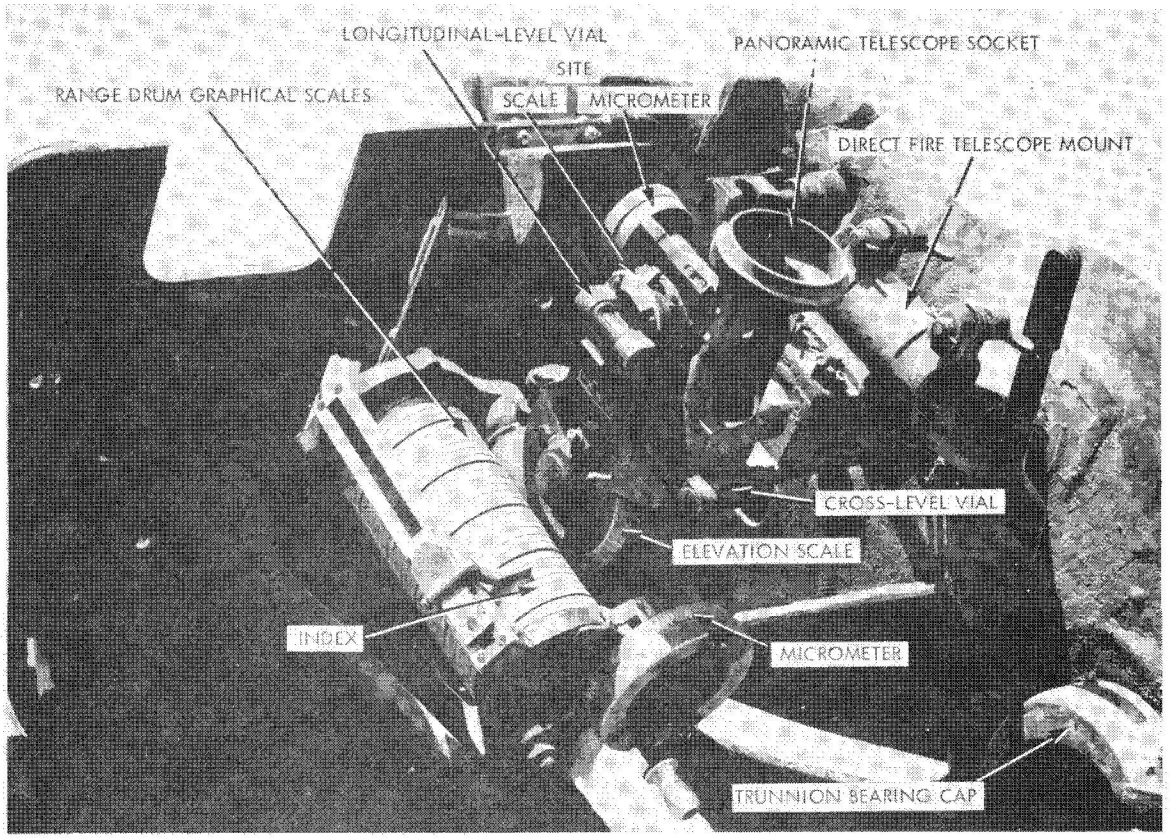

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Figure II-G-19. 122-mm D-30, on-carriage fire control (U).

lead scale (inscribed 0 to 40, right and left) graduated for target speed in km/h, and a deflection scale (22 M right and left) to facilitate bringing the fall of shot onto line.

(6) Crew protection. In the firing configuration, some protection is provided by a three-piece gun shield (fig II-G-4). The shield has essentially straight lines, is approximately 4.5 mm (0.175 inches) thick, and is fabricated from mild steel sheet exhibiting a Rockwell hardness of C-16. The right and left sections, which are mildly winged, are angled at approximately 35° from the vertical. The wheel assembly, raised when the weapon is emplaced, provides shielding on the underside of the winged portions of the shield, and the wheels serve to extend the shielded area laterally. The lower shield, attached by a hinge fixture to the upper portions of the shield, extends between the wheels. This shield is latched into position for firing. The shields

are attached with quick-disconnect fittings to facilitate maintenance. The upper center of the shield, unlike several other Soviet weapons such as the 122-mm M-30 howitzer, is open; there is no center sliding section. The front of the left shield has a storage box for electrical cables, and a battery carrier for night lighting devices is located on its lower rear face. The rear face of the right shield mounts a box containing the bore brush. The D-30 shield is designed to permit the weapon to present a low silhouette of 1420 mm (55.9 inches) measured from ground level to the top of the shield. Two apertures are provided in the left shield for engagement of targets by direct fire with the direct fire telescope and the panoramic telescope. The panoramic telescope increases the height of the weapon, in firing position at 0° elevation, by approximately 108 mm (4.25 inches).

(7) Equilibration. Compensation for muzzle preponderance is provided by a single pusher-type pneumatic equilibrator located on the right side of the top carriage (fig II-G-15). The equilibrator consists of a chrome-plated inner cylinder, which acts as a piston, and an outer cylinder with a packing device installed between the cylinders. The inner cylinder rides on the packing, which seals the device. A spring assembly is incorporated inside the equilibrator to balance the elevating force at elevations above 45° and to protect inner fittings at maximum depression (-7°). The equilibrator is mounted between a bracket that is welded to the right side of the cradle and the bearing lever of the wheel lifting mechanism. In addition to counterbalancing the muzzle preponderance, the equilibrator provides assistance in the lifting and lowering of the road wheels by applying torque to the axle through a linkage (fig II-G-20) attached to a lever mounted at the lower end of the equilibrator. The ends of the equilibrator cylinder are provided with ball fittings that engage, and are locked into, upper and lower mating sockets. A valve assembly is provided for charging the equilibrator. The outer cylinder is charged with a mixture of 0.45 liter of Steol M and 20 to 30 grains of graphite, and then is pressurized with dry air to 103.3 kg/cm^2 (100 atm or 1470 lb/in^2). A screw-type adjusting mechanism is provided on the attachment bracket that is welded to the cradle; this mechanism provides for making those minor adjustments to equilibrator pressure that are necessitated by changes in the ambient air temperature. Corrections made from the center of its adjustments range can compensate for temperature changes of ±14° C from that temperature at which the cylinder was charged.

(8) Axle. Unlike conventionally designed weapons, the tubular axle of the D-30 is mounted through an axle sleeve integral to the top carriage. In both the travel (wheels down) or firing (wheels up) configurations, the axle housing and two associated torsion bars are locked

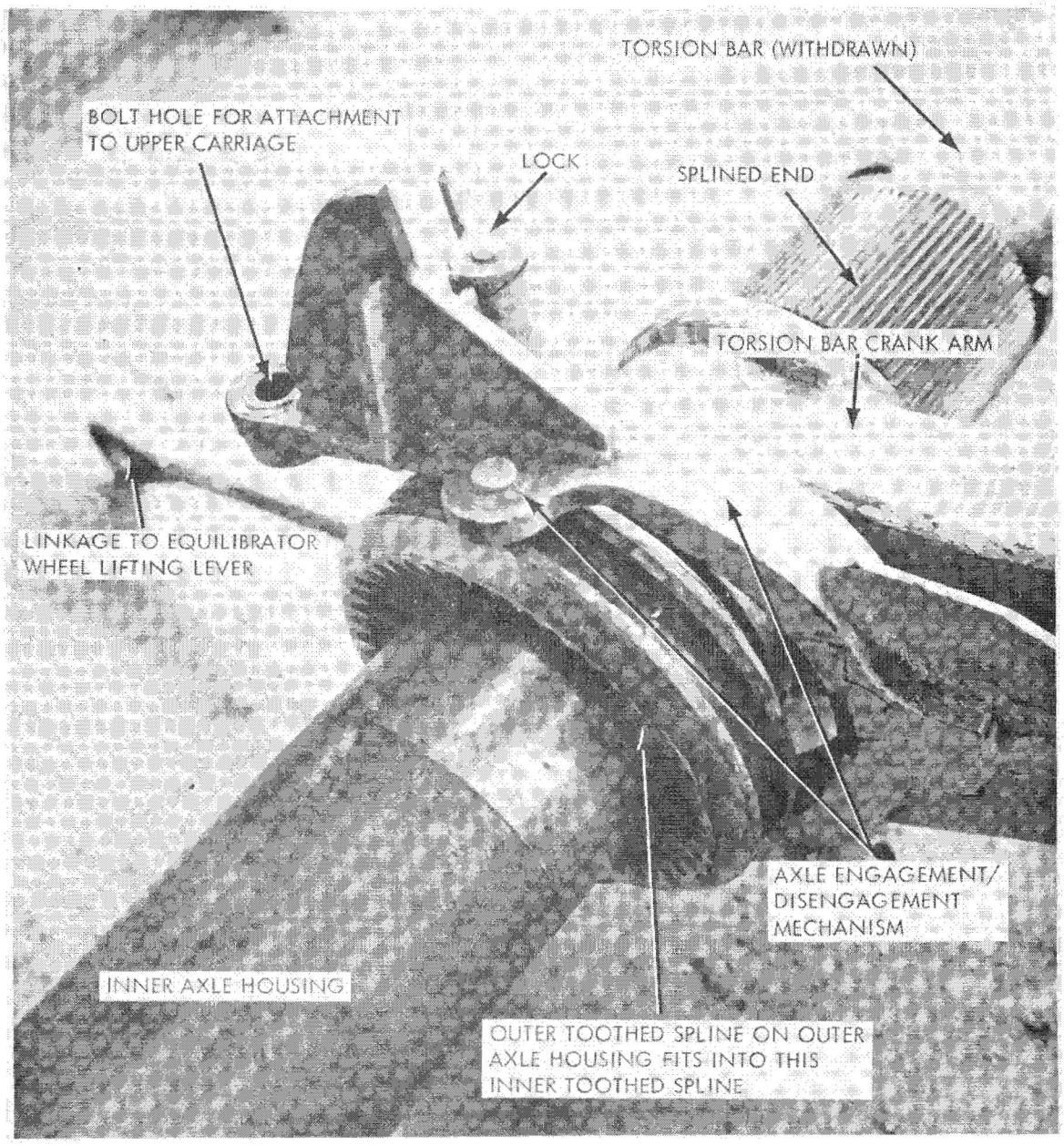

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Figure II-G-20. 122-mm D-30, axle engagement/disengagement mechanism (U).

to the top carriage through a throwout splined sleeve that engages a mating spline on the top carriage axle sleeve (fig II-G-20). The two torsion bars are locked in position by a splined central base in the axle housing. Centrally fixed torsion bars and external torsion limiters are associated with the assembly. After the howitzer's wheels are jacked off the ground and the splined axle tube-locking device is released, equilibrator force is applied as torque to the axle to assist the crew in raising (or lowering) the wheels. The weight of the axle and wheels is a component of the total top carriage (traversing) weight when the D-30 is in the firing configuration. Crank arms (fig II-G-15) are splined to the outer ends of the two torsion bars, and the opposite ends of those cranks are fitted with axle spindles on which the road wheels are mounted. A wheel lifting lever is attached to the wheel end of each crank (fig II-G-4). Suspension movement of the wheels moves the crank arms and loads the torsion bars. Overloading of the torsion bars is prevented by rubber buffered stops integral to the fixed torsion bar housing. The wheels, which are ZIL-150-type steel disks, are fitted with conventional high-speed tapered-roller bearings. The D-30 wheels mount Ya-37A, 9.00x20 GK (sponge rubber-filled) tires. These tires function effectively even after sustaining major damage. No significant difficulties were encountered during the exploitation of the 122-mm D-74 field gun, which mounted a tire of this design from which fist-sized chunks of material had been shot by counterbattery fire.

c. Bottom Carriage. This assembly is composed of a fixed trail welded to the cast bottom carriage body and two movable hinged trails that open and lock in position with 120° intervals between the trails. The trails provide a very stable base for the howitzer and permit unlimited 360° traverse. A gun (tube) stay is attached to the fixed trail for locking the tube to the trail when the weapon is placed in the travel configuration. The bottom carriage is composed of upper and lower sections welded to each other (fig II-G-16). A full circle traversing worm wheel is welded to the upper section of the bottom carriage; this worm wheel provides the stationary fixture bearing surface about which the top carriage is traversed by means of the handwheel-operated worm gear assembly. The worm wheel hub serves as the centering surface for the top carriage. The upper face of the periphery of the worm wheel is machined, and the three Belleville spring-loaded rollers of the top carriage travel upon it. Firing interlock cams (fig II-G-16) are incorporated on the lower exterior circumference of the worm wheel over the positions of the trails in the firing configuration. These cams, which through interaction with the firing mechanism interlock roller (fig II-G-10) initiate lockout of the firing mechanism trigger handle (fig II-G-18) at +18° of elevation and prior to the attainment of +22°

elevation, preclude firing of the weapon whenever the breechring is positioned over any one of the three trails. The central section of the lower part of the bottom carriage contains the screw jack; this jack is not a firing jack nor a firing pedestal. Two sockets enter the bottom carriage from the rear at an angle of 70° from each other. These sockets house the crank drives that terminate in bevel gears that operate against the ring gear at the base of the jack shaft (fig II-G-16). Vertical hinge pin holes are provided for each of the two movable trails. Locking pin holes and spring-loaded, pedal-operated, lockpins are provided to secure the trails in the firing position at 120° intervals. The top and bottom carriages are joined by a brass bushing installed through the bottom carriage (fig II-G-16) and a steel sleeve installed through the top carriage (fig II-G-17). The lifting jack worm shaft is installed through the inside sleeve and bushing from the underside. The upper end of the jack shaft thus serves as the pintle between the top and bottom carriages and the fixture about which the top carriage rotates. This assembly is joined with a ring, a collar, and a rubber ring, and is locked into position with a cover that is bolted to the top carriage. Rotation of the shaft of the firing jack is prevented by an internally splined locking collar that slips over the external splines of the jack shaft and is secured by cap screws.

(1) Jack assembly. A mechanically operated screw jack is provided on this weapon to enable the guncrew to raise the weapon's wheels clear of the ground, rotate the roadwheels upward, spread the movable trails, and then lower the trails to ground engagement to emplace the weapon. This procedure is reversed to march order the weapon. Again, this jack is not used as a firing pedestal. Operation of the jack is accomplished through the manual operation of dual cranks having needle bearing-mounted bevel gears which engage the ring gear on the jack nut. The jack nut and jack shaft have mating helical grooves that house 126 thrust ball bearings as the male components through which screw action is achieved. A brake device that prevents spontaneous lowering of the howitzer is provided by spring-loaded rollers in the housing of the right jack crank. This brake is activated by holding the left crank in position when the jack is extended, and then turning the right crank in a clockwise direction to place additional tension onto the brake disk. The long axis of the oval, hinge-connected, firing jack float (pad) is aligned parallel to the axis of the cradle trunnions to minimize instability when the weapon is in the raised position. The spline at the upper end of the jack shaft (fig II-G-16) meshes with the splined locking collar shown in figure II-G-17 to prevent rotational movement of the jack shaft during the raising and lowering of the weapon.

(2) Trails. The three trails (fig II-G-11), all of which are of welded-box design, are reinforced with bars both internally and externally. The primary trail is welded to the bottom carriage body. This fixed trail has a hinged gun stay attached to it proximate to the trail end; the tube is fixed in the gun stay when the weapon is placed in the travel configuration. The gun stay is latched down to the trail during firing. The two movable trails are hinged to the bottom carriage through a conventional hinge pin arrangement. These trails are locked in the extended position with pedal-operated, spring-loaded locking pins (fig II-G-16). Each of the three trail ends has a circular pad with an aperture through which a painted, angled, steel trail stake that is perforated for weight reduction is driven to provide for anchoring and for stability similar to that provided by a trail spade. The firing stability of this howitzer is excellent. Normal attaching clips for ancillary equipment, including trail stakes, ramrods, pioneer tools, etc., are provided on the trails. Additionally, a mounting base is provided on the right (movable) trail for the model 52-I-035 hydraulic pump, which is used to service the recoil mechanism and the equilibrator.

(3) Mobility. During exploitation, the D-30 was towed over various types of terrain, including off-road travel as well as travel on hard-surfaced and secondary roads. Formal test speeds ranged from 2 to 56 km/h (1 to 35 mi/h). Informally, it is understood that the D-30 was towed by a US M-35 truck at the maximum speed attainable, some 50 to 55 mi/h, without exhibiting instability. No difficulties were encountered and no damage was incurred by the weapon during road testing. The absence of road brakes caused no noticeable effects. A handbrake would be of assistance when manhandling the weapon on a slope. Good weight distribution, the torsion bar suspension, the foam rubber-filled tires, and the towing of the weapon by the muzzle end resulted in the D-30 tracking the prime mover in an excellent and very stable fashion. The D-30 surpasses equivalent US weapons in roadability characteristics by a considerable margin, possibly being as much as 50% better.

H. SOVIET 122-MM FIELD GUN D-74

15. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 122-mm Field Gun D-74 (fig II-H-1) was first sighted in 1955. Obviously intended as the replacement for the 122-mm A-19 (M1931/37) field gun (fig II-H-2), it has replaced that weapon in most Soviet units. The D-74 in turn has been replaced in most Soviet first-echelon units by the 130-mm M-46 field gun (fig II-J-2). The D-74 is intended for use in both direct and indirect fire. It is easily recognized by its circular firing pedestal (which, in the travel position,

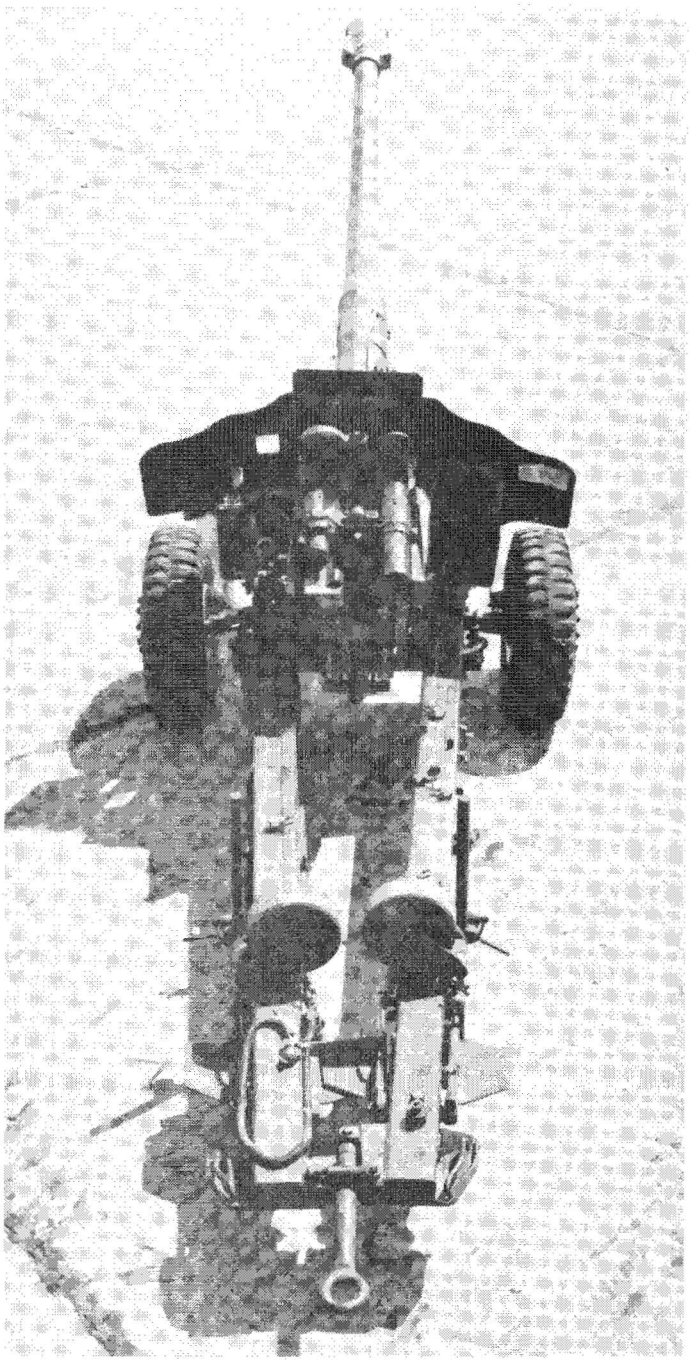

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Figure II-H-1. Soviet 122-mm field gun D-74 (U).

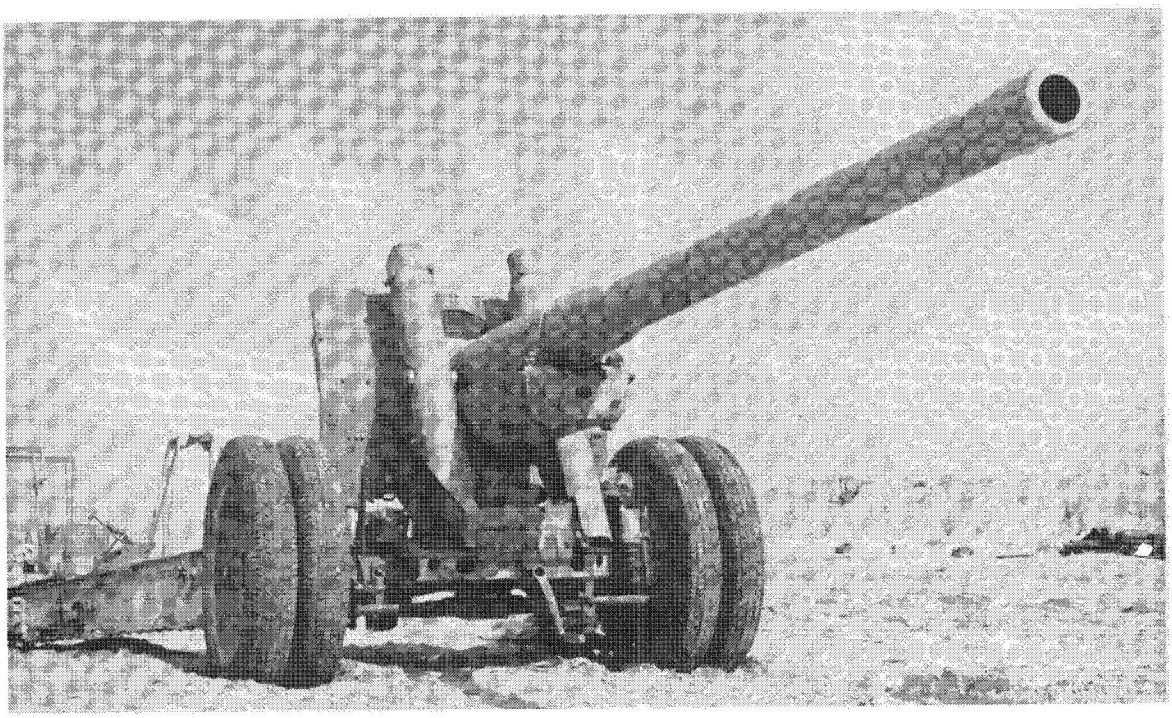

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Figure II-H-2. Soviet 122-mm A-19 field gun (U).

is inverted to act as a travel lock), a double-baffle muzzle brake, and a winged-type gun shield that extends over the two single wheels. While the carriage and its general configuration are very similar to its companion weapon, the 152-mm D-20 gun-howitzer (fig II-N-1), the 46.6-caliber length tube on the D-74 is more slender and much longer. Weighing 5.57 tonnes (12 280 lb), the D-74 in travel position is 9.98 meters (32.7 ft) long, 2.5 meters (8.2 ft) wide, and 2.75 meters (9.02 ft) high. This weapon is deployed to some front-level artillery brigades in both 4- and 6-gun batteries; i.e., 12- or 18-gun battalions. The USSR also has provided the D-74 to some Warsaw Pact countries and to North Korea, North Vietnam, Egypt, Syria, and the Sudan. The People's Republic of China (PRC) manufactures a copy of the D-74 that is designated the type 60.

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The D-74 fires a 27.5-kg (60.6-lb) HE projectile (OF-472) to a maximum range of 23 900 meters. Prescribed rates of fire over 1, 3, 5, 15, 30, and 60 min are 5, 12, 20, 50, 75, and 100 full-charge rounds, respectively. This cannon is fatigue limited,

since a safe fatigue life of approximately 1000 EFC rounds is to be expected, according to theoretical and empirical analyses conducted at Watervliet Arsenal. Nevertheless, it is evident the Soviets use the tube beyond 1000 rounds, although they do caution the user to carefully inspect for cracks after each cleaning of the cannon assembly. The Soviet medium tracked artillery tractor, AT-S, is the prime mover most frequently used with the 5568-kg (12 280-lb) D-74. This vehicle achieves a maximum speed of 48 km/h (30 mi/h) on hard-surfaced roads and 24 km/h (15 mi/h) when traveling off improved roads. The 8x8 ZIL-135 truck, as well as other wheeled vehicles of the KrAZ-214 class, has been observed towing this field gun. Other ECC use either Soviet prime movers or indigenous vehicles of generally comparable performance. The D-74 requires approximately 3 to 5 minutes to emplace or displace under normal conditions when its full crew of nine men (eight, plus driver) is employed. The unit of fire at battery level is estimated to be 70 rounds. The on-vehicle load carried by each prime mover is estimated to be 35 rounds. This weapon utilizes cased, separated loading ammunition having four propellant zones. Full charge is nonadjustable and reduced charge consists of three zones: 1st, 2d, and 3d charges. The full charge-to-projectile weight ratio is 0.351:1. Characteristics of projectiles commonly employed with the D-74 are set forth in table II-H-1. In addition the D-74 can fire the A-19's G-471 concrete-piercing projectile.

Table II-H-1. Projectiles, 122-mm D-74 Field Gun (U)

Type	Designation	In-flight weight (kg)	Muzzle velocity (m/s)	Penetration, 1000 m at 0° obliquity (mm)
Frag-HE	OF-472	27.5	885	NA
APC-T	BR-472	25.1	885	185

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(2) ~~(c)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data are depicted in table II-H-2.

Table II-H-2. Probable Errors in Indirect Fire; 122-mm D-74 Field Gun, Shell HE (OF-472) (U)

Percent of maximum range (23 900 m) (measurements in meters at various percentages)	PE_r (m)	PE_d (m)
90 (21 510, chg full)	91	16
70 (16 730, 1st chg)	60	10
50 (11 950, 2d chg)	36	5.1
30 (7170, 3d chg)	22	3.1

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(b) ~~(C)~~ Effectiveness. One measure of effectiveness is the amount of warhead weight that can be delivered in a given time. An 18-gun D-74 battalion can deliver approximately 1.5 tonne (3 volleys) of projectiles on a large (8-PE_r-deep) area target in the first 20 seconds of fire. When firing upon a 250x200-meter counterbattery-type target at a range of 20 000 meters (PE_r, 1st chg = 78 meters), and considering errors in precision only, 0.93 tonne of projectiles can be delivered on target in 20 seconds. Although not as precise as the US 175-mm gun, the D-74 due to its higher rate of fire, still delivers 1.12 times as much projectile weight within this size target area.

(c) (U) Fragmentation. The standard OF-472 fragmentation-HE projectile fired by the D-74 field gun has a forged steel body. This projectile, having a charge-to-mass ratio of 0.107:1, bursts into an average of 8201 fragments. Mean fragment mass is 2.981 grams and average initial fragment velocity is 745 m/s (2444 ft/s). Although the OF-482M projectile fired from the 130-mm M-46 gun produces 30% more fragments than does the OF-472 projectile fired from the 122-mm D-74, the 41% greater initial velocity exhibited by the fragments from the D-74's projectile produces better effect against materiel, rather than personnel.

(d) (U) Lethality. Lethal areas for the 122-mm OF-472 projectile, the primary high explosive-fragmentation projectile fired from the D-74, are presented in figures II-H-3 and II-H-4. These illustrations provide lethal areas measured in square meters for personnel

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in the standing, prone, and crouching-in-foxhole attitudes, all at four angles of fall plotted against height-of-burst in meters. Figure II-H-3 gives values for open terrain conditions; figure II-H-4 gives values for temperate forest conditions. For a definition of the concept of lethal area and its applications, see appendix II.

(3) ~~(C)~~ Direct fire.

(a) (U) Precision. Probable errors in direct fire of the 122-mm D-74 field gun are shown in table II-H-3.

Table II-H-3. Probable Errors in Direct Fire; 122-mm D-74 Field Gun (U)

Range (m)	PE_d (m) (APC-T projectile)	PE_v (m) (APC-T projectile)	PE_r (m) (HE projectile)
500	0.1	0.1	47
1000	0.2	0.2	45
1500	0.3	0.3	43
2000	0.4	0.4	42
3000	0.6	0.7	39
4000	0.8	1.0	36

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(b) (U) Grazing range. According to Soviet range tables, grazing range for the D-74's APC-T (BR-472) projectile versus targets of various heights are:

- 1060 meters when target height is 2.0 meters.
- 1220 meters when target height is 2.7 meters.
- 1280 meters when target height is 3.0 meters.

(c) ~~(C)~~ Effective range. Estimated effective range (50% probability of a first round hit) of the D-74 vs. a US M60A1 tank is about 1325 meters. The HE projectile scale on the reticle of the OP 4-28 direct fire telescope is graduated to a range of 7500 meters and the scale for the APC-T projectile (BR-472) extends to 4000 meters. First-round hit probabilities for the D-74 firing the BR-472 APC-T projectile against a frontally presented US M60A1 tank are shown in figure II-H-5. Similar probabilities for the Soviet T-12 antitank gun and the D-30 howitzer also are presented for comparison. For a description of the methodology used in the derivation of these data, see appendix III.

(d) ~~(C)~~ Engagement range. This weapon probably will open fire upon a US M60A1 tank at about 1500 meters. Depending upon the terrain and the ambient atmospheric attenuation, the D-74 probably will engage field fortifications and like stationary targets with direct fire at ranges up to 4 km.

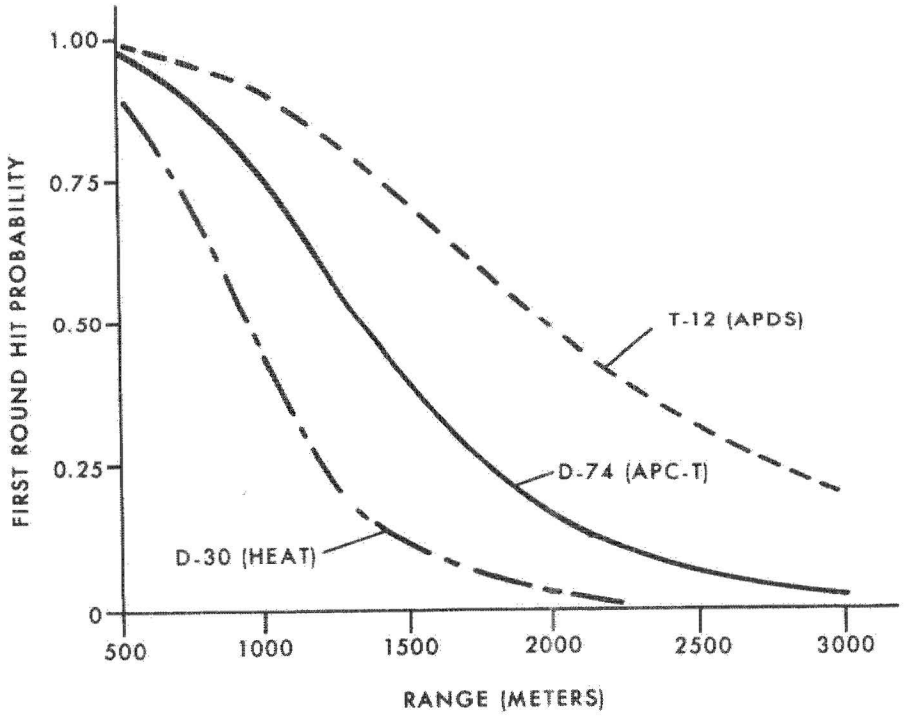

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Figure II-H-5. First-round hit probability, 122-mm D-74 field gun vs. US M60A1 tank, front attack (U).

(e) ~~(C)~~ Armor penetration. Table II-H-4 is an extract from Soviet firing tables whose figures have been confirmed by test firings.

Table II-H-4. Armor Penetration, 122-mm D-74 Field Gun Firing APC-T Projectile BR-472 (V_o=885 m/s) (U)

Range (m)	At 0° obliquity (mm)	At 30° obliquity (mm)
500	200	170
1000	185	160
1500	175	150
2000	165	140
3000	140	120
4000	120	100

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c. (U) Configuration. The carriage of the D-74 is of conventional split trail configuration and the trails are of box-section construction. A lunette is attached to the right trail end and a trail latch is attached to the left. A caster wheel is mounted at each trail end (fig II-H-1). These wheels, with the previously mentioned firing pedestal, facilitate the shifting of the weapon to engage targets lying outside of the total of 58° of on-carriage traverse. Positioning limits in elevation are -5° and +45°. The D-74's recoil mechanism (which probably is the same as that of the 152-mm D-20 howitzer) is an independent-type hydropneumatic Schneider system having a constant (nonvariable) length of recoil; such systems are distinguished by both the recoil brake and the recuperator having piston rods. The sleeve-type cradle is of cast construction. On-carriage fire control is a dependent-type system consisting of a Model S-71-28 telescope mount, a Model PG-1 or PG-1M panoramic telescope, and a Model OP-28 direct fire telescope.

d. ~~(C)~~ Summary. The D-74 (fig II-H-6) is a high performance field gun that is more mobile and lighter than Soviet 122-mm guns of earlier vintage. The D-74 achieves a 30% decrease in weight and a 12% increase in range when compared with its immediate predecessor, the 122-mm A-19 (fig II-H-2). The absence of a limber and the presence of a hydraulic jack-activated firing pedestal, as well as the trail jacks and the caster wheel on each trail end, enables the lighter weight D-74 to be emplaced, to effect large shifts in deflection, and to be displaced much easier than the 122-mm A-19 gun. The overall design philosophy exhibited in the D-74, as in most presently standard towed Soviet artillery weapons, is to develop a rugged, durable, simple weapon; as a consequence, the D-74 is relatively easy and inexpensive to manufacture and exhibits very good reliability and availability factors. The factor of safety is low in all Soviet cannon, including the D-74. The toughness of the material used in the D-74 cannon is less than that of the D-30 and M-46 guns. Although nonfunctioning features, such as welds, are not finished to a smooth appearance, they are strong and well made. The gun-to-system weight ratio of 0.4:1 and the utilization of a low-pressure Schneider-type recoil mechanism represent sound design. The time and effort necessary to train personnel to operate and maintain the D-74 is less than that required for most free world towed field artillery pieces. The D-74, although quite precise in direct fire, suffers from increasing imprecision beyond two-thirds of its maximum range; at 70% of maximum range the probable error is 0.35% of the range; at 90% of maximum range it is 0.42%; and at maximum range it is 0.45%. For comparison, precision of the US 175-mm M-107 (when similarly expressed as a percentage of range) is 0.18% at 70% of maximum range, 0.21% at 90% of maximum range, and 0.23% at maximum range, according to US firing tables. The low charge-to-mass ratio (0.107:1.0), the large fragment size, and the relative imprecision of the D-74 at the greater ranges seriously degrades the antipersonnel effects obtainable. Its relative imprecision at more than two-thirds of maximum range also attenuates an otherwise very good capability against light materiel targets. The torsion bar-type suspension and the foam rubber-filled tires provide excellent and dependable mobility during both on and off-road travel. Probable reasons for Soviet retention of both the 122-mm D-74 and the higher performance and more precise shooting 130-mm M-46 gun in the USSR's active inventory are:

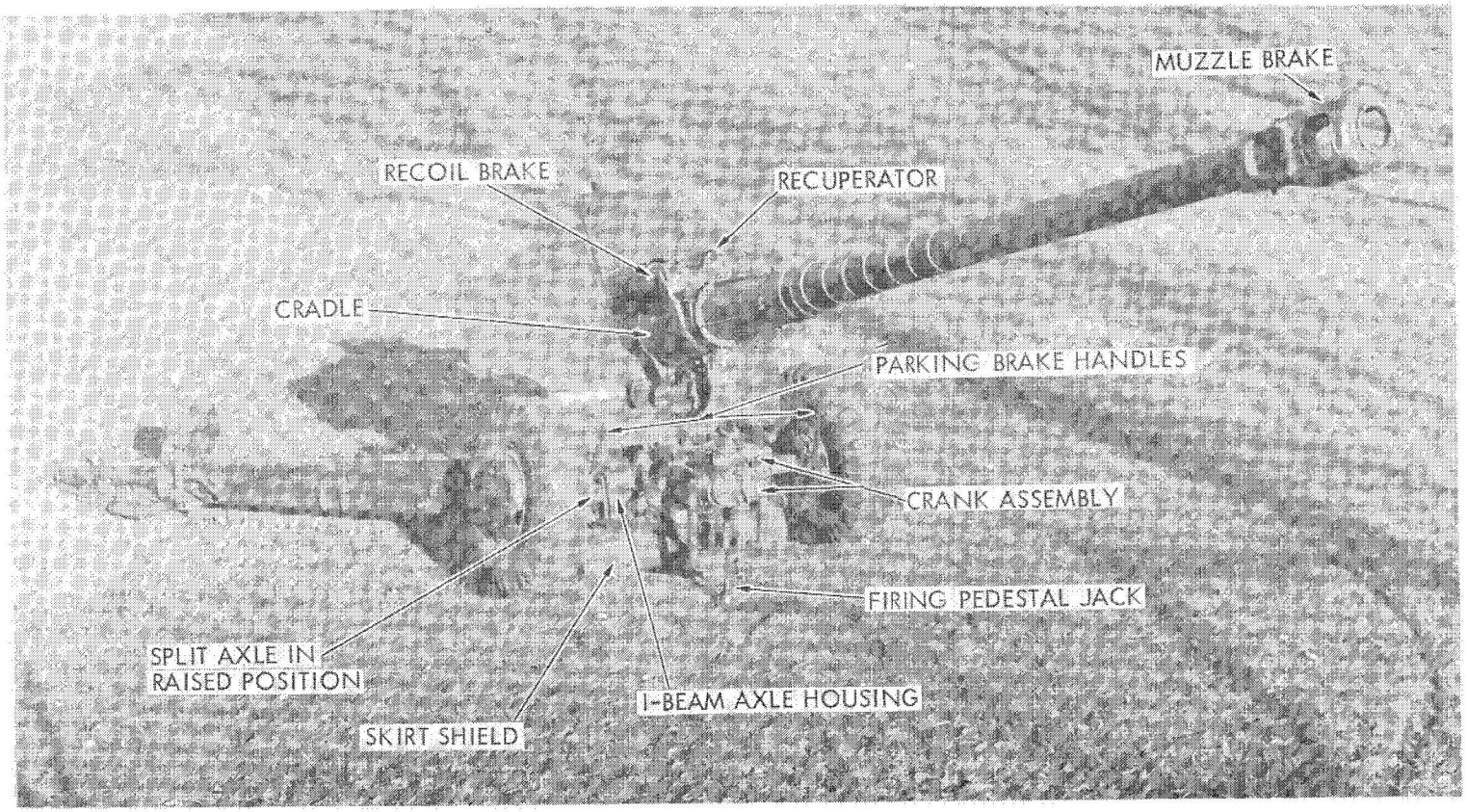

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Figure II-H-6. 122-mm D-74 field gun in firing configuration, right front view (U).

- The tube wear life of the D-74 is about twice that of the M-46.
- The time required to shift trails of the D-74 is considerably less than required for the M-46, which makes the D-74 a better weapon overall for executing direct fire missions.
- The imprecision of the D-74 is not so extensive as to preclude good execution of harassing and interdiction missions and the engagement of area targets.
- The presence of a considerable stockage of relatively unused D-74's.

16. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) (C) Tube. The monobloc gun tube is made from steel similar to US 93XX. This high performance cannon operates at a pressure of 4010 kg/cm^2 (57 000 lb/in^2). The tube design is further strengthened by an adapter sleeve made of the same steel used in the gun tube. The sleeve, which is not a reinforce (although it does serve to strengthen the tube), is used to lock the tube to the breechring and to adapt the gun to the same cradle and recoil mechanism used with the 152-mm D-20 howitzer, and, thereby, to the carriage, which is common to both weapons. Total tube length, without the double-baffle muzzle brake, is 46.6 calibers. The muzzle end has continuous left-hand threads for mounting the muzzle brake. The rifling is of uniform right-hand twist, one turn in 25 calibers. The configuration of the lands and grooves is unique for this caliber weapon. The deep [2.4-mm (0.095-inch)] rifling produces a significant increase in tube wear life, which is estimated to be 1600 EFC rounds, double the tube wear life normally realized in a gun of this performance that has conventional shallow rifling. A safe fatigue life for the D-74 is estimated to be somewhat less than 1000 rounds; therefore, this gun may be fatigue limited rather than wear limited. The impact and fracture toughness values of the material used in the tube are low in comparison with US cannon steels.

(2) (U) Breechring. The breechring houses a conventional vertical sliding-wedge breechlock that operates semiautomatically. The breech operating mechanism is manually operated for its initial opening. A fixed cam path and a follower attached to the breechring provide for semiautomatic operation of the breech, which opens during the counter-recoil cycle and closes as the rim of the cartridge case strikes the

extractors during loading. The estimated 10 000-plus round fatigue life of the breech should permit about 5 or 6 tube exchanges in actual practice.

(3) (U) Muzzle brake. The muzzle brake is a double-baffle, four-port, winged-type brake exhibiting medium efficiency. The muzzle brake contributes to overpressures at the gunner and number 1 man's stations that range up to 0.40 kg/cm^2 (5.7 lb/in^2). These overpressures exceed the US permissible limit of 3.0 lb/in^2.

b. ~~(C)~~ Top Carriage. The top carriage supports the gun, the recoil system, the cradle, the trunnions, the elevating mechanism, the on-carriage fire control, the gun shield, the equilibrator, and the pinion side of the traversing mechanism (fig II-H-7). The top carriage is constructed as a yoke to fit both over and under the bottom carriage; the lower part of the top carriage is a separate piece which, positioned beneath the bottom carriage, bolts into the top carriage, thereby attaching the top to the bottom carriage. See subparagraph c, below, and PRC 130-mm type 59-1 gun (section II-V) for details concerning the assembly of the top carriage to the bottom carriage.

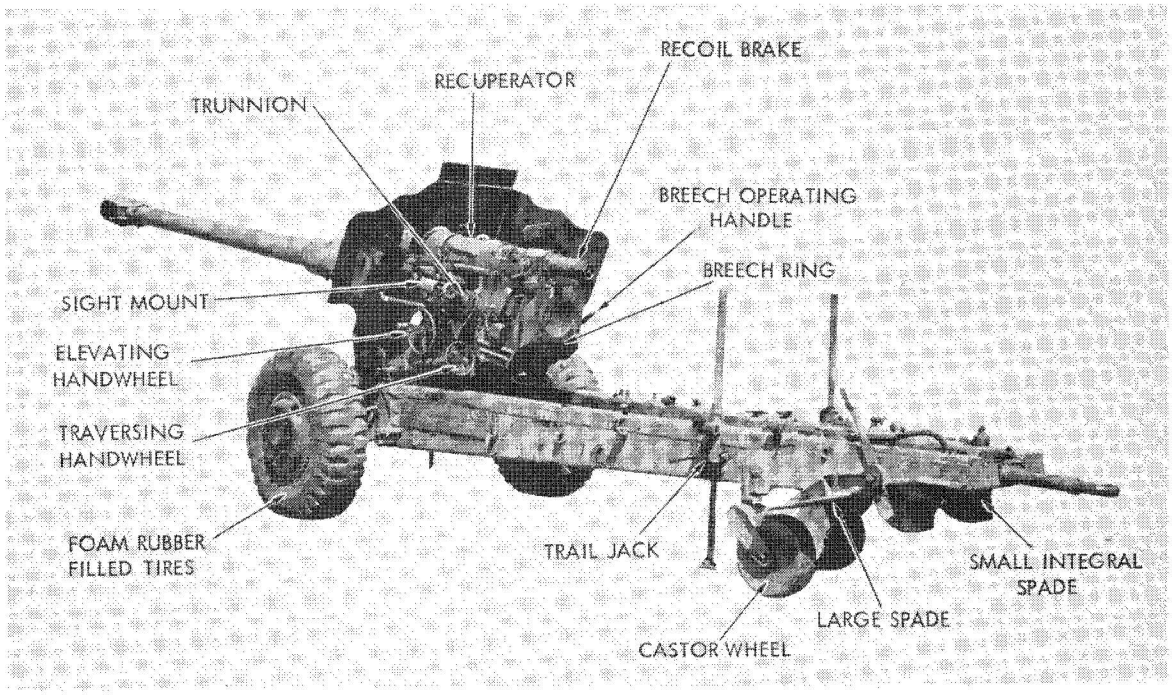

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Figure II-H-7. 122-mm D-74 field gun, left rear view (U).

(1) ~~(C)~~ Cradle. This fixture consists of a cylindrical sleeve of two-piece cast construction, the front and rear sections being welded together. The front section of the cradle incorporates three brass riders, two at the top of, and a larger rider at the bottom of, the interior of the cradle. The rear section incorporates a brass rider ring. The tube resting on these riders is held in place by a key and keyway (tongue-and-groove) arrangement to preclude any rotation of the tube during firing; the key (tongue) is on the tube and the keyway (groove) is within the cradle.

(2) (U) Elevating mechanism. This assembly is a conventional handwheel-operated rack-and-pinion-type mechanism. Elevation limits are -5° and +45°. Positioning in elevation is facilitated by the use of a dual cylinder equilibrator to overcome muzzle preponderance.

(3) ~~(C)~~ Traversing mechanism. This assembly is of conventional worm-and-pinion construction. It provides 29° of traverse, right and left of center, for a total of 58° of on-carriage traverse. Belleville springs are used in the elevating and traversing mechanisms of the D-74, apparently both to attenuate the shock of firing transmitted to these mechanisms and to tend to reposition them to the original lay.

(4) ~~(C)~~ Recoil mechanism. A Schneider-type, hydropneumatic, independent-type, constant length [890-mm (35-inch) maximum] recoil mechanism is employed. It consists of the recoil brake and the recuperator (counterrecoil cylinder). The buffer, mounted in the end of the recuperator, is adjustable to accommodate differences in the ambient temperature. Adjustment limits range over seven incremental steps. The seals in Soviet recoil mechanisms are much simpler in design and construction than comparable US seals. Soviet honing of cylinder walls is much less smooth than US honing, but is considerably less costly to accomplish. Initial pressure in the recuperator is 61±2 atm (867 to 926 lb/in^2). Maximum recuperator pressure when firing full charge at 45° of elevation is 101.6 atm (1494 lb/in^2). During the early phases of the exploitation of the D-74, US engineers were of the opinion that the relatively rough Soviet cylinder walls, plus the type of recoil fluid used (Steol M), would cause the weapon to malfunction at very low ambient temperatures. Considering the widely varying climatic conditions existent in the USSR, plus their considerable experience in cold weather operations, it would appear improbable the Soviets would deploy a weapon that does not function reliably in extremely cold weather. Soviet recoil fluid is a mixture of water, methyl alcohol, and glycerine; these are in varying proportions, dependent upon local ambient temperature. The fluid is mixed and injected into the recoil mechanism by battery-level

personnel. There is no reason to believe the D-74 is not reliable at low temperatures, since the Soviet 122-mm D-30 howitzer (which has the same type of recoil mechanism, exhibits the same degree of honing, and uses the same recoil fluid mixture) and the 130-mm M-46 gun have been fired at -65°F with no malfunctions. The greater recoiling parts weight vis-a-vis system weight, which is common to Soviet design, enables Soviet designers to develop relatively inexpensive, simple, rugged, low-pressure recoil mechanisms.

(5) ~~(C)~~ On-carriage fire control. These equipments (fig II-H-8) consist of:

- A model PG-1 or PG-1M panoramic telescope.
- Telescope mount, Model S-71-28 (fig II-H-6).
- A direct fire telescope OP 4-28.

The PG-1 type panoramic sight is standard to all Soviet field artillery pieces. The dependent-type Model S-71-28 telescope mount, which has an elevation scale inscribed from 0 to 750 M, has four graphical range scales on its range drum. Three of the range scales are for the HE projectile using charge full, 1st charge, or 2d charge, respectively. When firing 3d charge, by use of the 2d charge scale as a vehicle for the entry of range numbers from the 3d charge section of the firing table, one division of the range scale does not equate to 50 m. The fourth scale, designated the "BR" scale, is graduated for firing the APC-T projectile up to a range of 3000 m. The angle of site scale, located on the sight mount, reads from 28-00 (-200 M) to 34-00 (+400 M). The reticle of the OP 4-28 direct fire sight has a "BR" scale for firing the BR-472 AP-T projectile using charge full, an "OF/full" scale for the HE projectile with charge full, and an "OF/1" scale for the HE projectile with 1st charge. In addition, the reticle has a scale for lateral corrections, a scale for target leads, and a stadia-type scale for range determination. This direct fire telescope is fitted with a light-polarizing cap.

(6) (U) Crew protection. The D-74's gun shield is winged to extend over the wheels and is scalloped on the top edge (fig II-H-6). A hinged, skirt-type shield is attached to the bottom carriage. Thickness of each of these steel shields is 5.2 mm (0.205 inch). Apertures and doors are provided in the shields to provide visibility for the panoramic and direct fire telescopes.

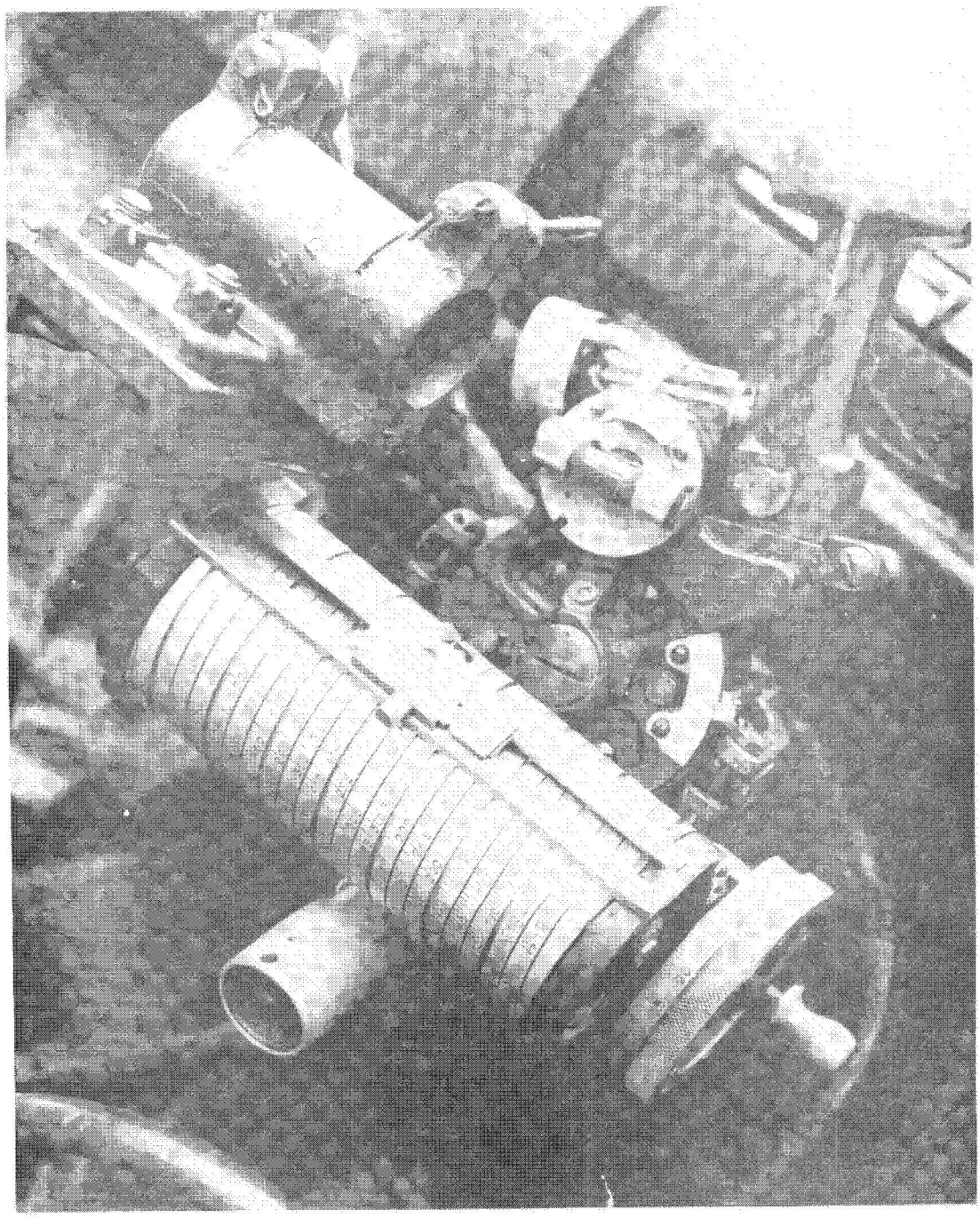

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Figure II-H-8. 122-mm D-74 gun, on-carriage fire control (U).

(7) (U) Equilibration. A dual cylinder, puller-type, pneumatic equilibrator assembly, which is centered under the rear of the cradle, is secured to the cradle and the top carriage. These cylinders are adjusted simultaneously for changes in temperature by means of a rachet-type adjustment that is common to both cylinders.

c. ~~(C)~~ Bottom Carriage. This assembly consists of a large casting that provides the mountings for the top carriage, the rack component of the traversing mechanism, the suspension system and running gear, the firing jack and pedestal, the skirt-type gun shield, and the trails. Because of their interdependence, all of these items will be discussed in conjunction with the bottom carriage proper. The bottom carriage probably contains, as does the PRC type 59-1 copy of the D-74 carriage, an upper and a lower pintle, which protrudes from the bottom carriage. The top carriage is assembled to the bottom carriage by placing the top carriage yoke (British: saddle) upon the upper pintle, which, equipped with a double set of raced roller bearings about 150 mm (6 inches) in diameter, enters a hole in the top carriage. The upper pintle, which is hollow and contains a ball thrust bearing and a set of three Belleville springs, supports the top carriage. The lower part of the top carriage yoke (the separate piece) is placed upon the lower pintle, which is equipped with a single set of roller bearings. The lower part of the yoke is then bolted to the main (upper) part of the top carriage's yoke, thereby securing the top to the bottom carriage. Clearance between the top and bottom carriages is adjusted by turning a bolt in the top carriage that bears upon the Belleville springs in the upper pintle. When the weapon is fired, the Belleville springs are compressed and the top carriage bears upon a lubricated race on the bottom carriage.

(1) ~~(C)~~ Axle. The axle housing, of I-beam construction (fig II-H-6), encompasses the two independent axles upon which the wheels are mounted. Torsion-bar suspension is utilized. The cylindrical torsion bars are splined at both ends. One end is mated to the axle upon which the wheel is mounted. The other end is mated to the crank assembly, which incorporates a gear and screw reduction mechanism for each torsion bar (fig II-H-9). The hydraulic jack to which the firing pedestal is attached is affixed to the crank assembly. With the gun in travel position, this jack/firing pedestal assembly is swung upward and the underside of the pedestal is attached to a fixture on the cradle; it thus serves as a travel lock (fig II-H-10). When the jack/pedestal assembly is lowered so as to place the pedestal upon the ground, operating the jack raises the weapon. Once the wheels are clear of the ground (and the trails are spread), two men (one per crank) operate the crank assembly, thereby loading the torsion bars, which causes the two separate axles to

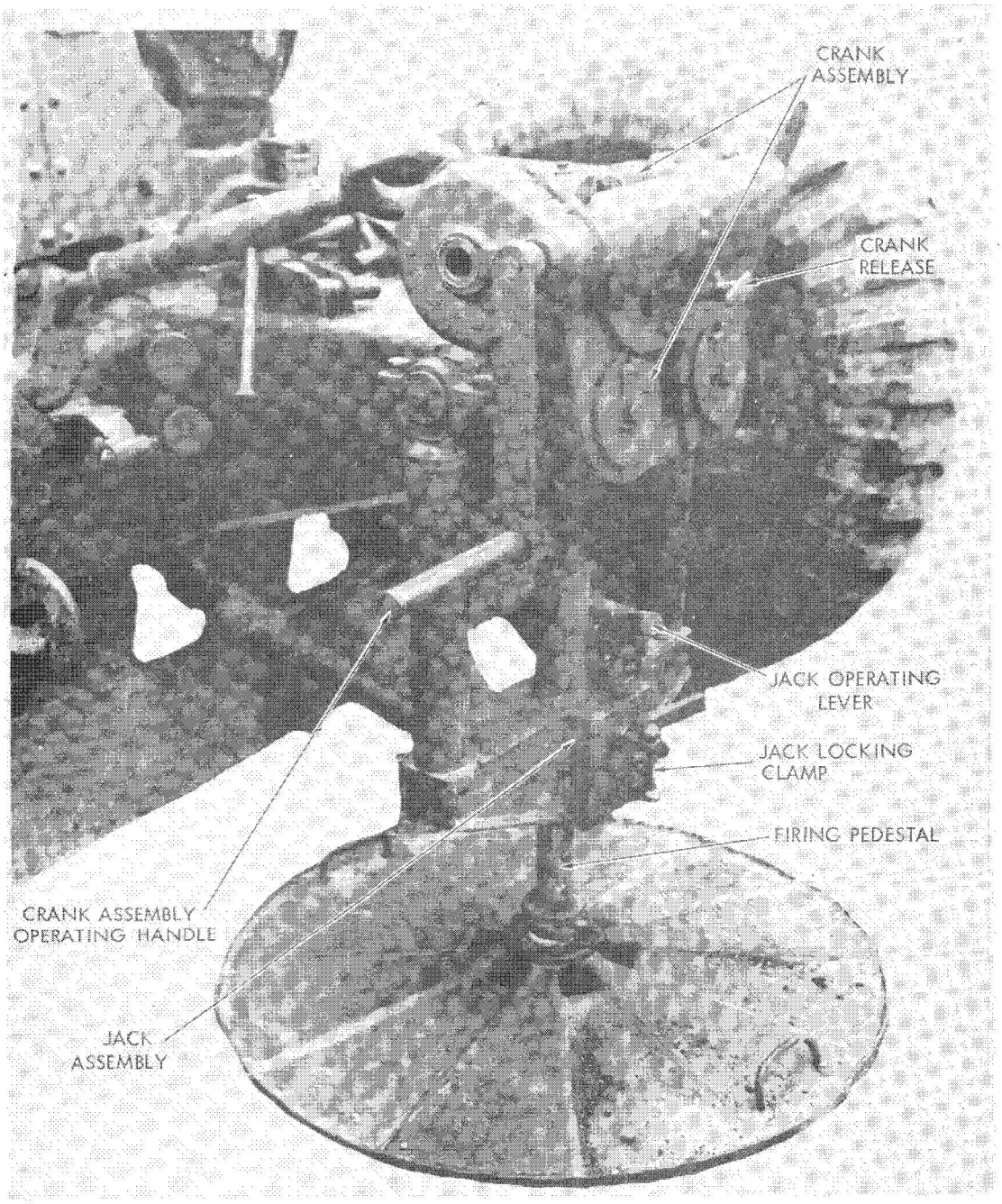

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Figure II-H-9. 122-mm D-74 field gun; crank, jack, and firing pedestal assembly in lowered position (U).

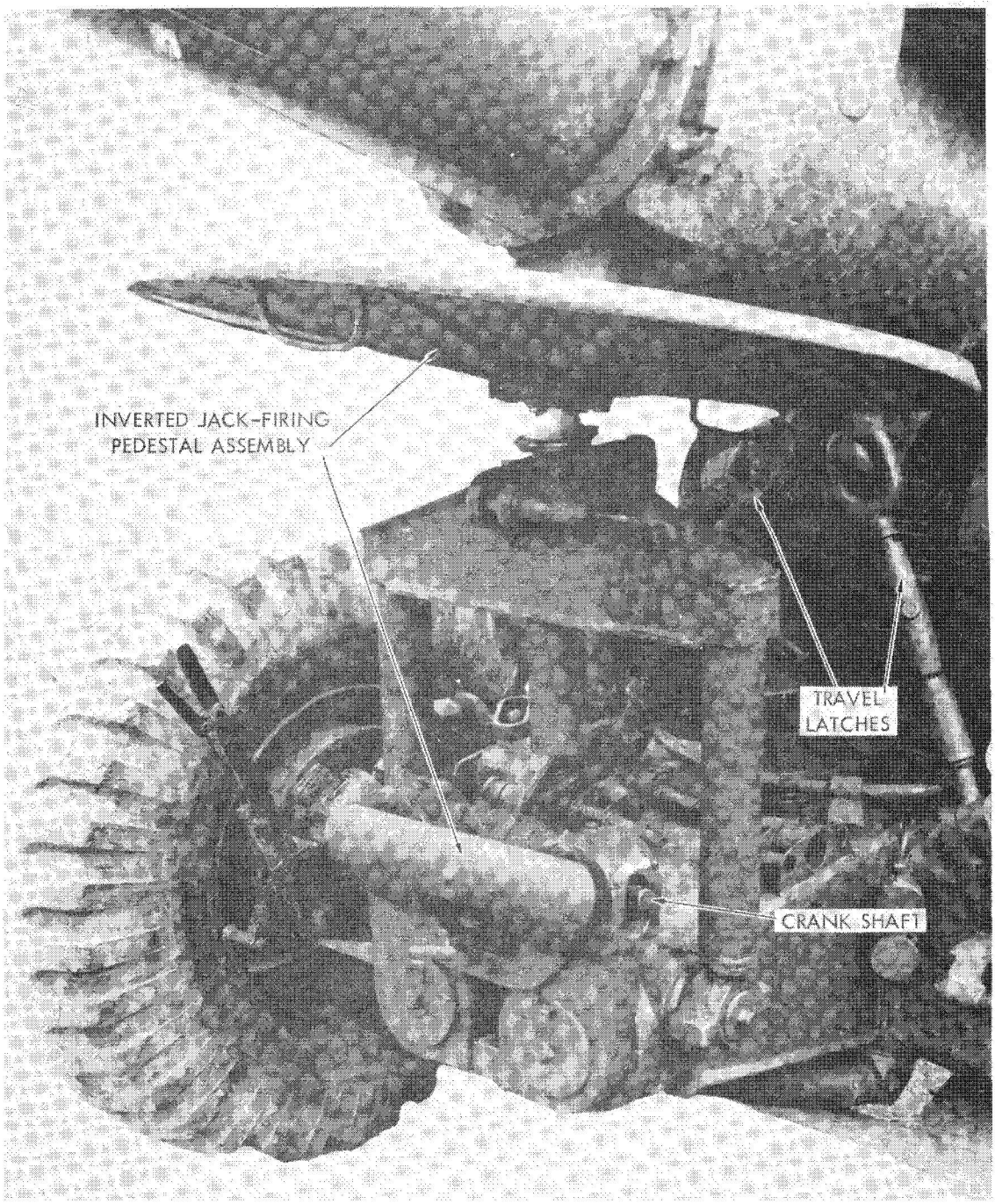

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Figure II-H-10. 122-mm D-74 field gun; crank, jack, and firing pedestal in raised position as the travel lock (U).

elevate, thereby raising the wheels higher and, the torsion bars being loaded, causes the top of the wheels to cant inward a considerable amount. The hydraulic jack can then be bled until the weapon is lowered to that position at which the wheels are just clear of the ground; when so lowered, the gun has a relatively low silhouette (fig II-H-6).

(2) ~~(C)~~ Wheels. The steel disk wheels are equipped with mechanical-type parking brakes. The primary braking system is said to be activated from the prime mover by either pneumatic or mechanical means. If true, this capability enables the weapon to be towed by prime movers employing different types of braking systems. There is no self-energizing, emergency braking feature to activate the brakes if the gun breaks free from its prime mover. This could be considered a deficiency; yet, should the Soviet experience have indicated an initial or subsequent requirement for emergency self-braking, the USSR certainly would have incorporated such a simple device into this gun. The foam rubber-filled tires are approximately the size of US 12:00x20s. Although foam rubber-filled tires are heavy, and develop a flat spot when remaining stationary for any length of time, their reliability is unequalled. One of the two tires on the D-74 tested at Aberdeen Proving Ground had the sidewall cut to such an extent that the foam-rubber filler was exposed; nevertheless, this tire performed as though it were undamaged.

(3) (U) Trails. These members are of welded box-type construction. Spreading the trails automatically unlocks the axles from their travel position by means of withdrawing a block from a socket in each independent axle; this block-in-socket arrangement maintains axle alignment during travel. The right trail end mounts the lunette and the left trail end the trail latch. Each trail end has an integral small-size trail spade. Mounted on each trail is a trail jack, a caster wheel, and a large-size trail spade (fig II-H-7). All of these items are permanently secured by being pinned to the trail so they rotate into and out of their operating positions. Operating the jacks quickly raises the trail ends to either break the spades free or to permit the caster wheels to be lowered. With the caster lowered, large shifts in direction of fire can be effected by pushing the trail ends about the pivot provided by the firing pedestal. During firing, the trail jacks and caster wheels are rotated to their inoperable (travel) position. The outer side of each trail has fixtures for carrying sections of the cleaning rod.

(4) ~~(C)~~ Mobility. The D-74 displayed excellent mobility, stability, and tracking characteristics in traveling either on or off-road.

I. SOVIET 122-MM SELF-PROPELLED GUN M1974

17. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The above titling reflects the official quadripartite nomenclature for this weapon system. This nomenclature may change because Soviet references to the system indicate that they consider it to be a howitzer. The M1974 system (fig II-I-1) was first observed [redacted] in regimental artillery batteries within GSFG. The M1974 is replacing the D-30's assigned to those batteries organic to BMP-equipped motorized rifle regiments within both motorized rifle and tank divisions. Subsequently, most of the re-equipped batteries have been upgraded from 6-gun batteries to 18-gun, 3-battery battalions. Two artillery associated armored command and reconnaissance vehicles (ACRV) are found at the battery level [one each M1974-(1) and -(2)]. The battalion headquarters has one M1974-(2) for support of the battalion commander/COP functions and one M1974-(3) for support of the battalion COFS/FDC functions plus one SMALL FRED that is believed to be a ground surveillance radar. The M1974 self-propelled gun system was paraded in limited numbers by indigenous units at Warsaw in July 1974 and at Prague in May 1975, thereby indicating that this system had been furnished to Poland and Czechoslovakia in at least token numbers. It is suspected that the M1974 self-propelled guns have been provided to other nations.

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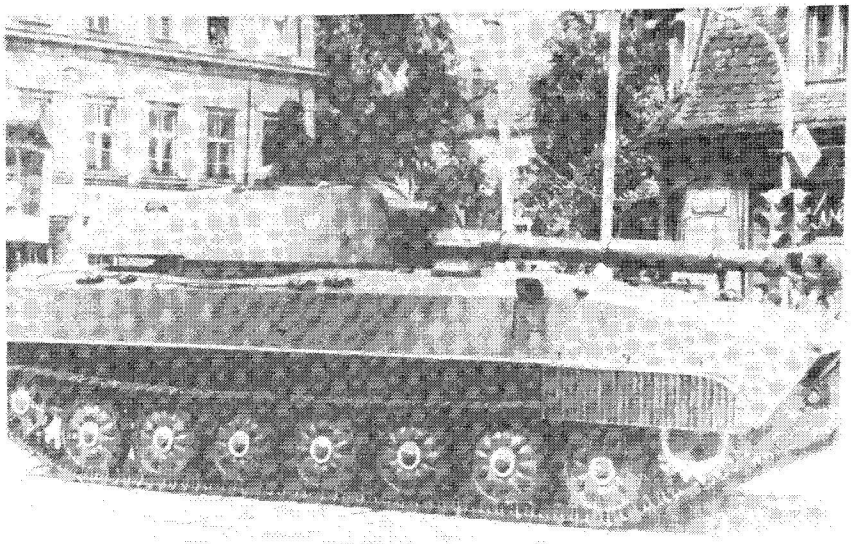

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Figure II-I-1. Soviet 122-mm self-propelled gun M1974, right side view (U).

(1) ~~(C)~~ Description. In the main, postulations concerning the M1974 self-propelled gun are based on photographic coverage and, therefore, are tenuous. The system mounts a 122-mm cannon assembly that resembles that of the D-30 howitzer on a newly designed amphibious capable chassis. Estimated general characteristics of the 122-mm M1974 self-propelled gun are provided in table II-I-1 and figures II-I-2, -3, and -4.

Table II-I-1. Estimated General Characteristics, 122-mm M1974 Self-Propelled Gun (U)

General description	Soviet full-tracked, armored, turreted, amphibious, 122-mm field artillery cannon (howitzer) system
Soviet official model designation	Unk
Soviet nickname	"GVOZDIKA" (carnation)
Recognition features:	
Initial impression	Low silhouette/trim appearance
Weight (combat-loaded)	17.0 to 17.5 t (90%)
Length, overall (including 304-mm swim ducts)	7.41 m (24.3 ft) (90%)
Width, overall	2.95 m (9.7 ft) (90%)
Height to:	
Hull deck	1.68 m (5.5 ft) (90%)
Top of cupola	2.37 m (7.8 ft) (90%)
Ground clearance	385 mm (1.26 ft) (90%)
Primary armament caliber	122 mm (99%)
Visible length of tube w/muzzle brake	3.57 m (11.71 ft) (90%)
Armor thickness	13 mm (0.5 in) (60%)
CBR protection	Probable filtered air over-pressure system (80%)
Number of roadwheels	7
Commander's IR light	TKN type on cupola (90%)
Secondary armament	None

~~(CONFIDENTIAL)~~

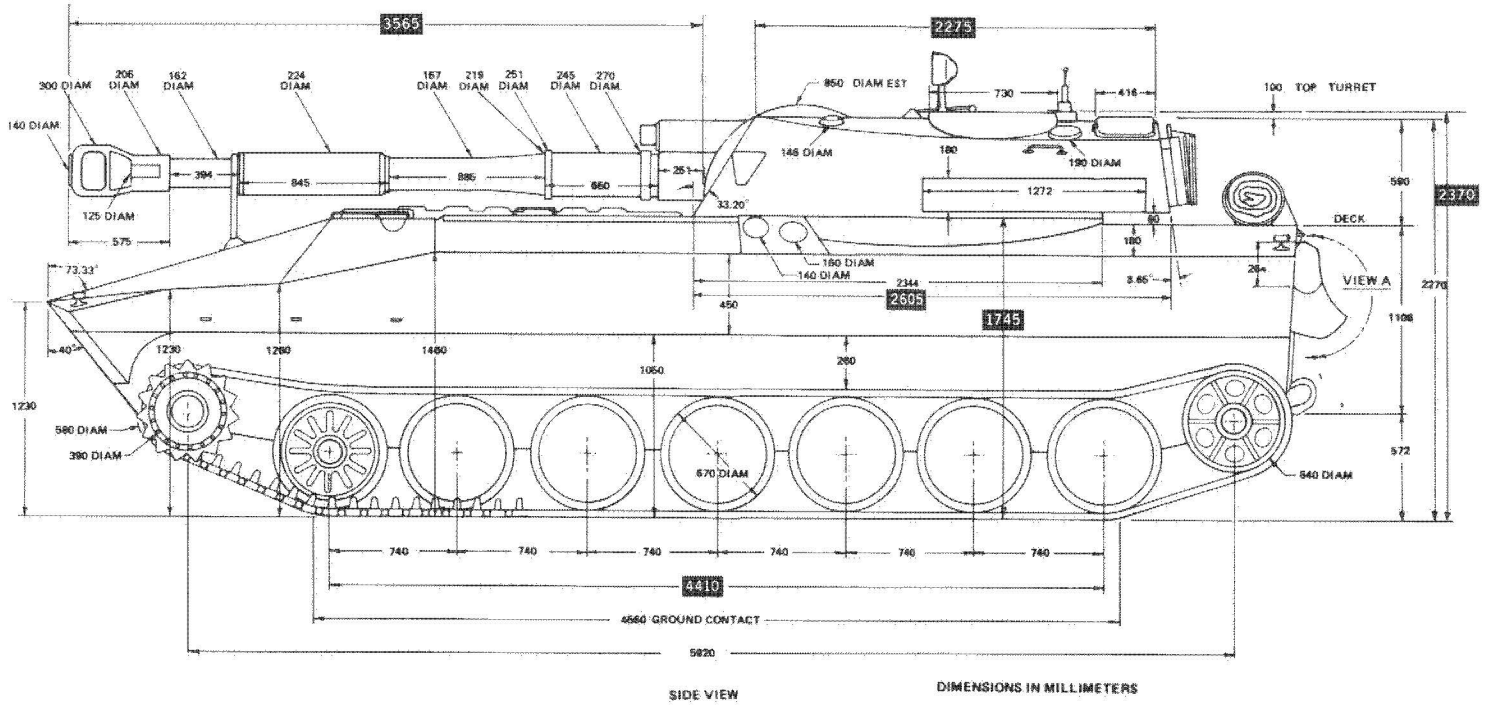

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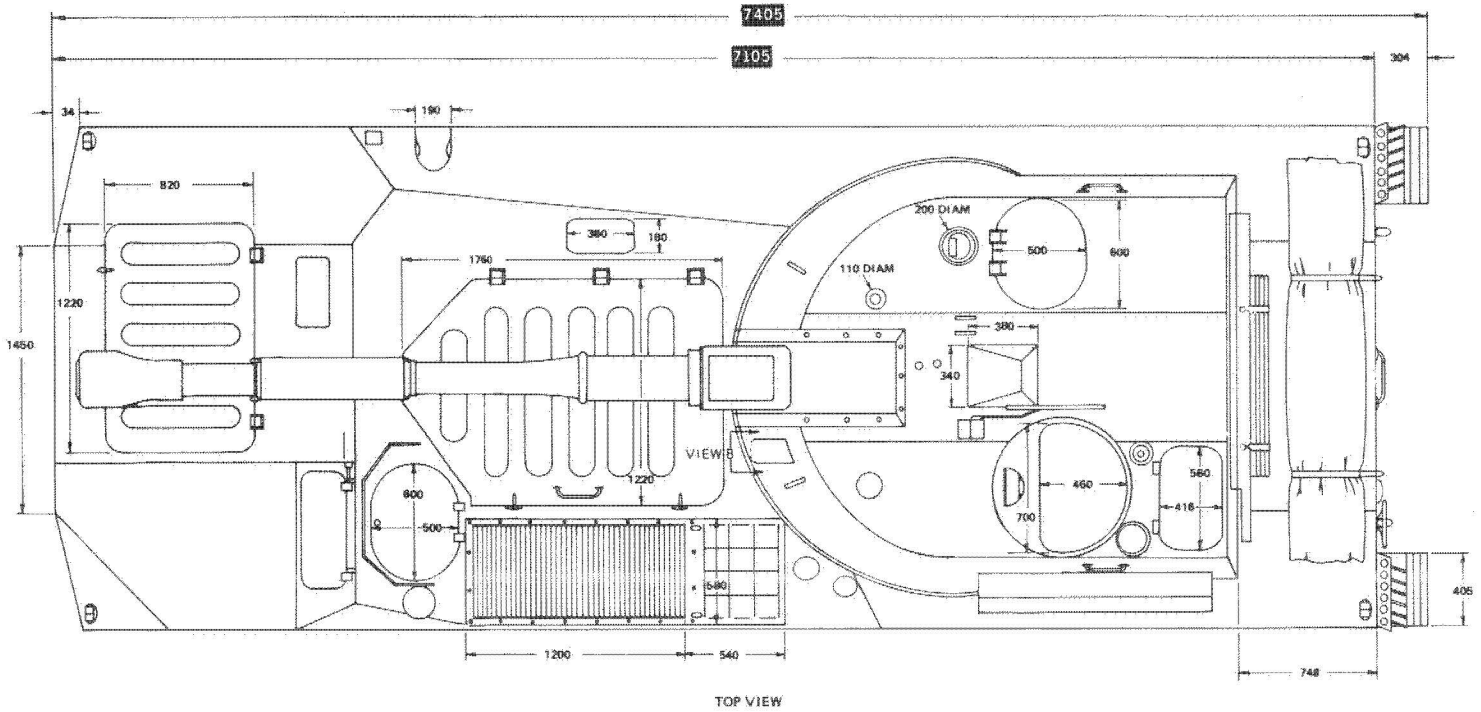
Figure II-I-2. Soviet 122-mm self-propelled gun M1974, mensuration of left side (U).



TOP VIEW

DIMENSIONS IN MILLIMETERS

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(~~CONFIDENTIAL~~)

Figure II-I-3. Soviet 122-mm self-propelled gun M1974, mensuration of top (U).

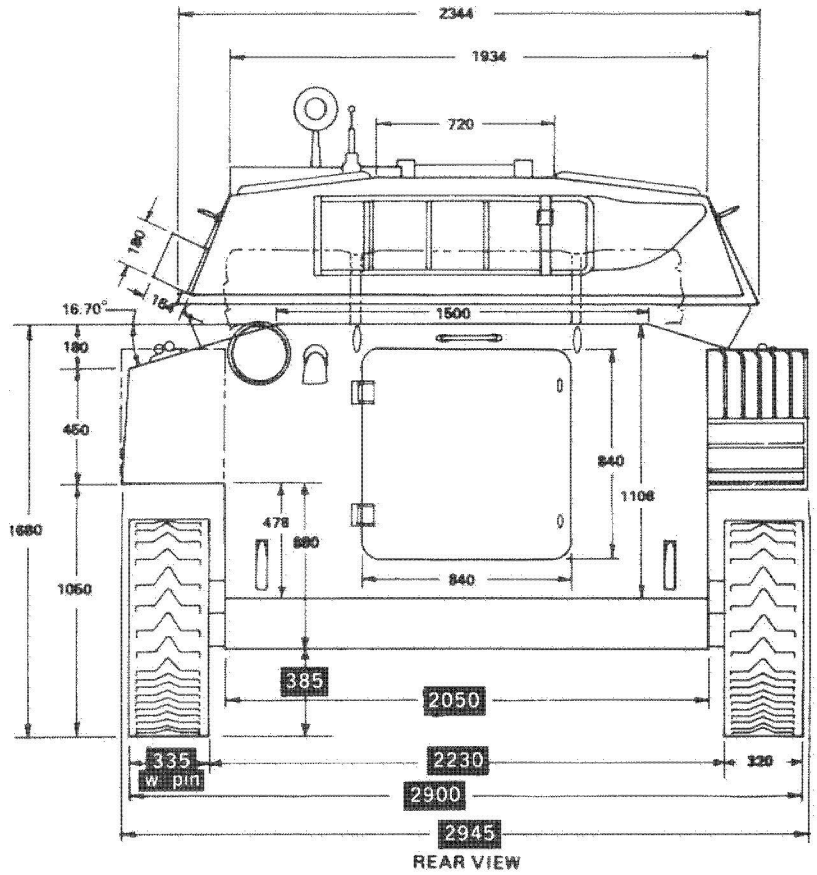

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Figure II-I-4. Soviet 122-mm self-propelled gun M1974, mensuration of rear (U).

(2) ~~(C)~~ Capabilities and limitations. Available information indicates that, when firing ammunition utilized by the 122-mm D-30 towed system, the M1974's cannon is a ballistic match of the D-30's cannon, which has a maximum range of 15 300 meters. It is possible that the M1974 could be provided, either presently or in the future, with some type of extended range projectile. In comparison with the 122-mm D-30 and M-30 howitzers, which this system is replacing in selected Soviet units, the 122-mm M1974 SP gun exhibits considerable improvements in mobility, reaction time, burst rate of fire, crew size,

crew protection against fragments, barrier-crossing capability, and CBR protection, as well as powered loading and laying devices that enhance crew performance during extended and/or mobile operations. The amphibious capability of the M1974 obviously enhances its ability for rendering continuous fire support in highly mobile operations (e.g., exploitation, pursuit, or retirement) (fig II-I-5). Nevertheless, from photography of these vehicles swimming and considering the type of traction employed, it is apparent that amphibious operations are limited to waters exhibiting low-velocity currents and low wave heights; possibly no more than 4 m/s (9 mi/h) current velocity and about 150 mm (6 in) wave height. In addition, in common with other self-propelled weapon systems, the M1974 requires increased maintenance and logistic effort above that required by a towed cannon; i.e., its RAM-D characteristics are not as good as those of a towed cannon. The limited confines of the M1974 fighting compartment and the small crew size should tend to induce crew fatigue over prolonged periods of operation; nevertheless, such fatigue can be materially attenuated depending upon the degree of sophistication present in the on-board loading and materials handling mechanisms. Table II-I-2 presents some estimated overall capabilities of the M1974.

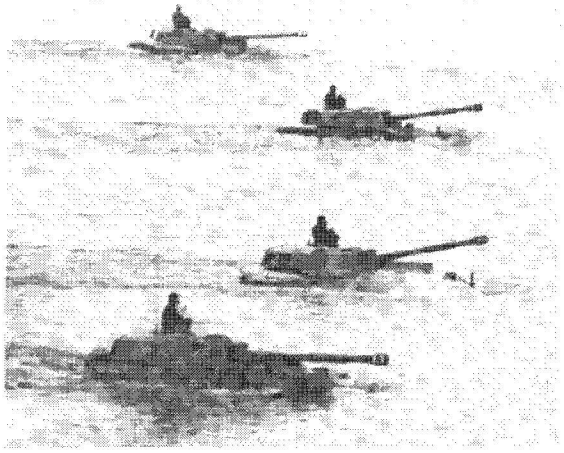

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Figure II-I-5. Soviet 122-mm M1974 self-propelled guns crossing a water barrier (U).

Table II-I-2. Estimated Overall Capabilities, 122-mm M1974 Self-Propelled Gun (U)

Caliber	121.92 mm (99%)
Maximum range w/conventional projectile	15 300 m (90%)
Complete round weight (uncrated)	29.16 kg (64.3 lb) (95%)
Weight of HE projectile (fuzed)	21.76 kg (48.0 lb) (95%)
Burst rate of fire	5 rd/15 s (70%)
Sustained rates of fire:	
1 min	10 to 12 rd (70%)
3 min	24 rd (70%)
5 min	35 rd (70%)
15 min	55 rd[1] (80%)
30 min	70 rd[1] (85%)
60 min	90 rd[1] (90%)
Onboard ammunition	40 rd (80%)
Traverse Capability	360° (90%)
Elevation limits	-4° to +65° (90%)
Tube wear life	≈6800 EFC (80%)
Speed, maximum:	
Onroad (w/governor)	70 km/h (43.5 mi/h) (80%)
Offroad	35 km/h (21.8 mi/h) (80%)
Cruising range	500 km (311 mi) (80%)
Normal crew size	4 peace (90%)
Emplace/displace time[2]	0.25 to 0.75 min (80%)
Onboard communication	R-123 (?) radio and intercom (95%)

[1]Degraded, in comparison to the D-30, by probable overheating of the tube and possible fatigue of ammunition resupply crewmen.

[2]"Emplace" is time required from arrival on position until ready to accept lay. "Displace" is time required from receipt of "march order" until vehicle commences to move.

~~(CONFIDENTIAL)~~

b. ~~(C)~~ Primary Armament. Visible portions of the M1974's tube and recoil mechanism resemble those of the D-30 howitzer (fig II-I-6). Maximum range of the M1974 equals, and could exceed, that of the D-30. The M1974 is postulated to be capable of firing all projectiles that are available to the D-30. There is a distinct possibility that other ammunition having improved ballistic performance is available for the M1974. The M1974's turret can be traversed 360°, although firing of the higher charges at the lower elevations may be restricted to 45°

right and left of the longitudinal axis because of stability considerations. Elevation limits are estimated to be -4° and +65°. Power-assisted (or, more probably, some type of semiautomatic) loading, as well as powered traverse and elevation mechanisms (probably electric drives with manual backup), is postulated for the M1974. Assuming these postulations are correct, the M1974 should attain a burst rate of fire of about 5 rounds in 15 seconds and 10 to 12 rounds within the first minute; i.e., with fuze options set and propelling charges cut on 5 rounds, and with the first round loaded into the chamber, this system should be capable of firing those 5 rounds in about 15 seconds. Estimated prescribed rates of fire are contained in table II-I-2. Three of the usual four crew members are positioned in the fighting compartment. In combat, it is probable that an additional man, possibly two, from an ammunition resupply vehicle is positioned in rear of the vehicle to onload ammunition from on-ground stockage. Onboard ammunition stores, powered loading and laying, a semiautomatic sliding wedge breechblock, and considerably improved mobility all should contribute to enhancing the conduct of fire support during a war of movement.

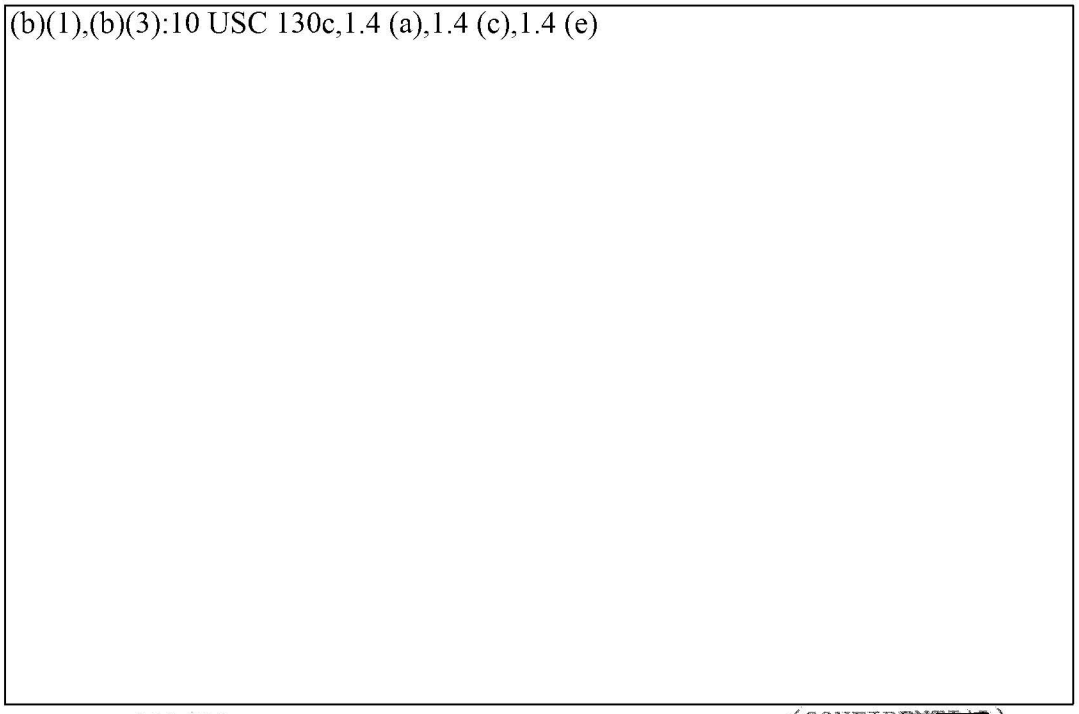

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Figure II-I-6. Platoon of Soviet 122-mm M1974 self-propelled guns (U).

c. ~~(C)~~ Effectiveness.

(1) ~~(C)~~ General. At the estimated rates of fire, and presuming compatibility of D-30 ammunition with the requirements of this system, it is expected that each 18-gun battalion of these weapons can place between 3.9 and 4.7 tonnes of ammunition on an 8-PE_r deep target during the first minute of firing. In view of the improvements noted in mobility, in the powered or power-assisted devices that probably have been incorporated, and in the sophisticated supporting equipment that has been sighted in association with this system, it is anticipated that potential Soviet field artillery combat support, especially in the conduct of mobile operations, has been vastly improved in those units equipped with the M1974. Nevertheless, these attributes probably have been attained at a considerable cost in RAM-D characteristics.

(2) ~~(C)~~ Ammunition. The 122-mm D-30 howitzer projectiles and the cased propellant used with the D-30 are compatible with this system (95%). A "super" charge may be available to provide increased range. Present or future availability of an extended-range projectile or, less probably, a RAP also is a possibility. Further, at some future date, system performance could be materially improved by effecting an exchange of the cannon assembly for a higher energy weapon in a manner similar to the upgrading of the US 155-mm M109 to the M109A1 system. The on-vehicle ammunition load is estimated to be about 40 rounds (approximately 1.16 tonnes) of primarily HE munitions but to include four or five HEAT rounds and, possibly, two or three smoke (WP) rounds.

(3) ~~(C)~~ Indirect fire.

(a) ~~(C)~~ Precision. Utilizing the D-30 ammunition identified in table II-G-1, the precision attained should be essentially the same as that presented in table II-G-2 for the D-30 howitzer firing the OF-462 HE-fragmentation projectile.

(b) ~~(C)~~ Effectiveness. Table II-I-3 provides an illustration of the attainments of the identified systems based on probable rates of fire.

(c) ~~(C)~~ Fragmentation. The OF-462 (and OF-462 Zh) projectiles used by the D-30 also are used by this system. The OF-462 projectile has a charge-to-mass ratio of 0.158:1 and bursts into an average of 14 467 fragments. Mean fragment weight is 1.231 grams. Average initial fragment velocity is 672 m/s.

Table II-I-3. Comparative Effectiveness (U)

Weapon	8 PE_r deep target, tonnes delivered by an 18-gun bn			
	first 20 s	first 4 min	first 15 min	first 18 min
122-mm howitzer D-30 (Soviet)	1.18	8.63	21.58	23.15
122-mm self-propelled gun M1974 (Soviet)	1.96	11.75	21.54*	21.93*
155-mm self-propelled howitzer M109 (US)	1.55	10.09	17.07	19.40
*Reflects the probability that the capability for replenishing onboard ammunition stockage from on-ground or other external sources commences to lag behind the rate of fire capabilities of the cannon.				

~~(CONFIDENTIAL)~~

(d) ~~(C)~~ Lethality. Presuming that the OF-462 (or OF-462 Zh) projectile fired by the D-30 is the principal HE-fragmentation round used in this system, the lethal area data presented in figures II-G-7 and II-G-8 are appropriate for use with this system.

(4) ~~(C)~~ Direct fire.

(a) ~~(C)~~ Precision. Precision data for direct fire currently are not available for the 122-mm M1974 self-propelled gun; however, those data presented in table II-G-3 should closely approximate the precision that is attained by the M1974 when firing D-30 ammunition.

(b) ~~(C)~~ Grazing range. These data are not available for the 122-mm M1974 self-propelled gun; however, the capabilities described in table II-G-4, are expected to be approximately equal to the capabilities of the 122-mm M1974 self-propelled gun when firing D-30 ammunition. If further refinement is desired, the data in table II-G-4 may be multiplied by 0.97 to account for the difference in trunnion height between these two weapons (90%).

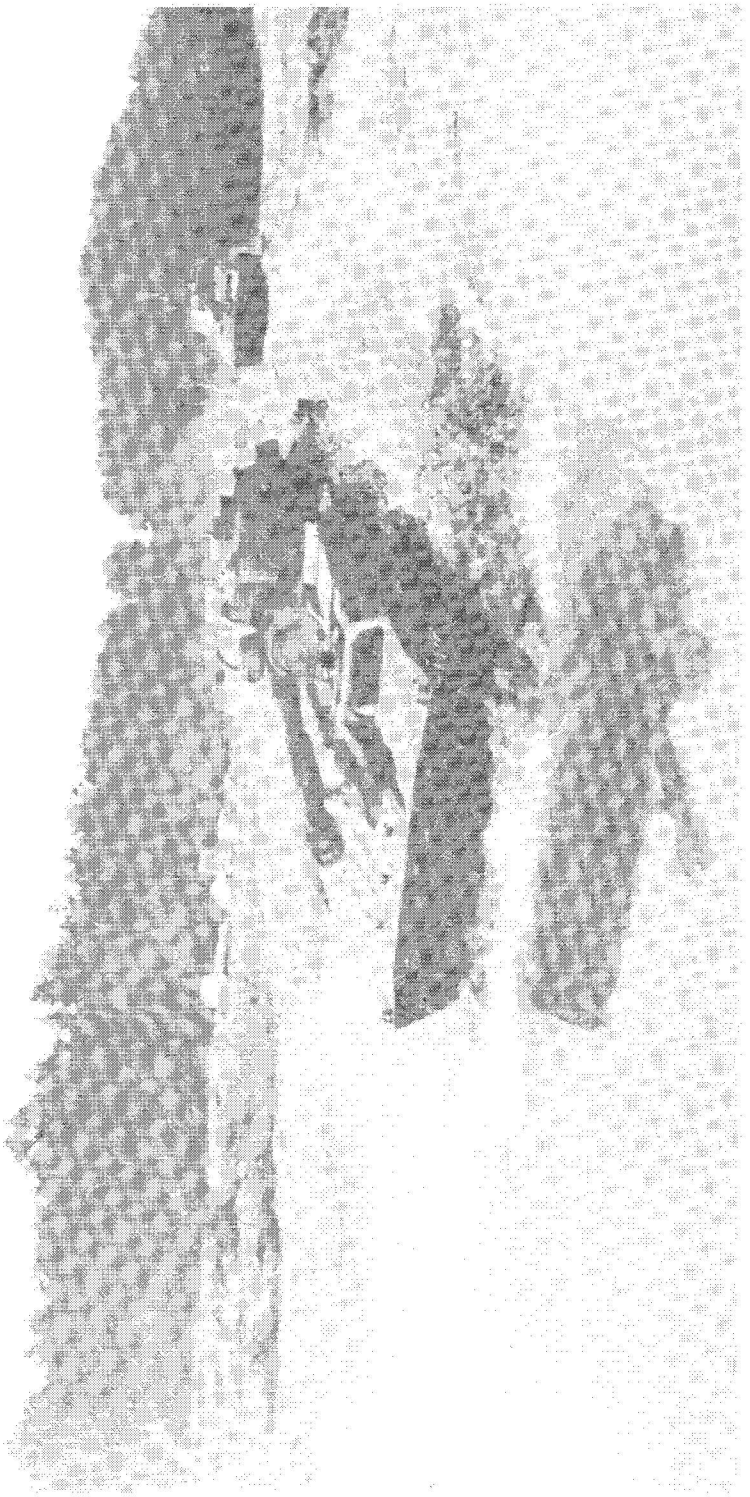
(c) (U) Effective range. This system is expected to achieve at least equal, and possibly improved, hit probabilities as compared to those achieved by the 122-mm D-30 howitzer as illustrated in appendix III.

(d) ~~(C)~~ Engagement range. The 122-mm self-propelled's gun crew is expected to commence firing against a US M60A1 tank at a range of about 1050 meters.

(e) ~~(C)~~ Armor penetration. Antiarmor ammunition available to the 122-mm self-propelled gun M1974 is believed to be that which is already available for the D-30. Projectile identification and related penetration data for these rounds are provided in table II-G-5.

d. ~~(C)~~ Mobility. Possessing mobility comparable to that of the Soviet BMP infantry fighting vehicle and currently deployed medium tanks, the M1974 is a highly mobile, amphibious, technologically modern system that enhances the responsiveness of the field artillery support available to Soviet maneuver units (fig II-I-7). The high mobility inherent in this system also results in increased survivability and added flexibility in task execution. This system is quiet-running and emits a high-pitched whine typical of turbocharged engines. The track is also relatively quiet in operation. Table II-I-4 provides data derived from analyses of available information.

e. ~~(C)~~ Summary. Introduction of this 122-mm, amphibious-capable, self-propelled system is indicative of the Soviets' appreciation that, to sustain momentum in the exploitation and pursuit phases of an offensive (and to maintain their frequently stated high daily rates of advance), the mobility of direct-support artillery units must be equivalent to that of the maneuver unit. Deployment of this system as organic to maneuver regiments equipped with the BMP infantry fighting vehicle is indicative of a Soviet appreciation that accompanying artillery is a prerequisite for continued success in the conduct of highly mobile operations. The currently ongoing increase in M1974 units from battery to battalion strength materially enhances the Soviets ability to sustain the momentum of the advance. The M1974 exhibits greatly improved mobility, communication, and crew protection capabilities over those afforded by the excellent D-30 towed system. Nevertheless, maintenance and other logistic requirements in support of the M1974 are materially increased.



Neg. 523267

Figure II-I-7. Soviet 122-mm M1974 self-propelled gun crossing a ford (U).

(~~FOR OFFICIAL USE ONLY~~)

Table II-I-4. Estimated Mobility Parameters, 122-mm M1974 Self-Propelled Gun (U)

Maximum speed:	
High gear	70 km/h (43 mi/h) (80%)
Low gear	12 km/h (7.5 mi/h) (80%)
Reverse	12 km/h (7.5 mi/h) (80%)
In smooth water	5 to 6 km/h (3 to 4 mi/h) (80%)
Engine noise level	Low
Track noise level	Low
Driving aid (IR)	TVN-2 type (90%)
Commander's searchlight (IR)	TKN series (90%)
Engine: YaMZ-238N (turbocharged) (95%)	220.6 kW (300 hp @ 2100 r/min) (90%)
Onboard fuel capacity	600 liters (159 gal) (70%)
Transmission type	Mechanical (90%)
Forward speeds	6 (80%)
Transmission ratio	6:1 in top gear (80%)
Operating radius	500 km (311 mi) (80%)
Trench-crossing capability	2.2 m (7.2 ft) (80%)
Vertical step negotiation	70 cm (2.3 ft) (80%)
Minimum turning radius	3.9 m (80%)
Gradeability	35° (75%)
Fording depth	NA
Ground pressure (average)	0.56 to 0.59 kg/cm^2 (80%) (8.0 to 8.4 lb/in^2) (55 to 58 kPa)

~~(CONFIDENTIAL)~~

18. ~~(C)~~ Component Analysis

a. ~~(C)~~ Armament.

(1) ~~(C)~~ Cannon assembly. Visible portions of the cannon assembly that are mounted through the rotor/mantlet on this weapon system (fig II-I-8) display some general similarities to the 122-mm D-30 howitzer, although there are, conversely, several elements of dissimilarity.

(a) (U) Tube. Based upon the visible portion of the cannon assembly vis-a-vis the probable location of the rear face of the breechring, the M1974's tube should be approximately three calibers shorter than that of the D-30 towed howitzer. Table II-I-5 provides data based on analysis of available information.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555530 ~~(CONFIDENTIAL)~~

Figure II-I-8. Soviet 122-mm M1974 self-propelled gun, right side, cannon and engine air intake and exhaust (U).

Table II-I-5. Estimated Tube Characteristics, 122-mm M1974 Self-Propelled Gun (U)

Tube identification (Soviet)	Unk
Soviet tube designator	Unk
Caliber	121.92 mm (99%)
Length, including breechring:	
w/muzzle brake	≈4.20 m (80%)
w/o muzzle brake	≈3.66 m (80%)
Weight (tube only)	≈680 kg (80%)
Construction	Monobloc (90%)
Autofrettaged	No (80%)

Table II-I-5. Estimated Tube Characteristics, 122-mm M1974 Self-Propelled Gun (Continued) (U)

Method of fabrication	Rotary forging (70%)
Type material	ESR steel (70%)
Chemical composition	?
Microstructure	?
Rockwell C hardness	?
Yield strength (0.1% offset)	?
Fracture toughness K_{1c}	?
Tensile strength	?
Elongation	?
Impact value (charpy)	?
Reduction in area	?
Tempering temperature	?
Tempering duration	?
Rifling	Increasing RH (90%)
Twist rate(s)	1:45 to 1:25 cal (80%)
Number of land/grooves	36 (80%)
Land width	4.0 mm (80%)
Groove width	6.6 mm (80%)
Groove depth	1.0 mm (90%)
Length of rifling	≈3.07 m (85%)
Chamber type	Tapered (95%)
Chamber length	≈600 mm (95%)
Chamber volume	≈6.9 liters (95%)
Chambrage ratio	1.05 (90%)
Chamber pressure (maximum)	?
Number of major tube diameters	4 to 5 (?) (80%)
Method of mating tube:	
To breechring	Unthreaded tube (threaded sleeve)
To recoil mechanism	Piston rods to breechring yoke (80%)
To bore evacuator	Shoulders and a threaded sleeve (90%)
To muzzle brake	Left-hand threads on tube (90%)
To mount	Tube is inserted through the sleeve and inverted cradle that are integral to the mount (95%)
Tube wear life (EFC)	≈7000 rd (80%)
Tube fatigue life (EFC)	?
Gun stay (travel lock) forward of bore evacuator	Remotely operated (95%)

~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Breech.

1. ~~(C)~~ Breechring. This fixture most probably incorporates a semiautomatic vertical sliding wedge breechblock that operates in conjunction with a powered or, as a minimum, power-assisted loading mechanism. The breechring probably is attached to the recoil mechanism by a yoke that accepts the cylinder ends. Table II-I-6 presents estimated data derived from analysis.

Table II-I-6. Estimates of the Breech, 122-mm M1974 Self-Propelled Gun (U)

	Breechring	Breechblock
Width	?	?
Height	?	?
Length	?	?
Weight	300 kg	36 kg
Material:		
Chemical composition	?	?
Microstructure	?	?
Rockwell C hardness	?	?
Yield strength (0.1% offset)	?	?
Fracture toughness K_{1c}	?	?
Tensile strength	?	?
Elongation	?	?
Impact value (charpy)	?	?
Reduction in area	?	?
Estimated breech life (EFC rounds)	21 000 (80%)	14 000 (70%)

~~(CONFIDENTIAL)~~

2. ~~(C)~~ Breechblock. The breechblock operation is estimated to be somewhat similar to that of the D-30. The breech should open, cock the firing mechanism, and latch in the open position semi-automatically through employment of a recoil-activated cam plate and crank arrangement. The breechblock closes and locks automatically when the cartridge case is inserted, and, upon seating in the breech, its rim trips the extractor latch. The breech-closing operation is powered by coil-spring-stored energy. Recoil energy provides both the direct and the stored forces required to operate the breech mechanism.

(c) ~~(C)~~ Bore evacuator. The leading edge of the low-profile bore evacuator is located approximately 390 mm behind the trailing edge of the muzzle brake. Figure II-I-3 presents the dimensions of the evacuator. The diameter of the tube under the evacuator plenum is approximately 162 to 165 mm.

(d) ~~(C)~~ Muzzle brake. The four-port, double-baffle, winged muzzle brake probably is thread-mounted to the tube and locked thereon with set screws. The brake and mounting appear similar to those used on the Soviet 122-mm D-74 field gun. Table II-I-7 presents estimated data concerning this fixture.

Table II-I-7. Muzzle Brake, 122-mm M1974 Self-Propelled Gun (U)

Type brake	Double baffle (99%)
Length	575 mm (90%)
Weight	90 kg (80%)
Efficiency	Approximately 50% (90%)
Mounting method	Left-hand threads
Max overpressures in crew area (full-charge rd)	?
Yield strength	8500 kg/cm^2 (80%) (833.6 MPa)
Rockwell C hardness	28 (70%)

~~(CONFIDENTIAL)~~

(e) ~~(C)~~ Weapon characteristics. Weight of the cannon assembly is about 1115 kg. The muzzle impulse is believed to be 1525 kg second (3360 lb second) and the muzzle energy 1.172×10^6 N·m (3.815×10^6 ft lb). System weight (≈17 tonnes) to cannon weight is about 15.25 to 15.70:1.

(2) ~~(C)~~ Cradle. The M1974's cannon assembly is secured in a mount that incorporates a sleeve-type fixture to accept the cannon (fig II-I-8 and -9). The mount also incorporates the recoil mechanism, the rotor shields, and the trunnions. The trunnions, in turn, probably are secured in a heavy support that is attached to the turret wall at two locations. Upon firing, the firing force is transferred from the cannon through the mount to the trunnions, and thence, through the mount supports, in turn to the turret, the hull, the suspension, and into the ground. In a sense the mount corresponds to the cradle of a towed weapon, and the mount support corresponds to a towed weapon's top carriage (saddle).

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555528 ~~(CONFIDENTIAL~~)

Figure II-I-9. Soviet 122-mm M1974 self-propelled gun, overhead view of turret (U).

(3) ~~(c)~~ Recoil mechanism. The M1974's recoil mechanism (fig II-I-8) appears to be essentially that of the towed D-30 howitzer. It is probable that this Schneider-type mechanism (a hydropneumatic, independent, short-stroke, constant-length type) has been modified by the incorporation of a variable length of recoil feature. Almost certainly the length of recoil has been shortened to about 650 to 700 mm. As is the case with the D-30, the cylinders of the hydraulic recoil brake and the hydropneumatic recuperator probably are attached to the breechring and thereby move in recoil. The cap positioned at the muzzle end of the mount probably protects the replenisher's tubing, the piston rod nuts, and, possibly, other components. The recoil fluid probably is Steol M. The recuperator probably is pressurized with nitrogen in peacetime and dry air in time of war. A length of recoil scale probably is incorporated into the mount. Table II-I-8 presents estimates pertaining to the recoil mechanism.

Table II-I-8. Estimated Recoil Mechanism Parameters, 122-mm M1974 Self-Propelled Gun (U)

Type	Hydropneumatic, independent, probably variable length; modified Schneider (90%)
Weight of recoil mechanism	148 kg (80%)
Method of attachment	Cylinder ends to breechring. Piston ends to front of the mount (90%)
Recoil cycle time	≈0.7 second (85%)
Maximum length of recoil	≈700 mm (80%)
Recoil pressure (maximum)	≈125 kg/cm^2 (80%)
Initial pressure in recuperator	≈47.5 + 2.1 kg/cm^2 (80%)
Fluid in:	
Recoil brake	10.3 liters (80%)
Recuperator	9.77 ±0.2 liters (80%)
Replenisher:	
Function	Serves recoil brake
Fluid quantity	0.5 liter (70%)
Surface finish (RMS):	
Piston rod	12 (80%)
Recoil cylinder	35 (80%)
Throttling rod	75 (80%)

~~(CONFIDENTIAL)~~

(4) ~~(C)~~ Crew and crew compartment. The normal onboard crew for this weapon system is believed to be four, including the gun commander, the gunner, the loader, and the driver (90%). There have been some indications that in stressful situations the crew may be augmented to five; however, the addition of another crew member into the limited space available would certainly crowd the crew compartment. Additional ammunition handlers from the ammunition resupply vehicle probably are used to process and on-load ammunition from the outside of the vehicle during periods of heavy or extended firings. The usual crew members are estimated to be located and to function as follows.

(a) ~~(C)~~ Gun commander. This man normally is located in the commander's cupola (fig II-I-9) from which he can control the activities of the other crew members and direct the operation of his weapon. Aids provided for his use include an intercom system, a radio for external communications, an IR illuminator and related equipment, vision blocks, and other (as yet unidentified) equipment. Depending upon the degree of automation, the gun commander may control the indexing of ammunition to the loading mechanism.

(b) ~~(C)~~ The gunner. This crew member is located forward of the gun commander and to the left of the trunnions. He performs the standard Soviet gunner's duties in positioning the tube for elevation and direction. The fire control instruments provided probably are more sophisticated than the conventional items normally seen associated with towed systems; however, their ultimate purpose is the same. The gunner may be provided with some improved capability for accomplishing direct fire; nevertheless the presence of an image intensifier or a passive IR imaging sight is not indicated. The elevation and traverse mechanisms are estimated to be powered, and thereby to enhance system firing capabilities. Manual backup systems are provided for emergency use.

(c) ~~(C)~~ The loader. This crewman is physically located within the periphery of the turret ring, as are the gun commander and the gunner. He is located on the right side of the cannon opposite to the gun commander. The loader probably is required to cut charges and set fuzes in addition to operating the postulated mechanized loader that is associated with this system. Much of the manual exertion normally associated with loading probably is no longer required because of the postulated powered loader; this should improve firing rates as well as reduce errors occasioned by fatigue.

(d) ~~(C)~~ The driver. The driver-mechanic is positioned in the left forward quadrant of the hull deck (fig II-I-10). A window with an armor plate cover is located directly in front of the driver for use in buttoned-up operations. A TVN-type driver's IR device probably is provided (90%).

(5) ~~(C)~~ Elevating mechanism. The elevating mechanism in this system almost certainly is power-driven. It could be an electro-hydraulic or, perhaps more probably for the Soviets, a potentiometer-controlled electric drive assisted by an equilibrator. Either type of elevating mechanism will have a manual back-up. In either case the angular rate of elevation should vary on the order of 0.1° to 5.0° per second. Due to limited space, it is probable that the Soviets have incorporated some version of the BM-21 multiple rocket launcher's single handwheel for manual positioning in both elevation and deflection. A selector on the BM-21's handwheel permits engagement of either the elevation or the traversing mechanism's gear train as desired. Angular rate of elevation with manual operation probably is quite slow, perhaps but 1 to 2 M per turn of a small radius handwheel. It is postulated that the mechanical loader can load the cannon at ≤30° of elevation and that at higher elevation the cannon must be returned to ≤30° for loading. Elevation limits are -4° and +65°.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-I-10. Soviet 122-mm M1974 self-propelled gun; forward deck, overhead view (U).

(6) ~~(C)~~ Traversing mechanism. The traversing mechanism is thought to consist of a ring and race, positioned at the hull-turret interface, being driven by an electrically powered bevel gear. This type of potentiometer-controlled electric drive should traverse the turret thru 360° at a rate of ⩾0.1° to 7° per second. If employed, the BM-21-type single wheel for both elevation and traverse should exhibit an angular rate of about 3 M per revolution.

(7) ~~(C)~~ On-carriage fire control.

(a) ~~(C)~~ Indirect fire sight. The indirect fire sight for this weapon system is located on the left side of the weapon near the left trunnion. A truncated cone shroud hood (fig II-I-9) protects the sight when it is not in use. This cover is provided with a shaft at the rear circumference that, when operated from the inside of the SP, pushes the hood up and acts as an eccentrically mounted fixture. When the shaft is up and turned, the hood is moved from over the sight and can be lowered to rest on the turret roof. The sight itself appears to have a moderate-sized head. When in use the panoramic sight head appears to be extended to about twice the height of the protective hood.

It is possible that, rather than the PG-1M, the panoramic sight is similar to the sight in the M1973. A data insertion capability direct to the sight and sight mount via data link, automatic leveling, read-out displays, and similar devices is possible; however, it is not currently postulated as having been incorporated in this system because the addition of such items to the system (as differentiated from other field artillery associated equipment such as the ACRVs), would seriously escalate cost and complicate the maintenance problem. The reticle pattern in the panoramic sight is estimated to be a standard type, useable with a collimator and, in emergencies, effective in support of direct fire requirements.

(b) ~~(S)~~ Direct fire sight. A hooded aperture is located in the forward face of the turret to the left of the rotor housing (fig II-I-11 and -15). This rather large opening has a glass window equipped with a windshield wiper. The direct fire sight is postulated to operate through this opening and to perform the functions required in delivering direct fire. The reticle of this sight is expected to include patterns associated with each of the rounds available to this system for direct fire application (e.g., HEAT and HE-fragmentation). The incorporation of some type of passive image intensification in the direct fire sight is improbable due to the small size of the interior face of this aperture.

(8) ~~(S)~~ Secondary armament. No secondary armament has to date been observed mounted on the 122-mm self-propelled gun M1974; however, a firing port is positioned in the upper central portion of the rear access door and often in the left turret wall at the gunner's station as well. Smoke generators and/or similar equipment have not been seen mounted on this vehicle.

b. ~~(C)~~ Turret. The turret, essentially a flat-roofed, horse-shoe-shaped fixture with sloped forward, side, and rear surfaces (fig II-I-6 and -9) is capable of 360° traverse. Table II-I-9 gives dimensional data for the turret.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555531 ~~(CONFIDENTIAL)~~

Figure II-I-11. Soviet 122-mm M1974 self-propelled gun, left front view of forward deck and turret (U).

Table II-I-9. Turret Dimensional Data (U)

	122
Turret top:	
Length	2.28 m (90%)
Width	1.94 m (90%)
Turret base:	
Length	2.61 m (90%)
Width	2.34 m (90%)
Height of:	
Turret proper	0.69 m (90%)
Cdr's hatch from ground	2.37 m (90%)
Diameter, at base, of:	
Cdr's hatch/cupola	0.70 m (90%)
Loader's hatch	0.60x0.50 m (90%)
Pantel housing	≈150 mm (80%)
Loader's periscope	200 mm (85%)
Slopes from vertical:	
Front of turret	33.2° (85%)
Bustle of turret	8.7° (85%)
Sides of turret	20° (85%)

~~(CONFIDENTIAL)~~

A rotor, through which the cannon, its sleeve, and recoil assembly protrude (fig II-I-6, -8, and -9), is located in the central forward wall of the turret. An 18x127-cm section chest is mounted on the left turret wall. The two track swim shrouds and a short metal ladder are attached to the turret bustle for travel (fig II-I-9). The rearmost lower edge of the turret bustle terminates some 750 mm forward of the rear hull plate. A probable speaker (or klaxon horn) is positioned on the left bustle face on some of these vehicles (fig II-I-12). The 700x460-mm rotatable commander's hatch (fig II-I-9) is located midway along the left side of the turret roof in a cupola. Soviet models and those paraded in Poland, but not those paraded in Czechoslovakia, are equipped with IR searchlights, probably the TKN-1 system, mounted on the forward part of the hatch ring. Three BMO-190 or TNPO-170 antifog/antifrost periscopes are mounted in the forward edge of the hatch ring. A "baton-like" device, which is erectable (fore and aft) on a pivot fixture, is positioned along the right side of the commander's cupola when it is oriented in the "down" attitude (fig II-I-9). Unlike a similar fixture on the M1973 self-propelled gun, this device does <u>not</u> erect over the optical axis of the panoramic telescope and therefore could not be an aiming reference for that fixture (fig II-I-17). It is postulated that, in the case of the M1974, this device is used to signal "command received," "ready to fire," etc., and, further, that it may serve as a stadia to determine the gun's relative position within the battery. The loader's 500x600-mm oval hatch is hinged on the forward edge and is nonrotatable. This fixture is located along the right side of the turret roof approximately opposite the commander's cupola. A relatively large (200 mm diameter) rotatable periscope is located forward of the loader's hatch (fig II-I-9). The purpose of this fixture has not been determined. A rectangular hinged cover approximately 56x42 cm is located in the turret roof directly behind the commander's cupola. This fixture is estimated to provide access to a probable R-123 transceiver (fig II-I-14 and -17). An antenna mount and associated antenna are located between the right forward corner of this cover and the commander's cupola.

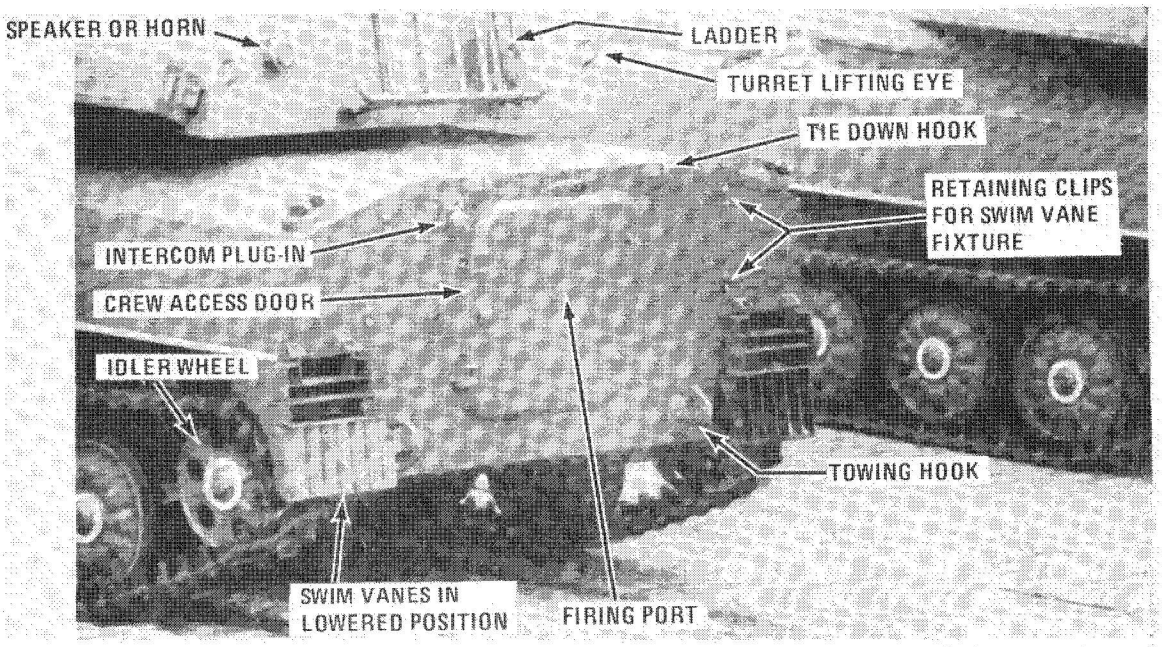

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Figure II-I-12. Soviet 122-mm M1974 self-propelled gun, rear view (U).

c. ~~(C)~~ Hull and Suspension.

(1) ~~(C)~~ Hull.

(a) ~~(C)~~ Description. This vehicle is a new design that bears some resemblance to the MTLB and the BMP. The width of the upper hull extends to the outer edges of the tracks (fig II-I-10 and -12). The upper glacis and the sponsons incline at 16.7° and the lower glacis at 40° from the vertical. The upper corners of the lower glacis contain rectangular recesses that appear to contain driving lights and, when swimming, may also provide for an inflow of water to reduce cavitation in the region of the shrouded drive sprocket. A top-hinged wave deflector is affixed to the lower glacis (fig II-I-13). The rear-hinged transmission compartment is in the upper glacis (fig II-I-10). The rear-hinged driver's compartment hatch is located at the left front of the forward deck; the radiator grill and the cooling air exhaust along its left side; the right-hand-hinged engine compartment cover in its center; and the engine air intake to the right of the center hinge on the engine compartment cover. Some M1974's have a single rectangular engine air intake; others have two circular ones. The engine exhaust is on the right sponson adjacent to the forward end of the engine compartment. A

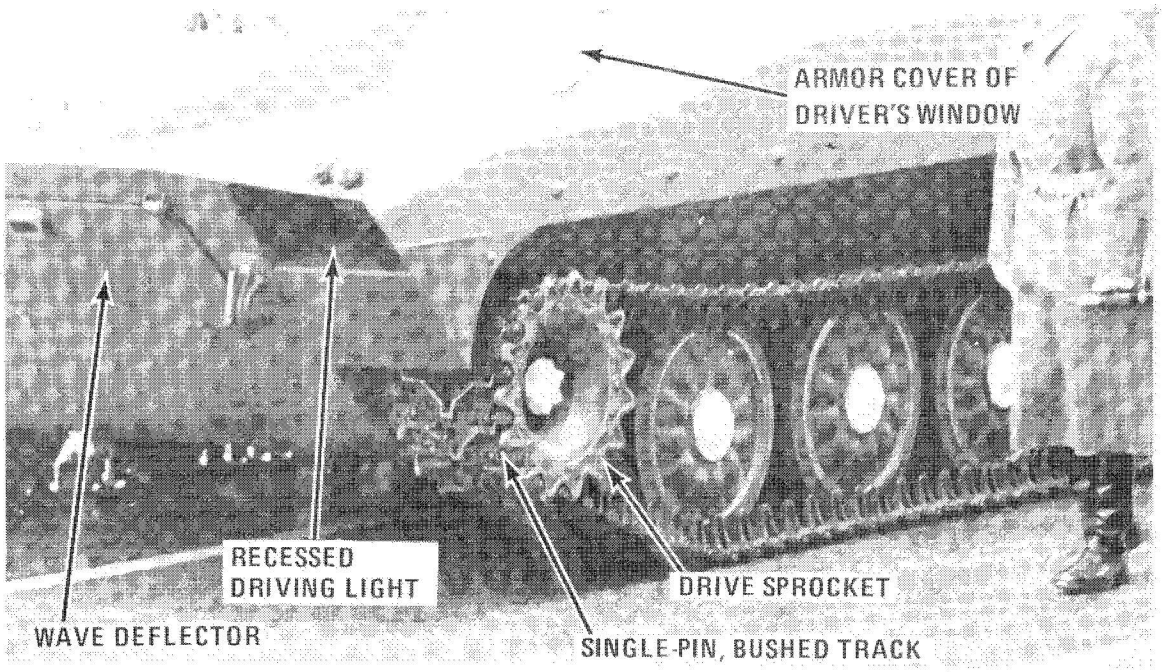

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Figure II-I-13. Soviet 122-mm M1974 self-propelled gun, left front view of lower glacis and track (U).

remotely controlled gun stay (tube travel lock), positioned in rear of the transmission compartment, engages the gun tube immediately forward of the bore evacuator (fig II-I-8). Two towing cables are stowed on the right sponson below the turret. A left-hand-hinged crew access door is positioned in the center of the rear plate (fig II-I-12). A plug to accept the intercom jack of offboard personnel (e.g., ammunition resupply personnel) is located outward from the upper left corner of the door. Towing hooks are positioned near the lower corners of the rear hull plate. Detachable, lowerable swim vane fixtures are attached above each track (fig II-I-12 and -17). "Cat eyes" are attached to the rear corner of each sponson, and fuel filler protective covers are positioned inboard and slightly forward of each "cat eyes" (fig II-I-9). Road clearance of the hull is 38.5 cm.

(b) ~~(C)~~ Protection. Hull and turret armor probably is only sufficient to afford protection from most small-arms fire and low-velocity fragments. All M1974's have a firing port in the crew access door. Some M1974's have a firing port in the turret to the left of the gunner's station; other M1974's have a plate welded over this aperture in the hull (fig II-I-14 and -11). One photograph (fig II-I-15) shows

a scab-like, apparently open-bottomed fixture mounted between the direct fire sight aperture and the gunner's firing port locations; the purpose of this scab fixture has not been determined. The presence of an NBC protective system similar to that installed in the BMP is 80% probable. In addition, considerable protection is provided by the mobility inherent in this system.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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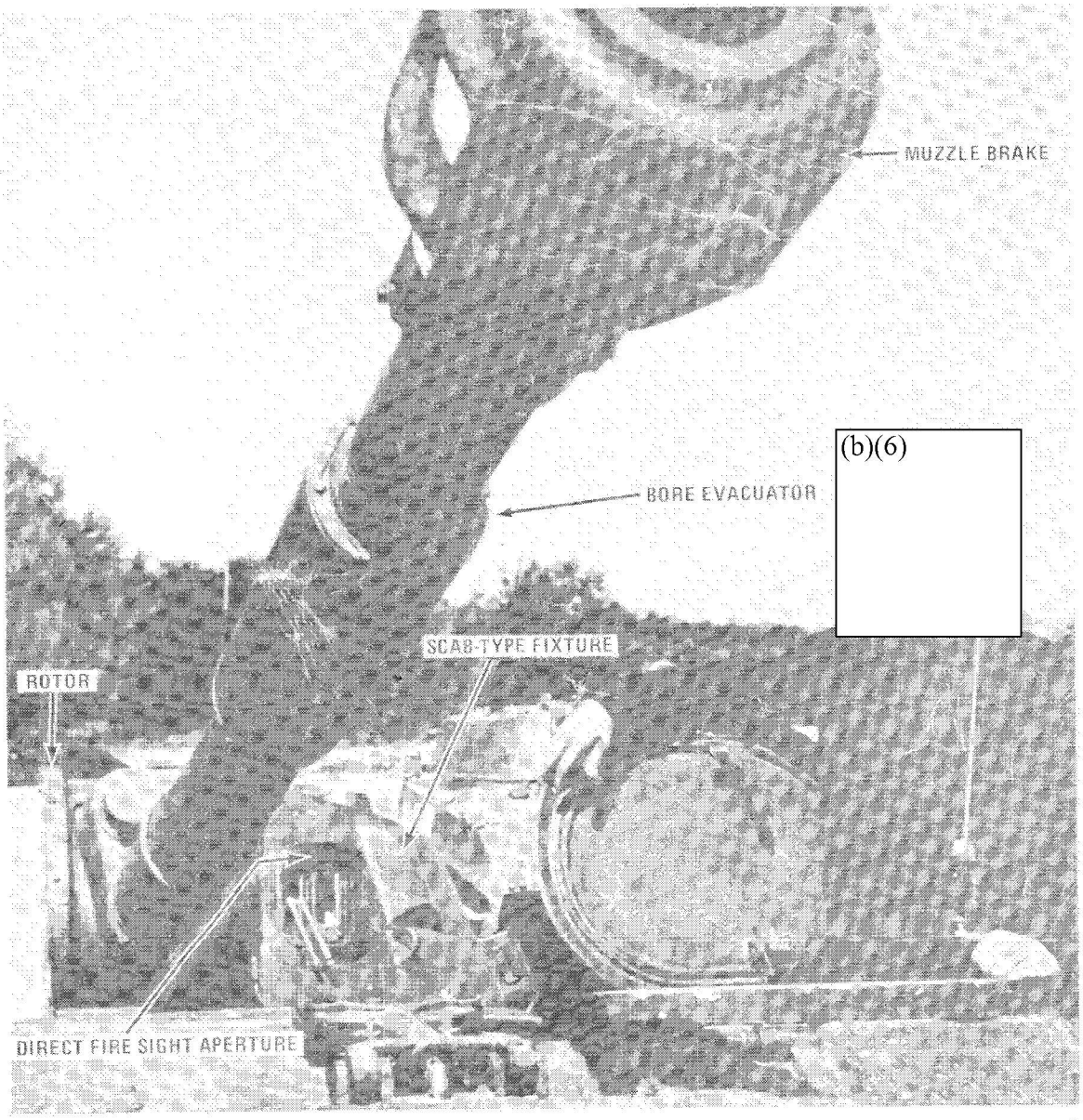
Figure II-I-14. Soviet 122-mm M1974 self-propelled gun, left side view (U).



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~~(FOR OFFICIAL USE ONLY)~~

Figure II-I-15. Soviet 122-mm M1974 self-propelled gun, front view of gun stay, cannon, and turret (U).

(2) ~~(C)~~ Suspension. A front-mounted drive sprocket, seven equally spaced torsion bar mounted roadwheels, and a trailing idler wheel support each track (fig II-I-14). The steel track, of single-pin construction, is unidirectional (fig II-I-13). The roadwheels resemble, and may be the same as, those used on the BMP. No shock absorbers are visible. No firing spade is visible; it is probable that, with emergency brakes set, the suspension can accommodate the firing force. Table II-I-10 presents additional data on the suspension.

Table II-I-10. Suspension Data (U)

Type suspension	Torsion bar, flat track
Roadwheels	7, evenly spaced
Support rollers	None
Type track	Steel, single pin, bushed, unidirectional (80%)
Track width (w/pin)	33.5 cm (90%)
Track length, ground contact	5.46 m (90%)
Total ground contact, both tracks	30 550 cm^2 (90%)
Ground pressure	0.56 to 0.59 kg/cm^2 (80%) 55 to 58 kPa

~~(CONFIDENTIAL)~~

Amphibious propulsion is accomplished by tractive effort only; i.e., the tracks propel the vehicle, no powered water jet system is utilized. Propulsion and directional stability are facilitated by the track shrouds mounted on both sides of the vehicle outboard of the drive sprocket and the leading roadwheel (fig II-I-11); by the rear-mounted swim vanes that tend to fill the wake (fig II-I-12); and, possibly, by an intake of water through the top outboard corners of the front glacis that may reduce cavitation in the vicinity of the drive sprockets (fig II-I-13). Preparing the M1974 for amphibious operations entails the following actions (note that the M1974 shown entering the ford in fig II-I-7 is not prepared for swimming):

- Raising, and latching in the upright position, the hinged wave deflector that is mounted on the lower glacis (fig II-I-13).
- Removing the track shrouds from their stowed position on the turret bustle and installing them (fig II-I-11).

- Raising the engine air intake(s) to the extended position (fig II-I-8).
- Installing the approximately 100-mm-high barrier plates around the radiator grill and the louvered cooling air exhaust (fig II-I-10).
- Releasing the gun stay and elevating the cannon to about 150 M to preclude any intake of water through the tube (fig II-I-5).
- Lowering and securing the swim vanes in rear of the idler wheels (fig II-I-12).
- Securing the driver's window and his hatch (fig II-I-11).
- Probably, equalizing of the fuel level between the port and starboard fuel tanks.
- Energizing the bilge pump circuit.
- After becoming waterborne, the cannon may be shifted in elevation and traverse to refine the trim of the vehicle (fig II-I-5).

d. ~~(C)~~ Ammunition Loading and Ammunition Handling Mechanisms. The 122-mm self-propelled gun M1974 is postulated to be equipped with a mechanical loader that selects the designated projectile from stowage, positions it on a loading tray and, after the loader sets the fuze, rams it into the tube with a repeatable seating thrust. A ribbon rammer reminiscent of that used in the BMP probably is employed. The loading tray then accepts a cartridge case, in which the propellant has been "cut" by the loader, and the rammer inserts the case into the semi-automatic breech. The cartridge case rim striking the extractor trips the breech closing mechanism. The whole process from the time the loader activates the sequence by selecting the projectile through breech closing and readiness to fire should take approximately 3 to 4 seconds and should be approximately repeatable throughout the first minute of firing. A burst rate of fire of about 5 rounds in 15 seconds and about 10 to 12 rounds within the first minute should be achievable. The spent casings probably are evacuated through the rear access door. The on-vehicle load of ammunition is estimated to be 40 rounds, including 4 to 5 rounds of armor defeating ammunition and, possibly, 2 or 3 WP. The M1974 also fires those projectiles set forth in table II-G-1 for the D-30 howitzer, although probably only HE, HEAT, and possibly, WP are available within on-vehicle stockage.

e. ~~(C)~~ Power Train.

(1) ~~(C)~~ Engine. The diesel-fueled engine mounted in this vehicle is located slightly to the right of center and somewhat forward of the middle of the hull. The powerplant appears to be the Model YaMZ-238N, eight-cylinder, 90°, four-stroke cycle, turbocharged, liquid-cooled engine, which has an output of 220.6 kW (300 hp) at 2100 r/min. An unblown, 176.5-kW version of this engine is mounted in the MTLB (M1970 artillery tractor/APC). The M1974's engine is equipped with an engine air filtration system that includes an exhaust-aspirated primary centrifugal particulate filter and a wire-mesh and oil-type final filter. The engine access door cover (fig II-I-10) is approximately centered in the hull deck forward of the turret. The 1740x580-mm louvered radiator grill (fig II-I-10) includes a 540x580-mm exhaust vent area in the rear section. The louvers in the rear section are movable and appear to be in the "open" position only when the engine is at operating temperature. The grill is located along the left side of the deck between the driver and the leading edge of the turret. Prior to amphibious operation vertical plates are installed around the grill to provide an approximately 100-mm-high "coffer dam" to preclude the intake of water.

(2) ~~(C)~~ Transmission. The transmission for this vehicle is estimated to be a variant of the transmission mounted in the MTLB. It is probably a manual device having six forward speeds, integrally controlled differential braking and steering, and hydraulically operated controls. As is the case with the MTLB, reduction gearing probably is utilized with 2d thru 6th gears. This arrangement results in the equivalent of 11 forward speeds, e.g., 1, 2, 2 1/2, 3, 3 1/2, etc. Due to the distance between the engine and the transmission it is improbable that they can be removed as one assembly.

(3) ~~(C)~~ Final drive. The final drive is expected to exhibit a 6:1 ratio and probably is a two-stage arrangement with pinion and bull gears followed by a planetary gear train.

f. ~~(C)~~ Cruising Range. The cruising range for this system, without auxiliary tanks, is expected to be approximately 500 km. The onboard fuel storage required to attain this range should approximate 600 liters (159 gallons).

g. ~~(C)~~ Auxiliary Engine/Generators. To date there has been no evidence that an auxiliary engine is mounted in this system even though it would apparently be advantageous to have such a capability in order to support sustained firings without having to operate the primary engine for that purpose.

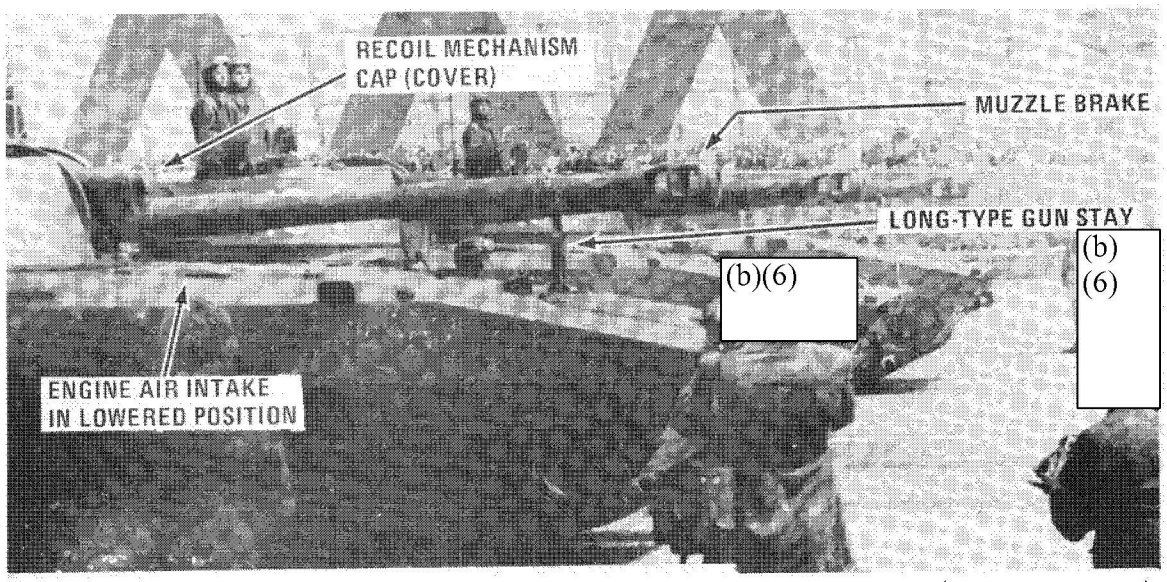

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Figure II-I-16. Soviet 122-mm M1974 self-propelled gun, right side view of cannon (U).

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555534 ~~(CONFIDENTIAL)~~

Figure II-I-17. Soviet 122-mm M1974 self-propelled gun with two engine air intakes (U).

h. ~~(C)~~ Communication Equipment. An R-123 transceiver is estimated to be mounted in the turret bustle behind the commander's cupola. It is probably associated with the access hatch located in that area of the turret as well as the antennae mounted between the access hatch and the commander's cupola (fig II-I-14). An intercom system is believed to have been provided for crew control as well as to support firing activities. This equipment very likely can be interconnected to either radio or wire communication equipment.

i. ~~(C)~~ Protective and Night-Driving Aids.

(1) ~~(C)~~ Commander's searchlight. The device (fig II-I-9) appears to be of the TKN series. This is an active, near-IR surveillance system having a range of 250 to 300 meters.

(2) ~~(C)~~ Night-driving aid. The M1974 probably employs active IR night-driving aids, probably of the TVN series. The TVN-2, for example, has a range of 60 meters.

j. ~~(C)~~ Modifications and Variances Noted. The following variances in components of this system have been observed although the purpose for the modifications have not been determined:

- The travel lock (gun stay) is remotely operated, probably by the driver. Mounted on the hull deck just aft of the transmission compartment, the gun stay engages the tube immediately forward of the bore evacuator. This fixture has been seen in both a high and low (long and short) configuration as is shown in figures II-I-8 and -16.

- Certainly two, and perhaps three, variations of the engine air intake that is located adjacent to the center of the three hinges on the engine compartment cover have been observed. Figures II-I-8 and -16 show the rectangular type fixture and figure II-I-17 shows the type consisting of two circular intakes. It is probable that the rectangular fixture can be raised or lowered and that the circular fixtures also are extendable.

- The left forward face of the turret in most models appears smooth; however, in some models there is a scab-type fixture apparently welded in place. This fixture, shown in figure II-I-15, appears to have an open area along the bottom. Purpose of this variation is unknown.

- A fixture that appears to be either a small speaker or a klaxon horn has been observed to have been mounted either on the left turret bustle, as illustrated in figure II-I-12, or on the upper rear hull plate.

J. SOVIET 130-MM FIELD GUN M-46

19. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The Soviet 130-mm field gun M-46 (fig II-J-1) was first sighted in 1954. This weapon is not the replacement for a specific weapon but represents the Soviet post-World War II requirement for extended range and greater precision for artillery weapons, particularly those used in the counterbattery role. One weapon whose role the M-46 has assumed is the 152-mm gun BR-2 (M-1935). Ultimately, the M-46 should replace the Soviet 122-mm field gun D-74. The M-46 is intended for use in both the direct and indirect fire roles. Its recognition features (fig II-J-2) are its long tube, which is transported out-of-battery;

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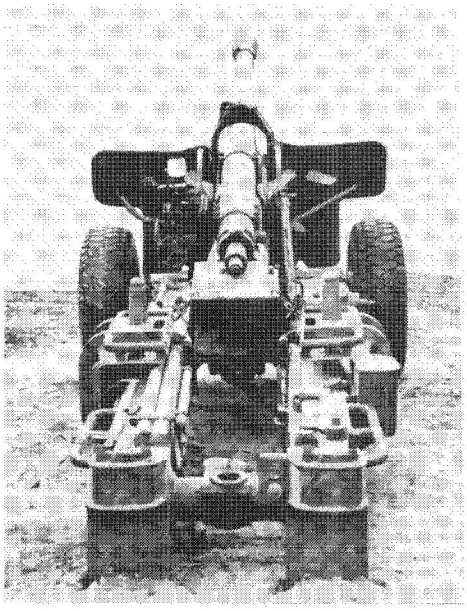

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Figure II-J-1. Soviet 130-mm field gun M-46 (U).

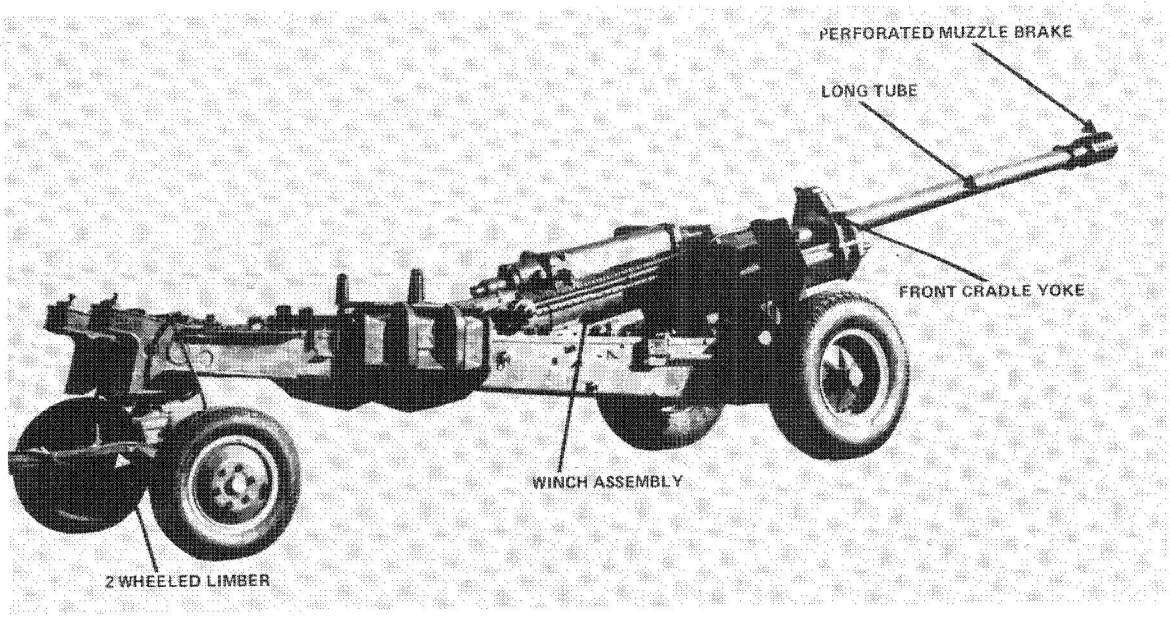

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Figure II-J-2. Recognition features--Soviet 130-mm M-46 field gun (U).

a cylindrical multiperforated muzzle brake; a two-wheeled limber; a cannon winch assembly, mounted on the right side of the weapon; and a front cradle yoke. According to Soviet design standards, the M-46 in travel position weighs 8.45 tonnes (18 630 lb), and is 11.73 meters (38.5 ft) long, 2.45 meters (8.04 ft) wide, and 2.55 meters (7.38 ft) high to the top of the muzzle brake. This weapon is deployed in the independent artillery "brigade" at army level and in the brigades of the artillery division at front level. Increasingly, unit organization is a 6-gun battery and an 18-gun battalion; nevertheless, some 4-gun batteries and 12-gun battalions are said to exist. The M-46 is classified standard in the Soviet inventory. Other countries also employing this gun include: Bulgaria, the People's Republic of China (PRC), Cuba, Czechoslovakia, East Germany, Egypt, Finland, Hungary, India, Iran, Iraq, Poland, Yugoslavia, North Korea, Pakistan, Romania, Somalia, Sudan, Syria, North Vietnam, Peru, and Yemen. The PRC produced a copy of the M-46 until about 1969. The PRC produces an unusual 130-mm gun, the type 59-1. This weapon consists of a copy of an M-46 gun tube (but with a scaled-up semiautomatic breechblock, muzzle brake, and recoil mechanism of the types used on the 122-mm) mounted upon a copy of the carriage that is common to the Soviet 122-mm D-74 gun and the Soviet 152-mm D-20 gun/howitzer.

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The M-46 fires a 33.4-kg (73.6-lb) HE projectile (OF-482) to a maximum range of 27 490 meters. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 minutes are: 5, 12, 20, 45, 70, and 100 full-charge rounds, respectively. Some recent reports indicate that there is a modified version of the M-46 which has a tube five to six calibers longer than that of the standard weapon. This version allegedly achieves a maximum range of from 30 to 31 km. The Soviet medium-tracked artillery tractor ATS-59 is the tracked prime mover used with the 8450-kg M-46. The gun is designed to achieve a permissible traveling speed of 50 km/h (31 mi/h) on hard-surfaced roads and 10 to 20 km/h (6 to 12 mi/h) when traveling on improved roads. The 8x8 ZIL-135 truck, as well as other heavy-wheeled vehicles in the Soviet inventory, increasingly have been observed towing this field gun. Other ECC use either Soviet or indigenous vehicles of comparable performance (such as the Czechoslovak TATRA-813) as prime movers. The M-46 requires approximately 4 minutes to emplace or displace under average terrain and weather conditions when its full crew of eight men (including prime mover driver) is employed. The unit of fire is estimated to be 70 rounds per gun. The on-vehicle load carried by each AT-S prime mover is estimated to be 35 rounds. This weapon utilizes cased, separate loading ammunition having four propellant zones. The charges for the M-46 are packaged in either full variable charge or a reduced variable charge, both of which require the removal of a reinforced lid. The full variable charge may be

fired intact, in which case it is referred to as charge full. With the removal of a bagged powder increment, this charge becomes 1st charge. The reduced variable charge, when fired intact, is referred to as 2d charge. With the removal of one and two bagged powder increments, the charge becomes 3d and 4th charges, respectively. The full variable charge is used with the HE and APC-T projectiles; the reduced variable charge is used with the HE and illuminating projectiles. Characteristics of projectiles employed with the M-46 are disclosed in table II-J-1.

Table II-J-1. Projectiles, 130-mm M-46 Field Gun (U)

Type	Designation	In-flight weight (kg; lb)	Muzzle velocity (m/s)	Penetration @ 0° obliquity (mm; in) @ 1000 m
HE	OF-482M	33.4; 73.6	930	NA
APC-T	BR-482	33.4; 73.6	930	240; 9.4
Smoke	DTS-2	34 (est)	930 (est)	NA
Illum	SP-46	25.8; 56.9	687	NA
Chem	?	?	?	NA

(UNCLASSIFIED)

(2) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data is depicted in table II-J-2.

Table II-J-2. Probable Errors in Indirect Fire; 130-mm M-46 Field Gun Firing Shell HE OF-482M (U)

Percent of maximum range (27 490 m) (measurements in meters for various percentages)	PE_r (m)	PE_d (m)
90 (24 740; chg full)	62	12.0
70 (19 240; chg full)	44	8.4
50 (13 750; 2d chg)	32	6.0
30 (8250; 3d chg)	21	2.9

(UNCLASSIFIED)

(b) (U) Effectiveness. One measure of effectiveness is the amount of warhead weight that can be delivered in a short time. An 18-gun M-46 battalion can deliver approximately 1.79 tonne (3 volleys) of projectile on a large (8-PE_r-deep) area target in the first 20 seconds of fire. When firing upon a 250x200-meter area counterbattery target at a range of 20 000 meters (PE_r, full chg = 46 meters), and considering precision error only, 1.48 tonnes of projectiles can be delivered on target in 20 seconds. Although 25% less precise at 20 km than the US 175-mm gun, the 18-gun M-46 delivers virtually 2 times (1.48 tonnes vs. 0.73 tonne) more projectile weight within the target area than does the 12-gun US battalion; this is due to its higher rate of fire. Even on a gun-to-gun basis the M-46 has a 35% advantage over the M107 after 20 seconds and a 71% advantage after 4 min of firing.

(c) (U) Fragmentation. The standard OF-482M high explosive fragmentation projectile fired by the M-46 field gun has a forged steel body. This projectile, having a charge-to-mass ratio of 0.152:1, bursts into an average of 10 700 fragments. Mean fragment mass is 2.722 grams (42 grains) and average velocity is 525 m/s (1722 ft/s).

(d) ~~(C)~~ Lethality. Lethal areas for the OF-482M (the primary high explosive-fragmentation projectile fired from the M-46) are presented in figures II-J-3 and II-J-4. These figures provide lethal area measures in square meters for personnel in the standing, prone, and crouching-in-foxhole attitudes, all at four angles of fall plotted against height-of-burst in meters. Figure II-J-3 gives values for open terrain conditions; figure II-J-4 gives values for temperate forest conditions. For a definition of the concept of lethal area and its applications, see appendix II.

(3) ~~(C)~~ Direct fire.

(a) (U) Precision. Round-to-round dispersion in direct fire of the 130-mm M-46 field gun are shown in table II-J-3.

(b) ~~(S)~~ Grazing range. Grazing range values from Soviet documents for the M-46 APC-T (BR-482) projectile versus targets of various heights are:

- 1140 meters when target height is 2.0 meters.
- 1220 meters when target height is 2.7 meters.
- 1400 meters when target height is 3.0 meters.

II-129 and II-130 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Table II-J-3. Probable Errors in Direct Fire; 130-mm M-46 Field Gun Firing APC-T Projectile BR-482 (U)

Range (m)	PE_d (m) APC-T projectile	PE_v (m) APC-T projectile	PE_r (m) HE projectile
500	0.1	0.1	34
1000	0.2	0.2	33
1500	0.3	0.3	32
2000	0.4	0.4	31
3000	0.6	0.6	30
4000	0.9	0.8	29

(UNCLASSIFIED)

(c) ~~(C)~~ Effective range. Estimated effective range (50% probability of a first-round hit) of the M-46 vs. a frontally presented US M60 tank is approximately 1450 meters; against the standard NATO target it is 1250 meters. The HE projectile scale on the reticle of the OP4-35 direct fire telescope is graduated to a range of 8000 meters and the scale for the APC-T projectile (BR-482) extends to 4000 meters, being graduated every 100 meters and numbered every 200 meters.

(d) ~~(C)~~ Engagement range. The estimated range at which an armor target may expect to start to receive direct fire from this weapon is 1700 meters.

(e) ~~(C)~~ Armor penetration. Table II-J-4 is an extract of penetration capabilities from Soviet firing tables; these capabilities have been confirmed by US test firings.*

*Limited US penetration firings resulted in a 5% increase in the penetration data shown.

Table II-J-4. Armor Penetration Soviet 130-mm M-46 Field Gun Firing APC-T Projectile BR-482 (U)

Range (m)	At 0° obliquity (mm)	At 30° obliquity (mm)
500	250	205
1000	240	195
1500	225	185
2000	210	170
3000	180	145
4000	150	120

(UNCLASSIFIED)

(f) ~~(C)~~ Hit probability. First-round hit probabilities for the M-46 firing the BR-482 APC-T projectile against a frontally presented US M60A1 tank are shown in figure II-J-5. Similar probabilities for the Soviet T-12 antitank gun and D-30 howitzer also are presented for comparison. For a description of the methodology used in the derivation of these data, see appendix II.

c. (U) Configuration. The trails of the M-46, of conventional split trail configuration, are made of steel plates welded into box-section construction. In travel position, the trails are attached by a lunette to a pintle on the limber. Positioning limits in elevation are -2.5° and +45°. The M-46's recoil mechanism is a hydropneumatic, variable length, independent, modified Schneider-type system. It differs from the true Schneider mechanism in that the recoil brake cylinder remains stationary while the piston rod moves in recoil; also, there is a counter-recoil buffer located in the recuperator. The recoil brake and the recuperator operate independently of each other. The cradle assembly consists of a frame, two guide rails, a front yoke, a center support bracket, and auxiliary elements. The frame is a steel-stamping, and the center support bracket is a steel casting. On-carriage fire control is

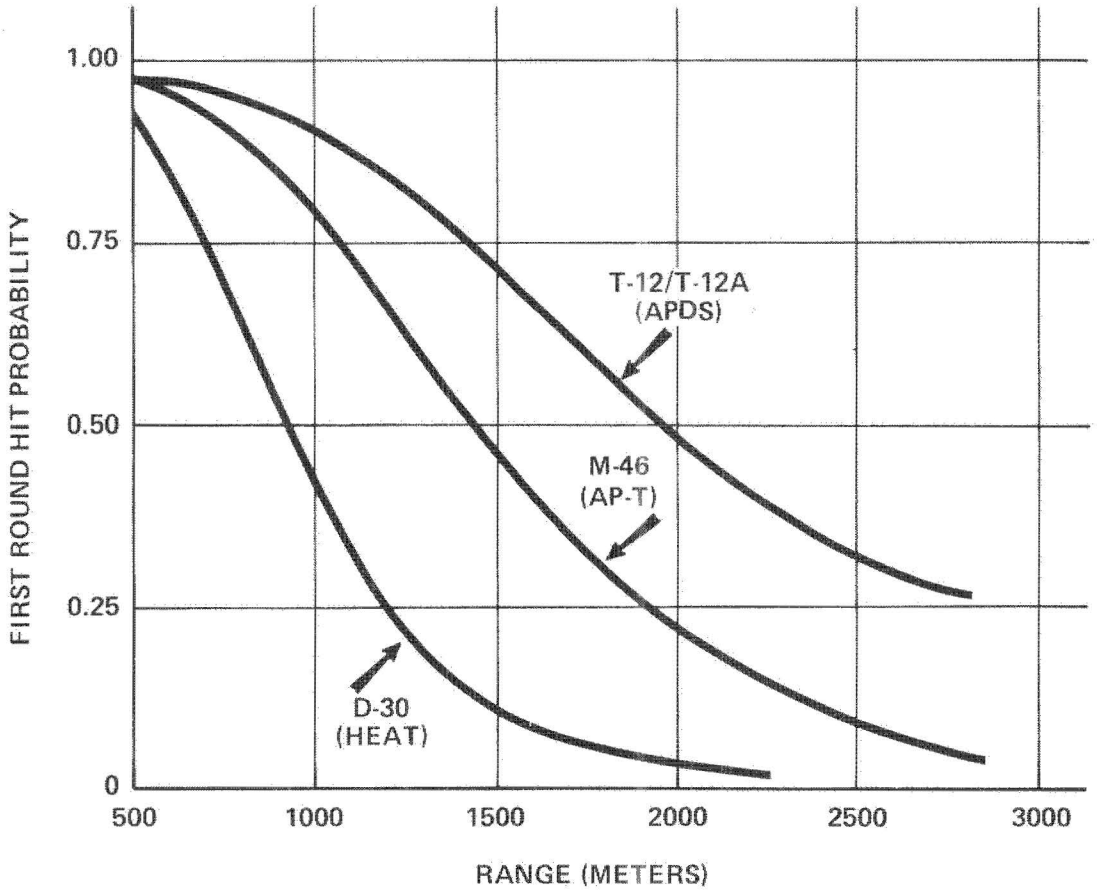

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Figure II-J-5. First-round hit probability of the Soviet M-46 field gun vs. the US M60A1 tank (U).

a dependent-type system consisting of a Model S71-35 sight mount with range drum, a Model PG-1M panoramic telescope, and a Model OP2M-35 (or OP2-35) direct fire telescope.

d. ~~(C)~~ Summary. The M-46 is a high performance field gun that possesses mobility and performance characteristics superior to the old 152-mm gun BR-2 (M1935) and the 122-mm Corps Gun A-19 (M1931/37). The M-46 has less than half the travel weight of the 152-mm BR-2, has approximately the same range, fires a projectile 33% lighter, and has a rate of fire 12 times greater than that weapon. The M-46 is approximately

500 lb heavier and has approximately the same rate of fire as does the 122-mm corps gun A-19. The limber design for the M-46 is superior to that of the 122-mm corps gun, and the M-46 possesses a vast improvement in mobility and transportability over the 152-mm gun. The M-46 represents the latest example in Soviet design philosophy for towed, high performance, high velocity field guns. By adhering to the Soviet criteria for artillery (ruggedness, durability, and simplicity of design and operation), the Soviets have in the M-46 a weapon that is relatively easy and inexpensive to manufacture. It exhibits exceptional reliability, maintainability, and availability. Tube wear life is estimated to be 800 EFC rounds. The theoretical factor of safety is low by US standards (1.06 in the chamber and 1.19 in the bore). Fatigue life also seems to be low; nevertheless, the material is tough, as measured by K_{IC} tests (130 000 $lb/in^{3/2}$ vs. 115 000 $lb/in^{3/2}$ for the martensite steel used for US gun tubes). This toughness provides a measure of safety, because a crack should grow slowly enough while a number of rounds are being fired to permit detection before a catastrophic failure occurs. The M-46 is a precise direct and indirect fire weapon. Table II-J-5 compares the precision of the M-46 with that of the US 175-mm (M-107) gun at common percentages of their respective maximum ranges. The low charge-to-mass ratio (0.152:1), large fragment size, and relatively low velocity of the bursting fragments decrease the antipersonnel effectiveness of the OF-482M projectile, compared with other Soviet and US projectiles. Its relative imprecision in indirect fire, compared (in table II-J-5) with the US 175-mm M-107 gun, is of questionable validity; nevertheless, it does not negate the M-46's higher rate of fire and overall effectiveness as a general support weapon organic to corps, army, and higher levels. The suspension system, consisting of the two noninflatable sponge rubber-filled tires and two independently acting torsional spring assemblies, provides exceptional roadability and dependable performance. The torsion bars provide excellent stability during both on- and off-road travel. The tires, generally not vulnerable to fragmentation, have been demonstrated to still be usable after large chunks have been shot off.

20. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) ~~(C)~~ Gun tube. The monobloc gun tube is made of steel having a bainite structure, which will withstand forces up to medium yield strength [10 125 kg/cm^2 (144 000 lb/in^2)]; the tube is not autofrettaged. The external surface of the tube has four major tapers and three major diameters in addition to the recoil bracket configurations. The breech end of the tube has a shoulder and an adapter nut to lock it to the breechring. The rifled portion of the tube consists of 40 uniform

Table II-J-5. Comparison of Precision;
Soviet M-46 vs. US M-107 Gun (U)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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rifling grooves. The twist of the constant twist, right-hand rifling is one turn in 30 calibers. The width and depth of the rifling grooves are 5.99 mm and 2.7 mm, respectively, width of rifling lands is 4.2 mm, and length of rifling from origin to muzzle is 5860 mm. The length of the barrel, without muzzle brake, is 7.15 meters (23.5 ft). The muzzle brake is affixed to the muzzle with continuous left-hand threads and is locked with two bolts which are secured with wire. Tube life is estimated to be 800 EFC rounds. Fatigue life is unknown, but probably is relatively low and approximates wear life.

(2) (U) Breechring. The breechring is designed to receive and secure the breech mechanism and to connect the tube with the recoil mechanism. The breechring is joined to the monobloc gun tube by a threaded sleeve that forces the circular shoulder of the gun tube into the locking recess of the breechring. The breechblock is a manually operated,

horizontal sliding wedge that opens to the right; approximately 8.16 kg of force is required for breech operation. Major subassemblies of the breechblock are: The locking device that secures the breechblock during firing, the firing mechanism that contains the firing pin, the extracting mechanism that removes the spent case from the chamber, and the safety lock mechanism that includes a device for retaining the projectile in the chamber until it is rammed into the bore.

(3) ~~(C)~~ Muzzle brake. The muzzle brake is a multiperforated cylindrical fixture, the design weight of which is 80.5 kg (177 lb); this brake absorbs approximately 35% of the recoil force. The principal braking action results from the flow of powder gases through the 40 ports (20 on each side) of the muzzle brake. The muzzle brake contributes an additional 0.07 kg/cm^2 (1.0 lb/in^2) to overpressures, which range up to 0.32 kg/cm^2 (4.6 lb/in^2) at the gunner's and number 1 man's stations.

b. ~~(C)~~ Top Carriage.

(1) (U) General. The top carriage (fig II-J-6 and 7) supports the following: Gun, cradle, elevating mechanism, traversing drive mechanism, equilibrators, trunnions, on-carriage fire control, and pivot bearing of the bottom carriage.

(2) (U) Cradle. The cradle (fig II-J-8) is the structural mount for the tipping parts of the gun. Its purpose is to guide the motion of the cannon during recoil and counterrecoil, to fasten the recuperator rod, and to mount the sighting equipment. The cradle assembly basically consists of a frame, two recoil slide rails, a front yoke, a center support bracket, and auxiliary elements. The frame is a trough-shaped, steel-stamping reinforced by braces and welded brackets. The recoil brake is housed inside the recesses of the frame. A bracket on the top of the front yoke acts as a fastening for the recuperator rod. Steel recoil slide rails are welded to the frame throughout the length of its top edges. The cannon assembly slides along these rails. The rails act as guides for bronze slide bushings in the hoops and for the bottom edges of the breechring of the cannon assembly.

(3) (U) Elevating mechanism. This mechanism, a conventional rack-and-pinion type, consists of a crankshaft, worm gearing, a bevel gear, a handwheel, a pair of spur gears, and two intermediate shafts with ball joints. By rotating the elevating handwheel, movement is transmitted through the bevel gearing, joint and shaft assemblies, and spur gears to the worm shaft and worm wheel, and then to the elevating shaft, which is meshed with the elevating arc secured to the cradle. An axle brake on the worm shaft prevents self-elevation or depression, and thus retains the desired elevation of the tube. Elevation limits are -2°30' and +45°.

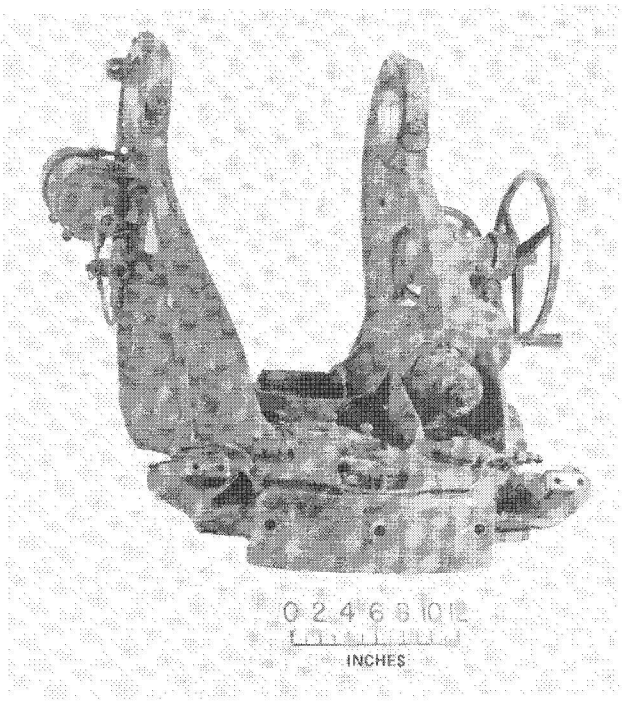

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Figure II-J-6. Top carriage, 130-mm M-46 field gun, front view (U).

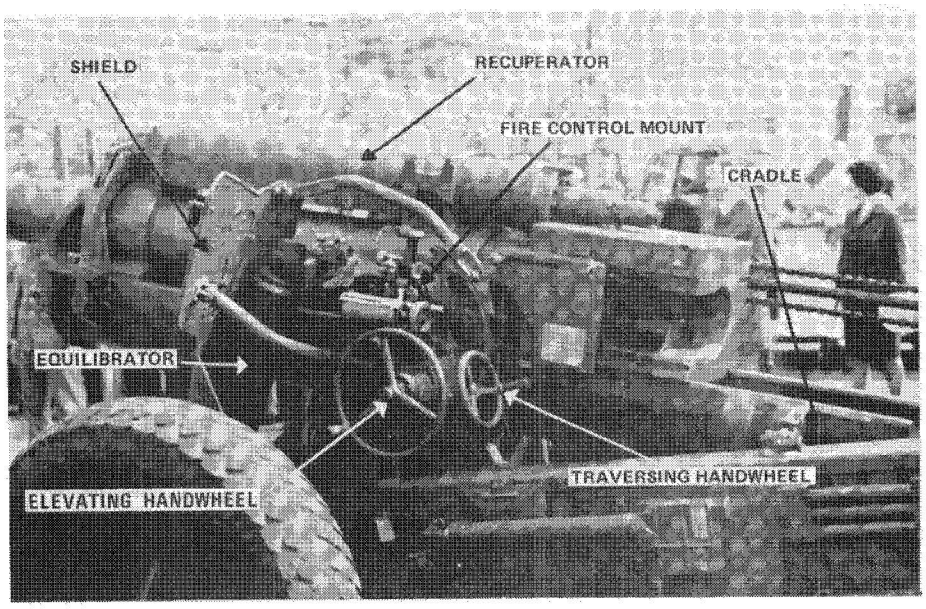

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Figure II-J-7. Top carriage components, 130-mm M-46 field gun (U).

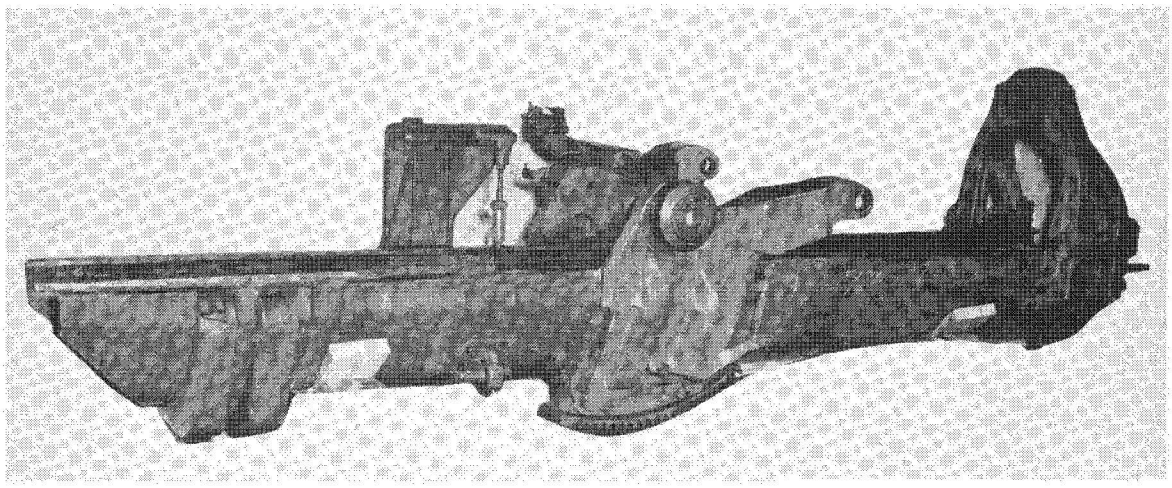

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Figure II-J-8. Cradle assembly, 130-mm M-46 field gun (U).

(4) ~~(C)~~ Traversing mechanism. This mechanism consists of a traversing pinion and bevel gears, joint and shaft assemblies, and a handwheel. Rotation of the traversing handwheel, located at the left side of the gun, is transmitted through a system of shafts and gears to the traversing pinion, located on a vertical shaft under the lower platform of the top carriage. This pinion engages the traversing gear sector attached to the platform of the bottom carriage. Rotation of the pinion against the gear sector causes the top carriage to turn about the center pivot axis. Stops located at the ends of the rack limit the range of traverse to 25° right and left of center, for a total of 50° of on-carriage traverse.

(5) ~~(C)~~ Recoil mechanism. The recoil mechanism is an independent, hydropneumatic, variable recoil length Schneider-type system. It is composed of a hydraulic recoil brake and a hydropneumatic recuperator. These systems are independent of each other; however, they act in concert to absorb, store, and dissipate the energy of recoil, thereby limiting the recoil stroke and returning the cannon assembly smoothly into battery. The recoil brake is mounted in the cradle underneath the cannon. This location is advantageous from the standpoint of reducing vulnerability. The muzzle end of the recoil brake cylinder is anchored to the front inner brace of the cradle. The breech end of the brake cylinder is supported by the inner rear brace of the cradle. The recoil brake rod is attached to the breechring by means of a bracket and a quarter turn nut. The recoil brake is of the variable-length-of-recoil type; i.e., an automatic throttling linkage changes the length of recoil stroke as a function of

the angle of elevation; as the tube is elevated, the throttling rod is rotated to increase the severity of throttling. "Long" recoil of approximately 1250 mm (49 in) occurs (under minimum throttling) at elevation from -2°30' to +20°. The length of recoil becomes variable as throttling is increased between 20° to 34° of elevation. "Short" recoil of approximately 775 mm (30 in) occurs, under maximum throttling, at elevations from 34° to 45°. The brake cylinder is filled with 28.7 liters of Steol M fluid. The recuperator is filled with 22.6 liters of the same type of fluid and precharged with dry air to a pressure of 56 ±2 atm. Its rod is attached to the front bracket of the cradle, and the cylinder, bolted to the tube, moves in recoil. A buffer is incorporated in the recuperator. The recoil mechanism of the M-46 operated smoothly and efficiently during all exploitation testing and subsequent range firings.

(6) ~~(c)~~ On-carriage fire control. On-carriage fire control (fig II-J-9) consists of: A Model PG-1 or PG-1M panoramic telescope, a Model S-71-35 telescope mount, and an OP4-35 direct fire telescope. The PG-1-type panoramic telescope is standard to all Soviet towed field artillery pieces. The Model S-71-35 telescope mount is essentially the same as the S-71-28 telescope mount for the 122-mm D-74 except for inscription of the range drum. The cylindrical surface of the range drum for sight mount S-71-35 has three range scales. Scale "full" is for firing APC-T projectile BR-482 to a range of 4000 meters and HE shell OF-482M to ranges greater than 5400 meters. The scale division of 50 meters is used with these projectiles. Scales two and four are for firing HE OF-482M shell using the 2d and 4th charges. When HE shells are fired with the 1st and 3d charges, firing table values for range drum settings must be used, since in these cases the interval between graduations on the range drum do not equate to 50 meters. The direct fire telescope OP2-35 or OP4-35 are designed for the delivery of direct fire. The sight reticle of the OP4-35 direct fire telescope has a "Br" scale for the BR-482 APC-T projectile using full charge. To the right of the Br scale marked OF4 for use with the OF-482M HE projectile using reduced charge. Between these two scales is the range scale for the OF-482M HE projectile using full charge. In addition to these three scales, the reticle has: a scale for lateral corrections to 24 mils right and left of the target, a vertical line for correction of cant, a stadia scale for range determination, and a deflection scale for target leads. A light filter is provided for use when laying the piece into the sun or upon brightly lit targets. The sighting system is a one-man system in both direct and indirect fire; this man (the gunner) also fires the weapon. Additional fire control equipment and accessories include: The illuminating set for the mount, telescopic sight, and panoramic telescope; an infinity aiming reference collimator; and a gunners' quadrant.

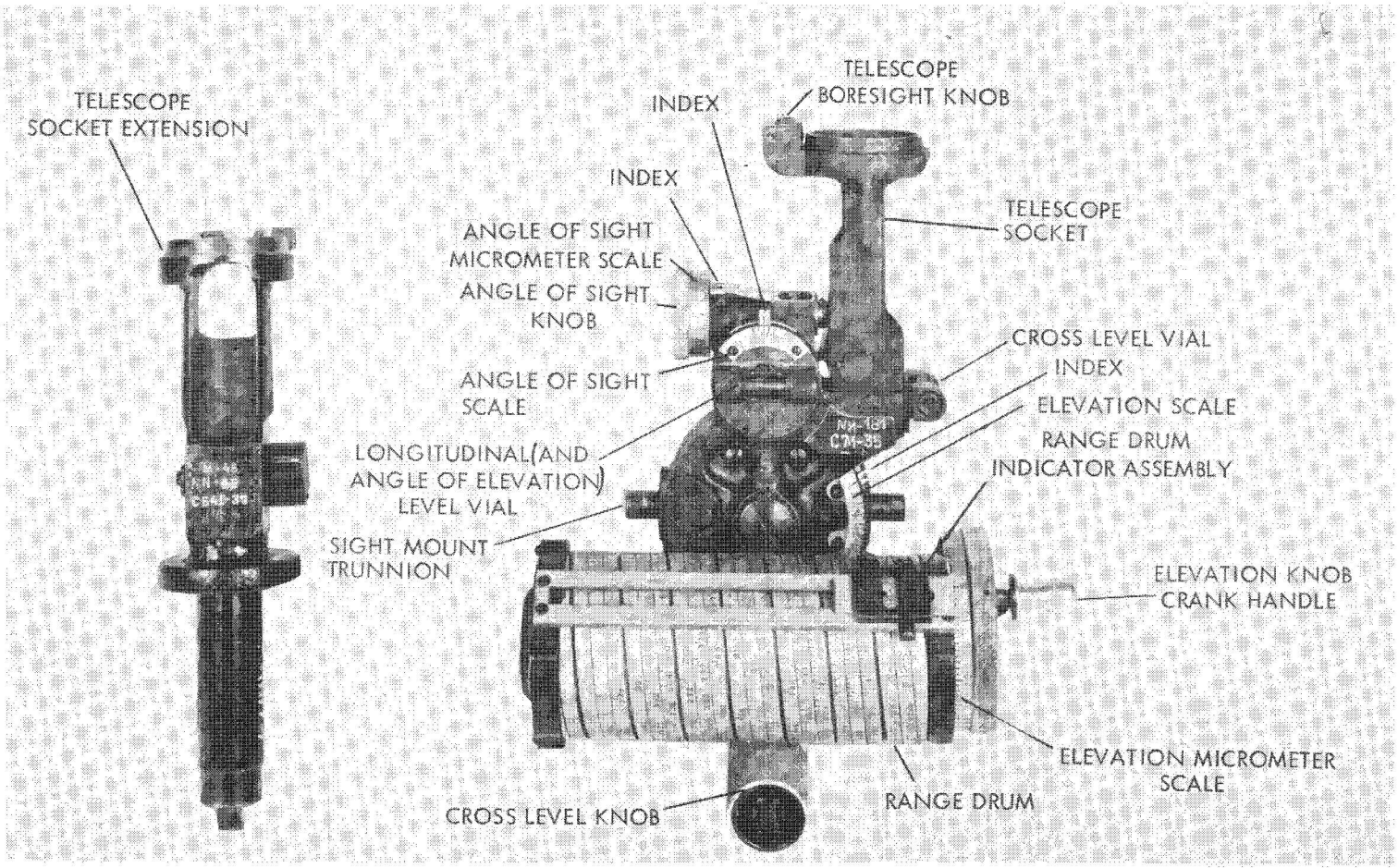

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Figure II-J-9. On-carriage fire control, 130-mm M-46 field gun (U).

(7) (U) Crew protection. Protection afforded the M-46 crew consists of the gun shield assembly, designed to protect the crew from small arms fire and fragments originating in the forward direction, as well as to attenuate muzzle blast effects. The shield assembly consists of a left and a right shield that are attached to the upper carriage by means of struts. The left half of the shield has apertures and doors to provide visibility for the panoramic and direct-fire telescope. Thickness of each of the armored steel shields is about 4 mm.

(8) (U) Equilibration. Equilibration is provided by a pneumatic pusher-type equilibrator with an internal spring equilibrating system (fig II-J-10) that consists of: Two separate but interconnected cylinders, a compressed air tank, a distributor, and flexible tubing. Since the center of gravity of the tipping parts lies 1.02 meters (40 in) forward of the trunnion axis, without equilibration a large gravity torque would have to be overcome when elevating the gun. The equilibrators, mounted on each side of the tube and attached to the top carriage, apply upward force upon lever arms attached to the cradle. The equilibrators act primarily as pneumatic units, although they do contain a coil spring and a small quantity of oil for lubrication. The units are filled with dry air, precharged to approximately 25.8 kg/cm^2 at 45° gun elevation. At 2.5° of depression, the equilibrator pressure is at its maximum value of approximately 45.5 kg/cm^2. The air bottle, mounted on the right side of the top carriage, is pressurized to 120 kg/cm^2. The purpose of the coil spring and plunger is to augment the pneumatic force of the equilibrator at low gun elevations. At 6° gun elevation, the plunger comes into first contact with the inside of the outer cylinder. At zero gun elevation, the spring force is 340 kg, which is approximately 6% of the pneumatic force.

c. ~~(C)~~ Bottom Carriage.

(1) ~~(C)~~ General. The bottom carriage (fig II-J-11) serves as the structural link between the top carriage, the wheels, and the trails. It is a steel casting reinforced by ribs on its underside. The upper face is machined flat to provide bearing surfaces for the top carriage and the two roller assemblies. A central cavity provides a housing for the traverse thrust bearing, and two grease grooves provide lubrication for the interface of the top and bottom carriages. The front portion of the carriage casting is a machined arc that forms a lug that is gripped by the holddown gib of the top carriage. To the immediate rear of the lug is an arc-shaped gear rack that meshes with the traversing mechanism pinion; two stops on this rack delimit traverse of the weapon. The torsion bar assemblies for the wheel axles are mounted at the sides of the bottom carriage. The rear of the bottom carriage has two lugs that form part of the trail hinges. The bottom carriage houses the air brake

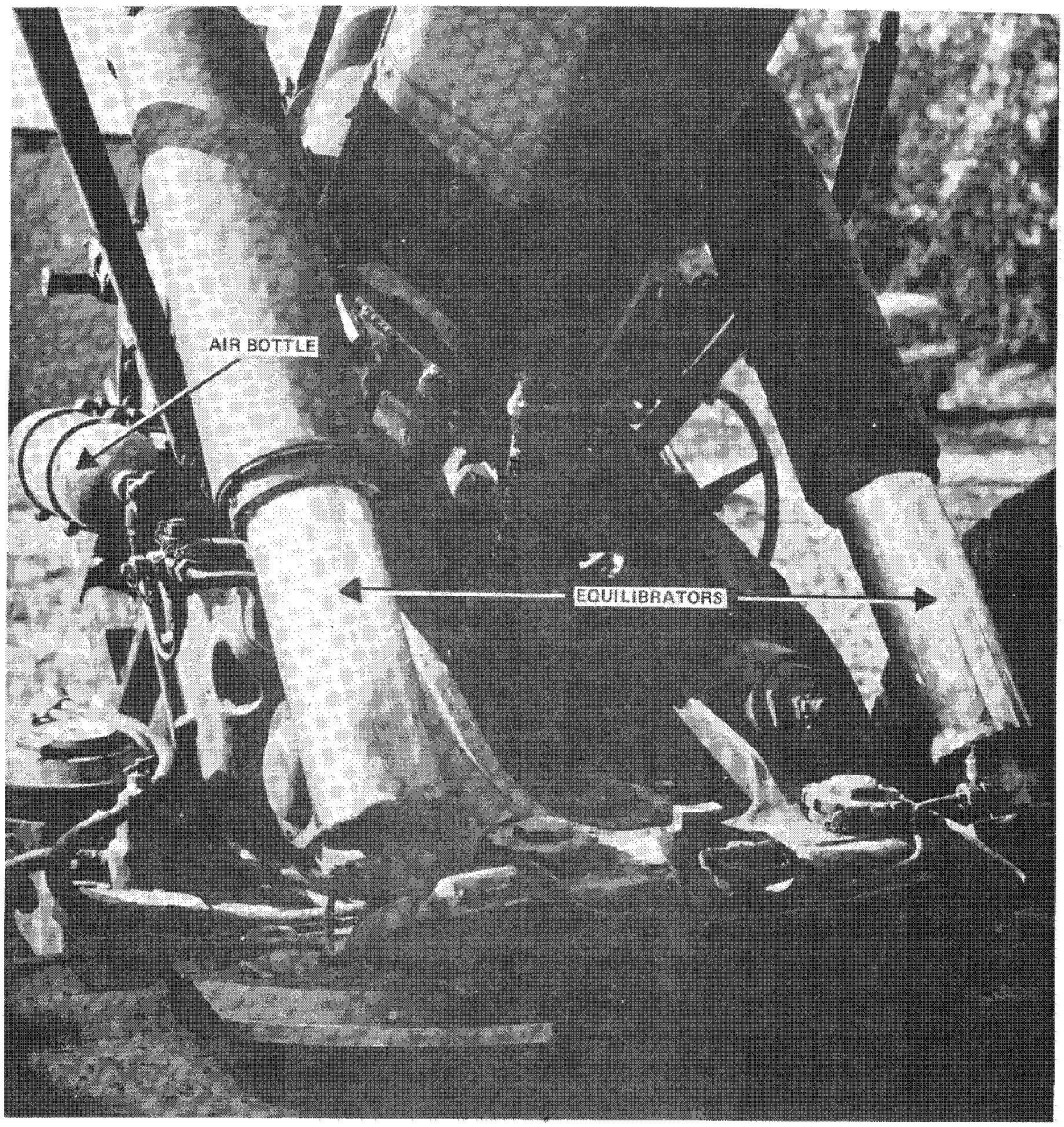

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Figure II-J-10. Equilibrating system, 130-mm M-46 field gun (U).

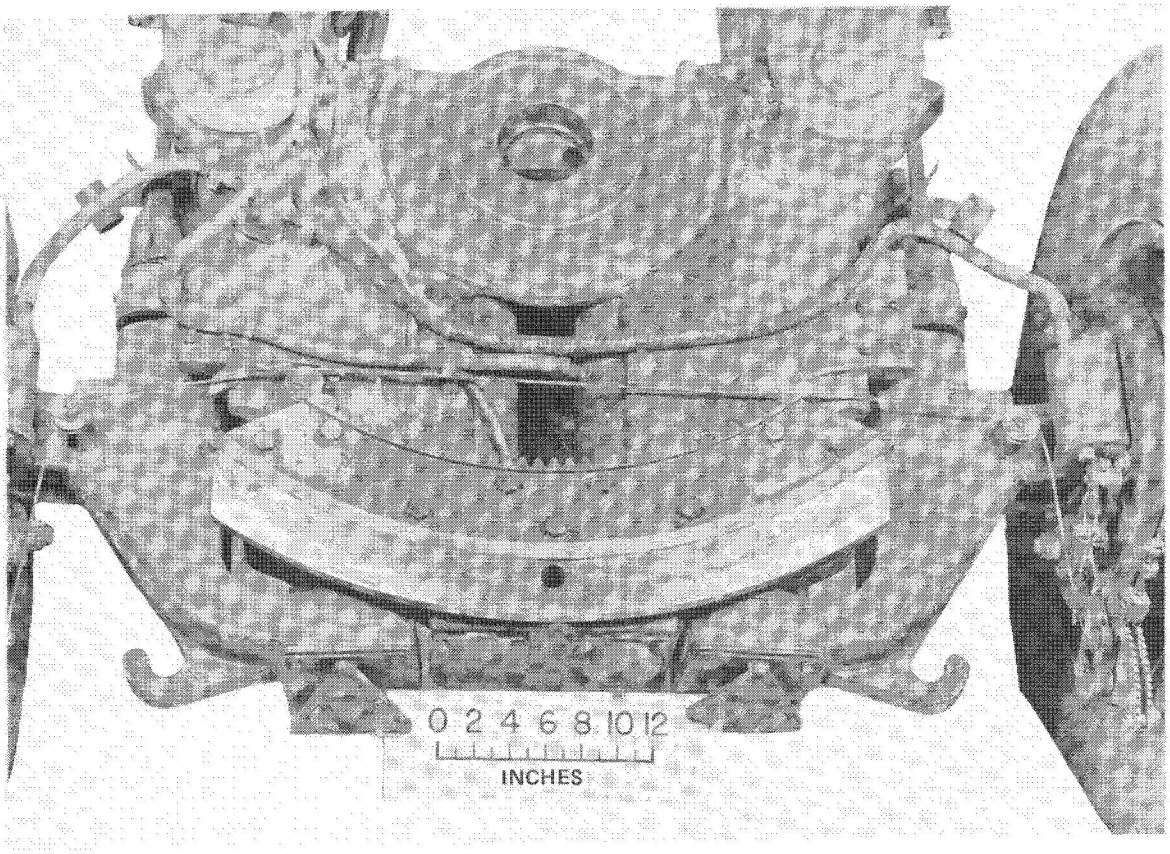

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Figure II-J-11. Bottom carriage, 130-mm M-46 field gun (U).

receivers. The rear surface of the bottom carriage has a scale graduated in mils for coarse laying of the gun. Finally, a vertical hole is provided in the forward top surface for insertion of the traveling lock.

(2) ~~(C)~~ Axle housing. This housing is mounted at the sides of the bottom carriage. Two independent acting spring assemblies are mounted in the housing. Torsion-bar suspension is utilized. The cylindrical torsion bars are splined at both ends; one end is splined to an anchor lever and the other to the axle yoke. As the axle pivots up and down, the spring end of the torsion bar is rotated and the torsion bar is correspondingly twisted. The system has two modes of operation, traveling and firing. In the travel mode, the anchor linkage is restrained while the axles are free to pivot; therefore, the suspension system operates conventionally. In the firing mode, the anchor linkage is

free, while the axle yokes are fixed; this arrangement bypasses the torsion bars; thus, transmitting the force directly to the wheels. When the gun is in the firing mode (with trails spread), the anchor linkage is allowed to rotate in each direction 6° from neutral. The axles are now free to pivot 6° as a unit. This design allows the gun to be positioned on uneven ground, whereas without this feature the two trail ends and the two wheels would consitute a rigid four-point suspension.

(3) ~~(C)~~ Primary braking. The primary braking system is conventional drum-type air brakes, the brakes being operated simultaneously with the braking of the prime mover. When the brakes are applied, air is fed through a hose on the limber, thence through a line inside the right trail to a filter, and then, via a distribution valve, to the receivers on each wheel brake. Air is delivered from the prime mover at a pressure of 5 to 6 atm. A hand lever and ratchet on the left wheel assembly operates the brakes mechanically for parking the weapon; in an emergency, during travel, a rope attached to the lever assures this function.

(4) ~~(C)~~ Tires. The foam rubber-filled tires are normally 1350x390 mm, with some M-46 guns using the 1350x380-mm (approximately 53x15-inch) size. The tires have conventional tread and external appearance. Their lack of resilience is compensated for in the suspension by the torsion bar springs.

(5) (U) Trails. The trails (fig II-J-12) are box-shaped welded structures with steel castings welded at each end. The forward casting is the trail hinge, which is pinned to the bottom carriage by the vertical trail bolt. The rear casting consists of the spades, which are integral to the trails. In addition to these small spades, larger, detachable, soft-ground spades may be mounted over the permanent spades to increase the ground contact area. When not in use, the larger spades are stored in carrying brackets attached to the outside of each trail. Also mounted on each trail is a hydraulic trail jack. The jacks are used to raise the trails, both for mounting the limber and for extracting the spades from the ground. The jacks are permanently mounted, and, when placed in use, swing from their traveling locks on the sides of the trails to a vertical position. A footpad is provided for each jack. The top surface of each trail has a bracket with a folding lug against which the cradle stop rests when the gun is in the traveling mode. The inner side walls of the trails have breechring supports for securing the cannon during travel. The trails are equipped with fittings and sockets for securing cleaning equipment, tools, and accessories carried with the gun.

(6) ~~(C)~~ Winch assembly. The cannon's winch assembly is mounted on the right trail. It consists of a gear drive and a brake in a cast

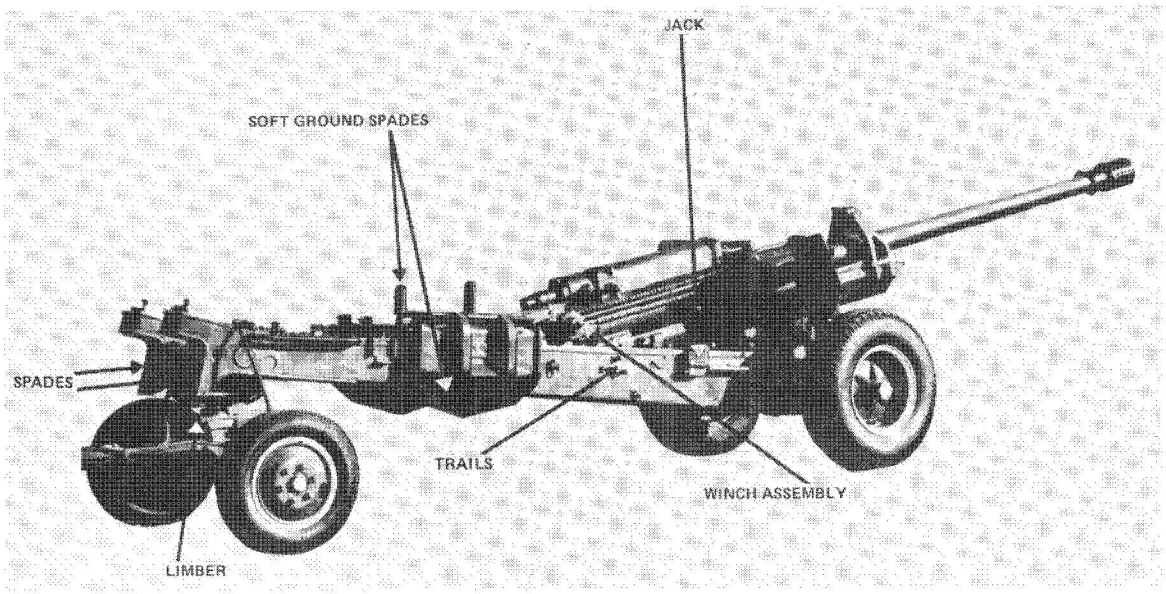

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Figure II-J-12. Trail components and accessories, 130-mm M-46 field gun (U).

steel housing, a bar and sprocket assembly, and an endless roller chain. The winch is used to move the cannon assembly forward or rearward, relative to the cradle. This procedure allows the muzzle-heavy cannon to be secured in the out-of-battery position for travel. Both the bar and sprocket assembly and the roller chain extend forward parallel to the trail, terminating at an attachment point in the top carriage. To prepare the cannon for travel, a pin fastened to the roller chain is inserted into an appropriate hole in the breechring. The recoil and recuperator rods are then disconnected, and the cannon is moved rearward in its cradle by turning the handcrank. To prepare the gun for firing, the operation is reversed. When the gun is in the firing configuration, both the bar and front sprockets are disconnected from the top carriage. The entire assembly, which is pivoted at the gear housing, is then swung upward and rearward and brought down horizontally upon the right trail, where is is secured.

(7) ~~(c)~~ Limber. The limber is connected to the prime mover by a lunette. In the travel position, the trail ends of the gun are placed onto the limber frame and secured. The major parts of the limber are: The axle, frame, drawbar, and wheels. The limber also contains the electrical and airhose connections for the weapon. Its 865x180-mm (34x7-in) wheels are sponge-rubber-filled. Limber weight is 650 kg.

(8) ~~(C)~~ Mobility. When compared with conventional rigid US suspensions and air-filled tires, employment of torsion-bar suspension and foam-filled tires provides an improvement in mobility to the M-46 over rough terrain. The torsion bar system increases the ability to negotiate rough roads at higher speeds. The foam-filled tires, which remain serviceable even after sustaining considerable damage, represent an increase in survivability.

K. SOVIET 152-MM GUN M-47

21. ~~(C)~~ Description and Performance

a. General. The Soviet 152-mm Gun M-47 (fig II-K-1) allegedly is the companion piece to the Soviet 130-mm Field Gun M-46 (sec II-J); this "counterpart" arrangement parallels the companion piece relationship that exists between the Soviet 152-mm Gun-Howitzer D-20 and 122-mm Gun D-74. A 152-mm M-47 gun was observed on display in a Leningrad museum in about 1960. This weapon has not been further observed since its initial sighting. It therefore was presumed that the M-47 was developed but never manufactured in other than prototype production quantities, nor had it ever been deployed to troop units. These conclusions appear to have been fallacious since several publications pertaining to the 130-mm M-46 also address the 152-mm M-47. Several Soviet technical and doctrinal manuals published from 1969 into the 1970s continue to address the M-47 together with the D-30, M-46, D-20, and other currently standard Soviet field artillery pieces and mortars. Some weapons of approximately the same vintage as the M-47, for instance the 180-mm S-23 gun, do not appear in these documents. Conversely, weapons that are older than the M-47, and are known to remain in service with Soviet field units (for instance, the 152-mm D-1 howitzer, the 203-mm B-4 howitzer, and the 160-mm mortar), continue to appear in these publications.

[redacted] Nevertheless, in the opinion of the authors, the 152-mm M-47 gun is deployed to Soviet field artillery units, possibly RVGK elements, in some, but admittedly unknown, quantity. Figure II-K-2 shows the M-47 in firing position.

(b)(1),1.4 (c)

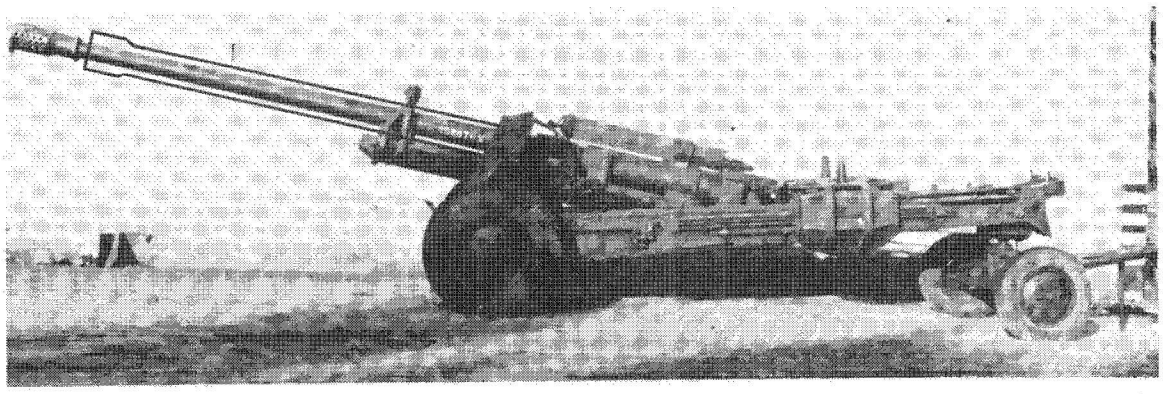

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Figure II-K-1. Schematic of Soviet 152-mm M-47 tube superimposed on M-46 gun (U).



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Figure II-K-2. Soviet 152-mm M-47 gun in firing position (U).

b. Capabilities.

(1) General. According to available documentation, the 152-mm M-47 gun fires the 43.56-kg OF-547 fragmentation-HE projectile to a range of 20 470 meters. The carriage, recoil mechanism, on-carriage fire control equipment (with the exception of the range drum, if any), height of bore, and elevation and traverse limits are identical to those of its companion weapon, the 130-mm M-46. Both the M-47 and the M-46 weigh approximately the same in the firing and travel configurations; about 7700 kg and 8450 kg, respectively. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are 4, 12, 20, 40, 70, and 100 full-charge rounds, respectively. Length of this weapon in firing configuration is 10.67 meters (35.00 ft); length in travel configuration is 11.32 meters (37.14 ft). These lengths are 430 and 410 mm (16.9 and 16.1 in), respectively, shorter than those of the 130-mm M-46. Width and height of the gun in travel (and in firing) configuration is the same as the M-46, 2.45 and 2.55 meters, respectively. The M-47 is towed by the same prime movers as are used with the M-46 at the same maximum speed (50 km/h, 31 mi/h). Crew size and emplacement/displacement times are the same as for the M-46, eight men and 3 to 4 minutes, respectively. The OF-547 fragmentation-HE projectile uses four charge increments: full, 1st, 2d, and 3d; weight of propellant is 10.9, 8.45, 3.54, and 2.21 kg, respectively. A special propelling charge is used with the armor piercing-tracer (AP-T) projectiles BR-540B and BR-540; this charge contains 9.84 kg of propellant. The unit of fire is estimated to be 60 rounds, possibly 30 of which are transported on the prime mover.

(2) Indirect fire. The precision, effectiveness, fragmentation, and lethality of the OF-547 fragmentation-HE projectile fired from the M-47 is not known. This projectile apparently is unique to the M-47 gun.

(3) Direct fire. The Soviets claim that the grazing range of the M-47, with height of target unspecified, is approximately 900 meters. It is probable that this range is valid for a 2.5-meter-high target; certainly it is reasonable for a 3.0-meter-high target. It is probable that firing against a US M60A1 tank would be commenced at about 1100 meters.

c. Configuration. As previously stated, the carriage, recoil mechanism, on-carriage elevation and traverse limits, and on-carriage fire control (with the obvious exception of the graphical scales on the range drum, if any) are the same as these items on the 130-mm M-46; see section II-J for these data. The limbers also are identical; limber weight is 650 kg. The cannon assembly and muzzle brake are the only components that are said to differ between the 152-mm M-47 and the 130-mm M-46.

(1) Cannon assembly. The monobloc M-47 tube is 152.4 mm in caliber. Length of barrel with breech is 6650 mm (21.82 ft); with muzzle brake, 7170 mm. Length of rifling is 5470 mm and there are 48 grooves. Land width is 4.0 mm, groove width is 5.97 mm, and groove depth is 1.5 mm. Twist of rifling is one turn in 25 calibers; an angle of inclination of 7°9'45". The weight of the barrel with breech is 2750 kg versus the 2780 kg of the 130-mm M-46. Maximum chamber pressure is 2350 kg/cm^2.

(2) Muzzle brake. This component on the M-47 is a scaled-up version of that found on the M-46. The muzzle brake on the M-47 weighs 117 kg versus the 80.5 kg of the M-46's brake. See section II-J for additional data.

(3) Tipping parts. The tipping parts of the M-47, at 3862 kg, weigh 18 kg less than those of the M-46.

22. ~~(C)~~ Summary

The 152-mm M-47 gun is believed to be deployed to an unknown, but probably limited, number of Soviet field artillery units. Possible level of deployment is to RVGK artillery. The Soviet stated mission capabilities for both the 130-mm M-46 and the 152-mm M-47 guns are the same: Counter-battery fires, engagement of concentrations of personnel and tanks, destruction of field fortifications, fires to disrupt the rear guard of the enemy, and the engagement of self-propelled guns and heavy tanks (by direct fire). Inherently it is sensible to have both a 130-mm and a 152-mm gun that utilize the same carriage, weigh the same, employ the same-sized crews, and utilize the same types of prime movers. Nevertheless one is forced to question the rationale of a 152-mm gun that fires a 43.56-kg projectile vis-a-vis a 152-mm gun-howitzer that routinely fires a 40.0-kg projectile but which also can fire a Czechoslovak-made projectile that weighs 43.5 kg and which (when fitted with a copper rotating band) exceeds the range of the 40-kg projectile by 2%. Three trade-offs (considerations) are obvious: Range capability, system weight, and facility of employment. The M-47 attains 3000 meters more range than does the 152-mm ML-20, but only 2000 more than the D-20. This increased range represents a considerable, and, in some circumstances, a crucial additional capability. Nevertheless, this additional range is attained at the cost of a significant increase in weight; 2550 kg in the travel, and 1800 kg in firing configuration over the ML-20, either of which is a considerable price to pay. Allegedly, emplacement of the M-47 is accomplished in about 1 to 2 minutes less time than is required for the D-20. Once the D-20 is emplaced, however, gross shifts in traverse are easier and faster to accomplish. In short, the situation is that of two weapons which differ but have about the same overall efficiency. In sum,

the authors, from a perusal of the Soviet literature, are convinced that the 152-mm M-47 gun exists. Conversely, the authors are not convinced that this gun is deployed to any echelon lower than RVGK. It is possible indeed probable, that such RVGK units as are armed with this weapon are allocated to fronts on an "as needed" basis and are further allocated by the front to the army(ies) designated to effect the breakthrough; primarily for the purpose of delivering counterbattery and the longer ranged preparatory fires.

L. SOVIET 152-MM SELF-PROPELLED GUN M1973

23. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The Soviet 152-mm self-propelled gun M1973 was first sighted in February 1974 (fig II-L-1). As with the 122-mm M1974 self-propelled gun, the term "gun" is used in the British sense of the term and should not be construed to mean that the cannon of the M1973 is a gun rather than a howitzer. Under Soviet criteria this weapon is probably classified as a gun-howitzer. The M1973 is being deployed to first-echelon Soviet motorized rifle divisions (MRD) as the replacement

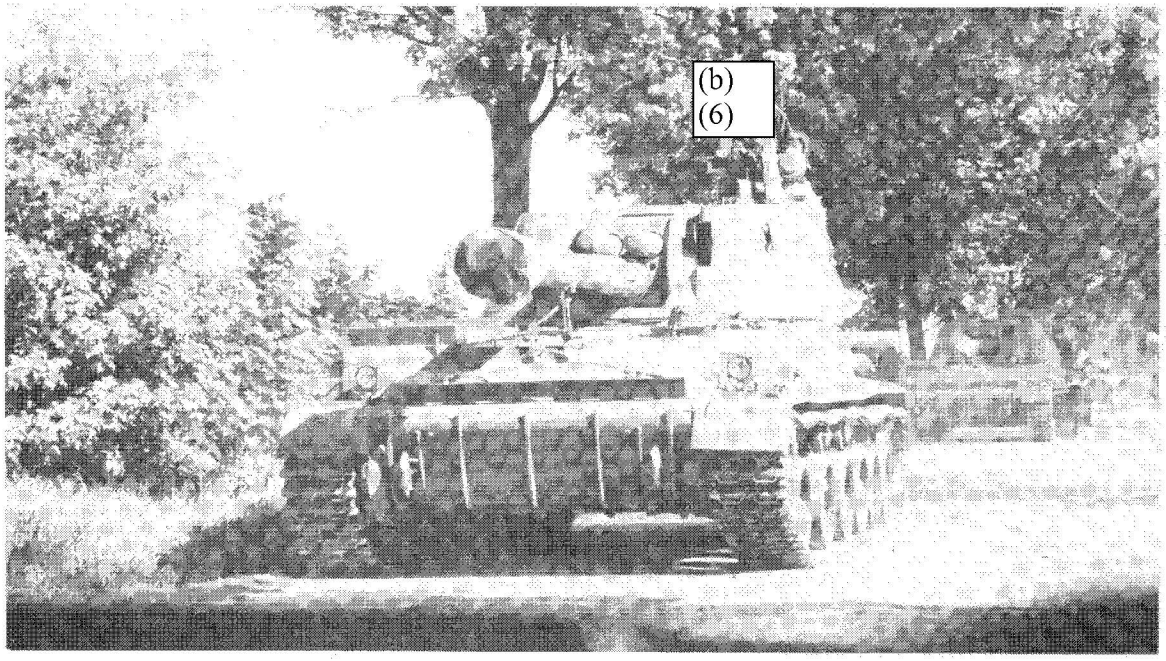

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Figure II-L-1. 152-mm self-propelled gun M1973, front view (U).

for the 152-mm D-1 towed howitzers in the general support-type battalion that is organic to all MRD. Priority of deployment probably is being afforded to those MRD that have one or more rifle regiments equipped with the BMP. The 152-mm M1973 also is being issued to some tank divisions to replace the 122-mm D-30 howitzers in one of the three 122-mm howitzer battalions that are organic to tank divisions. Further, the 152-mm D-1 howitzer regiments within the artillery division in GSFG are being re-equipped with the M1973. Recent information indicates that some 152-mm M1973 battalions are being expanded from 18 to 24 guns, apparently three 8-gun batteries per battalion. Such action appears consistent with Soviets efforts to increase firepower on the battlefield. Eight artillery associated ACRVs (app IV) are organic to each M1973 battalion: one ACRV M1974-(1) to each battery, one M1974-(2) to each battery and to the battalion headquarters, and one M1974-(3) to the battalion headquarters. In addition, each M1973 battalion has one SMALL FRED that is believed to be a ground surveillance radar. In a few years the Soviets are expected to commence providing 152-mm M1973 systems to selected Warsaw Pact countries.

(b)(1),1.4 (c) (1) ~~(C)~~ Description. [redacted] The system mounts a 152-mm cannon that the Soviets term a howitzer on an extensively modified SA-4 GANEF TEL chassis. The M1973 chassis has 6 roadwheels rather than 7 found on the GANEF TEL. The M1973 is not inherently amphibious, although a water crossing capability possibly could be achieved by employing a flotation kit; another, much lesser, possibility is the use of snorkeling equipment. Some estimated overall characteristics of the 152-mm M1973 system are presented in table II-L-1. Figures II-L-2 thru -5 show the mensuration of the M1973.

(2) ~~(C)~~ Capabilities and limitations. Available information indicates that the M1973's cannon attains the same maximum range as that of the 152-mm ML-20 towed system, i.e., 17 230 meters. It is possible that the M1973 could be provided, either presently or in the future, with some type of extended range projectile. Compared to the previous 152-mm D-1 towed howitzer (which remains deployed to the majority of Soviet divisions) the M1973 exhibits a great improvement in range and crew protection and considerable improvement in mobility, crew size, and initial rate of fire. As is the case with other tracked self-propelled weapons, the M1973 requires a greater maintenance and logistic effort than towed weapons; its RAM-D characteristics are not as good as those of a towed cannon. Lift requirements for ammunition resupply tonnage should be increased by about 30% for battalions that are upgunned from 122-mm howitzers to this 152-mm system. The apparent limited size and configuration of the fighting compartment may well be a factor in increasing crew

fatigue, thus limiting effective operation over prolonged periods. This condition may be attenuated, however, by prudent use of automation and/or the alleged two supernumeraries within the wartime crew. Estimated overall capability parameters are presented in table II-L-2.

Table II-L-1. Estimated General Characteristics, 152-mm M1973 Self-Propelled Gun (U)

General description	Soviet full-tracked, armored, turreted, 152-mm field artillery cannon (howitzer or gun-howitzer) system
Soviet official model designation	Unk
Soviet nickname	"AKATSIYA" (acacia)
Recognition features:	
Initial impression	Appearance similar to US 155-mm M109 SP
Weight, combat-loaded	27 t (90%)
Length, overall:	
Incl tube w/muzzle brake	8.40 m (27.6 ft) (90%)
Vehicle only	7.03 m (23.1 ft) (90%)
Width, overall	3.20 m (10.5 ft) (90%)
Height to:	
Hull deck	1.60 m (5.26 ft) (90%)
Top of cupola	2.88 m (9.44 ft) (90%)
Ground clearance	384 mm (1.26 ft) (90%)
Primary armament caliber	152.4 mm (99%)
Visible length of tube w/muzzle brake forward of the rotor	4.31 m (14.1 ft) (90%)
Armor thickness	15 mm (0.6 in) (70%)
CBR protection	Possible filtered air overpressure system (40% to 50%)
Number of roadwheels	6, irregularly spaced (99%)
Commander's IR light	TKN-1 type on cupola (90%)
Secondary armament	7.62-mm PKT machinegun mounted on cupola (95%)

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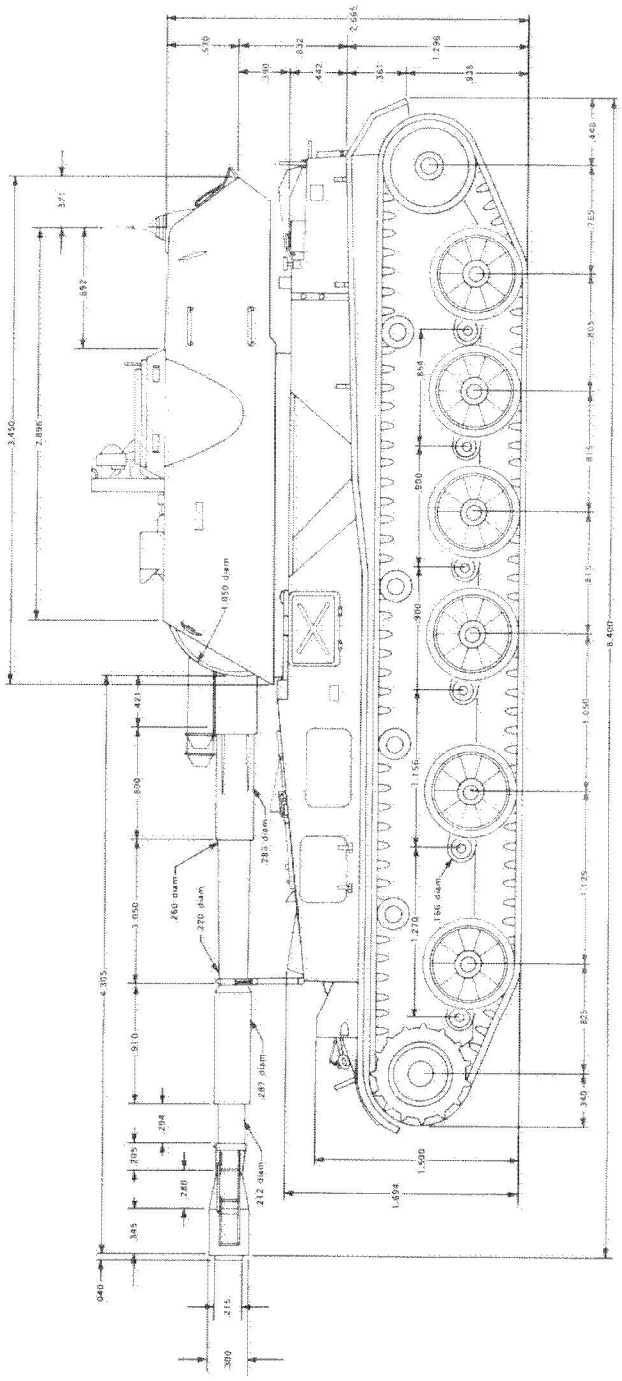

(b)(3):10 USC 424

(~~CONFIDENTIAL NOFORN~~)

Figure II-L-2. Soviet 152-mm self-propelled gun M1973, mensuration of left side (U).

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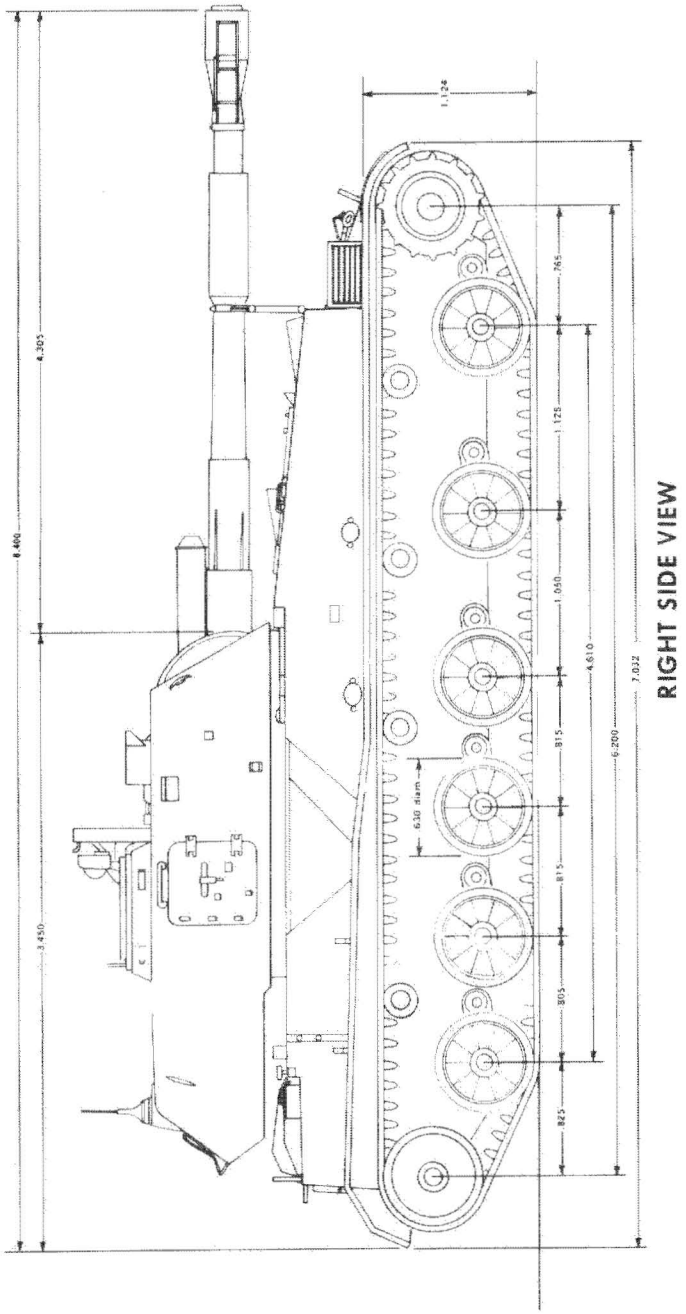
~~NOT RELEASABLE TO FOREIGN NATIONALS~~--THIS INFORMATION HAS BEEN AUTHORIZED FOR (b)(3):10 USC 424



(b)(3):10 USC 424

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Figure II-L-3. Soviet 152-mm self-propelled gun M1973, mensuration of right side (U).

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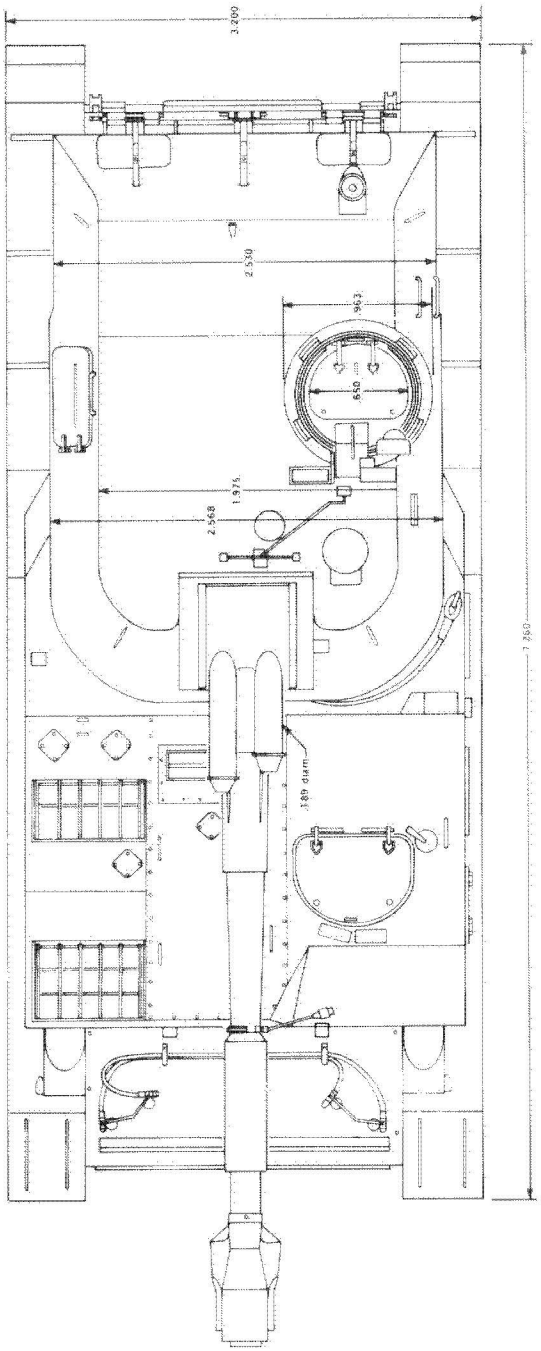

TOP VIEW

DIMENSIONS IN METERS
ACCURACY DIMENSIONS ± 5%
THIS DRAWING NOT TO SCALE

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Figure II-L-4. Soviet 152-mm self-propelled gun M1973, mensuration of top (U).

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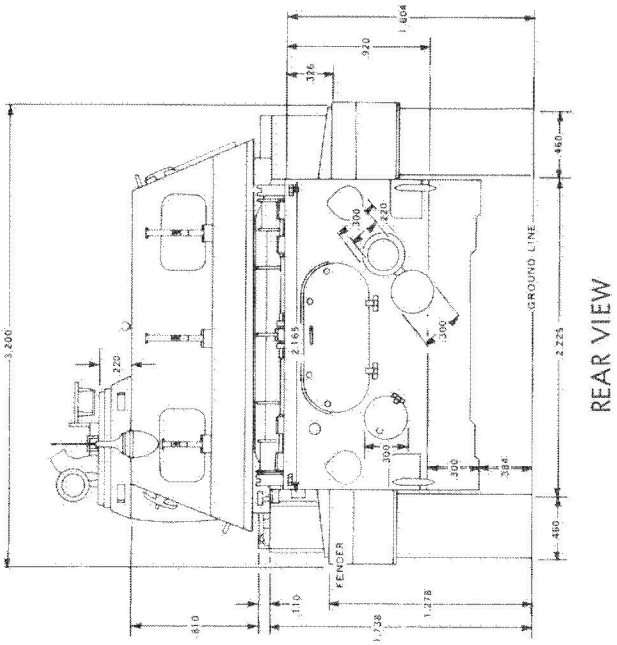

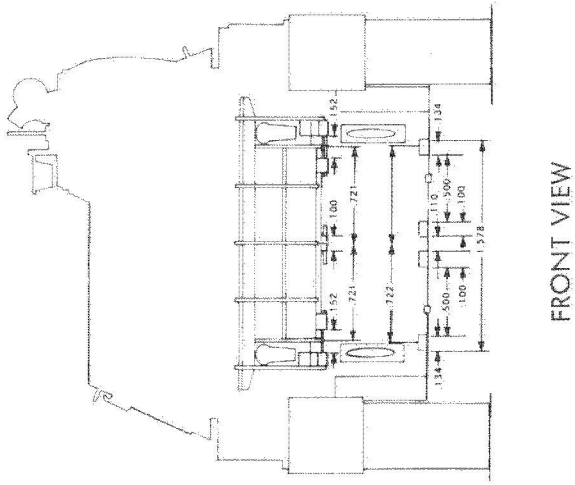

(b)(3):10 USC 424

(~~CONFIDENTIAL-NOFORN~~)

Figure II-L-5. Soviet 152-mm self-propelled gun M1973, mensuration of front and rear (U).

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~~NOT RELEASABLE TO FOREIGN NATIONALS~~--THIS INFORMATION HAS BEEN AUTHORIZED FOR (b)(3):10 USC 424

Table II-L-2. Estimated Overall Capabilities, 152-mm M1973 Self-Propelled Gun (U)

Caliber	152.4 mm (99%)
Maximum range w/conventional projectile	17 230 m (95%)
Complete round weight (uncrated OF-540)	60.60 kg (133.6 lb) (95%)
Weight of HE projectile (fuzed)	43.56 kg (96.0 lb) (95%)
Burst rate of fire	3 rd/15 s (70%)
Sustained rates of fire:	
1 min	8 rd (70%)
3 min	18 rd (80%)
5 min	25 rd (80%)
15 min	40 rd (90%)
30 min	55 rd[1] (90%)
60 min	80 rd[1] (90%)
Onboard ammunition	40 rd (80%)
Traverse capability	360° (95%)
Elevation limits	-4° to +60° (80%)
Tube wear life	≈3000 EFC (70%)
Speed:	
Onroad (w/governor)	70 km/h (43.5 mi/h) (90%)
Offroad	30 km/h (18.6 mi/h) (80%)
Cruising range	500 km (311 miles) (85%)
Normal onboard crew size	4 (99%)
Emplace/displace time[2]	0.25 to 0.75 min (80%)
Onboard communication	R-123 radio and intercom (95%)

[1]Degraded, in comparison to the D-20, by probable overheating of the tube and possible fatigue of ammunition resupply crewmen.
[2]"Emplace" is time required from arrival on position until ready to accept lay or until the first round is fired in direct fire. "Displace" is time required from receipt of "march order" until vehicle commences to move.

~~(CONFIDENTIAL)~~

b. ~~(C)~~ Primary Armament. Visible portions of the M1973's cannon assembly (fig II-L-6 and -7), although not exactly the same, resemble the cannon on the towed D-20 system. Indications are that the ballistic performance of the M1973 equals that of the ML-20 and that the M1973 can fire most, if not all, of the ammunition available to the ML-20 and D-20 systems. The M1973 could be provided, either presently or in the future, with ammunition having improved ballistic performance. Further, at some

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-L-6. Soviet 152-mm self-propelled gun M1973, right front view (U).

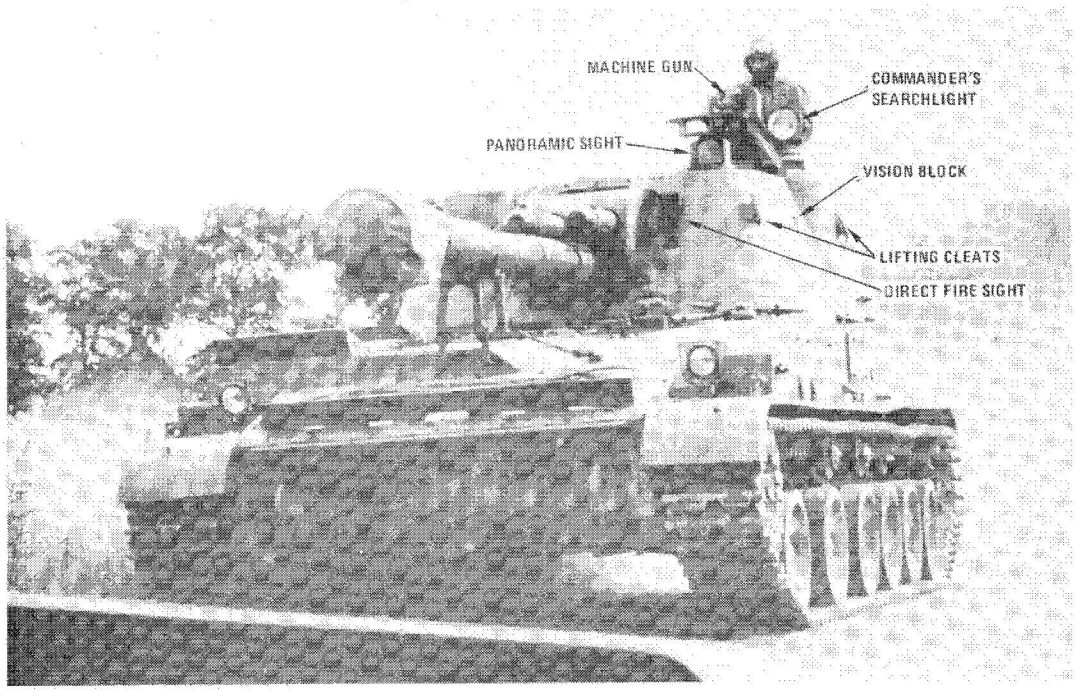

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Figure II-L-7. Soviet 152-mm self-propelled gun M1973, recognition features (left front view) (U).

future date, system performance could be materially improved by effecting an exchange of the cannon assembly for a higher-energy weapon in a manner similar to the conversion of the US M109 to the M109A1 system. The turret can be traversed 360°, although firing of the higher charges may be restricted, at the lower elevations, to 45° right and left of the longitudinal axis because of stability considerations. Elevation limits are estimated to be -4° and +60°. Overall performance of the M1973 reflects significant improvements compared with the towed 152-mm D-1 howitzer that it is replacing. Power-assisted or, more probably, some form of semiautomatic loading, as well as powered traverse and elevation mechanisms (probably electric drives with manual backup), is postulated for the M1973. Because the turret ring is quite small in diameter for a weapon of this size, thereby engendering crowded conditions in the fighting compartment, and because only three crew members occupy that compartment, it is postulated that the loading mechanism and ammunition materials handling equipment is relatively sophisticated. Should the M1973 not approach the French 155-mm GCT or the tripartite 155-mm AH-70 in loading capability the crewman loading the weapon could not attain, nor could he sustain for more than a few minutes, an acceptable rate of fire. Assuming these postulations are correct, this system should achieve a burst rate of fire on the order of three rounds in 15 seconds, and eight rounds in the first minute of firing; i.e., with fuze options set and propelling charges cut on three rounds, and with one of the rounds loaded into the chamber, this system should be capable of firing three rounds in about 15 seconds. This contrasts with the maximum prescribed rate of four rounds per minute for the D-1, ML-20, and D-20 towed systems. Estimated prescribed rates of fire for the M1973 are presented in table II-L-2.

c. ~~(C)~~ Effectiveness.

(1) ~~(C)~~ General. At the estimated rates of fire an 18-gun 152-mm M1973 battalion can deliver 6.27 tonnes of OF-540 projectiles upon an 8 PE_r deep target during the first minute of firing. In view of the postulated improvements in mobility, rate of fire, range, etc., effected in the M1973, plus the improvements in associated target acquisition and fire control means, the self-propelled M1973 system represents a marked improvement over the towed D-1 system, albeit at a considerable cost in RAM-D characteristics.

(2) ~~(C)~~ Ammunition. In addition to a spin-stabilized HEAT projectile (that probably is available as well to the towed 152-mm systems), this system is postulated to be capable of firing most, if not all, of the projectiles utilized in the towed 152-mm ML-20 and D-20 systems as depicted in table II-M-1. In addition, a "super charge" may be available to provide these projectiles with increased range. Present or future availability of

full bore-hollow base, subcaliber, or, less probably, rocket-assisted projectiles also is possible. The onvehicle ammunition load is estimated to be 40 rounds, including 4 rounds of HEAT and, possibly on occasion, 2 or 3 rounds of smoke (WP). Figure II-L-8 depicts a partial load of HE ammunition and the usual four HEAT rounds.

(3) ~~(C)~~ Indirect fire.

(a) (U) Precision. Utilizing the OF-540 HE-fragmentation projectile, the precision attained should be equal to or better than that depicted in table II-M-2 for the 152-mm ML-20 system.

(b) ~~(C)~~ Effectiveness. Table II-L-3 provides an illustration of the attainments of the identified systems based on probable rates of fire.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-L-8. Soviet 152-mm self-propelled gun M1973 ammunition (U).

Table II-L-3. Comparative Effectiveness (U)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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(c) ~~(c)~~ Fragmentation. The M1973 probably fires the OF-540 HE-fragmentation projectile to a range of 17 230 meters and may fire the highly lethal O-530A cast-iron projectile to ranges below 15 740 meters. Fragmentation parameters of these projectiles are set forth in paragraphs 29b(2)(c) and 25b(2)(c), respectively.

(d) (U) Lethality. Data pertaining to lethality of the OF-540 and OF-530 (not the more lethal cast-iron O-530A) are presented in figures II-M-3 and -4 and II-O-3 and -4, respectively.

(4) (C) Direct fire.

(a) ~~(c)~~ Precision. Precision data for direct fire currently are not available for the M1973 system; nevertheless, the M1973 system, when firing its HEAT-SS projectile, should approximate those data presented in table II-M-3 for the ML-20 firing its AP-T projectile.

(b) ~~(C)~~ Grazing range. Because the increased trunnion height of the M1973 should approximately negate the probable 50-plus m/s increase in muzzle velocity of the M1973's HEAT projectile over the ML-20's AP-T projectile, it is believed that those data set forth in paragraph 25b(3)(b) for the ML-20 are applicable to the M1973.

(c) ~~(C)~~ Effective range. Empirically, the effective range (50% probability of a first-round hit) of the M1973 should approximate 750 to 800 meters.

(d) ~~(C)~~ Engagement range. It is estimated that a M1973 gun crew probably would open fire upon a US M60A1 tank at a range of about 900 to 1000 meters.

(e) ~~(C)~~ Armor penetration. Data are not available upon the penetration achieved by the 152-mm HEAT-SS projectile. The 122-mm VBK-3 HEAT-FS projectile, rated by the Soviets as penetrating 350 mm of homogeneous armor of 0° obliquity, actually penetrated 579 mm according to US criteria; at 350 mm depth of penetration, the diameter of the penetration was on the order of 12 to 14 mm. It is probable, therefore, that the 152-mm HEAT-SS projectile should penetrate 225 mm or more of armor by Soviet standards or 300 mm (approximately 12 in) or more by US standards.

d. ~~(C)~~ Mobility. With the introduction of self-propelled field artillery, circa 1973, the Soviets deployed field artillery systems possessing mobility comparable to that of their armored fighting vehicles (fig II-L-9). Such a level of mobility on the part of the fire support arm greatly facilitates the conduct of the exploitation and the pursuit. Another major, if not prime, consideration in the decision to develop and deploy self-propelled cannon systems was survivability. On the nuclear battlefield the Soviets see self-propelled artillery as a means to rapidly concentrate their field artillery at a place and time of their choice thus enhancing system survivability. Further, the protection afforded by the turreted and enclosed vehicle materially enchances the survivability of the onboard crew. Self-propelled artillery also enhances the capability to utilize roving gun and roving battery techniques to complicate further the enemy's counterbattery problem. There are two key words associated with self-propelled artillery, mobility and survivability. Survivability is not solely associated with armor protection; it is also, perhaps even more likely, the result of a prudent use of inherent mobility. Estimated mobility parameters are presented in table II-L-4.

(b)(6)

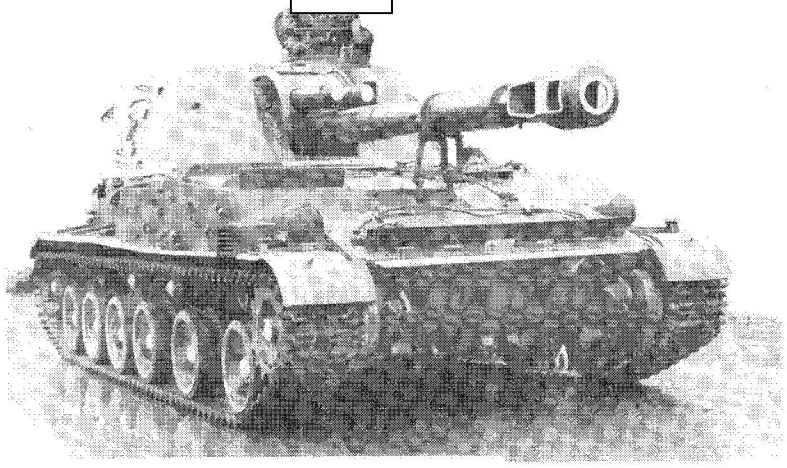

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Figure II-L-9. Soviet 152-mm self-propelled gun M1973, three-quarter front view (U).

Table II-L-4. Estimated Mobility Parameters, 152-mm M1973 Self-Propelled Gun (U)

Maximum speed:	
High gear	70 km/h (44 mi/h) (90%)
Low gear	12 km/h (7.5 mi/h) (80%)
Reverse	12 km/h (7.5 mi/h) (80%)
In smooth water	NA
Engine noise level	Relatively low*
Track noise level	Relatively low*
Driving aid (IR)	TVN-2 type (90%)
Engine: V-12 diesel engine used in T-54 tank	382 kW (520 hp) (90%) @ 2000 r/min*
Onboard fuel capacity	810 liters (214 gal) (80%)
Transmission type	Mechanical (80%)
Forward speeds	5 (80%)
Transmission ratio	6:1 in top gear (80%)
Operating radius	500 km (311 mi) (85%)
Trench-crossing capability	2.3 m (7.5 ft) (90%)
Vertical step negotiation	102 cm (3.3 ft) (80%)
Minimum turn radius	3.9 m (80%)
Gradeability	30° (80%)
Fording depth	120 cm (3.4 ft) (80%)
Ground pressure (average)	0.64 kg/cm^2 (90%) (9.1 lb/in^2) (63 kPa)

*Compared to other 25- to 30-tonne self-propelled, tracked systems.
**This engine could be replaced by the 426 kW (580 hp) @ 2000 r/min engine of the T-55 tank.

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e. ~~(C)~~ Summary. By introducing this self-propelled system into their inventory, the Soviets have improved the mobility, emplacement/displacement times, crew protection, range capability, communication capability, and the rate of fire of their former divisional general-support cannon system (the towed 152-mm D-1 howitzer). Although maintenance and other logistic requirements obviously are increased by introduction of the M1973, the employment of an organic battalion of 18 M1973 self-propelled gun-howitzers considerably enhances the ability of a Soviet division to provide continuous artillery fire support during the rapid execution of mobile operations. Attachment of the organic M1973 battalion to one maneuver regiment (or battalion), and a second or third battalion of M1973's (from a division in reverse or from the front artillery division) to other maneuver regiments, should be anticipated. Such attachments will provide for continuous fire support of committed forces during the exploitation and pursuit phases of an offensive operation.

24. ~~(C)~~ Component Analysis

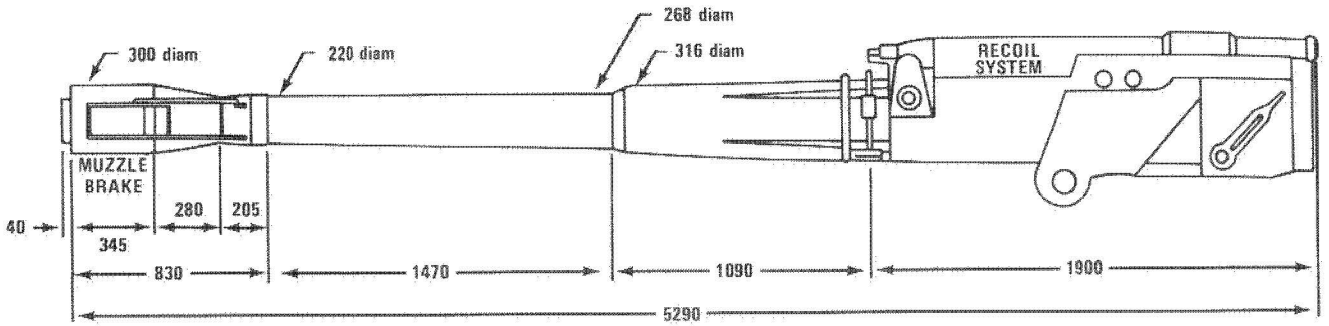
a. Armament.

(1) Cannon assembly. Visible portions of the cannon assembly that are mounted through the rotor/mantlet on the M1973 bear a resemblance to the cannon assembly of the 152-mm D-20 towed howitzer.

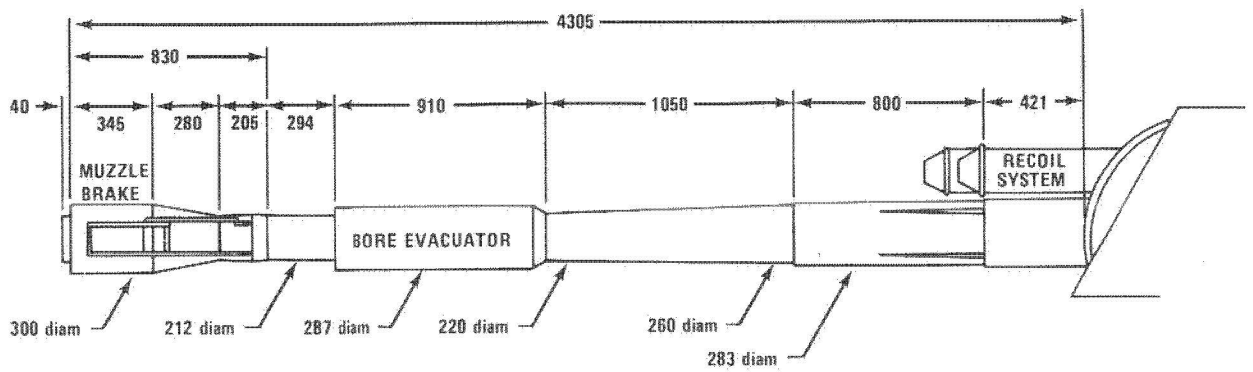
(a) Tube. The tube of the cannon assembly mounted on the M1973 is in the 152-mm Soviet gun-howitzer class. Its length approximates that of the D-20 and ML-20 tubes. The visible length of the tube and muzzle brake forward of the rotor is approximately 4.31 meters (14.1 ft) (fig II-L-10). A remotely controlled gun stay (travel lock) is located in the center of the forward deck (fig II-L-6). The tube, including the muzzle brake, protrudes about 1.0 meter (3.3 ft) beyond the leading edge of the vehicle. Table II-L-5 provides data based on analysis of available information.

(b) Breechring.

1. This fixture most probably incorporates a semiautomatic vertical sliding wedge breechblock that operates in conjunction with a powered, or at least a power-assisted, loading mechanism. The breechring probably is attached to the recoil mechanism by a yoke that accepts the piston rod ends. Table II-L-6 presents estimated data pertaining to the breech.



LEFT SIDE VIEW
152 mm D-20 TOWED



LEFT SIDE VIEW
152 mm SP GUN M1973

DIMENSIONS IN MILLIMETERS
ACCURACY DIMENSIONS: ± 5%

DRAWING NOT TO SCALE

Neg. 555329

~~(CONFIDENTIAL)~~

Figure II-L-10. Soviet 152-mm tube comparison, D-20 and M1973 (U).

Table II-L-5. Estimated Tube Characteristics, 152-mm M1973 Self-Propelled Gun (U)

Tube identification (Soviet)	Unk
Soviet tube designator	2A33
Caliber	152.4 mm (99%)
Length, including breechring:	
w/muzzle brake	5.20 m (80%)
w/o muzzle brake	4.42 m (80%)
Visible length of tube and muzzle brake forward of mantlet	4.31 m (90%)
Weight (tube only)	?
Construction	Monobloc (85%)
Autofrettaged	No (85%)
Method of fabrication	Rotary forging (70%)
Type of material	ESR steel (70%)
Chemical composition	?
Microstructure	?
Rockwell C hardness	?
Yield strength (0.1% offset)	?
Fracture toughness K_{1c}	?
Tensile strength	?
Elongation	?
Impact value (charpy)	?
Reduction in area	?
Tempering temperature	?
Tempering duration	?
Rifling	Uniform RH (90%)
Twist rate(s)	1 turn in 25 cal (7°10' inclination)
Number of land/grooves	48 (85%)
Land width	?
Groove width	?
Groove depth	?
Length of rifling	≈3.47 m (85%)
Chamber type	Tapered (90%)
Chamber length	≈66 cm (95%)
Chamber volume	≈12+ liters (95%)
Chamber pressure (maximum)	≈2350 kg/cm^2 (90%)
Muzzle velocity, full charge, OF-540 projectile	655 m/s (90%)
Number of major tube diameters	5 (80%)
Method of mating tube:	
To breechring	Unthreaded tube (threaded sleeve)
To recoil mechanism	Piston rods to breechring yoke
To bore evacuator	Shoulders and a threaded sleeve
To muzzle brake	Left hand threads on tube
To mount	Tube is inserted through the sleeve that is integral to the mount

Table II-L-5. Estimated Tube Characteristics, 152-mm M1973 Self-Propelled Gun (Continued) (U)

Tube wear life (EFC)	≈3000 EFC (70%)
Tube fatigue life (EFC)	?
Gun stay (travel lock) in rear of bore evacuator	Remotely operated

~~(CONFIDENTIAL)~~

Table II-L-6. Estimates of the Breech 152-mm M1973 Self-Propelled Gun (U)

	Breechring	Breechblock
Width	?	?
Height	?	?
Length	?	?
Weight	≈500 kg	≈60 kg
Material:		
Chemical composition	?	?
Microstructure	?	?
Rockwell C hardness	?	?
Yield strength (0.1% offset)	?	?
Fracture toughness K_{1c}	?	?
Tensile strength	?	?
Elongation	?	?
Impact value (charpy)	?	?
Reduction in area	?	?
Estimated breech life (EFC rounds)	≈9000 (70%)	≈6000 (70%)

~~(CONFIDENTIAL)~~

2. The breechblock operation is estimated to be similar to that of the 152-mm D-20. The breech should open, cock the firing mechanism, and latch in the open position semiautomatically by means of a recoil activated cam plate and crank arrangement. The breechblock closes and locks automatically when the cartridge case is inserted and, upon seating in the breech, its rim trips the extractor latch. The breech-closing operation is powered by coil-spring-stored energy. Recoil energy provides both the direct and the stored forces required to operate the breech mechanism.

(c) Bore evacuator. A bore evacuator is mounted on the tube immediately forward of the travel lock and approximately 300 mm to the rear of the muzzle brake. Figure II-L-2 presents dimensions of the evacuator that covers the approximately 215-mm-diameter tube.

(d) Muzzle brake. The muzzle brake is a double-baffle, four-port, winged-type fixture and is similar, if not identical, to the muzzle brake used on the 152-mm D-20 gun-howitzer (fig II-L-2, -9, and -10). Brake efficiency is estimated to be approximately 40%. Table II-L-7 presents estimated data for the muzzle brake.

Table II-L-7. Muzzle Brake, 152-mm M1973 Self-Propelled Gun (U)

Type brake	Double baffle (99%)
Length	870 mm (90%)
Weight	140 kg (90%)
Efficiency	≈40% (80%)
Mounting method	Left-hand threads
Max overpressures (full-charge rd)	?
Yield strength	?
Rockwell C hardness	28 (80%)

~~(CONFIDENTIAL)~~

(e) Weapon characteristics. The cannon assembly (tube, breech, muzzle brake, and bore evacuator) is estimated to weigh 2450 kg. System weight to cannon weight is about 11:1.

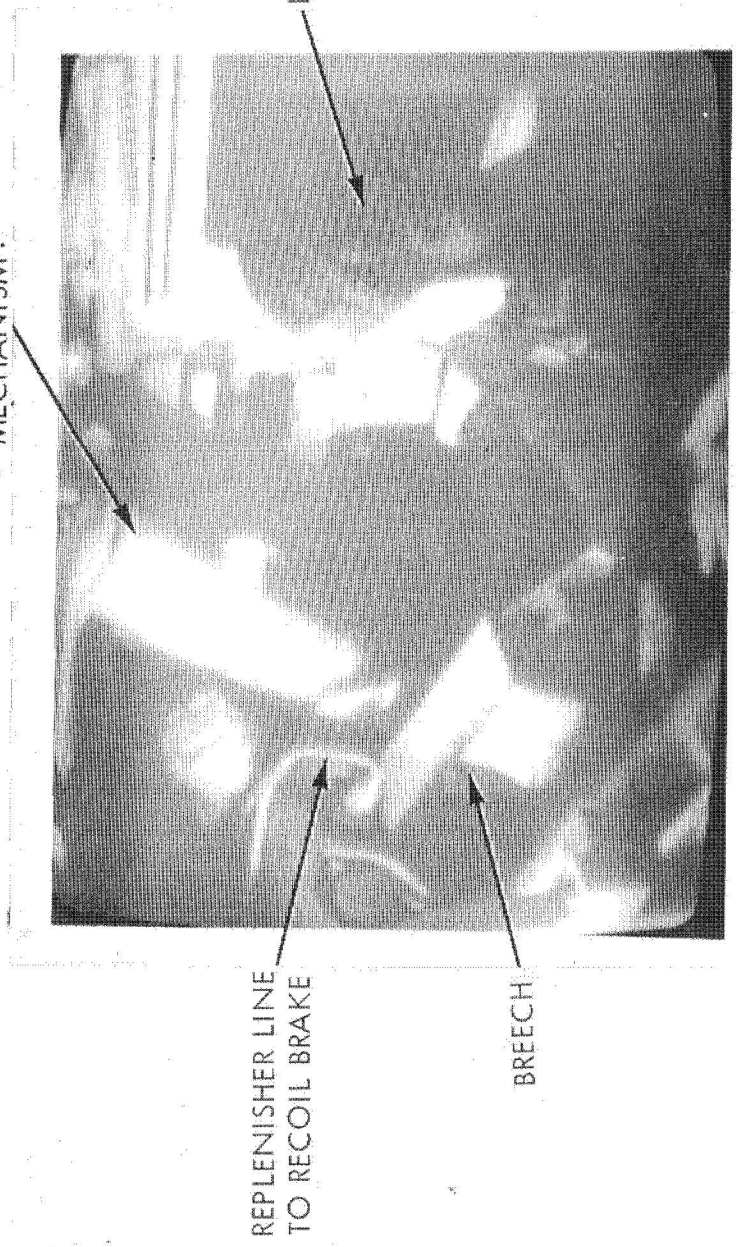
(2) Cradle. The M1973's cannon assembly is secured in a mount that incorporates a sleeve-type fixture to accept the cannon. The mount also incorporates the recoil mechanism, the rotor shields, and the trunnions. The trunnions, in turn, probably are secured in a heavy support that is attached to the turret wall at two points. Upon firing, the firing force is transferred from the cannon through the mount to the trunnions, and thence, in turn, through the mount support to the turret, the hull, the suspension, and into the ground. In a sense the mount corresponds to the cradle, and the mount's support to the top carriage (saddle) of a towed weapon.

(3) Recoil mechanism. The recoil mechanism appears to be an adaption of the mechanism found upon the towed D-20 system. The left cylinder, the recuperator, is shorter than the recoil brake cylinder that is positioned to its right. The poor-quality interior view that is available shows a fluid line, probably running from the replenisher, connected to the rear face of the recoil brake (fig II-L-11). The recoil mechanism has been reversed end-for-end from the positioning found on the D-20 system. Although the cylinders protrude unequally, outside of the turret, both cylinders terminate at the forward face of the breechring. It is probable that, unlike most Soviet cannon systems, the piston rod ends are attached to the breechring and the cylinders are secured within the mount. Recoil fluid probably is Steol M. The recuperator probably is pressurized with nitrogen in peacetime and dry air in time of war. A length of recoil scale probably is incorporated into the mount. Table II-L-8 presents estimates pertaining to the recoil mechanism.

Table II-L-8. Estimated Recoil Mechanism Parameters, 152-mm M1973 Self-Propelled Gun (U)

Type	Hydropneumatic, independent probably variable length; modified Schneider (90%)
Weight of recoil mechanism	?
Method of attachment	Cylinder ends to mount piston rod ends to breechring (90%)
Recoil cycle time	?
Maximum length of recoil	≈540 to 740 mm depending on QE (80%)
Recoil pressure (maximum)	?
Initial pressure in recuperator:	67, +1 -2 kg/cm^2 (80%)
Fluid in:	
Recoil brake	13.2 liters (80%)
Recuperator	13.2 liters (80%)
Replenisher:	
Function	Serves recoil brake (95%)
Fluid quantity	0.5 liter (85%)
Surface finish (RMS):	
Piston rod	12 (80%)
Recoil cylinder	35 (80%)
Throttling rod	75 (80%)

~~(CONFIDENTIAL)~~



(~~FOR OFFICIAL USE ONLY~~)

Figure II-L-11. Soviet 152-mm self-propelled gun M1973, interior view (U).

Neg. 525139

(4) Crew and crew compartment. The normal onboard crew for this weapon system is believed to be four, including the gun commander, the gunner, the loader, and the driver. There have been some indications that in stressful situations the crew may be augmented to five; however, the addition of another crew member into the limited space available would certainly crowd the crew compartment. Additional ammunition handlers from the ammunition resupply vehicle probably are used to process and onload ammunition from the outside of the vehicle during periods of heavy or extended firings. The usual crew members are estimated to be located and to function as follows.

(a) Gun commander. This man normally is located in the commander's cupola (fig II-L-12) from which he can control the activities of the other crew members and direct the operation of his weapon. Aids provided for his use include an intercom system, a radio for external communications, an IR illuminator and related equipment, vision blocks, and other, as yet unidentified, equipment. Depending upon the degree of automation, the gun commander may control the indexing of ammunition to the loading mechanism.

(b) The gunner. This crew member is located forward of the gun commander and to the left of the trunnions. He performs the standard Soviet gunner's duties in positioning the tube for elevation and direction. The fire-control instruments provided (fig II-L-13) probably are more sophisticated than the conventional items normally seen associated with towed systems; however, their ultimate purpose is the same. The gunner is also believed to be provided an improved capability for accomplishing direct fire, to include an image intensifier or passive IR imaging sight to improve the results of such fire during periods of restricted visibility. The elevation and traverse mechanisms are estimated to be powered, thereby enhancing system firing capabilities. Manual backup systems probably are provided for emergency use.

(c) The loader. This crewman is physically located within the periphery of the turret ring, as are the gun commander and the gunner. The loader is located on the right side of the cannon opposite to the gun commander. He probably is required to cut charges and set fuzes in addition to operating the postulated mechanized loader that is associated with this system. Much of the manual exertion normally associated with loading probably is no longer required because of the postulated powered loader; this should improve firing rates as well as reduce errors occasioned by fatigue.

II-156.16 is denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

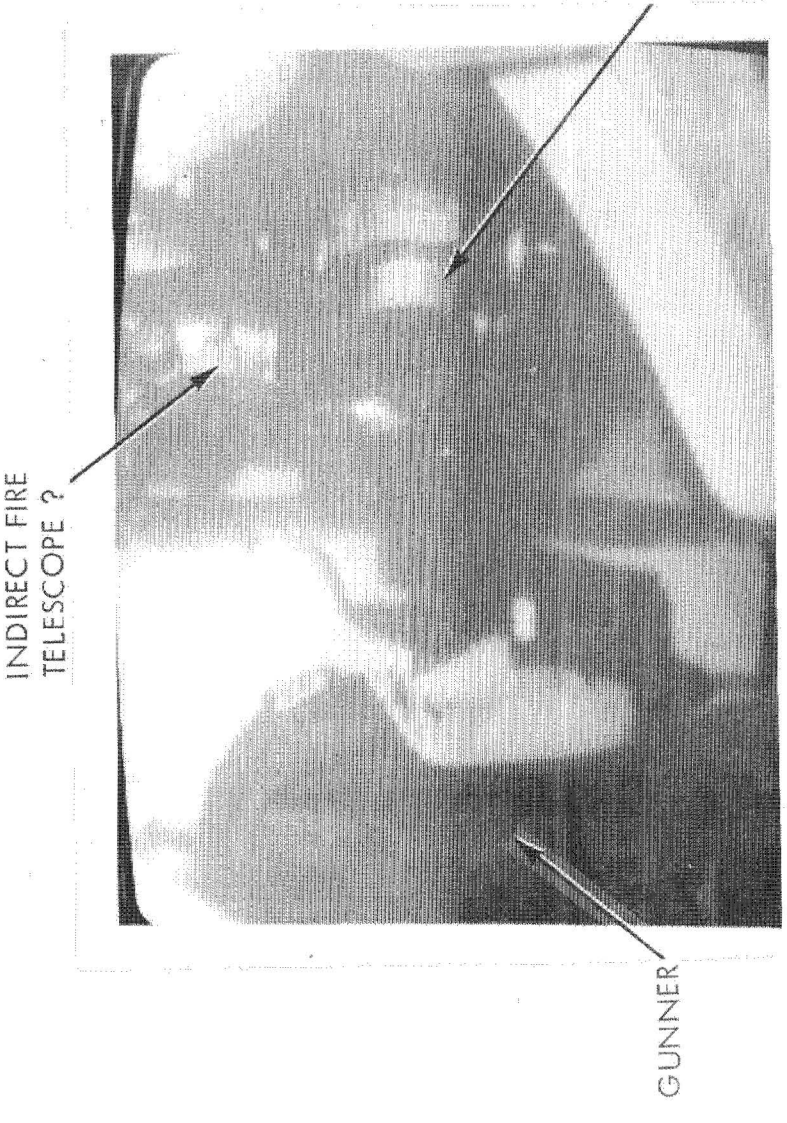


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Figure II-L-13. Soviet 152-mm self-propelled gun M1973, sighting system (U).

Neg. 525138

(d) The driver. The driver-mechanic is positioned in the left forward quadrant of the hull deck in association with the rear hinged driver's hatch (fig II-L-12). A window with an armor plate cover is located directly in front of the driver for use in buttoned-up operations. The driver is provided with a portable rain cover that attaches to the open hatch. The top and sides of this rectangular cover appear to be metal, the bottom and rear are open, and the front is of a transparent material and mounts a windshield wiper. Probably attached by quick release bolts, this device affords much better vision than is possible when driving buttoned-up during inclement weather. A TVN-2-type driver's IR device probably is provided.

(5) Elevating mechanism. The elevating mechanism in this system possibly is an electrohydraulic or, perhaps more probably for the Soviets, a potentiometer-controlled electric drive that is assisted by an equilibrator. Either type of elevating mechanism will have a manual backup. In either case the angular rate of elevation should vary on the order of 0.1° to 5.0° per second. Due to limited space, it is probable that the Soviets have incorporated some version of the BM-21 multiple rocket launcher's single handwheel for manual positioning in both elevation and traverse. A selector on the BM-21's handwheel permits engagement of either the elevation or the traversing mechanism's gear train as desired. Angular rate of elevation with manual operation probably is quite slow, perhaps but 1 to 2 M per turn of a small-radius handwheel. It is postulated that the mechanical loader can load the cannon at $\leq$30° of elevation and that at higher elevations the cannon must be returned to $\leq$30° for loading. Elevation limits are -4° and +60°.

(6) Traversing mechanism. The traversing mechanism is thought to consist of a ring and race, which is positioned at the hull-turret interface and driven by an electrically powered bevel gear. This type of potentiometer-controlled electric drive should traverse the turret thru 360° at a rate of 0.1° to 7° per second. If employed, the BM-21-type single wheel for both elevation and traverse should exhibit an angular rate of about 3 M per revolution in traverse.

(7) On-carriage fire control.

(a) Indirect fire sight. A panoramic telescope (fig II-L-13), a new design that probably provides capabilities greater than those associated with the PG-1M telescope (e.g., apparently digital readout), operates through the telescope head housing located in the left forward section of the turret roof adjacent to the left trunnion (fig II-L-7). It is possible that the telescope body is capable of being extended to raise the telescope head and its housing to provide a clear

line of sight in all directions. The comparatively large cover on the panoramic telescope probably is only a protective cover for the optical head, particularly the objective, of the panoramic telescope. A data insertion capability direct to the sight and sight mount is possible but not probable. The reticle pattern probably is of the standard type that is usable with a collimator and, in an emergency, for direct fire.

(b) Direct fire sight. A direct fire telescope operates through the hooded aperture located in the left side of the forward turret wall adjacent to the rotor (fig II-L-7). The relatively small area in this aperture militates against the inclusion of a long-range, passive image intensifier-type sight, i.e., one having a large objective. Nevertheless, it is probable that the direct fire telescope exhibits some improvement in target detection over that exhibited by the 152-mm towed cannon systems.

(8) Secondary armament. A 7.62-mm model PKT machinegun is positioned at the commander's cupola (fig II-L-12). This electrically triggered machinegun appears to be aimed and fired from within the vehicle when the vehicle is buttoned up. Sighting probably is accomplished by using the periscope located under the gun as a linkage is visible between the mount trunnion and periscope housing. The usual PKT "butterfly" trigger is retained for emergency manual firing when the vehicle commander has his hatch open. This gun is probably used for close-in vehicle defense against ground attack and, because of limitations on the sighting system, has little, if any, antiaircraft capacity.

b. Turret. The turret, a square structure with rounded forward corners and a flat periphery, is capable of 360° traverse. Basic dimensions of the turret are provided in table II-L-9 and figures II-L-2 through -5. Lifting cleats are located high on the sides of the turret near its rear corners and the front rounded corners (fig II-L-7). Three tiedown straps are located on the rear face of the turret. An antenna base is located on the port side of the upper bustle face. Two large access plates are situated on the rear face of the turret bustle. A square hatch, hinged on the right side, is located in the center of the starboard side of the turret. A commander's cupola with a rotatable hatch is centrally located along the port side of the turret; the upper portion of this fixture protrudes cylindrically upward from below the center of the port side of the turret (fig II-L-7, -12). A forward looking vision block, a TKN-1-type IR light, and a 7.62-mm PKT machinegun are positioned at the commander's cupola. Three additional peripheral vision blocks are mounted in the cupola ring. The base of hinge-mounted baton-like fixture is located immediately forward of the turret ring. This fixture and a similar fixture on the 122-mm M1974 self-propelled

Table II-L-9. Turret Dimensional Data (U)

Turret top:	
Length	2.90 m (90%)
Width	1.98 m (90%)
Turret base:	
Length	3.45 m (90%)
Width	2.57 m (90%)
Height of:	
Turret proper	0.92 m (90%)
Cdr's hatch from ground	2.88 m (90%)
Diameter, at base, of:	
Cdr's hatch/cupola	0.96 m (90%)
Pantel housing	≈230 mm (80%)
Slopes from vertical:	
Front of turret	≈30° (90%)
Bustle of turret	≈35° (90%)
Sides of turret	≈21° (90%)

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gun have been observed in a raised (vertical) posture. When raised, the baton on the M1973 is vertically aligned over the apparent optical axis of the panoramic telescope; this condition is not true for the 122-mm M1974. Being aligned on the M1973, this object can be used as an aiming reference for laying the gun and perhaps as a stadia for determining the position of the M1973 relative to the battery XO's vehicle [ACRV M1974(2)]. Almost certainly, this device is used (on both the M1973 and M1974 systems) in lieu of the signal flag used by gun commanders of towed artillery pieces, e.g., to indicate "ready," "your command received and understood," etc. These batons may have lamps at one or both ends for night use. A relatively large housing for the head of the panoramic telescope is located forward of the commander's hatch adjacent to, and apparently slightly in rear of, the probable position of the left trunnion. A hooded direct-fire sight aperture is located on the forward turret wall to the left of the rotor assembly (fig II-L-7). There is a round, partially mushroom-shaped object located on top of the turret in rear of the left side of the rotor. A similar object is positioned near the right rear corner of the driver's compartment hatch. These objects appear to be ventilation ports capable of being rotated to their opened or closed positions.

c. Hull and Suspension.

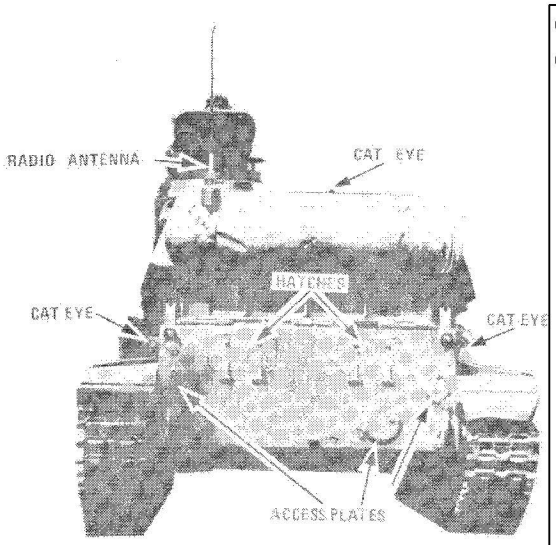
(1) Hull.

(a) Description. The hull is a modified GANEF TEL hull. The width of the forward upper hull extends nearly to the outer edges of the tracks (fig II-L-9 and -12). The forward upper hull extends to approximately 60% of the overall length of the vehicle. The rear third of the upper hull is approximately equal in width to the lower hull. Approximately above the fourth roadwheel (counting from the front of the vehicle), there is a beveled area in which the forward hull narrows to its juncture with the rear hull (fig II-L-14). The rearward extension of this area is overridden on both sides of the hull by a segment of the turret ring. Three access hatches appear in the left (port) side of the forward hull over the tracks (fig II-L-2 and -14). Fenders extend the full length of the tracks; a small (50 to 75 mm) portion of the track width is not covered by the fenders. A baffle is mounted in rear of the leading edge of the upper glacis; this baffle is probably used for deflecting water when fording streams or traveling on wet roads. Two cables are stowed to the rear of this baffle. These cables probably attach to the tracks for use with a log during deditching operations. It is common practice for Soviet track vehicles to carry a log to assist in vehicle extraction. Driving lights and "cat eyes" are positioned at the front of the vehicle forward of the main hull and above the tracks. Towing hooks are mounted inboard of the tracks on the lower glacis at the front of the chassis. The forward upper glacis plate slopes at about 20° and is hinged at the rear to provide a large access panel to the transmission compartment. A bolted-down engine access cover is positioned to the right of center in the upper deck of the forward hull (fig II-L-12), which slopes at angle of about 7°. A large, vented access plate appears directly to the rear of the engine access cover near the forward edge of the turret. This item provides air to the engine compartment and, when removed, permits servicing of the engine air filtration system. Two louvered, partially covered vents are located adjacent to the starboard side of the forward hull. These vents are the exhaust and intake for the engine cooling system. The rear-hinged driver's hatch is located in the left (port) side of the upper deck of the forward hull; its leading edge falls approximately midway between the leading edge of the turret and the forward edge of the vehicle. This hatch is equipped with forward-looking vision blocks. Another aforementioned circular, partial mushroom-shaped, probable vent is located to the right rear of this hatch. The rear hull plate is flat and nearly vertical. In the first model observed (fig II-L-5) and the right view in figure II-L-15, a bottom-hinged, rectangular hatch appears in the center of the rear hull plate. Two pairs of what appear to be

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555510 ~~(CONFIDENTIAL)~~

Figure II-L-14. Soviet 152-mm self-propelled gun M1973 left front view (U).



(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure II-L-15. Soviet 152-mm self-propelled gun M1973, rear view comparison (U).

circular access plates appear in the rear plate. One pair is located symmetrically below the bottom corners of the hatch and the other pair above and outboard from the first pair. More recently, a different version of the M1973 has been observed (left view, fig II-L-15). This version has two smaller rectangular hatches, aligned horizontally in the upper section of the rear plate, in lieu of the single large rectangular hatch. The modified (two hatch-type) version of the M1973 retains the lower right circular access plate and the two smaller outboard plates; i.e., the lower left access plate is missing on this version. The lower right plate has been observed being used as a loading port for projectiles. Towing hooks are located at the lower rear corners of the hull. A large, curved, ribbed, blade-like fixture is stowed atop the rear hull plate and beneath the inwardly beveled rear of the turret bustle (fig II-L-12). When operational this fixture is hinge-mounted at the lower edge of the frontal plate. For travel it is swung upward and latched flush with the frontal plate. Keyhole-type openings in this fixture permit towing hook penetration and possible locking of the fixture to the frontal plate. The purpose of this fixture currently is unknown. "Cat Eye" fixtures are located on the side hull plates outboard from the vehicle headlights.

(b) Protection. The thickness of the hull and turret armor probably is adequate to protect the crew and components from most small-arms fire and from relatively-low-velocity shell fragments. While there are no positive indications of a crew air filtration system, the Soviet practice of installing such systems on combat vehicles indicates the possible presence of NBC protection. Should an NBC system not be present, the vehicle would inherently afford some crew protection against the effects of NBC, especially in the buttoned-up configuration. It should be noted that NBC protection is an important consideration to the Soviets and no doubt weighed heavily in favor of the adoption of self-propelled artillery. Such protection provides the capability for a system to traverse contaminated terrain and to fight, albeit at less than normal efficiency, in an NBC environment.

(2) Suspension. The track and suspension of the M1973 are a modified, six-roadwheel version of the seven-roadwheel SA-4 GANEF TEL chassis. The track is of single-pin construction. The roadwheels appear to be the same as those mounted on the GANEF. There is an easily identifiable uneven spacing of the roadwheels. The spacing of the first and last roadwheel also differs between the right and left sides of the vehicle. The left side interval between the drive sprocket and the first roadwheel is 825 mm, and between the last roadwheel and the idler is 765 mm; these intervals are reversed on the right side. This difference in interval is due to the presence of independent

torsion-bar suspension. The intervals between the other roadwheels are the same for both the right and left sides (see fig II-L-2 and II-L-3). The grousers of the M1973 and the four support rollers are located similarly to those on the GANEF TEL. The two center rollers, positioned outside the track center guides, are located closer to one another than they are to the front and rear rollers. The forward and rear rollers are positioned inside the track guides. There are four shock absorbers on each side on the hull: a double type on roadwheel No. 1, a single type on roadwheel Nos. 2 and 5, and a double type on roadwheel No. 6. These shock absorbers are a volute type spring and are of the type found on the US M41 light tank. On the US tank they are called "bumper stop springs." Neither a firing spade nor other stabilizing fixture can be seen mounted on this vehicle. This vehicle is not believed to employ a suspension lock-out system. The large vehicle mass and comparatively large track-ground contact area should permit acceptable distribution of the firing force to the ground. According to available information the only action necessary in this regard is that the driver set the "mountain brakes"; these brakes probably are equated to the US term "emergency brakes." As previously indicated, the function of the blade-like fixture that attaches to the front of the vehicle is not known. Table II-L-10 presents data on the suspension.

Table II-L-10. Suspension Data (U)

Type suspension	Independent torsion bar (95%)
Roadwheels	6, irregularly spaced (99%)
Support rollers	4 (99%)
Track type	Steel, single pin, bushed, unidirectional (90%)
Track width (w/pin)	46 cm (90%)
Track length, ground contact	4.61 m (90%)
Total ground contact (both tracks)	30 887 cm^2 (90%)
Ground pressure	0.637 kg/cm^2 (90%) (62.5 kPa)

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d. Ammunition Loading and Ammunition Handling Mechanisms. It is postulated that the M1973 has a partially automated loading system, with the projectiles being removed from stowage and placed in the ready for ramming position by a mechanical arm (fig II-L-11). The loader sets the fuze option, then power-rams the projectile by activating an electrical switch. The cartridge case probably is selected manually by the loader,

who places it on the loading tray, cuts the charge and throws the unused increments into a foot-operated, closed bin, and then activates the circuit for power-loading of the cartridge case. The rim of the cartridge case striking the extractors automatically closes the breech. Both projectiles and powder case are loaded through access doors on the rear of the hull onto a postulated belt-like system that is powered to position (index) these items as required. It is possible that, beyond certain limits, the gun must be returned toward the center of traverse and below a specific elevation prior to reloading in order to index the automatic loading system. With powered elevation and traverse this procedure should not be a time-consuming operation, but it could result in a somewhat slower rate of fire. It is presently assumed that the cannon can be loaded over a relatively wide range of positions in elevation and traverse without being returned toward center of traverse and below a particular elevation. The M1973 utilizes separate loading, cased ammunition with variable charge selection. This weapon probably is capable of firing all those projectiles associated with the D-20 and ML-20 152-mm gun-howitzers (table II-M-1). It is possible that some new munitions have been developed for the M1973, D-20, and ML-20 systems or that the Soviets have evolved improvements in propellant, projectiles, and the cannon that provide increased range and effectiveness to the M1973 over that associated with the D-20 and ML-20. The on-vehicle ammunition load is estimated to be 40 rounds (nominally 36 HE and 4 HEAT). In addition to firing HE and HEAT projectiles the M1973 152-mm gun-howitzer probably fires smoke, CP, illuminating, and chemical munitions from ammunition resupply vehicle or on-ground stockage. There is a possibility that the M1973 also has a nuclear delivery capability.

e. Powertrain.

(1) Engine. The engine in the M1973 is located to the right of center in the forward section of the hull (fig II-L-4 and -12). The engine in this vehicle is the V-12, liquid-cooled diesel used in either the T-54 or T-55 tanks. The exact model is unknown at this time. The T-54's engine provides 382 kW (520 hp) vs. the 426 kW (580 hp) available in the T-55. A change in the fuel system, plus a slight increase in the compression ratio, provides the increased power output of the T-55's engine. Minor improvements are a hydraulic drive for the generator, a different type oil filter, and "winter/summer" settings for the fuel injecting timing. In the tank application the intake manifolds connect to the air cleaner at the output end of the engine; in the T-54 through T-62 this is at the vehicle's right side. The location of the air cleaner in the M1973 is to the rear of the engine and immediately forward of the turret. The M1973 does not appear to be turbocharged. There are some indications that turbocharging of the tank V-12 engine has been

attempted without success; structural problems in the lower part of the engine could be the source of these failures. Analysis indicates that this V-12 engine can be modified to produce 515 kW (700 hp), as was done with the T-10 heavy tank, without turbocharging. This could be accomplished by changing the fuel system, intake and exhaust manifolds, and valve timing and sizes. The air cleaner in the M1973 appears to be identical to that used in the T-54 through T-62 tank series. It consists of an exhaust-aspirated cyclone first stage and a second stage composed of three oil-soaked wire gauze filters. Cooling air is drawn over the relatively small area radiator by a ducted fan positioned to the rear of the radiator. The fan appears to be motor-driven, although possibly it is driven by a power takeoff from the engine. Engine overheating probably occurs during operation in ambient air temperatures in excess of 40° to 44°C (105°-110°F). The M1973 self-propelled gun should have a power-to-weight ratio of about 14.2 kW/tonnes [27 tonnes vs. 382 kW (520 hp)].

(2) Transmission. It is postulated that a mechanical transmission similar to those found in the AT-T or ATS-59 artillery tractors is used in the M1973. The transmission, located in the extreme front of the vehicle between the two drive sprockets, probably has five forward speeds and one reverse; servo/hydraulic controls are probably used. Steering and braking are accomplished through controlled differential systems either mounted on or internal to the transmission. Because of the distance between the engine and transmission, it does not appear likely that they can be removed as one unit.

(3) Final drive. The final drive probably is a two-stage assembly, consisting of spur-pinion and bull gears and planetary train, that is expected to exhibit a 6:1 ratio.

f. Cruising Range. The cruising range for this system is expected to approximate 500 km. Onboard fuel storage necessary to attain this range should approximate 810 liters (214 gal). Reportedly five fuel tanks are mounted in this vehicle.

g. Auxiliary Engine Powered Generators. According to current information, the M1973 relies entirely upon the main engine for power supply to all subsystems. Nevertheless, the advantages associated with an auxiliary-engine-powered generator are indicative of a possible presence.

h. Communication Equipment. Photographic analysis of the antenna assembly on the left rear of the turret (fig II-L-15) indicates that the M1973 probably has a transceiver radio, most likely the R-123. It should be noted that it is common Soviet practice to put transceivers in all their armored vehicles. The R-123 is a relatively new radio that has a

frequency range of 20.0 to 51.5 MHz, a 20-W output, a range of approximately 20 km, and the capability to preselect four channels (frequencies). It is believed that the M1973's radio is used primarily as a receiver; e.g., routine commands from the battery XO's radio are acknowledged visually so as to reduce the amount of radio traffic. It is assumed that the M1973 also incorporates an intercom system that permits the vehicle commander to communicate with the driver and other crew members in the presence of vehicular and firing noise.

i. Protective and Night Driving Aids.

(1) Commander's searchlight. This device (fig II-L-7) on the M1973 appears to be of the TKN series. This is an active, near-IR surveillance system with a range of 250 to 300 meters. Various models of the TKN are installed on Soviet T-54 through T-62 medium tanks, and other self-propelled weapon systems.

(2) Night-driving aid. The M1973 probably employs active IR night-driving aids, most likely the TVN series of IR night-driving aids installed on the T-54 through T-62 medium tanks and several other self-propelled weapon systems and personnel carriers. The TVN-2 has a range of 60 meters (90%).

j. Modification and Variances Noted. To date, modifications consist of a change in the type of driving lights used and, of much greater import, a major redesign in the layout and number of hatches and access plates in the rear hull plate. This redesign, described in paragraph 24b(1)(a), probably is indicative of major changes in the configuration of the ammunition stowage and/or the ammunition handling mechanism.

M. SOVIET 152-MM GUN-HOWITZER ML-20 (M1937)

25. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 152-mm gun-howitzer ML-20 (M1937) (fig II-M-1) is a well-designed and sturdily constructed split trail weapon. Mounted on the same basic carriage as the 122-mm A-19 corps gun (M1931/37), it displays the same type of prominent, rearward sloping equilibrators mounted forward of a similarly sloping shield. One of the most obvious

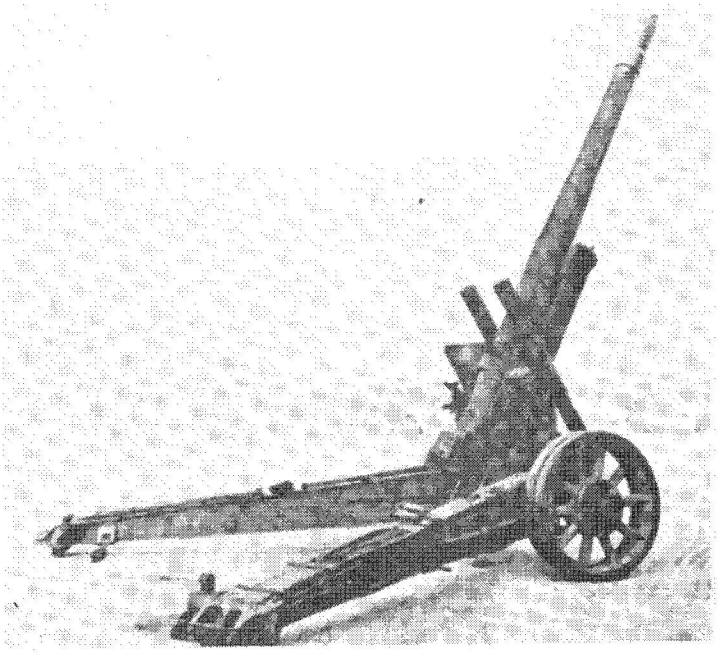

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Figure II-M-1. 152-mm gun-howitzer ML-20 (M1937) (U).

distinguishing features of the ML-20 is its long 520-mm (1.70 ft) multi-baffle muzzle brake. This weapon was used by the Soviets in large numbers for counterbattery, destruction, and long-range interdiction fires during World War II. The ML-20 is currently obsolescent in the Soviet Army, having been replaced in first-echelon units by the lighter, and more versatile, 152-mm D-20 gun-howitzer (M1955); however, the ML-20 still is utilized extensively by other Warsaw Pact land forces. The tube of this gun-howitzer, with breechring and muzzle brake, is 4925 mm (16.5 ft) long. The weapon weighs 7290 kg (16 074 lb) in the firing position and 8070 kg (17 794 lb) when limbered for travel (fig II-M-2). The tube is retracted out of battery when the weapon is march ordered. In travel configuration (fig II-M-2), the ML-20 is approximately 2345 mm (7.69 ft) wide, 2270 mm (7.45 ft) high, and 8175 mm (26.81 ft) long (including the limber's tow bar), and has 315-mm (1.03-ft) road clearance. Normal employment of this weapon in the Warsaw Pact nations is in heavy artillery units at army, front, and military district level. The ML-20 weapon was provided to the People's Republic of China and has been furnished to numerous other recipient nations of Soviet arms, including Cuba, Finland, Albania, Yugoslavia, Syria, Iraq, Egypt, Yemen, and North Korea.

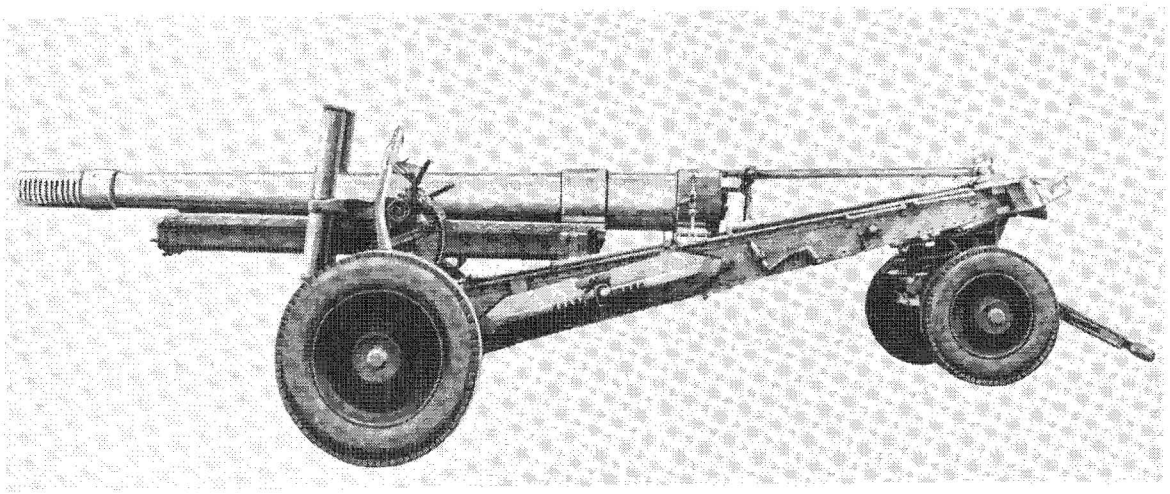

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Figure II-M-2. 152-mm ML-20 in travel position (U).

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The ML-20 fires a 43.56-kg (96.05-lb) HE projectile (OF-540) to a maximum range of 17 230 meters. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are 4, 12, 20, 40, 60, and 80 full-charge rounds, respectively. The weapon normally is towed by the AT-S medium or the AT-T heavy artillery tractors and non-Soviet tractors of equivalent performance. The weapon is limited to maximum speeds of 25 km/h (16 mi/h) over improved roads and approximately 15 km/h (9.3 mi/h) over unimproved roads. The tube of the ML-20 is retracted in the travel configuration; however, in unusual circumstances, the weapon may be moved with the tube in-battery for short distances if speed is limited to no more than 4 to 5 km/h. This weapon can be emplaced or displaced by nine men (eight crewmen plus driver) in approximately 8 to 10 minutes. The ML-20 uses cased propellant; the projectile and the propellant are loaded separately. The subject of propelling charges for the ML-20 is inherently confusing. When the ML-20 first was deployed a six-charge system (full charge and five numbered charges in two cartridge cases) was used; these charges were designated ZhN-544U and Zh-544. During World War II a 13-charge system was fielded; full charge plus 12 increments with full charge and increments 1 through 5 in one case (ZhN-545U) and increments 6 through 12 in a second case (Zh-545). Full charge in this system equated to full charge in the old system while 3d = old 1st, 5th = old 2d, 8th = old 3d, 10th = old 4th, and 12th = old 5th. Although requiring two cases, this charge system provided excellent overlap in range. It is probable that stocks

of this 13-increment charge system still exist for use in the ML-20. A newer charge system, one that probably was developed in the mid-1950's for use primarily by the D-20, is a seven-charge system; this consists of a full variable charge, in which the increments equal the full, 2d, and 4th charges in the 13-charge system, and a second case that contains the equivalent of the 6th, 8th, 10th, and 12th charges. Still more recently, probably in the late 1960's, the ZhN-546 and Zh-546-U charges appeared (fig II-M-2a and -2b). Allegedly the increments in these two cases constitute a seven-charge system: Full and 1st charges in the ZhN-546 and five more charges in the Zh-546-U. Which charges the various increments represent has yet to be determined. It is probable that the ZhN-546 contains the full and 1st charges and that the ZhN-546-U contains the 2d through 6th charges, which may duplicate the 4th, 6th, 8th, 10th, and 12th charges of the older 13-charge system. It is believed that the D-20 and the M1973 systems utilize the ZhN-546 and the Zh-546-U charges. Czechoslovakia also produces a 152-mm case that contains one very large and two quite small increments. In addition to the full variable and the reduced variable charges, there is a special one-increment charge for the AP-T projectiles and a base plus 7 increments charge also for the AP-T. Powder chamber pressure using full charge is 2350 kg/cm^2 (33 425 lb/in^2). The unit of fire is estimated to be 60 rd per weapon. The on-vehicle load of ammunition carried by each tracked prime mover is estimated to be 20 rd; when used as prime movers, the wheeled 8x8 ZIL or TATRA trucks probably carry at least 30, and perhaps 40, rounds. Characteristics of projectiles most commonly employed with the 152-mm ML-20 gun-howitzer are shown in table II-M-1.

(2) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data from a 1943 edition firing table are shown in table II-M-2. It is believed likely that the Soviets have reduced the ≈0.4% PE_r downward toward the ≈0.35 to 0.32% of the range fired.

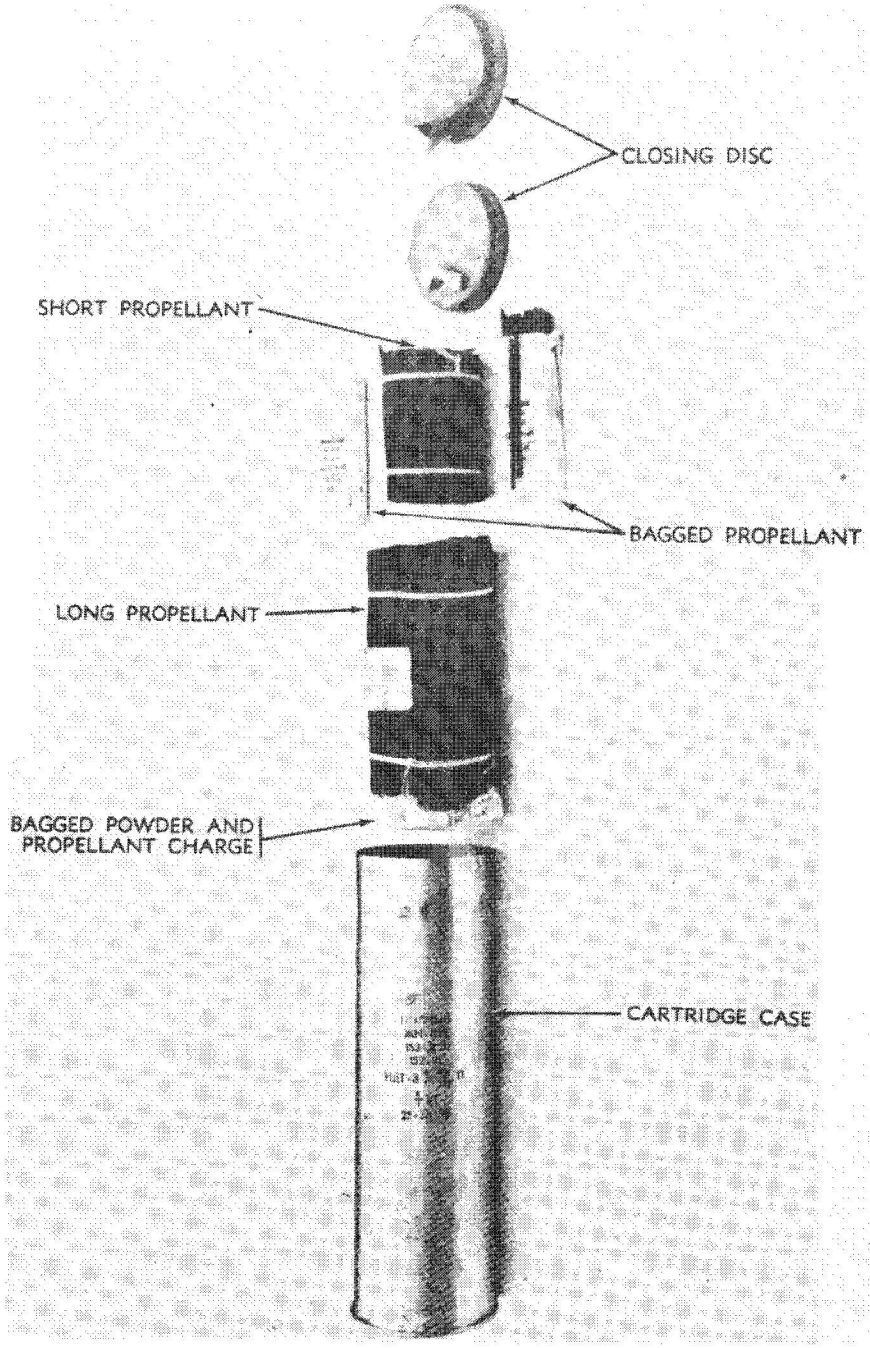

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Figure II-M-2a. Soviet ZhN-546 propelling charge for D-20 and ML-20 (U).

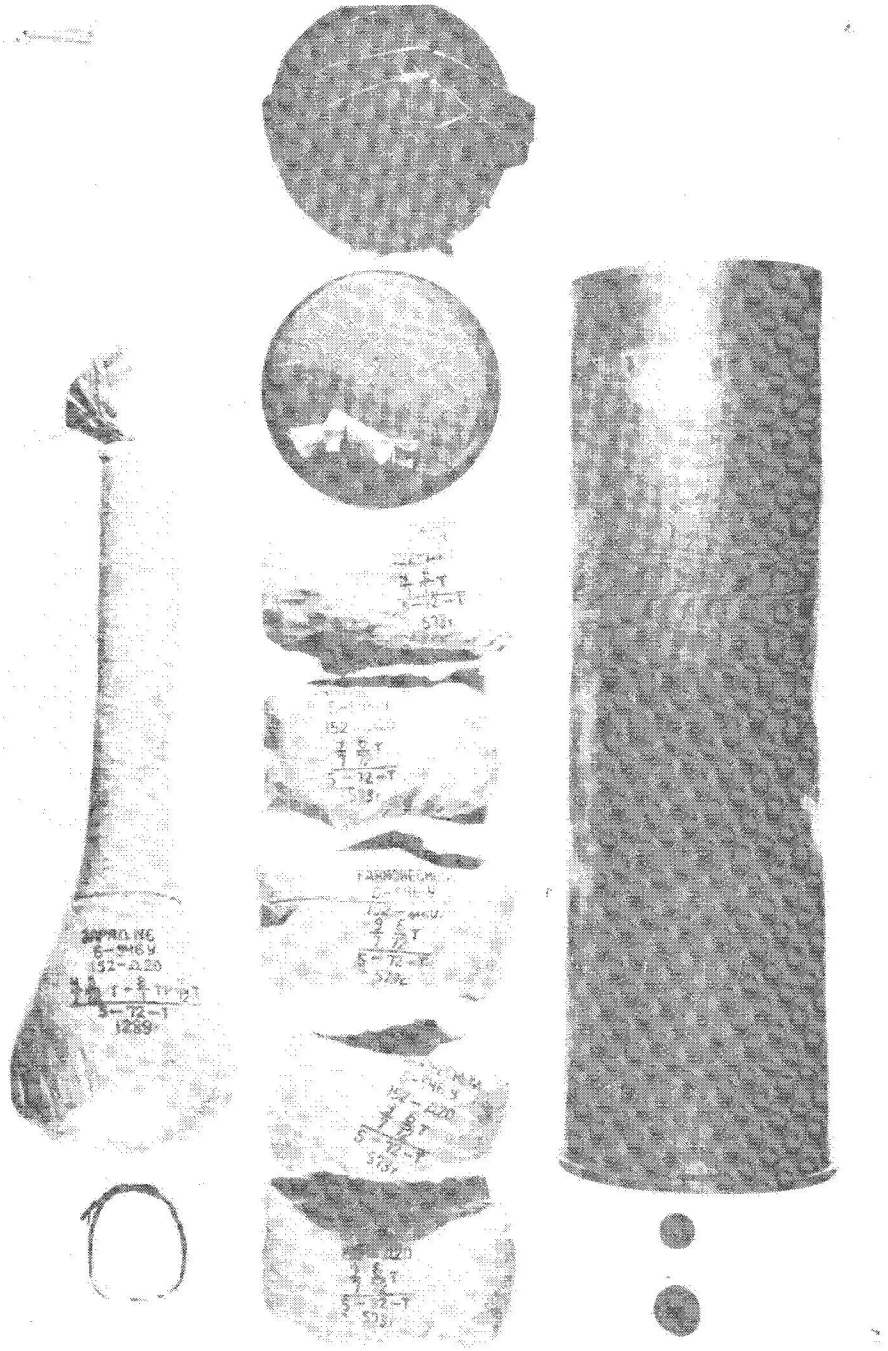

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Figure II-M-2b. Soviet ZhN-546-U propelling charge for D-20 and ML-20 (U).

Table II-M-1. Projectiles, 152-mm ML-20 Gun-Howitzer (U)

Type	Designation	In-flight weight (kg)	Maximum muzzle velocity (m/s)	Penetration at 1000-m range 0° obliquity
Frag-HE steel	OF-540	43.56	655	NA
Frag-HE steel	OF-530	40.0	?	NA
HE-cast iron	O-530A	40.0	?	NA
HE	Czechoslovak	43.50	655	NA
AP-T	BR-540	48.78	600	114 mm of armor
AP-T	BR-540B	48.96	600	123 mm of armor
HEAT-T-SS	BP-540	27.56	650 (est)	225 mm (est) by Soviet std; 380 mm (est) by US std.
CP	G-530	40.0	670	1070 mm, max, new concrete

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Table II-M-2. Probable Errors in Indirect Fire; 152-mm ML-20 Gun-Howitzer, Firing HE Fragmentation Projectile OF-540 (U)

Percent of maximum range (17 230 m) (measurements in meters at various percentages)	PE_r (m)	PE_d (m)
90 (15 500 m--chg full)	63.5	11.0
70 (12 100 m--chg 3)	46.0	8.5
50 (8600 m--chg 8)	31.0	5.7
30 (5200 m--chg 12)	26.0	5.2

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(b) ~~(C)~~ Effectiveness. An 18-gun ML-20 battalion can deliver 1.57 tonnes (2 volleys/36 rounds) of projectiles on a large (8 PE_r deep) area target during the first 20 seconds of fire. When firing upon a 250-meter-wide by 200-meter-deep counterbattery target at two-thirds of maximum range (11 500 meters, PE_r: Third charge = 44.5 meters), and considering range errors in precision only, 1.193 tonnes of projectiles can be delivered on the target in 20 seconds.

(c) ~~(C)~~ Fragmentation. The standard HE fragmentation projectile OF-540 fired by the ML-20 gun-howitzer has a steel body. This projectile has a charge-to-mass ratio of 0.167:1, and bursts into an average of 8970 fragments. Mean fragment mass is 4.3 grams, and average initial velocity is 827 m/s (2710 ft/s).

(d) ~~(C)~~ Lethality. Lethal areas for the OF-540 projectile against personnel are presented in figure II-M-3 for open terrain and in figure II-M-4 for temperate forest. These graphs provide lethal areas in square meters for personnel in the standing, prone, and crouching-in-foxhole postures, all at four angles of fall plotted against height-of-burst in meters. Values are based on the assault 5-minute casualty criterion and the six-layer cold/wet uniform.

II-162 and II-163 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(3) ~~(C)~~ Direct fire.

(a) (U) Precision. Probable errors in direct fire of the 152-mm ML-20 gun-howitzer firing BR-540 or BR-540B projectiles at 600 m/s muzzle velocity are shown in table II-M-3.

Table II-M-3. Probable Errors in Direct Fire; 152-mm ML-20 Gun-Howitzer (U)

Range (m)	AP-T projectile		
	PE_d (m)	PE_v (m)	PE_r (m)
300	0.1	0.1	15
500	0.1	0.1	15
1000	0.3	0.2	16
1500	0.4	0.4	15
2000	0.6	0.5	14

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(b) ~~(C)~~ Grazing range. Calculated grazing range for the ML-20 AP-T (BR-540 or 540B) projectile, using special charge, vs. targets of various heights are:

- 755 meters when target height is 2.0 meters.
- 814 meters when target height is 2.5 meters.
- 886 meters when target height is 3.0 meters.

(c) ~~(C)~~ Effective range. Empirically, the effective range (50% probability of a first-round hit) of the ML-20 using the AP-T (BR-540 or BR-540B) projectile vs. a US M-60 tank is estimated to be about 800 meters. Conversely, Soviet firing tables (F-152-2) list "Direct fire against tanks" (grazing range?) for the AP-T projectile

BR-540 as 700 meters, and for the OF-540 HE rd using full charge as 800 meters. The disparity between the Soviet-stated and US-estimated effective ranges well may lie in the amount of armor penetration attainable rather than in any large disparity in hit probability. The probably lighter, higher velocity HEAT projectile may have an effective range on the order of 800 to 850 meters.

(d) ~~(C)~~ Engagment range. An ML-20 gun crew probably would open fire upon a US M60A1 tank at about 850 meters with the AP-T projectile and perhaps 1000 meters with the HEAT projectile.

(e) ~~(C)~~ Armor penetration. Table II-M-4 is an extract from Soviet firing tables relating to the armor penetration capabilities of the AP-T. See table II-M-1 for an estimate of the performance of the HEAT projectile.

c. ~~(C)~~ Configuration. The carriage of the ML-20 is of split-box trail design. For travel, the trail ends are secured together on lugs and attached to a saddle mounted on the limber pintle. The limber has leaf spring suspension at each wheel and a conventional hinged drawbar and lunette arrangement. The ML-20 has a total of 58° of on-carriage traverse. Elevation limits for this weapon are -2° and +65°. The ML-20 has an independent, variable length hydropneumatic recoil system encompassed in the cradle. This system consists of a single hydraulic recoil brake centered in the cradle and two recuperators, each consisting of two interconnected cylinders; one pair of recuperator cylinders is positioned on either side of the recoil brake adjacent to the cradle walls (fig II-M-5). This a most unusual design for a recuperator. The cradle is of "U"-shaped riveted construction with a forward cap, recoil rails, and a riveted-on casting containing the trunnions, two equilibrator brackets, and the elevating arc centered in a fore-and-aft position on the bottom of the fixture. The cradle, which contains brackets on the outer rear edge for locking the cradle to the trails in travel, has a fixed recoil gage mounted inside the left rear of the cradle. On-carriage fire control consists of a sight (range quadrant) mount, Model CB 42-10, with an independent or semi-independent line-of-sight, depending on the model. A panoramic telescope, model CT-10, was used with very early models of this weapon for both direct and indirect fire. This telescope employed a French Schneider system (or a copy thereof), and was graduated in 6400 mils per circle rather than the usual Soviet 6000 mils per circle. However, the Soviets must have replaced the older 6400-mil system with a 6000-mil system employing the PG-1 panoramic telescope.

d. ~~(C)~~ Summary. The 152-mm gun-howitzer ML-20 (M1937), which replaced the older 152-mm gun (Model 1910/34), was employed extensively by the Soviets during World War II in the counterbattery and general

Table II-M-4. Armor Penetration, 152-mm ML-20 Gun-Howitzer; Firing AP-T (600 m/s) Projectiles (U)

Range (m)	BR-540, AP-T		BR-540B, AP-T	
	At 0° obliquity (mm)	At 30° obliquity (mm)	At 0° obliquity (mm)	At 30° obliquity (mm)
100	138	113	139	114
300	133	108	136	110
500	127	103	132	107
1000	114	93	123	100
1500	103	84	114	93
2000	92	75	107	87
3000	76	62	93	76
4000	64	52	81	66

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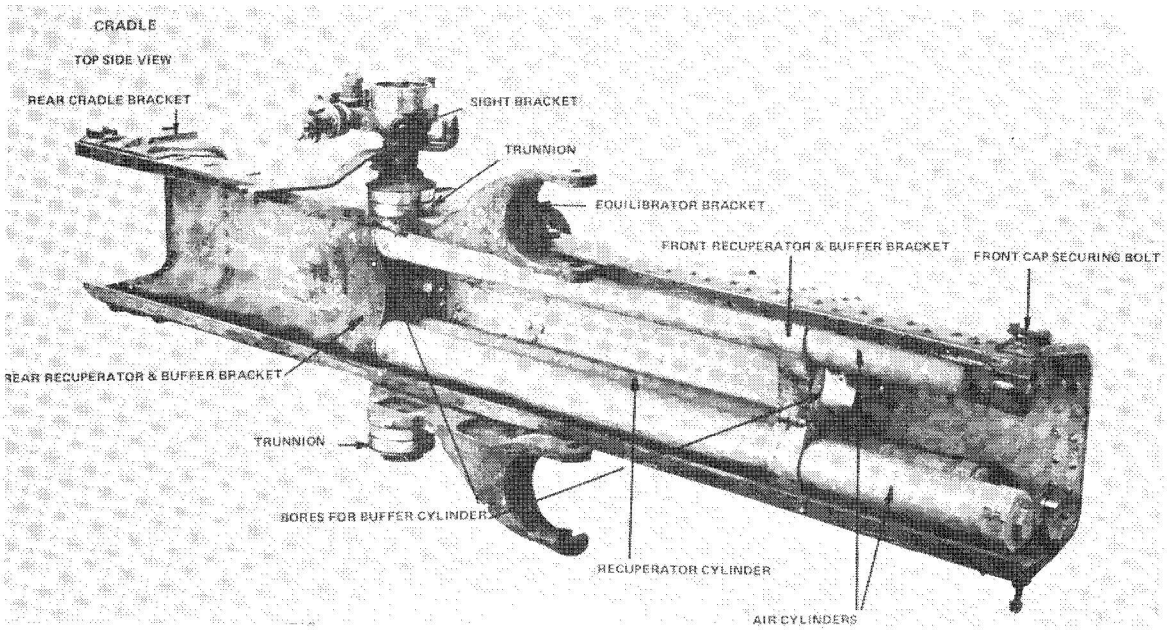

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Figure II-M-5. 152-mm ML-20 gun-howitzer; cradle with sight mount and recuperator cylinder (U).

support roles. Currently obsolescent in the Soviet Army, the weapon has been replaced in first line units by the 152-mm gun-howitzer D-20 (M1955); however, the ML-20 remains in the active forces of the other Warsaw Pact nations as well as in the armies of a number of other countries. Traverse is limited to the on-carriage capability or alternatively to displacement of the weapon, because during emplacement two elongated steel plate spades are driven into the ground through recesses in each trail end (fig II-M-6). Nonetheless, despite its age, this weapon is reliable and durable. Originally, the weapon was equipped with cast steel, spoked wheels and double-tread, solid rubber tires on the primary wheels and with single disk solid rubber-tired wheels on the limber. Subsequently, the wheels were upgraded to dual disk wheels with pneumatic (or sponge rubber-filled) tires as primary and similar single disks on the limber. Recent sightings indicate the wheel system has been further upgraded to large-volume tires on single disk primary wheels and single disk wheels with smaller tires on the limber. Although this weapon is obsolescent it has been modernized both to improve mobility and to extend its useful life. Precision of this weapon is not impressive. Expressed in terms of PE_r as a percentage of range, precision is 0.421% when projectile OF-540 is fired with full charge at 70% of maximum range (12 100 meters); at 90% of range (14 000 meters), precision is 0.415%; and at maximum range (17 230 meters) it is 0.417%. Charge-to-mass ratio of the HE projectile OF-540 is 0.167:1. The 8-to-10 min emplacement/displacement time associated with a total on-carriage traverse capability of 58° indicates this weapon would be only marginally proficient in the antitank role.

26. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) (U) Tube. This tube is of monobloc construction. A tube jacket, which incorporates recoil slides on overload jacket rings, also tends to reinforce the tube. The rifled portion of the 152.4-mm bore is 3467 mm (11.37 ft) long. The 48 lands and grooves impart a right-hand 1:25 twist. Height of the axis of the bore is 1515 mm (4.97 ft). At march order, the tube is released from the recoil mechanism and withdrawn out of battery, attached to the trail ends by a turnbuckled longitudinal strut hooked to the breechring, and locked to the center of the trails laterally by lugs and turnbuckles. The cradle also is secured between the trails on lugs in the travel mode. Tube wear life is 2500 EFC rounds. Tube fatigue life probably approximates wear life.

(2) (U) Breechring. This component houses a conventional interrupted screw-type breechblock. The breechblock opens to the right on a carrier, which utilizes a cammed horizontal arm and latch arrangement.

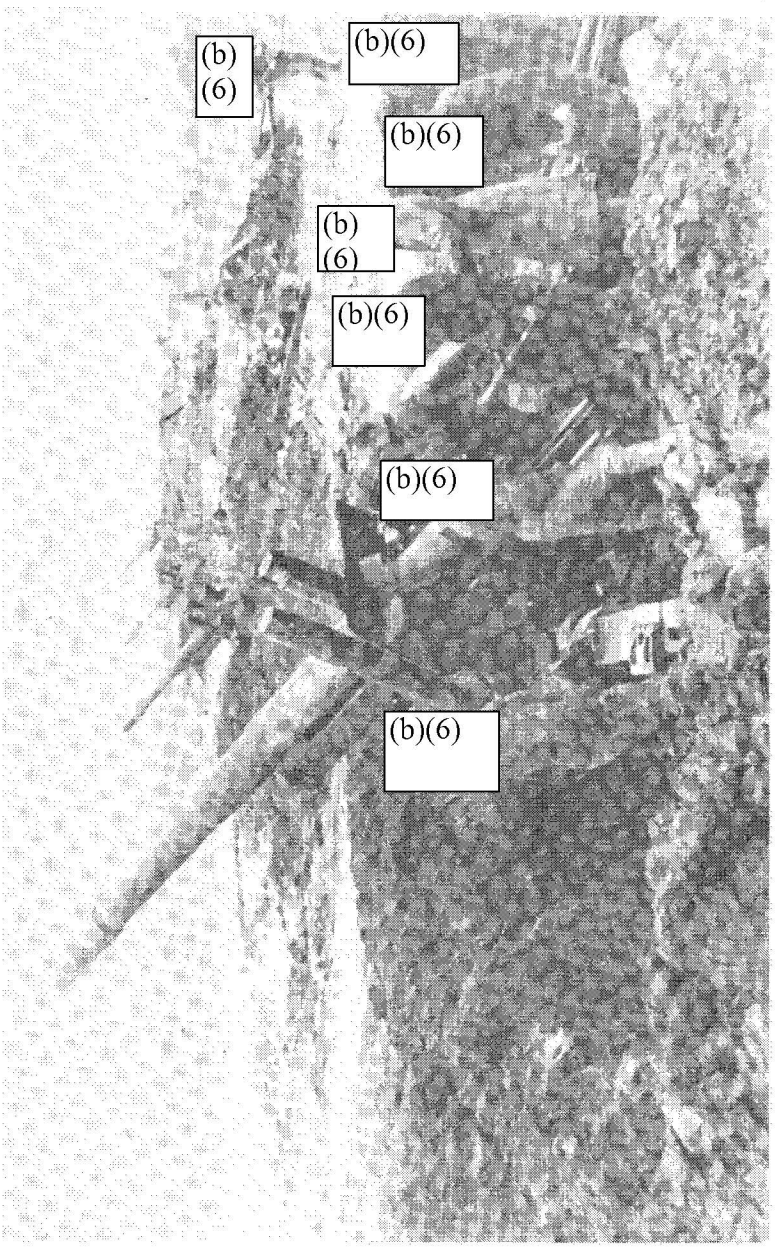

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Figure II-M-6. 152-mm ML-20 battery (U).

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Safety and case extractor mechanisms and a continuous pull firing device are included in the assembly. Fatigue life of the breech mechanism is unknown.

(3) ~~(C)~~ Muzzle brake. This fixture is a screw-on multiple baffle type having 12 ports on either side. This brake is a distinguishing characteristic of the ML-20. Brake efficiency is estimated to be about 35% to 40%.

b. ~~(C)~~ Top Carriage.

(1) (U) General. This fixture supports the gun, recoil system, cradle, elevating mechanism, on-carriage fire control, gun shield, equilibrators, and the pinion side of the traversing mechanism.

(2) (U) Cradle (fig II-M-5). This fixture consists of a "U"-shaped basic channel with accessories riveted to the component. Accessories are attached so they reinforce the cradle as well as provide mountings. Accessories include a rear cradle bracket; recoil slides; forward and rear recoil system brackets; a trunnion yoke that incorporates the trunnions, a lower elevating arc, equilibrator brackets, a mount for the on-carriage fire control equipment; and recoil rails along the cradle edges. A recoil index is mounted on the inside rear of the cradle. Each of two rings on the tube jacket mount short recoil slides (grooves) on either side. These slides ride on the cradle recoil rails in tongue and groove fashion.

(3) (U) Elevating mechanism. A handwheel-operated rack-and-pinion device with an integrated worm and worm wheel arrangement drives the cannon in elevation. The single elevating handwheel is located on the right side of the weapon. The system includes an intermediate gearbox to transmit movement through the top carriage to the lower centrally located elevating pinion gear, and thus to the horizontally centered elevating rack. Elevating limits are -2° and +65°. Positioning in elevation is assisted by two spring-loaded pusher-type equilibrators.

(4) (U) Traversing mechanism. This mechanism is operated by a conventional handwheel located on the left side of the weapon. The traversing handwheel shaft passes through the left side and central forward wall of the top carriage to a worm and worm gear with a vertical pinion that engages a traversing arc gear mounted on the forward part of the bottom carriage. Machined surfaces on the top carriage engage similar surfaces on the bottom carriage, and the interface of the two carriages is by a pintle pin and raced ball bearings. Total on-carriage traverse is 58°.

(5) (U) Recoil mechanism. This hydropneumatic, independent-type mechanism is a Schneider design with the addition of a mechanically-controlled, variable-length recoil feature. It consists of one recoil cylinder, two counterrecoil cylinders, and two recuperator cylinders, all contained within the U-shaped cradle. All five cylinders are affixed to the cradle and, unlike most Soviet applications, do not move in recoil. The recoil piston rod and the two counterrecoil piston rods are attached to a yoke that incorporates a recoil nut that attaches to the breechring for firing.

(a) (U) Recoil cylinder. All controls are in the recoil cylinder. The recoil brake consists of three concentric components: the control rod/buffer assembly, the hollow recoil piston rod assembly, and the outer cylinder:

- The control rod fits inside the hollow recoil piston rod, through an orifice ring, and is attached to the outer cylinder. Four orifice grooves are machined down the length of the control rod for throttling the recoil oil and controlling the recoil deceleration. There are two separate sets of grooves, one set for short recoil and one set for long recoil. As the cannon is elevated or depressed, the control rod is rotated, through mechanical linkage to the bottom carriage, to index the orifice grooves for either a long or short recoil stroke. At the breech end of the control rod is the buffer assembly, which consists of a one-way, spring-loaded valve and piston that permits recoil oil to flow easily behind the buffer piston in the hollow recoil rod during the recoil stroke.

- Two orifice grooves machined inside the hollow recoil rod allow for buffering throughout the counterrecoil stroke. As the recoil rod returns into battery, the depth of these grooves decreases at the closed end of the recoil rod so that the oil flow is highly restricted and sufficient buffering force occurs at the end of the counterrecoil stroke. The recoil rod/piston assembly has a ported throttling ring inside the recoil piston, which diverts the oil flow to the long or short grooves in the control rod. The throttling of the oil through the orifice ring and control rod grooves is the major action for slowing and stopping the recoiling cannon assembly.

- Maximum permissible length of recoil is 1400 mm (4.59 ft). At elevations from 0° to 30° normal length of recoil is 1150±100 mm. At 30° elevation the variable length of recoil feature becomes operable. Between 30° and 45° length of recoil is reduced from a maximum of 1250 to 875 mm. From 45° to 65° length of recoil does not exceed 875±25 mm. The recoil brake is filled with 22 liters of Steol M.

(b) (U) Counterrecoil assembly. The counterrecoil assembly consists of two counterrecoil cylinders and two recuperator cylinders (pressure vessels). This counterrecoil assembly is filled with 22±1 liters of Steol M and pressurized with nitrogen (or dry air) to 45±1 kg/cm^2 (43 to 45 kPa) of dry air. Upon firing, the counterrecoil pistons move, forcing the Steol through connecting passages to the recuperators. At the end of the recoil stroke the pressure in the recuperator cylinders forces the oil back through the connecting passages, supplying the necessary energy to force the pistons back to the in-battery position.

(6) ~~(C)~~ On-carriage fire control. Inspection of an ML-20 at Aberdeen Proving Ground discerns that fire control equipment consists of a range quadrant, Model CB 42-10, which incorporates a panoramic telescope mount and a panoramic telescope, Model PG-1. This equipment has either an independent or semi-independent line-of-sight, depending on the weapon. The range quadrant has a mil scale located on the front face. Mil graduations, which are provided on the range quadrant from 0 to 1250, are identified by figures every 50 mils. The angle of site, which is graduated at 2-mil intervals from 0 to ±250 mils, is numbered every 10 mils. The panoramic telescope CT-10, which was in use with early versions of the ML-20, has a crosshair index for indirect fire and three scales for direct fire. These scales, reading from left to right, are used to fire the following: HE OF-540 projectile with charge 1 and the BR-540 projectile with special charge; the CP projectile, G-530, using charge 1; and the CP projectile, G-530, using full charge. The scale on the CT-10 panoramic telescope is graduated from 0 to 3200 mils right and left in 4-mil graduations. Soviet firing tables disclose this 6400-mil wide, and 2470 mm (8.1 ft) high to the top of the muzzle brake. The D-20 has essentially the same carriage as the 122-mm Field Gun D-74 (fig II-H-1), and, consequently, has most of the same recognition features. The principal visual identification differences are the longer and more prominent double-baffle muzzle brake and the shorter length, but larger external diameter, tube of the D-20 as compared with that of the D-74. Positioning of the circular firing pedestal float, which acts as a travel lock when attached to the cradle in front of the shield, is a distinctive

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sighting system was in use with the 152-mm gun-howitzer ML-20 (M1937) when the tables were republished in November 1943; however, the employment of the 6400-mil circle probably reflects the basic French (Schneider) origin of this Soviet artillery weapon. The ML-20 has been otherwise upgraded and the sighting system has been modified to include use of the PG-1 panoramic telescope which employs the Soviet standard of a 6000-mil circle.

(7) (U) Crew protection. This is afforded by a comparatively small, single-piece, sheet steel shield that extends across the tube and terminates in a straight vertical side inside the wheels. Some of these weapons have flat shields and others have shields bent horizontally at the level of the height of the trunnion. An aperture is provided in the left shield for direct fire when the on-carriage panoramic telescope is used.

(8) (U) Equilibration. This action is provided by dual, spring-loaded, pusher-type equilibrators with one mounted on each side of the tube forward of the main shield. The equilibrators are attached by a ball socket at the forward base of the top carriage and by a "Y" fixture on each side of the upper forward sides of the trunnion yoke. Contemporary weapons have bowed, semicylindrical, shielding mounted on the forward sides of the equilibrators to protect these otherwise exposed components.

c. (U) Bottom Carriage.

(1) (U) General. This assembly is a large casting that provides a pintle bore for mounting the following: The top carriage, the rack component of the traversing mechanism, a pair of compression locks for centering and fixing the top carriage for travel, the trail hinge mountings, and a large traverse opening for mounting the axle and suspension system. The top carriage is affixed to the bottom carriage with a pintle pin that incorporates raced ball bearings.

(2) (U) Axle. Of I-beam construction, this fixture, in older models, had a flat, full-shaft bearing surface on which the wheel hub bearing surface rode. Newer models have either dual or single tires and probably are equipped with conventional raced wheel bearings to improve the mobility of this weapon. The suspension system consists of a leaf spring mounted on the axle with shackles. To eliminate spring action during the firing, the axle is locked to the bottom carriage with a manually operated plunger lock. The mass of this weapon is removed from, or loaded onto, its lateral leaf spring suspension by use of worm geared jacks that are fixed to the right and left sides of the bottom carriage and operate against the spring ends.

(3) (U) Wheels. On older models, the wheels were of spoked, cast steel design with twin solid rubber tires and full-surface axle bearings. Subsequent models were equipped with dual, probably sponge rubber-filled, tires mounted on steel disk wheels. The latest sightings of these weapons indicate some are now equipped with large-volume, probably sponge rubber-filled, tires mounted on single steel disk wheels. Conventional wheel bearings have probably been incorporated into the last two versions. Limber wheels, each of which are equipped with a single disk wheel, have kept pace with the progress of the primary wheels.

(4) (U) Trails. These components are of riveted box-trail design. The hinge-pin fixture is of conventional design. Trail locking lugs, which are riveted on the inner walls of the trail bases, provide the means for strut locking the trails in an open position for firing. Breechring supporting brackets are attached to the center top sections of the trails to secure the breech during travel. Each of the trail ends has the following: Slotted openings for two drivable steel trail spades, lugs for securing the trails together, and lifting handles to facilitate manual trail movement. A locking arm is riveted to the right trail to secure the trails to the limber pintle. The exterior of each trail has brackets, on which the trail spades are mounted for travel, and fixtures, in which pioneer (construction) tools, cleaning rods, and related accessories are mounted for transport.

(5) (U) Mobility. Available mobility data are related to the World War II configuration of this weapon. The weapon wheel design has been modified twice in the intervening years, and the system currently being employed is therefore credited with a mobility similar to the equivalent caliber of Soviet artillery pieces of more modern design. The mobility of this weapon when on the march should therefore not be considered a restriction on its employment.

N. SOVIET 152-MM GUN-HOWITZER D-20

27. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 152-mm Gun-Howitzer D-20 (fig II-N-1) was first sighted in a Moscow parade in 1955. This weapon has replaced the 152-mm Gun-Howitzer M1937 (ML-20) in first-echelon Soviet field artillery units. Although primarily an indirect fire weapon, the D-20, like all other light and medium Soviet field artillery pieces, is designed and equipped to fulfill both the direct and indirect fire roles. The D-20's tube, with breechring and muzzle brake, is approximately 5060 mm (16.6 ft) long. In the travel configuration, the weapon weighs approximately 5900 kg (13 010 lb), and is approximately 8140 mm (26.7 ft) long, 2030 mm (6.7 ft)

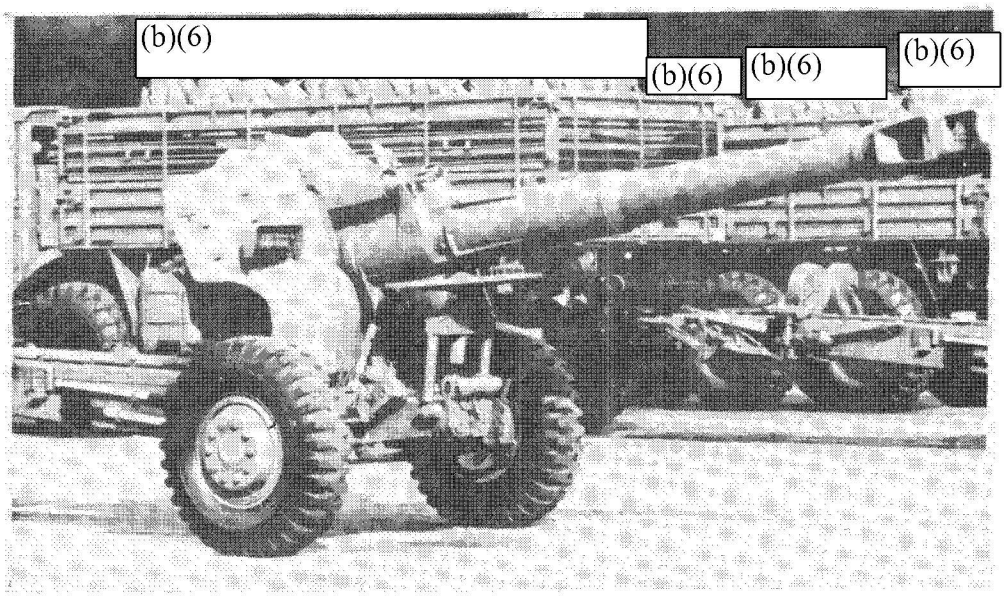

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Figure II-N-1. Soviet 152-mm gun-howitzer D-20 (U).

recognition feature for both the D-20 and D-74. The D-20 has a scalloped, winged, shield. The center section of the shield moves with the gun in elevation. The top of the center section of the shield on some (apparently the older) D-20's is straight (fig II-N-2), whereas other shields (fig II-N-1) have tops that are scalloped. Although this weapon has been deployed for more than 20 years and is present in considerable numbers, to date no service manuals, range tables, and like data are available to US analysts. The D-20 has reportedly been provided to East Germany, Poland, Czechoslovakia, the People's Republic of China, North Korea, Eqypt, Iraq, Finland, and Cuba.

b. ~~(C)~~ Capabilities. Available information indicates that the D-20 can fire the same models of ammunition as the ML-20. The maximum range of the D-20 firing the OF-540 projectile is the same as that of the ML-20; i.e., 17 230 meters. The D-20 employs the ZhN-546 (full variable) and the Zh-546U (reduced variable) propelling charges. The D-20 also is known to employ a spin-stabilized HEAT projectile (BP-540) that also is used in the ML-20 and M1973 systems. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are 4, 12, 20, 40, 65, and 90 full-charge rounds, respectively. As with the D-74, the Soviet M1954 AT-S medium-tracked artillery tractor (fig II-N-2) is the tracked prime mover normally associated with the D-20. Mobility of the D-20 is the same as that of the D-74 with the AT-S tractor. Nevertheless, the

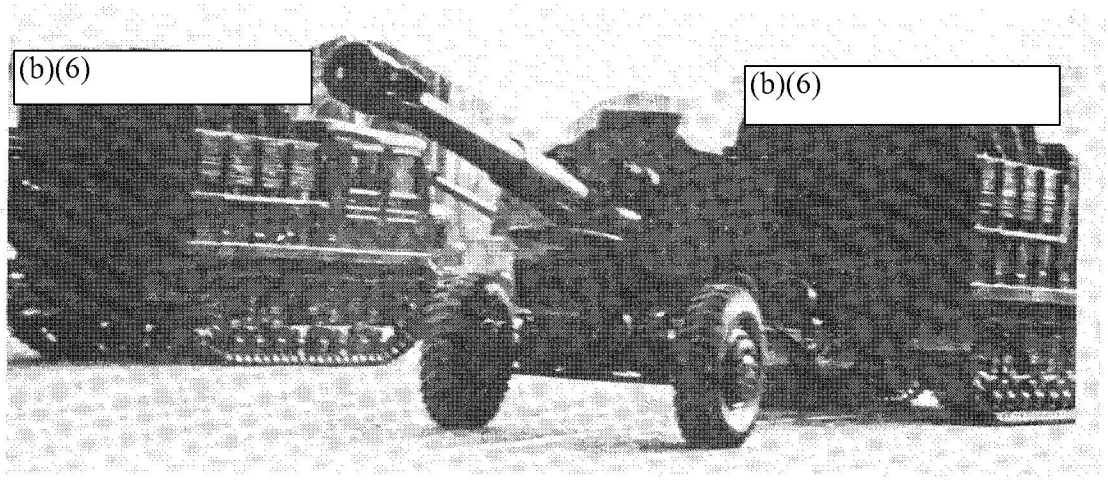

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Figure II-N-2. 152-mm D-20 towed by M1954 AT-S artillery tractor (U).

D-20 has been increasingly observed being towed by the 14-ton TATRA 813 S-1 8x8 COLOSSUS truck (fig II-N-3). The D-20 can be emplaced/displaced by a 10-man crew (plus driver) in approximately 5 minutes. This weapon uses separate loading ammunition with cased propellant. The total of 13 selectable charges (full charge plus 12 numbered charges) available for the ML-20 probably are not used in the D-20 which nominally employs a 7-charge system. The projectiles used by the D-20 are estimated to be those whose availability, characteristics, and effectiveness are listed for the 152-mm gun-howitzer ML-20 in table II-M-1. In addition, an improved and/or extended range ammunition could be made available for both the D-20 and ML-20, and the M1973 systems.

c. ~~(C)~~ Configuration. The basic carriage of the D-20 (fig II-N-2) is the same as that of the D-74 (fig II-H-7); nevertheless, positioning limits in elevation for the D-20 are -5° and +63°, whereas these limits on the D-74 are -5° and +45°. The 58° total traverse capabilities, the recoil system, and the cradle and sleigh design appear to be the same as those of the D-74. On-carriage fire control equipment (fig II-N-4) is both similar in appearance and performs the same functions as corollary equipment mounted on the D-74.

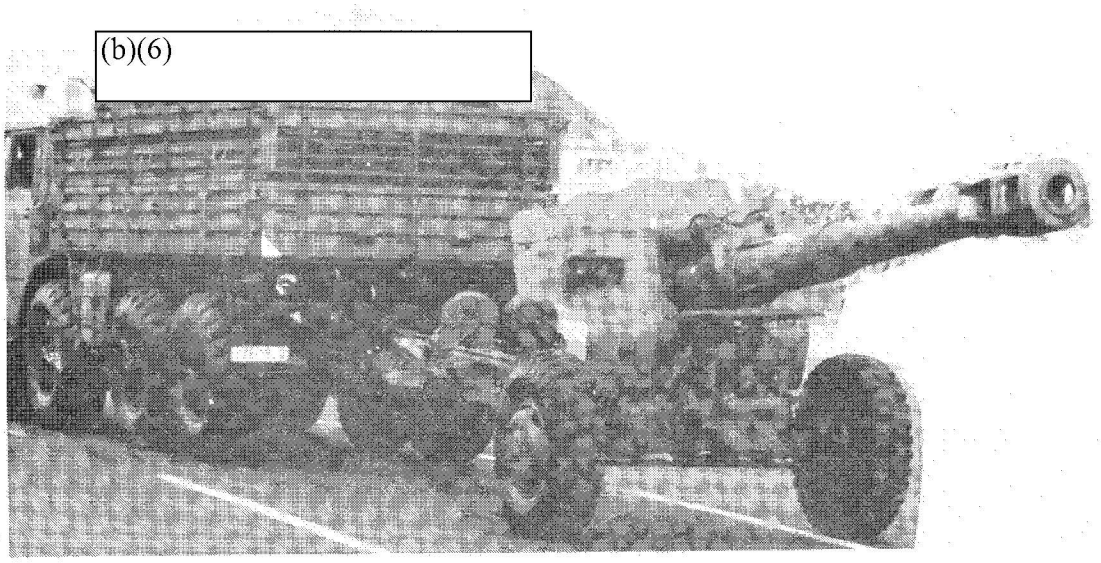

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Figure II-N-3. 152-mm D-20 gun-howitzer towed by TATRA 813 S-1 8x8 truck (U).

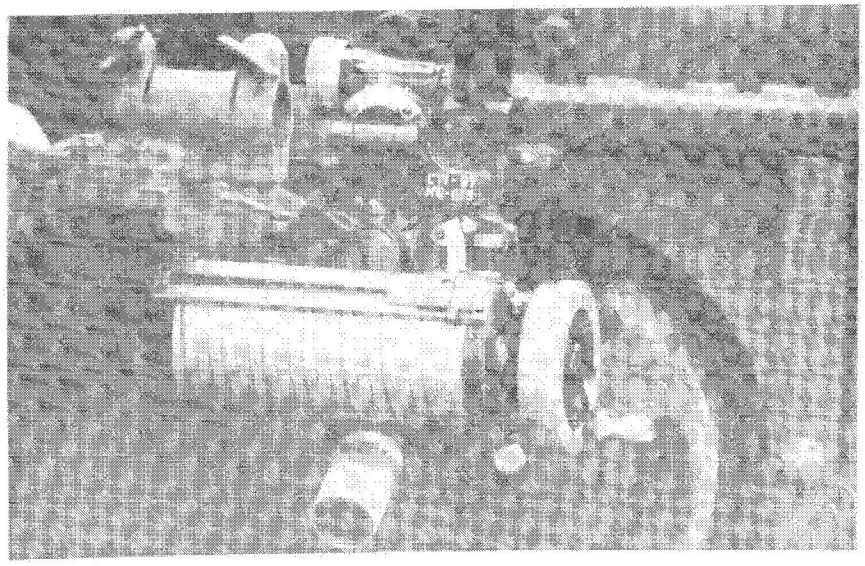

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Figure II-N-4. 152-mm D-20 gun-howitzer sight mount (U).

d. (U) Capabilities in Indirect and Direct Fire. See data discussed in tables II-M-2 and II-M-3 for the 152-mm gun-howitzer ML-20. The difference in maximum range between the D-20 and ML-20 suggests that when firing its postulated extended range projectile, or other projectiles that ballistically match that projectile, the D-20 should attain about a 6.35% increase in performance over those data presented for the ML-20.

e. ~~(C)~~ Summary. The D-20 gun-howitzer is considerably lighter, is easier and faster to emplace/displace, and is more mobile than the 152-mm gun-howitzer ML-20 (M1937), which it replaced. Weapon precision attributed to the D-20 is estimated to be at least equal to that of the ML-20.

28. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) ~~(C)~~ Tube. The tube is of monobloc construction. An adapter sleeve, used to lock the tube to the breechring, adapts the gun to the cradle. Tube length is 29 calibers, and there are 48 lands and grooves. Tube wear life is estimated to be 2500 EFC rounds, similar to the number of the 152-mm gun-howitzer ML-20 (1937).

(2) (U) Breechring. The breechring houses a conventional semiautomatic, vertical sliding-wedge breechblock (fig II-N-5). Operation of the breech is similar to that of the 122-mm D-74 field gun.

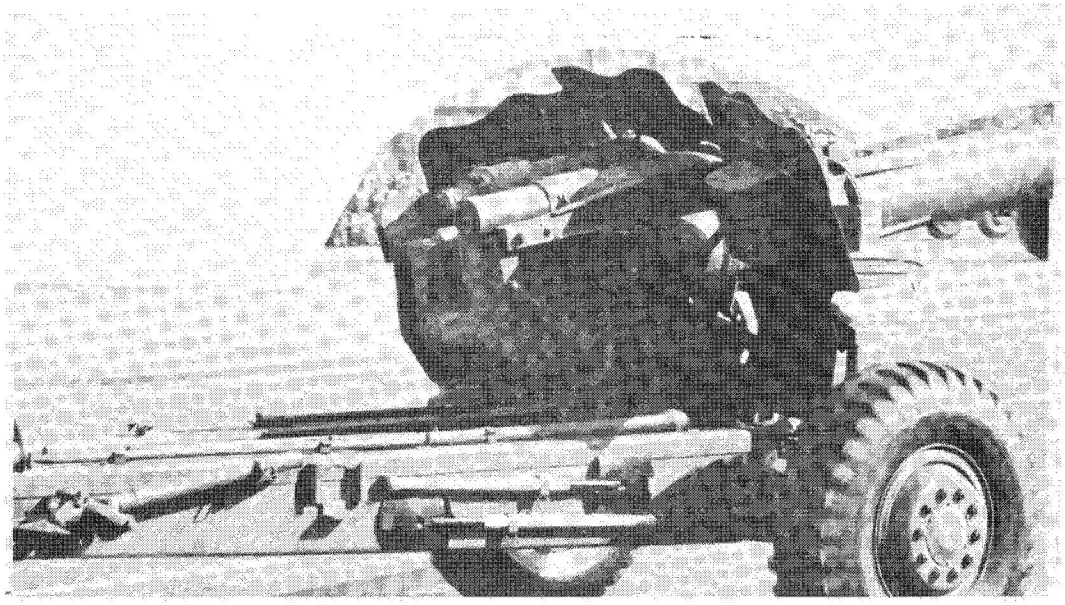

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Figure II-N-5. 152-mm D-20 gun-howitzer, right side view (U).

(3) (U) Muzzle brake. The muzzle brake is a double-baffle, four-port, winged-type fixture, similar to, but larger (approximately 790 mm long) than, the muzzle brake on the D-74. Brake efficiency reportedly is 50%. The brake is threaded onto the muzzle, using left-hand threads in a manner similar to that followed in the D-74.

b. ~~(C)~~ Top Carriage. The top carriage, except for the elevating mechanism, is similar to the carriage of the D-74. The elevation mechanism provides a capability of -5° to +63° to permit firing in the upper register (high angle fire). The cradle, traversing mechanism, gun shield, and equilibrators are similar to equivalent items on the D-74. The recoil system, although similar in appearance, reportedly has provision for five manual settings associated with various charges. This arrangement provides for a manually selected length of recoil that varies between 200 and 900 mm, depending upon the propelling charge and recoil setting used. Maximum length indicated on the recoil gage is 950 mm. The on-carriage fire control equipment, except for the variations due to weapon and ammunition relationships, is similar to that equipment used in the D-74. The weapon is equipped with an S71-97 mount having direct and indirect fire sight offsets identical to those of the D-74. The PG-1M panoramic and the OP-4M direct fire sights are used with this weapon.

c. ~~(C)~~ Bottom Carriage. The bottom carriage of the D-20 is the same model as that of the D-74 but may have been additionally reinforced in nonvisible areas.

d. ~~(C)~~ Mobility. Mobility of the D-20 and the D-74 is believed to be equivalent. The D-20 is estimated to be air transportable by the AN-8 CAMP, the AN-12 CUB, and the AN-22 COCK, as well as by the MI-6 HOOK and MI-10 HARK helicopters.

O. SOVIET 152-MM HOWITZER D-1 (M-1943)

29. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 152-mm Howitzer D-1 (M-1943) was developed by the Soviets in 1939/1940 (fig II-O-1). Production was initiated in 1943 and is known to have continued until 1955. The weapon was employed by the Soviet Army during World War II and remains the standard general support weapon in the motorized rifle division (MRD) to this day. During World War II this howitzer normally was deployed as an army (corps) general support-type weapon. Subsequently, the D-1 became a divisional general support weapon in many Warsaw Pact armies. Currently the D-1 is being replaced, albeit rather slowly considering the numbers presently deployed,

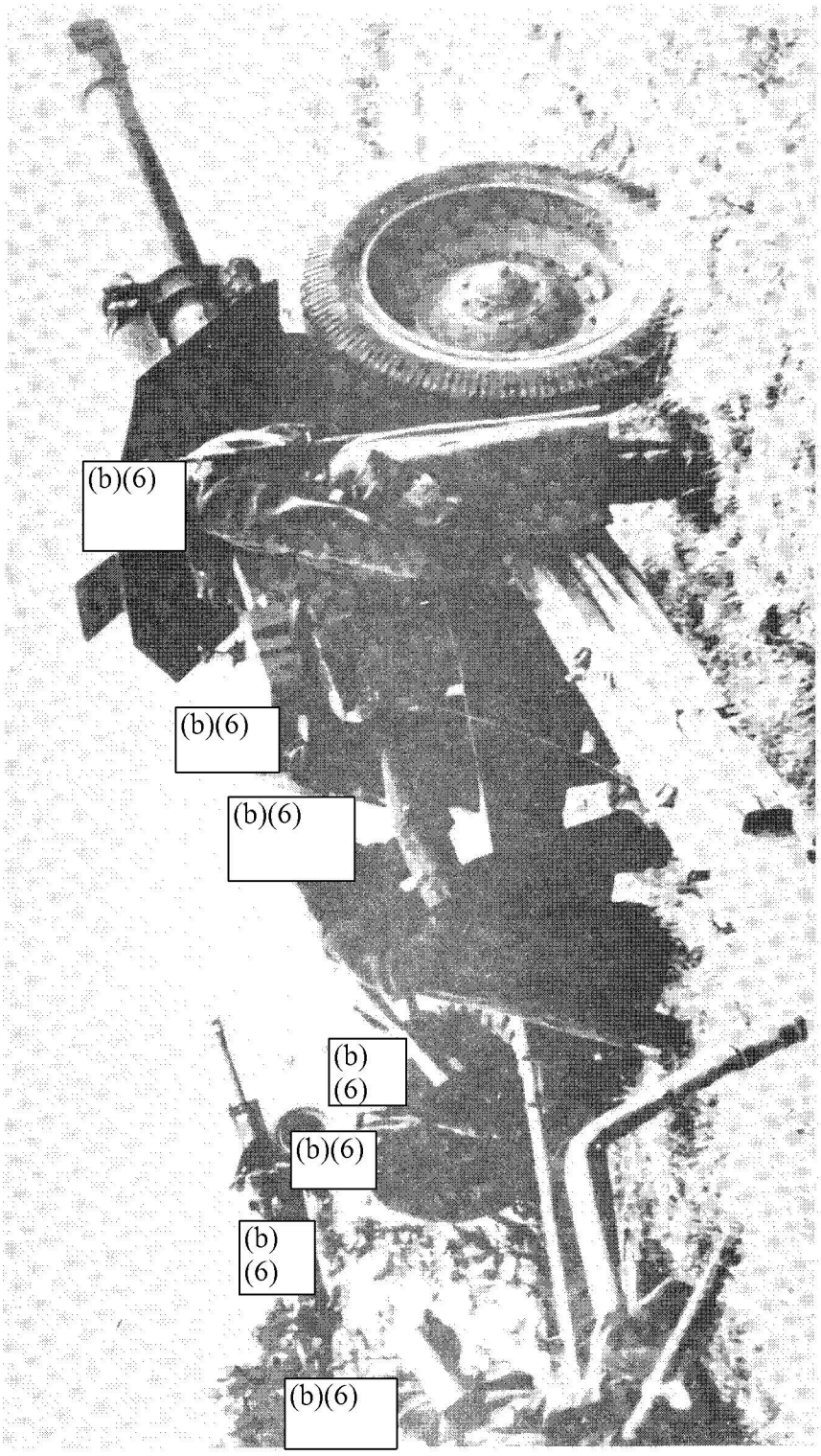

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Figure II-O-1. Soviet 152-mm howitzer D-1 (M1943) (U).

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in the Soviet army by the 152-mm M1973 SP gun. The D-1 also has been provided to non-Warsaw Pact ECC as well as to a number of other nations. It is probable that considerable stocks of the 152-mm D-1 howitzer and appropriate spare parts are maintained in Soviet war reserves. Usual employment of the D-1 is in 6-howitzer batteries, 18-howitzer battalions. The weapon is mounted on a carriage identical to that of its companion weapon, the 122-mm M-30 howitzer, except that the D-1 carriage (principally the trails) has been reinforced to accommodate the heavier cannon. The D-1, similar to other Soviet field artillery weapons, can be employed in both the direct and indirect fire roles. The 122-mm M-30 and 152-mm D-1 may be differentiated by the size of their tubes and, especially, by the presence on the D-1 of a double-baffle muzzle brake which does not appear on the M-30.

b. ~~(C)~~ Capabilities

(1) ~~(C)~~ General. The 152-mm D-1 howitzer fires a 40.0-kg (88.2-lb) projectile to a maximum range of 12 390 meters. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are 4, 12, 20, 40, 65, and 90 full-charge rd, respectively. The ZIL-151 and the later Model ZIL-157 trucks are the prime movers normally associated with this 3640-kg (8025-lb) howitzer (fig II-0-2). A variety of other prime movers of similar or larger capacity may be used. The D-1 may be towed at maximum speeds of 40 km/h (25 mi/h) over improved roads, 30 km/h (19 mi/h)

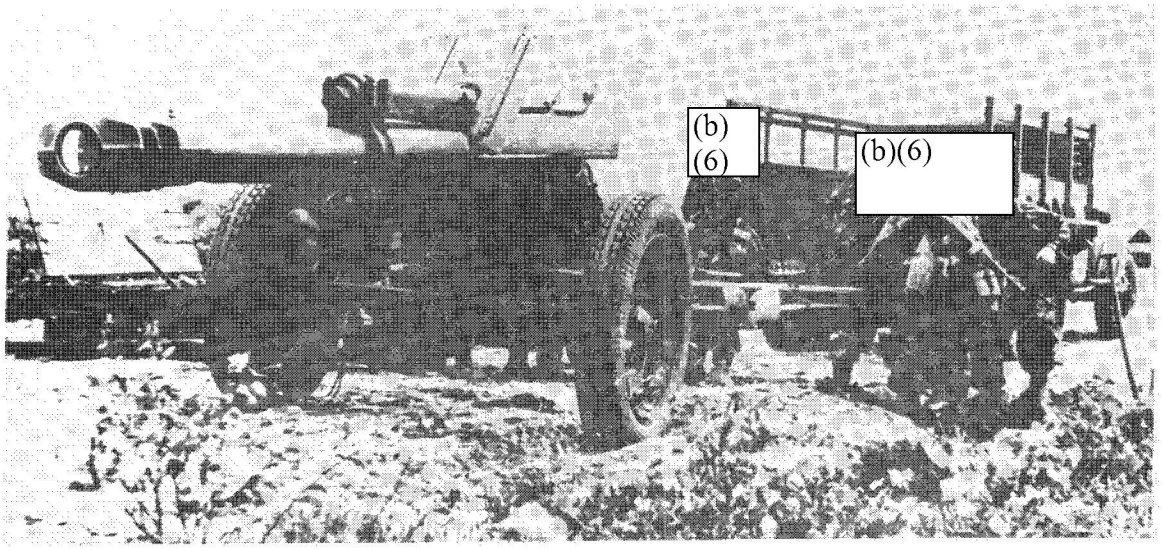

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Figure II-0-2. 152-mm D-1 howitzer in travel configuration (U).

over cobblestone or unimproved roads, or at 10 km/h (6 mi/h) cross country. This howitzer can be emplaced or displaced by its nine-man crew (including driver) in approximately 2 minutes. Eight propellant charges, including full charge and seven numbered charges, are available for use with the standard fragmentation-HE projectiles used in this howitzer. The D-1 can also fire rounds designated for the obsolescent 152-mm M-10 howitzer. Only in exceptional cases may rounds from the obsolete 152-mm M-1909/30 howitzer be fired from the D-1. The M-1909/30 round has only four charges available and the maximum range attained is but 10 200 meters. A special charge is used with the naval semi-armor piercing (SAP) projectile. Table II-O-1 shows projectile data for the D-1 howitzer. The unit of fire (UOF) is estimated to be 60 rounds per weapon; depending upon the prime mover being employed, it is probable that up to 0.5 UOF (30 rounds) is transported with the weapon.

Table II-O-1. Projectiles, 152-mm D-1 Howitzer (U)

Type	Designation	In-flight weight (kg)	Muzzle velocity m/s	Penetration at 0° obliquity (mm)
HE, steel	OF-530	40.0	508	NA
HE, cast iron	O-530A	40.0	508	NA
Chem	?	?	?	NA
CP	G-530	40.0	508	New concrete 1040 @ 500 m; 980 @ 1100 m
HEAT-SS	BP-530	?	?	200 (Soviet), 340 (US) @ 0° (est)
HE, naval SAP (obso-lescent)	KTMF	51.07	432	Armor plate 87 @ 500 m; 82 @ 1000 m

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(2) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data are depicted in table II-O-2.

Table II-O-2. Probable Errors in Indirect Fire; 152-mm D-1 Howitzer; Shell HE (OF-530 or O-530A) (U)

Percent of maximum range (12 390 m) (measured in meters at various percentages)	PE_r (m)	PE_d (m)
90 (11 200, chg full)	47.0	6.0
70 (8700, 2d chg)	31.5	4.6
50 (6200, 4th chg)	25.0	3.2
30 (3700, 6th chg)	19.5	1.9

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(b) ~~(C)~~ Effectiveness. An 18-howitzer D-1 battalion can deliver 1.44 tonnes (36 rounds) of projectiles in the first 20 seconds of fire. At a range of 10 000 meters, a D-1 battalion, considering precision errors only, can deliver 1.31 tonnes within a 250x200-meter target area (PE_r, 1st charge = 40 meters).

(c) ~~(C)~~ Fragmentation. The OF-530 projectile (VOF-536 round) fired by the D-1 has a steel body. The O-530A projectile has a cast iron body. These projectiles have a charge-to-mass ratio of 0.212:1 and 0.167:1, respectively. The OF-530 projectile bursts into an average of 13 160 fragments having a mean weight of 2.50 grams and average fragment initial velocity of 956 m/s. The O-530A projectile bursts into an average of 79 900 fragments having a mean weight of 0.40 grams and average initial fragment velocity of 855 m/s; obviously, the O-530A is very effective against unprotected personnel.

(d) ~~(C)~~ Lethality. Lethal areas for the OF-530 fragmentation-HE projectile in open terrain and in temperate forest are shown in figures II-O-3 and II-O-4, respectively.

(3) ~~(C)~~ Direct fire.

(a) (U) Precision. A sampling of precision data in direct fire of the 152-mm D-1 howitzer is presented in table II-O-3.

II-182 and II-183 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Table II-O-3. Probable Errors in Direct Fire, 152-mm D-1 Howitzer; Naval Semi-Armor Piercing (SAP) Projectile (U)

Range (m)	PE_d (m)	PE_v (m)	PE_r (m)
500	0.15	0.1	10.0
1000	0.3	0.3	11.0
1500	0.45	0.55	11.5
2000	0.6	0.8	12.0
3000	0.9	1.4	14.0
4000	1.3	2.5	16.0

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(b) (U) Grazing range. Estimated grazing range for the HEAT-SS projectile vs. targets of various heights is:

- 580 meters when target height is 2.0 meters.
- 720 meters when target height is 2.7 meters.
- 800 meters when target height is 3.0 meters.

(c) ~~(C)~~ Effective range. It is estimated that effective range with the HEAT-SS projectile (50% first-round hit probability) vs. a US M60A1 tank is about 725 meters.

(d) ~~(C)~~ Engagement range. It is probable that fire will be opened against an M60A1 tank at about 800 to 900 meters.

(e) (U) Armor penetration. Armor penetration of the obsolescent naval SAP round (432 m/s) is shown in table II-O-4. Estimated penetration of the BP-530 HEAT projectile is shown in table II-O-1.

Table II-O-4. Armor Penetration, 152-mm Naval SAP Projectile (U)

Range (mm)	Penetration (mm)	
	At 0° obliquity	At 30° obliquity
100	90	73
500	87	71
1000	82	67
1500	78	64
2000	74	60
2500	70	57
3000	68	55

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c. (U) Configuration. The carriage of the D-1 is of split trail design. It is the same carriage as that of the 122-mm M-30 howitzer, except it has been reinforced at the major points of stress. The trails are of riveted box design with internal reinforcement. The solid steel axle is of rectangular construction. A leaf suspension spring is mounted longitudinally along the axle. The spring is engaged by freeing a locking dowel when the trails are closed as the howitzer is placed in the travel configuration. The locking dowel locks the carriage to the axle when the trails are spread, thus locking out the suspension system during firing. The lunette is a separate fixture that, when the weapon is in the travel configuration, fixes the trails together through lugs and a turnbuckle arrangement. This howitzer has 35° of on-carriage traverse (17°30' right and left of center) and must be repositioned if larger shifts in direction are required. Elevation limits are -3° and +63.5°. A recoil pit 200 to 300 mm deep must be provided when firing is conducted at elevations above 37°. It is necessary to position wooden cross beams under the trail spades for all firing. The recoil mechanism of the D-1 is an independent type hydropneumatic system that employs a constant (non-variable) hydrauli recoil brake and a hydropneumatic recuperator. Normal length of recoil is 960 to 1000 mm. Maximum permissible recoil is 1100 mm. The cradle, of semi-cylindrical, riveted construction, has forward and aft yokes. The trunnions and the elevating rack are integrated into the rear yoke

component. On-carriage fire control is the independent type with a semi-independent line of sight; see paragraphs 11c and 12b(5).

d. ~~(C)~~ Summary. The D-1 remains the standard organic general support weapon in the majority of Soviet MRD. It is being selectively replaced by the 152-mm M1973 SP gun. Since this replacement likely will require several years to complete and, since the D-1 also is in the active inventory of all Warsaw Pact and a number of other ECC, it is probable that a number of D-1's will remain in active use for about 10 years. The precision of the D-1 is comparatively poor. Using full charge at approximately 70% (8700 meters) of maximum range, probable error in range, when expressed as a percentage of range, is 0.41%. This error increases to 0.42% at 90% (11 200 meters) and to 0.46% at maximum (12 390 meters) range. Conversely, the lethality of the D-1's O-530A cast iron bodied fragmentation-HE projectile is excellent. The charge-to-mass ratio of the steel bodied OF-530 is 0.212:1 as compared with the US 155-mm howitzer's TNT-loaded M107 projectile's ratio of 0.150:1. Whether or not the Soviets have undertaken a program to supplement the OF-530 with improved conventional munitions is unknown. The D-1 is a facile and reliable medium howitzer. Its principal deficiency is its limited range. Its imprecision is partially offset by its good lethality.

30. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) ~~(C)~~ Tube. The rear portion of the monoblock gun tube is encased in a sleeve which serves to join the tube and the breechring and simultaneously provides some counterweight for equilibration. The sleeve houses recoil slides which engage the recoil rails incorporated as a component of the rear cradle yoke. Tube length without muzzle brake is 23.3 calibers (3527 mm). Length of the barrel assembly with muzzle brake is 4207 mm. The double-baffle muzzle brake assists in braking the howitzer in recoil. Efficiency of the brake is estimated to be about 45%. The tube has 48 lands and grooves having a progressive right-hand twist. The angle of inclination at the origin of rifling is 3°54'25" and increases to 8°55'37" at the muzzle. Land width is 3.00 mm, groove width is 6.97 mm, and groove depth is estimated to be slightly more than 2 mm. Design length of the 5.707 liters powder chamber is 410 mm. Average tube wear life using full charge is 5000 EFC rounds. Tube fatigue life is unknown.

(2) (U) Breechring. The manually operated, right-hand opening, interrupted-screw-type mechanism (fig II-0-5), which operates on a hinged carrier by use of a conventional lever and latch arrangement, is a larger version of the M-30's breech. The breechblock contains a percussion pull-type firing device; the firing pin impacts upon the primer

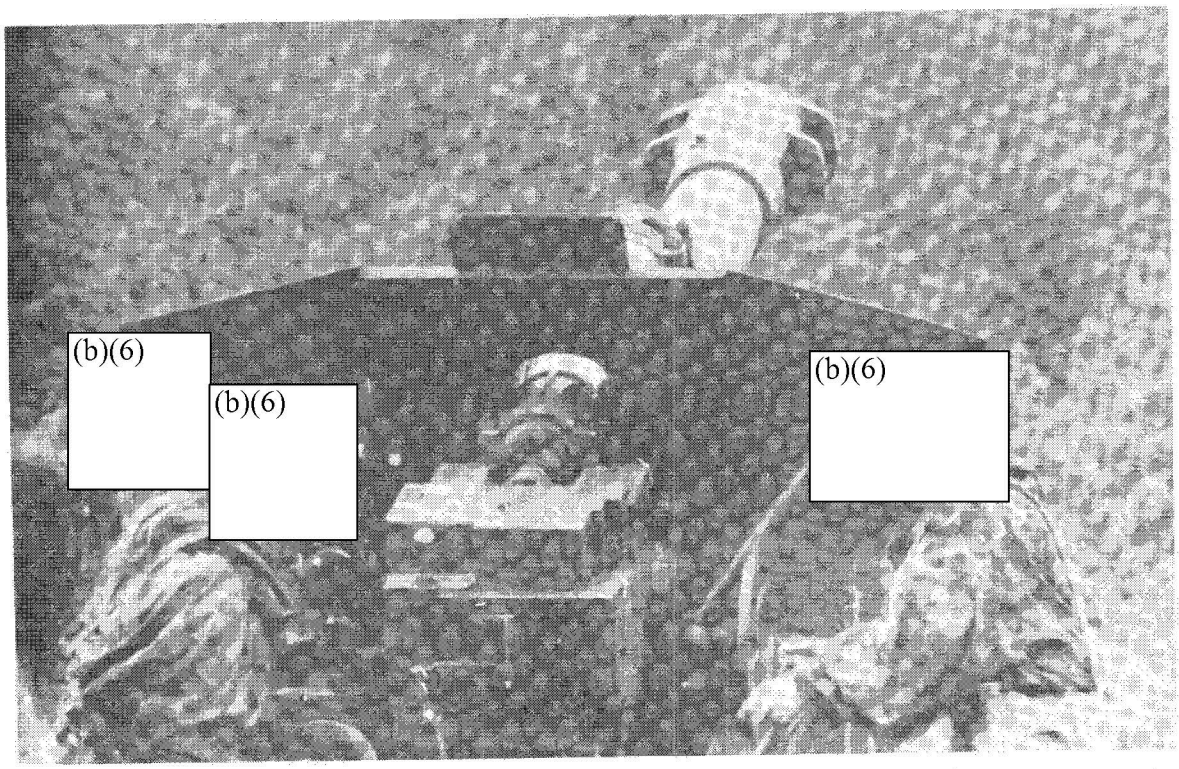

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Figure II-O-5. 152-mm D-1 howitzer, rear view (U).

that is integral to the propellant case. Obturation is performed by the interaction of the cartridge case with the face of the breech and the walls of the chamber. The fatigue life of the breech is unknown.

(3) ~~(C)~~ Muzzle brake. A double baffle, four port, winged-type muzzle brake is mounted on this weapon. The brake is somewhat similar in appearance to those mounted on the 152-mm M1973 SP Gun and the 152-mm D-20 Gun-Howitzer, but is not as large or so prominently winged.

b. (U) Top Carriage. This assembly is composed of the cannon assembly with associated sleeve, the muzzle brake, the cradle, the recoil mechanism, the elevating mechanism, the on-carriage fire control equipment, the gun shield, the equilibrators, and the handwheel and gear train of the traversing mechanism. Except for the cannon assembly, the top carriage is identical to that of the 122-mm M-30 howitzer. Differences in positioning limits, recuperator pressure, etc., are set forth below.

(1) (U) Positioning limits. Traverse is limited to 17°30' right or left from center for a total on-carriage traverse of 35° vs. the 49° available on the M-30. Elevation limits are -3° and +63.5°, the same as on the 122-mm M-30.

(2) (U) The recoil mechanism. The same type hydropneumatic, independent constant length recoil mechanism as is found on the M-30 is used on the D-1. Normal length of recoil is 960 mm to 1000 mm; maximum permissible length is 1100 mm. The recuperator of the D-1 is filled with 11 ±0.4 liters of "Steol M" and is pressurized with dry air (at 0° elevation) to 52 ±2 atm (53.73 kg/cm^2 ±2.06 kg/cm^2 or 764.4 lb/in^2 ±29.4 lb/in^2). In recoil, the maximum pressure attained in the recuperator is unknown. The recoil cylinder is filled with 9.7 liters of Steol M.

(3) (U) On-carriage fire control. This equipment is located on the left trunnion and consists of the same standardized Model 1930 sighting system (telescope and mount) as is used on the M-30. The range drum utilized with the D-1 is inscribed with six scales identified as DG full, DG-1, DG-2, DG-3, DG-4, and DG-7, which are used with corresponding charges. The DG-4 scale is used for 5th charge and DG-7 is used with 6th charge, both in conjunction with appropriate firing tables. The DG-1 scale is used with the naval semi-armor piercing (SAP) round (VG-536M).

c. (U) Bottom Carriage. With the exception of the trails being reinforced internally, the bottom carriage of the D-1 is the same as that of the M-30.

P. SOVIET 180-MM GUN S-23*

31. ~~(C)~~ Description and Performance

a. General. The Soviet 180-mm gun S-23 (fig II-P-1) was previously erroneously identified as the Soviet 203-mm gun-howitzer M1955. The Soviets first displayed this weapon in the 1955 Moscow May Day Parade; because it was first observed in that year, it was assigned the tentative model-year designation of M1955. Current information appears to substantiate the belief there is no 203-mm version of the S-23. The Soviets have a developmental history in 180-mm guns, including naval, coastal, and railroad guns; therefore, existence of the S-23 does not represent the introduction of a unique caliber. The Soviet 203-mm howitzer B-4 (M-1931) (fig II-P-2) does exist as an obsolescent artillery weapon. The 180-mm S-23 utilizes an interrupted screw breechblock and uncased, bagged propellant charges. It is postulated that a limited number of S-23's may be deployed to Soviet national level artillery brigades that would be assigned to fronts in the event of war. The role of the S-23 should be to deliver long-range harassing and interdiction fires and, possibly, nuclear strikes. Recognition features of the S-23 (fig II-P-3) include:

*Formerly identified as Soviet 203-mm howitzer, M1955.

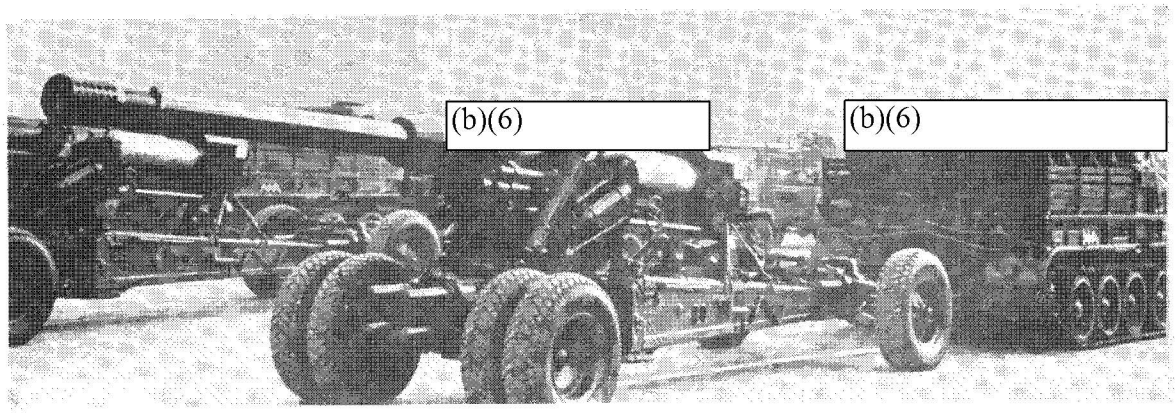

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Figure II-P-1. Soviet 180-mm gun S-23 (U).

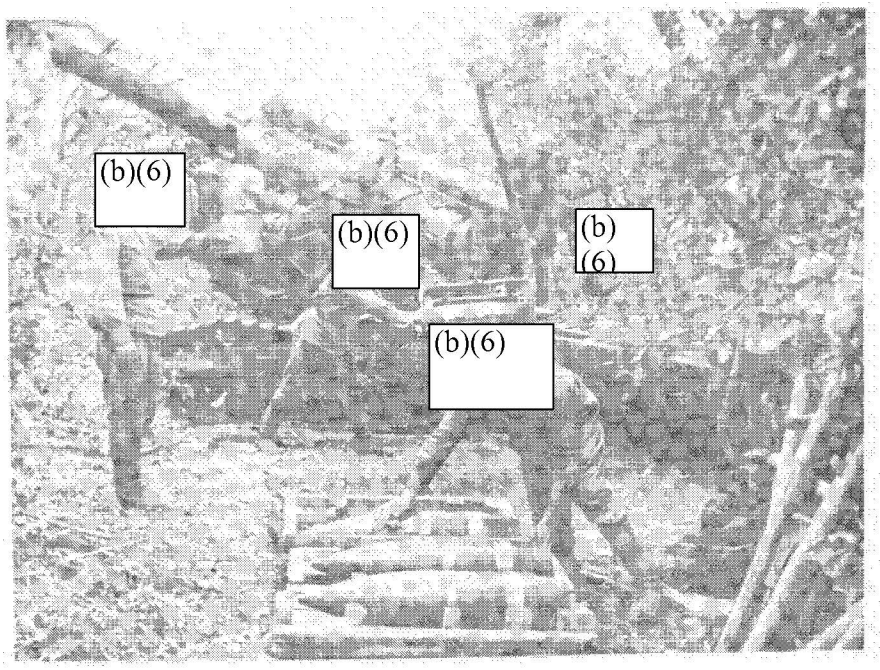

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Figure II-P-2. Soviet 203-mm howitzer B-4 (U).

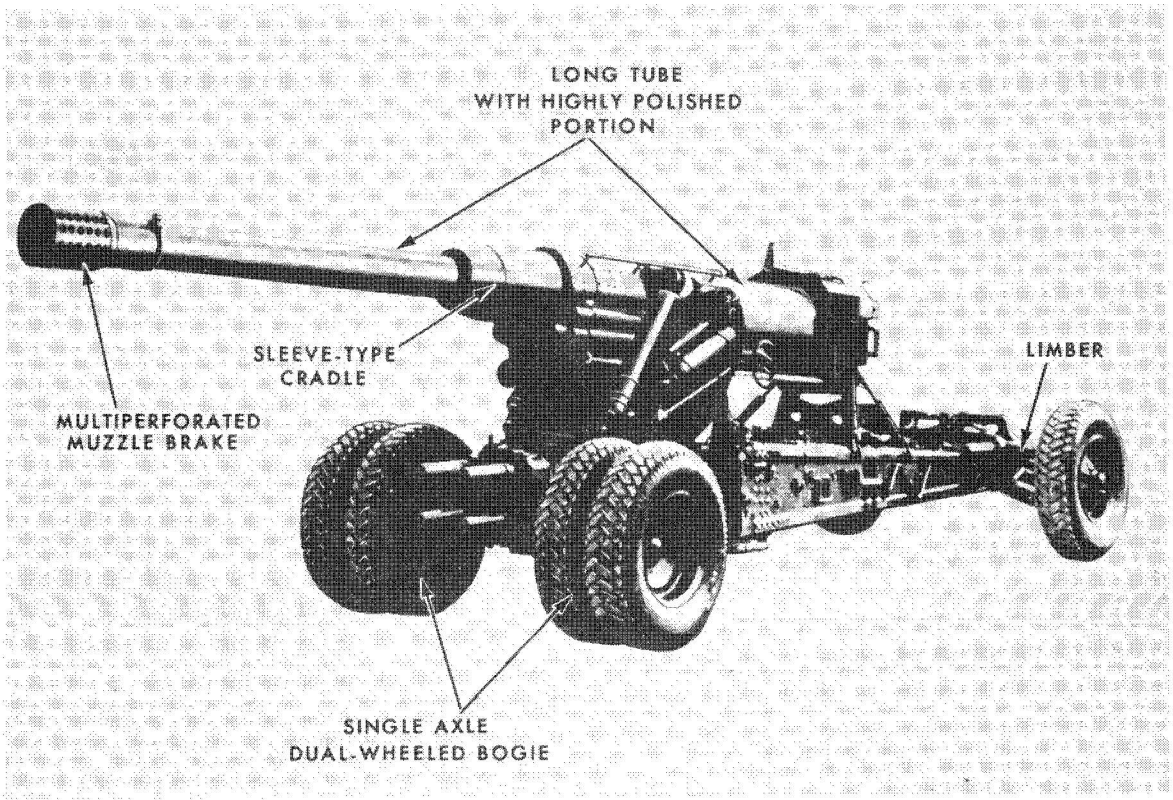

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Figure II-P-3. Soviet 180-mm S-23 gun, recognition features (U).

Its long tube, which has a highly polished portion that is exposed between the breechring and the rear of the cylindrical sleeve-type cradle when the weapon is in the travel configuration, a cylindrical multi-perforated muzzle brake, and an articulated torsion-bar main suspension mounting a single set of dual tires. The S-23 in travel position weighs 21.5 metric tons (23.7 short tons), is 13.00 meters (42.65 ft) long, 3.00 meters (9.84 ft) wide, and 2.70 meters (8.86 ft) high. In the firing position, with tube in battery, the gun is 14.0 meters (45.95 ft) long and 1.65 meters (5.41 ft) high. Unit organization usually is a 4-gun battery and a 12-gun battalion. In view of its exceptional range capability and good design, continued deployment to the national and/or front levels in some non-Soviet ECC and other armies is expected. Its appearance in a field army may indicate an intention to employ low yield nuclear warheads. Countries reported as possessing this weapon include: Syria, North Korea, North Vietnam, Egypt, and Czechoslovakia.

b. Capabilities.

(1) General. The S-23 fires a 88.0-kg (194-lb) HE projectile (F-572) to a maximum range of 30 390 meters, a 84.0-kg (185-lb) rocket assisted (RAP) incendiary-fragmentation-HE projectile (ZOF-23) to a maximum range of 43 800 meters, and a 97.5-kg (215-lb) concrete piercing projectile (G-572) to a maximum range of 27 380 meters. In addition to the high explosive, the incendiary-fragmentation-HE RAP, and the concrete piercing projectiles, the S-23 may possess a nuclear capability. The separate loading ammunition for the S-23 is manually loaded from a loading tray and is hand rammed. The uncased bagged propellant for the HE and CP projectiles provides four charge options, only three of which are used with the CP projectile. The propellant charge for the RAP projectile provides no charge option. Rates of fire over 1, 3, 5, 15, 30, and 60 min are 1, 2, 3, 9, 18, and 30 full-charge rounds, respectively. The 13-man crew (12 men plus the tractor driver) requires approximately 25 to 30 min to prepare the S-23 for action. The Soviet heavy, tracked artillery tractor AT-T is the prime mover usually used with the S-23. The gun is designed to achieve a permissible traveling speed of 35 km/h (21.7 mi/h) on hard-surfaced roads. The weapon sometimes is towed by heavy-duty, wheeled prime movers such as the KrAZ-219 in the Soviet Union and comparable vehicles in other countries. The recoil mechanism of the S-23 consists of two interconnected recuperators, a variably throttled recoil brake, and a replenisher, all mounted under the sleeve-type cradle. The equilibrators, one on each side of the tube, are inclined to the rear. A compressed air cylinder positioned in rear of the left equilibrator is used to maintain pressure in the equilibrators. Fire control for the weapon is by a panoramic telescope and mount on the left side and a range quadrant on the right side of the gun. The split trails of the S-23 are of box-section construction. The detachable spades are carried on the prime mover. A limber is provided to support the trail ends when the weapon is in the travel configuration. The unit of fire is estimated to be 40 rounds per weapon. In a battalion equipped with AT-T artillery tractors as prime movers some 6 to 10 rounds probably are carried with the gun. Should a unit have heavy trucks for prime movers, it is feasible that about 15 to 20 rd may be transported with the gun.

(2) Ammunition. A complete round for the 180-mm S-23 gun consists of a fuze, a projectile, the propelling charge, and a primer.

(a) Fuzes. Each of the projectiles for the 180-mm S-23 has a unique fuze that is not interchangeable between projectiles. Table II-P-1 depicts fuze functions and effects. All of the point detonating-type fuzes must be used with the cover on during heavy rainfall to preclude occasioning a premature burst.

Table II-P-1. Fuze Data, 180-mm S-23 Gun (U)

Type of projectile	Fuze	Effect desired	Fuze cover	Fuze option setting	Initial posture of fuze
HE, F-572	V-491	Fragmentation	Off	"0"	Cover on and option set on "0"
	RGM-2	*Fragmentation w/cratering	On	"0"	do
		Cratering	On	"3"	do
CP, G-572	DBT	Fragmentation w/cratering	N A**	"0"	Option is set on "3"**
		Cratering	N A**	"3"	
Incendiary-frag-HE RAP, ZOF-23	V-429	Fragmentation w/incendiary effect	Off	"0"	Cover on and option is set on "0"
		Fragmentation w/some incendiary and cratering effect	On	"0"	do
		Cratering w/some incendiary effect	On	"3"	do

~~(CONFIDENTIAL)~~

*RGM-2 may be used with an adapter in the fuze well.
**Fuze DBT for the CP projectile is a base fuze, and does not have a cover.

(b) Projectiles. Distinguishing marks are found on the body of the projectiles. HE projectiles are marked with an "F." Concrete piercing projectiles, which are marked with a "G," have a blue line inscribed around the body just below the bourrelet. The incendiary-fragmentation-HE RAP has "OF-23" painted on the body. Characteristics of projectiles used in the S-23 gun are set forth in table II-P-2.

Table II-P-2. Projectiles, 180-mm S-23 Gun (U)

Type	Designation	In-flight weight (kg; lb)	Muzzle velocity (m/s)	Penetration @ 0° obliquity (mm; in)
HE	F-572	88.0; 194	860	
CP	G-572	97.5; 210.5	805	2410; 95*
Incendiary-frag-HE RAP	ZOF-23	84.0; 185	884	

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*Penetration against vertical reinforced concrete wall at 1000 meters.

(c) Propelling charges. Two different propelling charges are used with this gun. The charge used with the HE projectile and the CP projectile provides four charge options (full, 1st, 2d, and 3d); the full charge increment is discarded prior to firing the CP projectile since 1st charge is the maximum permissible charge with that projectile. The propelling charge for the RAP, which is full charge only, contains more propellant than the full charge used with the conventional HE projectile.

1. Propelling charge used for the conventional HE and the CP projectiles. Due to the large quantity of propellant involved, the propellant is packaged into two major sections (fig II-P-4), a forward section of four increments, retained by tie straps, and a rear section consisting of a single large cylindrical bag that has a 0.25-kg black

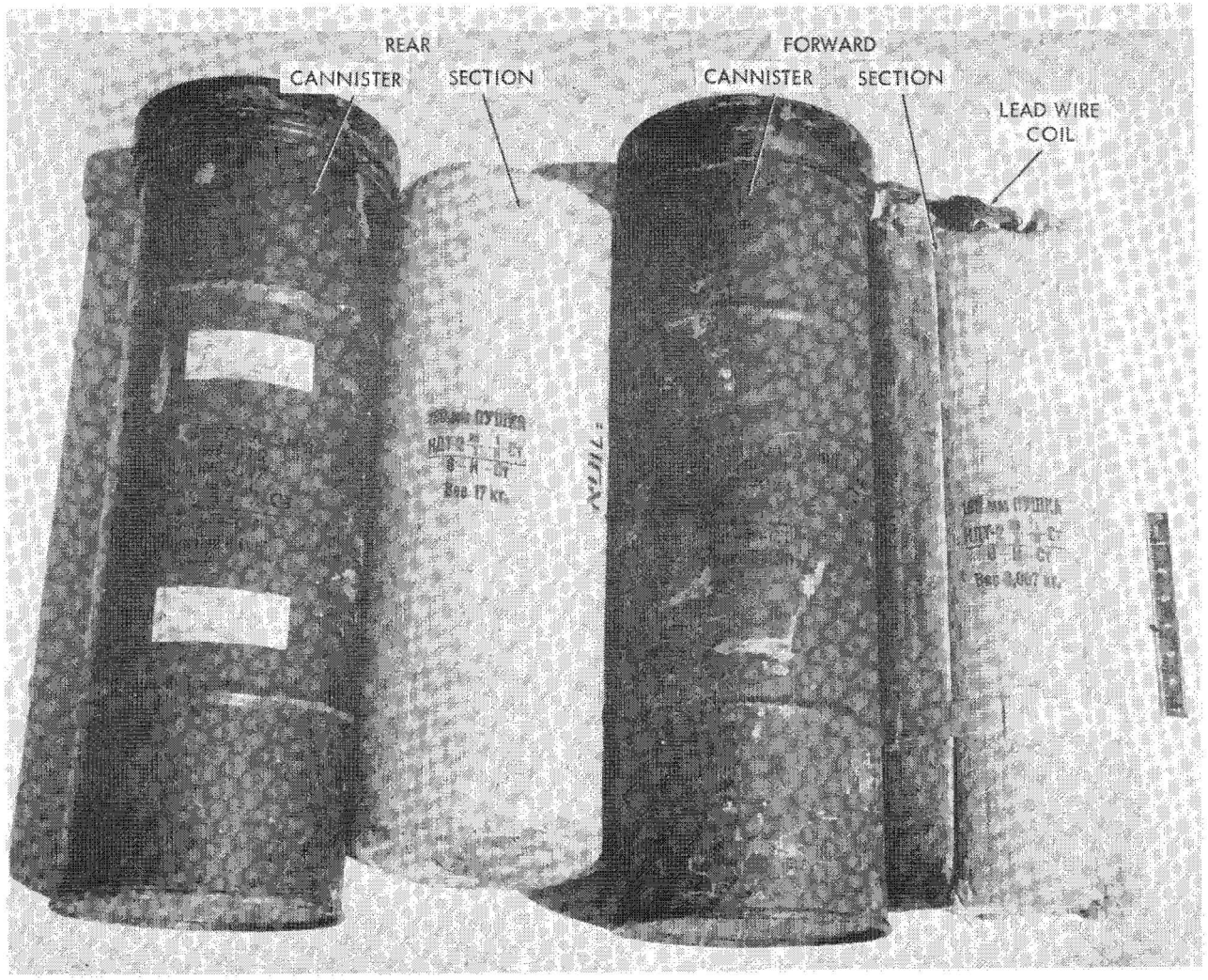

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Figure II-P-4. Propellant charge for HE and CP projectiles, 180-mm S-23 gun (U).

powder filled igniter pad affixed to each end. The presence of two igniter pads permits the lower propellant section to be inserted into the chamber (after loading all or part of the forward section) without regard to which end faces the primer positioned in the firing mechanism in the breechblock. Both sections of propellant contain NDT-2, 25/1 propellant. The forward propellant section consists of four bagged powder increments, all of equal length, as follows (fig II-P-5):

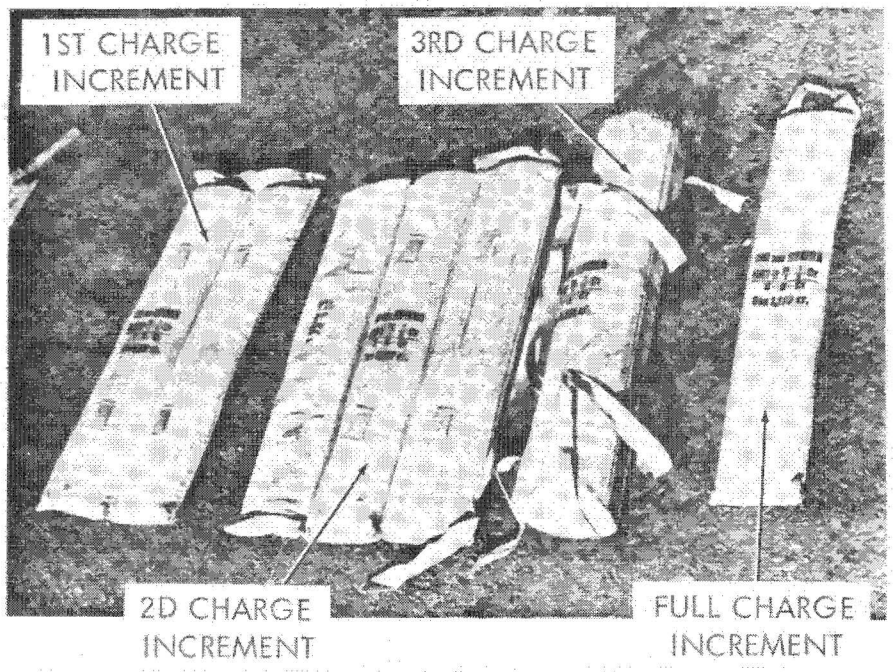

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Figure II-P-5. Incremental forward section of propellant charge for HE and CP projectiles, 180-mm S-23 gun (U).

- One of the increments is a cylindrical bag to which two tie straps are affixed, one at a point about one-fourth of the length of the bag and the other at about three-quarters the length of the bag. These straps serve to bind the four increments that comprise the forward section into one package. This increment plus the rear propellant section constitute the 3d charge, containing 22.3 kg (49.2 lb) of propellant.

- The second of the four increments consists of bagging that has been fabricated into a wide but rather flat sack. This sack is further divided longitudinally into three compartments. One of these compartments contains a phlegmatizer. A phlegmatizer may perform one or more of four functions: Reduce bore erosion, reduce muzzle flash, provide a desensitizer for the propellant, and/or reduce the emission of smoke. The volume of the compartment containing the phlegmatizer relative to the volume of propellant present in the entire propelling charge (full charge, the complete forward section plus the rear section) indicates that the phlegmatizer performs several of these functions. The text of the firing table claims the presence of a flash reducer, also indicates the presence of a bore erosion reducer, and hints at smoke reduction and a desensitizer. It should be noted that, to date, the simultaneous reduction of both smoke and flash has proved to be mutually exclusive. This three-compartment second increment of the forward propellant section constitutes (with the aforementioned first increment and the rear section) the 2d charge, which contains 25.4 kg (60.0 lb) of propellant.

- The third of the four increments is similar to the above-described second increment, except that the bag has two, rather than three, compartments, and contains propellant only. The weight of propellant in this increment is the same as that in the second increment; that is, the second and third increments are the same propellant-wise, although the second increment has a third compartment containing the phlegmatizer. This two-compartment third increment, with the two increments previously described plus the rear section, constitutes the 1st charge, having a propellant weight of 28.4 kg (52.6 lb).

- The fourth increment consists of a single compartment bag about the size of one of the compartments found in the three-compartment second increment or the two-compartment third increment. This fourth increment is further distinguished by having a cloth "handle" or "carrying strap" on the upper end. This strap is used to remove this increment from the tied bundle of propellant making up the full forward section without having to untie the straps that tie the forward propellant

section into one bundle. This is possible since the forward propellant section is secured by the straps attached to the cylindrical first increment. In tying the forward propellant section, the second increment is placed to surround a portion of the first increment, the fourth increment is inserted between the first increment and the center of the three compartments in the second increment. The third (two-compartment) increment is placed upon the first increment, adjacent to the second increment, and the straps are passed through the loops on the second and third increments and tied; the first, second, and third increments are then secure since they are strapped to one another. The fourth increment is held in position by virtue of being surrounded by the other three increments. Should lst charge be called for, the fourth increment is removed by grasping the "top handle" on its forward end and pulling that increment from the four increment bundle of propellant; this is done without untying the straps that secure the forward propellant section. No increments are removed when firing full charge, which contains 29.27 kg (64.53 lb) of propellant.

- A decoppering agent, consisting of a bundle of lead wire weighing 200 grams (7.05 oz), is tied to the forward end of the cylindrical 3d charge increment in the forward propellant section.

2. Propellant charge for RAP. The propellant used with the incendiary-fragmentation-HE RAP projectile also is packaged into a forward and a rear propellant section. Unlike the charge used with the HE and CP projectiles, the forward section of this charge is not divisible into increments; i.e., this charge is full charge only, containing 30.35 kg (66.91 lb) of propellant in its two sections.

3. Indirect fire.

- Precision. A sampling of precision data based upon a comparison of PE_r of the Soviet 180-mm S-23 and the US 175-mm M107 is presented in table II-P-3. It should be understood that the minimum range at which the OF-23 HE RAP is employed is 34 000 meters. Firing table data commence at 28 000 meters to provide appropriate interface between the conventional HE projectile and the incendiary-fragmentation-HE RAP.

II-198 is denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Effectiveness, fragmentation, and lethality. To date, none of the projectiles used in the 180-mm gun have been exploited. The conventional HE and CP projectiles probably exhibit individual effectiveness equal to that one would expect from projectiles in this class; i.e., better than that of a 175-mm and somewhat less than that of a 203-mm projectile. The comparatively slow rate of fire, plus the sizable probable errors in range at much more than 50% of maximum range, combine to delimit the effectiveness of the standard HE projectile in the rapid neutralization of a target such as an enemy battery. It is postulated that a 12-gun battalion, and particularly a 4-gun battery, simply cannot place enough HE projectile weight into a limited target area (such as an enemy battery position) within a short time to obtain effective and timely neutralization. The US M107, firing conventional HE, suffers from many of the same problems. The M107's allegedly better precision is more than offset by its much lighter projectile, 66.04-kg versus the 88.0-kg projectile weight of the S-23. For example, when firing at an enemy battery (target size 250 meters wide x 200 meters deep) at a range of 27 500 meters with conventional HE shell, and considering that the engagement is continued for the quite lengthy period of 30 minutes to get enough projectile weight on target to achieve some degree of neutralization, an S-23 battery will fire 18 battery volleys (72 rounds), of which 37.43 rounds will fall within the target area, for a total projectile weight of 3.294 tonnes. Conversely, the US M107 will fire 15 volleys (60 rd), of which 47.53 rd will fall within the target area, for a total projectile weight of 3.139 tonnes. Considering the extensive time of engagement and the relatively light weight of metal on-target, neither weapon is very effective in the counter-battery role when using conventional HE projectiles. The US M110 (203 mm), with the same rate of fire as the M107, with a slightly heavier projectile than the S-23, and with much better precision (within its more limited range capability) than either the M107 or the S-23, obviously is the counterbattery weapon of preference. The S-23's CP projectile achieves good penetration for a projectile of its weight class; nevertheless, for effective engagement of heavy concrete fortifications a 240-mm weapon represents about the minimum, and even the German 420-mm "Big Bertha" was not very effective at Verdun in World War I. The 180-mm S-23's CP projectile is best suited to the direct fire role and

to indirect fire using assault fire-type adjustments at relatively short ranges, 7 km maximum. The incendiary-fragmentation-HE RAP achieves its maximum range of 43.8 km in 117 seconds time-of-flight. The rocket motor contains 6.9 kg of propellant and occupies essentially all of the volume within the cylindrical portion of the projectile. The explosive filler is confined to a cavity delimited by the ogival section of the projectile; i.e., the "warhead" consists only of the ogival section of the projectile. Although such delimitation still results in a weight of fragmenting metal and explosive filler that commonly is associated with artillery projectiles in the 150-mm (6.0-inch) class, the ogival shape of the fragmenting material should reduce the lethal area resulting from detonation of the projectile to about that area expected of a light artillery projectile in the 100-mm (4.0-inch) class. The blast and incendiary effects created by the addition of flaked aluminum to the RDX filler, however, enhance the overall terminal effectiveness of this projectile, possibly to the level of a 125-mm to 130-mm (5.0-inch) class projectile. In short, the 180-mm RAP primarily is for use in harassing and interdiction fires delivered deep into the enemy's rear.

4. Direct fire. Except when firing the CP projectile, this weapon, it is postulated, is not normally utilized in the direct fire role. An armor defeating round, per se, is not known to exist. Nevertheless, this weapon will be employed in direct fire to reduce concrete or other types of improved field fortifications that present a visible, vertically oriented face. If the 95.7-kg (211-lb) CP projectile were employed against armored vehicles, the resultant kinetic energy and blast are sufficient to inflict serious damage upon, if not destroy, a tank; the effect upon an APC should be total destruction. Grazing range against a 2-meter and a 3-meter-high target are 1000 meters and about 1225 meters, respectively. In the interest of conserving ammunition, employment doctrine recommends not engaging stationary targets with the CP projectile at ranges beyond 7000 meters. Probable errors for the CP projectile are shown in table II-P-4.

c. Configuration.

(1) General. In the travel position, the split trail carriage of the S-23 is supported, at each end of a torsion bar sprung single bogie, by dual steel wheels mounting foam rubber-filled tires and by a torsion bar sprung limber mounting a single wheel on each side. The tube, which is equipped with a multibaffle muzzle brake, is mounted in a cylindrical

Table II-P-4. Precision in Direct Fire, 180-mm S-23 Gun, CP Projectile (U)

Range (m)	PE_r* (m)	PE_d* (m)	PE_h* (m)
600	27	0.2	0.2
1000	21	0.3	0.3
1600	20	0.4	0.4
2000	20	0.5	0.5
3000	19	0.8	0.8
4000	20	1.3	1.0

*All for charge 3 (650 m/s). ~~(CONFIDENTIAL)~~

sleeve-type cradle (fig II-P-6). In firing position, the weapon weighs about 21.2 metric tons. The variable length recoil mechanism, mounted beneath the cradle, consists of a variably throttled recoil brake, two interconnected recuperators, and a replenisher.

(2) Positioning limits. Two elevation handwheels, one for gross and the other for fine changes in elevation, are located on the right-hand side of the carriage (fig II-P-7). These handwheels drive a rack-and-pinion-type elevating mechanism that positions the tube between -2° and +55° of elevation. On-carriage traverse is limited to a total of 40°. The traversing handwheel is located on the left side of the carriage.

(3) Fire control. The dependent-type fire control subsystem consists of a Model PG-1M panoramic telescope on a sight mount that is attached to the left trunnion. The panoramic telescope is positioned on its mount so the eyepiece is facing outward at a 90° angle to the tube. This results in the index of the sight reading 4500 M in relation to the axis of the bore. An arc-type range quadrant with angle of site scale is mounted upon the right trunnion. The telescope and the range quadrant mounts are both identified as models S-85 (C-85).

d. Summary. The cannon and carriage of the Soviet 180-mm S-23 gun is a decided improvement over the Soviet 203-mm B-4 howitzer. The S-23's split-trail, wheeled carriage employs torsion-bar suspension; it provides good mobility, maneuverability, and reduced emplacement time when compared with towed heavy-gun systems of earlier vintage. The range

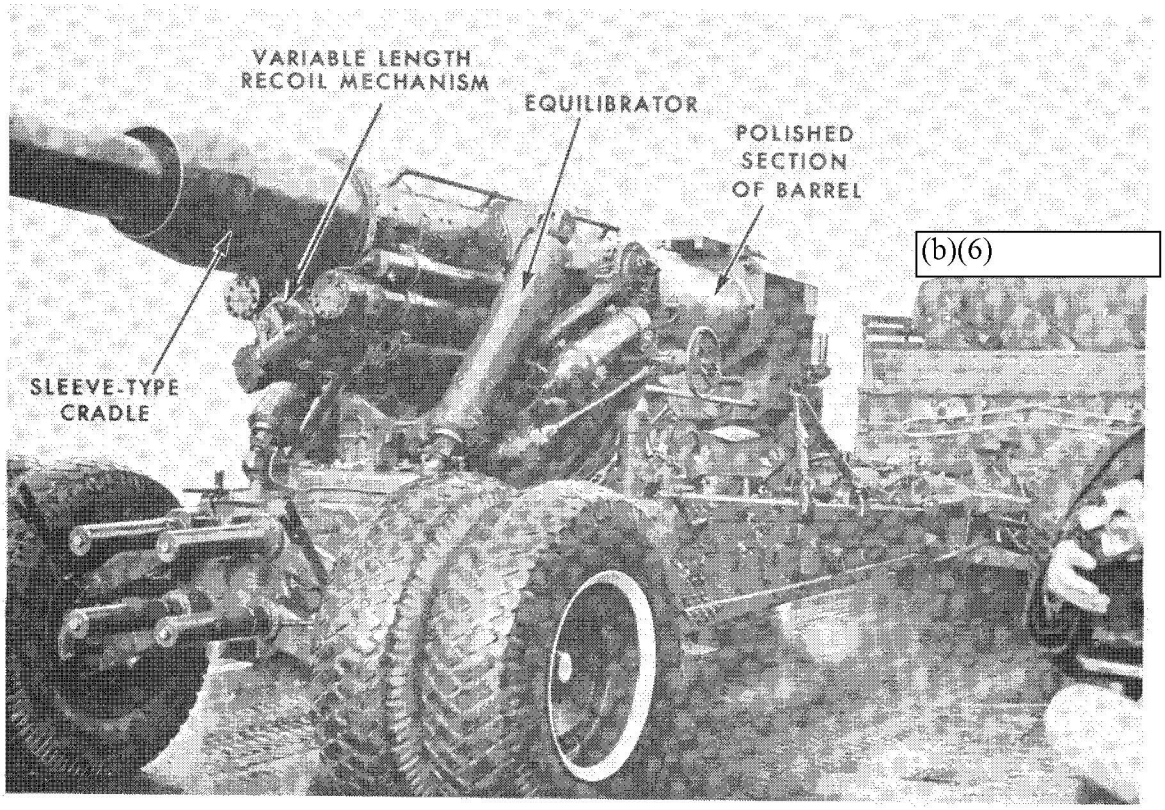

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Figure II-P-6. 180-mm S-23 gun, cradle, and recoil mechanism (U).

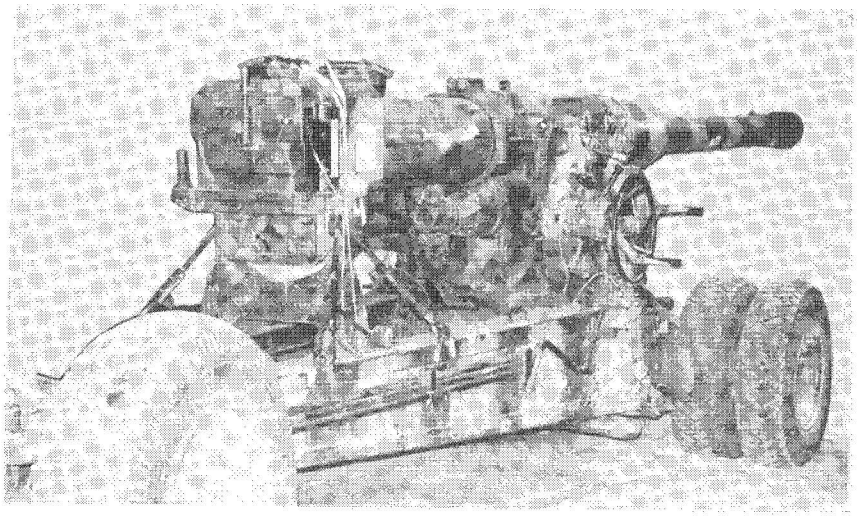

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Figure II-P-7. 180-mm S-23 gun, right side view (U).

capability of the weapon may dictate that the Soviets retain this system in their inventory for firing long-range counterbattery, harassment, and interdiction missions; to provide a gun that has some capability against hardened targets [albeit not as great as that of very heavy (240-mm) or superheavy (420-mm) weapons]; and, possibly, a moderately long-range low-kiloton nuclear capability. The rocket assisted projectile capability of this gun represents advanced state-of-the-art; nevertheless, because of the large probable errors associated with it, the combat effectiveness of this projectile is subject to question. Documented information reveals that the S-23 should not be fired unless all crew members within 10 to 15 meters of the gun are protected by being in trenches; it is suspected that extremely high overpressures in the crew area necessitate this precaution. When the RAP is being fired, friendly troops are subject to a remote possibility of injury when positioned along the path of the trajectory from about 4 to 8 km from the weapon, since the closure plug of the rocket motor should fall to earth within these ranges.

32. ~~(C)~~ Component Analysis

a. Cannon.

(1) Tube. The tube is estimated to be of monobloc construction, and, in accordance with normal Soviet practice, probably has not been autofrettaged. The tube, without breechring or muzzle brake, weighs 6000 kg (13 228 lb) and is 7850 mm (25.75 ft) long. Including the breechring and the muzzle brake, the tube weighs 6980 kg (15 388 lb) and is 8800 mm (28.87 ft) long. The outside diameter of the tube just forward of the breechring is approximately 470 mm (18.5 inches). The rear portion of the tube, which is cylindrical, provides a bearing surface that rides within the sleeve-type cradle in recoil. A forward section of the sleeve cradle is tapered to a smaller diameter than that of the main cradle (fig II-P-3). A multiperforated, pepperpot-type muzzle brake is attached to the muzzle. The tube has 40 lands and grooves, which have a uniform right-hand twist at the rate of one turn in 25 calibers. Length of rifling is 6462 mm. Estimated tube life is 600 to 800 EFC rounds. Chamber volume is 42.4 dm^3 (42.4 liters, 1.497 ft^3).

(2) Breechring. The breechring with breechblock and its operating mechanism (fig II-P-7) weighs approximately 980 kg (2160 lb). The breechblock is a conventional (not stepped), rightward opening, interrupted screw-type device having what appears to be conventional parts, including a mushroom head, split rings, obturator pad, and screw block mounted on what appears to be a conventional carrier. The carrier provides for a normal one-eighth of a revolution turning motion to seal or unseal the breech mechanism. A latch is provided on the operating handle to secure the breechblock in the closed position. A lanyard-operated, continuous-pull, primer-armed firing mechanism is mounted on the rear of

the carrier, and is associated with a flash channel located in the mushroom spindle and head. A simple cam-operated, plunger-type latch interrupts operation of the firing mechanism if the gun is not in-battery. A simple breechring-mounted probe is provided to assist in restraining tube rotation in the cradle during firing. Unlike many lighter Soviet weapons, the S-23 breechring does not incorporate a device to preclude projectile fallout. This indicates that the weapon probably is loaded only at relatively low angles of elevation, probably at about 10°.

(3) Muzzle brake. The muzzle brake is a multiperforated cylindrical fixture having four rows of six 39-mm diameter holes (24 perforations) on each side (fig II-P-3). Muzzle brake efficiency is estimated to be approximately 35% to 40%. This probably contributes significantly to the requirement that crewmembers be located in slit trenches located no closer than 10 to 15 meters from the gun when it is fired.

b. Top Carriage. The top carriage supports the gun assembly, cradle, elevating mechanism, traversing mechanism drive, equilibrator, trunnions, and on-carriage fire control equipments, plus those elements of the interface with the bottom carriage that move in traverse.

(1) Cradle. This fixture is a sleeve-type assembly (fig II-P-6). A blocklike section appears to be cast into the top rear cradle. An add-on section to the breechring rides over this stud-like piece when the gun is in-battery; this fixture is believed to provide a means that assists in preventing rotation of the tube in the cradle upon firing. Two other mechanical linkage fixtures of undetermined purpose appear on the upper cradle. One of these fixtures is associated with the right trunnion and the other is a long shaft along the upper left cradle. The trunnion associated fixture may be a part of the control linkage for the variable length recoil mechanism. The trunnions are located at mid-level in the rear third of the cradle. A central recoil brake and paired, interconnected, recuperator cylinders (one on each side of the recoil brake) are located on the bottom of the cradle between the sides of the top carriage (fig II-P-6). Unlike most Soviet weapons, the recoil system cylinders of this weapon are fixed to the cradle and do not move with the tube in recoil. An additional hydraulic cylinder having a reversible flow valve is positioned below the left recuperator cylinder. Following detachment of the recoil system yoke from the breechring, this hydraulic device is used to withdraw the tube from the battery into the travel position and to return it into battery preliminary to locking the breechring to the recoil mechanism for firing. The gun tube travels in the cradle sleeve during recoil. The breechring is attached to the recoil mechanism yoke by an interrupted screw device associated with the lower portion of the breechring. This device (a gun nut ?) provides a quick connect/disconnect capability.

(2) Elevating mechanism. A conventional elevating arc is attached to the bottom of the recoil brake cylinder between the sides of the top carriage. A simple stop fixture is located in the right rear edge of the elevation arc. A coarse elevation handwheel and associated gearbox with enclosed linkage and worm-and-pinion gears is located on the right side of the top carriage below the trunnions (fig II-P-7). A fine elevation mechanism with a crank located forward of the coarse elevation handwheel is attached to the coarse elevation handwheel gearbox by an open shaft fixture, probably worm gear activated. A selector device is provided so that interchange between the coarse and fine elevation mechanisms may be accomplished. Gross elevation changes are accomplished with the "coarse elevation" handwheel, and all final movements in elevation are made using the "fine elevation" mechanism. Angle of elevation and site scales are associated with the right trunnion. Elevation limits are -2° and +55°.

(3) Traversing mechanism. The traversing handwheel is located on the left side of the top carriage (fig II-P-6). The observable linkage for this mechanism (bevel gear, shaft, gearbox, shaft) is conventional. Internal configuration is estimated to include a worm gear, a pinion gear, and tension devices associated with an enclosed rack gear through which movement in traverse is accomplished. On-carriage fire control equipment associated with laying the weapon in the horizontal plane is located on the left trunnion. Total on-carriage traverse is limited to 40°.

(4) Recoil mechanism. The recoil mechanism is an independent, hydropneumatic, variable length Schneider-type system. The recoil mechanism's cylinders are positioned below the sleeve-type cradle, and, unlike most Soviet recoil systems, are fixed to the cradle and do not travel with the tube in recoil (fig II-P-6). The large recoil brake is positioned between and slightly below the two recuperators. The recoil brake has elevation associated linkage connected by a shaft to a conventional gear and segment device on the forward end of the brake. This device rotates the recoil rod to provide for increased throttling and a resultant decrease in the length of recoil as elevation is increased. Between 0° and 30° elevation, recoil length is from 1250 to 1450 mm; between 30° and 40° elevation, the length of recoil varies, decreasing as the elevation is increased; and from 40° to 55° the length of recoil is from 650 to 750 mm. The recoil brake is charged with 53 liters of Steol M fluid. The paired recuperator cylinders are located adjacent to the recoil brake, one on each side and slightly above the brake cylinder. The recuperator cylinders are interconnected. These cylinders are charged with 19 liters of Steol M fluid and pressurized to 64.1 ±1 kg/cm^2 (62±1 atm). The recoil brake and the recuperator cylinder piston rod ends are affixed to a shallow "Y" yoke at the rear lower edge of the cradle. This

yoke has an interrupted screw stud that marries with a fitting nut in the lower breechring, thereby providing a quick connect/disconnect fixture to permit either withdrawing the gun from battery for travel or returning it to battery and connecting the recoil system for firing.

(5) Tube positioning cylinder. A fifth cylinder (in addition to the recoil brake, the two recuperators, and the replenisher) is positioned below and slightly to the left of the left recuperator cylinder. This fixture is a handpump-operated hydraulic cylinder. The piston rod of this fixture is attached to the lower left breechring. A three-position switch valve is provided to enable the piston either to be placed in a neutral (firing) position for free fluid flow in both directions or in a position to provide hydraulic pressure on one side of the piston or the other to either withdraw the tube from battery after unlocking the recoil system or to move the tube into battery to lock the breechring to the recoil mechanism for firing. A four-wheel "A-frame"-type dolly is positioned with two wheels riding on a special faced piece on each of the trails, with the top of this fixture positioned in slots in the breechring to support the breech end of the tube assembly during travel. Two pairs of turnbuckles fix this dolly to the trails during travel. This appears to be a unique, but simple, device for achieving the required results.

(6) On-carriage fire control. On-carriage fire control equipment consists of: a Model PG-1M panoramic telescope with mount that is attached to the left trunnion. This telescope mount incorporates the normal longitudinal and cross-level vials and associated hand-operated worm-equipped adjustment fixtures. Line of sight for this weapon is offset 90° from the axis of the bore. An elevation quadrant, Model S-85, is provided on the right trunnion. The primary scale of this device is indexed in hundreds of Soviet mils from -200 to +1200. The elevation micrometer scale is indexed in mils. Primary and micrometer scales are provided for application of site. A second gross matching pointer-type elevation scale marked at 20-M intervals and indexed in hundreds is provided on this fixture. Presumably, this device enables the crewman operating the coarse elevation handwheel to approach the announced elevation setting prior to use of the fine elevating crank. Conventional longitudinal and cross-level vials and a hand-operated cross-leveling mechanism are provided.

(7) Crew protection. No shields are provided on this weapon. The crewmembers are required to position themselves in trenches 10 to 15 meters from the weapon when it is fired; firing apparently is by means of a long lanyard.

(8) Equilibration. Muzzle preponderance is overcome by two pusher-type pneumatic equilibrators (fig II-P-6). These equilibrators are located, one on each side, outboard of the sides of the top carriage. They are pivot mounted at their upper ends to the cradle forward of the trunnions. Their lower ends are socket mounted to the forward bottom edge of the top carriage. The equilibrators are charged with 2 liters of Steol M and pressurized with dry air to 51.7 kg/cm^2 (50 atm). A pressure cylinder for recharging the equilibrator as needed is mounted outboard on the left side of the top carriage. This vessel contains nitrogen pressurized to 155 kg/cm^2 (150 atm).

c. Bottom Carriage. The bottom carriage serves as the link between the top carriage and the road wheels and trails. This structure is estimated to be of cast design, and to contain an essentially standard Soviet pintle device incorporating thrust bearings and Belleville springs to fulfill the required functions. Hydraulic jacks, mounted through each trail hinge pin, have associated floats (foot pads) directly below the hinge pins. These devices are employed to remove the weight from the torsion bar suspension so it can be disengaged for firing. The hand-operated hydraulic pumps and associated fixtures are located on top of each of the trail hinge pins. Apertures are provided in the bottom carriage wall to the rear of the wheels. A selector device to provide for either mechanical (manual) or hydraulic operation of the jacks is provided inside this aperture. A hinged access door normally covers this area.

(1) Axle assembly. The S-23 has torsion bar suspension. Two pairs of longitudinally mounted torsion bars are associated with the single pair of dual wheels. Heavy upper and lower axle arms, attached to the torsion bars located on the forward extension of the bottom carriage, are hinge-fitted to the wheel backing plate to maintain each of the dual wheels in a vertical orientation during functioning of the torsion bar suspension. A disengagement/engagement lever is provided in the forward bottom carriage extension between the torsion bars. This lever, used in conjunction with the hydraulic jacks, facilitates dis-association of the primary suspension system for firing and returning the weapon to wheel (torsion bar) suspension for travel.

(2) Primary braking. The primary brakes are conventional drum-type air brakes. Hand brake levers and ratchet latches are provided on each of the two road wheels.

(3) Tires. These are estimated to be sponge rubber-filled tires similar to the tires normally found on other Soviet field artillery weapons. The tire tread is of conventional design.

(4) Trails. The trails, of riveted and welded box-section construction, are hinged to the main structure of the bottom carriage. An "A-frame"-shaped wheeled dolly, which rides on top of the trails, supports and secures the breechring to the trails for travel. Miscellaneous tools, including cranks, staff sections, wrenches, etc., are attached to the trails for travel.

(5) Limber. Each trail employs two hinge bolts to attach it to fore-and-aft female-slotted fixtures cast into the primary limber axle. The limber is provided with two single wheels that are equipped with torsion bar suspension. Pitman arms and tie rods are connected to the wheels. A long drawbar hinged at the limber provides for directional tracking of the limber. Trail spades are provided and attach to a large ball joint on each trail end; however, they are carried in the prime mover rather than on the trails, as are those for other weapons.

(6) Mobility. This weapon should exhibit good roadability characteristics due to the incorporation of all-round torsion bar suspension. It is capable of being towed at 35 km/h over hard-surfaced roads, 30 km/h on improved roads, or at 12 km/h on unimproved trails.

Q. 203-MM HOWITZER B-4 (M-1931)

33. ~~(C)~~ Description and Performance

a. General. The 203-mm Howitzer B-4 (M-1931) (fig II-Q-1) was a standard Soviet artillery piece during and after World War II. Although many World War II vintage artillery pieces are no longer mentioned in Soviet training and planning documents, the 203-mm B-4 howitzer, the 152-mm D-1 howitzer, the ML-20 gun-howitzer, and the 240-mm mortar continue to be addressed. These weapons continue to be retained in both the active and war reserve inventories and will be employed during any extended major conflict. The 203-mm B-4 and the 240-mm mortar are deployed to heavy artillery units within the Soviet Union. In firing position, the B-4 is 9.365 meters long and 2.490 meters wide. It also is quite heavy (17.7 tonnes in firing position), is cumbersome since it is transported in two loads totaling 24.8 tonnes, exhibits slow speed on the march (12 km/h), requires up to 2 hours to emplace, and has limited on-carriage traverse (8° total). Nevertheless, it poses a considerable threat since it fires a 98.75-kg (217.7-lb) HE projectile to a range of 18 025 meters. The B-4 is an example of Soviet vs. US design of cannon assemblies of comparable caliber. Compared to the cannon on the US 8-inch M110 and M115 systems, the B-4 attains 7.3% more range with a 4.8% shorter rifled section than the US cannon but a 5.33% greater chamber volume. The B-4's prescribed rates of fire for 1, 3, 5, 15, 30, and 60 min are 1, 2, 3, 9, 18, and 30

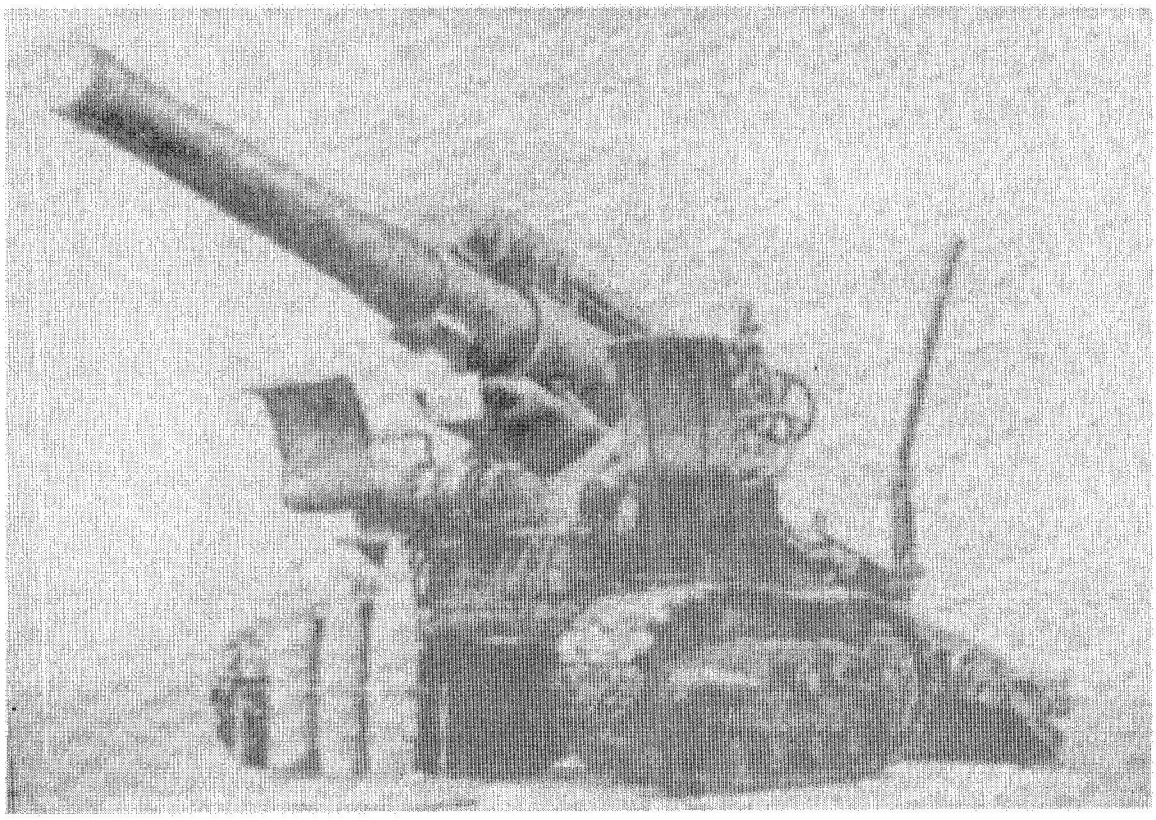

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Figure II-Q-1. Soviet 203-mm howitzer B-4 (M-1931) (U).

full-charge rounds, respectively. The B-4 also fires a 100-kg (220-lb) CP projectile to 18 km and a second CP projectile weighing 146 kg (322 lb) to an undetermined range. This 146-kg CP projectile probably represents one of the capabilities that make the B-4 currently attractive to the Soviet Army. At ranges not in excess of about 6 km (beyond which range ammunition consumption should commence to become excessive), this 146-kg projectile should be a good "bunker-buster"; the Soviets probably consider that this capability will become most useful in any area of operations containing prepared defensive positions. The caliber of this weapon also makes it a prime candidate for possessing a nuclear capability and, further, for being scheduled for replacement by a new weapon of the same caliber in the near term. Other than for short moves across good terrain, the B-4 is transported in two tractor-drawn loads. One load is the carriage with its limber, less the cannon assembly; this load weighs approximately 11.9 tonnes and is 8.50 meters long, 2.50 meters wide, and

2.50 meters high. The second load is the cannon transporter with the 203.2 mm cannon assembly (fig II-Q-2); this load weighs about 12.9 tonnes and is 8.95 meters long, 2.50 meters wide, and 1.95 meters high. Ground clearance of the carriage is 320 mm and that of the cannon transporter is 310 mm. There have been at least three variants of this tracked weapon. These three variants all utilize essentially the same tracked carriage used with the obsolete 152-mm M-1935 gun and 280-mm BR-5 mortar, the latter actually being a howitzer. The difference between variants of the 203-mm B-4 howitzer lie in the cannon assembly, the cannon transporter, and the limbers. What was probably the first B-4 (and one no longer used) employed a 22-caliber-long gun tube mounting an interrupted screw-type breech that apparently had to be locked (in an additional operation) after closing the breech by means of its operating handle. The second version of the cannon assembly was 25 calibers in length and apparently employed a Schneider-type (unstepped, interrupted screw) breech. The third version of the cannon assembly, probably the one currently utilized, allegedly is the 25-caliber tube of the second version equipped with a Welin (stepped, interrupted screw) breech, one which may close and lock in a single movement of the breech operating handle. One version of the cannon transporter has four solid disk wheels mounting solid rubber tires; a second version presents the appearance of an unpowered light tank chassis; and a third version (probably the one currently used) is a dual bogie, logitudinally sprung, version which has a single axle (or a limber) supporting its forward end. This transporter utilizes six solid disk wheels mounting solid rubber tires, the tread design of which gives the appearance of dual tires. There are some indications that current models

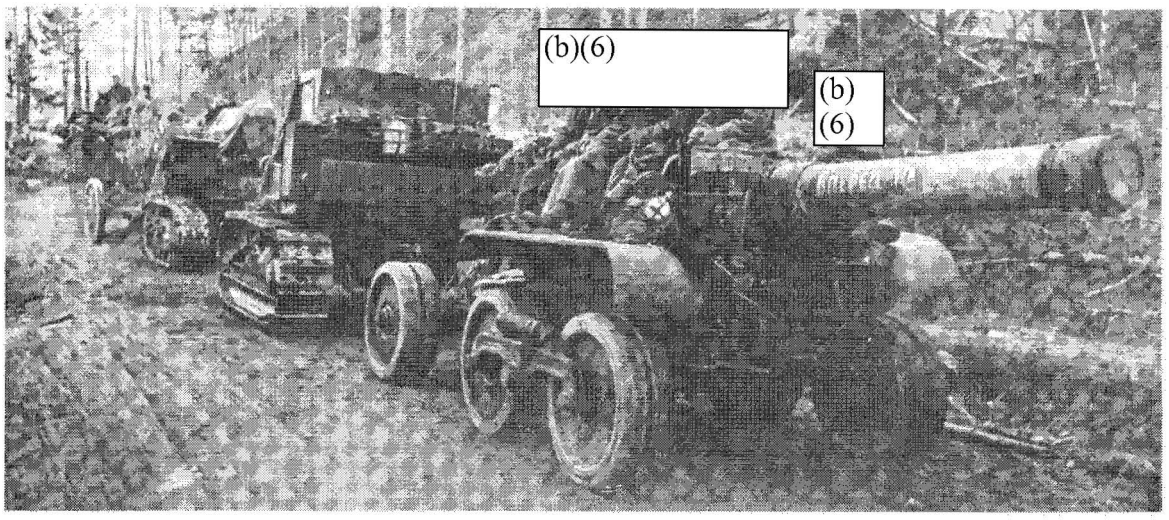

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Figure II-Q-2. 203-mm B-4 howitzer on the march in disassembled configuration (U).

mount sponge rubber-filled tires. The weapon addressed herein will be the tracked carriage that uses the 25-caliber tube, the six-wheeled transporter, and, probably, the Welin breech. The B-4 is known to have been furnished to Poland during World War II and to Bulgaria, Yugoslavia, and Albania (probably during the late forties and early fifties). With the possible exception of Poland, such B-4's as remain in active use in these countries probably are employed in a coastal defense role.

b. Capabilities. Emplacement of the B-4 from the carriage plus cannon transporter travel configuration is said to require the estimated 12-man crew as much as 2 hours in difficult situations. It is improbable this weapon can be assembled and prepared for action in less than 1 hour under the best of circumstances. For towing this weapon into position in the assembled configuration, emplacement time is estimated to be about 35 to 40 minutes. The carriage of this weapon and its cannon transporter are towed by Soviet ATT heavy artillery tractors at a maximum road speed of 15 km/h. The maximum rate of fire over periods of 1, 5, 15, 30, and 60 min is 1, 3, 9, 18, and 30 rd, respectively. The weapon's maximum range with the 98.75-kg HE projectile [F-620 (charge-to-mass ratio 0.2:1.0)] is 18 025 meters. Maximum range with the 100-kg CP projectile (G-620) also is 18 km. Both of these HE projectiles have a maximum muzzle velocity of 607 m/s. The 146-kg (322-lb), 481-m/s, CP projectile (designation unknown) is estimated to have a maximum range of less than 15 km. Maximum range of this 146-kg projectile is relatively meaningless since, when firing at point targets, such as bunkers or concrete emplacements, the ammunition expenditure required to attain a hit becomes prohibitively excessive at ranges in excess of about 40% of maximum range. Ammunition used in this weapon is separate loading with bagged propellant charges. All projectiles are propelled by one of two propelling charges. The full charge weighs 15.47 kg (34.11 lb), is variable, and is composed of a base charge and six increments (i.e., full through 6th charge). Reduced variable charge weighs 5.42 kg (11.95 lb) and contains the 7th through 11th charges. Only the G-620 CP and the F-620 HE projectiles can be fired using full charge. Due to the excessive time required to emplace the B-4, this weapon probably moves out to engage fortifications by direct fire only after the barrel has been assembled to the carriage. It is highly probable, when the destruction of particular prepared positions and fortifications has been preplanned, that the B-4 is moved to a previously surveyed defiladed position that is quite close (500 to 1000 meters) to the Soviet FEBA. In such circumstances, the target will be engaged by using an "assault fire-type" of adjustment. The B-4, once in position and registered, outranges the US M115 8-inch towed howitzer by 1200 meters. The B-4's rate of fire is 40% greater than that of the M115 over a period of 30 min but the M115's rate is some 44% greater than that of the B-4 over the first 5 min of firing; either weapon is considered to be very effective in the counterbattery role. Precision data are presented in table II-A-2c.

The M115, depending upon terrain, can be emplaced from about two and one-half to four times faster than the B-4, but the B-4's HE projectile weighs almost 10% more than that of the US M115. The B-4's 322-lb CP projectile is much heavier, and should exhibit considerably more penetration and capability for destruction than that of the US M115. During World War II, the B-4 was the most widely deployed heavy artillery piece in the Soviet inventory. It was used extensively in fighting within built-up areas and against prepared defensive positions.

c. Configuration.

(1) General. The bottom carriage fixture of this weapon is a built-up and riveted structure made of steel plate and located upon the forward end of the massive open-box trail. The track assemblies are mounted on the sides of the bottom carriage fixture (fig II-Q-3). Each track assembly is equipped with a handbrake and a manually powered, crank-driven, drive that moves the track to effect those shifts in direction that exceed the total of 8° of on-carriage traverse. The top carriage is oriented upon the bottom carriage by means of a pintle. A manually operated jack is mounted in the center of the trail 3.4 meters in rear of the pintle. An ammunition hoist is located on the left-hand side of the trail in rear of the left track and the crank for this hoist is mounted on the right side of the trail. A large summer spade is available in addition to the permanently mounted winter-type trail spade. The trails are fitted with various brackets and clips to hold the on-vehicle ancillary equipments. The limber for the carriage is a two-wheeled, solid steel axle, solid rubber-tired vehicle with drawbar and lunette. A fifth-wheel arrangement atop the limber accepts the trail end of the howitzer. The top carriage (British=saddle) consists of a cast base that is machined on the underside to provide a bearing surface at the interface of the top and bottom carriages; included in this fixture are a vertical bearing for the pintle and the Belleville spring-loaded rollers. Two 12-inch wide gibs hold the top carriage to the bottom carriage. The side frames of the U-shaped top carriage are of built-up and riveted box construction. The elevating mechanism, a rack and pinion type, is equipped with a clutch and gear that affords two-speed operation by utilization of one of the two elevating handwheels. The traversing mechanism, located on the left side of the weapon, is pintle oriented and apparently of the worm and worm-gear type. Elevation limits are 0° and +60°. Traverse limits are 4° left and right of center (8° total). The winch (fig II-Q-4) for assembling and disassembling the cannon assembly to the carriage is mounted on the front of the top carriage. This handcrank-operated winch has two drums that are grooved opposite to each other. Rollers, located to the left of center under the front and rear of the top carriage and centrally upon the top of the trail, guide the winch cable during assembly and disassembly of the weapon. The outer

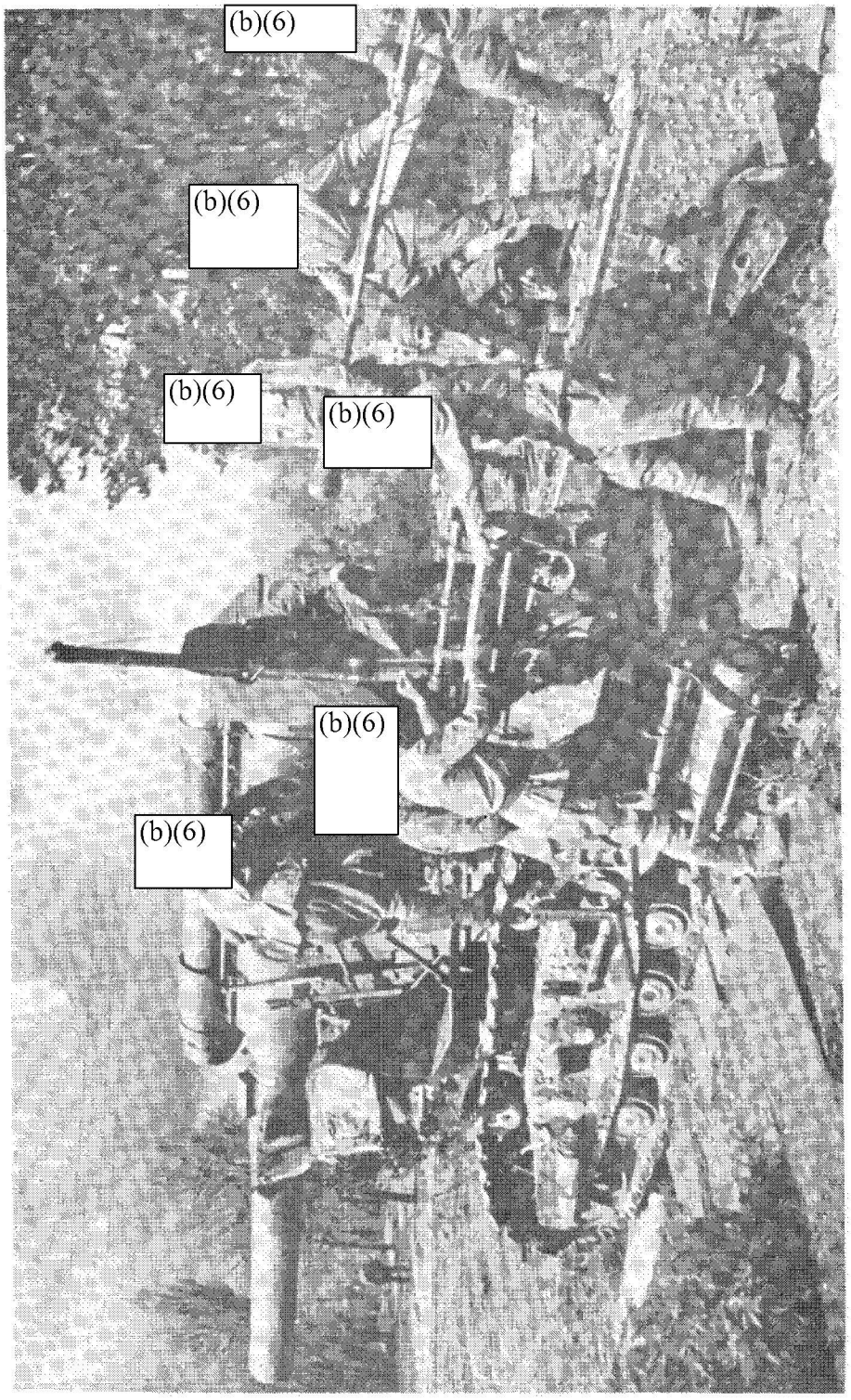

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Figure II-Q-3. 203-mm B-4 howitzer in firing position, left rear view (U). (~~CONFIDENTIAL~~)

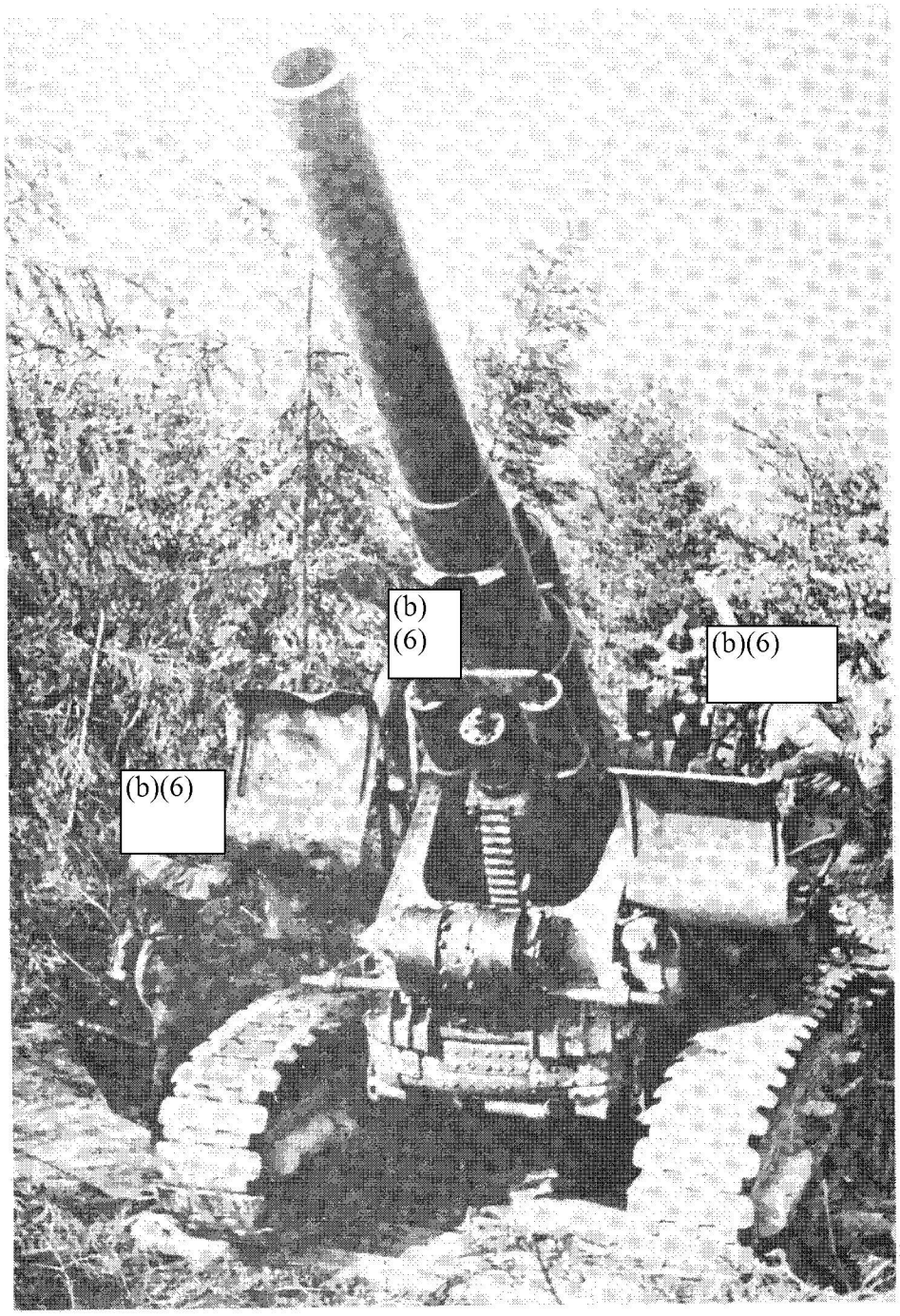

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Figure II-Q-4. 203-mm B-4 howitzer, front view of assembled weapon (U).

halves of the trunnion bearings are fitted with adjustable shock absorbers that bear the roller bearing portion of the trunnions, and thereby the deadweight of the cannon assembly and cradle. This is an innovative way of reducing the effort required to elevate and depress this heavy cannon, which is not equipped with an equilibrator.

d. The B-4M. A wheeled version (the B-4M) of the tracked B-4 carriage appeared following World War II (fig II-Q-4a and -4b). The B-4M appears to predominate over the B-4 in numbers of weapons currently deployed to active Soviet heavy artillery units. Except for their tracked vs. wheeled suspensions, the weapons appear to be identical. Although the wheeled, approximately 21-tonne B-4M probably does not exhibit the flotation possessed by the B-4, it does offer the advantages of being transported in one load and at higher road speeds (≈25 vs. 12 km/h). Negation of the requirement to mate the cannon assembly to the carriage probably reduces emplacement/displacement times to approximately 30 minutes. Whereas the B-4 fires from its tracks, the bottom carriage of the wheeled B-4M is lowered to the ground. This is accomplished by rotating the front wheels upward and to the rear and the rear wheels upward and to the front; i.e., from the "straight-line level-wheeled" travel configuration (fig II-Q-4a) the wheels are raised to present a "wide-vee" appearance when the weapon is emplaced. Raising and lowering of the carriage, by the action of the wheels, probably is accomplished by a cranking or jacking-type action. Unlike the B-4, which is traversed beyond its 8° on-carriage limits by cranking one track forward and the other track rearward, the B-4M's spade probably must be broken loose by means of the trail jack and the trail moved manually to attain the required amount of shift.

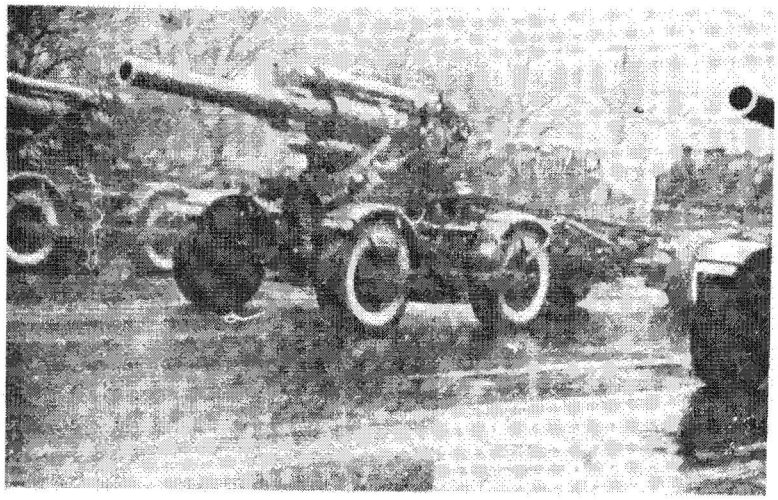

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Figure II-Q-4a. Soviet 203-mm B-4M howitzer, travel position (U).

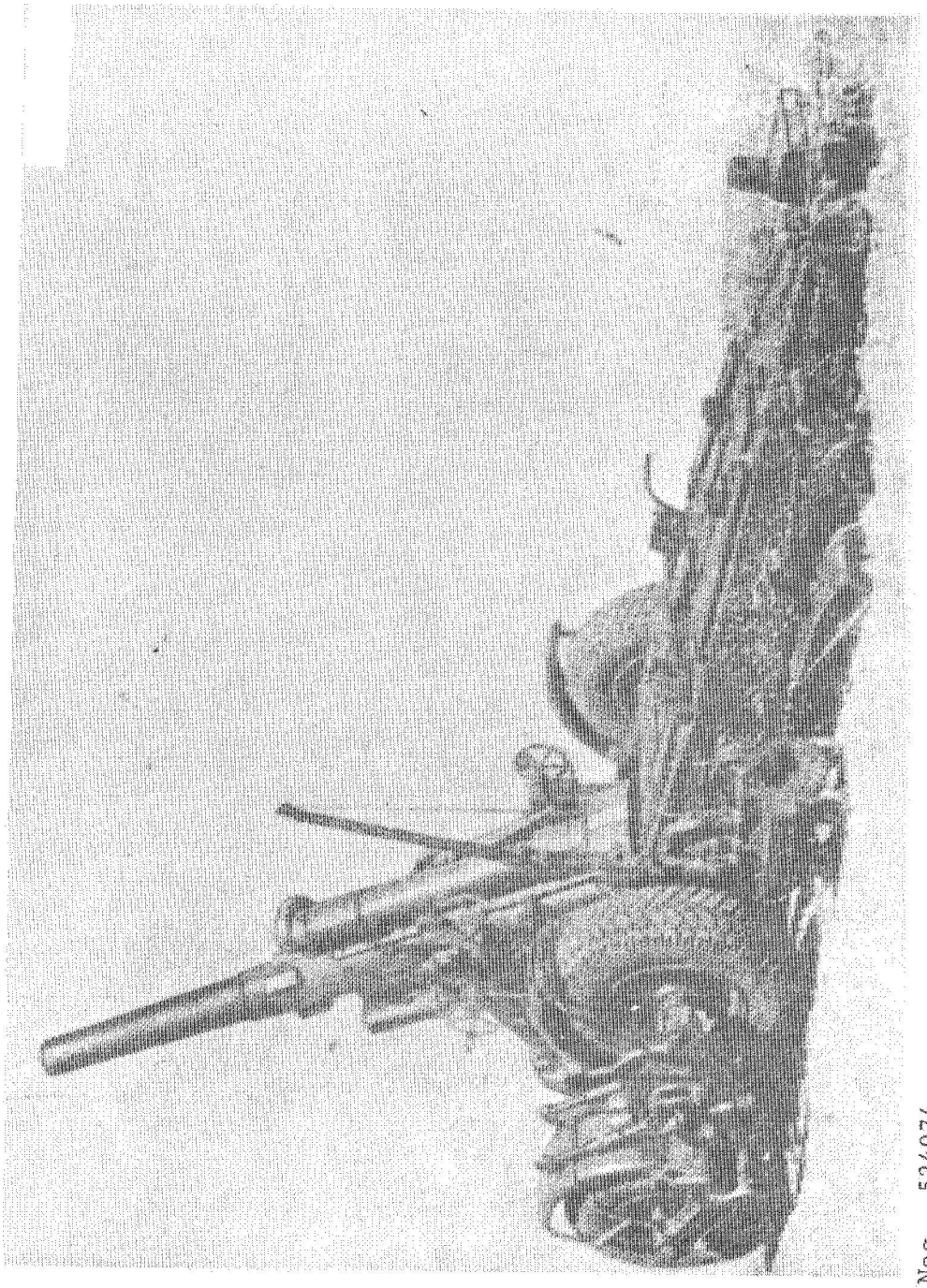

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Figure II-Q-4b. Soviet 203-mm B-4M howitzer, firing position (U).

e. Summary. The Soviet-stated role for the B-4 is:

"(1) Demolition of especially solid concrete, steel and concrete, or armored structures.

(2) Combat against heavy enemy artillery or artillery protected by solid cover."

Although once in firing position the B-4 is an excellent 203-mm weapon, its demolition role should be accomplished more effectively by the 280-mm BR-5 mortar (actually a howitzer), which fires 200.7-kg (442-lb) and 286.7-kg (632-lb) HE projectiles plus a 246-kg (542-lb) CP projectile. Since the 280-mm BR-5 (fig II-Q-5) is mounted on the same carriage as the 203-mm BR-4, its width and height are the same. Its overall length in the travel configuration is but 319 mm (1.0 ft) less than that of the BR-4. At 18.4 tonnes, the BR-5 weighs but 0.7 tonnes more than the BR-4. Maximum range of the BR-5 is 7.5 km less than that of the BR-4 (18.0 km vs. 10.5 km); nevertheless, when firing CP projectiles at concrete emplacements maximum range is not a major consideration. It may be that the BR-5, in addition to the BR-4, has been reintroduced into the active Soviet inventory.

34. ~~(C)~~ Component Analysis

a. Cannon Assembly. The cannon, of built-up construction, consists of two tubes, a jacket, the breechring with breechblock and breech operating mechanism, and a breech bushing.

(1) Tube. The "A" tube is a full length tube that is rifled, chambered, and coned in the normal way. Rifling is uniform right-hand twist, one turn in 20 calibers. There are 64 grooves, each 6.0 mm wide x 4.0 mm deep. Land width is 3.97 mm. Length of rifling is 3981 mm. Chamber volume is 28 dm^3 (liters) and chamber length 912.4 mm. Chamber pressure is 2350 kg/cm^2. Length of the "A" tube is about 4897 mm. The breech collar on the "A" tube is interrupted to form four antirotation keys, and the exterior of the muzzle end is threaded for about 40 mm to accept the muzzle locking collar. The "B" tube is about 4871 mm long, some 26 mm shorter than the "A" tube. The bore of the "B" tube conforms to the exterior configuration of the "A" tube. The "B" tube has the same wall thickness as the "A" tube except it has double the wall thickness of the "A" tube in the area of the "A" tube's chamber. The breech end of the "B" tube has four longitudinal keyways to accept the four keys on the "A" tube. The jacket is 3284 mm long and its exterior is machined parallel to a diameter of 514 mm over a length of 1676 mm; the bore of the jacket conforms to the exterior configuration of the "B" tube. The

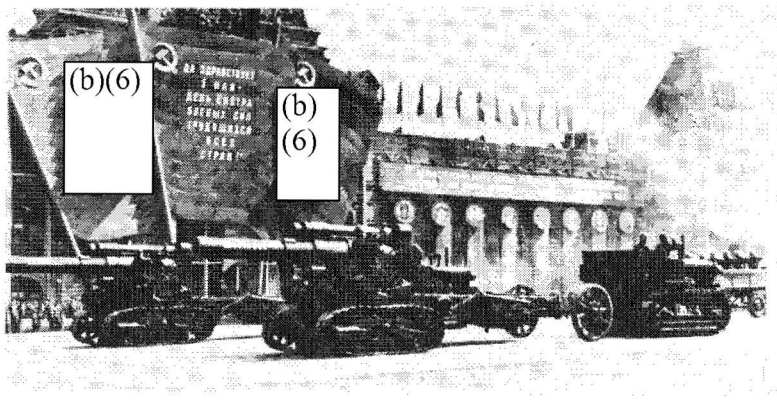

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Figure II-Q-5. Soviet 280-mm howitzers on parade (U).

wall thickness of the jacket is decreased over the "chamber" area of the thickwalled "B" tube. The exterior of the breech end of the jacket has two antirotation keys at the top and bottom of its vertical axis. These keys fit into corresponding keyways in the rear end of the cradle. The muzzle end of the jacket has four diametrically opposed guides that are positioned diagonally to the vertical center line. The ends of these guides are machined to conform to a diameter of 514 mm. During the recoil cycle, these guides contact four full length bearing strips in the interior of the cradle. The tube assembly may either be of the "shrunk"-type or of the "loose tube" sort. In either method, the "B" tube first is pulled over the "A" tube; the tubes then are inserted into the jacket, and the breech bushing is screwed into the jacket up to the rear faces of the "A" and "B" tubes and locked in that position with a set screw. The muzzle locking collar secures the muzzle ends of the "A" and "B" tubes to each other. In the "loose tube" type of assembly, the diameter of the "A" tube is machined very slightly smaller than that of the "B" tube and the "A" tube is pressed into the "B" tube; the "A" tube may be chilled (or the "B" tube heated slightly) to facilitate inserting the "A" tube into the "B" tube. When worn out, the "A" tube (which contains the rifling and chamber) can be withdrawn from the tube assembly and replaced with comparative ease. In the built-up method, each member that is surrounded by another is manufactured slightly larger than the surrounding member; for instance, the outside diameters of the "A" tube is slightly larger than the inside diameters of the "B" tube. To permit insertion of the "A" tube, the "B" tube is heated (to expand it), the "A" tube is inserted into the "B" tube, and, as it cools, the "B" tube shrinks onto the "A" tube, thereby substantially reinforcing it. In either the "loose" or the "shrunk"-type assembly, the remaining steps are the same; that is, the jacket is heated (or the "B" tube is chilled, or both) so the jacket is

shrunk onto, thereby reinforcing, the "B" tube. This weapon does not employ a muzzle brake. Tube life is estimated to be approximately 2500 EFC rounds.

(2) Breechring. The breechring (fig II-Q-3) is screwed onto the jacket and then secured to it by two large set screws. Following assembly of the cannon, the breechblock and its operating mechanism are incorporated into the breechring. Different models of this weapon employ one of three different types of interrupted screw breechblocks; i.e., either a lockable interrupted screw, a Schneider interrupted screw, or a Welin stepped-interrupted screw. Breech life should exceed tube life by a factor of 2.5 to 3.5.

b. Top Carriage.

(1) General. The top carriage is connected to the bottom carriage through a pintle fixture. It supports the cannon assembly, the recoil system, the cradle, the trunnions, the elevating mechanism, the on-carriage fire control, and the pinion side of the traversing mechanism.

(2) Cradle. This fixture is made from a cast steel cylinder 1930 mm long and 23 mm thick with an inside diameter of 535 mm (fig II-Q-4). A 400-mm wide brass strip is mounted longitudinally inside at the bottom of the cradle and two 115-mm wide brass strips are mounted 190 mm apart from each other at the top of the cradle. These strips, which have grease grooves, are attached to grease cups mounted on the outside of the cradle. A 230-mm-wide, 30-mm-thick band, cast integrally with the cylinder, encircles the cradle cylinder at its midpoint. This band is thickened on both sides to form a block for supporting the trunnion pins, which are screwed through the block and into the cylinder. Over the right-hand block is a pad for supporting the gearbox containing the pinion that engages the toothed quadrant mounted on the inner side of the top carriage; this assembly is a part of the control mechanism for the variable length recoil mechanism. The bottom of the encircling band is shaped to form a support for the elevating rack. The end portions of the 153-mm-diameter trunnion pins run on roller bearings that bear on adjustable spring shock absorbers mounted in the trunnion mounts of the top carriage. On top of the cradle at each end, rings to mount the recoil brake are riveted to the cradle. On the upper left-hand side of the cradle is mounted a telescopic rod that is a length of recoil indicator graduated from 700 to 1450 mm. The other end of this indicator is attached to the breechring. On the rear of the cradle, four standoffs contact the breechring to position the cannon assembly at the end of counterrecoil. Three-hole bearings are fitted beneath the cradle near its front and rear to mount the recuperator assembly (fig II-Q-4). The rear bearing provides the connecting passageways

between the recuperator proper and the two air cylinders. The right-hand side of the rear bearing mounts the valve and inlets for charging the recuperator with Steol and air; the left side is fitted with a relief valve for bleeding off Steol. The sides of the rear bearing mounts also are housings for the locking pins on the top carriage, which secure the cannon assembly at 10° of elevation for loading and for travel.

(3) Elevating mechanism. The tipping parts of this weapon are balanced; the use of equilibration is not necessary to overcome either breech or muzzle preponderance. The elevating mechanism is a rack-and-pinion device that incorporates high speed and low speed drive options that operate through a clutch and gear arrangement. Elevation limits are 0° and +60°.

(4) Traversing mechanism. On-carriage traverse is limited to a total of 8°. The traversing mechanism is of the rack-and-pinion type.

(5) Recoil mechanism. The hydraulic recoil brake is mounted above the cannon assembly (fig II-Q-3). A hydropneumatic recuperator assembly consisting of three cylinders [two of the three cylinders are pressure vessels (air cylinders) that are classic recuperators which are located outward from and above the piston rod equipped counterrecoil cylinder (recuperator) proper] is mounted below the tube (fig II-Q-4). The recoil brake provides for variable length of recoil. The control rod, projecting from the front end of the brake cylinder, is fitted with a fork operated by a crank fitted to the transmission shaft, which runs longitudinally along the brake cylinder and attaches to the aforementioned gearbox mounted on the right cradle block. Length of recoil from 0° to 30° of elevation is from 1300 to 1400 mm; from 30° to 42°, length of recoil reduces progressively to 850 mm; and from 42° to 60°, length of recoil is from 850 to 880 mm. Total weight of the recoil brake, complete with 41 liters of Steol and the length of recoil control linkage, is about 672 kg. The recuperator cylinder has an air valve in its front cover. The two air cylinders are interconnected at their forward ends by a copper tube protected by a covered housing (fig II-Q-4). Operation of the recuperator assembly is conventional. The recuperator cylinder contains 63±1 liters of Steol and is pressurized with dry air to 40±2 atm.

(6) On-carriage fire control. This equipment is said to consist of an M-1930 dependent quadrant-type sight mount that accepts a PG-1 type panoramic sight. A gunner's quadrant probably is available for cross-leveling and for precisely laying the weapon in elevation.

(7) Crew protection. This weapon is not equipped with a shield.

c. Bottom Carriage. The bottom carriage, of cast-riveted construction, is supported by two unpowered track assemblies that provide good flotation to this heavy weapon. In the travel position, the modified box trail (of riveted construction) is supported by a leaf spring-suspended two wheel limber that employs disk wheels equipped with solid tires. A lifting jack, located below the trail, is employed in raising and lowering the trail end from the limber and in positioning the hinge-type spade. A crane, secured to the left side of the trail, is used in loading the projectile. The two tracks are equipped with manually powered brakes, one for each track, that are operated when the weapon is on the march from the two rearward facing, bucket-type seats that are affixed to the top carriage above the tracks. Shifts in deflection greater than that obtainable from the on-carriage traversing mechanism are effected by cranking one track forward and the other rearward. Mobility of this weapon is limited to approximately 12 km/h. This very low road speed plus it being transported in two loads thereby requiring excessive emplacement and displacement times are the major deficiencies inherent in this heavy howitzer system.

R. CZECHOSLOVAK 85-MM FIELD GUNS M-52 AND M-52/55

35. ~~(C)~~ Description and Performance

a. ~~(C)~~ General. The 85-mm Field Gun M-52 (fig II-R-1) was first observed at a parade in Prague in 1954. The 85-mm M-52/55 is a variant of the M-52; this variant has not been observed but it is referred to in Czechoslovak firing tables, service manuals, and other documents. The M-52/55 is reported to be 16 kg heavier and 30 mm longer than the M-52. The differences in the M-52/55 lie in minor modifications to the suspension, recoil system, and the bottom carriage. For all practical purposes, both models are essentially the same and the information presented herein for the M-52 also is applicable to the M-52/55. The M-52 is obsolescent; it has been almost completely replaced in Czechoslovak and East German regular army antitank units by the Czechoslovak 100-mm M-53 field gun and various Soviet 100-mm guns. The M-52, however, is provided to field artillery battalions and batteries for local antitank defense. The M-52 is intended for both the direct and indirect fire roles. Principal identification features (fig II-R-2) include: An extended trough-type cradle, the split-box section trails, single wheels, a double-baffle muzzle brake, truncated breechblock, and a wrap-around, V-shaped shield having a scalloped top edge. The M-52 may be distinguished from the Czechoslovak 100-mm M-53 by careful consideration of the shield, breech-ring, and trails. The top of the M-52's shield is scalloped; that of the M-53 is straight. The rear of the M-52's breechring is truncated at the top and bottom and is a vertical sliding-wedge type; that of the M-53 presents a square silhouette and is a horizontal sliding-wedge. The trails

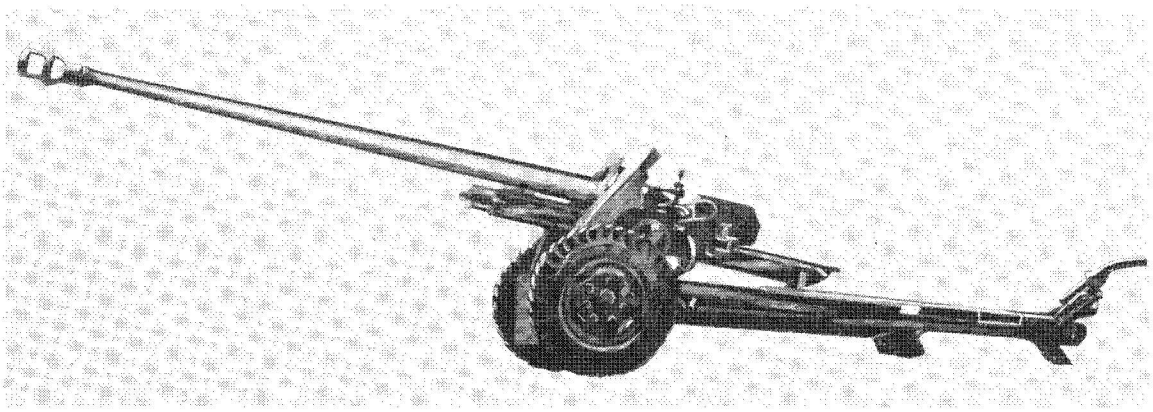

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Figure II-R-1. Czechoslovak 85-mm M-52 field gun, left side view (U).

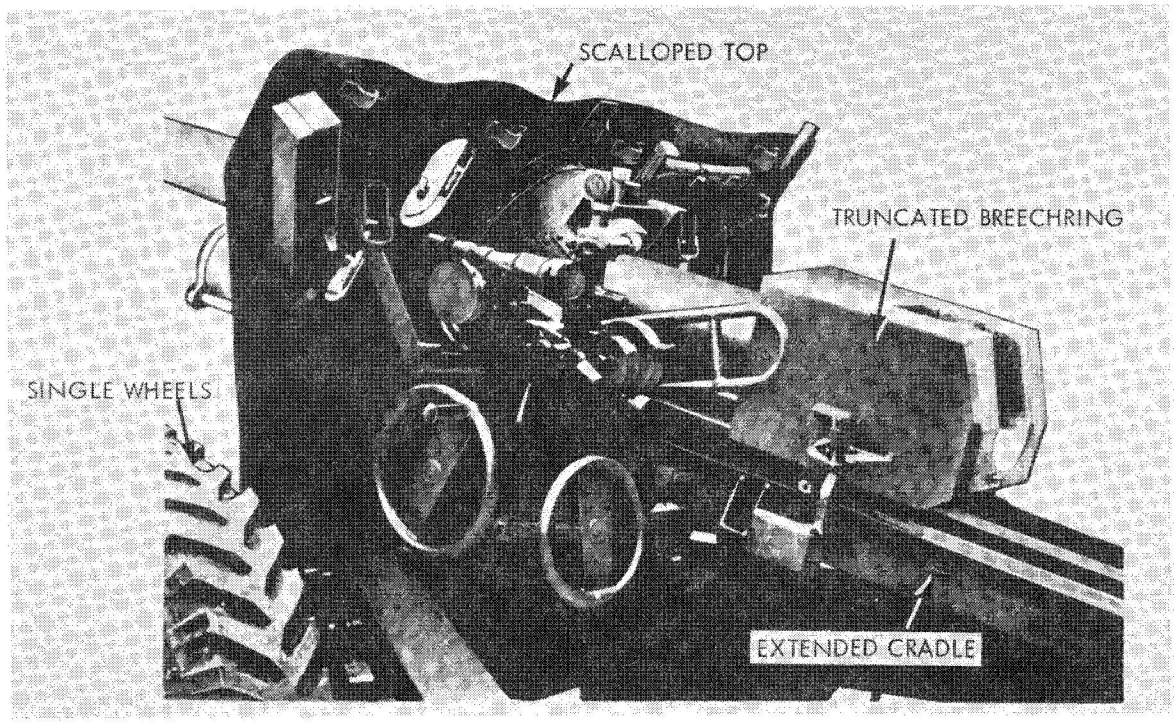

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Figure II-R-2. Czechoslovak 85-mm M-52 field gun, recognition features (U).

of the M-53 have caster wheels, while those of the M-52 have none. The M-52 has the same ballistic performance as the Soviet 85-mm D-44 gun and their ammunition is interchangeable. In travel configuration the M-52 weighs 2.13 tonnes (2.35 tons), is 7.52 meters (24.6 ft) long, 1.98 meters (6.5 ft) wide, and 1.14 meters (4.99 ft) high. On-carriage traverse totals 60°. Elevation limits are -6° and +38°. The tactical unit organization is a 6-gun battery and an 18-gun battalion. The M-52 is classified limited standard in the Czechoslovak Army. This weapon has been employed by both the Austrian and East German armies.

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The M-52 fires a 9.54-kg (21.04-lb) HE projectile to a maximum range of 16 160 meters. It also fires AP-T and HVAP-T ammunition. Rates of fire are reported to be 20 rd/min; however, when delivering precisely aimed fire the rate is probably closer to 10 rd/min. Prescribed rates over periods of 1, 3, 5, and 15 min should approximate 10, 25, 40, and 60 full-charge rounds, respectively. In the Czechoslovak Army, the M-52 is normally towed by the Praga V3S 6x6 truck. The gun is designed to be towed at the following maximum speeds: Paved roads--50 km/h; unimproved roads--30 km/h; and cross-country--10 km/h. The seven-man crew (including driver) requires an estimated 1 to 1.5 minutes to emplace the gun. This weapon fires fixed ammunition; essentially there are three charge options available in the HE rounds: Full (Czechoslovak at 805 m/s V_0 or Soviet at 810 m/s), reduced (Soviet at 665 m/s), and light (Czechoslovak at 450 m/s). The unit of fire is estimated to be 80 rounds per gun. The on-vehicle load carried by each prime mover is estimated to be 40 rounds. Characteristics of projectiles commonly employed with the M-52 are shown in table II-R-1.

(2) (U) Indirect fire.

(a) (U) Precision. A sampling of precision data is shown in table II-R-2.

(b) (U) Effectiveness, fragmentation, and lethality. These data are the same as those presented in paragraph 5b(2)(b)-(d).

(3) (C) Direct fire.

(a) ~~(C)~~ Precision. Probable errors in direct fire for the 85-mm M-52 field gun are shown in table II-R-3.

Table II-R-1. Projectile Performance, 85-mm M-52 Field Gun (U)

Type	Designation	In-flight weight (kg;lb)	Muzzle velocity (m/s)	Armor penetration at 0° obliquity @ 1000 m (mm;in)
Czechoslovak:				
HE (light)	O	9.54; 21.04	450	NA
HE	O	9.54; 21.04	805	NA
AP-T	PS_v	9.20; 20.29	820	123; 4.84
HVAP-T	P_pSv	4.99; 11.00	1070	115; 4.53
Soviet:				
AP-T	BR-365 (blunt)	9.20; 20.29	810	103; 4.06
AP-T	BR-365-K (sharp)	9.20; 20.29	810	196; 7.72
HVAP-T	BR-365-P	4.99; 11.00	1070	115; 4.53
HE (full chg)	OF-365-K	9.54; 21.04	810	NA
HE (reduced chg)	OF-365-K	9.54; 21.04	664	NA

~~(CONFIDENTIAL)~~

Table II-R-2. Probable Errors in Indirect Fire;
85-mm M-52 Field Gun Firing Shells
HE O & Fragmentation-HE OF 365-K (U)

Percent of maximum range (16 160 m) (measurements in meters for various percentages)	PE_r (m)	PE_d (m)
90 (14 550, chg full)	53	7.3
70 (11 310, chg full)	44	4.8
50 (8080, chg light)	20	2.8
30 (4850, chg light)	11	1.4

~~(CONFIDENTIAL)~~

Table II-R-3. Probable Errors in Direct Fire;
85-mm M-52 Field Gun (U)

Range (m)	PE_d (m)			PE_v (m)			PE_r (m)
	HE	AP-T	HVAP-T	HE	AP-T	HVAP-T	HE
500	0.1	0.2	0.2	0.1	0.1	0.2	35
1000	0.2	0.3	0.4	0.2	0.3	0.4	36
1500	0.3	0.4	0.7	0.4	0.4	0.7	36
2000	0.4	0.5		0.6	0.7		36
3000	0.6	0.7		1.3	1.3		36
4000	0.9	0.9		2.4	2.1		37

~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Grazing range. Czechoslovak firing tables show that grazing ranges for the M-52 firing various projectiles against a 2-meter-high target are as follows:

- AP-T: PSv, 925 meters; BR-365, 960 meters.
- HVAP-T: P_pSv or BR-365P, 1150 meters.
- HE: O, 950 meters; OF-365K, 760 meters.

(c) ~~(C)~~ Effective range. Estimated effective range (50% probability of a first round hit) of the M-52 firing HVAP-T projectiles versus a US M-60A1 tank is 925 meters.

(d) ~~(C)~~ Engagement range. It is probable that the M-52 gun crew will commence to engage lightly armored vehicles such as APCs at a range of about 1500 meters; nevertheless, due to limited armor penetration capability, engagement of enemy tanks may be delayed until they are within 600 to 800 meters.

(e) (U) Armor penetration. These data are presented in table II-R-1.

c. ~~(C)~~ Configuration. The Czechoslovak 85-mm field gun M-52 and a slightly modified variant, the M-52/55, have split box-section trails. A hinge-mounted handspike is mounted at each trail end. The weapon is towed by its prime mover through a lunette connected to the trail ends. The weapon is provided with a variable length hydropneumatic recoil system and a semiautomatic vertical sliding-wedge breechblock. The relatively long tube is equipped with a double-baffle muzzle brake. The flat rearward-sloped gun shield has a scalloped top edge and is angled sharply rearward adjacent to and above the wheels. On-carriage fire control equipment includes a range drum with four selectable scales, a direct fire sight, and a panoramic telescope with associated mountings. Some of these weapons have been equipped with infrared-type night sights for use in the direct fire mode.

d. ~~(C)~~ Summary. The Czechoslovak 85-mm Field Guns M-52 and M-52/55 are obsolescent weapons that have been replaced in Czechoslovak antitank units by the 100-mm M-53 field gun. Nevertheless, these weapons exhibit very good ballistic characteristics in direct fire, albeit a limited capability for armor penetration. They should be very effective in the role of providing local antitank defense for field artillery units. It also is expected that the M-52 will continue to be found in reserve Czechoslovak antitank units and other ECC reserve units during the mid-term.

36. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon Assembly. The length of the monobloc tube is 4780 mm including the breechring and 5070 mm with the muzzle brake attached. Rifling consists of 24 lands having a constant right-hand twist, one turn in 27 calibers for an angle of inclination of 6°38'12"; length of rifling is 3893 mm. The tube is attached to the breechring in the Soviet manner (by means of a locking collar). Combustion chamber volume with the O and OF-365K cartridges is 3.8 liters (3.8 dm^3 or 0.134 ft^3). Tube wear life and tube and breech fatigue life are not known. The breechring (fig II-R-2) houses a semiautomatic, vertical sliding wedge breechblock and its operating mechanism. Front and rear bridges (rail guides) are attached to the underside of the tube and perform the function of a sleigh by guiding the recoiling cannon assembly along the rails of the cradle. Estimated tube life is 1000 AP-T rounds. A double-baffle muzzle brake is screwed to the muzzle. Claimed efficiency of this brake is 65%; if true, overpressures at the gunner's station probably are on the order of 0.42 to 0.56 kg/cm^2 (6 to 8 lb/in^2).

b. ~~(C)~~ Top Carriage. The long, U-shaped cradle extends a considerable distance to the rear of the trunnions. Guide rails for the recoiling cannon assembly extend the full length of the cradle. The recoil mechanism lies within the cradle. The elevation gear, the upper ends of the equilibrators, a travel lock, the sight brackets, and the trigger lever are attached to the cradle. The recoil mechanism consists of a hydraulic brake, a hydropneumatic recuperator, and a replenisher. This mechanism is a variable length device of the same type and configuration as that of the Czechoslovak 100-mm M-53 gun [para 37c and 38b(4)]. The brake contains 3.5 liters of Steol M, the replenisher 0.75 liters, and the recuperator 7.5 liters. Initial pressure in the recuperator is 60 + 5, -2 atm (853 to 956 lb/in^2). Length of recoil is 1250 mm from -6% to +22% of elevation and is 750 mm at angles greater than about 22°. The elevating mechanism is of the rack-and-pinion type with its handwheel located on the left side of the weapon. The worm and pinion-type traversing mechanism also has its handwheel on the left side of the weapon. Both the elevating and traversing mechanisms are essentially the same as those on the 100-mm M-53 (para 37). Two spring-type equilibrators compensate for muzzle preponderance.

(1) ~~(C)~~ On-carriage fire control. The direct and indirect fire sighting equipment has the same configuration as similar equipments on the 100-mm M-53 gun [para 38b(5)]. The range drum of the Model 42 indirect fire sight has four graphical scales: One scale is graduated in Soviet mils; a scale inscribed for the full charge HE round is graduated into 324 increments, each equaling 50 meters; a scale inscribed for the HE reduced charge (665 m/s) has 280 50-meter increments; and a scale inscribed for the AP-T (PSv) projectile has 80 50-meter increments. The

Model 52a direct fire sight mount has two scales, one for the 820 m/s AP-T and 805 m/s full charge HE projectiles and the other for the 664 m/s reduced charge HE projectile. Both scales are divided into 100-meter increments; the scale for the AP-T and full charge HE projectiles extends to 3300 meters, the scale for reduced charge HE to 2300 meters. The direct fire telescope is a Model 52/55 3X, 8° field of view instrument. The LUC-2 illumination set provides night lighting for both the indirect and direct fire sights. A number of 85-mm M-52 guns are equipped with the Soviet APNS-7 infrared telescopic sight.

(2) (U) Crew protection. The primary shield is mounted on the top carriage and the upper and lower halves of the skirt shield are mounted on the axle housing (fig II-R-3). The left upper portion of the shield has two oval apertures with steel doors to accommodate the panoramic telescope and the direct fire scope. Fixtures for attaching pioneer equipment are mounted on the inside right upper portion of the shield. The housing for transporting the direct fire scope is mounted on the inside left upper portion of the shield.

c. ~~(C)~~ Bottom Carriage. The bottom carriage of the 85-mm M-52 essentially is a scaled-down version of the bottom carriage of the 100-mm M-53 gun. Rather than the caster wheels on the trails of the M-52, there is a single wheeled dolly available to facilitate moving the M-52 manually over short distances. The M-52 does not employ pneumatic brakes as does the M-53. The two drum-type brakes on the M-52 are operated by a single hand lever; their main purpose is to facilitate manhandling of the gun. When in the travel configuration, a rope can be attached to the hand lever and passed into the cargo bed of the prime mover. By pulling upon this rope, a crewmember can apply the brakes on the gun. Pneumatic 8.25x20 tires have rubber "fillers" which allegedly permit the weapon to travel up to 50 km after a puncture is incurred. A section chest is carried between the trails. The air-fluid pump, used to fill and pressurize the recoil mechanism, probably is carried in this chest. The main body of the bottom carriage, the axle, torsion bar suspension system, disk wheels, and spades are similar to those features on the 100-mm M-53.

S. CZECHOSLOVAK 100-MM FIELD GUN M-53

37. ~~(C)~~ Description and Performance

a. General. The 100-mm Field Gun M-53 (fig II-S-1) first was sighted in the 1957 Prague May Day Parade. Designed and manufactured in Czechoslovakia, this weapon represents that country's efforts to upgrade the capabilities of the older Soviet 100-mm Field Gun M-44. The M-53 gun can fire ammunition designed for the Soviet 100-mm M-1944 field gun and the Soviet SU-100 assault gun, although not all of these projectiles



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Figure II-R-3. Czechoslovak 85-mm M-52 field gun, left front view (U).

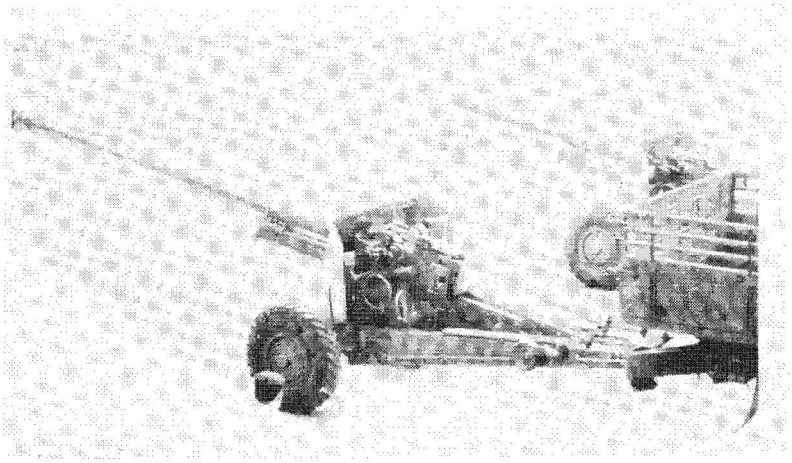

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Figure II-S-1. Czechoslovak 100-mm field gun M-53 (U).

are a ballistic match. The M-53 is normally found in the antitank battalion of the Czechoslovak MRD, the antitank brigade at front, and the artillery brigade at army level. Used primarily as an antitank weapon, its recognition features (fig II-S-2) include: An exceptionally long tube; a unique double-chambered, modified wing muzzle brake; caster wheels on each trail, to facilitate opening of the trails and handling the gun; a V-shaped shield; and the recoil mechanism positioned under the tube. These features are similar to those of the Czechoslovak 85-mm Field Gun M-52. In travel position, the M-53 weighs 4.39 tonnes (9746 lb), is 9.10 meters (29.85 ft) long, 2.36 meters (7.74 ft) wide, and 2.60 meters (8.43 ft) high. Unit organization is a 6-gun battery and an 18-gun battalion. The M-53 is classed standard in the Czechoslovak inventory. There is evidence of limited employment of this weapon by other Eastern European Communist countries; for example, Yugoslavia.

b. Capabilities.

(1) General. The M-53 fires the 15.60-kg (34.40-lb) Soviet OF-412 HE-fragmentation projectile to a maximum range of 21 000 meters. Prescribed rates of fire over periods of 1, 3, 5, 15, 30, and 60 min are estimated to be 10, 20, 30, 65, 80, and 100 full-charge rounds, respectively. At angles of elevation in excess of 15°, the 10 rd/min rate is reduced to 8 rd/min. The prime mover usually observed towing the M-53 is the TATRA 111, 6x6, medium cargo truck; however, newer Czechoslovak medium wheeled vehicles also are used as prime movers. The gun is designed to achieve a permissible traveling speed of 60 km/h (37 mi/h) on hard-surfaced roads and 12 km (7.4 mi/h) cross country.

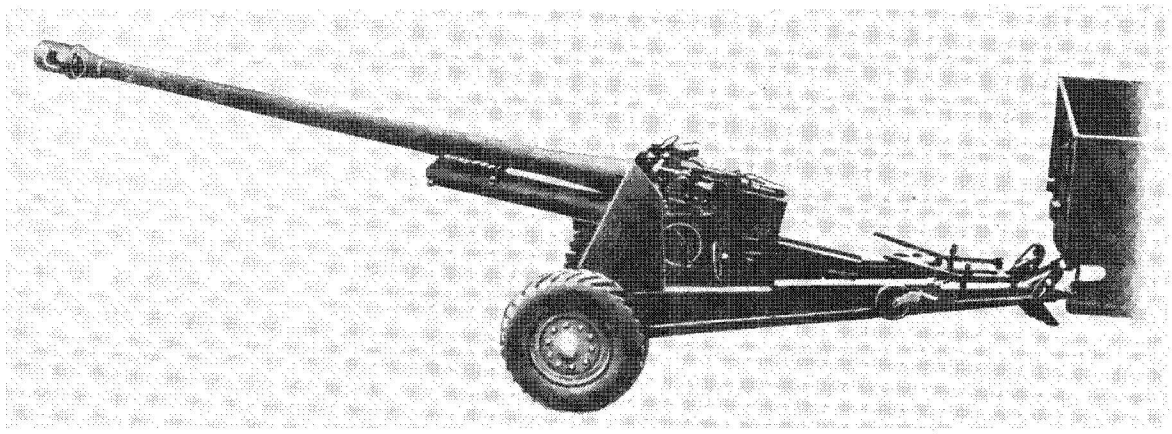

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Figure II-S-2. Recognition features, Czechoslovak 100-mm field gun M-53 (U).

Under normal field conditions, the six-man crew can emplace or displace this weapon in 3 minutes. The M-53 fires fixed ammunition having full and reduced charges. The unit of fire for the M-53 is estimated to be 100 rounds. Projectiles are packed and shipped in both the fuzed and unfuzed (with closure plug) configurations. Using Soviet ammunition, the Czechoslovak 100-mm M-53 gun should ballistically match the Soviet 100-mm field gun M-1955. When firing Czechoslovak AP-T ammunition, the M-53 slightly exceeds the performance of the Soviet M-1955 gun firing Soviet AP-T projectiles. The three Czechoslovak and eight Soviet projectiles fired from the M-53 are identified in table II-S-1. Three of the Czechoslovak rounds are shown in figure II-S-3. The spike nose of the HEAT-T-FS projectile provides the standoff necessary for effective penetration of the jet. This projectile also employs the slip ring rotating band principle to minimize the impartation of spin to the projectile by the rifling. Figure II-S-4 shows the HEAT-T-FS projectile in flight. Exploitation results indicate this projectile is very stable in flight.

(2) Indirect fire. The 100-mm M-53 normally is not employed in the indirect fire role but has, however, an indirect fire capability.

(a) Precision. A sampling of precision data for the OF-412 projectile is depicted in table II-S-2. These data are from incomplete Czechoslovak firing tables.

Table II-S-1. Projectiles, Czechoslovak 100-mm M-53 Field Gun (U)

Type	Designation	In-flight weight (kg; lb)	Muzzle velocity (m/s)	Armor penetration 0° @ 1000 (mm; in)
Czechoslovak:				
HEAT-T-FS	PrSv	9.5; 21.0	995	300; 11.8
AP-T	PSv	14.7; 32.4	955	170; 6.7
AP-TRNG	PCrSv	8.8; 19.4	1015	NA
Soviet:				
HEAT-T (steel liner)	ZBK-5	12.2; 26.8	900	300; 11.8
HEAT (copper liner)	ZBK-5M	12.2; 26.8	900	390; 15.4
APC-T	BR-412D	15.8; 34.9	916	170; 6.7
AP-T (blunt)	BR-412B	15.8; 34.9	925	155; 6.1
(pointed)	BR-412	15.8; 34.9	925	145; 5.7
HVAP-DS-T	BM-8	5.69; 12.54	1015	310; 12.2
HE	OF-412	15.6; 34.3	930	NA
	OF-412SH	15.6; 34.3	926	NA
Smoke	D-412	16.9; 37.3	915	NA
Chemical	?	?	?	NA

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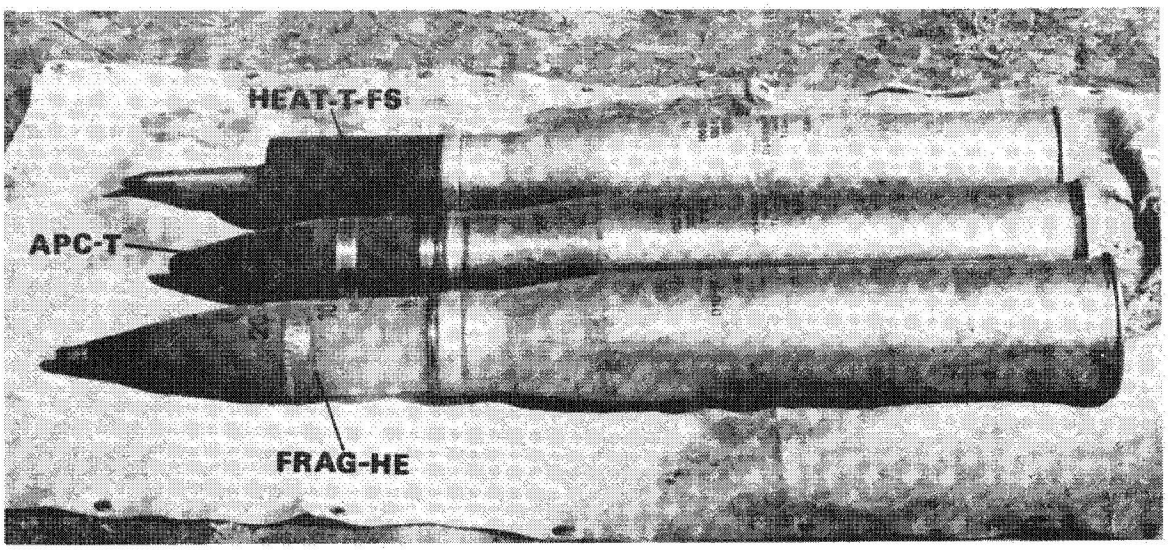

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Figure II-S-3. Projectiles, Czechoslovak 100-mm field gun M-53 (U).

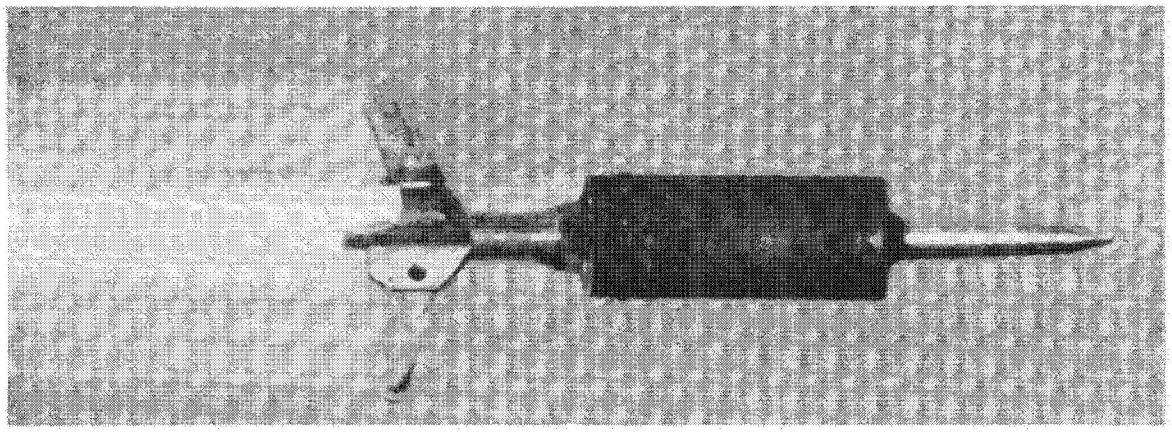

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Figure II-S-4. Czechoslovak 100-mm HEAT-T-FS projectile in flight (U).

Table II-S-2. Probable Errors in Indirect Fire; 100-mm M-53 Field Gun (U)

Percent of maximum range (21 000 m) (measurements in meters at various percentages)	PE_r (m)	PE_d (m)
90 (18 900, chg full)	71	11
70 (14 700, chg full)	55	8.1
50 (10 500, chg full)	37	4.7
30 (6300, chg full)	28	2.1

~~(CONFIDENTIAL)~~

(b) Effectiveness. An 18-gun 100-mm battalion (Czechoslovak M-53 or Soviet BS-3 and M-1955 guns) can deliver 1.123 tonnes (4 volleys/72 rounds) of projectiles upon a large area target within 20 seconds. When firing upon a 250-meter wide x 200-meter deep target at two-thirds of maximum range (14 000 meters; PE_r=52 meters), and considering errors in precision only, 0.904 tonnes of projectiles can be delivered on the target in 20 seconds.

(c) Fragmentation. The standard HE-fragmentation projectile is the Soviet OF-412. This steel projectile, having a charge-to-mass ratio of 0.162:1, produces 6408 fragments having an average weight of 2.074 grams and an initial velocity of 568 m/s.

(d) Lethality. At zero height-of-burst in open terrain, a 30° angle of fall produces a lethal area of 232 m^2 against standing personnel and 86 m^2 against personnel in the prone position; these figures are based upon the assault 5-minute casualty criteria.

(3) Direct fire.

(a) Precision. Probable errors in direct fire for the 100-mm M-1953 field gun are shown in table II-S-3.

Table II-S-3. Probable Errors in Direct Fire; M-53 Field Gun Firing Czechoslovak HEAT-T[1], AP-T[2], HE[3], and Soviet APC-T[4] Projectiles (C)

Range (m)	PE_d (m)				PE_v (m)				PE_r (m)
	1	2	3	4	1	2	3	4	Frag-HE
500	0.07	0.1	0.2	0.1	0.07	0.1	0.1	0.1	33
1000	0.15	0.2	0.3	0.2	0.15	0.2	0.2	0.2	32
1500	0.3	0.2	0.4	0.4	0.3	0.3	0.3	0.3	32
2000	0.4	0.3	0.5	0.5	0.7	0.4	0.4	0.4	31
3000	NA	0.5	0.8	0.9	NA	0.6	0.7	0.8	30
4000	NA	0.7	1.1	1.2	NA	0.9	1.0	1.6	30

[1],[2],[3],[4]Indicate figures in column heads in table representing these projectiles. ~~(CONFIDENTIAL)~~

(b) Grazing range. Czechoslovak firing tables show grazing ranges for the M-53 firing various projectiles against a 2-meter-high target to be as follows:

AP-T (Czechoslovak PSv) ---------- 1230 meters

Frag/HE (Soviet OF-412) ---------- 1180 meters

AP-T and APC-T (Soviet BR-412D and B) ---------- 1150 meters

HEAT-T (Czechoslovak PrSv) ---------- 1070 meters

(c) Effective range. Calculated effective range (50% probability of a first round hit) of the M-1953 vs. the standard NATO target and the US M60A1 tank are 1260 meters and 1450 meters, respectively. Hit probabilities calculated for the M-53 against the standard NATO target and the US M60A1 tank are shown in table II-S-4.

(d) Engagement range. An M-53 using the Czechoslovak AP-T projectile probably will open fire on a US M60A1 tank at a range of about 1500 meters.

Table II-S-4. Probability of a First Round Hit, 100-mm M-53 Field Gun Firing the PSv AP-T Projectile (U)

Range (m)	Hit probability versus NATO target	Hit probability versus M60A1 in the frontal presentation
500	0.98	0.98
1000	0.69	0.80
1260	0.50	----
1450	----	0.50
1500	0.33	0.46
2000	0.14	0.22

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(e) Armor penetration. See table II-S-1 for these data.

c. Configuration. The monobloc barrel, 59 calibers long, has rifling with a constant right-hand twist, one turn in 30 calibers for a lead angle of 5°53'42". The muzzle brake, which is double chambered, is screwed onto the barrel muzzle and locked with four screws. The muzzle brake reportedly absorbs 65% of the recoil force, a high percentage for a field gun; this indicates that overpressures in the crew area are high. The breechblock is a semiautomatic, horizontal sliding-wedge type. Loading a round automatically trips the cartridge case ejector claws, which releases a spring that closes the breech. After a round is fired, the breech opens and the cartridge case is ejected. The firing mechanism within the breechblock is automatically cocked by opening the breech. The recoil mechanism is unique, since the hydraulic brake and hydropneumatic recuperator both are contained in one cylindrical housing mounted beneath the barrel. This recoil system also is variable from 950- to 1500-mm length of recoil; this is accomplished by rotation of the brake piston rod to change the degree of throttling as the gun is elevated or depressed through the 28° to 32° range. Equilibration for the long tube is provided by two compressed spring equilibrators, one mounted on either side of the barrel between the cradle and the top carriage. The shield consists of a fixed upper section, a smaller section fixed to the cradle, and a skirt section. The box trails are of welded steel construction. Caster wheels which are used for opening and closing the trails and for manually moving the gun for short distances are attached to the outer side of each trail. With trails spread, there is a total of 60° of on-carriage traverse; with trails closed, traverse is limited to 10°. Elevation

limits with trails spread are -6° and +42°; with trails closed, elevation limits are reduced to -6° and +15°. The separate lunette must be attached to the trail ends when preparing the weapon for travel. Single disk wheels mount foam rubber-filled tires. Torsion-bar suspension, similar to that of the 122-mm D-74 gun, is utilized. When the trails are spread, the suspension is locked out. Fire control on the M-53 consists of a 6x6° field of view, model 52b telescope for direct fire and a Soviet PG-1 panoramic telescope on a model M42 sight mount for indirect fire. The model M42 mount incorporates an elevation arc and a range drum. Some M-53's mount the APN 3-5 IR telescope for firing at night. A standard Soviet gunner's quadrant is issued with each gun.

d. Summary. The Czechoslovak 100-mm M-53 field gun is a high-performance gun whose primary role is the destruction of enemy tanks. It is one of two Czechoslovak artillery pieces (the other being the 85-mm Field Gun M-52) of indigenous design and manufacture that remains standard. Production of the M-53 was apparently discontinued in the mid-1950s as a result of Czechoslovakia meeting the requirements for its field forces and, possibly, the production of the Soviet 100-mm M-1955 field gun negating any Warsaw Pact requirement for the Czechoslovak M-53 gun. The M-53 has been offered for sale to several countries in Africa, Asia, and the Middle East, and therefore it is possible that export has taken place. The M-53 is found in some other Eastern European Communist countries, one example being Bulgaria. Currently, the standard Czechoslovak antitank weapon, the M-53, is found in antitank units at the Czechoslovak front, army, and motorized rifle division levels. It affords greater firing stability, maneuverability, and flexibility than does the Soviet 100-mm M-1944 field gun. The M-53 has an excellent direct fire capability, and its versatility in firing both Czechoslovak and Soviet armor defeating projectiles increases its effectiveness.

38. ~~(C)~~ Component Analysis

a. (U) Cannon Assembly.

(1) (U) Tube. The barrel of the M-53, of monobloc construction, has rifling that consists of 40 grooves, each 4.7 mm wide and 1.5 mm deep; land width is 3.15 mm. Length of rifling is 5434 mm. Length of the entire cannon assembly is 6735 mm with muzzle brake and 6407 mm with brake removed. The barrel is affixed to the breechring by means of a threaded locking ring; tube rotation is prevented by a keyway with key arrangement between the barrel and the breechring. Tube wear life of this gun should approximate 1500 AP-T rounds.

(2) (U) Breechring. This component houses a semiautomatic, horizontal, leftward opening, sliding wedge-type breech mechanism. After the weapon is fired, the breech opens automatically and ejector claws throw out the expended cartridge case. As a fresh round is loaded, the rim of the cartridge case trips the cartridge case ejector claws, which, in turn, release the spring that closes the breech. An operating handle is provided for manual operation, such as opening the breech to load the first round and to close it after firing the last round.

(3) (U) Muzzle brake. The double-baffle muzzle brake has two ports on either side. The Czechoslovaks claim the efficiency of this brake is 65%. Such a high efficiency index indicates the probability of high overpressures in the crew area.

b. ~~(C)~~ Top Carriage. This component supports the cannon assembly, recoil mechanism, cradle, elevating mechanism, on-carriage fire control, gun shield, and gear train side of the traversing mechanism.

(1) (U) Cradle. This fixture, attached by means of its trunnions to the trunnion seats located in the side frames (yoke) of the top carriage, guides the barrel during recoil and counterrecoil. The cradle supports the barrel assembly and the recoil mechanism, the elevating arc, recoil mechanism mountings, sight mount, small shield, and firing levers (triggers). The M-53 uses a two-part cradle. The cradle trough, a U-shaped fixture, constitutes the rear part of the cradle and mounts the rails. The recoil mechanism housing (body) forms the front part of the cradle, the rear part being welded to the bottom of the recoil mechanism body. The rails on the rear section of the cradle continue forward along the upper portion of the recoil mechanism housing. The shoes on the breechring slide in recoil along the rear section of the rails, and a small sleigh attached to the barrel recoils along the forward section of the rails. A length of recoil indicator scale is mounted on the right side of the cradle. The sight mount is affixed to the left trunnion. Either of two firing levers (upper and lower triggers) can be used to fire the gun. In direct fire, the gun is fired by the gunner pushing the lower firing lever toward the cradle with his right elbow. In indirect fire, he may fire the weapon by pressing the upper firing lever downward with his right hand or by attaching a short lanyard to a hole provided in either lever. The gun is locked for travel by centering the weapon in traverse and first elevating and then depressing the tube until a clamp is attached to a fixture on the bottom of the recoil mechanism body (front section of the cradle). In addition, clamps on the trails secure a boss located on either side of the rear section of the cradle.

(2) (U) Elevating mechanism. The elevating mechanism, of the rack-and-pinion-type, is driven by a handwheel located on the left side of the carriage. Two bevel gears and a worm gear are located in the drive train of this mechanism.

(3) (U) Traversing mechanism. The traversing handwheel, located on the left side of the carriage, drives a gear train containing bevel gears that terminates in a worm-driven pinion. This worm-driven pinion gear, affixed to the top carriage, drives the pintle-mounted top carriage about the stationary bottom carriage by engaging the rack located in the bottom carriage.

(4) ~~(c)~~ Recoil mechanism. The recoil mechanism contains 21 liters of Steol M recoil fluid in the hydropneumatic recuperator under a pressure of 60 ±3 atmospheres, 6.1 liters in the hydraulic recoil brake, and 1.5 liters in the replenisher for the recoil brake; the 6.1-liter quantity completely fills the brake, and the 1.5 liters occupy two-thirds of the space in the replenisher. Length of recoil at 42°, elevation is 950 mm, and maximum length is 1500 mm.

(a) (U) Configuration. Because it is contained in one housing (body), the recoil mechanism of the M-53 is unique. Oversimplified, the recoil cylinder serves as the recuperator's piston rod; i.e., the recuperator cylinder surrounds the recoil brake. The recoil mechanism housing, in turn, surrounds the recuperator cylinder, and the space between the walls of these two structures serves as the air cylinder (air pressure vessel) for the recuperator. The replenisher is located in the front part of the recoil mechanism housing.

(b) (U) Operation. As the barrel recoils, it carries with it the brake cylinder and its regulating rod; the brake piston rod with piston remains in its original position. This causes braking action to occur by displacing fluid from in front of the brake piston to the rear of the piston via paths through the piston head and the regulator rod. The fluid also impinges against a slide valve that controls two flow-through slots in the counterrecoil control rod. Additional braking action is accomplished in the recuperator. During recoil, that fluid in the recuperator located in the space between the walls of the recoil brake cylinder and the recuperator cylinder is forced through throttling orifices into the recuperator's air cylinder to further compress the air located therein. This further compression of the air in the recuperator air cylinder provides the force necessary to return the cannon assembly into battery after the braking action halts its rearward movement. Buffering is accomplished by throttling action plus a leather padded stop against which the breechring comes to rest at the conclusion of the counterrecoil cycle.

(c) (C) Comment. The description of this recoil mechanism indicates that it is unique in concept and design. This mechanism may be based upon the St. Chamond concept. The capability for disassembly without removal of the barrel assembly from the cradle demonstrates a marked degree of design foresight. Based solely upon its description, this system probably works very well. Nevertheless, it has at least one considerable tactical disadvantage when compared with the Schneider-type recoil systems. The manual for this gun clearly states that disassembly of this recoil mechanism must be accomplished in a "clean room" or, as a minimum, in an area protected from contamination insofar as achievable (in which case steps must be taken to keep out dirt, dust, sand, or other solid particles that could damage the parts), that all personnel handling the parts must wear gloves, and that disassembly must be accomplished under the supervision of the Artillery Armament Service (i.e., a supervisor from the Ordnance Corps). Such restrictions indicate that, compared with Soviet recoil mechanisms, much closer tolerances and smoother surface finishes are used to manufacture this Czechoslovak mechanism. Nevertheless, the inability to disassemble the recoil mechanism in the open under field conditions (as do the Soviets) represents a tactical disadvantage common to the Puteaux, Filloux, and St. Chamond concept designs as opposed to the Schneider design.

(5) (U) On-carriage fire control. The on-carriage fire control devices are secured to the left trunnion by means of a bracket that mounts the direct fire sight on the outboard (left) side of the bracket and the indirect fire sight on its inboard (right) side.

(a) (U) Indirect fire sight. The model 42 indirect fire sight consists of a mount (affixed to the sight bracket) containing cross- and longitudinal-level vials, an elevation arc and micrometer, a range drum, and a Soviet PG-1 or PG-1M panoramic telescope. The range drum is inscribed with four graphical range scales, as follows:

- Scale, purpose unknown.
- Scale for HE projectile, full charge.
- Scale for HE projectile, reduced charge.
- Scale for AP-T projectile.

(b) (U) Direct fire sights. The model 52b direct fire sight mount is secured to the left side of the sight mounting bracket. The sight mount contains both a knob-like range drum for direct fire and the telescope mount, which is connected to the direct fire mount through an eccentric pin that transmits those changes in the angle of elevation

introduced by turning the range drum knob. The 6x6° field of view direct fire telescope contains a simple reticle displaying a mils scale in deflection, the point of aim by means of a wide inverted "V," and the vertical axis of the field of view. Some M-53 guns also are equipped with an APN 3-5 infrared telescope. This telescope, when used, is mounted with its forward mounting attached to the front shackle of the equilibrator and its rear mounting attached to an extension of the left trunnion bearing.

(c) (U) Night lighting. Sight illumination for both the indirect and direct fire sighting equipment is provided by a model LUC-2 illuminating set that is battery operated. In addition, the gun commander (section chief) is provided with a belt-mounted battery to which is attached a 0.9-meter-long cord that terminates in a shaded light bulb. He uses this light to read maps and make computations at night.

(6) (U) Crew protection. A flat, rearward sloped, straight topped shield is provided. The main shield is angled sharply rearward to provide some lateral protection for the crew. A hinged skirt shield is mounted along the axle line between the trails.

(7) (U) Equilibrators. Muzzle preponderance is balanced by means of two spring-type equilibrators, one on either side of the gun. One end of each equilibrator is attached to the lower part of the top carriage and the other is attached to arms projecting from the trunnions. The springs of the equilibrators, upon becoming fatigued, are adjusted by turning the bottom of the cylinder to the right by use of a special wrench.

c. (U) Bottom Carriage. The bottom carriage supports the top carriage and mounts: The axle; the wheels; the brakes; the trails, which accommodate the pneumatic and electric lines; the bottom carriage pivots; the bearing for the axle pin; traversing rack and stops; the gib, which secures the top carriage; and the chain, which fastens the lower (skirt) shield.

(1) (U) Axle assembly. The M-53 is provided with torsion-bar suspension. The suspension system operates generally in the same manner as does the suspension system mounted on the Soviet 122-mm D-74 field gun (sec II, subsec H). Opening the trails locks out the suspension system whereas closing them permits the axle arms to be freely moved by action of the torsion bars. Maximum movement of the axle arms is limited by rubber-padded stops.

(2) (U) Wheels. Pneumatic tires are mounted on steel disk-type wheels. Air brakes are used when the gun is being towed. A hand lever applies the brakes manually when the gun is disconnected from the prime mover. A brake light is attached to the right face of the shield and connected to the prime mover when the gun is march ordered.

(3) (U) Trails. The box-type trails taper in height toward the trail ends. The forward ends of the trails are forked to engage the bottom carriage, and are secured thereto by pins. The forward inner sides of the trails mount stops that limit traverse of the weapon when the trails are closed. Near the center of the trails, lengthwise, clamp pins, seated in bearings, are mounted to secure the cradle during travel. Spades are welded to each trail end. Handspikes are pivoted in forks that are welded to the trail just forward of the spades. The coupling (trail lock) that secures the trails together is located forward of the spades. The lunette is secured by rods to the bases that mount the trail lock. Mounts for carrying a two-section ramrod are affixed to the outside of the right trail. Retractable caster wheels are mounted near each trail end. The pneumatic line runs along the inner face of the left trail, and the electric cable for the gun's traveling light runs along the inner face of the right trail.

(4) (U) Mobility. The M-53 possesses good mobility, primarily due to its torsion-bar type of suspension.

T. YUGOSLAV 76-MM MOUNTAIN GUN M-48 (B-1)

39. ~~(C)~~ Description and Performance

a. (U) General. The 76-mm mountain gun M-48 (B-1) (fig II-T-1), nicknamed the "Tito Gun," was observed first in early 1950. Actually a howitzer rather than a gun, this weapon appears to be a modernized version of the Skoda 75-mm mountain howitzer used by Yugoslav artillery units during World War II. In the direct fire role, the M-48 employs either HEAT or HE ammunition at ranges between 30 and 500 meters. Direct fire can be undertaken at ranges up to 1000 meters if circumstances so dictate. This howitzer can be disassembled into components constituting eight animal-packed loads. It can be towed either by two draft animals or by a variety of military vehicles. Employment of the M-48 normally is associated with partisan activity and special operations such as mountain or jungle warfare. The M-48 has appeared in four versions: The B-1, the B-1A1-I, the B-1A2, and the B-2. The B-1, which has pneumatic tires, is the weapon described herein. The B-1A2 is the same as the B-1 except for light alloy wheels, solid rubber tires, and some minor modifications to the suspension. The B-1A1-I has the same types of wheels and tires as the B-1, plus some of the suspension features of the B-1A2. The B-1A2,

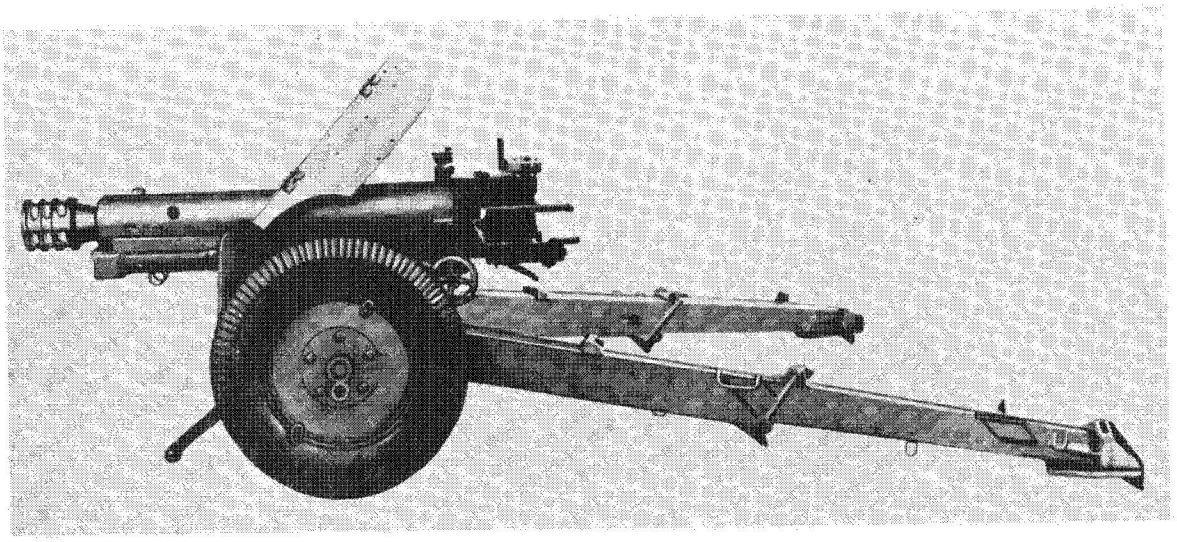

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Figure II-T-1. Yugoslav 76-mm M-48 mountain gun, left side view (U).

strictly a field piece, is not suited to transport by either animal draft or animal pack. Little is known about the newer B-2 variant.

b. ~~(C)~~ Capabilities.

(1) (U) General. The M-48 fires a 6.2-kg (13.67-lb) HE projectile to a maximum range of 8600 meters. The semiautomatic, horizontal sliding-wedge breech mechanism assists in attaining the 20 rd/min maximum rate of fire. Claimed rates of fire over periods of 1, 30, and 60 min are: 20, 110, and 163 rounds, respectively. The B-1, which weighs 705 kg (1554 lb), can be towed over improved roads at a maximum speed of 60 km/h (37 mi/h). The B-1A2, the variant equipped with solid rubber tires, is limited to a maximum road speed of 30 km/h (19 mi/h). Rate of march, when packed or towed by animal transport, is limited to about 6 km/h. The M-48 can be emplaced or displaced by its six-man crew in approximately 2.5 minutes. This howitzer uses semifixed ammunition having four propellant charges. On-carriage traverse is 25° left or right of center, for a total of 50°. Elevation limits are -15° and +45° with the full length trails, and are +12° and +65° in the shortened, dug-in trails, configuration. Characteristics of projectiles more commonly employed with this weapon are shown in table II-T-1.

Table II-T-1. Projectiles, 76-mm M-48 Mountain Gun (U)

Type	Designation	Type of round	In-flight weight (kg)	Muzzle velocity (m/s)	Armor penetration at 0° obliquity (mm)
HE	M-55	Semifixed	6.2	398	NA
HE	OF-350	Semifixed	6.2	398	NA
HEAT	BP-350/2	Fixed	5.1	346	99
HEAT	M-50	Fixed	5.1	346	99

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(2) ~~(C)~~ Unit of fire. The UOF is estimated to be 60 rounds per weapon. Normal ammunition supply accompanying each vehicular-towed howitzer section is estimated to be 36 to 42 rounds (12 to 14 boxes). When the prime mover is a 1.5-tonne, or larger, truck and 12 to 15 crated rounds are to be transported, the more usual "jeep-type" of truck is used. The number of rounds transported when the weapon is packed by animals is dependent upon the number of pack animals provided to transport ammunition. A heavy pack mule should carry eight or nine rounds of uncrated ammunition. When transported in the crated configuration, one three-round box could be carried on each side of the pack frame, for a total of six rounds per mule.

(3) ~~(C)~~ Indirect fire.

(a) (U) Precision. A sampling of precision data is depicted in table II-T-2.

(b) (U) Effectiveness. This weapon normally is employed in 4-gun batteries. For purposes of comparison, a hypothetical 18-gun M-48 battalion could deliver approximately 0.893 tonne (8 volleys, 144 rounds) of projectiles on an 8-PE_r-deep area target (176 meters at 6000 meters) in the first 20 seconds of fire. The nominal 4-gun battery can deliver but 0.198 tonne on target in the same time.

(c) ~~(S)~~ Fragmentation. The standard Yugoslav M-55 projectile and the Soviet OF-350 HE projectile fired by the M-48 have steel bodies and are filled with TNT. These projectiles have charge-to-mass ratios of 0.140:1 for the M-55 projectile and 0.139:1 for the OF-350 projectile.

Table II-T-2. Probable Errors in Indirect Fire; 76-mm M-48 Howitzer, HE Projectile M-55 or OF-350 (U)

Percent of maximum range (m) (8600 m) (measurements in meters at various percentages)	PE_r (m)	PE_d (m)
90 (7700, chg 4)	31.0	5.2
70 (6000, chg 4)	22.0	3.5
50 (4300, chg 3)	22.0	3.1
30 (2600, chg 2)	19.0	2.0

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(d) ~~(C)~~ Lethality.

1. (U) Yugoslav data. Lethal areas for the M-55 and OF-350 projectiles indicate that:

- Lethal areas are 5x8 meters (40 m^2) for "90% effectiveness" and 15x30 meters (450 m^2) for "50% effectiveness" against personnel standing in open terrain.
- The number of injury-producing fragments anticipated per round is approximately 200 to 250.
- Yugoslav doctrine necessitates the delivery of 480 rounds of 76-mm ammunition (2.976 tonnes) on a counter-battery target at 6000-meter range or 288 rounds (1.786 tonnes) on the identical target at 4000-meter range to assure destruction of that target. Neutralization of the same target necessitates the delivery of 72 rounds in the first half hour, followed by 72 rounds over the next 1.5 hours, 36 rounds during the third hour, and 24 rd/h thereafter (204 rounds or 1.265 tonnes), in the first 4 hours. For each metric ton of 76-mm projectiles delivered on a target, a logistic lift of 4.288 tonnes of packaged ammunition is required.

2. ~~(C)~~ US Army data. Information derived for the OF-350 projectiles states that the projectile bursts into an average of 5973 fragments having a mean weight of 0.907 grams (14.0 grains) and an average initial velocity of 705 m/s. A sampling of lethal areas is given in table II-T-3.

Table II-T-3. Sample of Lethal Areas, 76-mm M-48 Mountain Gun Firing Soviet OF-350 Projectile (U)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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(4) ~~(C)~~ Direct fire.

(a) ~~(C)~~ Precision. Data for the 76-mm M-48 gun in direct fire are shown in table II-T-4.

(b) ~~(C)~~ Grazing range. Grazing ranges for M-48 firing the UPB-357M HEAT round (BP-350/2 or M-50 HEAT projectiles) versus targets of specified heights are, according to the Yugoslav firing tables, as follows:

- 400 meters when target height is 2.0 meters.
- 540 meters when target height is 3.0 meters.

(c) ~~(C)~~ Effective range. Estimated effective range (50% probability of a first round hit) of the M-48 (vs. a US M60A1 tank) is around 425 meters. Maximum direct fire range graduated on the M-57 panoramic telescope, with which this howitzer is equipped, is 1000 meters graduated in 200-meter intervals.

Table II-T-4. Probable Errors in Direct Fire; 76-mm M-48 Mountain Gun Firing HEAT Projectile BP-350/2 or M-50* (U)

Range (m)	Maximum ordinate (m)	PE_d (m)	PE_v (m)
100	0.3	0.1	0.1
200	0.6	0.2	0.1
300	1	0.2	0.2
400	2	0.3	0.3
500	4	0.3	0.4
600	10	0.5	0.6
1000	16	0.7	0.8

*NOTE: The firing table shows that the PE_r, at all ranges from 100 to 1800 meters, is 14 meters for the HE projectiles fired with charge 3. The muzzle velocity of the HE projectile being but 3 m/s slower than that of the HEAT projectiles, this 14-meter PE_r should also be valid for the HEAT projectiles.

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(d) (~~e~~) Engagement range. Fire should be opened on a US M60A1 tank at 600 meters or less.

(e) (~~f~~) Armor penetration. Both HEAT projectiles described here display equivalent armor penetration capability. Armor penetration is 99 mm at 0° obliquity, 86 mm at 30° obliquity, and 51 mm at 60° obliquity.

c. (U) Configuration. The trails (fig II-T-2) of the M-48 are of the split-box type. Each trail is made in two sections, enabling the weapon to be used in high angle fire by removing the rear sections and digging in the shortened trails; however, when this mode is employed the minimum elevation is $\geq$+12° and direct fire (e.g., antitank fire) therefore is severely limited if not precluded. The rear half of the trails fold back over the forward half on a hinge pin; these sections latch in the

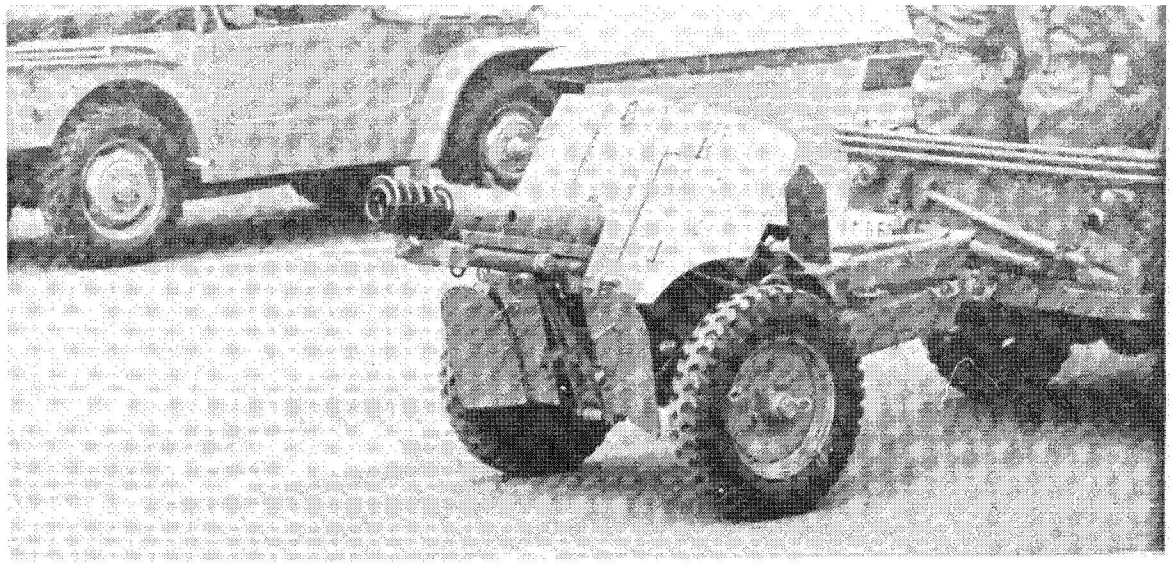

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Figure II-T-2. 76-mm mountain gun M-48, left front view (U).

folded position for travel. A lunette is attached to the shortened trails by lugs and a slot and pin device. Elongated, drivable, steel trail spade stakes, mounted in slots provided in the trail ends, project upward from the folded-back rear trail sections when the howitzer is in the travel configuration. Total on-carriage traverse is 50°. Elevation capability with extended trails is -15° to +45°. By removing the rear trail halves (fig II-T-3), digging in the shortened trails, and providing a recoil pit, high angle fire can be conducted since elevation limits become +12° and +65°. The M-48 has a hydropneumatic variable-length recoil mechanism. The hydraulic recoil brake cylinder, a compensator (replenisher) cylinder, and the hydropneumatic recuperator cylinder are positioned in the base of the cradle. The recoil and recuperator piston rods attach to the breechring with a quick-disconnect fixture. Variable-length recoil is accomplished by rotational alignment of the recoil throttling device through use of a mechanical linkage, the movement of which is actuated as the cannon is elevated or depressed. The weapon has a three-position counterrecoil speed regulator that is adjustable to speed up or slow down the return of the cannon into battery. The barrel is encased in a full length adapter that provides the means for assembling the barrel to the breechring and for attaching the three-baffle muzzle brake. The adapter contains the slides on which the tube rides in recoil. The cradle is a shallow "U"-shaped casting in which the three recoil system cylinders appear to be structural parts. The elevation trunnions and other accessories are bolted to the sides of the cradle. Lipped recoil

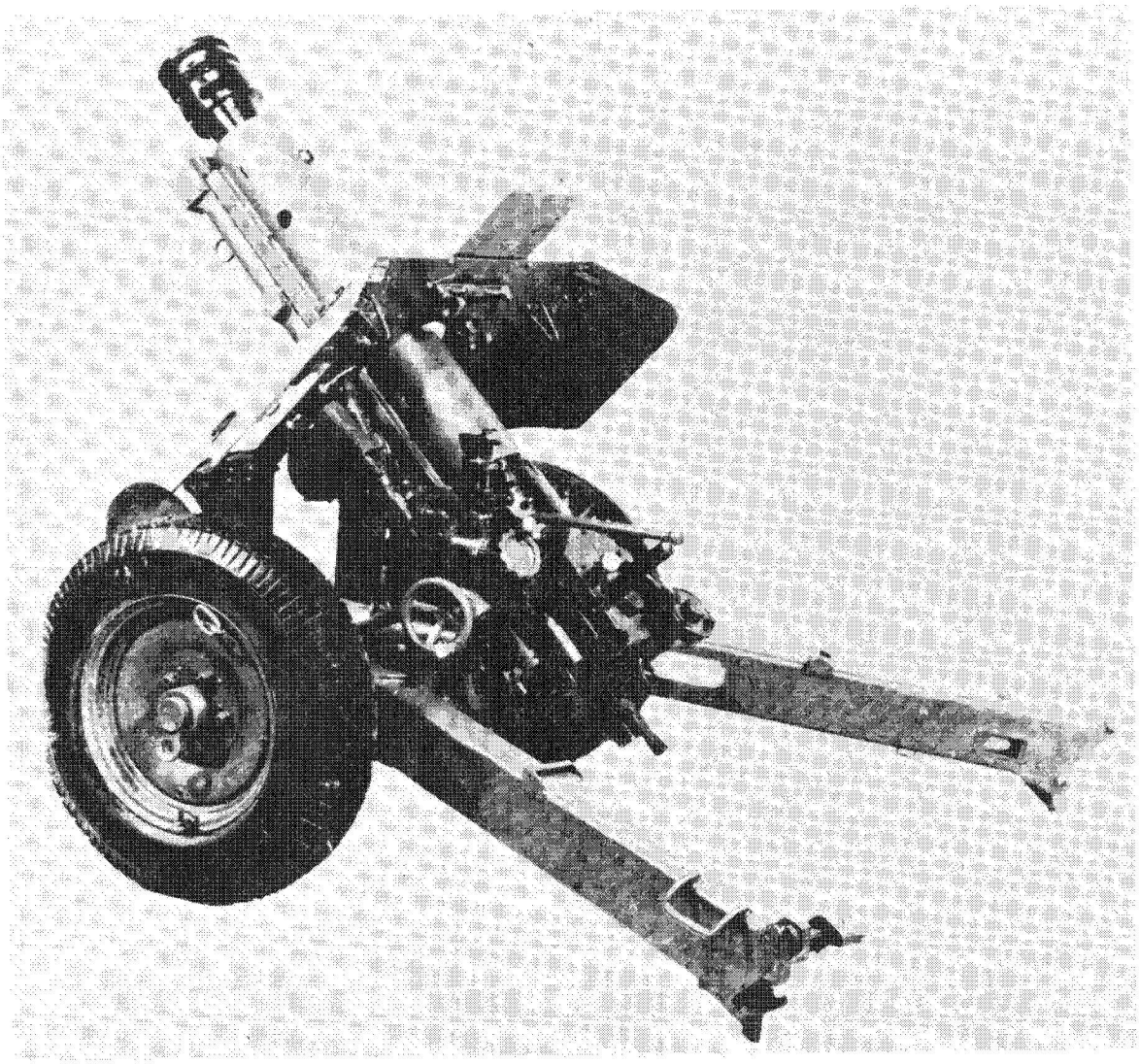

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Figure II-T-3. 76-mm M-48 mountain gun, left rear view (U).

rails are provided on the upper longitudinal edges of the cradle. The on-carriage fire control equipment has a dependent line of sight. The range quadrant has an elevation arc and micrometer marked in US mils (6400 ⋔) and one range scale (marked in the Soviet 50-meter increment system) for both HEAT projectiles and the HE projectiles when using charge 3. A site scale marked from 29 (00) to 35 (00), with an associated micrometer graduated in mils (⋔), is provided. Zero (level) position on

the site scale is 32 (00). An M-57 panoramic telescope is used with this weapon. This instrument is graduated in hundreds of mils (64) on the azimuth ring, and in mils on the micrometer scale. A direct fire reticle, with horizontal lines indicating 200-meter intervals in range and numbered from 2 to 10 to indicate ranges from 200 to 1000 meters, is incorporated in the panoramic telescope. Normal maximum range for direct fire is 500 meters. The telescope indices are provided for use with the HEAT round but also are valid for the high explosive round (VOF-357M) when using charge 3.

d. ~~(C)~~ Summary. The 76-mm M-48 mountain gun is a weapon normally associated with use in difficult terrain or partisan-type warfare. This lightweight, relatively short-range (8600 meters), weapon is provided with both a variable-length recoil mechanism and a muzzle brake to facilitate employment both under difficult operating conditions and in high angle fire. Precision of this howitzer, expressed in probable error as a percentage of range, at 70% maximum range (6000 meters) is 0.366%, and at maximum range (8600 meters) is 0.488%; this is about one-third greater dispersion than that characteristic of a really good artillery piece. Performance of this weapon is not impressive, although in the setting for which it is intended it should give fair to good service. Each major component of this weapon is equipped with lifting and lashing loops and eyes to aid in its assembly/disassembly and its lashing for transport. The M-48 exhibits considerable ingenuity in the design of some of its components; for instance, in the tube adapter and the recoil mechanism.

40. (U) Component Analysis

a. Cannon Assembly.

(1) Tube. The barrel is of monoblock construction. The materiel in current models is composed of a chrome-molybdenum-vanadium alloy; earlier models were of chrome-nickel-molybdenum alloy. An adapter completely encases the tube, providing the means for assembling the muzzle brake, tube, and breechring to one another. The breechring is fitted to the adapter with interrupted threads. The tube is locked in place between the two fixtures. The adapter also mounts the recoil slides. Tube length without breechring and muzzle brake is 1178 mm (15.45 calibers). In this configuration the tube weighs 77 kg. Rifling consists of 24 lands and grooves with increasing right-hand twist; inclination at the origin of rifling is 3°17'10" and at termination of rifling is 7°10'. Land width is 3 mm. Grooves are 7 mm wide and 0.762 mm deep. The length of rifling is 779 mm. Design length of the powder chamber is 306 mm. Tube wear life is approximately 15 000 EFC rounds; fatigue life is not known.

(2) Breechring. This fixture houses a horizontal sliding-wedge breechblock. A cam on the breech mechanism and a cam-operating guide along the cradle extension operate the breechblock in a semiautomatic manner during the counterrecoil phase of the recoil cycle. The fatigue life of the breechring, breechblock, and breech operating mechanism is not known.

(3) Muzzle brake. The triple baffle-type muzzle brake has four ports at each baffle. Port area constitutes approximately 50% of the circumferential area delimited by their location.

b. Top Carriage. This assembly supports the tipping parts of the howitzer. It includes the cradle with the recoil mechanism; the elevating worm, pinion and shaft, and associated accessories; the trunnion mounts and elevation rack that are affixed to the cradle; and the shields, the traversing handwheel with linkage, and the on-carriage fire control equipment that are attached to the top carriage.

(1) Cradle. This fixture is of cast construction. The recoil brake cylinder, the recuperator cylinder, and a compensator (replenisher) cylinder are integral to this shallow depth cradle. The cradle's trunnions fit into trunnion seats in the upper carriage. The linkage for the variable-length recoil mechanism is mounted externally along the right side of the cradle. Lipped recoil rails are provided along the longitudinal edges of the cradle. A lug is provided on the lower forward side of the cradle. A locking strut is attached to this lug when the weapon is march ordered in its towed configuration. The elevating worm, worm gear, and pinion are affixed to the central portion of the cradle base. A recuperator-filling valve is provided on the left forward side of the cradle casting. The fixtures mounting the trunnions are bolted to the sides of the cradle.

(2) Elevating mechanism. This assembly is a conventional, handwheel-operated, worm-gear stabilized, rack-and-pinion-type device. The worm and associated gearing is affixed to the bottom of the cradle. To provide for rapid disassembly of the weapon into pack transport loads, a spring-loaded quick-disconnect is affixed at the juncture of the universal joint and the shaft. A bevel gear is provided at the handwheel and shaft juncture. Quick-connect/disconnect, split, trunnion bearing seats are located on the upper carriage yoke.

(3) Traversing mechanism. Traverse is accomplished by means of a small crank-operated handwheel, a universal joint, a shaft with bevel gear, and a worm gear that operates against a bronze gear sector mounted on a projection of the axle casting. The axle casting contains a central hole, having upper and lower bearings, to accommodate the pintle about which the top carriage moves in traverse.

(4) Recoil mechanism. A hydropneumatic, independent, variable-length, recoil-type mechanism is used on the M-48. The three cylinders that house the mechanism are integral parts of the shallow cradle casting. The hydraulic recoil brake is connected to a linkage, which, as the cannon assembly is elevated or depressed, causes the recoil brake piston rod to rotate, thereby adjusting the throttling grooves to provide for variable length recoil. The compensator, a spring-loaded replenisher and a cylinder, is associated with the recoil brake; it contains reserve fluid for the recoil brake as well as a fill valve for recharging the system. The hydropneumatic recuperator cylinder also incorporates the counter-recoil speed regulator arrangement of the recuperator. The speed regulator can be manually adjusted before firing to one of three selectable positions; i.e., faster, normal, or slower. The variable-length recoil also can be adjusted, if required, at the forward end of the cradle by removing the cap from the cradle end and adjusting the gear linkage housed in the front of the cradle. Recoil fluid level, recuperator fluid level, and gas pressure can be ascertained at this same location.

(5) On-carriage fire control. This equipment consists of a range quadrant with a dependent line of sight. The quadrant, mounted at the left trunnion, is provided with two scales graduated in mils (US-type) and meters, respectively. The mils scale is provided with an arc indexed from 1 (00) to 8 (00) and with a micrometer. Reading precision on this scale is within 1 mil. An M-50 gunners' quadrant must be used when conducting high angle fire. The range scale is indexed in 50-meter increments. Even-numbered indices are identified up to 140 (7000 meters), with only index marks continuing to 155 (7750 meters). The range scale is directly usable with the 76-mm M-50 HEAT round and the third charge of the VOF-375M HE round since the ΔV_0 between the two rounds is but 3 m/s. Mil values for range settings are derived from the firing tables for this weapon. A scale, graduated from 29 (00) to 35 (00) (±300 ₥), and a 100-mil micrometer scale are provided for the entry of site. The setting for zero site is 32 (00). Reading precision for the angle of site micrometer is 1 mil. A 6400-₥ model M-57 panoramic telescope is mounted on the range quadrant. Zero position for this telescope is 32 (00). Sixty-four graduations (100 ₥ each) are provided on the azimuth ring, and a 100-₥ micrometer with a reading precision of 1 ₥ is incorporated on the telescope. This instrument has a standard cross reticle plus five horizontal range lines with associated lead ticks inscribed for direct fire application. Each range line, representing 200 meters of range, is identified with the digit of that range in even hundreds of meters (2 to 10). Maximum direct fire range is 500 meters, except in unusual circumstances.

(6) Crew protection. The crew is partially protected by split, winged, half shields (fig II-T-4), which have three hinge fixtures on each half, and a central moving portion that provides crew protection as the tube is being elevated or depressed. The left shield half has three small hinged apertures to provide a direct fire sighting capability. The folding shield arrangements facilitate portability. The shield, made of sheet steel, has quick-attach/detach connections to facilitate assembly and disassembly. Crew protection provided by this shield appears to be marginal.

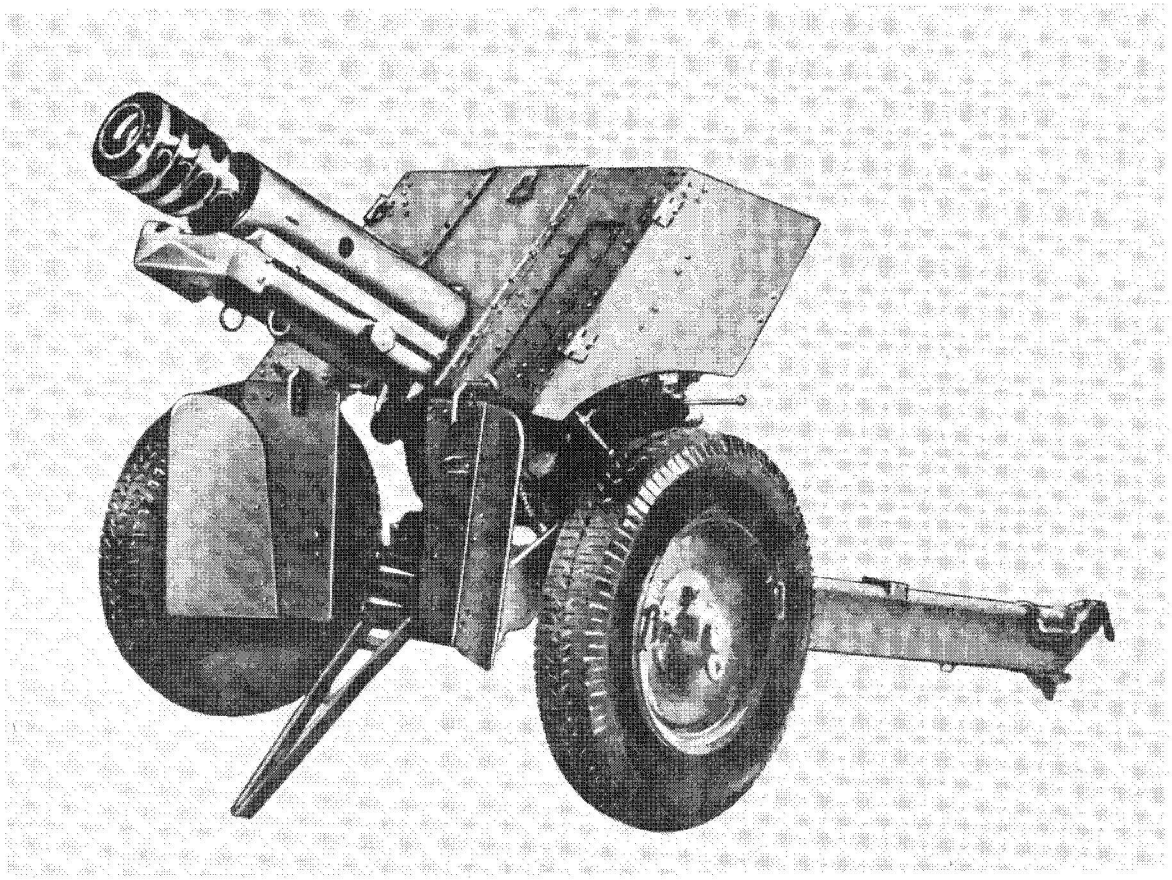

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Figure II-T-4. 76-mm M-48 mountain gun, left front view (U).

(7) Equilibration. A spring-loaded pull-type equilibrator, located under the center rear portion of the cradle, neutralizes muzzle preponderance.

c. Bottom Carriage. This assembly is composed of several castings. It may be disassembled for pack transport. The basic casting is the axle base with a pintle hole in which the upper carriage is mounted on incorporated bearings, a mounting to which the traversing worm sector is affixed, axle studs to which the trail hinge fixture and wheel assemblies are attached, and a major rearward projection on which the axle equalizer assembly casting is mounted.

(1) Wheel assemblies. These assemblies consist of disk wheels mounting pneumatic tires (alternative wheel assemblies include modified disk wheels and solid rubber tires); normal wheel spindles with bearings; individual helical or coil spring-loaded offset wheel suspension devices, depending on the model; and a quick-connect/disconnect fitting that secures to the axle stud. The wheels are not equipped with brakes.

(2) Trails. These fixtures are of welded-box construction and hinged, split trail design. When this weapon is march ordered, approximately the rear half of each trail is folded back on the corresponding forward section and the abbreviated trails are locked in place by lugs on the separate lunette. To provide for stability during firing, the trail ends of the full trails have thin wide slots through which compatible steel trail stakes are driven into the ground. The rear trail halves are separable from the forward halves; they are detached to shorten the trails and thereby facilitate high angle fire. The short trails are dug in approximately 400 mm, and a 500-mm deep recoil pit is required prior to undertaking fire in the upper register (elevations above 45°).

(3) Mobility. Due to its light weight and its capability of being towed, packed, or air dropped, this weapon possesses very good mobility in almost any type of terrain.

U. YUGOSLAV 105-MM HOWITZER M-56

41. (U) Description and Performance

The 105-mm howitzer M-56 (fig II-U-1) is designated by the Yugoslavs as "Howitzer 105-15/550." The designation denotes the 105-mm caliber, 15-kg weight of projectile, and 550 m/s muzzle velocity. This weapon, first displayed in the 1961 Belgrade May Day Parade, does not present any original or unique design features. In fact, this weapon is an amalgamation of light artillery weapon characteristics from several countries. The M-56 has a horizontal sliding-wedge breechblock, split tubular trails, a multibaffle muzzle brake, and panoramic and direct fire telescopes. The recoil mechanism resembles and functions like that of the Soviet 76-mm ZIS-3 field gun, the wraparound shield is copied from the Czechoslovak 100-mm M-53 field gun, the breech resembles that of the German 105-mm

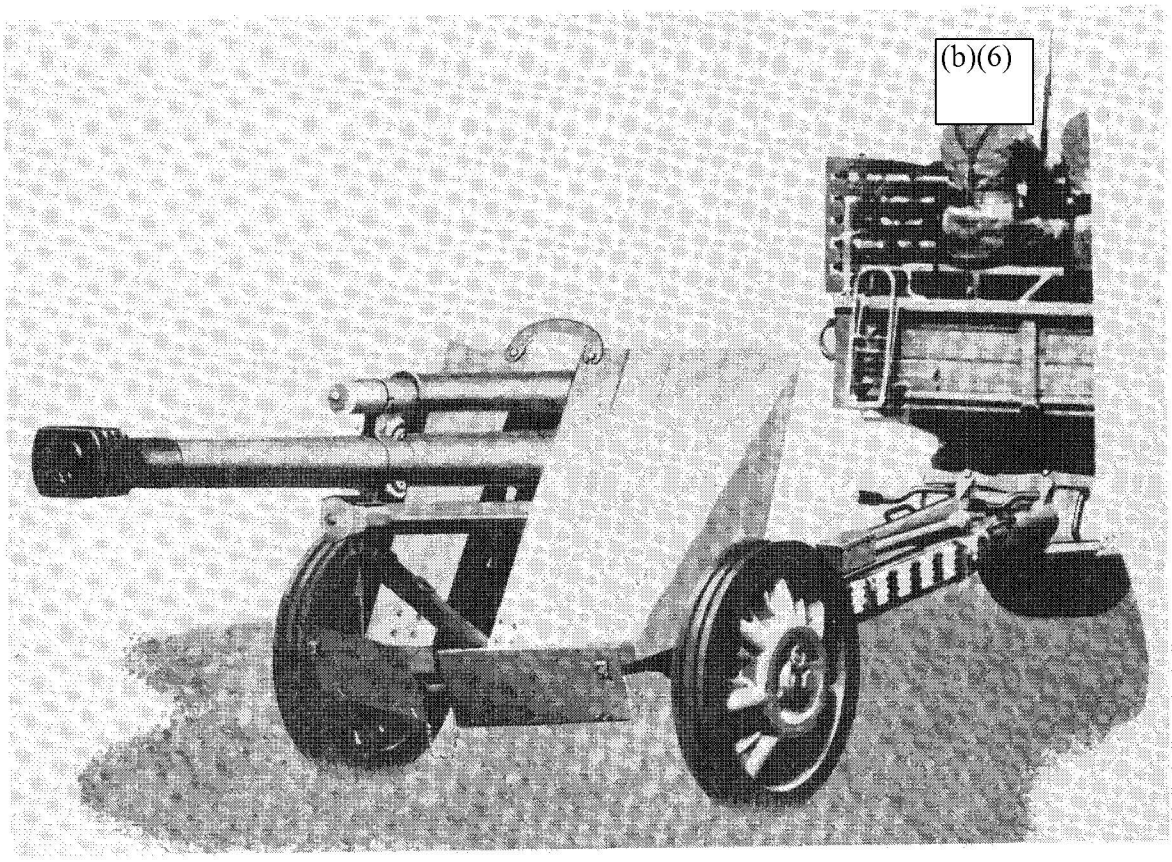

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Figure II-U-1. Yugoslav 105-mm howitzer M-56 (U).

leFH 18 howitzer, and this weapon fires all types of US 105-mm howitzer ammunition. Held in limited quantities by Yugoslavia, this weapon is relegated primarily to reserve field artillery units. In Yugoslavia, this weapon is equipped with solid tires. Reportedly the M-56 is being produced in limited quantities for export. Such weapons are equipped with pneumatic tires similar to those mounted on the Czechoslovak 85-mm M-52 field gun. To date, no known export of this weapon has been effected. A Yugoslav brochure for the M-56 is shown in figure II-U-2.

42. ~~(C)~~ Capabilities

The M-56 fires a 15-kg (33.1-lb) HE projectile to a reported range of 13 000 meters when using charge 8. It is also reported to fire US HEAT, smoke, WP, and illuminating projectiles or copies thereof. The M-56 uses semifixed ammunition having eight charge selections. Total on-carriage traverse is 50° and elevation limits are -8° and +65°. The reported



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Figure II-U-2. Yugoslav 105-mm M-56 howitzer, brochure (U).

rate of fire is 16 rd/min. This weapon is towed by any vehicle having a rating of 2.5 tonnes or greater. The seven-man crew and driver require approximately 3 minutes to emplace/displace the weapon. This weapon poses a threat similar to that posed by the US M-102 howitzer firing conventional ammunition. The M-56 is a good weapon but apparently not good enough to attract foreign purchasers.

V. YUGOSLAV 155-MM HOWITZER M-65

43. ~~(C)~~ Description and Performance

The Yugoslav 155-mm Howitzer M-65 (fig II-V-1) apparently is produced in limited quantities. Actually these weapons are reconditioned, slightly modified US 155-mm M114A1 howitzers that were provided to Yugoslavia by the United States. Subsequently, minor component modifications were made in these weapons by Yugoslavia. It is postulated that the M-65 became excess to Yugoslavia's needs upon the acquisition of the Soviet 130-mm M-46 and other relatively modern Soviet artillery weapons. It has become evident in recent years that, commensurate with the acquisition of larger quantities of Soviet artillery, the Yugoslavs primarily have restricted their R&D and manufacturing efforts to smaller caliber artillery weapons. As an excess item to Yugoslavia's needs, the M-65 is being offered for sale on the international armaments market.

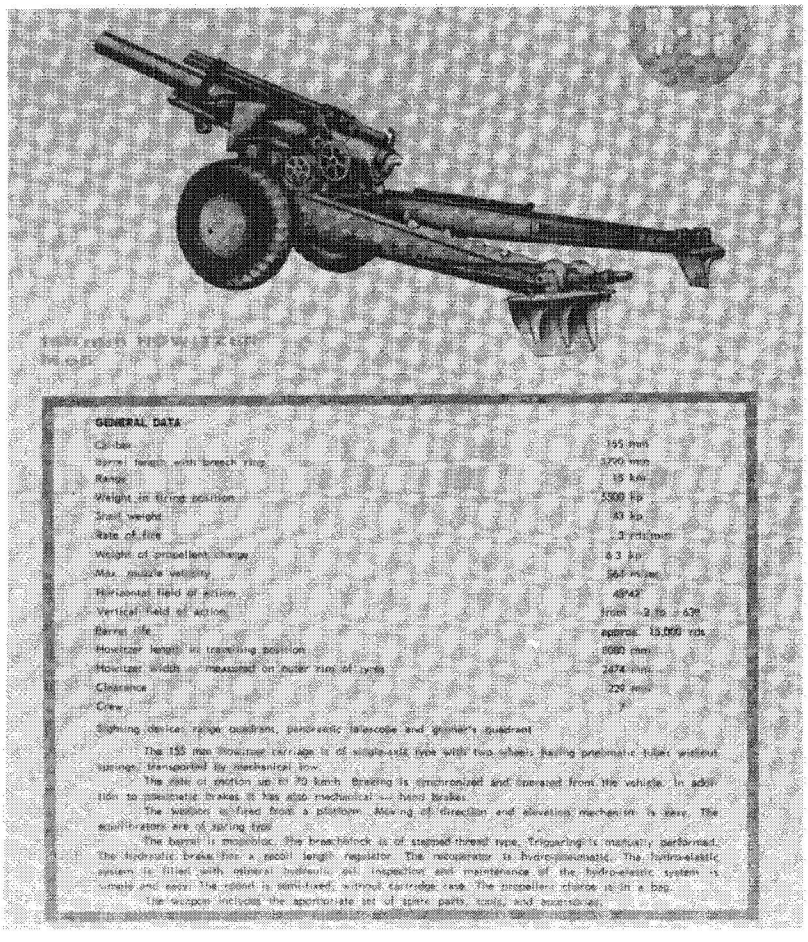

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Figure II-V-1. Yugoslav 155-mm M-65 howitzer, brochure (U).

44. ~~(C)~~ Capabilities and Configuration

Other than minor modifications to components (i.e., breechblock operating lever and external trail brackets), the M-65 has no apparent deviations from the US 155-mm M114A1 howitzer. The Yugoslav indicated 625 lb lesser weight is questionable. The claim of a range of 15 km (versus the 14.6 km attainable by the US M114A1) is fallacious. The length, width, tube, recoil mechanism, etc., are identical. The Yugoslavs produce an indigenous sight and projectile, but these are copies of equivalent US items. The M-65 fires all types of US 155-mm M114A1 howitzer ammunition.

W. PRC COPIES OF SOVIET FIELD AND ANTITANK ARTILLERY

45. ~~(C)~~ General

a. Historical Background. The PRC's Peoples Liberation Army (PLA) is equipped with field and antitank artillery that range in caliber from 57 through 152 mm. These weapons are either Soviet-manufactured PRC copies of Soviet weapons or indigenous reproductions of major assemblies of two Soviet weapons incorporated into a hybrid PRC system. Most Soviet-manufactured weapons held in the PRC inventory are from World War II to 1953 vintage; these cannon were supplied to the PRC during the period commencing with the Korean war and ending with the Sino-Soviet ideological split in the early sixties. Three exceptions to the substantial quantities of older equipment given to the PRC are the 130-mm M-46 field gun, the 152-mm D-20 gun-howitzer, and the 122-mm D-74 field gun, all of which are weapons of the early fifties. Soviet weapons are particularly well suited for use by the PRC owing to their rugged construction, simplicity of operation, reliability, and ease of maintenance. PLA artillery forces initially were dealt a severe blow when the Soviets stopped sending military aid in about 1962; however, PRC industrial production facilities reacted quite rapidly to the challenge and currently appear to be responsive to the needs of the PLA. PRC arsenals are capable of producing artillery in any caliber.

b. PRC Hybrid Cannon. The PRC type 59-1, essentially a 130-mm Soviet M-46 type gun tube mounted on a Soviet 122-mm D-74 type carriage, displays considerable design ingenuity. This weapon is described in section II-X and the M-46 and D-74 are described in sections II-J and II-H, respectively.

46. ~~(C)~~ Present and Possible Near-Term PRC Production of Soviet-Designed Cannon

a. Present Production. The designations of PRC-produced cannon systems of Soviet design are set forth in table II-W-1.

Table II-W-1. Designations of PRC-Produced Cannon of Soviet Design (U)

Weapon	PRC designation	Soviet designation
57-mm antitank gun	type 55	ZIS-2 (M-1943)
76-mm field gun	type 54	ZIS-3 (M-1942)
85-mm field gun	type 56	D-44 (M-1945)
100-mm field gun	type ?	BS-3 (M-1944)
122-mm howitzer	type 54	M-30 (M-1938)
122-mm field gun	type 60	D-74
130-mm field gun	type 59 ?	M-46
130-mm field gun	type 59-1	(M-46 tube, D-74 carriage)
152-mm howitzer	type 56	D-1 (M-1943)
152-mm gun-howitzer	type ?	ML-20 (M-1937)
152-mm gun-howitzer	type 66	D-20

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b. Possible Near-Term Production. It is envisioned that the PRC will obtain, or already has obtained, samples of the Soviet 122-mm D-30 howitzer from North Vietnam, and may produce indigenous copies of these weapons. Considering much of the terrain and the limited road net within the PRC, the most urgent operational requirement probably is for a mountain gun (pack howitzer) of modern design in the 85-mm to 100-mm class. There are indications that the PRC currently is placing emphasis on development and fielding of self-propelled field artillery. The PRC has fabricated one light self-propelled system by mounting what appears to be a PRC 122-mm type 54 field gun on an M-1967 APC chassis. Additionally, a new 155-mm self-propelled gun currently is reported to be under development; the alleged selection of 155-mm (rather than 152-mm) is most unusual.

X. PRC 130-MM FIELD GUN TYPE 59-1

47. ~~(C)~~ Description and Performance

a. (C) General. The PRC 130-mm Field Gun Type 59-1 (fig II-X-1) first was identified when one of these weapons was captured in Quang Tri Province, South Vietnam in July 1972. A towed weapon, the type 59-1 is

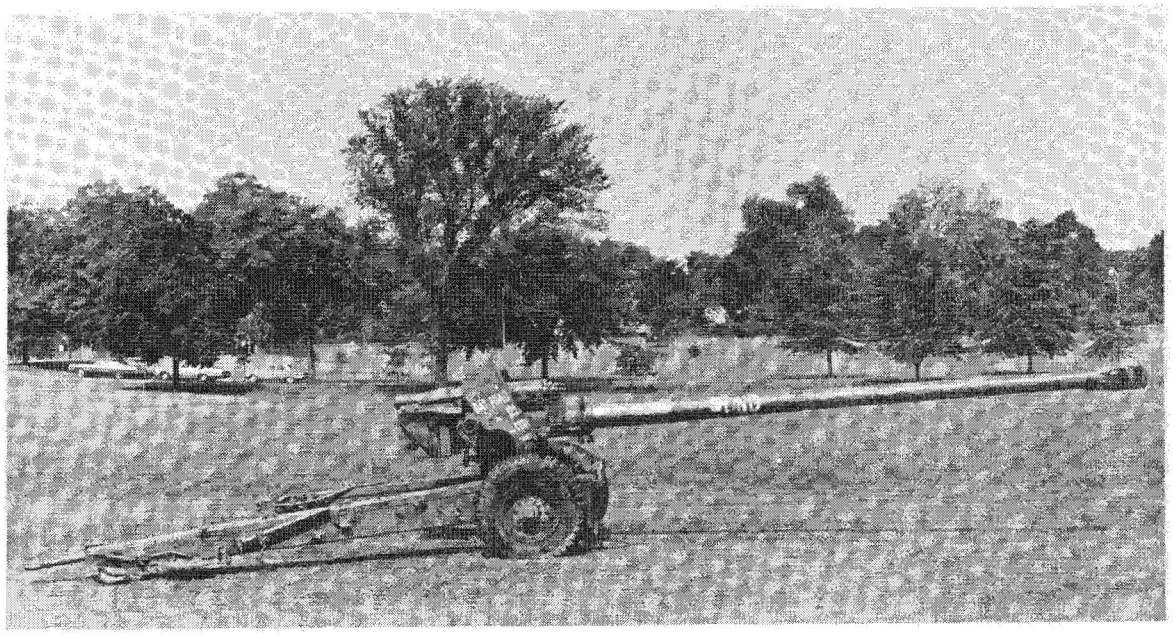

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Figure II-X-1. PRC 130-mm type 59-1 field gun (U).

a hybrid. Essentially, the type 59-1 consists of a copy of the Soviet 130-mm M-46 gun tube fitted with scaled-up versions of the 122-mm D-74's breech mechanism, muzzle brake, and recoil mechanism, all mounted upon a copy of the D-74's carriage. Unlike the Soviet M-46, the PRC type 59-1 does not require a limber. The tube remains in the in-battery position during travel. The type 59-1 can be employed in both the direct and indirect fire roles. The type 59-1 has an essentially straight topped, winged shield, whereas the shield of the PRC 122-mm type 60 has a scalloped top similar to the Soviet D-20 and D-74 systems. Neither the type 59-1 nor the type 60 have the movable central shield section found on the Soviet M-46 and D-74 guns. Tube lengths and diameters and shield configurations, as well as differences in the travel configurations, provide a means of discriminating between these weapons. The carriages common to the PRC types 59-1 and 60 and the Soviet D-74 and D-20 have a circular firing pedestal base that in the travel configuration is inverted to a position under the cradle, where it serves as a travel lock. In the travel configuration, the PRC type 59-1 weighs approximately 5.6 tonnes and is 10.98 meters long (including lunette), 2.4 meters wide, and 1.88 meters high to the top of the shield. The type 59-1 system is about the same weight as the Soviet 122-mm D-74 and approximately 2.8 tonnes lighter than the Soviet 130-mm M-46 in its travel configuration.

b. ~~(C)~~ Capabilities.

(1) ~~(C)~~ General. The PRC type 59-1 tube essentially is a copy of the tube used on the Soviet 130-mm M-46 field gun. The cradle and the carriage appear to be identical to those of the Soviet 122-mm D-74 and its PRC corollary the type 60. The recoil mechanism also appears to be the same as that used on these weapons but the outer diameter of the recoil brake cylinder actually is 10 mm (0.39 in) larger to provide additional braking for the higher energy 130-mm cannon assembly. The semiautomatic, vertical sliding-wedge breech and the double-baffle muzzle brake on the type 59-1 are similar to those same items as found on the Soviet 122-mm D-74. The chamber and bore of the type 59-1 tube are approximately the same dimensions as those of the Soviet 130-mm M-46. The M-46, when firing full charge, achieves a muzzle velocity of 930 m/s and a maximum range of 27 490 meters; it is believed that the PRC type 59-1 exhibits essentially the same performance. The prescribed rate of fire of the type 59-1 for periods of 1, 3, 5, 15, 30, and 60 min is estimated to be 5, 12, 20, 47, 70, and 100 full-charge rounds, respectively. Emplacement/displacement time for the type 59-1 is estimated to be about 3 min compared with about 4 min required for the Soviet M-46 gun. This improvement results from the type 59-1 not using a limber, plus its traveling in the in-battery configuration (rather than the out-of-battery configuration employed with the M-46). The approximately 1-meter added overall length of the type 59-1 will create difficulty in negotiating tight turns and narrow passages; nevertheless, this is estimated to be a tolerable disadvantage. Many of the parts and assemblies used in the PRC type 59-1 appear to be interchangeable with parts from the PRC 122-mm type 60 gun and/or the Soviet 122-mm D-74 or 152-mm D-20 weapons. Projectiles designed and produced for the Soviet 130-mm M-46 field gun are estimated to be compatible with the PRC 130-mm type 59-1 field gun (see table II-J-1). The unit of fire (UOF) desirably should be the same quantity as the Soviet UOF for the M-46 gun. Nevertheless, considering the generally smaller cargo capacity of PRC ammunition resupply vehicles, it is postulated that the PRC UOF may be but 65% to 75% of the Soviet UOF; i.e., about 50 rounds.

(2) ~~(C)~~ Indirect fire.

(a) ~~(C)~~ Precision. It is estimated that the precision of the type 59-1 is comparable to, if not exactly the same as, that of the Soviet 130-mm M-46 gun.

(b) ~~(C)~~ Effectiveness. The effectiveness of a type 59-1 unit should be the same as that of an M-46 unit of comparable size in the first 15 to 25 seconds of firing [para 19b(2)(b)]. Commencing at about 30 seconds and going to about 30 min of firing, the type 59-1 should be about 15% to 20% more effective due to its higher rate of fire, which increases the weight of projectiles delivered on target.

(c) (U) Fragmentation. The high explosive projectile used with the PRC type 59-1 is estimated to be equivalent to the high explosive projectile (OF-482M) used with the Soviet 130-mm gun M-46 [para 19b(2)(c)].

(d) (U) Lethality. The PRC 130-mm high explosive projectile is estimated to have the same lethality as the Soviet OF-482M projectile. Lethal areas for the Soviet OF-482M 130-mm high explosive projectile are provided in figures II-J-3 and II-J-4.

(3) ~~(C)~~ Direct fire. Ballistically, the direct fire capabilities of the PRC type 59-1 are estimated to be the same as those of the Soviet M-46 [para 19b(3)]. The type 59-1 may exhibit somewhat more jump than does the M-46. Conversely, its higher rate of fire and greater facility in effecting large shifts in direction should give the 59-1 an advantage over the M-46 in direct fire.

(a) (U) Precision, grazing range, effective range, and engagement range. These data are estimated to be the same for the type 59-1 as those data presented for the Soviet M-46 in paragraph 19b(3).

(b) ~~(C)~~ Armor penetration. Available information does not indicate whether armor piercing-tracer projectiles (similar to the Soviet 130-mm AP-T projectiles BR-482 or 482B) are available to PRC units equipped with the 130-mm type 59-1. Table II-J-4 provides penetration data for the Soviet 130-mm M-46, using full charge and projectiles BR-482 or BR-482B.

c. ~~(C)~~ Configuration. The type 59-1 carriage essentially is the same as the carriages of the PRC type 60 and the Soviet 122-mm D-74 field gun and 152-mm D-20 gun-howitzer. Numerous carriage parts probably are interchangeable among these weapons. The type 59-1 has 58° of on-carriage traverse (30° left and 28° right from center). Elevation limits are -6° and +44.5°. The recoil system is an independent, constant length, short-stroke, Schneider-type hydropneumatic mechanism. The cradle is of cast cylindrical design.

d. ~~(C)~~ Summary. The PRC 130-mm type 59-1 field gun is a high performance weapon that is lighter, more maneuverable, and has a higher rate of fire than its Soviet counterpart, the 130-mm M-46 field gun. The type 59-1 in the travel configuration weighs approximately 5.63 tonnes compared with 5.57 tonnes for the Soviet 122-mm D-74 and 8.45 tonnes for the 130-mm M-46 guns. Installation of a semiautomatic vertical sliding-wedge breechblock and the mounting of a tube equivalent to the Soviet 130-mm M-46 on the D-74-type carriage enabled the PRC to improve on the M-46's rate of fire. The type 59-1 has no limber, and, therefore, is quicker

and easier to emplace/displace than the M-46. In achieving these improvements, however, the PRC sacrificed some maneuverability in restricted areas and, possibly, some stability during firing compared with the M-46. In the travel mode, in confined or otherwise restricted areas, the rearward extension of the tube beyond the wheels was increased by approximately 1 meter compared with the M-46; this results from the weapon being transported in the in-battery configuration, as is the D-74, rather than in the out-of-battery configuration of the M-46. The PRC type 59-1 is simple, rugged, and durable in design and fabrication; it also is estimated to enjoy an extensive commonality of parts, with several other weapons currently in use (PRC type 60 and Soviet D-20, D-74, and M-46). It is postulated that the type 59-1 is comparatively easy and relatively economical to produce. It is simple to operate and maintain in the field; the RAM-D characteristics of this weapon should be excellent.

48. ~~(C)~~ Component Analysis

a. ~~(C)~~ Cannon.

(1) ~~(C)~~ Tube. The tube of the type 59-1 is a PRC copy of the Soviet M-46 tube. Of monoblock construction, it probably is not auto-frettaged. It is 6855 mm (52 calibers) long and is provided with deep (2.75-mm) rifling, having a uniform right-hand twist at the rate of one turn in 30 calibers. There are 40 lands and grooves. Land width is 3.96 mm and groove width is 6.2 mm. The tube of the type 59-1, as are the tubes on most Soviet cannon, is locked to the breechring by a separate threaded locking collar that engages a shoulder on the tube and is threaded to the breechring. The tube configuration of the type 59-1 is similar to that of the Soviet 130-mm M-46 gun and displays a similar pattern of tube wear. Tube wear life for the type 59-1 should approximate the 800 EFC rounds of the Soviet M-46.

(2) ~~(C)~~ Breechring. A semiautomatic, vertical sliding-wedge breechblock (fig II-X-2) is employed; it is very similar to the breech mechanism used on the Soviet 122-mm D-74 field gun, and most of the components are interchangeable between these two weapons. As with other similar breech mechanisms, this breech must be operated manually by rotating the handle downward to open the breech initially. Located on the right side, a semiautomatic cam engages the follower and rotates the operating crank to open the breech during recoil. When the breech is opened, the extractors eject the case, the firing mechanism is cocked, and the breech mechanism is latched. The breech closes automatically when the cartridge case is loaded. The firing lever and a recocking lever are located on the left side of the weapon. A round retaining lever (block) and safety interlock are provided in the breech mechanism. The breechring assembly, including the breechblock assembly (59 kg), weighs approximately 717 kg.

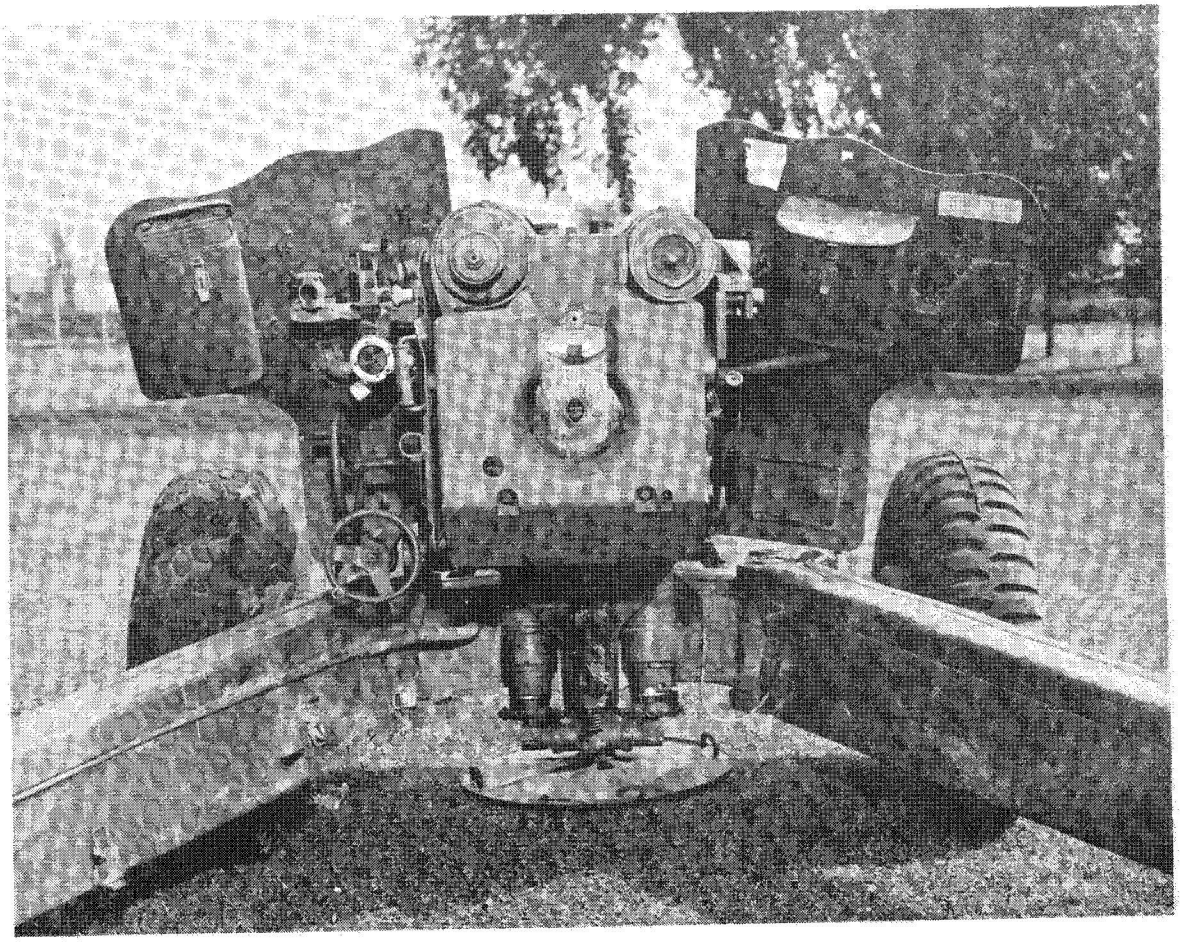

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Figure II-X-2. PRC 130-mm type 59-1 gun, rear view (U).

(3) ~~(C)~~ Muzzle brake. The muzzle brake is an open, double-baffle brake that appears to be a scaled-up version of the device used on the Soviet 122-mm D-74. A medium efficiency brake of cast construction, it is estimated to provide approximately 48% efficiency.

b. ~~(C)~~ Top Carriage.

(1) (U) General. The top carriage, which is constructed as a yoke, engages the top and bottom vertical pivot bearings mounted on the bottom carriage. It assembles to the top pivot and support bearing and lower pivot through a separate casting (fig II-X-3) that bolts on to the underside of the top carriage, thus forming a horizontal clevis over the bottom carriage. The cradle mounts to the top carriage through the

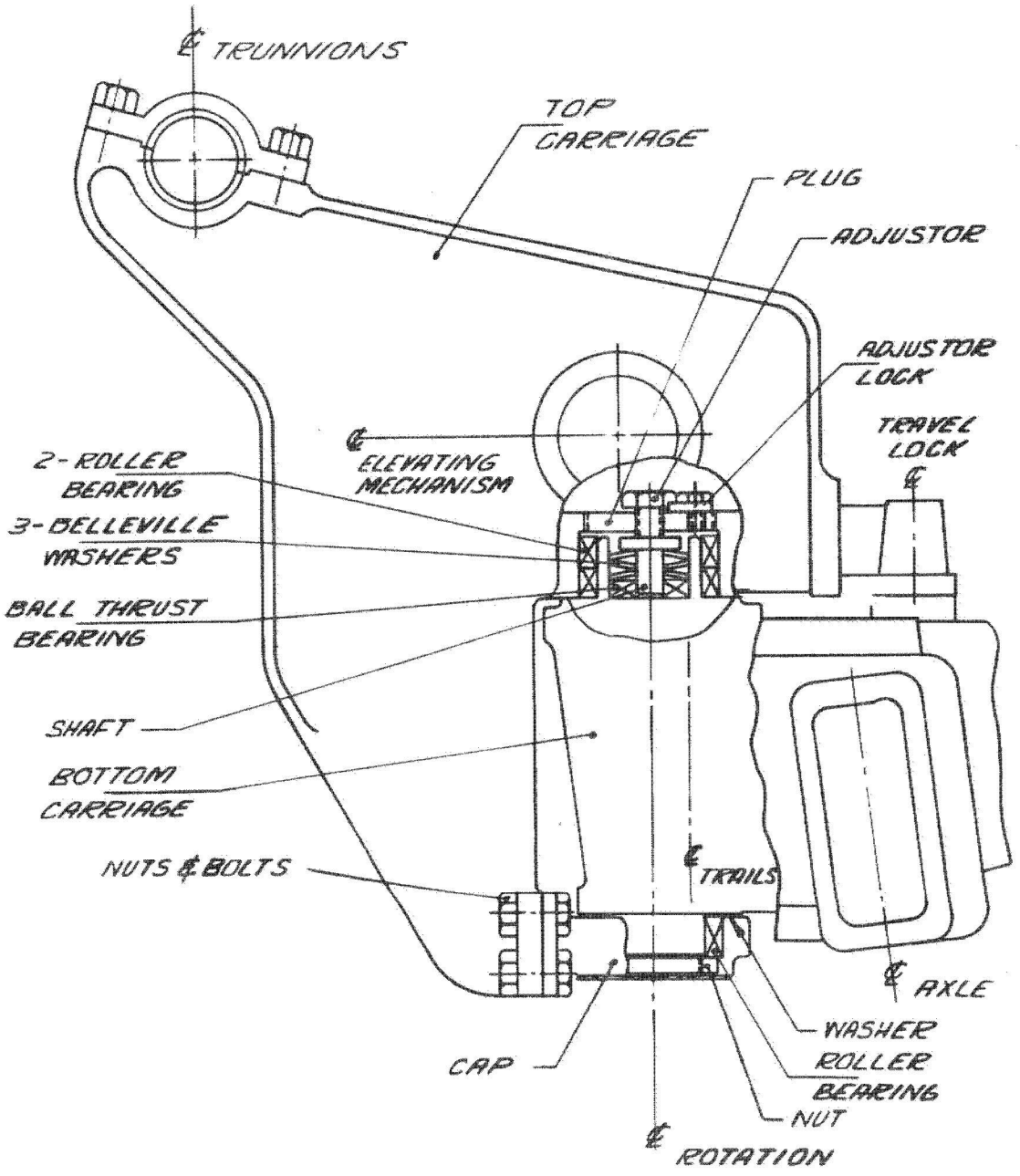

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Figure II-X-3. PRC 130-mm type 59-1; schematic of interface of top with the bottom carriage (U).

cradle's trunnion seats. The top carriage mounts the gun, recoil system, cradle, trunnion, elevating mechanism, on-carriage fire control, gun shield, and equilibrator, plus the pinion side of the traversing mechanism.

(2) ~~(C)~~ Cradle. This fixture (fig II-X-4) is a copy of the D-74's cradle (para 16b). The prolonged fixture mounted on the lower forward edge of the recoil brake cylinder, to retain the baseplate when that fixture is raised and placed in the travel configuration, differs in configuration from that fixture on the D-20 and D-74.

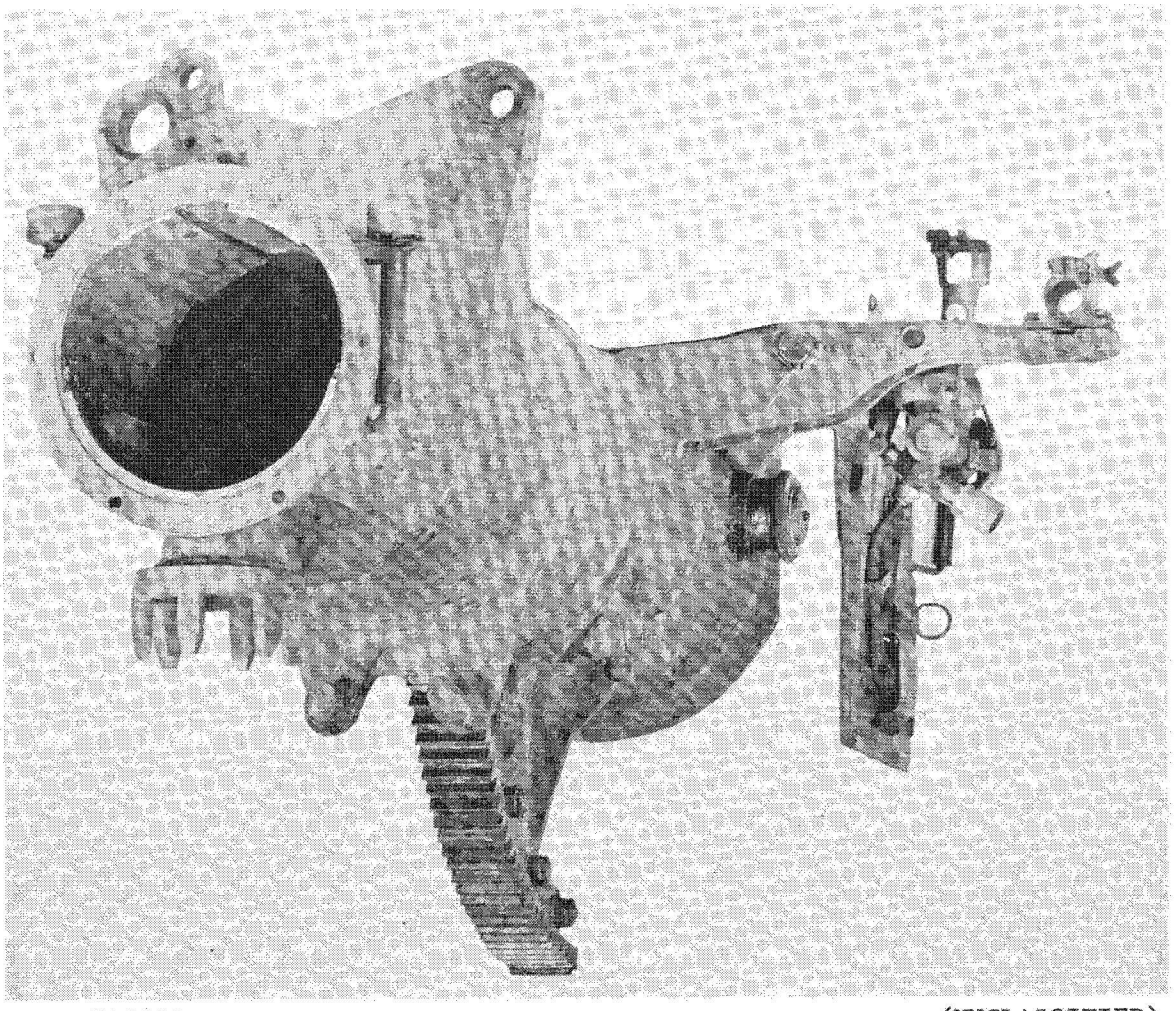

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Figure II-X-4. 130-mm type 59-1 gun; cradle (U).

(3) (U) Elevating mechanism. This mechanism is a copy of the conventional handwheel-operated rack-and-pinion type mechanism used on the D-20 and D-74. Elevation limits are -6° and +44.5°. Positioning in elevation is assisted by paired push-type pneumatic equilibrators.

(4) (U) Traversing mechanism. This component also is a copy of the mechanism used on the D-20 and D-74. Total on-carriage traverse is 58° (30° left and 28° right of center).

(5) ~~(C)~~ Recoil mechanism. A Schneider-type mechanism, essentially the same as that on the Soviet D-20 and D-74 weapons, is employed (fig II-X-5). This constant length of recoil, short stroke mechanism is charged with an estimated 14.7 liters of Steol M rather than oil. The recoil and recuperator cylinder bodies, fixed in a yoke on the breechring, recoil with the gun, as do the cylinders on the D-20 and D-74. The recoil cylinder is on the right and the recuperator cylinder is on the left. The recoil cylinder is approximately 0.4 in (10 mm) larger in outside diameter than is the recoil cylinder on the D-74. The recoil and recuperator cylinders operate independently of each other. Internal operation of the recuperator is conventional. In operation, the system is estimated to be charged with approximately 13.4 liters of Steol M and pressurized with dry air to 63.04 ±2.07 kg/cm^2 (897 ±29 lb/in^2), as is the D-74. Maximum length of recoil is 950 mm. The top of the recoil system is protected from fragments by a curved protecting plate made of steel.

(6) (U) On-carriage fire control. This equipment (fig II-X-6) consists of a panoramic telescope and a direct fire telescope that are mounted on a sight mount that has primary and micrometer elevation and site scales, associated linkages, and longitudinal and cross-level vials. Unlike similar Soviet sight mounts, the type 59-1 mount does not employ a range drum. Although PRC telescopes have not been available, the panoramic telescope used by the PRC is estimated to be of a type equivalent to the Soviet PG-1M and the PRC direct fire telescope is estimated to be equivalent to the Soviet OP4-28. A guard, fabricated of sheet steel, is mounted on the left side of the upper carriage to protect the gunner from the recoiling gun assembly. The firing and recocking levers are mounted on this guard. A handle, mounted on the upper rear edge of the guard, enables the crewman loading the weapon to obtain leverage during insertion of the projectile and/or cartridge case.

(7) (U) Crew protection. Protection for the crew is afforded by a bent shield having a straight top; the shield is fabricated from steel sheet. Unlike Soviet shields, the PRC type 59-1 shield does not have a traveling central section (scab shield). No lower or skirt shield is provided below the axle and between the wheels of this weapon.

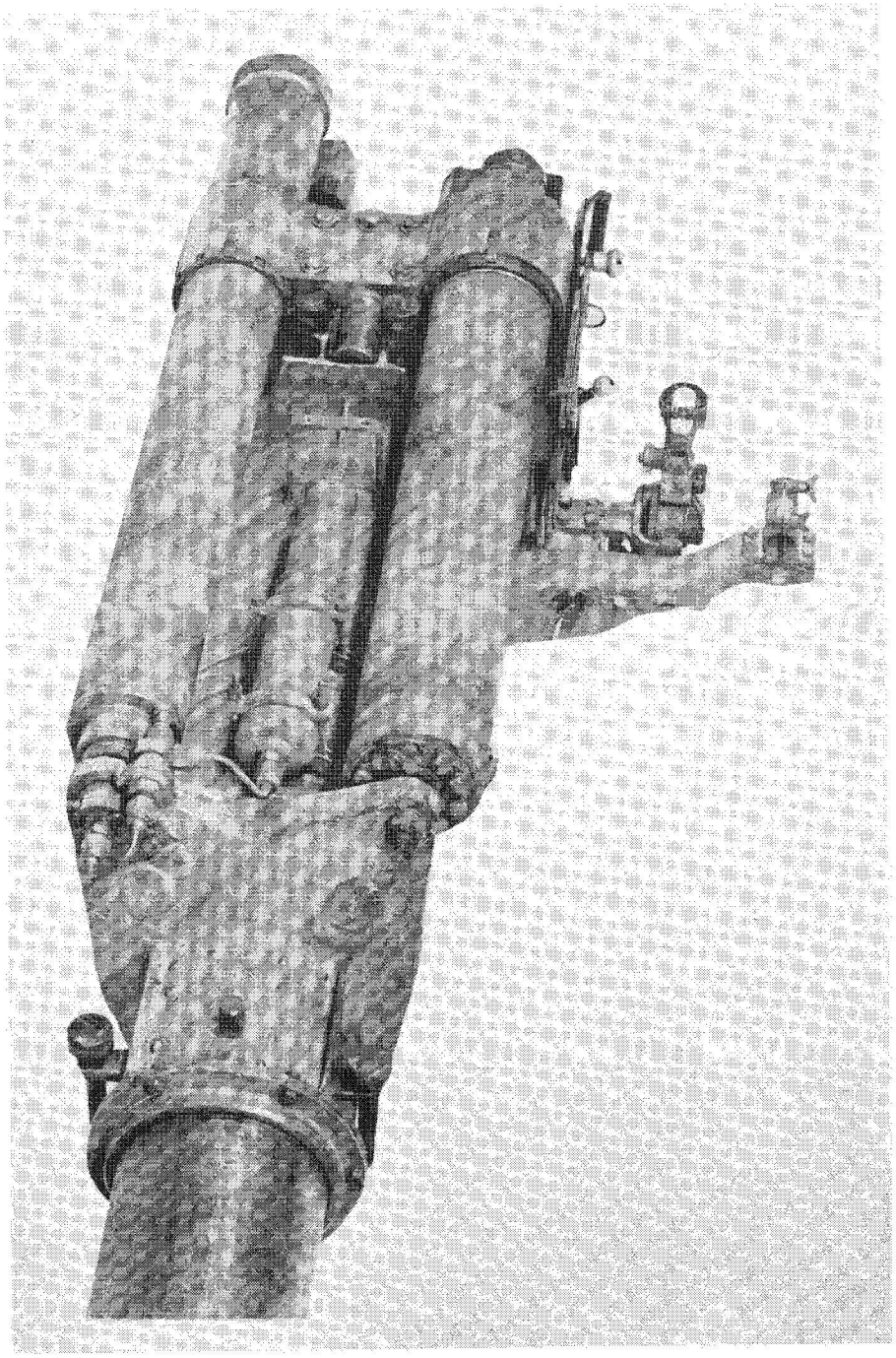

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Figure II-X-5. 130-mm type 59-1 gun; recoil mechanism (U).

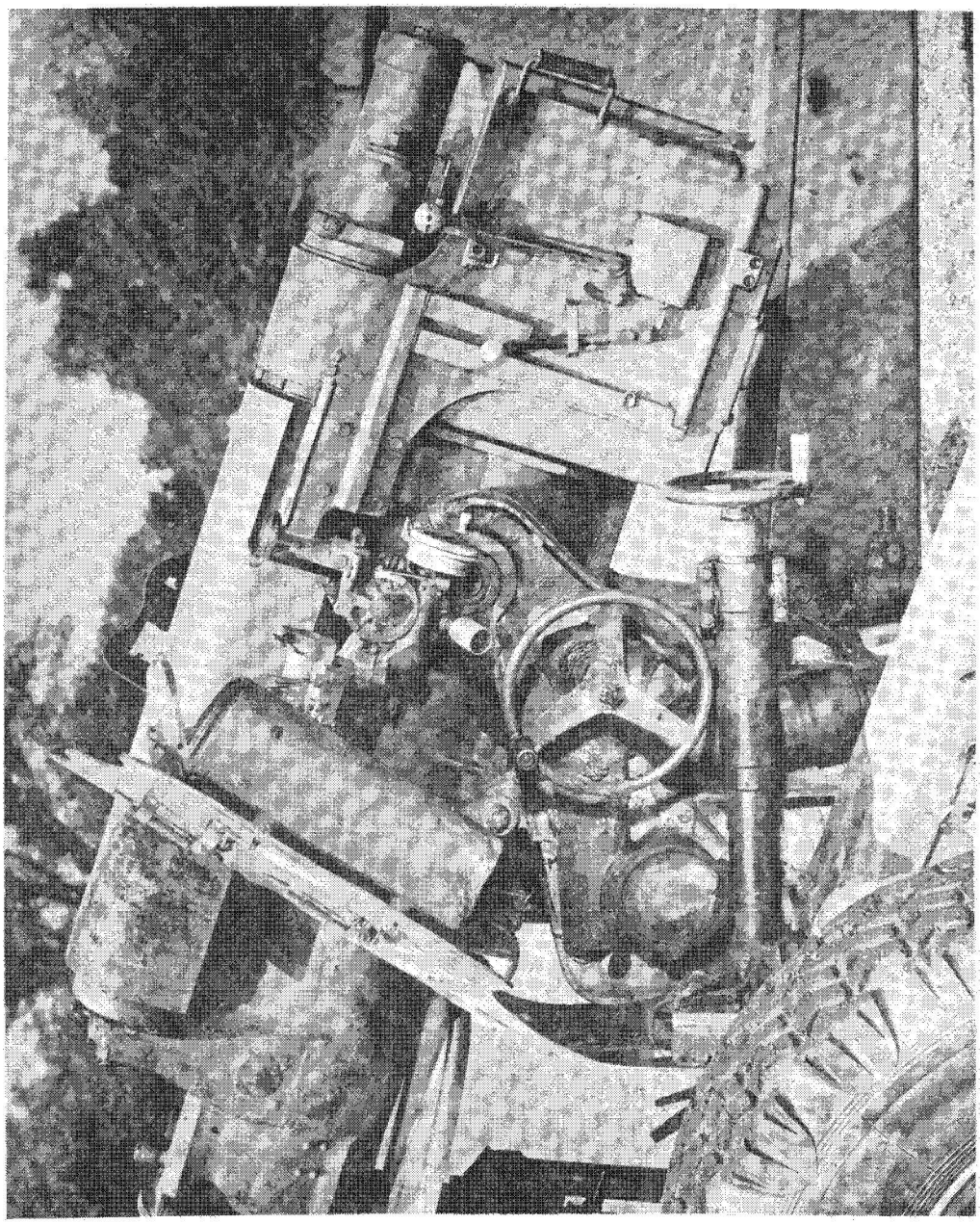

Figure II-X-6. 130-mm type 59-1 gun; left side (U). (UNCLASSIFIED)

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(8) ~~(C)~~ Equilibration. The equilibrator cylinders are copies of the D-20 and D-74 equilibrators; they are charged with approximately 0.5 liter of Steol M and pressurized to approximately 72.1 kg/cm^2 (1025 lb/in^2) at maximum depression and to approximately 46.1 kg/cm^2 (656 lb/in^2) at maximum elevation.

c. (U) Bottom carriage.

(1) (U) General. The bottom carriage, of split trail design, closely resembles the Soviet 122-mm D-74 and 152-mm D-20 bottom carriages. The top carriage is assembled to the bottom carriage through a pintle pin. Traverse is facilitated through the use of two sets of roller bearings at the top and one set of roller bearings at the bottom of the clevis fixture (fig II-X-3). Firing shock is attenuated through use of a set of ball thrust bearings and three heavy Belleville springs between the top and bottom carriages. The closure of the top carriage clevis is formed by a cast plate bolted to the lower extension of the top carriage. An adjusting nut is provided at the top of the pintle pin to enable the maintenance of proper tension against the Belleville springs.

(2) (U) Axles. The independent, torsion-bar suspended axles appear to be almost exact copies of the D-20 and D-74 suspension.

(3) (U) Wheels. The disk wheels (fig II-X-7) and the brakes are copied from the D-20 and D-74. The sponge rubber-filled tires mounted on this weapon are approximately the size of US 12:00x20s.

(4) (U) Trails. These fixtures and their associated items are copied from the D-20 and D-74.

(5) (U) Mobility. This weapon is towed as a semitrailed load in the same fashion as the Soviet D-20 and D-74; unlike the Soviet M-46, it does not utilize a limber. The PRC type 59-1 is estimated to have roadability comparable to the excellent mobility, stability, and tracking characteristics achieved with other torsion-bar suspended weapons of similar design.

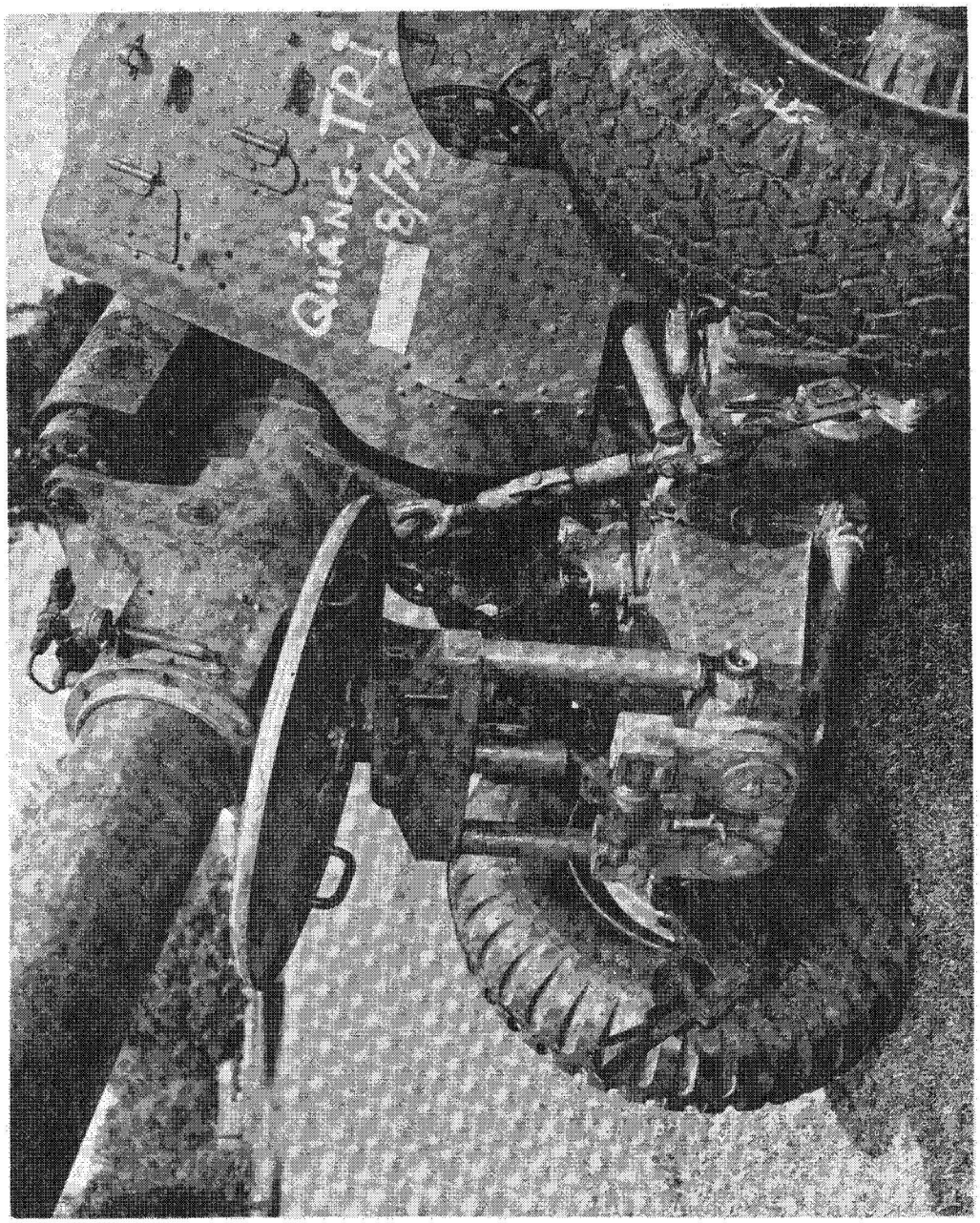

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Figure II-X-7. 130-mm type 59-1 gun; front left view (U). (UNCLASSIFIED)

Section III.

ANALYSIS OF LIMITED-STANDARD AND OBSOLESCENT ECC FIELD ARTILLERY CANNON SYSTEMS

A. OPERATIONAL AND TECHNICAL CHARACTERISTICS

1. (U) Analysis of Operational and Technical Characteristics

The analysis of ECC field artillery cannon systems, set forth in the following subsections, does not include all cannon systems within ECC. This is particularly true of some of the cannon systems employed by the less prominent European Communist countries such as Albania, Bulgaria, and Romania, and for the Far Eastern Communist countries of the PRC, North Korea, and Vietnam. These countries have limited quantities of cannon that are not only old and obsolete but whose systems technology is outmoded to the extent that unless these cannon are encountered in defensive positions their battlefield effectiveness would be minimal. Those outmoded systems that are still deployed are relegated to the augmentation of limited-standard equipment deployed for homeland defense. Free world cannon systems captured during the Korean and Vietnam wars, and in the possession of some Far Eastern Communist countries, are also excluded from this analysis. In short, the following cannon systems are not included in the analysis: Those that are obsolete, those void of significant and unique technical features, and those held in insignificant quantities.

2. ~~(C)~~ Summary of Operational and Technical Characteristics

Four tables (tables III-A-1 to III-A-4), which summarize the operational, technical, and tactical capabilities of each of the cannon systems addressed in this section, are provided in order to furnish a ready and comparative reference for the capabilities and significant characteristics of the cannon systems discussed in the following subsections. The categories of information in each table are those that most frequently have been the subject of inquiry and interest by US developers, tacticians, and field commanders. Some data contained in these tables are not repeated in the discussion of the individual systems.

Table III-A-1. General Characteristics (U)

Nomenclature	Year introduced status	Maximum range (m)	Measurement in travel position				Crew/w driver	Time to * emplace / displace (min)	Weight of fuzed HE projectile (kg)	Rate of fire (rd/min)		
			Weight (kg)	Length (mm)	Width (mm)	Height (mm)				1	15	30
Soviet Antitank and Dual-Purpose Field Guns												
57-mm antitank gun ZIS-2 (M1943)	1943 limited-standard	8400	1150	7030	1400	1380	5	0.6 / 0.6	3.70	25 (est)	?	?
57-mm APAT gun Ch-26	1959 limited-standard	8400	1450 (est)	7250 (est)	1650	1550 (est)	5	0.6 / 1	3.70	25 (est)	?	?
76-mm field gun ZIS-3 (M1942)	1942 limited-standard	13 300	1116	6095	1645	1375	6 (est)	0.6 / 0.6	6.20	15	85	115
85-mm field gun D-44 (M1945)	1945 limited-standard	15 650	1703	8340	1730	1420	6	1 / 1	9.54	10	60	90
100-mm field gun BS-3 (M1944)	1944 limited-standard	20 000	3450 (est)	9210	2200	(1435 to top of shield)	6	3 / 3	15.60	7	60	75
Soviet Field Guns and Howitzers												
122-mm field gun A-19 (M1931/37)	1936 obsolescent	19 750	8050	8900	2345	1860	?	8-10 / 8-10	25.0	5	50	75
152-mm howitzer M-10 (M1938)	1938 obsolescent	12 390	4550	7550	2100	1900	7	8-10 / 10	40.0	4	40	65
310-mm gun self-propelled (M1957)	1957 unknown	25 000+ (est)	65 000 (est)	15 970 (est)	3220	3170 (est)	12 (est)	5 (est) / 5 (est)	325 (est)	1	4	6

*Emplacement time is elapsed time from arrival on position until ready to accept lay or the first round is fired in direct fire. Displacement time is elapsed time from receipt of "March order" until gun first moves in departing the firing position.

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Table III-A-2. Tactical Considerations (U)

Nomenclature	Maximum range (m)	Principal task	Deployment		Position-Rear of FEBA		Principal prime mover	
			Assignment level	Operational level	Offense (m)	Defense (m)	Wheeled	Tracked
Soviet Antitank and Dual-Purpose Field Guns								
57-mm antitank gun ZIS-2 (M1943)	8400	Direct fire	MRB/MRR (non-Soviet Warsaw Pact)	AT bn, AT btry	50 to 300	50 to 500	ZIL-151/157 truck	AT-P arty tractor
57-mm APAT gun Ch-26	8400	Direct fire	Division (E Ger)	AT bn, AT btry	50 to 300	50 to 500	APAT, ZIL-151/7 truck	AT-P arty tractor
76-mm field gun ZIS-3 (M1942)	13 300	Direct fire, direct support	Div/Regt (Warsaw Pact, PRC, N Korea)	AT bn, AT btry, AT div, MVR Regt	100 to 3000	100 to 5000	ZIL-151, light trucks	AT-P arty tractor
85-mm field gun D-44 (M1945)	15 650	Direct fire, direct support	Division (non-Soviet Warsaw Pact)	AT bn	100 to 3500	100 to 5500	ZIL-485 amphibious truck	AT-P arty tractor, K-61 amphibious vehicle
100-mm field gun BS-3 (M1944)	20 000	Direct fire, general support, direct support	Division (PRC & Non-Soviet Warsaw Pact)	AT bn, AT btry	200 to 4000	100 to 5000	ZIL-157 truck	AT-P arty tractor
Soviet Field Guns and Howitzers								
122-mm field gun A-19 (M1931/37)	19 750	General support	Army, front (PRC, N Korea, Bulgaria)	Army, How div, Arty div	3500 to 5500	4500 to 7500	ZIL-135 TATRA-813	AT-S, medium arty tractor
152-mm howitzer M-10 (M1938)	12 390	General support	Army (PRC)	Arty bn, how div	2000 to 4000	2500 to 6000	ZIL-151 truck	AT-S, medium arty tractor
310-mm gun self-propelled (M1957)	25 000+ (est)	General support	Reserve of Supreme high command (Soviet)	Army	6000 to 11 000 (est)	8000 to 14 000 (est)	SP	SP

~~(CONFIDENTIAL)~~

Table III-A-3. Performance in Indirect Fire (U)

Nomenclature	Types of ammunition available	HE projectile designation	Lethality of HE projectile			Probable errors in range at percentages of maximum range					
			Average number of fragments	Average fragment weight (g)	Average initial fragment velocity (m/s)	90%		70%		30%	
						Range	PE_r(m)	Range	PE_r(m)	Range	PE_r(m)
Soviet Antitank and Dual-Purpose Field Guns											
57-mm antitank gun ZIS-2 (M1943)	HE	O-271U	548	6.3	660	7 560	32	5 880	25	2520	18
57-mm APAT gun Ch-26	HE	O-271U	548	6.3	660	7 560	32	5 880	25	2520	18
76-mm field gun ZIS-3 (M1942)	HE	OF-350	5 973	0.907	705	11 970	68	9 310	50	3990	26
85-mm field gun D-44 (M1945)	HE, WP	O-365K, O-367A	3 820	2.333	698	14 100	52	11 000	40	4700	22
100-mm field gun BS-3 (M1944)	HE, WP	OF-412	6 408	2.074	568	18 000	89	14 000	68	6000	36
Soviet Field Guns and Howitzers											
122-mm field gun A-19 (M1931/37)	HE, WP, CP	OF-471N	3 616	5.2	945	17 800	94	13 800	72	5900	36
152-mm howitzer M-10 (M1938)	HE, CP	OF-530 O-530A	13 160 79 900	2.5 0.40	956 855	11 200	47.0	8 700	32	3700	20
310-mm gun self-propelled (M1957)	HE?, CP?, NUC ?	?	?	?	?	?	?	?	?	?	?

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Table III-A-4. Performance in Direct Fire vs. Armored Vehicles (U)

Nomenclature	Type of ammo	Projectile designation	Grazing range		Effective (50% probability of a first round hit) range vs type target		Penetration of armor at 0° obliquity				
							Kinetic energy projectile			Chemical energy projectile	
			Target height (m)	Range (m)	Type target	Range (m)	Designation	Range (m)	Penetration (mm)	Designation	Penetration (mm)
Soviet Antitank and Dual-Purpose Field Guns											
57-mm antitank gun ZIS-2 (M1943)	AP-T	BR-271 SP	2	1100	NATO	1230	BR-271 SP	1000	96		
57-mm APAT gun Ch-26	AP-T	BR-271 SP	2	1100	NATO	1230	BR-271 SP	1000	96		
76-mm field gun ZIS-3 (M1942)	HEAT	BK-354M	?	?	?	?				BK-354M	300
	HVAP-T	BR-354P			2 m	774	BR-354P	1000	58		
	AP-T	BR-350, BR-350A, BR-350B	2	780	?	?	BR-350B	1000	61		
85-mm field gun D-44 (M1945)	HVAP-T	BR-367P	2	1120			BR-367P	1000	178		
	HEAT-SS	BK-2M	?	?						BK-2M	≈200+
	AP-T	BR-367	2	970	NATO	914	BR-367	1000	122		
100-mm field gun BS-3 (M1944)	HEAT-FS	ZBK-5M	2	1070	M60A1	1450				ZBK-5M	390
	AP-T	BR-412B	NATO	1360	NATO	1040	BR-412B BR-412	1000 1000	157 135		
	APC-T	BR-412D	2	1150	NATO	1040	BR-412D	1000	170		
	HVAP-DS-T	BM-8	2	1230	?	?	BM-8	1000	310		
Soviet Field Guns and Howitzers											
122-mm field gun A-19 (M1931/37)	AP-T	BR-471 BR-471B	2	900	NATO	1000 (est)	BR-471 BR-471B	1000 1000	131 160		
152-mm howitzer M-10 (M1938)	CP	G-530	2	700							
	SAP	VF-536M dp	3	580	?	?					
310-mm gun self-propelled (M1957)	CP ?	?	?	?	?	?					

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B. SOVIET ANTITANK AND DUAL-PURPOSE FIELD GUNS

3. ~~(C)~~ 57-mm Antitank Gun ZIS-2 (M1943)

a. ~~(C)~~ Description and Performance.

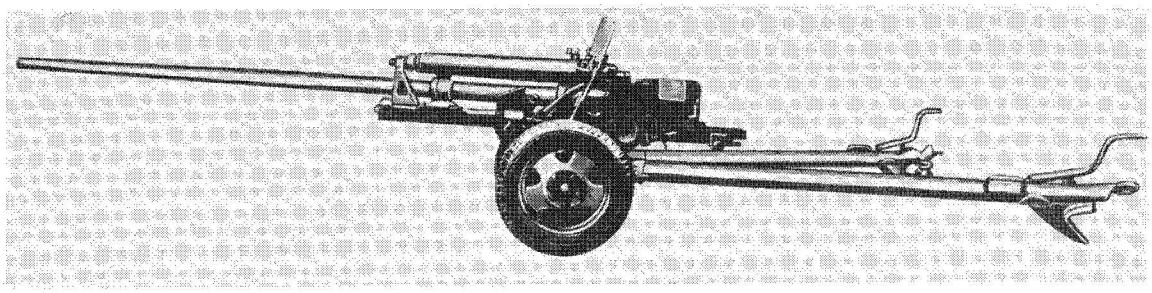

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Figure III-B-1. Soviet 57-mm antitank gun ZIS-2 (M1943) (U).

(1) ~~(C)~~ General. The 57-mm ZIS-2 (fig III-B-1), first deployed around 1943, was a product improvement of the M1941 antitank gun, which was intended to be a replacement for the 45-mm antitank gun. The ZIS-2 was found in the rifle battalion and rifle regiment, as well as in reconnaissance and motorized infantry elements of mechanized and tank divisions. It was later replaced by antitank guns of heavier caliber, and still later by the SPG-9 recoilless rifle. Nevertheless, a recent report states that a second-echelon motorized rifle division was equipped, through June 1971, with 57-mm antitank ZIS-2 guns and 76-mm ZIS-3 field guns towed by ZIL-157 trucks. In addition, a number of (if not all) Soviet 100-mm T-12A antitank battalions have one ZIS-2 per battery, probably for service practice.

(2) ~~(C)~~ Capabilities. Maximum range when using the HE projectile is 8400 meters and the rate of fire is 20 to 25 rd/min. The prime mover is usually a modified AT-P artillery tractor. Permissible rates of ground travel are 50 km/h and 30 km/h on hard-surfaced and secondary roads, respectively, and 10 km/h off-road. It is estimated that, depending upon the prime mover used, up to 200 rounds of ammunition may be transported with the gun. This ammunition may be a mix of the following: HE, AP-T, and HVAP-T. Characteristics of projectiles most commonly used with the ZIS-2 are shown in table III-B-1a.

Table III-B-1a. Projectiles, 57-mm ZIS-2 Antitank Gun (U)

Type of ammo	Model	In-flight weight (kg)	Muzzle velocity (m/s)	Penetration, 1000-meter range at 0° obliquity (mm)
HE	O-271 U	3.70	700	--
AP-T	Br-271 SP	3.14	990	96
HVAP-T	Br-271 P	1.76	1270	94

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(a) ~~(C)~~ Indirect fire.

1. (U) Precision. This weapon seldom if ever is used in indirect fire. Nevertheless, probable errors (PE_r, PE_d, and PE_v) for various percentages of maximum range when using the fragmentation shell O-271 U are shown in table III-B-1b.

Table III-B-1b. Probable Errors, 57-mm ZIS-2 Antitank Gun; Indirect Fire (U)

Appropriate percentage of maximum range (8400 meters) (measurement in meters for various percentages)	PE_d (m)	PE_r (m)	PE_v (m)
90 (7560)	4.0	32	22.0
70 (5880)	2.7	25	11.0
50 (4200)	1.6	19	3.5
30 (2520)	1.1	18	1.4

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2. ~~(C)~~ Fragmentation. The standard O-271 HE projectile fired by the 57-mm ZIS-2 antitank gun has a forged steel body. This projectile, having a charge-to-mass ratio of 0.071:1, bursts into an average of 548 fragments. Mean fragment mass is 6.3 grams (97 grains) and average initial fragment velocity is 660 m/s (2165 ft/s).

3. ~~(C)~~ Lethality. The fuzed O-271 projectile has the options of quick, nondelay, and short delay action. Time fuze apparently is not available for this system. At angles of fall of less

than 20°, the short delay fuze option permits the delivery of ricochet fire. Lethal areas for zero height-of-burst against personnel in the open are presented in table III-B-1c. Lethal area estimates against standing personnel in the open employing ricochet fire are 96, 104, and 98 m^2 at heights-of-burst of 2, 5, and 10 meters, respectively.

Table III-B-1c. Lethal Areas; Soviet 57-mm Projectile O-271 Against Personnel in Open Terrain (U)

Target posture	Lethal areas (m^2) at zero height-of-burst*			
	Angle of fall (degree)			
	15°	30°	45°	60°
Standing	82	91	110	144
Prone	28	31	36	46
Foxhole	0	0	0	0

*Assault 5-minute casualty criteria. ~~(CONFIDENTIAL)~~

(b) ~~(C)~~ Direct fire.

1. (U) Precision. Table III-B-1d presents probable errors for the ZIS-2 using AP-T projectiles (BP-271) in its primary role as a direct fire weapon.

2. (U) Grazing range. Soviet firing tables show that the grazing range in direct fire of the AP-T projectiles versus a 2.5-m-high target is 1250 meters; against a 3-m-high target, grazing range is 1350 meters; and against a 2-m-high target it is 1100 meters. Nevertheless, note the limited armor penetration shown in table III-B-1a.

3. ~~(C)~~ Effective range. Hit probabilities calculated for the HVAP-T projectile are shown in table III-B-1e. Calculated effective range (50% probability of a first round hit) is 1230 meters.

4. ~~(C)~~ Engagement range. Soviet doctrine prohibits firing the BP-271P HVAP-T projectile against tanks at ranges beyond 1000 meters; this due to poor armor penetration.

5. (U) Armor penetration. Soviet firing tables disclose that at 0° obliquity the 57-mm AP-T projectiles penetrate 96 mm of armor at 1000 meters; at 30° obliquity the penetration is 78 mm.

Table III-B-1d. Probable Errors for the 57-mm ZIS-2 Antitank Gun, Direct Fire, AP-T Projectiles (U)

Range (m)	PE_v (m)	PE_d (m)
500	0.09	0.12
1000	0.18	0.20
1500	0.28	0.27
2000	0.37	0.35
3000	0.52	0.57
4000	0.68	0.76

(UNCLASSIFIED)

Table III-B-1e. Probability of a First-Round Hit, 57-mm BP-271P HVAP-T Projectile (U)

Range (m)	Hit probability*
500	0.95
1000	0.67
1230	0.50
1500	0.30
2000	0.11

*Against 2.3x2.3-meter NATO target. (~~CONFIDENTIAL~~)

b. (U) Configuration. The weight of the 57-mm ZIS-2 in firing position is approximately 1150 kg. This configuration has a length, height, and track width of 7.03, 1.38, and 1.4 meters, respectively.

(1) (U) Cannon assembly. This gun is 73 calibers long, of monoblock construction, and equipped with a vertical sliding-wedge, semiautomatic breechblock. The 4160-mm-long tube is rifled with 24 grooves having an inclination of 5°58'41". Maximum gas pressure is 3100 kg/cm^2.

(2) (U) Carriage. This assembly consists of the recoil system, cradle, top and bottom carriages, laying mechanisms, equilibrator, suspension system, and sighting mechanism.

(3) (U) Cradle. This U-shaped fixture is supported in the trunnion bearings of the top carriage. A trigger mechanism is positioned on the left side of the cradle and the recoil brake is inside the cradle. Compensation for muzzle preponderance is provided by a spring-type equilibrator.

(4) (U) Recoil system. This system is composed of a hydraulic brake filled with 4.4 liters of Steol M and a hydropneumatic counterrecoil mechanism filled with 4.27 liters of Steol M plus dry air under an initial pressure of 32.0 to 34.1 kg/cm^2. The recoil brake is provided with a replenisher. The recoil and counterrecoil cylinders are located below and above the gun tube, respectively, and recoil with the gun. The normal recoil length is 970 to 1060 mm; maximum length of recoil is 1100 mm.

(5) (U) Positioning limits. The elevating limits of the rack-type elevating mechanism are -5° and +25°. A PP1-2 or PP2 sight is located on the left side of the top carriage. The sight and its mount have provisions for cross-leveling, reticle illumination, and the setting of elevation, range, site, and deflection data. The screw-type traversing mechanism is also assembled to the left side of the top carriage, and total on-carriage traverse is 57°.

c. (U) Summary. The primary role of the 57-mm ZIS-2 AT gun is the destruction of tanks and armored vehicles. Its secondary role is to destroy infantry weapons and troops in the open, usually by direct fire. The weapon proved to be very effective in its antitank role until late in World War II. Subsequent increases in the thickness of armor and the range of tank cannon generated a requirement for antitank weapons of heavier caliber, thereby considerably diminishing the role of the ZIS-2. Significant numbers of this weapon still are retained in the Soviet Union and other Warsaw Pact countries. Although this weapon does not pose a major threat to modern medium tanks, it should prove to be deadly against APCs and other lightly armored vehicles.

4. ~~(C)~~ 57-mm Auxiliary-Propelled Antitank Gun Ch-26

a. ~~(C)~~ Description and Performance.

(1) ~~(C)~~ General. The 57-mm auxiliary-propelled antitank gun (APAT) Ch-26 (fig III-B-2a) was designed to afford increased mobility to the 57-mm antitank gun ZIS-2 (M1943). The 57-mm APAT differs considerably in physical characteristics from the 57-mm ZIS-2 although the two weapons are ballistically identical. The Ch-26 has a shorter barrel and a double-baffle muzzle brake; its recoil system is more compact and the

hollow trails serve as fuel containers (35.9-liter capacity) for the auxiliary engine. The APAT replaced some antitank weapons of lesser caliber and augmented the towed M1943. Greater armor thicknesses and the increasing range of tank cannon necessitated a phasing out of the 57-mm APAT in favor of larger caliber AT weapons such as the 76-mm and 85-mm field gun, the 85-mm APAT, and the 100-mm field and antitank guns.

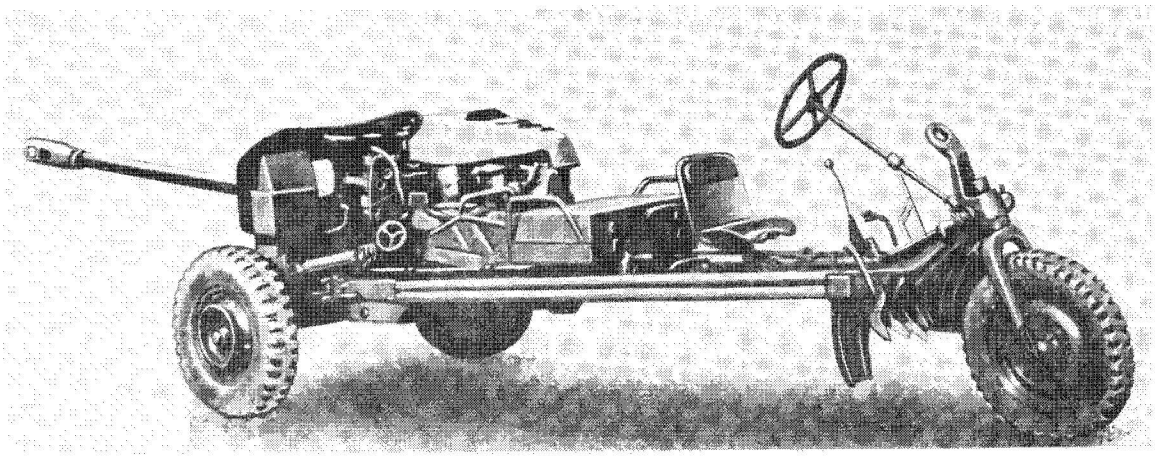

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Figure III-B-2a. 57-mm auxiliary-propelled antitank gun Ch-26 (U).

(2) (U) Capabilities. The maximum range, rates of fire, prime movers, towed road speeds, and types of ammunition for the Ch-26 are the same as for the ZIS-2 [para III-B-3a(2)]. Additionally, the APAT is capable of self-propulsion (fig III-B-2b). The weapon, carrying its crew of five, can move at speeds of 24 to 29 km/h over surfaced roads and smooth hard terrain. The auxiliary-propulsion unit consists of an engine, power train, transmission, steering mechanisms, and associated controls. The engine is a two-cylinder, four-cycle, air-cooled, 750-cm^3 motorcycle-type engine rated at 13.2 kW (18 hp). The gear-shift lever and clutch pedal are located on the right trail adjacent to the spade. Power can be transferred to each wheel independently by means of a power transfer lever on the rear wheels. The dual range transmission can be operated from the driver's seat or from a position near the engine by engaging an auxiliary selector.

(a) (U) Indirect fire. The performance of the 57-mm APAT in indirect fire is the same as that of the 57-mm ZIS-2 [para III-B-3a(2)(a)].

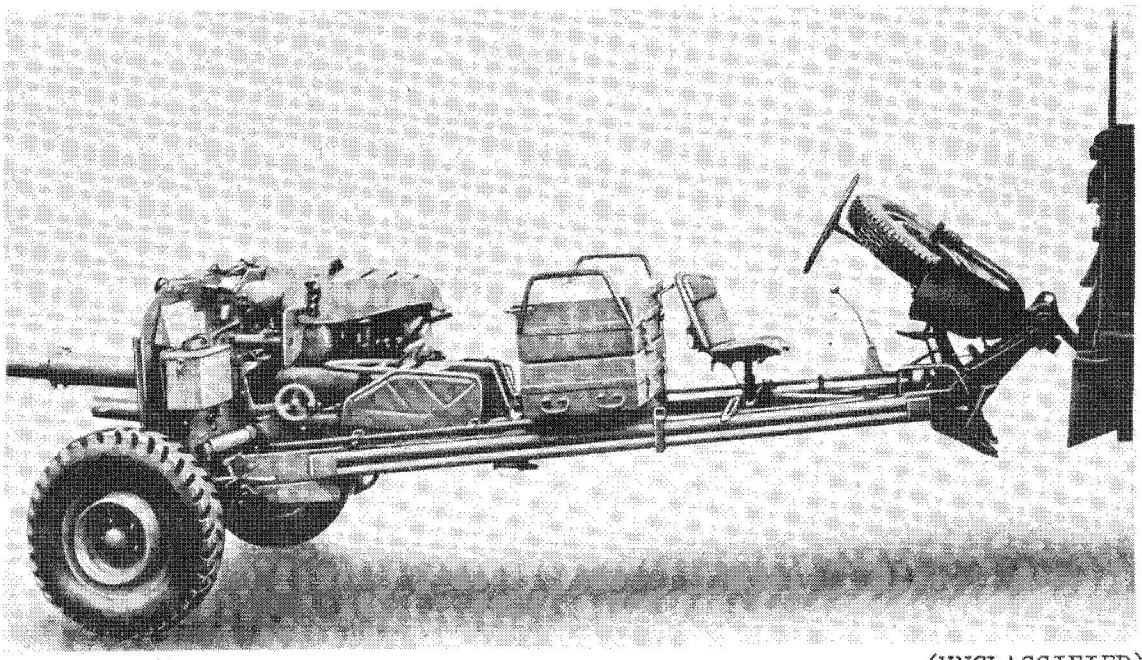

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Figure III-B-2b. 57-mm Ch-26 gun in towed travel position (U).

(b) (U) Direct fire. The 57-mm APAT is more maneuverable than the 57-mm ZIS-2; this greater maneuverability affords the APAT a tactical advantage over the ZIS-2. Nevertheless, its ballistic performance is the same as that shown for the ZIS-2 [para III-B-3a(2)(b)].

b. ~~(C)~~ Configuration. The major subassemblies of the 57-mm APAT are the barrel and breech assemblies, top and bottom carriages, auxiliary-propulsion unit, and fire control equipment. The basic carriage of the ZIS-2 has been slightly modified to incorporate the auxiliary propulsion unit. A third wheel, which supports the trail ends in the auxiliary-propelled travel position, is pivoted upward against the steering column during firing.

(1) ~~(C)~~ Cannon assembly. The barrel of the APAT is approximately 0.6 meters shorter than that of the ZIS-2. A muzzle brake that absorbs about 50% of the recoil energy is attached to the barrel. The vertical sliding-wedge, semiautomatic breechblock is manually closed by a lever on the right side of the breech. The gun is hand-loaded and lever-fired.

(2) ~~(C)~~ Recoil mechanism. The presence of a hydrospring recoil system is unusual on towed weapons, this being the first known application by the Soviets of this type of recoil on a field artillery piece.

(3) ~~(C)~~ Positioning limits. This weapon has the same limits as those of the 57-mm ZIS-2 [para III-B-3b(5)].

(4) ~~(C)~~ Fire control. In addition to the sighting system found on the ZIS-2, an active infrared illuminating source and IR detecting gunsight are employed on the 57-mm APAT for direct fire at night. Estimated maximum detection range is 800 meters.

(5) ~~(C)~~ Wheels. The sponge-filled tires are fitted with flanged rims that facilitate the attachment of a winch cable so the gun can pull itself free from mud and sand by its own power.

c. ~~(C)~~ Summary. The 57-mm Ch-26 APAT was developed to meet the increasing mobility requirements for towed antitank gun systems. Although ballistically outdated in its ability to defeat modern tanks, this versatile, lightweight weapon remains a threat to APCs and other lightly armored targets. No longer used in the Soviet Union, the Ch-26 is still deployed in the East German, Czechoslovak, Hungarian, Polish, and Romanian Armies.

5. ~~(C)~~ 76-mm Field Gun ZIS-3 (M1942)

a. ~~(C)~~ Description and Performance.

(1) ~~(C)~~ General. The 76-mm field gun ZIS-3 (M1942) (fig III-B-3a) is the third-generation weapon in the Soviet family of 76-mm divisional guns. The 76-mm divisional gun F-22 (1936) was, for its day, an exceptionally effective weapon; many weapons of this model were captured and used extensively by the Germans in World War II. The second-generation weapon in this series, the 76-mm USV divisional gun (1939), had a shorter tube, smaller disk wheels, a superior rate of fire (15 rd/min), and greater penetration when using APHE-T ammunition than did the F-22.

(a) (U) The 76-mm divisional gun ZIS-3 (1942), redesignated the 76-mm field gun ZIS-3 (M1942), is identical to the USV except for being fitted with a muzzle brake and mounted upon a modified, tubular-steel, split trail 57-mm antitank gun carriage. Adopted in February 1942, this weapon is remarkable for its light weight and mobility. During World War II, this weapon frequently was in position and firing when the German 105's were bogged down and out of action. This weapon was the standard light field piece in first-echelon Soviet rifle divisions in the last half of, and subsequent to, World War II. The ZIS-3 is a dual purpose weapon that furnished both close support and direct (antitank) fire support to Soviet maneuver elements. Prescribed time for coming to a halt, preparing for action, and firing the first round in direct fire is 30 to 40 seconds. A

remarkable weapon for its day, the major deficiency of the ZIS-3 is an outgrowth of one of its major advantages; although its lightweight [1116 kg (2460 lb) in firing position] makes this weapon highly maneuverable, it causes this gun to be somewhat unstable in firing. Length from muzzle to spades with trails closed is 6.095 meters and track width to tire center is 1.40 meters. Height of the axis of the bore is 0.90 meters.

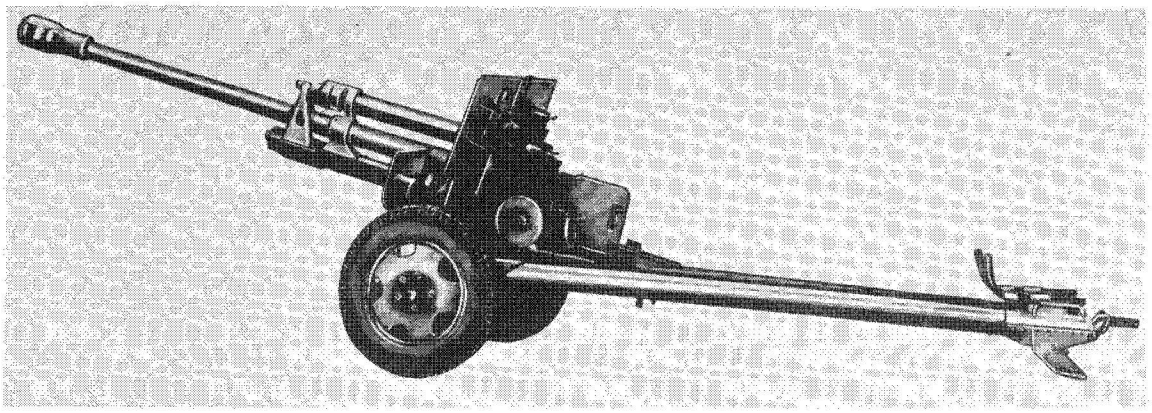

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Figure III-B-3a. Soviet 76-mm field gun ZIS-3 (M1942) (U).

(b) ~~(C)~~ The rapid trend toward greater armor thickness and the higher energy tank guns that emerged late in World War II engendered the development of the larger caliber and higher energy 85- and 100-mm field guns as replacements for the ZIS-3. Nevertheless, this weapon remains deployed in battery strength to some Soviet and all Warsaw Pact units. Several ZIS-3's also are issued to some artillery battalions armed with 122-mm, 130-mm, and 152-mm weapons. Originally, these ZIS-3's appeared to be used for service practice only; however, since introduction of a 75-mm fin-stabilized HEAT round, these weapons have more recently been observed apparently protecting logistical columns and the truck park and flanks of batteries deployed in the field.

(2) ~~(C)~~ Capabilities. The ZIS-3 fires the 6.2-kg HE OF-350 projectile to a range of 13 300 meters at a prescribed rate of 15 rd/min. Three types of antimateriel ammunition are available: HEAT, AP-T, and HVAP-T. The HVAP-T round, having a muzzle velocity of 950 m/s, penetrates about 100 mm and 60 mm of armor at ranges of 500 and 1000 meters, respectively, at 0° obliquity. A recent report identifying a 76-mm fin-stabilized HEAT round indicates that the Soviets have upgraded the performance of 76-mm armor-defeating ammunition. Maximum armor penetration of this round is estimated to be 300 mm, 260 mm, and 212 mm at obliquities of 0°, 30°, and 45°, respectively. In addition to the antimateriel

types of ammunition, this gun has fired several different models of HE shells and three types of shrapnel, as well as incendiary and smoke projectiles. The ZIS-3 was, and is, towed by any of a number of the currently standard artillery prime movers. It may be towed at speeds of 50 km/h on hard-surfaced roads, 30 km/h on dirt roads, and 10 km/h off-road.

(a) ~~(C)~~ Indirect fire.

1. (U) Precision. Data for the OF-350 HE-fragmentation projectile when using full charge are shown in table III-B-3a.

Table III-B-3a. Probable Errors; 76-mm ZIS-3 Field Gun, Indirect Fire (U)

Approximate percentage of maximum range (13 300 m) (measurements in meters for various percentages)	PE_d (m)	PE_r (m)	PE_v (m)
90 (11 970)	6.0	68	68.0
70 (9 310)	3.5	50	29.0
50 (6 650)	2.2	35	10.0
30 (3 990)	1.3	26	2.8

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2. ~~(C)~~ Fragmentation. The OF-350 projectile is estimated to produce 5973 fragments; average fragment mass is 0.907 gram and an average initial velocity is 705 m/s.

3. ~~(C)~~ Lethality. In open terrain, lethal areas for the OF-350 HE-fragmentation projectile are:

- At zero height-of-burst against standing troops: 197 m^2 at 15°, 205 m^2 at 30°, and 241 m^2 at 45° angle of fall. Against prone troops, these areas become 60 m^2, 70 m^2, and 78 m^2, respectively.

- At a 6-m height-of-burst, about that anticipated for ricochet action from this delay fuzing, the lethal area for standing troops is about 275 m^2. Against prone troops, the lethal area becomes about 235 m^2.

(b) (~~C~~) Direct fire.

1. (U) Precision. Probable errors for the AP-T projectile BP-354B are shown in table III-B-3b.

Table III-B-3b. Probable Errors; 76-mm ZIS-3 Field Gun, Direct Fire (U)

Range (m)	PE_v (m)	PE_d (m)
200	0.1	0.0
400	0.1	0.1
600	0.1	0.1
800	0.2	0.2
1000	0.3	0.3

(UNCLASSIFIED)

2. (U) Grazing range. Soviet firing tables disclose that "grazing range for a 2.5-m-high target" is 840 meters; against 2.0-m- and 3.0-m-high targets, grazing ranges are 780 meters and 920 meters, respectively.

3. (~~C~~) Effective range. Calculated 50% probability of a first round hit from the ZIS-3 when using the HVAP-T projectile is 774 meters.

4. (~~C~~) Engagement range. Due to limited penetration, fire is opened at 500 to 550 meters, or less with kinetic energy projectiles. With the new HEAT projectile, fire probably is opened at about 900 meters.

5. (~~C~~) Armor penetration. These parameters are shown in table III-B-3c, below.

6. (~~C~~) First round hit probability. Calculated hit probabilities for the ZIS-3 using the HVAP-T projectile vs. the standard NATO 2.3x2.3-meter target are shown in table III-B-3d.

Table III-B-3c. Penetration Data, 76-mm ZIS-3 Field Gun, Direct Fire (U)

Projectile		Range (m)	Obliquity			
Type	Model		0°	30°	45°	60°
			Penetration (mm)			
HVAP-T	BR-354P	500	92	76	53	23
		1000	58	46	36	16
AP-T	BR-350; BR-350A; and BR-350B	500	69	55	46	36
		1000	61	49	41	30
HEAT-FS	BK-354M	Any	300	260	212	150

(UNCLASSIFIED)

Table III-B-3d. Probability of a First-Round Hit; 76-mm ZIS-3 Field Gun, Direct Fire (U)

Range (m)	Hit probability
500	0.79
774	0.50
1000	0.26
1500	0.06
2000	0.01

~~(CONFIDENTIAL)~~

(3) (U) Configuration.

(a) (U) General. The ZIS-3 (fig III-B-3b) has a long (42-caliber) tube equipped with a double-baffle muzzle brake. Its recoil system consists of a recuperator cylinder mounted above the tube and a recoil brake mounted in the cradle. This weapon has split tubular-steel trails and mounts a square shield. Two equilibrators are located at the base of the top carriage. Shock absorbers are located above the axle adjacent to the wheels.

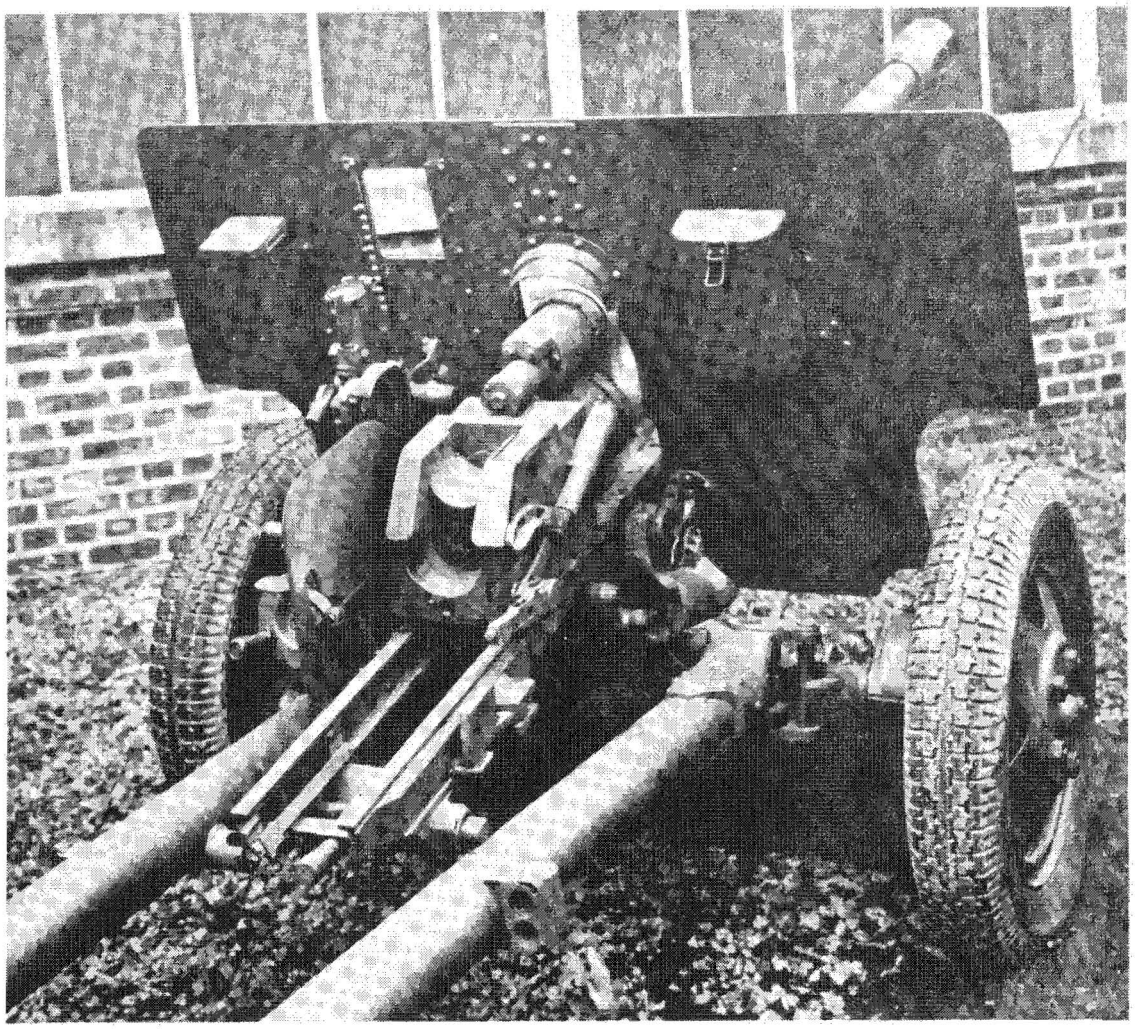

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Figure III-B-3b. 76-mm ZIS-3, rear view (U).

(b) (U) Cannon assembly. The monoblock gun tube has 32 lands and grooves over a length of 2587 mm; twist is one turn in 25 calibers. The breech mechanism is a semiautomatic vertically sliding-wedge. The trigger that actuates the firing mechanism is attached to the left side of the U-shaped cradle that houses the recoil brake.

(c) (U) Recoil mechanism. The hydraulically operated recoil brake and hydropneumatic recuperator (fig III-B-3c) are filled with 4.4 liters and 4.27 liters of Steol M, respectively. The recuperator is initially pressurized to 30.0 to 33.1 kg/cm^2. The recoil brake

is equipped with a replenisher. Length of recoil varies between 680 and 750 mm; maximum length of recoil is 820 mm.

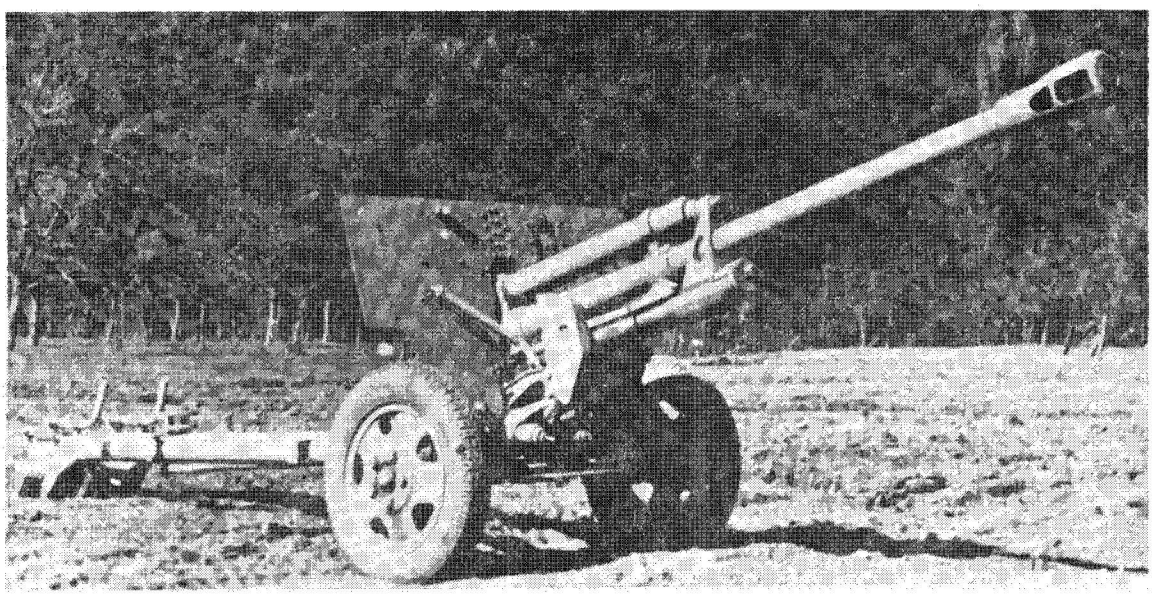

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Figure III-B-3c. 76-mm ZIS-3, right front view (U).

(d) (U) Positioning limits. The rack-and-pinion elevating mechanism, with operating handwheel located on the left side of the top carriage, allows the weapon to be elevated from -5° to +37°. The weapon can be traversed a total of 54° by the screw-and-nut type traverse mechanism. The traversing handwheel is located on the left side of the carriage. Basic fire control equipment consists of a panoramic telescope and a telescope mount incorporating a range drum having a mil scale and two range scales, one for the HE projectile and the other for the AP-T. An additional six different types of projectiles can be fired using the mil scale and/or the two range scales.

b. (U) Summary. The remarkably lightweight ZIS-3 (1116 kg in firing position) has excellent mobility. Conversely, this lightness gives the weapon a degree of instability during firing. It was, nevertheless, the backbone of the Soviet divisional artillery during World War II. Significant numbers of this weapon remain in war reserve stockage, a considerable number being used for training and local defense purposes. In addition, a number of these weapons remain deployed with light divisions or brigades stationed in areas having difficult terrain.

6. ~~(C)~~ 85-mm Field (Antitank) Gun D-44 (M1945)

a. (U) Description and Performance.

(1) (U) General. The 85-mm antitank gun D-44 (M1945) (fig III-B-4a) was adopted in July 1945. It was intended as the replacement, primarily in its antitank role, for the widely deployed and proven 76-mm ZIS-3, which could not defeat the heavier German tanks introduced during the latter stages of World War II. The cannon of the D-44 is the same model of cannon used on the SD-44 APAT (auxiliary propelled antitank) gun. This cannon was first mounted in the T-34 tank. The D-44 is used primarily as a direct fire weapon. In the indirect fire role, this weapon attains a maximum range, using full charge at maximum on-carriage elevation (35°), of 15,650 meters. Although no longer standard in the Soviet forces, the D-44 still constitutes a moderate threat to free world tanks and a serious threat to APCs since it has been widely deployed in Soviet-aligned countries. The D-44 weighs 1703 kg, and is 8340 mm long, 1730 mm wide, and 1420 mm high in the travel configuration.

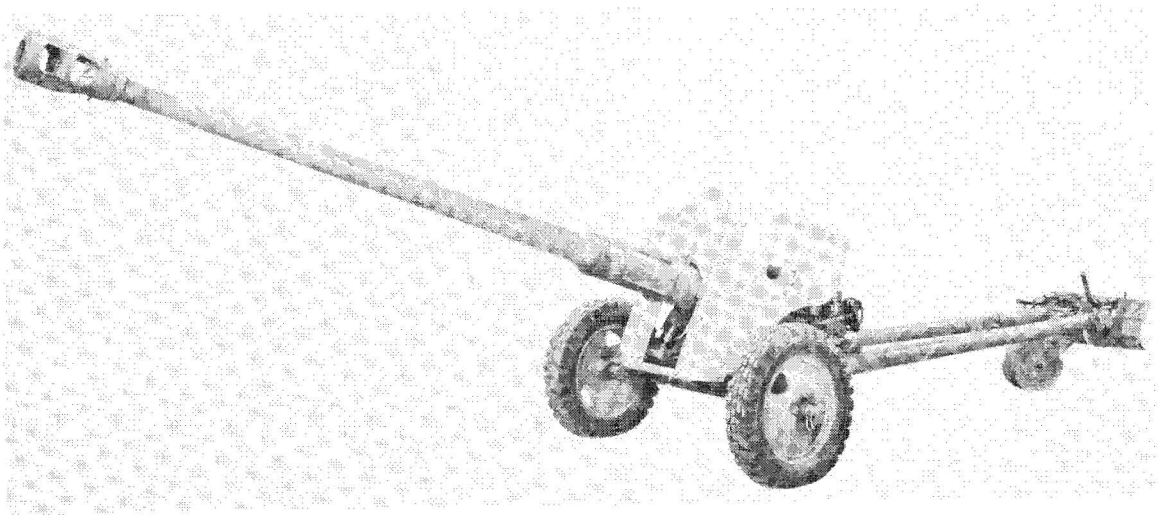

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Figure III-B-4a. 85-mm field (antitank) gun D-44 (M1945) (U).

(2) (U) Capabilities. Maximum range of the D-44 is 15 650 meters using a full charge HE round (0-365K steel or 0-367A cast iron and steel projectiles) at 35° elevation. Employing the reduced charge decreases the maximum range to 13 400 meters. If trails are dug in to achieve optimum elevation (45°), maximum range is reported to be 18 970 meters. Tube life is estimated to be 1000 EFC rounds. It is estimated that 48 rounds of HE, AP-T, HVAP-T, and, possibly, HEAT ammunition are transported with each weapon. All ammunition used by the D-44 is fixed. Characteristics of the projectiles most commonly used with the D-44 are presented in table II-C-1 as part of the 85-mm SD-44 auxiliary-propelled field (antitank) gun data. The D-44 can be towed on hard-surfaced roads at speeds up to 64 km/h and off-road at speeds up to 40 km/h. Prime movers for this weapon include the AT-P tractor, the ZIL-485 unarmored amphibious truck, and the K-61 tracked amphibious vehicle.

(a) (U) Indirect fire.

1. (U) Precision. Representative probable errors for the D-44 are the same as those provided in table II-C-2 for the SD-44.

2. (U) Fragmentation. The 0-365K and the 0-367A projectiles fired by the D-44 are the same as those fired by the SD-44 and fragment as indicated in para II C-5b (2)(d).

3. (U) Lethality. Lethal area data for HE projectiles fired by the D-44 are provided in para II C-5b (2)(e).

(b) (U) Direct fire.

1. (U) Precision. Probable errors for the D-44 are the same as those presented for the SD-44 in table II-C-3.

2. (U) Grazing range. These data are provided in table II-C-4.

3. (U) Effective range. These data are provided in table II-C-5.

4. (U) Armor penetration. Penetration data are the same as those provided in table II-C-6.

b. ~~(c)~~ Configuration.

(1) (U) General. The cannon assembly, recoil mechanism, muzzle brake, cradle, and top carriage are the same as those for the

SD-44 (para II C-6) (fig III-B-4b). The weapon can be fired by either a lanyard or a push rod located in the center of the elevating handwheel. The tubular split trails are equipped with a single caster wheel located at the trail ends. The caster wheel is positioned above the trails for travel and lowered to a position between the closed trails to facilitate manhandling the weapon in the position area.

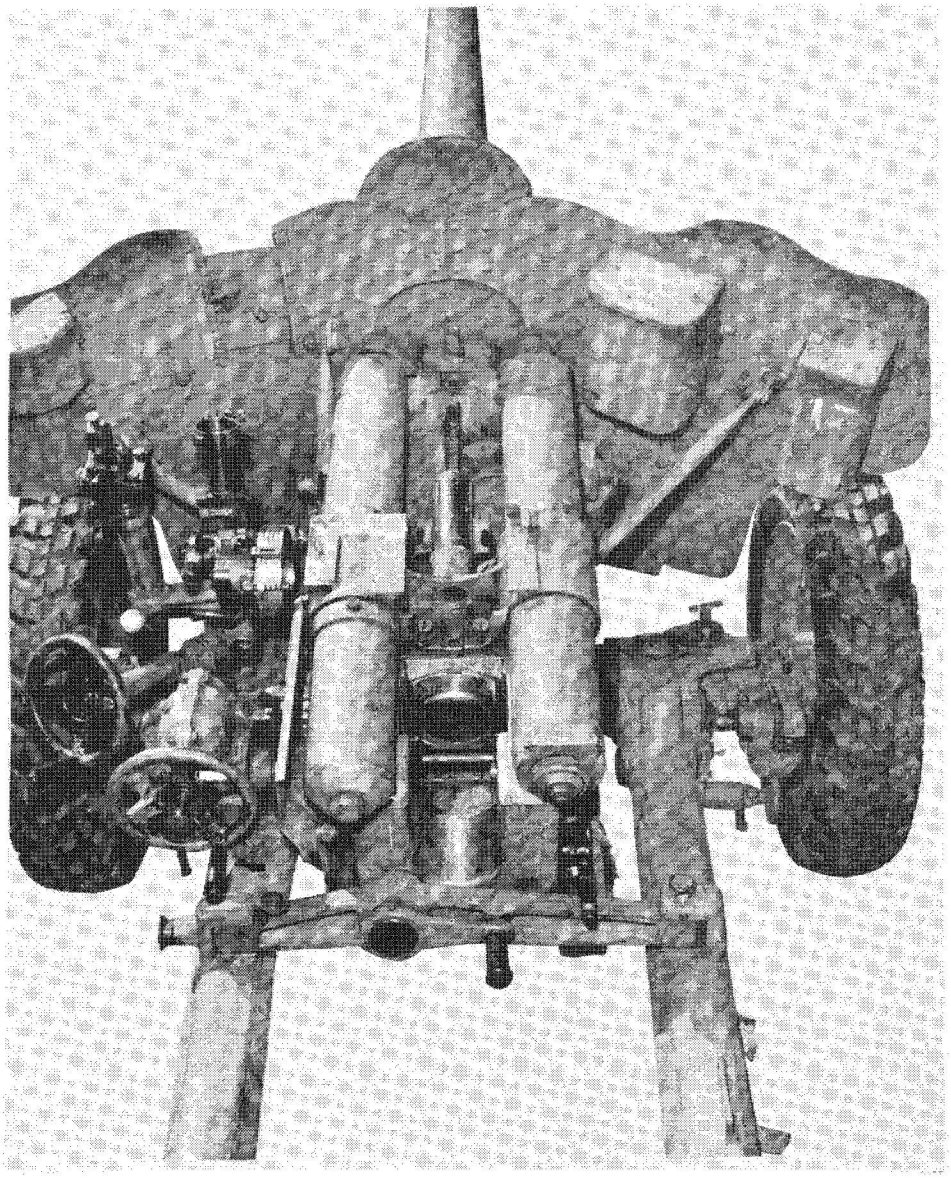

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Figure III-B-4b. 85-mm D-44 gun, rear view (U).

(2) (U) Positioning limits. The arc-and-pinion type of elevating mechanism provides for -7° to +35° of elevation. On-carriage traverse totals 54°, 27° right and left from center.

(3) ~~(C)~~ Fire control. The direct and indirect fire sighting systems on this gun are the same as on the SD-44 [para II C-6b(6)] (fig III-B-4c). The weapon can be equipped with an infrared illuminator and viewing apparatus. The illuminator observed on this weapon is approximately 425 mm in diameter.

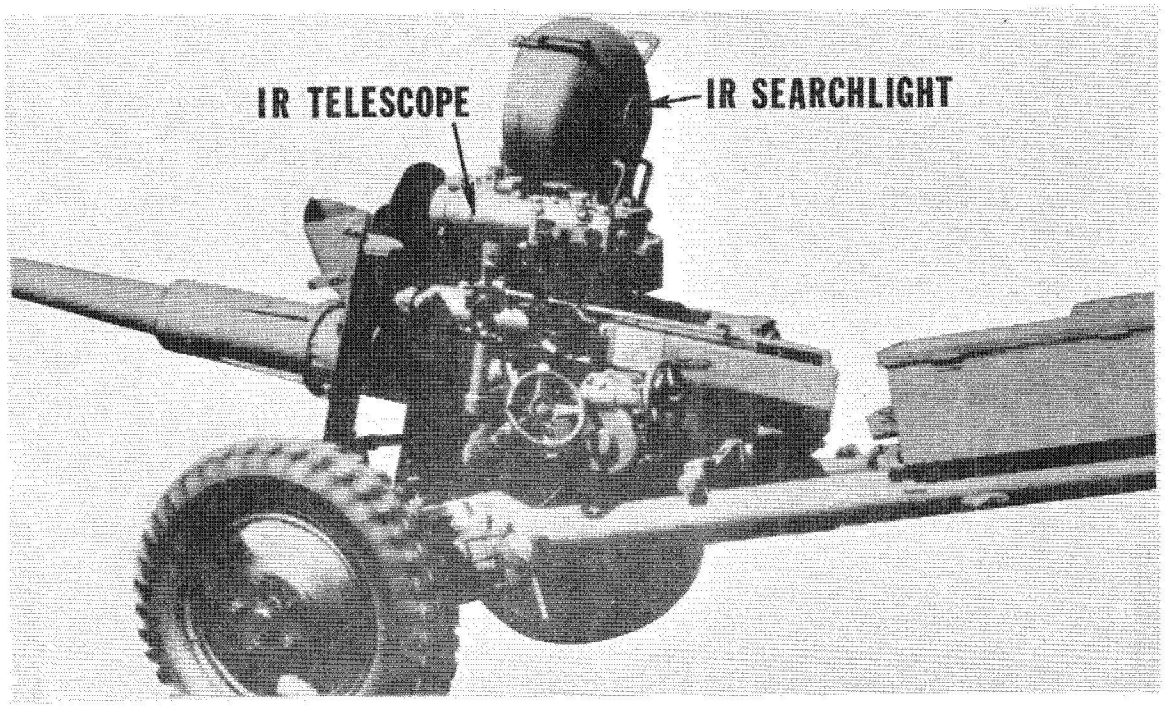

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Figure III-B-4c. 85-mm D-44 gun with infrared sighting equipment (U).

(4) (U) Equilibration. The equilibrator on the D-44 is the same model as that provided for the SD-44.

c. (U) Bottom carriage.

(1) (U) Bottom carriage. This assembly is of split tubular trail design. The outer axle, which is cast, includes a pintle pin housing. An equalizer axle is provided, within which the torsion bar suspension is mounted.

(2) (U) Wheels. These are steel disks that have locking rings to facilitate the mounting of sponge rubber-filled tires. Wheel spindles, mounted on torsion bar cranks, are fitted with normal raced wheel bearings.

(3) (U) The trails. These members are of welded tubular design. A locking bar, attached to the trails near the breech end, is latched with a bolt to the breech to provide stability during travel. A pivoted caster wheel, positioned near the trail ends, can be lowered for manhandling the weapon.

(4) (U) Mobility. This weapon can be towed at approximately 60 km/h on hard-surfaced roads, 35 km/h on country roads, or 12 to 15 km/h off-road.

d. (U) Summary. Although no longer standard in the Soviet Army, the D-44 continues to pose a threat to free world forces due to its wide availability among Soviet-aligned nations. A dual-purpose weapon, it could be used effectively as an antipersonnel weapon in addition to fulfilling the assigned primary role of attacking light to medium armored targets. The weapon is simple, light, rugged, and apparently easy to maintain. The D-44 can be emplaced/displaced in less than 1 minute. Its five-man crew fires the weapon at the prescribed rate of 10 rd/1 min, 60 rd/15 min, 90 rd/30 min, and 140 rd/60 min.

7. ~~(C)~~ 100-mm Field (Antitank) Gun BS-3 (M1944)

a. ~~(C)~~ Description and Performance.

(1) (U) General. The Soviet 100-mm field gun BS-3 (M1944) (fig III-B-5a) made its combat debut in the last part of World War II. It presented an excellent counter to the heavier armored German tanks. The BS-3 successfully augmented the divisional 76-mm field gun ZIS-3. This 100-mm weapon also was a good field gun, particularly in the counterbattery role. It remained standard in the Soviet inventory until 1955, when it was superseded by the improved 100-mm field gun M1955. The BS-3 is still used in various countries throughout the world, but is not deployed to Soviet first-echelon units. The cannon of the 100-mm BS-3 is essentially the same gun as that found on the T-54 tank and on the SU-100 assault gun. The principal deficiency of the BS-3 is excessive muzzle whip; when this gun is fired rapidly, the whipping of the long tube engenders inaccuracy.

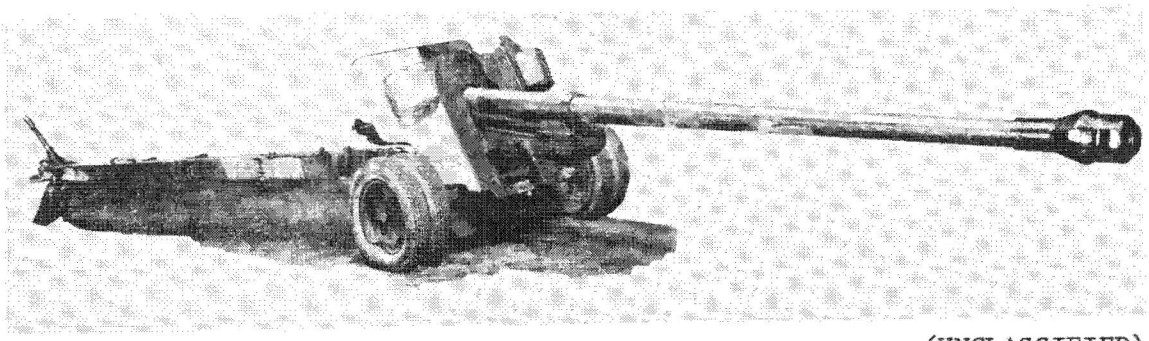

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Figure III-B-5a. Soviet 100-mm field (antitank) gun BS-3 (M1944), right front view (U).

(2) ~~(C)~~ Capabilities. The gun can fire 8 to 10 rd/min to a range of 20 000 meters; 7 rd/min is the prescribed rate. A muzzle velocity of 895 m/s and armor penetration of 135 mm at 0° obliquity at 1000 meters are achieved by the BR-412 AP-T projectile. Other types of projectiles used with this weapon include HE, AP-T, HVAP-T, HEAT-FS, and smoke. The shorter tube on this gun vis-a-vis the Czechoslovak 100-mm M-53 gun results in 20 to 30 m/s less V_o than those shown in table II-S-1. Soviet claimed tube life for the 100-mm gun on the T-54 tank is 8000 rounds with HE shell or 2700 rounds with AP-T with the notation: "This gun can be ruined soon." Using a 5.1 mm (0.2 in) wear criteria, Watervliet Arsenal estimates tube wear life at ≈1400 EFC rounds; the tough steel used in this gun withstood 8400 cycles of fatigue testing but, by US standards, fatigue life was estimated at 1000 EFC rounds. The BS-3 can be towed at 60 km/h on hard-surfaced roads and up to 12 to 15 km/h off-road. The six-man crew can emplace or march order the weapon in approximately 3 minutes.

(a) ~~(C)~~ Indirect fire.

1. ~~(C)~~ Precision. Dispersion at various ranges when firing the HE shell OF-412 with selected charges in indirect fire is presented in table III-B-5a.

Table III-B-5a. Estimated Probable Errors; 100-mm Field (Antitank) Gun BS-3, Indirect Fire (U)

Approximate percentage of maximum range (20 000 m) (measurement in meters for various percentages)	PE_d (m)	PE_r (m)	PE_v (m)
90 (18 000)	10	89	105
70 (14 000)	7.2	68	41
50 (10 000)	5.0	46	12
30 (6 000)	3.0	36	3.1

~~(CONFIDENTIAL)~~

2. (U) Fragmentation. Fragmentation characteristics of the OF-412 projectile are presented in section II S (100-mm Field Gun M-53).

3. (U) Lethality. Lethal areas of the HE-fragmentation projectile (OF-412) also are presented in section II S.

(b) ~~(C)~~ Direct fire.

1. ~~(C)~~ Precision. Probable errors to be expected when firing AP-T (BR-412) projectiles in direct fire are set forth in table III-B-5b.

Table III-B-5b. Probable Errors; 100-mm Field (Antitank) Gun BS-3, Direct Fire (U)

Range (m)	PE_v (m)	PE_d (m)
500	0.2	0.3
1000	0.3	0.5
1500	0.4	0.6
2000	0.6	0.9
3000	0.9	1.3
4000	1.6	1.9

~~(CONFIDENTIAL)~~

2. ~~(C)~~ Grazing range. The Soviet AP-T and APC-T projectiles have a grazing range of 1260 meters vs. a 2.5-meter-high target; grazing ranges against 2- and 3-meter-high targets are 1150 meters and 1360 meters, respectively.

3. ~~(C)~~ Effective range. Calculated effective range (50% probability of a first round hit) of the 100-mm BS-3 firing the BR-412B AP-T projectile against the standard NATO target is 1040 meters. Hit probabilities are presented in table III-B-5c.

4. ~~(C)~~ Engagement range. Fire probably will be opened at about 1400 meters against US M60A1 tanks.

5. (U) Armor penetration. These data are presented in table III-A-4.

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Table III-B-5c. Probability of a First-Round Hit; 100-mm BS-3 Field Gun, Firing AP-T Projectiles (U)

Range (m)	Hit probability
500	0.90
1000	0.53
1040	0.50
1500	0.19
2000	0.07

~~(CONFIDENTIAL)~~

(3) ~~(C)~~ Configuration.

(a) ~~(C)~~ General. The BS-3 (fig III-B-5a) is easily identified by its double-baffle muzzle brake affixed to a very long monoblock gun tube, a cradle-enclosed recoil system, its massive square breechring, and its dual wheels. The vertically sliding-wedge breechblock (fig III-B-5b) operates semiautomatically.

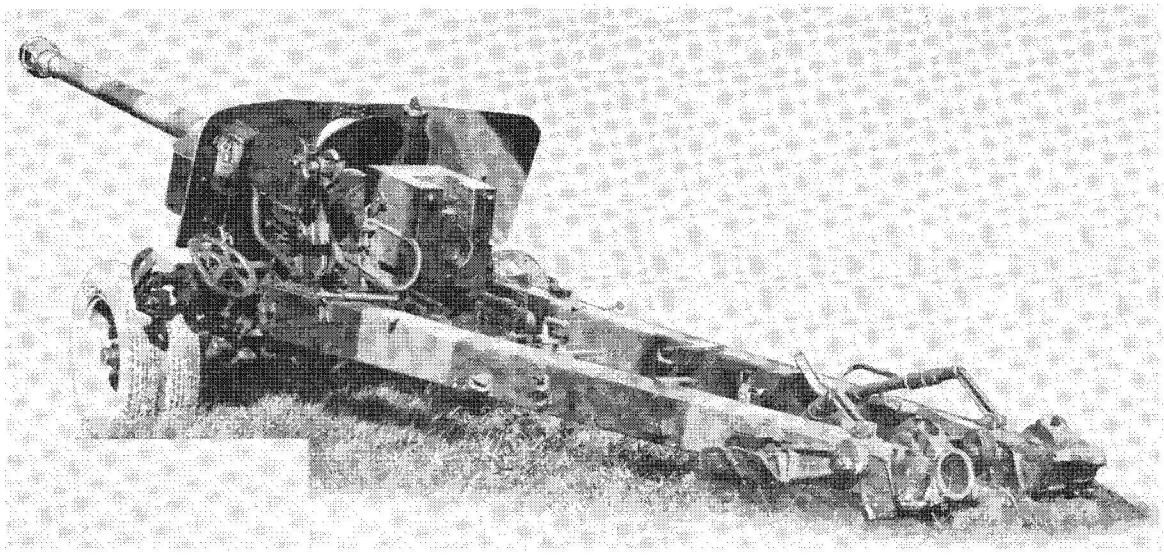

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Figure III-B-5b. 100-mm BS-3 field (antitank) gun (U).

(b) ~~(C)~~ Recoil mechanism. This assembly is located in the cradle below the tube. The recoil brake and the recuperator mechanism operate hydraulically and hydropneumatically, respectively. Recoil length varies between 965 and 1181 mm.

(c) ~~(C)~~ Positioning limits. The limits of the rack-and-pinion elevating mechanism are -5° and +45°. Traversing is accomplished by means of a screw-and-nut-type mechanism for a total of 58° of on-carriage traverse.

(d) ~~(C)~~ Fire control. A model PG-type panoramic telescope is employed in indirect fire. The OP-2-5 telescope is the direct fire sight.

b. ~~(C)~~ Summary. The BS-3 was an excellent artillery weapon for its intended purposes. Its massive breechring doubles as a counterweight for the relatively long tube. The torsion bar suspension system facilitates towing the piece; however, the sponge-filled tires do develop a heat buildup when the weapon is towed at speeds greater than 32 km/h. This weapon is simple in design, construction, and operation. These characteristics were carried over to the 100-mm M1955 which replaced the BS-3.

C. SOVIET FIELD GUNS AND HOWITZERS

8. ~~(C)~~ 122-mm Field Gun A-19 (M1931/37)

a. ~~(C)~~ Description and Performance.

(1) (U) General. The 122-mm field gun A-19 (1931/37), adopted in March 1936, is a modification of the 122-mm Corps Gun M1931. The two guns are ballistically identical, differing only in their carriages. The shield of the A-19 is curved, while that of the M1931 is straight; the equilibrators of the A-19 incline rearward and those of the M1931 incline forward. The maximum elevation of the A-19 is 65° for the original versions and 69° for those currently in use, whereas the M1931 could be elevated only 45°. The A-19 (fig III-C-6a) is mounted on the same basic carriage as the 152-mm howitzer M-10. The A-19 remained standard in the Soviet Army from its deployment in September 1938 until the 122-mm field gun D-74 was introduced as its replacement in 1955. Currently, the A-19 is widely distributed throughout the world. The principal disadvantages associated with this weapon are excessive weight (7117 kg) and low ground clearance.

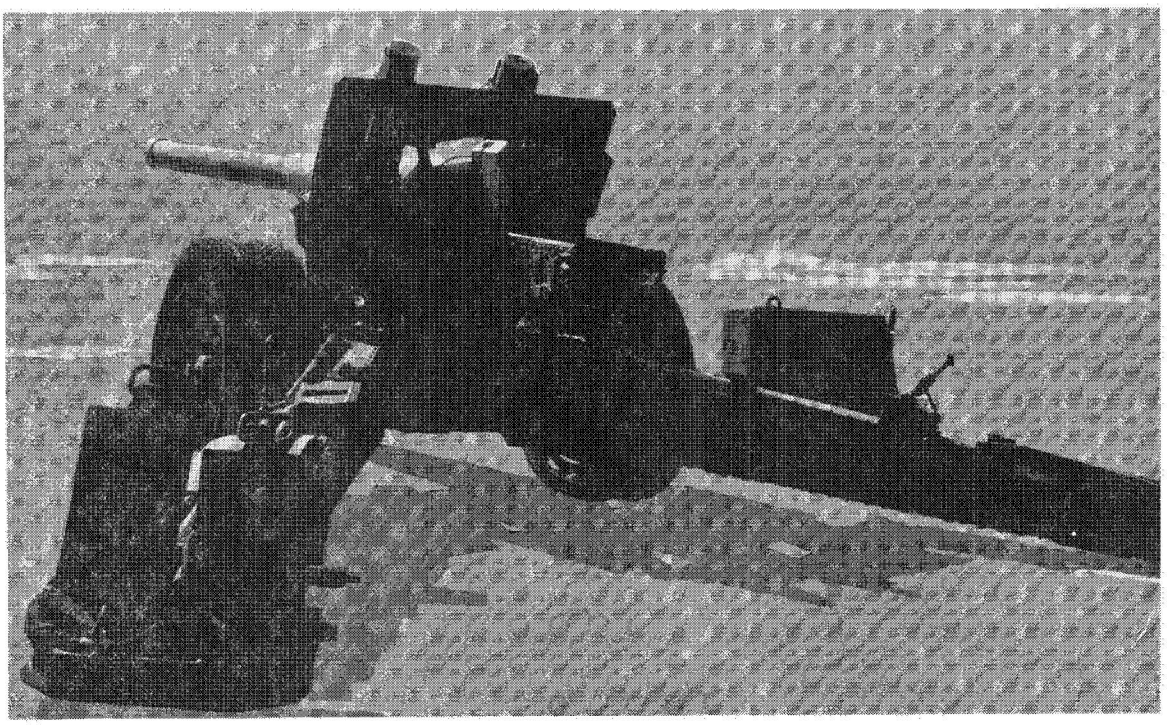

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Figure III-C-6a. Soviet 122-mm field gun A-19 (M1931/37) (U).

(2) ~~(C)~~ Capabilities. The time required to emplace and displace the A-19 is approximately 8 to 10 minutes. A medium class prime mover, possibly the obsolete C-80 tractor, was used to tow this weapon; currently deployed weapons utilize prime movers associated with the 130-mm M-46 field gun. Maximum travel speed during World War II was limited to 25 km/h; higher speeds caused the spoked, steel-shod (later solid rubber-shod) wheels to wear excessively. Post-World War II versions of the A-19 (fig III-C-6b) utilize dual, sponge rubber-filled tires mounted on steel wheels attached to a sprung axle; this arrangement permits towing speeds of up to about 50 km/h. The prescribed rate of fire of the A-19 when firing full or 1st charge over periods of 1, 5, 15, 30, and 60 minutes is 5, 20, 50, 75, and 100 rounds, respectively. Maximum range is 19 750 meters. Soviet firing tables state that average tube life is 1000 EFC rounds. The separate loading, cased ammunition is identical to that used in the older M1931 gun, consisting of HE, AP-T, HEAT, CP, and smoke rounds. Characteristics of projectiles most commonly used in the A-19 gun are shown in table III-C-6a.

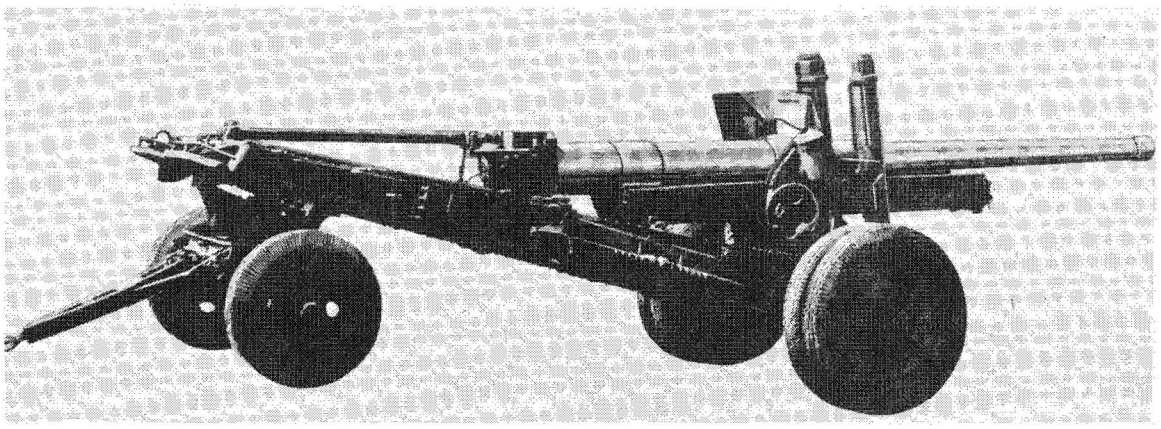

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Figure III-C-6b. 122-mm A-19 field gun in travel position (U).

Table III-C-6a. Projectiles, 122-mm A-19 Field Gun (U)

Type	Designation	In-flight weight (kg)	Muzzle velocity (m/s)	Penetration at 1000 meters	
				0° (mm)	45° (mm)
HE	OF-471N	25.0	800	NA	NA
HE	OF-462	21.8	765	NA	NA
AP-T	BR-471	25.0	800	131	89
AP-T	BR-471B	25.0	800 (?)	160	117
CP	G-471	25.0	800	?	?

~~(CONFIDENTIAL)~~

(a) ~~(C)~~ Indirect fire.

1. (U) Precision. Probable errors in firing OF-471 HE fragmentation projectiles with properly selected charges are shown in table III-C-6b.

Table III-C-6b. Probable Errors; 122-mm A-19 Gun, Indirect Fire With OF-471 HE-Fragmentation Projectiles (U)

Approximate percentage of maximum range (19 750 m) (Measurements in meters at approximate percentages)	PE_r (m)	PE_d (m)	PE_v (m)
90 (17 800) (chg full)	94	6.7	102
70 (13 800) (chg 2)	72	4.9	56
50 (9 900) (chg 3)	52.5	3.3	28
30 (5 900) (chg 3)	35.5	1.8	7.1

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2. ~~(C)~~ Fragmentation. The standard OF-471N HE fragmentation projectile fired by the A-19 field gun has a forged steel body. This projectile, having a charge-to-mass ratio of 0.161:1, bursts into an average of 3616 fragments. Mean fragment mass is 5.2 g (80 gr); average initial fragment velocity is 945 m/s (3100 ft/s). For fragmentation characteristics of the OF-462 projectile, see section II, subsection G, paragraph 13b.

3. ~~(C)~~ Lethality. Lethal areas of the OF-471N projectile for personnel standing in the open, with zero height-of-burst at indicated angles of fall are: 405 m^2 (4350 ft^2) at 15°, 445 m^2 (4790 ft^2) at 30°, 579 m^2 (6235 ft^2) at 45°, and 935 m^2 (10,065 ft^2) at 60°. For lethal areas of the OF-462 projectile, see section II, subsection G, paragraph 13b.

(b) (U) Direct fire.

1. (U) Precision. Table III-C-6c shows probable errors when firing BR-471 projectiles to ranges up to 4000 m.

2. (U) Grazing range. Soviet firing tables prescribe a 900-m range for firing against tanks. Grazing range for the BR-471 AP-T projectile versus a 2.5-m-high target is 1020 m; against 2-m- and 3-m-high targets, grazing ranges are 900 and 1100 m, respectively. Effective firing at fixed positions such as bunkers can be expected at ranges up to about 3500 meters.

3. (U) Effective range. Hit probabilities for this weapon have not been computed due to the obsolescence of this system.

Table III-C-6c. Probable Errors; 122-mm A-19 Gun, Direct Fire With AP-T (BR-471) Projectile (U)

Range (m)	PE_v (m)	PE_d (m)	PE_r (m)
500	0.15	0.15	38
1000	0.3	0.3	34
1500	0.45	0.45	31
2000	0.6	0.6	30
3000	1.0	0.9	28
4000	1.6	1.2	27

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4. (U) Penetration. These data are shown in table III-C-6a.

(3) (U) Configuration.

(a) (U) General. The 122-mm A-19 gun is characterized by an interrupted-screw-type breechblock, which is eccentrically shaped and has an off-centered firing mechanism. The split trail carriage is supported by a limber in the traveling position; total weight of the presently deployed weapon is about 8050 kg (older version was 7907 kg) in the travel position and 7250 kg (7117 kg for older version) in the firing position.

(b) (U) Recoil mechanism. This subsystem is composed of a hydraulic recoil mechanism and a hydropneumatic recuperator mechanism. Maximum length of recoil is 1400 mm. Under standard conditions the recuperator has a capacity of 22 liters of Steol M and operates at a pressure of 43.4 kg/cm^2. The recoil brake and the recuperator lie side by side in the cradle. Compensation for muzzle preponderance is provided by two spring-type equilibrators.

(c) (U) Positioning limits. Movement in elevation is from -2° to +69° (65° for the older version) and there is a total of 58° of on-carriage traverse. The elevating handwheel, which is attached to a rack-and-pinion-type mechanism, is located on the right side of the carriage. A pintle-type rack-and-pinion mechanism traverses the weapon.

The traversing handwheel is located on the left side of the carriage. The time required to lay this weapon exceeds that necessary for the newer D-74 gun, possibly by about 20%.

(d) (U) Fire control. This is a Schneider system, consisting of a panoramic sight, a sight mount having an elevation scale in mils, and a range drum inscribed for the AP-T projectile (BR-471B) and the HE fragmentation projectile (OF-471). An open-type direct fire sight also is provided. Quadrant seats are located atop the breechring.

b. (U) Summary. The 122-mm A-19 was designed as a corps gun; primary targets are artillery batteries, rear installations, assembly areas, and field-type fortifications. The A-19 is still utilized in many countries throughout the world.

9. ~~(C)~~ 152-mm Howitzer M-10 (M1938)

a. ~~(S)~~ Description and Performance.

(1) ~~(C)~~ General. The 152-mm howitzer M-10 (M1938) (fig III-C-7a) was the first indigenously produced Soviet weapon in this caliber. The M-10 weighs 4150 kg (9150 lb) in the firing position and 4550 kg (10 030 lb) in the travel position. The M-10 was the standard medium caliber divisional artillery piece used throughout World War II, although it gradually was replaced by the 152-mm howitzer D-1 (M1943) in the last 2 years of the war. The recuperator of the M-10 is positioned within the cradle instead of above the tube, as is that of the D-1. The M-10 has no muzzle brake, whereas the D-1 is fitted with a double-baffle brake. The M-10 is considerably heavier than the D-1; it weighs 910 kg (2000 lb) more in the travel position. Most M-10's seen today are equipped with dual pneumatic or sponge rubber-filled tires on the carriage, and smaller, single tires on the limber.

(2) ~~(C)~~ Capabilities. A crew of six plus the prime mover driver can place the M-10 into firing position (fig III-C-7b) from the travel position in about 8 to 10 minutes. Maximum rate of fire is 4 rd/min and maximum range is 12 400 meters. According to Soviet firing tables, average tube life is 5000 EFC rounds. Elevation limits are -1° and +65°; total on-carriage traverse is 50°. The 152-mm M-10 howitzer fires the same ammunition and evidences the same ballistics as the 152-mm howitzer D-1 (M1943); see section II, subsection 0 for ammunition and ballistic data.

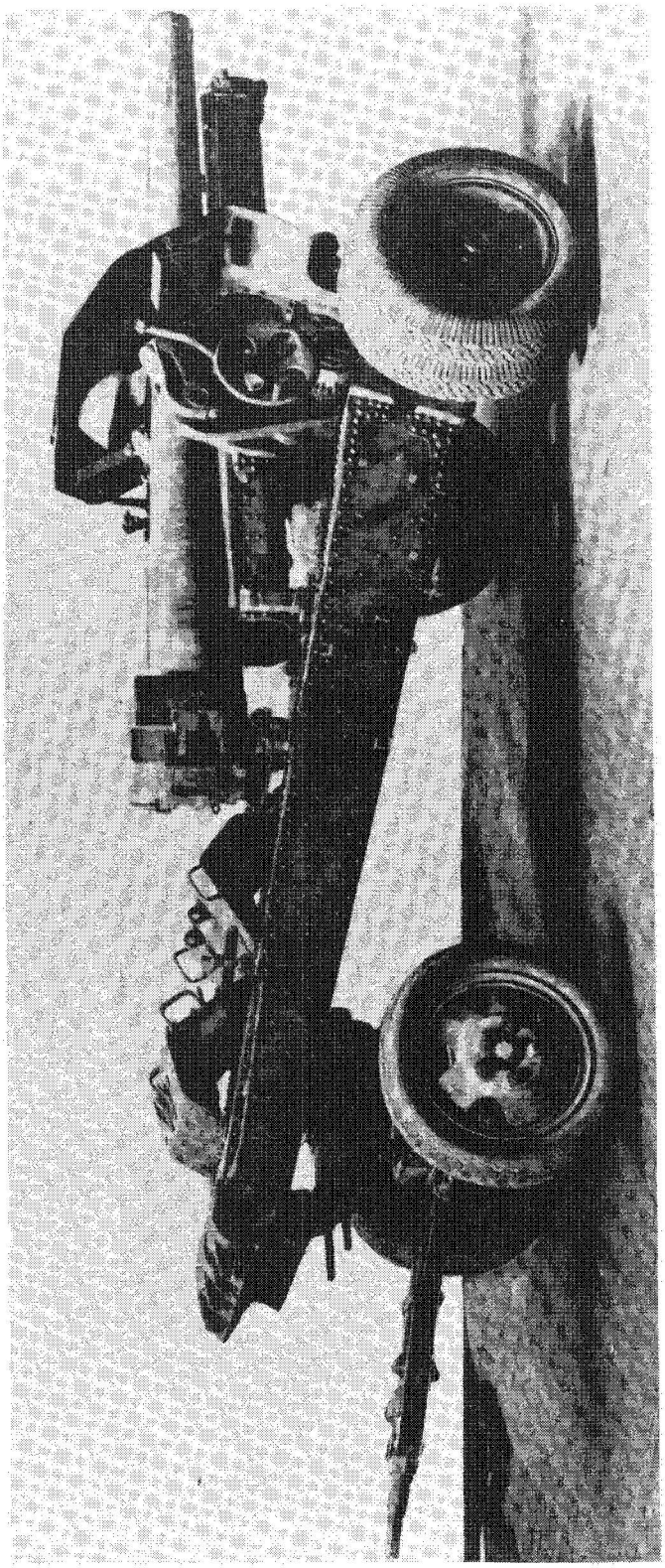

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Figure III-C-7a. Soviet 152-mm howitzer, M-10 (M1938) in travel position (U).

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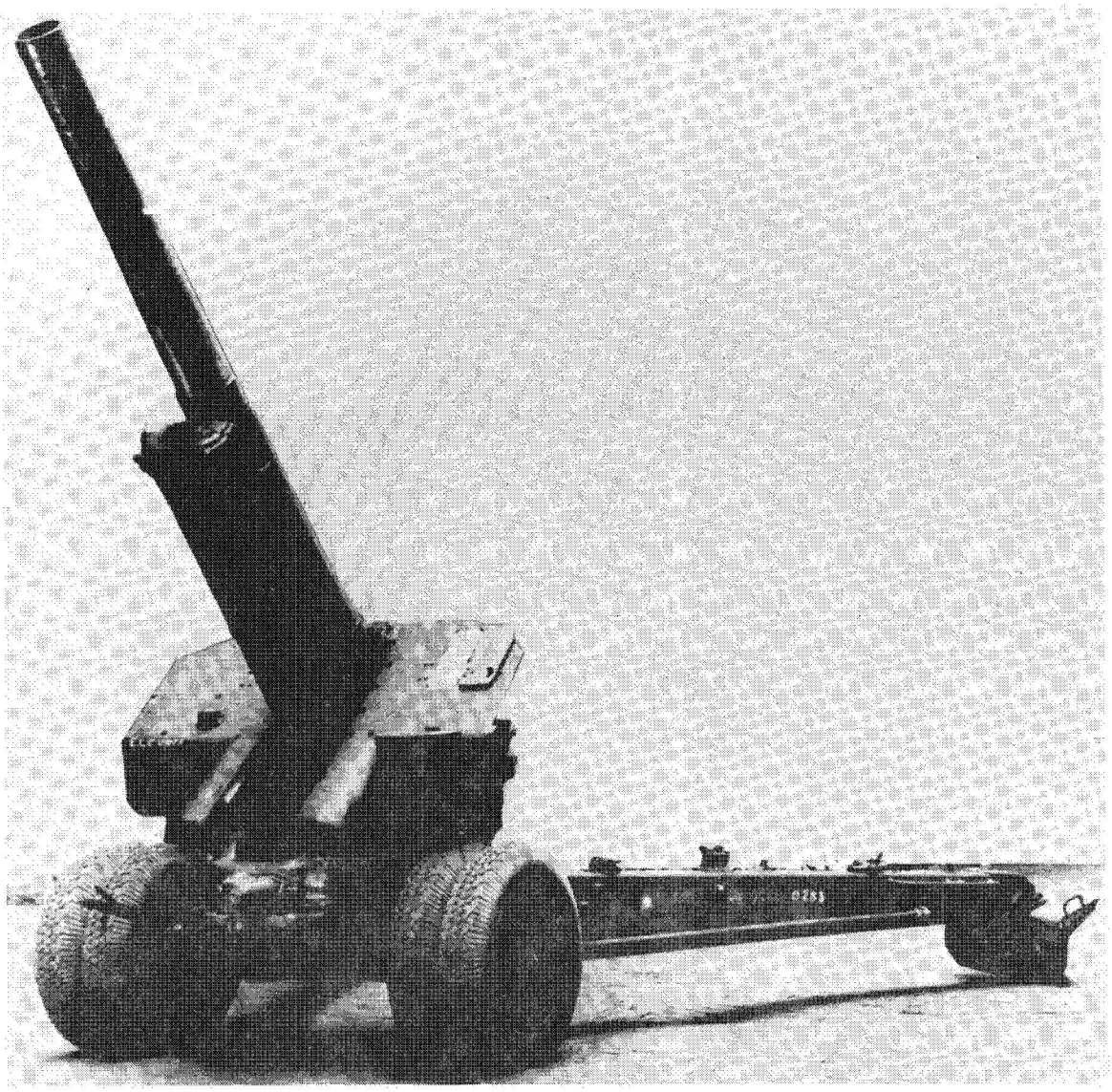

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Figure III-C-7b. 152-mm M-10 howitzer (U).

(3) ~~(C)~~ Configuration.

(a) (C) General. The barrel of the M-10 is physically identical to that used on the D-1 except it does not have a muzzle brake. The interrupted-screw-type breechblock is manually operated. The hydraulic recoil mechanism and hydropneumatic recuperator are located

below the barrel within the trough-type cradle. The weight of the recoiling parts is light for a Soviet weapon weighing 4150 kg; these parts weigh only 1400 kg (3086 lb). The slanting gun shield and matching pointer-type sight mechanism show up prominently in the gun silhouette. The riveted split box-section trails have detachable spades. A limber is used to support the trails in the travel configuration. Two spring-type equilibrators, slanted 30° from the vertical, are located behind the gun shield.

(b) ~~(C)~~ Positioning limits. Elevation limits are -1° and +65°. The cannon is elevated by means of a rack-and-pinion mechanism; the elevation handwheel is located on the right side of the carriage (fig III-C-7c). Total on-carriage traverse is 50°. The traversing handwheel, located on the left side of the carriage, positions the weapon in the horizontal plane.

(c) ~~(C)~~ Fire control. A Model PG panoramic telescope mounted upon a M1936 quadrant sight mount having an angle of site scale reading to ±300 M, and an elevation scale reading from 0 to 1240 M (0° to 75°) provide the on-carriage fire control. All fire control equipment is mounted on the left trunnion. This arrangement represents a two-man system since the elevation is set by the gunner on the left side and then the gun is elevated from the right side until the matching pointers, located on the left side, are in coincidence.

b. (U) Summary. The M-10 is typical of Soviet artillery construction--simple in design and rugged in construction. The limited range, low muzzle velocity, excessive carriage weight, and low ground clearance (305 mm) obviously were the primary reasons for replacing the M-10 with the 152-mm D-1 howitzer.

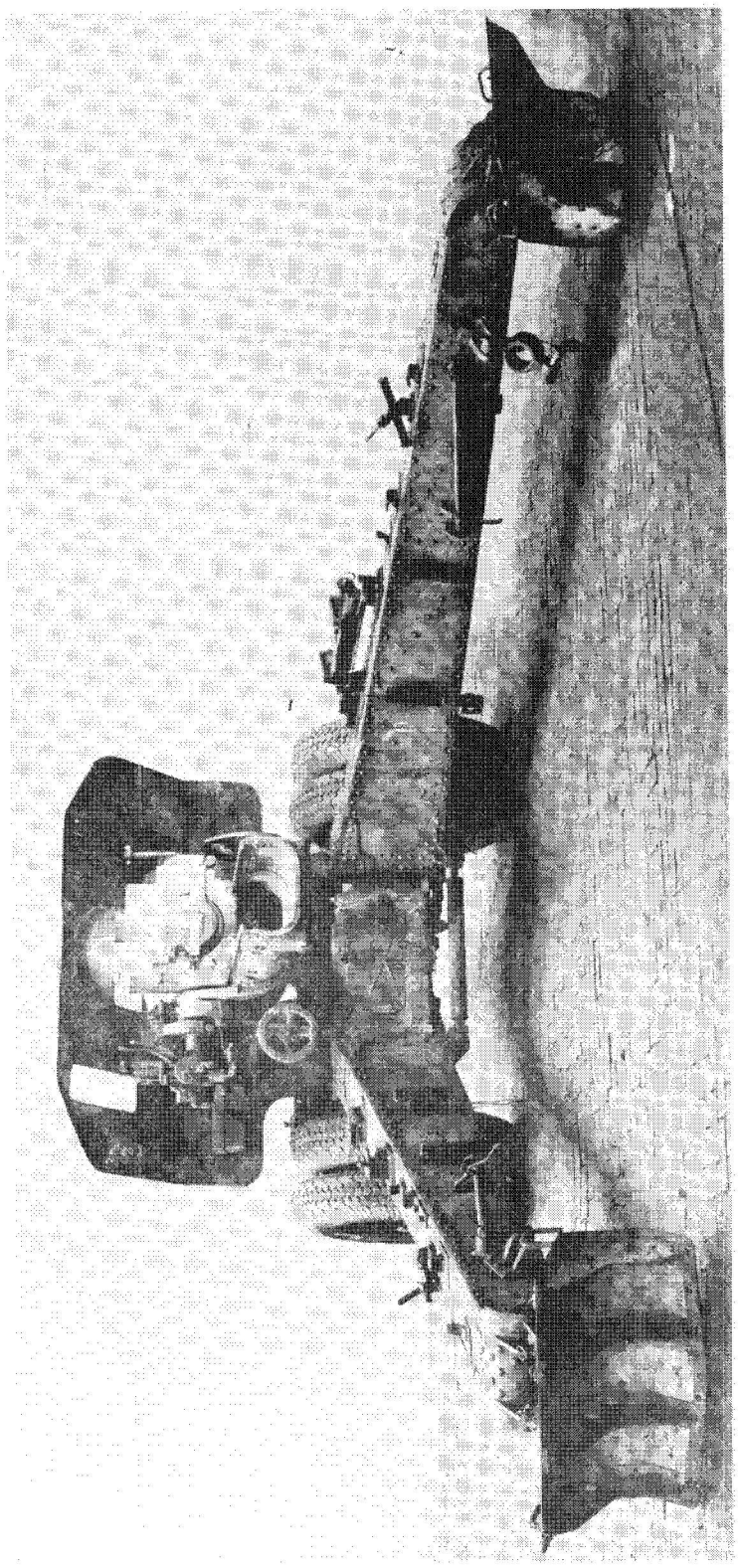

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Figure III-C-7c. 152-mm M-10 howitzer, rear view (U).

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10. ~~(C)~~ 310-mm Self-Propelled Gun M1957

a. ~~(C)~~ Description and Performance.

(1) ~~(C)~~ General. The Soviet 310-mm self-propelled gun M1957 (fig III-C-8a) was first sighted in the November 1957 Moscow Parade.

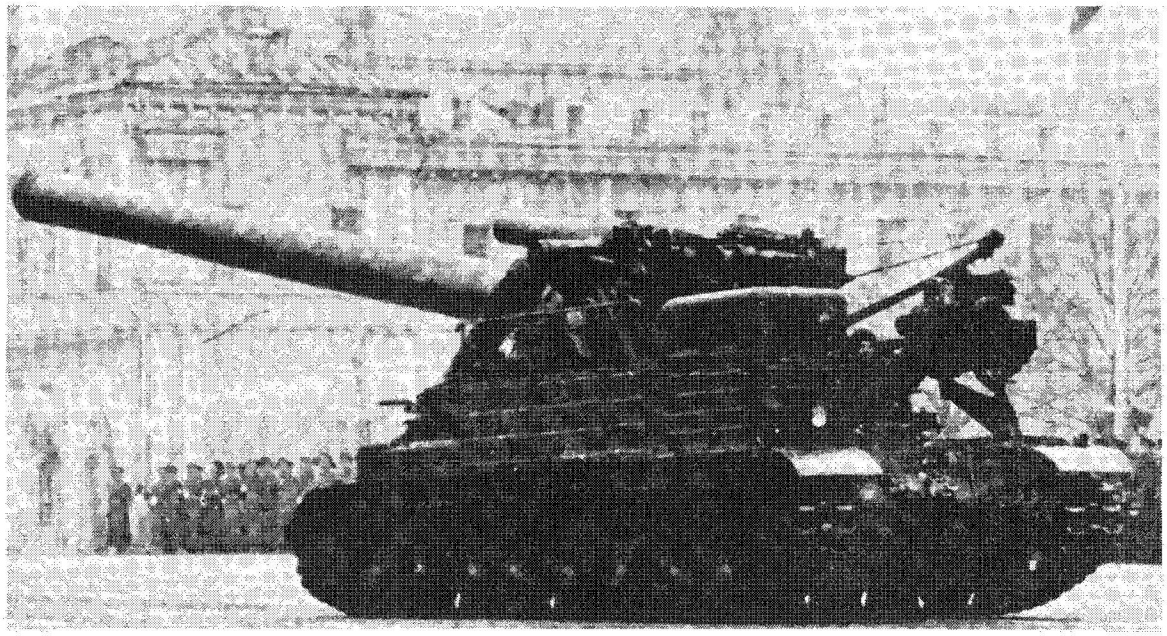

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Figure III-C-8a. Soviet 310-mm self-propelled gun M1957; left rear of gun (right front of carriage) (U).

(a) (U) The 420-mm self-propelled mortar also was first sighted in the same parade.

(b) ~~(C)~~ Full-scale deployment of this 310-mm gun probably was negated by the introduction into the Soviet Army of nuclear capable tactical rockets and guided missiles of greater mobility and greater

probable yield; it probably was never deployed to troop units, certainly not in any significant numbers. The inclusion of these guns in the November 1957 Moscow Parade likely was to display an example of Soviet technological ability.

(c) ~~(C)~~ Because of the probable high pressures generated during firing, the 310-mm, unstepped, apparently monoblock, tube may be auto-frettaged. Since the Soviets were not known to have facilities to auto-frettage such tubes, these barrels likely are either from World War II French auto-frettaged coastal defense guns having a range on the order of 40 to 50 km or their pressures are moderate and the maximum range is about 25 km. Further, considering the size of the gun as compared with its carriage and recoil system, the energy capable of being accommodated may restrict maximum range to about 25 km. In this latter case, considering shell weight and other factors, precision should be excellent; ≈0.23% of range.

(2) (U) Capabilities. Due to the minimal information available, the following characteristics of the M1957 are estimates only:

- Elevating limits: -2° and +42°.
- On-carriage traverse: 4°, or less, total.
- Weight: 65 tonnes.
- Overall length: 15.97 meters.
- Tube length: 13.14 meters.
- Maximum range: 25+ km.
- Projectile weight: 325 kg.
- Maximum muzzle velocity: 800 m/s.
- Rate of fire: 1 rd/3 min; 12 rd/h.
- Mount: Modified JS tank chassis, 376.6 kW (512-hp) engine.
- Road speed: 25 to 30 km/h.
- Cruising range: 130 km.

HE, CP, and, possibly, gun-assembly-type nuclear projectiles are assumed to be used in this gun. Because they are probably heavier, the CP and nuclear projectiles should achieve only about 85% of the maximum range

attainable with HE. On-carriage fire control probably consists of a panoramic telescope with mount, an elevation quadrant, and a gunners' quadrant.

(3) ~~(C)~~ Configuration. Prominent features of this weapon (fig III-C-8b) include a loading mechanism consisting of a crane, loading tray, and rammer (probably powered). Two massive equilibrators balance the barrel assembly. A spade appears to be attached to the chassis to provide stabilization during firing. The most visible difference between the 310-mm gun and the 420-mm mortar is the recoil system of the gun.

b. ~~(C)~~ Summary. Although the 310-mm self-propelled gun M1957 has appeared in parades subsequent to 1957, it probably never was standardized due to continued development and deployment of the more lethal and flexible rocket and missile systems. This weapon is said to have appeared in at least two countries outside the Soviet Union, but this information remains unconfirmed. It is not known to be in active use or, possibly with the exception of the USSR, to be presently stockpiled anywhere in the world. It also is probable that such numbers of this gun as have been produced are retained in Soviet war reserve stocks for use in the demolition of any heavy fortification that Soviet troops may encounter in future combat operations.

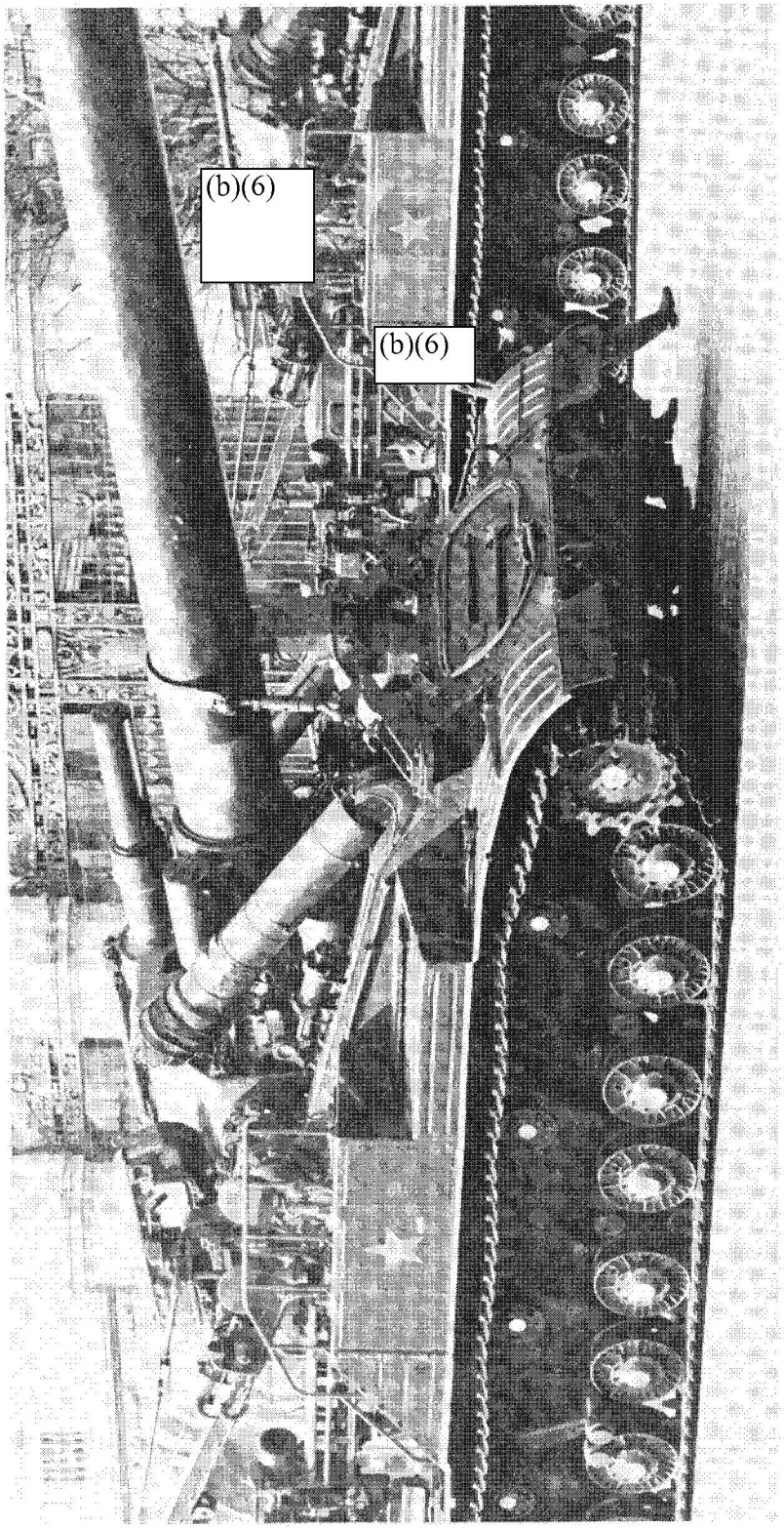

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Figure III-C-8b. 310-mm M1957 gun, right front side of gun (U). (~~CONFIDENTIAL~~)

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Section IV.

TRENDS AND FORECAST

A. TRENDS

1. (~~C~~) Field and Antitank Artillery Cannon Systems

a. The Soviet Union.

(1) General. A significant trend in Soviet provision for artillery fire support has been established since Khrushchev was deposed in 1964. During his period as Premier, Khrushchev deemphasized cannon units. Following the Khrushchev era, the Soviets reverted to their former practice of placing great reliance upon their conventional artillery (field and antitank artillery cannon, mortars, and MRL). Since 1964 there has been a material increase in Soviet artillery in terms both of number of units and system capabilities. This increase, in addition to the previous Soviet status, enables Soviet artillery to enjoy a considerably more powerful posture than that common to free world artilleries. The Soviet 122-mm D-30 howitzer, 100-mm T-12 antitank gun, and 76-mm mountain gun were deployed in 1963, 1965, and 1966, respectively. No further deployment of new cannon systems occurred until two new cannon systems, both self-propelled, were introduced: A 152-mm system in 1973 and a 122-mm system in 1974. Deployment of these new systems follows the previous Soviet cyclic pattern of introducing several new cannon systems at approximate 10-year intervals; the introduction of 100-mm AT cannon in 1944, 1955, and 1965 is illustrative of this cycle. This recent introduction of self-propelled cannon systems also is characterized by the concurrent deployment of at least four SP vehicles that are ancillary to these systems. The introduction of these self-propelled cannon systems evidences an appreciation on the part of the Soviets that a mix of self-propelled and towed cannon systems is necessary to insure, in the present-day military environment, timely and sustained artillery fire support throughout prolonged exploitation and pursuit operations involving high daily rates of advance. Doctrine, tactics, training, and the continued development of armor-defeating ammunition for cannon systems emphasize the importance afforded the direct-fire role within Warsaw Pact countries. According to the December 1975 issue of the US Armed Forces Journal, annual production of cannon by the Soviet Union (1200) is 7 times that of the United States (170), this without considering cannon produced by non-Soviet Warsaw Pact countries, the PRC, and other ECC. Recent acquisition by the USSR of several large SXP-55 and a number of smaller, rotary

forges (made by GFM of Steyr, Austria) has provided the Soviets a significant increase in their weapon production capability. Export of Soviet artillery weapon systems has broadened from their earlier "trade" with ECC. Export now includes sales of artillery systems both to third world and to some free world countries.

(2) R&D practices. Since the 1930s the USSR has developed and deployed a variety of artillery weapons. These include FROG; MRLs; light, medium, heavy, and very heavy field artillery systems; light and medium AT guns; light, medium, and heavy mortars; and light and medium AA gun systems. Figure IV-A-1-a1 shows one comparison of fire support weapons developed for the Soviet and the US armies by year group.

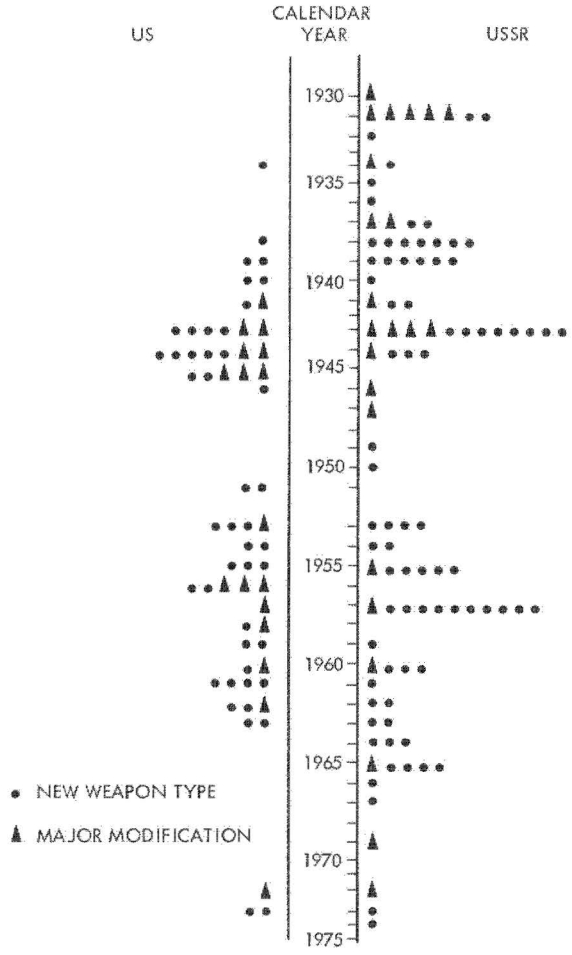

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Figure IV-A-1-a1. Soviet vs. US Army fire support weapon developments (U).

This illustration indicates that between 1930 and 1974 the Soviets developed 78 new weapons and made major modifications to another 25. During this same period the US Army developed 45 new weapons and made 17 major modifications. An anachronism exists in the replacement cycle for older Soviet artillery materiel. A weapon developed during the 1930s (for instance, the 203-mm B-4 howitzer) may continue in service, while a system developed in the 1940s and 1950s may be considered obsolete or obsolescent. The trend with cannon systems has been to retain in war reserve stocks those weapons deemed to contribute to some phase of warfare as envisioned in current operational plans plus some theoretical contingencies. For about 45 years Soviet development of artillery systems, within each caliber utilized, generally has followed the pattern of deploying a new system that incorporates the better features of the system being replaced and, at the same time, attaining improvements in one or more of the following factors:

- Ballistic performance.
- Reliability, availability, maintainability, and durability (RAM-D) characteristics.
- Mobility.
- Emplacement and displacement times.
- Fire Control.
- KE/system weight and system weight/momentum ratios.
- Weapon stability, firing and/or in travel.

Soviet practice is to introduce a weapon, shortly thereafter apply minor modifications, and, if that weapon doesn't serve their purposes in a most satisfactory fashion, replace it with a newly designed system; e.g., the 100-mm M-1955 gun was superseded by the 100-mm T-12 smoothbore gun within 10 years. Conversely, when the Soviets deploy a system of particular worth, they will make one or more major modifications during the long

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NOTE: In this context, the following approximate calibers apply: Light = < 111 mm, medium = 111 to 160 mm, heavy = 161 to 210 mm, very heavy = 211 to 300 mm, and superheavy > 300 mm.

service life of that system; e.g., large numbers of 122-mm World War II M-30 howitzers remain in service, although this weapon has been replaced in first-echelon units by the 122-mm D-30 howitzer. Minor modifications, usually quite numerous, are characterized by the rapidity with which they are effected. The design or the positioning of minor features such as tool brackets, etc. frequently is changed within a very short time following initiation of production. Major modifications also may be effected very shortly after commencement of the production run. For example, equipment and ammunition loading hatches on the rear of the 152-mm M1973 self-propelled gun were redesigned and/or relocated within about 18 months after the deployment of this weapon. Since these modifications indicate that the loading mechanism and/or ammunition stowage also was modified and redesigned, it is probable that an exceptionally rapid implementation of a major modification(s) was effected.

b. Non-Soviet Warsaw Pact Countries. Czechoslovakia enjoys a long history in the design and production of very good to excellent cannon systems. After World War II it produced the 85-mm M-52 and the 100-mm M-53 field guns. Since producing these very good weapons, Czechoslovakia is not known to have designed any additional field or antitank artillery systems. Nevertheless, Czechoslovakia continues to be active in the MRL and AAA gun fields, and probably continues to maintain its capability for the design of FA and AT guns. There are indications that Poland and/or Czechoslovakia play a part in the design and/or production of major components of the Soviet 122-mm M-1974 self-propelled gun system. East Germany is not known to have designed any cannon systems since World War II; nevertheless, it undoubtedly has the know-how, and probably the facilities, prerequisite to the design and production of cannon systems. It is improbable that either Hungary, except for fire control subsystems, or Bulgaria designs or produces artillery systems or subsystems.

c. Non-Warsaw Pact ECC. Following World War II and until the breach in Sino-Soviet relations, the USSR supplied field artillery materiel to the PRC. More recently, the PRC has produced copies of Soviet weapons and/or redesigned and upgraded weapons based on Soviet designs. For example, the PRC developed and deployed the 130-mm type 59-1 field gun. This weapon, although it utilizes a Soviet-designed 122-mm D-74 carriage and 130-mm M-46 gun tube, illustrates ingenuity and the ability to redesign and upgrade breechrings, breech mechanisms, and recoil mechanisms. Further, the PRC has displayed ingenuity in producing modified, and usually improved, versions of Soviet-designed on-carriage fire control equipment as well as a fire direction set. North Korea indigenously produces artillery systems of foreign design. With the exception of North Vietnam no southeast Asian ECC is credited with the

capability of producing an artillery cannon system. Conversely, Vietnam possesses artillery repair shops and, possibly, some manufacturing facilities that may be suitable for limited production of artillery systems; nevertheless, considering the plethora [by country of origin (the United States, the USSR, and the PRC), type, and quantity] of cannon systems presently in hand in Vietnam, there appears to be no need for such programs at the present time. Yugoslavia has a limited capability for the production of artillery cannon systems, yet largely employs Soviet systems.

2. ~~(c)~~ Ammunition

a. The Soviet Union.

(1) General. Trends in the development and fielding of Soviet field artillery cannon ammunition are indicated by past and continuing Soviet success in increasing munitions effectiveness through several means, including improved projectile and charge geometry, materials composition, range enhancement, and fragmentation or penetration. Past Soviet practice indicates that they will adopt applicable foreign technologies whenever such action facilitates the attainment of their R&D objectives.

(2) Propellants. Soviet production of propellants utilizes for the most part the large-batch extrusion process to produce double-base propellants that have a heat of explosion of ≈900 cal/g and flame temperatures of ≈2600 K. These double-base propellants exhibit very good stability during storage and produce repeatable results when fired. Propelling charges are surrounded by a sheet of waxed paper that serves as a wear reducer. The decoppering agent is a coil of lead wire tied to the top of the charge. The large-batch extrusion process is readily adaptable to the production of triple-base propellants. When and if the Soviets decide that it is necessary to utilize low-flame temperature, triple-base formulations to extend tube wear life, they should encounter little difficulty in the manufacture of these formulations. Currently, when the Soviets require a higher-flame-temperature propellant, such as is necessary for the full charge 122-mm D-30 round, they utilize a single-base propellant having a theoretical flame temperature of about 3100 K. Such utilization is acceptable from the standpoint of tube wear, since all other charges used with this system exhibit satisfactory tube wear characteristics; i.e., when approximately 10% of the total rounds fired are full-charge rounds and the remainder are reduced-charge rounds, tube wear life should remain within acceptable limits.

(3) Projectile fillers. The majority of ECC artillery shells are filled with TNT. The Warsaw Pact also uses RDX that is enhanced with flaked aluminum. Pressed 95% RDX and wax also is used. The 122-mm rocket warhead is filled with a combination of pressed RDX and wax booster and cast TNT and cast RDX-TNT-Al. Compounds containing RDX enhance brisance and apply that brisance (relative to the geometry and thickness of the projectile) to improve the uniformity of fragment size and to increase initial fragment velocity. The Soviets also produce HMX. Most Soviet shell bodies are forged from a steel that is comparable to that used by the United States. The trend is toward greater brisance and better fragmentation. To date, there is no evidence that an anti-personnel ICM projectile has been deployed for use in cannon systems.

(4) Increased range. The width of Soviet divisional sectors usually is much less than that of NATO divisions, and the density of deployment of Soviet artillery units usually is greater than that of NATO artillery. Although both of these parameters militate against the need for increased range, Soviet artillery weapons, with few exceptions, consistently have outranged free world artillery. The Soviet trend generally has been to increase range capability with each new weapons system that is developed; e.g., the 122-mm D-30 howitzer's 15.3 km vs. the older M-30 howitzer's 11.8 km, the 152-mm D-20's 18.4 km vs. the older ML-20's 17.3 km, etc. Soviet artillery is known to have one rocket-assisted projectile (RAP) that is fired from the 180-mm S-23 gun and attains a range of 43.8 km.

(5) Cannon delivered nuclear munitions. The Soviets probably have developed, and to some extent deployed, nuclear projectiles for cannon in the 152-mm gun-howitzer and heavier caliber classes. Initially, R&D efforts probably were directed toward nuclear projectiles for the 310-mm self-propelled gun, the 420-mm self-propelled mortar, and the 180-mm S-23 gun; however, there is no evidence the Soviets presently place emphasis upon the delivery of nuclear projectiles by these particular heavy and superheavy cannon systems. It is apparent that the Soviets currently rely primarily upon their tactical and intermediate-range missile systems, the FROG rocket system, and tactical air support means for the delivery of those nuclear strikes intended to facilitate the maneuver of combined-arms units of divisional and larger size. Soviet cannon-delivered nuclear munitions probably are intended mainly for the counterbattery role (particularly against missile launchers and self-propelled cannon units), and for other targets such as battalion-sized assembly areas, regimental and higher level command posts, and strongpoints larger than platoon size, rather than for such targets as critical terrain features and large unit assembly areas, the neutralization or destruction of which may be regarded as truly "maneuver-enhancing"

with regard to the employment of corps and army-sized forces. In short, the probable Soviet (Warsaw Pact) trend is for cannon artillery units to continue to play the leading role in the delivery of conventional munitions [and probably improved conventional munitions (ICM)] in support of maneuver units, and to utilize, when directed, cannon-delivered nuclear strikes in lieu of those large artillery concentrations that require the expenditure of hundreds of rounds of ammunition to assure neutralization or destruction.

(6) Improved conventional munitions. The Soviets have developed submissiling techniques and possess submunitions. Previous studies postulated that the Soviets had the capability to produce cannon-delivered ICM by 1975 if they desired to commit the resources necessary for that attainment. Although the USSR is believed to have cannon-delivered ICM, there is no firm supporting evidence for this assumption [see subpara (8)(a), below].

(7) Cannon-launched guided projectiles. The USSR recognizes the significance of cannon-launched guided projectiles (CLGP), and appears to be generally aware of the US state-of-the-art in this field. To date there is no evidence to indicate Soviet development of CLGP.

(8) Armor-defeating projectiles. For almost 35 years the Soviets have produced armor-defeating projectiles for all cannon of 152-mm and smaller caliber. Some Soviet (and ECC) systems have both chemical-energy and kinetic-energy projectiles. Improvements in both types have been continuous.

(a) Chemical-energy munitions. Soviet armor-defeating projectiles of the chemical-energy type exhibit excellent armor penetration. The Soviets realize that the thickness of armor effectively penetrated, rather than penetrated in terms of obtaining a pinhead-sized hole, is what is meaningful in the defeat of an armored vehicle; i.e., it avails nothing to obtain a penetration exhibiting such a small exit diameter that the munition doesn't inject enough particle-laden jet to disable either the crew or some critical system components. The BK-6M HEAT munition fired from the Soviet 122-mm D-30 howitzer produced armor penetrations that, by US Army criteria, were some 1.6 times greater in depth than those stated in Soviet publications. At the Soviet claimed penetration depth of 350 mm at 0° obliquity, the average diamater of the hole was 12 to 14 mm (about 0.5 in). Very recently, evidence was obtained that the Soviets have deployed a HEAT-SS round for use in their 152-mm gun-howitzer systems. Prior Soviet technology with regard to HEAT projectiles, in addition to the comparatively large diameter of this projectile, indicates that, given a target hit on conventional armor,

this projectile should be very effective. There also is an unconfirmed report that the Soviets have developed an ICM projectile of unknown caliber that probably is intended for the defeat of armor. This new projectile allegedly contains a relatively small number of comparatively large submunitions.

(b) Kinetic energy projectiles. The trend in Soviet development of KE projectiles has been toward increasing muzzle velocities and improving projectile materials and design. All Soviet guns, and some gun-howitzers, of 152-mm and smaller caliber have available kinetic energy (KE) projectiles. Soviet KE penetrators, with the exception of some 152-mm AP projectiles, exhibit good-to-excellent penetration. It is estimated that the armor-piercing, discarding-sabot, fin-stabilized (APDSFS) projectile fired from the Soviet 100-mm T-12A antitank gun can defeat in excess of 200 mm of armor at 0° obliquity at a range of 2000 meters. It is probable that, in addition to the T-12A's 1500 to 1550 m/s estimated V_o, the highly effective technique used in the 115-mm T-62 tank gun for discarding the sabot and obtaining spin also is used with the T-12's APDSFS projectile. Armor penetration can be increased by using denser materials than the ESR steel or tungsten carbide presently used in Soviet penetrators. The trend in Soviet KE rounds is toward higher initial velocities, denser penetrators, and improved sabot-discarding.

(c) Capability. The Soviets continue to require that all of their field artillery cannon systems of 152 mm and smaller caliber augment in the armor-defeating capability provided by their dedicated antitank means. That this trend continues is illustrated by the incorporation of a direct fire capability into each of the newly introduced self-propelled FA cannon systems. Soviet 100-mm antitank guns employ both KE and HEAT rounds. Generally, FA guns are provided with KE rounds, howitzers utilize HEAT munitions, and some gun-howitzers employ both KE and HEAT rounds.

(9) Fuzes. Time fuzes for Soviet artillery projectiles have been of the mechanical and powder train types. Soviet training literature, as well as training aids observed on subcaliber artillery ranges, strongly indicates that the Soviets have deployed a proximity (VT) fuze that probably incorporates one or more height-of-burst options. Further, in cannon systems any employment of ICM and, more particularly, nuclear projectiles dictates the utilization of very precise mechanical-time or electronic-time fuzing. Such fuzes are more likely to have been designed and produced in the USSR or Czechoslovakia rather than procured from other accessible sources. It is also possible that the Soviets obtained the necessary design data from another country and are producing indigenous copies of a suitable, foreign-designed fuze in quantity.

b. Non-Soviet Warsaw Pact Countries. Czechoslovakia leads these countries in ammunition design. Some Czechoslovak KE rounds exhibit slightly higher performance than do corresponding Soviet rounds. The 122-mm rocket used in the Soviet BM-21 and the Czechoslovak RM-70 MRL is believed to be, in large part, of Czechoslovak design. The production of artillery ammunition within these countries is based almost exclusively upon Soviet or Czechoslovak designs.

c. Non-Warsaw Pact ECC. With the exception of Yugoslavia and the PRC, the production of non-Warsaw Pact artillery ammunition is based upon Soviet and Czechoslovak designs. Yugoslavia produces 105-mm and 155-mm howitzer ammunition compatible with the US M101 and M114 howitzers, and 128-mm rockets for its MRL systems. The PRC produces ammunition for its 107-mm MRL systems.

3. (~~C~~) Prime Movers and Cargo Carriers

a. Eastern European Communist Countries. Recent trends within this area are as follows:

- Larger-capacity and more powerful 6x6 and 8x8 cargo trucks (prime movers).
- A growing preference for the use of wheeled, usually 8x8, prime movers rather than tracked tractors for the towing of medium (122-mm gun through 152-mm gun-howitzer) field pieces.
- An increase in the use of high-speed lightweight tracked tractors (such as the amphibious M-1970) for the towing of AT guns.
- Continued development and introduction into service of improved cargo trucks and tractors that exhibit greater mobility.

There is no shortage in the number of types of vehicles available for employment with artillery nor any serious overall deficiencies within vehicle design.

b. Asian Communist Countries. With the exception of Soviet-designed and -produced cargo trucks and copies of the Soviet AT-S tractor, these countries remain seriously deficient in motor transport suitable for use with artillery. With the probable exception of North and South Vietnam, the quantity of vehicles available for the support of extended military

operations apparently is inadequate. Nevertheless, considering the waterways, the rail facilities, and the tremendous quantity of manpower available, this apparent inadequacy in vehicular transportation must be tempered with the knowledge of past transport accomplishments on the part of Asian armies.

4. ~~(C)~~ Target Acquisition, Fire Control, Fire Direction, Surveying, and Meteorological Equipments

a. Warsaw Pact Countries.

(1) General. In addition to the large Soviet R&D base, Warsaw Pact countries such as East Germany (for example, Zeiss at Jena), Hungary (for example, MOM at Budapest), and some others produce excellent target acquisition, artillery fire control, and surveying equipments. With the exception of stereorangefinders, Warsaw Pact target acquisition and fire control equipments employing classic optics and mechanical components are relatively conventional in design, rugged, comparatively inexpensive, suitably precise, and exhibit good RAM-D characteristics. Taken in its entirety, target acquisition equipment presently deployed is as good or better than comparable US ground-based equipment; certainly the density of its deployment exceeds that usual to free world armies.

(2) Target acquisition equipment.

(a) Radars. The Soviet SMALL YAWN countermortar/counter-battery radar is similar to the US Army's AN/MPQ-10. Because it is more than 15 years old, the SMALL YAWN is not representative of the current state-of-the-art. Although its performance in the countermortar role is quite good, its capability as a counterbattery radar is limited. The Soviet SNAR-6 battlefield surveillance radar, currently 10 years old, is a good radar even though it does not represent present state-of-the-art. Although both of these Soviet radars are comparable to free world systems deployed through the early 1970s, advances in the state-of-the-art, as well as the present age of these systems, indicates their probable early replacement.

(b) Rangefinders. Artillery CP-OPs use stereorangefinders as an adjunct to target location. Also, when a CP-OP deploys a lateral OP, that battery is afforded the capability of locating targets by two-point intersection. Tripod mounted laser rangefinders, possibly designated as the DAK-1(?), are deployed to artillery target acquisition batteries. Recently the deployment of tripod-mounted laser rangefinders to cannon units equipped with towed pieces was begun. Incorporation of a laser rangefinder into the artillery associated Armored Command and Reconnaissance Vehicle (ACRV) M1974(2) is highly probable. The stereo-rangefinders in some East German artillery units have recently been replaced by instruments having about a 50-cm base, a length that in a classic stereoptical rangefinder is too short to satisfy field artillery requirements. This indicates that these

instruments may be optical correlation rangefinders; a type of instrument that, allegedly, approaches the accuracy of a laser rangefinder without occasioning the "false readings" incurred when the laser beam encounters a wire, twig, patch of light, fog, etc.

(c) Night observation devices. Passive image intensifiers are being used in increasing numbers on AT artillery weapons [and probably in the 122-mm M-1974 SP gun and ACRV M1974(2)] to replace the older IR systems. Whether similar devices are being presently employed upon CP-OPs is not known although, reportedly, instruments of these types are issued to artillery units.

(3) Fire control equipment.

(a) On-carriage. On-carriage fire control equipment, except on weapons of 180-mm and larger caliber, is mounted on the left side of the piece and is operated by one man. This relatively simple, rugged, and suitably precise equipment is sufficient to the need.

(b) Off-carriage. The Soviet collimator, generally used as a secondary aiming reference, is a relatively lightweight, easily read, sufficiently rugged piece of equipment. Apparently there is no trend toward replacing devices such as collimators and gunners' quadrants.

(4) Fire direction equipment. Current fire direction equipment used by Soviet field artillery cannon, mortar, and MRL units is designed primarily to facilitate manual solution of the fire direction problem. The Soviet PUO-9 fire direction (FD) set is operated by one man under the supervision of an officer or senior NCO. The PUO-9 is a very good manual FD set for use primarily at the battery level. The operator of the PUO-9 requires extensive, in-depth training. In the early 1970s, the East Germans fabricated a manual FD set (named Rostock) that uses magnets to secure the range arms and to designate target locations. Rostock presently is employed in some East German MRL batteries. Computer applications have been noted in Soviet antiaircraft and guided missile units for fire control and/or fire direction purposes. In most cases these computers are of the electromechanical analog variety. DDA (digital differential analyzers) probably are utilized in some of the newer Soviet equipment used for these applications. Electronic computers presently may be deployed to some field artillery cannon units. Soviet gunnery techniques practically dictate that the individual batteries either be equipped with a battery-level computer or be afforded the capability of directly addressing the battalion-level computer to obtain solutions of, as a minimum, battery-level technical fire direction problems. The open literature states that handheld electronic calculators, capable of solving algebraic and trigonometric formulae, are being field tested for

use in artillery units in one or more Warsaw Pact countries, and further, that results to date indicate a 30% (or better) reduction in the time required to compute survey, meteorological, and firing data. The apparent trend is toward the issue of handheld computers to expedite the solution of observed fire and survey problems.

(5) Survey equipment. Equipment used to perform artillery survey in Warsaw Pact countries is, on the whole, of high quality. Soviet theodolites are well made. For more than 10 years Warsaw Pact countries have made extensive use of tellurometers based upon the excellent South African designs. The use of tellurometers facilitates and expedites the execution of accurate survey in the rear areas and thereby enhances accuracy in the execution of the target acquisition, fire control, and fire direction functions. Soviet-made gyroazimuth indicators also have been used by Warsaw Pact artillery for more than 10 years. Gyroazimuth theodolites not only facilitate the establishment of the initial direction in survey but, in the absence of survey, permit cannon units to be laid on a common direction. Furthermore, for some 10 years Warsaw Pact countries have employed the Soviet-produced land navigation system mounted in the GAZ-69T vehicle. An obvious asset during road marches and in the conduct of reconnaissance, this land navigation equipment, although much too imprecise for the conduct of artillery survey per se, frequently is used to perform short-legged, hasty surveys, particularly in MRL units. Experience gained from the development, wide deployment, and extensive use of the Soviet land navigation system should give the Warsaw Pact a considerable lead in the development and deployment of a vehicle-mounted system that is truly capable of an acceptable level of artillery survey.

(6) Meteorological equipment. Under Soviet auspices, Warsaw Pact artillery has placed and continues to place great emphasis on the currency and accuracy of met data. The distribution and density of deployment of met stations are much greater than those available to NATO forces. The excellent, active-type Soviet ARMS-1 met station is the backbone of the Warsaw Pact met data collection system. The ARMS-1 is deployed to the AIR [artillery instrumental reconnaissance (target acquisition)] battery within divisional artillery regiments and to AIR battalions at higher echelons. The ARMS-1 utilizes the END TRAY radar to track, and measure the slant range to, the balloon-borne radiosonde. In addition, divisional FROG battalions utilize the older BREAD BIN radar to track, and measure the slant range to, a non-radiosonde-bearing balloon. Although a complete met message can be derived from soundings made by the BREAD BIN system, in FROG units the BREAD BIN primarily is used to obtain current wind data for correction of a previously disseminated ARMS-1 met message. In addition, Soviet field artillery

battalions frequently establish ad hoc "met posts" that, by using the one-point method of tracking a balloon by means of a theodolite and stopwatch, generate abbreviated met messages suitable for cannon artillery. Primarily, these met data are used for updating the wind direction and wind velocity segments of the ARMS-1 met message. The Warsaw Pact means for collecting current met data are, relatively, excellent.

b. Non-Warsaw Pact ECC.

(1) General. Non-Warsaw Pact ECC largely are dependent upon Warsaw Pact and, to some extent, third world and free world countries for the design of these types of equipment.

(2) Target acquisition equipment. The PRC indigenously produces copies of Warsaw Pact-designed optomechanical equipment (aiming circles, theodolites, etc.) and has produced copies of Soviet active infrared equipment used on tanks as driving, observation, and fire control aids at night. Information on other types of infrared devices, including any that may be used in target acquisition by the PRC, is not available. The PRC has purchased small numbers of image intensifiers from the United States and other free world countries. Requests, probably originating from the PRC, for prices and delivery dates on a total of several thousand image intensifiers have been received from and/or through other countries. The PRC is believed to have laboratories engaged in the development of night vision devices, but no details are available. Other non-Warsaw Pact ECC are almost totally dependent upon outside suppliers for all but the least sophisticated of target acquisition equipment.

(3) Fire control. The PRC produces indigenous copies of Soviet-designed on- and off-carriage fire control equipment for numerous models of artillery systems. Particularly in the field of direct fire sights, the PRC has incorporated improvements, in reticle patterns, for instance. Countries, such as North Korea and Yugoslavia, that manufacture small numbers of cannon generally restrict themselves to the production of the on-carriage fire control equipment required on these systems.

(4) Fire direction equipment. The PRC, after using the Soviet PUO-3 (and possibly the PUO-9) fire direction sets, has produced a most ingenious two-range arm adaptation of the PUO-9. Other ECC use Soviet fire direction sets, copies of free world FD equipment, or both.

(5) Survey equipment. The PRC produces copies of Soviet optomechanical instruments. It also uses Soviet equipment that was furnished to the PRC prior to the early 1960s. North and South Vietnam

obviously possesses considerable quantities of Soviet, PRC, and US surveying equipment. Except for Yugoslavia, which possesses both Warsaw Pact and free world equipment, the non-Warsaw Pact countries utilize Warsaw Pact surveying equipment. Other than the PRC, no non-Warsaw Pact ECC produces any significant quantity of surveying instruments.

(6) Artillery meteorological equipment. With the exception of those radar-type met stations that have been provided by or purchased from the Soviet Union, non-Warsaw Pact ECC are restricted to sounding the atmosphere for artillery purposes by means of the one-point method. This method entails observing the ascending balloon with a theodolite while timing these observations by means of a stopwatch to obtain the approximate altitudes attained by the balloon.

5. ~~(C)~~ Communications Equipment

Communications equipment used by ECC field, AT, mortar, and MRL artillery units primarily are designed and produced by Warsaw Pact countries and by the PRC. The density of deployment of communications equipment, particularly radio sets, within Warsaw Pact artillery units is less than that common to NATO artillery units. Much of this disparity is the result of the differing concepts and techniques employed in the exercise of the command, control, gunnery, and fire direction functions. For example, although the density of deployment of radio sets to Soviet towed artillery units is austere compared with that afforded US artillery, every 122-mm and 152-mm self-propelled gun is equipped with a radio receiver or transceiver; the US 155-mm M109 and M109A1 systems, on the other hand, are not. The Soviets probably consider these radios necessary for the expeditious execution by these weapons of the direct-fire, accompanying-gun, and roving-gun roles. Warsaw Pact production of additional quantities of presently deployed equipment, if and when such action is considered necessary, should not pose any great difficulty. In the last few years, radio sets developed and produced within the PRC have been surprisingly well made; however, the PRC could require considerable time to bring the density of its field radio equipment up to parity with that of the US Army, should such parity become necessary. Other ECC countries, excluding perhaps North Korea and Yugoslavia, are almost entirely dependent upon Warsaw Pact countries and/or the PRC for the satisfaction of their requirements. The production of field-type metallic circuit equipment (field wire, telephone sets, telegraph sets, switchboards, repeating coils, etc.) is within the production capability of all but the most backward of nations.

B. FORECAST

6. ~~(C)~~ Field and Antitank Artillery Cannon Systems

a. General. The USSR should continue to lead the ECC in R&D both of field and antitank artillery cannon systems and in the quantity and variety of such systems that are produced and deployed. Within the Warsaw Pact, Czechoslovakia, Poland, and possibly East Germany are each expected to become either the "prime contractor" or the "codesigner/co-developer or coproducer" of one or more new systems. Warsaw Pact countries are expected to retain, and may increase, the present percentage of field and antitank artillery within their troop bases. The Soviets presumably will maintain their present attitudes with regard to the design and modification of weapons and the employment of cannon artillery. The PRC should continue to modify and produce systems of foreign design and by 1986 may produce one or more cannon systems of indigenous design. Of the remaining ECC, a few of the more industrially oriented ones that are semi-independent of the Soviet and PRC hegemonies (for example, Yugoslavia and North Korea) probably will strive to reduce their reliance upon present suppliers by increasing their indigenous production of cannon systems, even though the systems so produced will for the most part be copies of foreign (usually Warsaw Pact) designs. In short, the design, development, and production of new cannon systems that exhibit materially increased worth will, almost without exception, be confined to Warsaw Pact countries until 1985 or later.

b. Warsaw Pact, Primarily Soviet, Activity in the Cannon System Field.

(1) Highly probable. The following developments are considered highly probable:

- Continuation of present methods of operation and policies in regard to R&D of artillery cannon systems.
- Retention of the 122-mm caliber for close support cannon and the 130- and 152-mm calibers for the great majority of their general support type of cannon.
- Development and deployment of a heavy, self-propelled gun-howitzer or gun system. Although a range on the order of 35 km should be attained, the primary goals are probably the achievement of short emplacement/displacement times and excellent precision (particularly within the 20- to 30-km zone) in indirect fire.

- From their present pattern of deployment, the attainment of a mix of cannon field artillery that approximates 50% towed and 50% SP in each first-echelon Soviet motorized rifle division, 40% or more SPs in each Soviet tank division, and about one-third SPs within Soviet front-level artillery formations; further, by about 1980 or earlier, to have made good progress in a similar program with regard to non-Soviet Warsaw Pact first-echelon units. These goals should be reached in the USSR and in the major non-Soviet Warsaw Pact countries by about 1986 (possibly somewhat earlier).

- Production from ESR steel of cannon tubes through 203-mm caliber upon recently acquired large SXP-55 GFM rotary forges. Tubes so produced should exhibit such enhanced physical parameters as yield strength. The production capability should be increased and unit cost per tube materially reduced.

- Warsaw Pact countries, especially the USSR, will increase their worldwide export trade in artillery systems, including field and AT cannon and artillery mortars. This activity should tend to support the Soviet production base and reduce unit costs.

(2) Probable. The following developments are considered probable:

(a) Self-propelled antitank cannon system. A replacement cannon system for the presently deployed 100-mm smoothbore T-12 and T-12A towed antitank cannon systems probably will be deployed before 1986. This estimate is based on a number of factors: The current vulnerability of these weapons during emplacement and displacement, the probable firing instability of the T-12 and the probable only fair-to-good performance of the T-12A in this respect, and the desirability of increasing the performance of antitank weapons with respect to rates of fire and effective range; i.e., 50% P_h. The replacement system will likely be mounted upon a very mobile, high-speed (≈80 km/h), lightly armored, CBR-protected, low silhouette, tracked chassis. An amphibious capability also would be desirable, but not at the expense of any serious degradation either in weapon stability or off-road mobility. No postulations presently can be made with regard to the cannon system per se, since it is not known what trade-offs the Soviets may elect to accept. They could opt for a smoothbore cannon larger in caliber than the 100-mm T-12, and thereby accept greater weight together with probably reduced mobility and

rate of fire. Although it is postulated that any self-propelled AT system will incorporate assisted loading, a cannon of 76 mm or thereabouts most likely could be made fully automatic for the delivery of bursts of about three rounds, thereby considerably enhancing hit probability. Whatever caliber the cannon may be, it is highly probable that it will be very effective.

(b) Soft recoil. Because of the Soviet approach to cannon system design, and the emphasis the USSR places upon relative simplicity and ruggedness, as well as, upon reliability, availability, maintainability, and durability (RAM-D) characteristics, it is postulated that R&D activity in the cannon system field will not include either component or system development in the area of "soft recoil."

(3) Possible. The development and deployment of a portee-type cannon system that is casemated, lightly armored, CBR-defense-equipped, capable of 360° of traverse, and equipped with generator-powered, electrically driven self-levelling, gun-positioning, and ammunition-loading subsystems is possible. Transported by a modified cargo truck, such as an improved ZIL-135 or the forthcoming 8x8 TATRA-815, a system of this type could be rapidly emplaced/displaced by means of a powered ramp or some other kind of materials-handling device. In an emergency, this weapon could be fired (at least with the lower-energy propelling charges) from its transporter. The postulation that this type of portee system will be developed and deployed is governed by an acute appreciation of the Soviets' propensity for ruggedness, relative simplicity, and excellent RAM-D characteristics in their field and AT artillery cannon systems, and their consequent long reliance upon towed systems. Such a portee system should be less costly than a self-propelled system; exhibit better RAM-D characteristics than an SP system; provide about the same degree of mobility as that afforded by an SP (albeit at some increase in emplacement/displacement times); and, when in position, be considerably less vulnerable than an SP and afford greater crew protection than is available with a towed cannon system. In addition, since a battalion's "transporter" and "ammunition" vehicles should be similarly equipped, the cannon would not necessarily be dependent upon the availability of its "assigned" transporter; as with towed artillery, loss of the transporter need not result in loss of the gun. Availability of the system would thereby be increased. Czechoslovakia or the USSR are the logical developers for such a portee system.

c. Non-Warsaw Pact ECC Activity in the Cannon System Field. The following developmental activity is postulated to occur within the forecast period:

(1) People's Republic of China. Within the near-term the PRC probably will deploy either an indigenously produced or a hybrid

adaptation of the Soviet 122-mm D-30 towed howitzer. Further, by 1986 the PRC is expected to deploy one or more cannon systems that largely reflect native design; the first of these systems may be a mountain gun. Adaptation of a pedestal-mounted cannon to a tracked APC or tank chassis, thereby evolving a first generation SP cannon system, may take place at any time.

(2) North Korea. This country will materially expand its capability for the production of cannon systems and related communication equipment. The weapons so produced will continue to be copies of foreign designs.

(3) Yugoslavia. This country will continue to design cannon and MRL systems; nevertheless, such activity will remain more a matter of national pride than a source of weapon systems of advanced design. The Yugoslav Army mainly will continue to employ weapons of foreign design, but will endeavor to build up a production base that will make it independent of foreign suppliers in time of war.

(4) Other ECC. The remaining ECC countries (Albania and SEA countries) probably will continue to be dependent upon foreign suppliers.

7. ~~(C)~~ Ammunition

a. The Soviet Union.

(1) General. The major developmental thrust in nonnuclear ammunition has been directed toward increasing effectiveness through the use of improved fuzing, chemical-energy, kinetic-energy, rocket-assist, and fragmentation technologies. The USSR possesses the necessary technology and probably has produced cannon-delivered nuclear munitions of 152-mm caliber that exhibit yields in the subkiloton range. Nevertheless, mass proliferation of such weaponry is not expected to occur during the forecast period.

(2) Propellants. The Soviets currently possess adequate single- and double-base propellants that exhibit good ignition reliability. It is anticipated that triple-base formulations will be introduced because the low flame temperatures associated with these propellants reduce weapon signatures and minimize bore erosion. The Soviets are capable of changing, with relative ease, all or part of their large-batch extrusion facilities for the manufacture of double-base propellant to the production of triple-base propellant. The initiation of Soviet production of triple-base propellant is dependent, in large part, upon their assessment of the advantages of increased tube life vs. the utilization of lower-energy propellants.

(3) Projectile fillers. The present Soviet posture with regard to projectile fillers is excellent. Available fillers range from TNT through RDX-Al to highly brisant RDX. It is postulated that, while the majority of HE projectiles will continue to be filled with TNT, an increasing number of types of projectiles will utilize RDX-Al, pressed RDX, or pressed HMX. Although research on fillers will continue, the introduction of fillers having a brisance higher than that of HMX is not foreseen during the forecast period.

(4) Increased range. Warsaw Pact artillery supports divisions that are deployed on much narrower frontages than is common to free world forces. The average density of deployment of Warsaw Pact artillery units also is much greater than that of free world forces. Because of these two conditions, Warsaw Pact artillery actually has a lesser need than free world artillery for increased range, particularly in direct support-type cannon systems. Nevertheless, Soviet artillery systems, with few exceptions, outrange free world systems. Indications are that the Soviets will continue to afford range capability a relatively high priority in weapons system design. It is likely that, with a 122-mm howitzer or gun-howitzer, the Soviets will attain a range of about 17 km with a conventional projectile and 21 km with a full bore hollow base (FBHB) extended range projectile. A 152-mm gun-howitzer should attain about 21 km with a conventional or 24 km with a FBHB projectile, and about 28 km with RAP. A 130-mm gun system should attain 30+ km with a conventional or FBHB projectile. Although a 130-mm gun could attain ranges of 38+ km with RAP, the payload available vis-a-vis range probable error (PE_r) becomes so unattractive as probably to cause the Soviets to question the cost effectiveness of attaining extended range in this caliber by means of RAP.

(a) Non-rocket assisted projectiles. During the forecast period, most of the projectiles that achieve ranges in excess of those currently attainable probably will be of conventional, but longer L/D ratio, and of FBHB designs.

(b) Rocket assisted projectile. During the forecast period, the Soviets are expected to deploy RAP for use in their 152-mm gun-howitzer systems. It is probable that the expenditure of RAP largely will be confined to the short-term suppression of particular types of targets at long ranges, such as air defense systems.

(5) Nuclear munitions. It is probable that the Soviet Union will continue to develop and deploy cannon-delivered nuclear munitions that exhibit subkiloton and low kiloton yields for the 152-mm gun-howitzer and larger calibers.

(6) Improved conventional munitions. In an attempt to achieve greater lethality from its munitions, the USSR has directed efforts toward controlling fragmentation and has successfully developed submissiling techniques. It is postulated that the Soviet Union will deploy artillery-delivered improved conventional munitions (ICM) in 152-mm and larger caliber, probably first in their heavy (240-mm ?) MRL, 203-mm howitzer, and/or 240-mm mortar. The antipersonnel submunition design most likely will be a wedge-shaped, airburst type of antipersonnel grenade similar to the US M43A1. Because of the armor threat, the Soviets also are expected to afford a higher priority to the development of a dual purpose (shaped charge and controlled fragmentation) submunition for the concurrent defeat of roof armor and personnel.

(7) Cannon-launched guided projectiles. The USSR recognizes the significance of precision-guided munitions [such as the US Army's cannon-launched guided projectile (CLGP)], and probably is aware of the US state-of-the-art in this field. To date, however, there is no evidence to indicate Soviet research or development in CLGP. It is probable, considering both their ATGM program and the capability of Warsaw Pact AT and field artillery cannon in defeating armored vehicles by means of direct fire, that the Soviets do not believe the expense and the tactical complexities inherent in the deployment of a CLGP to be warranted at present. The Soviets may consider that ICM are a more logical Soviet solution for the defeat of armor by indirect fire. Admittedly, guided projectiles represent a more viable solution for a high assurance of defeat of point targets than do ICM; therefore, it is believed that the Soviets will perform applied research in precision-guided munitions, but that such activity will be directed primarily toward air-delivered munitions.

(8) Shaped charge munitions. Although the Soviets have made significant advances in their shaped-charge munitions, they are expected to further improve the effectiveness of HEAT munitions during the forecast period. Currently, the Soviets achieve a 5 cone-diameter (CD) penetration; this is expected to increase to penetrations of about 6.5 CD during the forecast period. This approximately 30% increase will be achieved through the use of improved liner materials, pressed HMX, improved point initiating base detonating (PIBD) fuzing with graze-sensitive features, and improved wave-shaping techniques. To insure a kill upon obtaining a hit, the Soviets most likely will use followthrough concepts such as small diameter penetrators. The Soviets could incorporate the flat cone concept to increase entrance and exit hole diameters as well as higher charge-to-mass ratios to produce greater spalling of the armor.

(9) Kinetic energy projectiles. The Soviets have continually improved the performance of their kinetic energy munitions. Rather than the presently utilized tungsten carbide or electroslag remelt (ESR) steel penetrators, it is expected that during the forecast period the Soviets most likely will adopt denser (e.g., tungsten alloy) penetrators. These denser penetrators, coupled with a high ballistic coefficient, a high L/D ratio, and higher initial velocity (on the order of 1700 m/s), should provide the Soviets with as much as a 50% increase in penetration to an effective range of about 2500 meters in a 100-mm gun. The Soviets probably will conduct applied research and experimental development of penetrators made from depleted uranium. The Soviet doctrine which directs that all antitank and field artillery cannon systems of 152-mm and smaller caliber be capable of defeating armored combat vehicles by the delivery of HEAT and/or KE projectiles in direct fire will remain in effect.

(10) Fuzing. The Soviets are believed to have deployed a proximity fuze that may incorporate one or more height-of-burst options. It is postulated that the Soviets also possess a precise time fuze (most probably a mechanical time fuze). If this postulation is correct, the Soviets presumably will develop and deploy an electronic time fuze for use with their nuclear munitions and, if it is deemed necessary, with some of their ICMs. Further, should either the proximity or precision mechanical time fuzes currently exhibit undesirable or unacceptable characteristics, these deficiencies should be corrected prior to 1980. By 1980, ongoing Soviet research in solid state circuitry and infrared detectors will permit the production of proximity fuzings that exhibit even greater effectiveness. The Soviets also are likely to develop and deploy transistorized proximity fuzes that possess better ECCM properties as well as a range cut-off feature that permits effective functioning when munitions are fired at low angles of elevation.

b. Non-Soviet Warsaw Pact Countries. Among Pact members other than the Soviet Union, Czechoslovakia is foremost in the design and production of artillery ammunition and multiple-launched rockets. It is therefore probable that some of the activity postulated for the Soviet Union in fact may be accomplished either by Czechoslovakia alone or by Czechoslovakia acting in concert with the Soviet Union. Although Pact members other than the USSR manufacture artillery ammunition, the products will be either of Soviet or Czechoslovak design.

c. Non-Warsaw Pact ECC.

(1) PRC. The Chinese Communists presently lag the Soviet Union some 10 to 15 years in ammunition design. Although the PRC produces considerable quantities of artillery ammunition, these products, with

few exceptions (for instance, 107-mm rockets), are of Soviet design. It is anticipated that by 1986 the PRC will reduce the present 10- to 15-year gap to something on the order of a 7-year lag in the state-of-the-art.

(2) Other non-Warsaw Pact ECC. These ECC are dependent upon foreign ammunition designs. With the possible exception of North Korea and Yugoslavia, none of these countries has significant facilities for the manufacture of artillery munitions; each, therefore, is dependent (considering its position vis-a-vis South Korea) and Yugoslavia (an ECC not closely affiliated with either the Soviet or PRC hegemonies) are particularly concerned with attaining self-sufficiency in ammunition production.

8. ~~(C)~~ Prime Movers and Cargo Carriers

a. Eastern European Communist Countries. Several new wheeled prime movers and cargo carriers currently are being developed by the USSR and the more industrially advanced European Communist countries. These vehicles, to be deployed prior to 1986, will exhibit:

- Mobility in soft soil equal to the best of the current Soviet trucks.
- Improved power-to-weight ratios and on-road speeds.
- An increased utilization of diesel powerplants.
- Improved RAM-D characteristics.

Deployment of these newly developed trucks will permit an increased utilization of wheeled vehicles for the towing of artillery in situations that previously dictated the use of tracked artillery tractors. It is probable that heavy, tracked tractors will be confined to engineer usage, and that the issue of product-improved, medium artillery tractors to artillery units will be curtailed due to the improved performance that will be exhibited by these new wheeled vehicles. It also is predicted that the Soviets will develop a specialized, high-mobility, tracked prime mover as the replacement for the Soviet GT-T. Intended for use particularly in the Arctic, this specialized tractor(s) should feature an improved drive train (based on overall advances in the automative field) and suspension system; the possibility of a hybrid, air cushion-crawler track type of suspension and drive is within the state-of-the-art. Further, the USSR will continue its demonstrated pattern of developing and introducing into service wheeled vehicles that exhibit higher performance, greater mobility, and/or improved RAM-D characteristics.

b. Asian Communist Countries. It is postulated that the PRC will have largely solved its current quantitative deficiency in motor transport capability by the mid-1980s. Although such an achievement will constitute a major step forward, the PRC wheeled motor transport fleet will be characterized by:

- An admixture of many models and designs of vehicles of widely varying age.
- Problems in spare parts supply.
- Maintainability and availability problems on a fleet-wide basis during any extended period of combat.
- Substandard performance compared with then-current Eastern European Communist criteria.

In Asian Communist countries, tracked artillery tractors will be retained in use to a much greater degree than in Eastern European Communist countries, because of continuing deficiency in wheeled prime movers suitable for employment with guns such as the Soviet 130-mm M-46. Asian Communist countries other than the PRC, plus Albania, will remain dependent upon procurement from foreign (usually Communist) suppliers to satisfy their requirements for vehicles.

9. ~~(C)~~ Target Acquisition, Fire Control, Fire Direction, Surveying, and Meteorological Equipments

a. Warsaw Pact Countries. It is postulated that by 1986 or earlier, some Warsaw Pact countries (most likely the USSR) will accomplish the following with regard to these types of equipment.

(1) Target acquisition equipment.

(a) Radars. It is highly probable that, in the field of radar equipment, a system to replace the SMALL YAWN countermortar-counter-battery radar probably will be deployed by about 1980, and, further, that one or more systems to replace the SNAR-6 battlefield surveillance radar will be deployed within the forecast period. These new radar systems, which probably will incorporate electronic scanning phased arrays [particularly with respect to the countermortar-counterbattery radar(s)], will exhibit increased range and precision. Newly deployed Soviet countermortar-counterbattery radar(s) may be capable of locating a hostile mortar or gun after that weapon has fired only one projectile; to effect such a solution in near real time requires the use of a computer to derive target coordinates.

(b) Rangefinders. The Soviets currently are deploying DAK-1 (?) tripod-mounted laser rangefinders (LRF) to field artillery target acquisition units and to cannon and, probably, MRL battalions and batteries. Although applied research in LRF for artillery will continue, it is probable that the estimated 0.5-milliradian beam divergence, the 5/min repetition rate, the nominal range of 8 km and maximum range of ≈17 km, and the accuracy of ±10 meters in range and ±1 M in bearing will satisfy Soviet requirements until the mid-1980s. It also is postulated that the East Germans will continue to conduct applied research in optical correlation rangefinders to further improve the UOE within these systems and that they may deploy a successor to their present 50-cm base length system in the mid-1980s.

(c) Night observation devices. In addition to a proliferation of passive, image-enhancing, night vision sights on AT and some FA systems [para (2)(a) below], many Soviet, and some non-Soviet Warsaw Pact, FA CP-OPs probably will be equipped prior to 1986 with passive-type night observation devices that exhibit a detection capability vis-a-vis a tank-sized target on the order of ≈3 km or better. The ACRV M1974(2) presently may be equipped with a modified antitank gun-type, passive, night vision sight for observation purposes; very possibly, some CP-OPs of towed artillery units are similarly equipped.

(2) Fire control equipment.

(a) On-carriage. It is probable that developmental activity in indirect fire sights for towed artillery pieces will be restricted to improvements in night lighting, possibly reticle patterns, and the providing of gunners' aids for the setting of shifts in deflection. It is highly probable that all AT artillery, and possibly a number of 122-mm D-30 and M1974 and 152-mm M1973 howitzers, will be equipped with passive, low-light-level image intensifiers for use in direct fire at night; such sights probably will be improved versions of the sight presently used on some 100-mm T-12A AT guns. Direct input of computer-derived firing data is not expected to occur within the forecast period.

(b) Off-carriage. Although aiming circles, collimators, gunners' quadrants, and similar equipment may be product improved, such

improvements probably will be minor. The biggest improvement in fire control equipment is expected to be the use of items such as gyroazimuth indicators [para (4)(a) below] and rangefinders [para (1)(b) above].

(c) Chronograph. It also is postulated, particularly in view of their continued attention to ΔV_o, that within the forecast period the Soviets will deploy a chronograph, most probably a small radar chronograph issued as an ancillary item.

(3) Fire direction equipment. Generally, the use of calculators and computers by artillery entails survey, fire control, and fire direction applications. In addition, computers can be used for storage and retrieval of targeting and fire planning data, plus intelligence, logistical, and administrative information. Warsaw Pact armies probably use Soviet computer systems in missile units and mechanical calculators in FROG units for the computation of survey, meteorological, and firing data. Analog-type computers are used in the fire control/director systems of some AAA weapons/units. It is also postulated that small (handheld-type) electronic calculators capable of solving rapidly those arithmetic, algebraic, and trigonometric functions associated with survey and gunnery data will be widely deployed to field artillery units through the battery level within 3 to 5 years. Further, the introduction of a fire direction computer probably will occur within the near term. Soviet gunnery techniques practically dictate that a battery either have its own computer or that it be able to directly address a battalion-level computer to obtain solutions related to gunnery, survey, and target acquisition problems. Therefore, it is believed that batteries will continue to solve their tactical and technical fire direction problems, that battalions will provide batteries with technical fire direction only for battalion directed fires, and that higher echelons will input any battalion level computer with tactical fire direction parameters only. It also is probable that battery/battalion level computers, in addition to fire direction, will be limited to the solution of survey problems and met messages, the generation of target lists and schedules of fire, and the accountability of ammunition.

(4) Survey types of equipment. Good, timely artillery survey being prerequisite to an overall satisfactory execution of the target acquisition, fire-control, and fire-direction functions, it is postulated that the USSR or another Warsaw Pact country will accomplish the following within the forecast period.

(a) Gyroazimuth theodolites and tellurometers. Gyroazimuth theodolites that exhibit markedly faster runup times will be deployed initially to the cannon battalion level, and subsequently on the basis of one per cannon battery. Further, improved tellurometers will be deployed to the front, army, and division levels--and possibly down to the artillery brigade/regimental level--to facilitate and expedite the extension of highly accurate survey control.

(b) Artillery survey capable vehicles. The Soviets probably will continue to upgrade their land navigation systems. By 1980, the USSR or another Warsaw Pact country should deploy a survey vehicle similar in concept and capability to the US Army's proposed, vehicle-mounted, position-and-azimuth-determining (PAD) system; i.e., a vehicle truly capable of artillery survey. Non-Warsaw Pact ECC having a requirement for PAD equipment will have to obtain it either from a Warsaw Pact or a free world supplier.

(5) Artillery meteorological equipment. The currently deployed Soviet ARMS-1 meteorological station produces very good met data when compared to met stations presently deployed by other countries. Nevertheless, recognizing both the continued Soviet concern with exterior ballistics and the present limitations in the state-of-the-art with regard to meteorological soundings for artillery purposes, it is believed that the Soviets will remain in the forefront among countries active in the field of artillery meteorology. Although neither the technological approach that will be undertaken by the Soviets nor the time frame in which they will deploy a new met system can be predicted, it is probable that the USSR either will be first, or among the first, to deploy a new met station that exhibits significantly increased capabilities.

b. PRC and Other Non-Warsaw Pact ECC. It is postulated that by 1986 these countries will have taken action with regard to subject types of equipment as indicated hereinafter.

(1) Target acquisition equipment.

(a) Radars. Prior to the early 1980s the PRC probably will develop, and begin to deploy, a countermortar-counterbattery radar system; this action is expected to be followed by the deployment of a surveillance radar system. Further, should other national priorities preclude the indigenous production of these necessary systems, the PRC will endeavor to obtain suitable systems from other Communist or free world countries. It is postulated that non-Warsaw Pact ECC other than the PRC will continue to depend upon outside suppliers to satisfy any requirements for radar systems, and that North Korea will be among those countries first endeavoring to do so.

(b) Rangefinders. It is postulated that by 1986 the PRC either will develop and begin to deploy laser rangefinders (or instruments of roughly comparable accuracy) for application with field artillery or will procure suitable artillery laser rangefinders from another country. Non-Warsaw Pact ECC other than the PRC (and, possibly, Yugoslavia) will remain dependent upon other countries to fulfill their requirements for laser rangefinders. In view of its announced national objectives, it is believed that North Korea will be in the forefront of those countries attempting to purchase or otherwise obtain these items.

(c) Night observation devices. These devices are essential to the attainment of that visual observation that is necessary for artillery to support, in a satisfactory manner, combat operations undertaken at night. The PRC, North Korea, and Yugoslavia in particular will therefore endeavor to procure and deploy these devices.

(2) Fire-control equipment. It is postulated that the status of on-carriage fire-control equipment generally will parallel that of Warsaw Pact countries.

(3) Fire-direction equipment. It is postulated that the PRC will continue to improve its manually operated fire-control equipment. Although the PRC probably will not deploy fire-direction computer systems within the forecast period, handheld electronic calculators may be introduced into FA batteries by the early 1980s. Non-Warsaw Pact countries other than the PRC and Yugoslavia probably will remain dependent upon outside suppliers for other than the basic manually operated types of fire-direction equipment.

(4) Survey type equipment. The manpower available within Asian countries attenuates the requirement for equipment such as gyroazimuth theodolites and tellurometers in the performance of artillery survey. On the other hand, tellurometers are needed to expedite the performance of first through third order survey; i.e., that true survey control upon which artillery survey is established. It is therefore postulated that some Asian countries, particularly the PRC with its large land mass, will procure a number of these devices for the performance of high-order topographic surveys, thereby enhancing the density of trigonometric stations and the accuracy of the artillery common grid that is established therefrom. It is also postulated that Yugoslavia, with its rugged terrain, will procure this equipment both for engineer topographic and artillery survey.

(5) Artillery meteorological equipment. Within the forecast period it is believed non-Warsaw Pact countries, with the exception of Yugoslavia (and, possibly, North Korea), will remain largely dependent

upon met data obtained by means of the one-point or two-point manual methods. Nevertheless, the PRC will endeavor to obtain modern met stations in sufficient numbers to provide adequate support to both field army and artillery divisions; i.e., a minimum of one station per approximately 50 km of frontage.

10. ~~(C)~~ Communications Equipment

The Soviets in all likelihood will continue throughout most of the forecast period their present policy of replacing their older radio equipment with more recently developed equipment; i.e., replacement of the R-108 and R-108M FM radio sets with the R-107, the R-123 and R-112 high frequency sets with the R-130 single sideband transceiver, etc., will be continued. It is probable that around 1982, new, lighter weight, possibly solid state, radio equipment will begin to be issued to artillery units. Other Warsaw Pact countries will follow the Soviet pattern. The PRC is expected to apply the advanced state-of-the-art it has exhibited in the design and manufacture of small transceivers to larger size radio equipment within the forecast period. North Korea will replace its 1954-vintage radio equipment with more modern transceivers, probably through procurement from Warsaw Pact sources. North and South Vietnam, facing in large part much the same problem as North Korea, also are expected to satisfy their requirements through procurement from foreign sources.

APPENDIX I.

FIELD ARTILLERY GUNNERY AND FIRE DIRECTION AS PRACTICED IN THE SOVIET AND WARSAW PACT ARMIES

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1. ~~(C)~~ General

A general understanding of Soviet gunnery is most readily attainable by comparing the basic differences in the practice of gunnery between the Soviet and US armies; this because in toto there is a great deal more agreement than there is disparity between the practices followed by the two armies. The Soviets claim that Russia evolved modern gunnery techniques for the delivery of indirect fires during the Russo-Japanese War (1905). Nevertheless, basically, both the Soviet and US armies utilize the system of gunnery evolved by the French around 1900 and brought to culmination by them during and subsequent to World War I. Both the Soviet and US armies adhered very closely to the French system until the US Army's adoption of the target grid method for the adjustment of fire by the forward observer in 1950. The Soviet Army, although employing the target grid method on occasion, continues to adhere primarily to the "axial" and lateral ("small-T" and "large-T") methods of adjustment for ground-based observers. The Soviets refer to these terms as "small," "medium," and "large" displacement. In executing fire direction functions, both armies consider the same parameters, obtain the same basic data, apply essentially the same corrections, and generate the same results that are expressed as fire commands. Although there are differences in organization, locations, and execution of the fire direction functions, and many differences in the methodology and/or techniques that are employed, the basic principles and the firing data that are generated are essentially the same. As is usually the case with any two long-established and proven procedures, each probably is best suited to the requirements of its user and both exhibit some relative advantages.

2. ~~(C)~~ Firing Battery

~~(C)~~ The US firing battery, be it a four- or six-gun battery, is an organizational entity that is commanded by the battery XO. There is no Soviet "firing battery" per se; instead, there are two separate two- or three-gun firing platoons, each commanded by a lieutenant. When the two firing platoons are operating together, they comprise the "firing battery";

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the senior of the two platoon commanders essentially performs the duties of the US btry XO/FDO, and the junior performs the duties of asst btry XO/FDO.

a. (U) Laying for Direction. Artillery batteries and fire control instruments at the battery CP-OP plus any lateral OP are laid on a common grid azimuth, usually that particular 100 Soviet mils (M) of azimuth that most closely approximates the center of the battery's sector of fire. Azimuth, as in US artillery, is read clockwise. Unlike US artillery, deflection decreases when the piece is traversed to the left; i.e., the US LARS (left add, right subtract) becomes RALS (right add, left subtract) in Soviet practice; in short, ECC employ bearing rather than referred deflection. The Soviets, who consider diurnal changes as varying with time within a range of ±2 M from noon, correct for diurnal change during daylight between 21 March and 21 September when declinating aiming circles and when laying the battery. Initial shifts in deflection usually are announced as left or right from the principal (main or base) direction. In written rather than in oral form, shifts to the left are preceded by a minus sign; for instance, "-1-80" is "left 180 M." Subsequent shifts are announced as left or right from the deflection previously fired. The gunners apply individual correction for sheaf interval in response to a command such as "on number 3, open 2."

b. (U) Laying for Elevation. It is apparent that the Soviets most frequently (particularly when adjusting upon a target of opportunity) apply elevation by use of a range drum or scale rather than with a gunners' quadrant, elevation scale, or an elevation drum graduated in mils. The range drum on Soviet artillery cannon-type weapons has multiple graphical range scales, each of which represents a different projectile/propelling charge combination. These range scales are graduated in 50-meter equivalents. The numbering on the scales of the range drum equates to twice the range in hundreds of meters; for instance, a reading of 90 equates to a range of 4500 meters for a given projectile/propelling charge combination. The reason the Soviets chose to number their drums in this fashion is not known. Although Soviet on-carriage fire control equipment is graduated in both mils of elevation and range drum settings, in observed fire the scales on the range drum are used much more frequently than is the elevation scale (or gunners' quadrant). Use of the gunners' quadrant generally is confined to boresighting and performing the periodic checks. In literature pertaining to FDC-type operations, the Soviets refer to range drum scale settings as "normalized elevation settings" and/or "sight graduations"; site, per se, is referred to as "level." The principal advantage afforded by the use of a range drum is that in both axial and laterally conducted ("small-T" or "large-T") adjustments the observer is relieved from having to add algebraically the equivalent in mils of 1/2, 1, 2, 4, etc. "C" (100-meter change in range) or "forks"

(4 PE_r) to the elevation previously fired; e.g., rather than reminding himself that C=8, that the last elevation fired was 316 M, that the burst was short, that he should increase range by 400 meters, and that the command therefore is 316+32="Elevation 348 M!", the observer, knowing that the last round was fired to a range of 6200 meters, when using a classic range drum, simply commands "6600!". Soviet use of the equivalent of this command (132) probably is second nature to them. Aside from enabling the observer to effect a faster response in changing his sensing into a fire command, the simplicity inherent in the use of a range drum also tends to preclude the observer from "jumping" his range bracket. Conversion of "range drum setting" to "mils of elevation" is direct and rapid because the range scales and the elevation scales are indexed to each other; glancing at the indices, the gunner can determine, for the propelling charge/projectile combination being fired, that a drum setting of 132 (a range of 6600 meters) equates to an elevation of 431 M.

(1) (U) Muzzle velocity deviation. The Soviets place great emphasis on deviations from standard muzzle velocity (ΔV_o). In addition to addressing changes in V_o occasioned by the temperature of the propelling charge, deviation from standard in projectile weight, deviation of the mean V_o of a battery from standard, and deviation in V_o to be expected from each powder lot, a Warsaw Pact battery, when firing precision missions, may apply the ΔV_o (from standard) of the individual pieces. The V_o of each piece is known to its chief of section and gunner from chronographed data, or, between chronographings, an estimated V_o is determined by measuring the advancement in the origin of rifling (an imprecise method). The chief of section and/or gunner possesses a prepared nomogram that portrays the effect (in mils), for various charges and selected elevations therein, of the ΔV_o inherent in their gun. These nomograms enable the gunners to apply corrections for the ΔV_o of individual guns (probably to the angle of site scale) when directed to do so.

(2) (U) Deviation in altitude. The Soviet "btry XO" (i.e., the senior of the two gun platoon commanders), when necessary, announces special corrections to an individual piece(s) to account for the deviation in altitude of that piece from the battery center or base piece.

c. (U) Occupation of Position. Warsaw Pact batteries occupy position in line at regular intervals. In indirect fire type positions, irregular formations ("lazy W," hexagonal, etc.) may be assumed only upon approval by higher headquarters. The purposes of this regular interval, linear posture are to facilitate observation of the fall of shot, to provide a common base of departure for the application of corrections, and to permit the ready identification of any piece that is shooting long, short, or "out of sheaf." Actual interval between pieces ranges from about 20 to 40 meters, with the heavier caliber units employing the larger

intervals. As in most armies, the larger intervals prescribed by regulations seldom are attained. The frontage occupied by 122-mm batteries usually is about 100 to 125 meters and that of 152-mm batteries about 125 to 150 meters. Although the interval between pieces in a 180- or 203-mm battery may be 50 meters or more, the battery front (four-gun battery) seldom exceeds 150 meters unless that battery is positioned by platoons. The battery's "XO post" usually is centrally located some 50 meters in rear of the battery. When distant aiming points are available, one or more serve as the aiming reference(s); collimators, except when distant aiming points are not available, primarily are used as secondary aiming references and during periods of poor visibility. In direct fire, the battery may be deployed in line, in echelon, in two lines, in U-formation, etc., as a unit, by platoon, or in pairs of weapons. Following are East German time standards of various battery operations.

- Reconnaissance of battery position area. Party consists of the HQ platoon commander, gun commander, gunner, CBR scout, and radio operator. This party reconnoiters the proposed position area, to include checking for CBR contamination; establishes, and performs hasty survey of, the base piece location; establishes base direction for the base piece and stakes out that base line; determines the minimum elevation; stakes positions for the remaining guns in the battery; sets up the aiming circle at the btry XO post; posts guides; and reports the coordinates of the battery position to the gun position (US=btry XO) officer. Standards for accomplishing these functions are, in minutes: Very good--11, good--12, satisfactory--13, and adequate (poor)--15 minutes. It should be noted that 5 min of these times are allocated to CBR and engineer-type reconnaissance of the position area; e.g., about 6 or 7 min is all that is required for the purely artillery aspects of the task. After accomplishing the aforementioned functions, the reconnaissance party, while awating the arrival of the guns, proceeds to recheck the coordinates of the battery, establishes and improves the "XO post," etc.

- Occupation of indirect fire position by a towed 122-mm howitzer battery. Two min are allowed for the battery to reach its position area from the release point; this time is not included in the times indicated hereinafter.

- From 0 to 2 min: Unlimber, remove gun covers, spread trails, mount panoramic telescope, etc.

- From 2 to 6 min: Lay and refer the battery, record gun deflections, set up collimators and refer and record gun deflection, dig in the trails, set up FDC equipment and prepare the firing chart to include GP and OP locations, determine minimum elevations, lay out and prepare ammunition, measure powder temperature (≤10 min), complete position report, and report battery is ready to fire.

- From 6 to 18 min: Accomplish position area survey, camouflage weapons and prime movers, dig slit trenches and ammunition pits (commence construction of a prepared position), establish defense of the position, solve met message [for 3 deflections (usually ≈600 M apart) and 3 or more ranges at each deflection] and enter met corrections on PUO-9 FDC set, and determine initial data for all preplanned targets.

- After 18 min: Conduct fire on preplanned targets, boresight, refine survey data and accuracy of aim, continue to improve the position, select and prepare alternate position, conduct route reconnaissance, etc.

East German standards for accomplishing the foregoing occupation, from arrival of the gun at its position to reporting that the battery is ready to fire, are, in minutes: Very good--4.5, good--6.5, satisfactory--8.5, and adequate (poor)--10.5 minutes. These times assume the use of ice spades (the spade that is welded to the trail ends); when summer spades (the large, hinged supplementary spades) are used, 1.5 min additional time is allowed.

- East German standards for occupation of position by towed batteries of calibers other than 122-mm howitzer, all using ice spades, are:

  - 100-mm gun: Very good--2.2, good--2.6, satisfactory--3.1, and adequate (poor)--3.6 minutes.

- 130-mm gun: Very good--8.5, good--10.0, satisfactory--10.5, adequate (poor)--11.5 minutes.

- Occupation of the battery CP-OP. The battery CP-OP usually is occupied by the battery commander and a major portion of the personnel in the headquarters platoon under the command of the battery reconnaissance officer. East German time standards for establishing a CP-OP during daylight, from the command to do so until the OP is operational and prepared to observe, are: Very good--8 min, and adequate (poor)--10 min; at night, about 20% more time is allowed. These times include the location of the OP by hasty survey procedure; the setting up and orientation [upon the principal (or main) direction] of the aiming circle, the BC scope and the rangefinder; setting up the map table and the PUO-9 FDC set; establishment of radio communication; and camouflaging the OP. Subsequent improvement of the OP into a communications-type trench with niches for each member of the OP party involves, on the average, the removal of 25 m^3 of earth (not including a dugout or bunker with overhead cover). Time standards for evacuation of an OP, from initial order until the last man has evacuated the post are: Very good--3, good--4, satisfactory--4.5, and adequate--5 minutes. These standards are increased by a factor of 0.4 during hours of darkness; e.g., very good--5 minutes.

- Improvement of position. Warsaw Pact, particularly Soviet, field artillery is most conscientious in the improvement of its positions: The CP-OP; lateral, forward, and alternate OP; XO post; and gun positions usually are well camouflaged, and "digging in" is accomplished with rapidity and, frequently, with the assistance of a pioneer or engineer unit. For example, Von Mellenthin and numerous other ranking Wehrmacht officers with long combat experience, in their appraisals of the World War II Soviet soldier, are in agreement that the Soviet soldier "disappears into the ground within an incredibly short period of time." Well-prepared Warsaw Pact artillery positions not only are characterized by weapon pits but by ammunition pits, communication trenches, two large personnel bunkers, vehicle revetments, etc.

d. (U) Delivery of Fire. Area targets usually are zoned in range and, if the target frontage is too wide for good effect to be obtained by means of opening the sheaf, are attacked using two or more deflection settings. Zoning may be accomplished by firing at center range and over and short either by 0.5 or 1.0 C (50 or 100 meters) or by 2 or 4 PE_r (0.5 or 1.0 fork). When a Warsaw Pact battalion is firing for effect, all batteries usually zone the target simultaneously so as to reduce bias. The standard sequence is:

1st btry:	-	T	+
2d btry:	T	+	-
3d btry:	+	-	T

when T = center or adjusted range, - = T - ΔT, and + = T + ΔT. There also is a Warsaw Pact standard for executing a spread in deflection, upon order, when two or more of the batteries in a battalion are firing upon a target. For instance, when observing but two guns in a supposed six-gun battery, the observer cannot determine from only that evidence whether these weapons constitute the left, center, or right portions of the enemy battery's line of metal. In such cases, a Warsaw Pact battalion engages that target, with the 2d btry firing at the observed target center (of the two guns that were observed) while the 1st btry shifts 1/3 sheaf width (or assumed target width) to the right, and the 3d btry shifts 1/3 sheaf width (or assumed target width) to the left. Should only two batteries engage the target, these batteries follow this same procedure; e.g., if only the 1st and 3d battery are to fire, the 1st btry fires to the right and the 3d to the left of the apparent target center. This practice greatly reduces bias, albeit at the expense of density in the fall of shot. Obviously, when only one btry engages the target that btry fires at the apparent target center. Fuze action for percussion fuze generally is termed "fragmentation" (FQ), "burst" or "impact" (fuze nondelay, or "short delay"), and "demolition" (fuze delay or "long delay"). Rather than firing mechanical time fuze, Warsaw Pact artillery prefers to attain ricochet bursts. Ricochet action generally is attainable when the included angle between the line of impact and a plane tangent to the surface of ground at the point of impact falls between +3° and +20°; between +5° and +15° the probability of attaining ricochet action is very high. Some Soviet fuzings may have two delay options: Short delay and long delay. These options, plus the very small deviation in height of burst that is characteristic of ricochet action and the observer's not having to consider fuze time and height of burst during adjustments, make the use of ricochet an attractive option when 50% or more airbursts are attained thereby. Warsaw Pact methods of fire are:

- Single shot fire (or fire using single rounds) is analogous to the fire delivered by a single US piece in adjustment.

- Deliberate (or repeated) fire, fired by a single gun, platoon, or battery, is characterized by "No. 1, 6 rd, at 4 rd/min," "battery from the right (battery right) at 5 seconds (interval)," and similar commands that designate a rate of fire or assign a firing cadence.

- Running fire is fire delivered at maximum rate. Apparently, several methods are employed: "Fire in individual series," which is a series of battery rights (or lefts) fired at about ≷2-second intervals, and "round-by-round" fire, which is initiated by a battery volley that is followed by individual guns firing at maximum rate.

- "Salvo" fire, or "firing by volleys," is fire that is delivered in volleys, with each volley being fired on command from the btry XO post.

When engaging a point-type target, firing for destruction, or conducting a registration, a Warsaw Pact observer frequently utilizes the elevation scale that is inscribed in mils rather than the range drum. Although the range drum (with its 50-meter-range increments) is facile for the conduct of area fire-type adjustments, use of the mils scale further refines the adjustment for range in precision-type adjustments. When the mils scale and "C" (mils necessary to effect a 100-meter-range change) or "fork" (mils equating to 4 PE_r) are being used, location of the center of impact vis-a-vis the target can be improved after each series of rounds fired in effect. In addition to addressing changes in V_o occasioned by temperature of the propelling charge, deviation from standard in projectile weight, and deviation of the mean V_o of a battery from standard, Soviet (and Warsaw Pact) artillery units also consider the V_o to be expected from each powder lot and, when firing precision missions, the ΔV_o (from the battery norm) of the individual pieces. The V_o expected from the propellant is contained in each case of ammunition; this is not the "firing table velocity" (e.g., 600 m/s being "standard"); rather, it is the velocity that resulted from actual test at time of manufacture of that lot of powder. As is the case with projectiles, this variation is expressed by markings (-, --, +++, etc.) that indicate deviation from standard V_o in percent in the same manner as shown in figure A-I-5 (page A-I-42). To verify such information, one cannon in an army brigade, or regiment may fire a few rounds of a newly delivered lot and announce the

resultant deviation from standard to other artillery units deployed in that area; this practice attenuates for the effects of outgassing, long-term storage, etc. In addition, as heretofore stated, the chief of section and/or gunner have prepared nomograms that show the effect (in mils) for various charges and elevations therein of the ΔV_o inherent in their gun, and, when directed, they apply these corrections individually (probably to the angle of site scale). Unusual to normal free world practice, but economical in the expenditure of both time and ammunition, is the ECC practice of applying corrections in lay during firing without suspending fire (e.g., "check fire!", "cancel check fire!"). For example, assume that a Warsaw Pact observer engaged in firing six US-type battery salvos in fire for effect determines, during the first salvo, that better effect will be obtained if he shifts 5 M to the right. He sends the command "right 5" as number 4 is firing its first round; numbers 5, 6, and, perhaps, 1 guns will fire without applying the correction, but, on the second salvo, number 2 or 3 will have applied it, and all subsequent rounds will be fired with the new correction; the same procedure is applicable to individual guns, batteries within a battalion, or an entire battalion.

3. ~~(C)~~ Direct Fire

~~(C)~~ The greatest single difference between US and Warsaw Pact artillery doctrine and practice lies in direct fire. Warsaw Pact ECC place great emphasis upon the employment of field, in addition to antitank, artillery cannon in the direct fire role.

a. ~~(C)~~ Employment in Direct Fire. Soviet artillery employs direct fire in the defense of the battery position and in all other cases, wherein the US would employ field artillery in a direct fire role. The Soviets also classify gun positions in much the same manner as does US artillery. In Soviet parlance, "Case I" gunnery is fire conducted from an "open" or direct fire-type position. "Case II" gunnery is indirect fire; such fires are conducted from a "closed," "hidden," or "concealed" [US indirect fire-type (or defiladed)] position. Here, all similarity in employment of direct fire ends. To amplify the emphasis placed upon direct fire by Warsaw Pact artillery, the following quotes are presented:

- "Case I (direct) fire permits the most rapid execution of a fire mission with the least expenditure of ammunition against ground and surface targets in all forms of combat."

- "Emphasis on the use of individual artillery pieces (additional sources state batteries and platoons, as well) for direct fire missions and the manhandling

of these guns into positions from which direct assault fire can be delivered are unique features of Soviet field artillery employment."

- "All cannon and all rocket launchers (except FROG and heavier) are used in Case I pointing (direct fire)." (NOTE: Cannon >152 mm are not used in direct fire vs. moving targets but are so employed against improved defensive positions.)

- "In firing a short preparation (a preparation limited to 10- to 20-minutes duration so as to enhance the element of surprise), all 'long-term defensive positions' (pillboxes, revetted strongpoints, and the like) will be destroyed by Case I pointing; only when it is totally impossible to execute the mission from open positions will the destruction of these positions (targets) be undertaken from concealed (indirect fire) positions."

In World War II, the Soviets, on occasion [depending upon the situation (e.g., a river crossing operation or when defending against a major attack by armored units)] committed up to 28% of their available cannon to the direct fire role. Warsaw Pact artillery continues to utilize field, as well as antitank, artillery cannon in direct fire.

b. ~~(C)~~ Conduct of Direct Fire. Within grazing range, Warsaw Pact artillery uses the height of the target as a means of effecting changes in range. The point of aim is the center of mass of the target. The command "aim higher" directs the point of aim to the center of the top edge of the target; "aim lower" changes the aim to the center of the bottom of the target or to the center of the apparent line of contact between the target and the ground. When firing beyond grazing range or beyond 1500 meters (whichever is the greater), in the absence of met corrections, +200 meters is added to the estimated range when the ambient air temperature is between 0° and -15°C, and +300 meters is added when the temperature is >-15°C. Depending upon the cannon concerned, beyond grazing range (or another established limit) the gunner and/or chief of section bracket the target in range with a 200-meter-range bound. Both within and beyond grazing range, the Soviets also employ the technique (in the case of vertical-type targets) known as "lay-off"; i.e., commencing with the point of aim and sight settings used for firing the last round, they lay the sight upon the last point of impact and then train the piece upon the desired point of impact by using the newly derived sight setting.

(1) ~~(C)~~ Engagement of armor. Employment of Warsaw Pact artillery against a tank attack is described in I-A-3c and -3d. When armor is being engaged, optimum range is considered to be 600 meters except for high velocity guns, for which 1000 meters (probably 1500 meters for the 100-mm T-12 gun) is considered optimum.

(2) (U) Covering guns. A piece or platoon engaged in a direct fire-type destruction mission habitually is accompanied by a covering gun or platoon. The covering gun or platoon is assigned no target. The mission of the covering gun section or platoon is to continually observe the sector and to immediately take under fire any visible enemy weapon that engages the Soviet gun or platoon performing the destruction mission.

(3) ~~(C)~~ Non-Warsaw Pact artillery. The Soviets not only have imbued the field artillery of Warsaw Pact countries with their doctrines and gunnery techniques for both Case I and Case II types of fires but apparently non-Warsaw Pact ECC artillery as well.

4. ~~(C)~~ Indirect Fire

a. ~~(C)~~ Observed Fire. The number and variety of observed fire techniques that are available to, and used by, Warsaw Pact artillerymen are indicative of the fact that they are professionally competent and, usually, are able to exercise several options in selecting the best method for attacking a particular target. The Soviets frequently utilize forward observer technique (with or without the use of a locally fabricated target grid) for the adjustment of fire by aerial observers that are positioned off the gun-target line, for adjustments conducted by persons other than artillery observers, and, sometimes, by the artillery enlisted observer positioned in a lateral OP. Fires also are adjusted by means of radar, sound-on-sound, and flash ranging. Nevertheless, the majority of fires that are adjusted from CP-OPs and forward OPs are conducted by use of axial and lateral (small-T and large-T) procedures [fig A-I-1 (page A-I-18)]. When the included angle (angle-T) formed at the target by the GT (gun-target) and OT (observer-target) lines is 100 M or less, axial procedures are applicable. When angle-T is larger than 100 M, lateral procedures apply. Classically, when angle-T is between 100 and 300 M, small-T procedure is applicable, and when angle-T is larger than 500 M only large-T procedure is appropriate; between 300 and 500 M, either small- or large-T procedures can be used. Between 300 and 500 M, experienced observers customarily have employed large-T procedure, which usually enables the adjustment to be completed with a lesser expenditure of rounds than that expended by the less experienced observer who opts for the simpler small-T procedure; in fact, US observers were required to use large-T procedure when angle -T≤300 ₥. Nevertheless, Warsaw Pact observers usually employ small-T procedure at angle-T ≤500 Soviet

mils. Essentially, the axial and small-T procedures recognize that, when angle-T is <300 M, the adjustment of range is more difficult than that of deflection and, that with angle-T ≥300 M (classic large-T) the adjustment of deflection is more difficult than is that of range; i.e., in axial and small-T, the observer brackets the target in range, whereas in large-T he brackets it for deflection. It should be noted that both axial and lateral procedures are referenced to the OT- (rather than the GT-) line. US observers used axial and lateral procedures from World War I until the introduction of the target grid method in 1950. They also used the FO method (in which deviations from the target are sensed and reported to the FDC in relation to the GT-line). The use of FO procedure largely was confined to aerial observers until about late 1942, when FOs situated immediately in rear of the FEBA began to use this method extensively. Btry and battalion commanders and reconnaissance and staff officers at btry and bn OPs generally continued to use axial and lateral procedures. Nevertheless, the use of FO procedure expanded with the passage of time (when FOs became battery commanders and the percentage of artillery officers having long experience continued to decline in proportion to the increasing size of the army and combat losses). The target grid, and the introduction of the target grid procedure by the US Army in 1950, enabled FO procedure to be employed with relation to the OT- (rather than the GT-) line. Neither axial nor lateral procedures necessitate the use of an FDC; essentially, the observer is the FDC, and he sends fire commands directly to the guns. The present-day Soviet observer, located upon a CP-OP, possesses a marked advantage over the World War II era US observer. Except for a sometime recorder-RT operator who could maintain a "record of fire" for him, the pre-1950 US observer was "unaided" when firing lateral procedures. He kept all necessary factors in his head (the more absent minded wrote them on the back of their hand or a slip of paper), and, in addition, used mils of elevation rather than range drum settings. Conversely, a Soviet observer located at a CP-OP can have his OT-range measured by the rangefinder; his GT-range, angle-T, and initial shift determined from the mapboard and/or by computation; and the deviation in range of bursts from the target reported to him by his rangefinder operator; in addition, should he "jump his bracket," his reconnaissance officer or another member of the OP party almost certainly will correct this error.

When so aided, the Soviet observer frequently is able to enter fire for effect after only one or two rounds in adjustment; such procedure will be referred to hereinafter as "aided." It also should be remembered that the Soviet observer has an FDC at his CP-OP (in addition to the FDC at the battery position), and, when the occasion warrants, he may elect to effect a K- or map + met + ΔV_o (MMV)-type transfer of fire without adjustment; i.e., deliver surprise fire with or without a subsequent correction.

(1) ~~(e)~~ Initial data. In discussing axial, lateral, and other types of adjustments hereinafter, emphasis is placed upon the conduct of the adjustment rather than the determination of initial data (shift, site, and range). This approach is taken to give the reader an appreciation of the rapidity with which axial, small-T, and some other types of adjustments can be effected by the observer without assistance and, when he is assisted by either his "mapboard" or FDC chart (PUO-9) operator and his rangefinder operator, or lateral observer, etc., the great rapidity with which a bracket-type adjustment can be effected when but one or two rd are expended prior to entering fire for effect. Therefore, it suffices to state that the Warsaw Pact observer can derive his initial data by estimation, computation, or rapid plotting with or without instrument assist; by measurement from map or photo; from map or firing chart with or without ΔV_o plus met corrections; or by use of a K-factor. Warsaw Pact artillerymen term the determination of firing data to be either "deliberate" (also "full" and "complete"), "abbreviated" (also "hasty," "rapid," and "shortened"), or "visual."

- "Deliberate preparation," characterized by mean errors of 4 to 5 M in deflection and 0.8% to 1.2% in range (as opposed to 3 M in deflection and 0.75% in range for the Soviet preferred K-transfer technqiue that also is a "deliberate preparation"), necessitates that the target be accurately located (e.g., ≷35 meters radial error), the firing units be located on a common grid, and recent met and ballistic data be available. In short, with a "deliberate preparation" (the equivalent of the US map + met + VE technique), fire for effect is initiated without adjustment. Data set on the gun are to within 1 M in direction and 10 meters in range.

- "Abbreviated preparation" is used when all of the conditions prerequisite to a "deliberate preparation" are not available. Mean errors associated with this method are 15 to 20 M in deflection and 3% to 5% in range. Conditions associated with an "abbreviated preparation" are: "Hasty" survey has been accomplished, the relative position of the target is known, and ballistic parameters are known but the met data available are either stale or estimated; e.g., "fairly" accurate map, plus ΔV_o, plus poor met data. The use of such data for delivering fire for effect without adjustment necessitates a "judgement" or decision on the part of the commander, observer, or FDO. Roughly, this situation is analogous to the condition that exists in the use of the US "observed firing chart" for effecting a transfer of fire upon a target that has been intersected by two OPs or ranged upon with a laser rangefinder. Usually the target is adjusted upon with cannon, whereas MRL fire for effect.

- "Visual" preparation of data is employed in the absence of survey or the presence of an incomplete survey. Visual preparation is characterized by mean errors of ≷40 M in direction and 10% in range. Initial data determined "visually" may be derived either arithmetically, graphically, or by use of a slide rule or an artillery calculating device [fig A-I-4 (page A-I-38)]. Warsaw Pact artillery only uses the arithmetic method when the observed angle is ≷500 M, the graphical method when the observed angle is ≶500 M and no slide rule or calculating device is available, and the "slide rule" method for any case. Although the results from all three methods are rounded off to the nearest 10 M of deflection and 100 meters of range, the "slide rule" method is the more precise because such measurements (inputs) as are available are not rounded off prior to computation and the trigonometric functions are used in the calculation.

Warsaw Pact rules for bracketing in range (establishing a range bound) are based upon the "short" bracket. The short bracket, when firing with the elevation mils scale, equals 4 PE_r (1 fork). When the range drum is being used, the short bracket is assumed to be 2 range scale divisions (a total of 100 meters) when PE_r is <40 meters; when PE_r ≶40 meters, 4 range scale divisions (≈200 meters) establishes the short bracket. The

"long" bracket is 2 short brackets [i.e., 8 PE_r or 2 forks with the mils scale and 4 range scale divisions (≈200 meters) when PE_r is <40 meters or 8 scale divisions (≈400 meters) when PE_r ≥40 meters]. The "initial" bracket, as the term implies, is whatever size bracket is prescribed for use or is actually used in establishing the first range bound. Warsaw Pact regulations prescribe the following initial brackets for the type of initial data that has been derived:

- K-transfer or deliberate preparation = 1 short bracket.
- Rapid preparation or a transfer of fire by eye measurement (visual preparation) from a known point or previously fired target = 2 short brackets.
- Visual preparation = 4 short brackets.

Fire for effect is initiated upon splitting a short bracket or when the correlation of range sensings is <3:1. When the correlation of range sensings is from 3:1 to 4:1, range is changed by 1 PE_r (nominally 25 meters); when the correlation is greater than 4:1, a 2 PE_r (nominally 50 meters) range bound is used to enter fire for effect. Deflection brackets are discussed hereinafter under axial and lateral procedures.

(2) (U) Axial procedure. When angle-T is less than 100 M, the gunnery problem is axial; i.e., the deviation of the observer's location from the GT-line is so small that, with one exception, he can adjust fire in the same manner as if he were observing from the gun position. The Soviets refer to axial as "small deviation." Essentially, except for using a range coefficient to account for the relationship between the OT and GT ranges $\left(\frac{r}{R}\right)$, the Pact observer (as does a US FO using target grid procedure) "shoots what he sees"; i.e., the Pact observer senses the burst, mentally computes his corrections, and sends those corrections in the form of fire commands directly to the battery. In axial, only one factor is considered in addition to the initial range bound: The range coefficient $\left(\frac{r}{R}\right)$. This is the relationship $\frac{\text{OT-range}}{\text{GT-range}}$ or, stated another way, at what percentage of the distance from target to gun is the observer located? Application of this factor to the observed deviations in deflection is necessary because, unless he is located at or very close to the gun position, his measurements and the corrections that should be applied to the gun are not the same. For example, if GT-range is 8000 meters and OT-range is 2400 meters: $\frac{r}{R} = \frac{2400}{8000} = 0.3$; if the deviation of a burst from the OT-line is 50 M, the shift at the gun

position to bring that burst to line is only 15 M (50x0.3=15 M). Range coefficients $\left(\frac{r}{R}\right)$ are computed to the nearest 0.1 when $\frac{r}{R} = \geq 0.3$; when $\frac{r}{R}$ is <0.3 the results are calculated to the nearest 0.05; e.g., 0.15. It should be noted that a Pact observer conducting an axial (or small-T) adjustment can send his fire commands from the OP to the gun position about as fast as he can relay his initial fire request, and derive subsequent sensings, when using FO-target grid procedure. Since there is no relay of sensings to, or computation of firing data within, an FDC, an axial adjustment can be conducted with great rapidity. For example, assume that a Soviet 122-mm D-30 battery in a meeting engagement conducted a bracket adjustment upon one target that was designated target 101. Adjusted range to target 101 was 8800 meters and the OT-range was 2600 meters; $\frac{r}{R}$ was 0.3 [i.e., $\left(\frac{26}{88} = \approx 0.3\right)$]. Upon completing fire on target 101, the battery commander observes an infantry platoon to the left of, and an estimated 800 meters short of, the first target. Using his binoculars, the BC-observer measures the deviation from target 101 to the infantry platoon's location to be 70 M. By coincidence, target 101 lies along the base (main) direction upon which the battery was laid; e.g., 4500 M. The relative position of the target, the OP, and the battery assures that the problem is axial. Note in table A-I-1 the simple techniques used by the BC-observer when, without assistance from his OP party, he attacks this target. Further, assume the rangefinder operator reported he was ready to observe just as the BC completed his initial command to the battery (for the conduct of the axial adjustment depicted in table A-I-1) and that the BC ordered the rangefinder operator to range upon the target and then provide the deviations in range of the bursts from the target. The rangefinder operator reports the first two-gun salvo as 130 and 160 meters over. With this information, the BC may opt to command range 157, right 5, btry, 2 rd, etc.; i.e., proceed from command 1 to command 4 in table A-I-1, which decision results in his entering fire for effect after his first ranging. In that event, counting time of flight, the enemy infantry platoon should be neutralized (fire for effect completed) within about 3.5 min after the target was first sighted.

(3) ~~(c)~~ Small-T procedure. In small-T, as in axial, procedure the target is bracketed in range. The only difference in procedure stems from the fact that in small-T a change in the GT-range produces a change in both range and deflection (lateral deviation) with respect to the OT-line; this effect can be visualized by reference to the 300-M ray in figure A-I-1. Although this also is true of any obliquity present in an axial (<100 M) set up, the magnitude of the lateral deviation in axial is sufficiently small to usually permit deflection sensings of bursts

Table A-I-1. Bracket-type Axial Adjustment, "Unaided" (U)

Command	Sensing	Conversion
1. Btry halt (adjust), tgt 102, inf plat in open, btry fire, HE-frag, fuze immediate (FQ), 2d charge, scale OF-2 (range drum scale for 2d chg), range 160 (range 8000 meters), level 30-00 (Si 300), (from) base direction 0-20 M to the left (70 Mx0.3=21 M), open sheaf (nominally, open 2 M), numbers 3 and 4, 1 rd, fire!	Rg: + (over ≈150 meters) Def: 15 M left (-)	[-(drop) 200 (meters) = 160-4 each 50-meter divisions] = "range 156" (-15x0.3) = "right (+) 5 (M)"
2. Range 156, right 5, fire!	Rg: - (short ≈ 50 to 100 meters) Def: line	[+ (add) 100 (meters) = 156 + 2] = "range 158"
3. Range 158, fire!	Rg: + (over) Def: line	[-(drop) 50 (meters) = 158 - 1] = "range 157"
4. Range 157, btry, 2 rd, deliberate fire right (btry right) at 2 seconds (interval), fire!	Rg: correct (e.g., + - + + - ? and + - + - + ?) Def: center of sheaf is 3 M left of apparent target center; also No. 6 piece is firing 5 to 7 M right of its proper position in the sheaf.	(-3x0.3) = "right (+) 1 (M)" (+6x0.3) = "No 6 left (-) 2 (M)"
5. Right 1, No. 6 left 2, btry 4 rd, salvo (volley) fire, fire!	(Platoon neutralized)	
6. Observer to FUO-9 operator: "Plot tgt No. 102, base direction 0-14 M to the left, range 7850 meters."	Action FUO-9 opr, stripping out drift, Si [as determined by chart (map) opr], ΔV_o, met effects, etc. plots the target. BC (or rcn o) reports to bn	Report FUO-9 opr reports: Tgt 102 plotted at coordinates 2345 6785, alt 123. Tgt 102, inf platoon in open, coordinates 2345 6785, alt 123. Expended 42 rd OF-462, fuzed RQM-2. Tgt neutralized; platoon dispersed, estimate 12 casualties.

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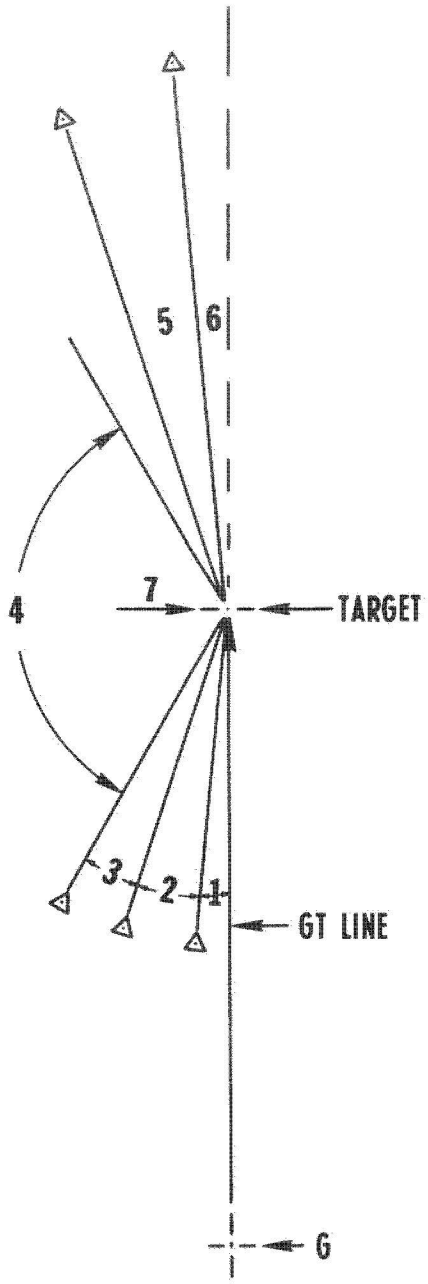

1. AXIAL: 0 to 100 M (0^0 to 6^0)
2. SMALL–T: 100 to 300 M (6^0 to 18^0)
3. 300 to 500 M (18^0 to 30^0); LARGE–T METHOD PREFERRED ALTHOUGH SMALL–T CAN BE USED.
4. LARGE–T: 500 to 2500 M (30^0 to 150^0)
5. SMALL–T (WITH RANGE AND DEFLECTION SHIFTS IN SAME SENSE AS DEVIATION OF THE BURST)
6. AXIAL (SAME COMMENT AS 5)
7. TRUE LATERAL (1600 M, 90^0): 100% OF DEVIATION IN RANGE IS DEFLECTION, AND VICE VERSA.

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Figure A-I-1. Limits of axial and lateral procedures (U).

that impact off the OT-line. Such is not the case when angle-T exceeds 100 mils (either M or ⋕), particularly when angle-T is greater than about 200 M. To maintain the burst on, or immediately adjacent to, the OT-line, it therefore is necessary to apply to the gun a shift in deflection concurrently with each change in range. This deflection shift is termed the S-factor (or in Soviet parlance, "Shu"), and a deflection shift of one "S" is applied concurrently with each 100-meter ("C") change in range made by the gun (i.e., in GT-range). It should be noted that the S-factor formerly used by the US Army (the same as that presently used by Warsaw Pact armies) is not the same as the "S" or $\frac{S}{2}$ factor presently addressed in US Army FM 6-40; e.g., the present US Army $\frac{S}{2}$ factor = $\frac{50 \text{ (sin angle-T)}}{0.001 \text{ GT-range}}$; therefore, S = $\frac{100 \text{ (sin angle-T)}}{0.001 \text{ GT-range}}$. A graphical representation of the S-factor that is used in lateral adjustments by Warsaw Pact artillery is shown in figure A-I-2; the D-factor depicted in that figure, applicable to large-T procedure, will be explained hereinafter. The derivation of the value of S is simple, S = $\frac{0.1 \text{ (angle-T)}}{0.001 \text{ GT-range}}$, or S = $\frac{\text{angle-T}}{0.01 \text{ GT-range}}$. Exact values for the S-factor are determined by: S = $\frac{100 \text{ (tangent angle-T)}}{0.001 \text{ GT-range}}$. For example, with angle-T being 650 M (39°) and GT-range being 8000 meters, S = $\frac{100 \times 0.80978}{8}$ = 10.12, and a factor of 10 is used rather than the $\frac{650}{80}$ = 8.13 or 8 obtained by the approximate method. Referring to table A-I-1, assume that this adjustment requires the use of small-T, rather than axial, procedure; OT-range, GT-range, and $\frac{r}{R}$ remain the same, but the battery is located to the observer's right, and angle-T is ≈300 M. The S-factor, therefore, is $\frac{300}{80}$ = 3.75, or 4. The "conversions" following the first command and sensing shown in the table remain valid except that the observer, when shortening his range by 200 meters, must make a deflection shift of 2 S's to the left to keep the burst on the OT line; therefore, the observer (mentally) brings the first salvo to line with his "Right (+) 5 M" correction, and then applies 2 S's or left (-) 8 M and announces, in lieu of Command 2 (Range 156, right 5, fire!), "Range 156, left 3, fire!" In deriving Command 3, in which he increases range by 100 meters, he must move 1 S to the right to remain on line so Command 3 in the table ("Range 158, fire!") becomes "Range 158, right 4, fire!" Upon entering fire for effect (Command 4), as he reduces range by 50 meters, he must concurrently shift deflection to the left by 2 M $\left(\frac{1}{2} \text{ S}\right)$. In short,

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Figure A-I-2. Concept of "S" and "D" factors (U).

Soviet small-T procedure, like axial, is simplistic and rapid in execution. In US experience up to about 1943, the average observer had little difficulty in rapidly conducting an adjustment when using small-T procedure. Such difficulty as he encountered usually was associated with the requirement to add or subtract the equivalent of 2 or 4 C's (or 2 or 4 "forks") from the elevation setting previously fired while also correcting for fuze time and height of burst of time fuzed HE or shrapnel. Good and excellent observers conducted small-T missions with almost the same rapidity as axial, and, when permitted to use the range drum on the 75-mm gun (as the Soviets do with their weapons), determined their commands for range with great rapidity and required but a second or so to apply the observed deviation times $\frac{r}{R}$ plus the S-factor to obtain their deflection shift. In short, the better than average observer can adjust with small-T procedure almost as fast as he can with axial. When this observation is applied to the rangefinder-aided Warsaw Pact battery commander or reconnaissance officer, when the range drum rather than the elevation scale is being used, the rapidity with which the observer can effect an adjustment when using small-T procedure should be apparent. One of the greatest attributes of both axial and small-T procedure is the ability of an observer (equipped with only radio, binoculars, and a firing table) to rapidly perform an adjustment without the intervention of an FDC. If necessary, an experienced Soviet observer can do without the binoculars and the firing table and, further (for example), the battery XO has no technical function; he merely relays the fire commands to the guns. When the OP-tgt-GP relationship permits, the use of axial and small-T procedures is particularly effective in meeting engagements, rear guard actions, during occupation of position, and, on other occasions, where speed is essential. It is no exaggeration to say that a good observer can complete an axial or small-T mission before FDC equipment can be off-loaded from a vehicle and placed in operation in support of an observer employing target grid procedure, and that the observer using axial or small-T procedure will have his first salvo "on the way" before a vehicular-mounted FDC can complete those procedures necessary to the issuance of its initial set of fire commands. Generally, a Warsaw Pact battery supporting a maneuver company in the <u>offense</u> can adjust all supporting fires by the use of axial and small-T procedures; i.e., without resorting to the more difficult large-T procedure. On the wider frontages characteristic of the <u>defense</u>, adjustments upon those targets along and immediately in rear of those portions of the enemy FEBA that are adjacent to the supported unit's boundries necessitate the use of large-T or other procedure. The US Army Field Artillery School is considering equipping FO parties with a graphical firing table and procedures that, under certain conditions, will permit the US FO to effect axial and small-T-type adjustments in the absence of an FDC.

(4) ~~(C)~~ Large-T procedure. As previously stated, large-T procedure must be used when angle-T exceeds 500 (either Soviet or US) mils. Also, although it is better to use large-T procedure whenever angle-T exceeds 300 mils, the Soviets customarily use small-T when angle-T is >100 and <500 mils. In small-T procedure, the burst is brought to the OT-line by applying a shift in deflection (to the GT-line) equal to $\frac{r}{R}$ times the observed lateral deviation, and the burst is maintained on-line by applying a deflection shift of one S concurrently with each 100-meter or 1-fork change in the GT range. Conversely, in large-T adjustments bursts are brought to line by changes in range; i.e., the target is bracketed in deflection rather than in range. Although the S-factor is used to retain the burst(s) on-line concurrent with a change in the GT-range, a factor other than $\frac{r}{R}$ must be used to determine the range change necessary to bring the burst(s) to line; this factor is $\frac{C}{D}$ $\left(US = \frac{c}{d}\right)$, or some expression equal thereto, such as $\frac{2 \text{ Soviet range scale divisions}}{D}$ or $\frac{1 \text{ fork}}{D}$. The concept of S and D are shown in figure A-I-2; essentially, both S and D are based upon the effects resulting from a 100- (or 50-) meter change in the GT-range. S is the change in deflection (or bearing) at the gun that is required to keep the burst on the OT-line. D is the angular deviation, as observed from the OP, resulting from a 100-meter change in GT-range. A Warsaw Pact observer, when confronted with an angle-T >500 M, effects (or causes to be effected) a graphical solution to derive the values from S and D. In the large-T procedure formerly used by US artillerymen, a trigonometric solution was preferred. As demonstrated in figure A-I-3, both methods give the same results. The principal differences between effecting an adjustment using axial, small-T, and large-T procedures are:

- Axial: Bring the burst to line using $\frac{r}{R}$ and make a 100-, 200-, or 400-meter range bound to bracket the target in range.
- Small-T: Bring the burst to line using $\frac{r}{R}$ and make a 100-, 200-, or 400-meter range bound together with the concurrent application of 1, 2, or 4 S to retain the burst on the OT-line.
- Large-T: The target is bracketed in deflection rather than in range. One, two, or four S (rather than 1, 2, or 4 C) is used to establish the bracket. Bursts deviating from the OT-line

SOVIET GRAPHICAL DERIVATION:

S (SOVIET EDC) = PB (≈ 81 m) ÷ 0.001 GT (8) = 10.13, or 10.

D (SOVIET DDC) = PA (≈ 63 m) ÷ 0.001 OT (2.4) = 26.25, or 26.

US METHOD:

$$S = \frac{100\ (\tan \measuredangle T)}{0.001\ GT\text{–}RANGE} =$$

$$\frac{100\ (0.80979)}{6} = 10.12, \text{ or } 10.$$

$$D = \frac{100\ (\sin \measuredangle T)}{0.001\ OT\text{–}RANGE} =$$

$$\frac{100\ (0.62932)}{2.4} = 26.22, \text{ or } 26.$$

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Figure A-I-3. Soviet graphical vs. US computed method for deriving S- and D-factors (U).

are brought to line by using $\frac{C}{D}$ rather than $\frac{r}{R}$. Bracketing [for deflection (which from the OP appears to be range)] is accomplished by using S with concurrent changes in range (C) to keep the burst on (or near to) the OP-line. Due to the effects of PE_r (which is several times larger than PE_d in cannon systems), in large-T the burst appears not to be as "responsive" or "obedient" to $\frac{C}{D}$ as it is to $\frac{r}{R}$ in small-T and, especially, in axial procedures. For this reason, whenever a sensing can be obtained from a burst that is somewhat off-line the $\frac{C}{D}$ factor is not applied.

(a) ~~(c)~~ Establishing the deflection bracket. The Soviets establish the first deflection bracket within the range of ≥20 M and ≤40 M, using the nearest full digit and, preferably, an even digit. Note that, within this span, 32 is the only number subject to successively even division (i.e., 32, 16, 8, etc.), and that some rounding is required with the other numbers that are multiples of "S" (e.g., 28, 14, 8 rather than 7, 4, etc.). In the former US large-T procedure, the deflection bracket was:

- One S, when using transfer or met data.
- Two S, when using map data or a rangefinder, or effecting a shift that represents a small change in range or deflection from a previously engaged target.
- Four S, when using estimated data.

In US large-T procedure, a trial deflection was a deflection that resulted in a target hit, the center of a 1-S bracket, or the center of a 16-# bracket when S was greater than 16 #. The Soviets proceed to fire for effect when:

- After obtaining a bracket in deflection (to include the initial bracket), the longitudinal and lateral deviations of the center of the burst group can be measured and corrections applied accordingly.
- A bracket ≤10 M is split.

- Obtaining a straddle if the correlation of senses is <3:1, or when the correlation is >3:1 after applying a 3 to 5 M deflection correction.

Large-T adjustments usually are initiated with a single piece, although a platoon or battery may be employed when converged sheaf is used. When a 10-M (or less) deflection-correction is introduced, 2 rd are fired at that setting when a single piece is being used. In large-T, when the burst is shifted toward the OP, range is decreased; when the burst is shifted away from the OP, range is increased. Likewise, in fire for effect, a burst occurring on the "battery side" of the OT-line is a "range short," while a burst on the opposite side of the OT-line is a "range over," and one falling on the OT-line is an "over and short" (or range approximately correct in the accounting). Similarly, a burst beyond the target is a "deflection over," and a burst between the OP and the target is a "deflection short."

(b) (U) Sample conduct of a large-T adjustment. Warsaw Pact large-T adjustments usually are characterized by the use of the calculating device or the AK-3 artillery protractor [fig A-I-4 (page A-I-38)], or the PUO-9 fire direction set (fig A-I-6). US artillerymen formerly used the US M10 or M17 plotting board to obtain a graphically aided adjustment. Nevertheless, a trained observer, who also possesses a natural appreciation of the relative geometry involved, can be very adept at shooting large-T adjustments without such assistance. Conversely, other observers learn large-T procedure "by rote" and seldom become truly adept in the conduct of "unaided" large-T adjustments. Using the setup depicted in figure A-I-3, deleting the initial fire command to the battery (except for the initial elevation), a large-T adjustment could go as follows when firing the 122-mm D-30 howitzer using 2d charge:

- Data from firing table are elevation 404 (M), C = 8; from figure A-I-3, OT-range is 2400, GT-range is 8000, S = 10, and D = 26. Therefore, $\frac{C}{D} = \approx 0.3$. An experienced observer also will note that the equivalent of 1 $PE_r = \approx 1.6$ M of elevation.

- Using number 3 gun, the observer fires 1 rd at elevation 404. This round bursts 40 M right of the target; therefore, deflection is doubtful and the shot must be "brought to line." The next command is derived by using $\frac{C}{D}$ (i.e., 40x0.3=12), and adding this result to the elevation previously fired; thus, the command is "elevation 416, fire!"

- The 2d rd falls about 5 M left of the OT-line but between the OP and the target. This burst is a "deflection short." The small deviation from the OT-line is ignored. The observer, seeking a "deflection over," commands: "Elevation 432 [416+16 (2 C)], right 20 (2 S), fire!"

- The 3d rd results in a positive sensing of "deflection over" (+); so the observer has established a 2-S deflection bracket. He splits this bracket by commanding: "Elevation 424, left 10, fire!"

- The 4th rd falls 3 M right of the target but definitely is a "deflection over." The observer needs to shift $\frac{1}{2}$ S and $\frac{1}{2}$ C to enter fire for effect. He therefore commands: "2 rd, elevation 420, left 5, fire!"

- The 5th rd falls 5 M right of the target for a sensing of "range short" (-), "deflection doubtful" (?). The 6th rd falls on-line and short of the target for a sensing of "range doubtful" (?), "deflection short" (-).

- Being within $\frac{1}{2}$ S, and probably within $\frac{1}{2}$ C, of the target, the observer calls in the battery. Depending upon the nature and posture of the target, he may elect to employ US-type volley fire in the hope of obtaining a greater number of casualties or US-type salvo fire at 2-second intervals to provide sensings for further refinement of his data. A more <u>experienced</u> observer probably would shift 2 or 3 M to the right and add 2 M of elevation (to account for a $\frac{1}{4}$ S and 1 PE_r refinement of his data) and fire two or more battery volleys. Either solution is acceptable.

(5) (U) <u>Ladder method of adjustment</u>. This method frequently is employed by Warsaw Pact artillery when using visually estimated initial data, or when the target is attacked at a long OT-range using axial or

small-T procedure. To form the ladder, the elevation and deflection setting for the number 1 piece [if the battery is to the right of the OP (if to the left, the number 6 piece is used)] is calculated. Then, by applying the "short bracket" (100 meters or 4 PE_r), the individual elevation settings of the remaining pieces are determined together with a 1-S shift in their respective positions within the sheaf; e.g., the number 6 piece would be laid 5 S to the left of, and 5 C short of, the number 1 piece. This arrangement should result in six bursts, usually delivered at 2-second intervals, being positioned 100 meters apart along the OT-line. Given this "scale" upon the ground, the observer can use $\frac{r}{R}$, S, and C to place fire for effect upon the target (with either a closed, parallel, or open sheaf) by shifting from one of the bursts in the ladder. If desired, 1.5 or 2 S and C may be used to construct a "longer" ladder.

(6) (U) Bilateral observation. In addition to being employed to determine the location of a center of impact or high burst, bilateral observation frequently is used by Warsaw Pact artillery as a method of adjustment when two OP of known location are available; e.g., a battery CP-OP and its lateral OP that is manned by the reconnaissance sergeant equipped with an aiming circle and a telephone. The Warsaw Pact standard for the angle of intersection is ≥100 M. The adjustment can be effected either graphically or arithmetically; Warsaw Pact artillerymen prefer to use the adjustment-fire instrument (computer) shown in figure A-I-4. With this hand held device, when properly set up for the problem and the observation from the left OP is entered on the left circle and that of the right OP on the right circle, the corrections for line and range become readily apparent.

(7) (U) Adjustment with observation provided by a sound ranging unit. Warsaw Pact artillery uses two techniques to adjust by means of sound ranging. The first, which is quite effective, is to effect a "sound-on-sound" adjustment upon a hostile weapon or battery that continues to fire throughout the adjustment (or a major part of it). In effecting this type of adjustment, it is best to fire one round from the same piece until the necessary "sound-on-sound" correlation is obtained; i.e., the sound ranging unit determines that the azimuth and range to the hostile weapon and to the friendly burst are identical. The second method is much less effective and is not used whenever another means of observation is available. In this method, a sound ranging unit, or sound subbase, has located a target which then ceases fire. This same sound ranging unit (not another) can provide observation for an adjustment upon that target. It is necessary that the adjustment be conducted promptly (e.g., ≈15 to 30 min) after the target has been located, because changes in met conditions degrade the accuracy of the adjustment. When using this

technique, Warsaw Pact artillery fires 4 rd from one gun and the sound ranging unit determines the rectangular or polar coordinates of the CI of that series. The artillery unit applies corrections and fires another 4-rd series, etc. until the location of a series and that of the enemy battery coincide (or is <50 meters from the hostile battery center), at which time fire for effect is initiated.

(8) ~~(C)~~ Adjustment with observation provided by a radar station. Unlike the aforestated sound ranging method of adjustment, a radar station can provide the requisite observation for adjustment upon a target that was located by another target acquisition means; nevertheless, to reduce bias, it is preferable that the target have been located by the radar station used to observe the adjustment. Two techniques are necessary, one for a radar station that incorporates a computer (such as would be expected of a counterbattery-type radar) and the other for a radar station that is capable of providing azimuth (bearing) and range only (or coordinates derived by manual plotting) such as may be expected of a ground surveillance-type radar.

(a) ~~(C)~~ Computer-equipped radar station. The radar station commander provides the BC of the adjusting battery with the coordinates and altitude of his station. The BC provides the radar station with the following initial information:

- Caliber and model of the adjusting cannon.
- Propelling charge to be fired (time of flight must be ≥20 seconds).
- Length of the baseline (i.e., horizontal distance between the radar and the adjusting gun).

Before commencing fire, the BC provides the radar with the following additional information:

- Purpose of the fire (neutralization, destruction, registration, etc.).
- Map range and grid azimuth to the target as measured from the gun position.
- Altitude of the target.
- The quadrant elevation in degrees, the maximum ordinate for that QE, and the time of flight.

- The grid azimuth and range from the radar station to the point at which the radar should commence tracking the projectile; this point usually is 0.3 to 0.35 of the GT-range.

Using one gun, a series of at least 3 rd is fired at the rate of 1 rd/10 to 15 seconds plus the time of flight. The radar station reports to the BC the lateral and longitudinal deviation from the target, as referenced to the GT-line, of each round fired in the series; the algebraic sum of these deviations when divided by the number of rounds in the series, and taken in the opposite sense, is the correction to be applied to bearing and range for firing the next series. Fire for effect is commenced, when deflection is approximately correct ($\approx \pm 2$ M), upon effecting a range change of ≤ 50 meters.

(b) ~~(c)~~ Radar station not equipped with a computer. In this situation, the BC provides the radar station commander with the grid azimuth and the range from the radar station to the target. The radar station provides the BC with the lateral and longitudinal deviation of each round fired as referenced to the radar station-target line, and the BC uses these data to apply necessary corrections to the gun as referenced to the gun-target line.

(9) ~~(e)~~ Adjustment using a stop watch. In the absence of a more efficacious means of observation, survey, etc., a Warsaw Pact artillery unit will range upon a flash-emitting sound source with the use of a stopwatch; i.e., ranging based on the time from "flash to bang." This technique will produce some effect on the target when the following criteria are adhered to:

- The same person must measure both the "flash to bang" times originating from the target and those emitted by each round in adjustment.
- A minimum of four measurements of "flash to bang" times must be recorded for each ranging. The "flash" of the enemy weapon must be visible from either the gun position or the OP, preferably both.
- The measurements, recorded to the nearest 0.1 second, are averaged for each series of four or more readings.
- The range to that source is determined by the formula: Range = $\frac{1000\ (t)}{3}$, when t is the average time from "flash to bang."

The adjustment is initiated by firing a 4-rd series from one gun along the GT-line at that GT-range indicated by the average "flash to bang" time. These rounds should be fired at an interval equal to the "flash to bang" time plus 5 or more seconds. The "flash to bang" time of this initial series of rounds is measured and averaged, and the range is computed by means of the foregoing formula. The difference between range to target and range to the 4-rd series is taken as the deviation in range. Lateral deviation is obtained by observation in the same manner as in axial, small-T, or large-T procedure. This method of adjustment is continued until the deflection is correct and, most important, the "flash to bang" time of a series equals the "flash to bang" time obtained to the target. Should the flash emitted by the series of bursts not be visible, an attempt is made to obtain ricochet bursts and, should that not be successful, time fuze is used.

(10) ~~(c)~~ By ranging with an optical rangefinder. The Soviet DS-0.9 and DS-1 stereoptic rangefinders (and comparable non-Soviet Warsaw Pact instruments) are considered by Warsaw Pact artillerymen to be capable of acceptable direct measurement to a range of 3000 meters. The longer based DS-2 rangefinder is considered effective at a range of 5000 meters. Although little is known of the recently introduced ≈50-cm optical-base, probable electrooptic-correlation rangefinder, this instrument probably is comparably effective at a range of 6000 to 8000 meters to the DS-1 at 3000 meters. The laser rangefinder recently deployed to Soviet target acquisition batteries should be effective to ranges ≈>10 000 to <20 000 meters. In addition to providing assistance to the observer by providing the longitudinal deviation of the burst from observed (visible) targets, a rangefinder can be (and is) used to adjust upon targets of known location that are positioned in defilade from an observer who is to effect the adjustment. Essentially, the target of known location is polar plotted from the OP. An aiming circle or BC scope is laid upon that azimuth, as is the rangefinder. Using single rounds fired for ricochet or time-fuzed airburst action (as appropriate), the observer conducts the adjustment, using the lateral deviations that he measures and the longitudinal deviations provided to him by the rangefinder operator. Fire for effect is entered as in an ordinary axial or lateral adjustment.

(11) ~~(c)~~ Adjustment by aerial observer. A Warsaw Pact observer in a helicopter may station himself along the GT-line and conduct an axial adjustment, or to one side of that line and conduct a small-T adjustment; in either instance, it is prudent that his positioning be in rear of the FEBA, at the lowest feasible altitude, and that he fly to one side or the other of the GT-line between firing rounds in adjustment on an "at my command" basis. An aerial observer, for so long as he effects his sensings from along a line that gives a fixed heading (bearing) to

the target, can employ target grid procedure. Pact observers also conduct adjustments using FO procedure (sensing lateral and longitudinal deviations, in meters, with reference to the GT-line). Pact aerial observers, in fixed wing (particularly high performance) aircraft, usually sense in meters of deviation from the target with relation either to the cardinal points (N, S, E, and W) or to a thrust line that is identifiable on both map and ground; e.g., a highway, railroad, or a line established by two points such as a road junction and a church. When a thrust line is used, the fire direction equipment operator usually orients a target grid sheet parallel to the thrust line to facilitate plotting the observer's sensings. In terrain characterized by an absence of identifiable points, the aerial observer, upon roughly firing the target location, may request a "battery-platoon" ladder. When using this technique, the battery fires a US-type salvo at the target location and follows immediately (≤15 seconds) with simultaneous platoon salvos; the 1st platoon fires 200 meters over the target location and the 2d platoon fires 200 meters short. This technique, in addition to providing the observer with a 400-meter-long "range scale" on the ground, also roughly establishes the bearing of the GT-line. Given a "battery-platoon" ladder, the observer may report "Number 3 burst, 1st platoon is 150 short, 50 right" or "number 1 burst, 2d platoon, 50 N, 50 E." If desired, the observer may request the usual (linear) type of ladder. The initial round or two, or 1 or 2 rd in the first salvo or two, usually is fired using WP or colored smoke to facilitate identification of the bursts by the aerial observer..

(12) ~~(C)~~ Firing upon moving targets. Warsaw Pact artillery is trained to conduct fire at moving terrestrial and waterborne targets. Two methods are employed; the first method is applicable when the target is visible from the battery position and the GT-range is ≤0.5 maximum range of the weapon. The second method is used when the GT-range exceeds 0.5 maximum range or when the target is not visible from the gun position.

(a) ~~(C)~~ First method. The range and estimated target lead is determined and the number 1 piece (number 6 if the target is moving to the left) is laid on the forward edge of the target and that piece is fired. When a range sensing is obtained, a corresponding correction is applied, together with a 200-meter correction for the direction in which the target is moving, and thereafter battery or platoon ladder fire is delivered in adjustment. During the adjustment phase, the best way to correct for lateral lead is for the battery XO to measure the angular distance between the target and the burst, algebraically add that measurement to the lead (deflection setting) previously fired, and announce a deflection shift to the guns (i.e., employ the technique commonly known as "lay-off"). Between salvos, a 200-meter (more or less as indicated by the previous salvos) change in the direction of the target's movement is introduced; e.g., 200 meters in range when the

target is frontally presented, ≈150 meters in range and deflection at 45°, and 200 meters in deflection when the target is on a "crossing course." Upon bracketing the target, the method of fire is changed to battery, or alternating platoon, volleys, using a single elevation setting. This elevation setting corresponds to:

- The future (predicted) position of the target for frontal and obliquely presented targets.

- The bracket center for laterally moving targets. When all bursts are in one sense, a 100- or 200-meter range change is applied. When mixed "overs" and "shorts" are observed, the range changed by 50 to 100 meters in the direction of target travel. Ricochet fire is used against both open-topped landing craft and vehicles. In engaging high-speed targets, the foregoing range corrections cited are doubled or tripled. When range to a sizable waterborne target (e.g., an LST) becomes ≤3000 meters (≤4500 meters with the 100-mm T-12A gun), this method is suspended in favor of direct fire technique; each piece determines its lateral lead, using "lay-off" or another acceptable method, and corrects its range by aiming at the top or bottom of the target to compensate for "shorts" and "overs," respectively. Against armored vehicles, the changeover to direct fire technique occurs at grazing range plus ≈200 to 300 meters.

(b) ~~(C)~~ Second method. When the target cannot be observed from the battery position, a method similar to that formerly employed by US Army coast artillery is employed; i.e., a "set forward" (predicted point) method. Observation may be provided by radar, a short base (or combined observation), or a single OP with the aid of a range-finder. Optimally, a radar station provides the battery with target location (fix) data every 20 seconds and an OP every 20 or 30 seconds. The "timekeeper" at the CP-OP (the radio-telephone operator) uses a stop watch to coordinate the timing of the observations and the plotting thereof. The BC also uses a stop watch to measure the "dead time minus time of flight" and to announce the time of fall of shot (splash). The PUO-9 fire direction set is used for plotting the "fixes," the establishment of the "set forward" (predicted) points (this is facilitated by use of the target course ruler), and the derivation of firing data. Essentially, the procedure for firing at moving targets consists of performing sequentially, yet simultaneously on a timed interval basis, the following functions:

- Radar (or rangefinder operator): Determines polar coordinates of target every 20 (or 30) seconds, and polar coordinates of the center of impact (of the volley or salvo) as ordered by the BC.

- Plotter: Plots (by +20 seconds) the location of the polar coordinates; after several plots, determines (within an additional 20 seconds) an impact point (a set forward point) and the range, shift, and time of flight thereto. Sets deflection and range corrections into the PUO-9 fire direction instrument as ordered.

- Battery commander (or observer effecting the adjustment): Announces (to the battery) corrections to the previously announced firing data (both to data "not yet fired" and "has been fired"); determines the predicted "dead time" [e.g., 100 seconds, after the time of that fix (the "0-time") from which the set forward point was established, minus 30 seconds time of flight and minus 5 seconds for transmittal and reaction to the Command for the battery to "fire" = the command to fire must be ordered at 1 min, 5 seconds after "0-time"].

- Battery: Lays in accordance with announced firing data; applies subsequently announced correction thereto and loads; fires on order of the BC. Also, immediately applies any correction that is announced while the battery is firing [this is done without suspending (checking) fire].

In a typical engagement:

- The radar station alerts the BC (or bn CO) of a moving target; e.g., "12 vehicles, moving from left to right, depth 300, width 8 M, range 5600."

- The BC orders the radar to "track." Alerts his "timekeeper" and plotters that the spotting rate is 20 seconds and to report, first, firing data to the "impact (predicted) point" and, second,

corrections to the "impact points" (i.e., CI of the fall of shot vs. target location).

- The "timekeeper" announces "Attention----Stop!" every 20 seconds.

- The radar, over a period of 100 seconds, provides five sets of polar coordinates to the "plotters," who, after the 2d or 3d set, upon order, commence plotting the "impact (set forward) points" by use of the moving target course ruler.

- Firing data to the first impact point (e.g., one established at "120 seconds") are announced by the "plotter" (FDC equipment operator); e.g., range 160 (8000 meters), right 1-40, flight time 30, offset small (small-T).

- The BC sends these data to the guns in the form of a fire command that terminates in the order to "Load!". He then mentally calculates that $\frac{r}{R} = \frac{5600}{8000} = 0.7$.

- When the "observation phase" of the 5th or 6th fix is completed (the 3d or 4th fix can be used with degraded accuracy), the "timekeeper" (in accordance with instructions previously indicated by the BC) commands: "First impact point, attention, ---stop!" Upon the command "stop!", the BC starts his stopwatch, while the plotter(s) lay off the predicted point (of impact) and announce: "Impact point": "Range 152, right 1-55, flight time 27." The BC determines the time of firing by subtracting the flight time from the predicted "dead time."

- By this time, the plotters inform the commander the "range rate" (target speed in meters/min in range) and the "deflection rate" (target movement in mils/min in deflection) are -160 (meters) and right 15 (M), respectively.

- The BC then commands the battery to effect a change equivalent to 20 seconds of the range rate and deflection rate; e.g., "by series (battery right), range 150, drop 1 (reduce range by 50 meters per 20 seconds of firing) deflection right 1-60, right 5 (shift right 5 M per 20 seconds), 4 rd, at my command!"

- As his stopwatch reaches the proper time, the BC commands FIRE! and concurrently orders the radar station and his plotters: "First impact point, report corrections for the second salvo" and, prior to "splash" of the first series, he commands: "Attention----Fall!" The BC then stops his watch, restarting it upon impact of the 1st rd. The BC measures the lateral deviation (4 M) of the CI of the first series and (applying $\frac{r}{R}$ = 4x0.7) commands the battery and the plotters: "Right 3!"

- The radar reports with regard to the second series: "44-08, 7450, left 6, over 100."

- Upon receiving this report, the BC checks to make sure his deflection correction was proper and commands: "Plotters, range drop 100."

- The plotters use the radar report to plot a new "fix," and lay off a new impact point therefrom. They then displace the vernier on the angle-measuring segment of the PUO-9 0-03 M to the left, and mark an auxiliary index on the range arm's cursor to introduce a "-100-meter range-K."

- The battery, at order of the BC, fires on the second impact point, etc.

- Should the target change direction, upon the second "fix" being plotted in the new direction a new impact point is evolved.

Moving target procedure is not as difficult as it appears to be. Furthermore, there are several variations that may be used to simplify and speed up this procedure, albeit at some loss in accuracy. When a battalion delivers fire using this type of procedure, each battery is assigned a successive impact point (by coordinates), and the moving

target is maintained almost continually under fire; i.e., it may undergo a "battery, 3 volleys" every 30 or 40 seconds from different batteries firing successively; e.g., 1st battery at 100 seconds, 2d battery at 140 seconds, 3d battery at 180 seconds, 1st battery at 220 seconds, etc.

(13) (U) Measured deviation technique. Warsaw Pact artillerymen frequently use the measured deviation technique. Essentially, a variation of this technique is employed in the foregoing example of adjustments effected by sound and radar observation. In observed fire, when the difference in location between the target and a terrain feature (which serves as an auxiliary target) can be determined, the observer adjusts on the terrain feature and upon entering fire for effect "transfers" the fire to the target by a predetermined shift in range and deflection. Another variation of this technique is to fire one round at the terrain feature and, by using axial or lateral procedure or combined observation, apply a correction to place that round more proximate to that auxiliary target. A 4-rd CI then is fired, and the deviation in range and deflection of that CI from the terrain feature (auxiliary target) is determined. After applying corrections for these deviations, "surprise" fire is transferred to the actual (primary) target.

(14) ~~(C)~~ Adjustments with time fuze. When time (non-proximity) fuze is employed, Soviet practice is to adjust using point detonating fuze (FQ) until both range and deflection are correct. The time adjustment then is initiated in the following manner:

- The battery (or platoon) fires a US-type salvo at the adjusted range using the corresponding fuze setting shown in the tabular firing tables minus 2 scale graduations (≈0.4 second) when the ambient air temperature is above 0°C or 4 scale graduations (≈0.8 second) when the temperature is below 0°C.

- If all of the bursts are graze (impact), the fuze setting is further reduced by 2 scale graduations; when more than 50% are graze (but one or more airbursts are obtained), the fuze setting is reduced by only 1 scale graduation. If 50% or more of the projectiles fired are airbursts, the fuze setting is assumed to be correct.

- The height of burst is then adjusted, if necessary, by use of the level (US-site) scale; adjusted average height of burst for mechanical time fuze should equate to 2 M of site on the gun regardless of range. The equivalent, at the OP, of 2 M of

site on the gun can be determined by dividing the range coefficient $\left(\frac{r}{R}\right)$ into 2 M; i.e., $\frac{r}{R}$ being 0.25, the average height of burst as measured from the OP should be 8 M. In determining average height of burst, graze bursts are assigned a value of zero; further, less than 50% airbursts are considered to be zero average height of burst. If all bursts are airbursts, before entering fire for effect, the fuze and elevation settings are increased simultaneously with the adjustment of the level (site) setting. If there are airbursts that permit a range sensing by observation of the airburst (rather than its effects pattern upon the ground), the fuze setting is increased by one graduation. If all the airbursts fail to permit a range sensing from the burst, the fuze setting is increased by two graduations, and the elevation is increased accordingly. If one or more pieces consistently deviate from the average height of burst, the average height of burst of those pieces is corrected individually by use of the level (site) scale, or by changing the fuze setting.

b. ~~(C)~~ Equipment Used in the Conduct of Observed Fire. Having an FDC at the CP-OP, as well as at the battery, FDC equipment (in part or in whole) also is used in conjunction with the conduct of observed fire. Conversely, equipment used in observed fire also is used in FDC operations. Therefore, in large part, no clear cut division in the utilization of Warsaw Pact fire direction and off-carriage fire control equipment is entirely feasible. Nevertheless, the equipment shown in figure A-I-4, together with the other equipment described below, in large part is utilized in observed fire.

(1) (U) The AK-3 artillery protractor. This device is used in effecting graphical solutions. The location of the gun position, OP, and target are plotted using either rectangular or polar coordinates. The main (principal) direction is inscribed from the gun position, and the back azimuth of the main direction is inscribed from the target location. Both the shift (at the gun position) from main direction to the target and the "shift" at the OP, as well as the GT and OT ranges, are measured from the target. Angle-T and the factors S and $\frac{r}{R}$ are determined. If angle-T is >500 M, the "30" line is pointed at the gun position and the sine and tangent factors are obtained from the appropriate scales on the protractor by pointing the range arm at the OP location.

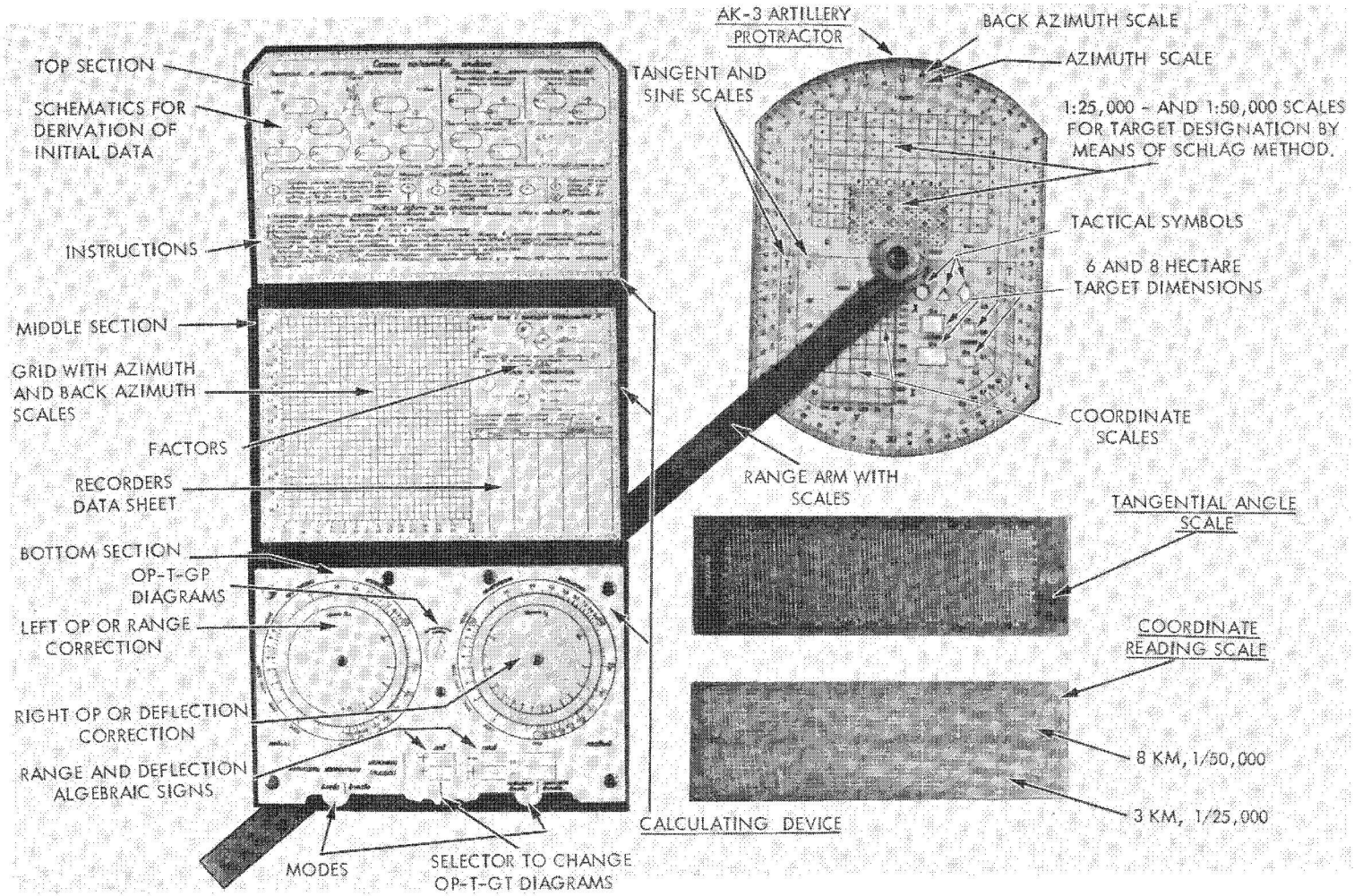

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Figure A-I-4. Soviet aids used in the conduct of observed fire (U).

(2) (U) The coordinate reading scale. This scale is used in conjunction with a pair of dividers. Map distance is measured with the dividers. The right leg of the dividers is placed on an even 1000-meter line and the left leg is projected into the first kilometer section (in which transverse lines are inscribed). Sliding the dividers evenly up the scale until the point of the left leg intersects one of the transverse lines gives the range or distance measurement to an accuracy of 10 meters.

(3) (U) The straight-line nomograph. This device (not pictured) permits the determination of ranges and distances. It also enables coordinates to be evolved without employing logarithmic calculations.

(4) (U) The artillery slide rule. This log-duplex-type rule (not pictured) has nine scales. Scales one through three are firing data, four and five are the multiplication (C and D) scales, scale six is X^2, and scales seven through nine are the S, T, and ST scales.

(5) ~~(C)~~ The artillery calculating device. The Soviets refer to this device as the "adjustment-fire instrument (computer)." This folding three-part device is composed of the top, center, and bottom sections.

(a) (U) Top section. This section contains diagrams for the recording of known data. These diagrams also facilitate the systematic derivation of initial and subsequently derived data.

(b) (U) Center section. This section contains a 1/50 000 grid, with azimuth and back azimuth scales printed around two sides. To the right of the grid is a recorder's type of form, upon which the factors are entered and sensings and fire commands can be recorded during an adjustment.

(c) (U) Bottom section. This section presents a graphical representation of the relative positions of OP, gun, and target. The signs ["+" (right or over) and "-" (left or short)] that pertain to these various relationships are concurrently presented. There are also two circular scales with rotatable plastic inserts. The periphery of each of these scales is a logarithmic scale. A mils scale is located under the plastic inserts. The left circle represents, and is used for, either range or the leftmost of two OPs [OL (left OP) or 01 (leftmost of two, or more, OPs)]. The right circle represents either deflection or the rightmost of two OPs (OR or 02).

(d) (U) Capabilities. This calculating device can be used to effect adjustments on the basis of measuring deflections from two OPs or on the basis of observation of the signs (+ or -) of the burst in relation to the target along the OT- and/or GT-lines. It facilitates the shifting of fire by use of firing coefficients (measured angle, $\frac{C}{D}$, S, etc.). It also is used to effect adjustments for range conducted on the basis of stopwatch measurements of "time to sound of burst," to calculate shifts to the target from CIs reported by a radar station or sound base, etc. In sum, this device is an excellent artillery calculator that greatly facilitates and expedites the conduct of an adjustment.

(e) ~~(C)~~ Comment. Warsaw Pact (particularly Soviet) artillery uses an unusual number of nomograms, forms, devices, and locally fabricated "aids." Many other artilleries, including that of the United States, over the years have issued (or locally fabricated) devices, forms, etc. many of which proved to be of marginal value, became obsolete, or the use of which was discontinued for other reasons. The Soviet artillery calculating device is an item of real worth that is capable of providing rapid solutions to many types of gunnery problems. It is surprising that the US Army did not develop and issue a similar item of comparable worth during World War II or, at least, prior to 1950. In seeking a procedure that permits US FOs to adjust fire in the absence of an FDC, the development and issue of a device of this type should be seriously considered because, in many ways, this device is a "hand-held FDC."

(6) (U) The F-58 compass. This magnetic compass (not pictured) has a distance scale inscribed on the base and angle of site scale inside of the opened cover.

(7) (U) Binoculars. These equipments (illustrated in sec I-A-4c) generally are comparable to similar glasses used in other armies. Binoculars used by Soviet field artillery are 6x30, 8x30, and 10x50 glasses.

(8) (U) Rangefinders and observation instruments. These types of instruments (illustrated in sec I-A-4c) are the primary means of determining range and angular measurement on battery and battalion-level artillery OPs.

c. ~~(C)~~ Unobserved Fire.

(1) ~~(C)~~ Ballistic and weather effects. Warsaw Pact calculations for meteorological and other effects consider the same principal parameters as US-NATO artillery; however, their calculations routinely provide for

effects incident to the use of flash reducer, fuze caps, and painted or unpainted projectiles. As previously indicated, great stress is placed upon remaining abreast of the continuing changes in ΔV_o due to tube wear, propellant temperatures, and changes in powder lot. The Soviets consider, calculate, and maintain ballistic and weather effects separately. This practice of separating the data contained in the met message from expected V_o, powder temperature, projectile weight (fig A-I-5), and deviations due to the use of flash eliminator (or other additives), fuze caps, or unpainted projectiles facilitates the updating of these data. The data contained in the met message are considered "met effects," while V_o, powder temperature, etc. are considered to be "ballistic effects." Met messages more than 2 hours old are not considered suitable for a "deliberate preparation" of data. With stable weather and a maximum ordinate of less than 2000 meters, however, the "old" data are considered usable for "hasty preparation" of data for up to 6 hours, 8 hours with a maximum ordinate of more than 2000 meters. In the absence of a met message, met data may be obtained locally by a unit's ad hoc "met post" (sec I-A-4b). In the absence of a met post, approximate data are generated based upon surface air temperature and ground wind. When approximate data are evolved and surface air temperature is within ±10°C from standard, deviation of the ballistic winds are taken as equal to the deviation of the surface wind. When greater than ±10°C, the surface deviation is multiplied by a correction, the value of which decreases with altitude. Whenever met data are calculated for a particular propellant charge, it is always calculated at a minimum of two ranges within the capabilities of that charge and, usually, for three directions. The foregoing constitute some reasons for the practice of often disseminating met-Ks for several charges (and several ranges within each charge) rather than the met message, per se. Assuming good survey data, the desire to achieve surprise and to reduce the ammunition expenditure incident to registering numerous batteries causes Warsaw Pact artillery often to disseminate met-Ks rather than met messages; obviously, Pact artillery is satisfied with this technique and the results attained.

(2) ~~(C)~~ Assignment of checkpoints. Senior commanders and target acquisition units, such as the divisional artillery target acquisition battery, usually assign checkpoints to the artillery battalions and/or batteries.

(3) (U) Preparation of data. Warsaw Pact artillery characterizes the preparation of firing data for unobserved fires into two general categories:

- "Deliberate (also complete or total) preparation of fire."

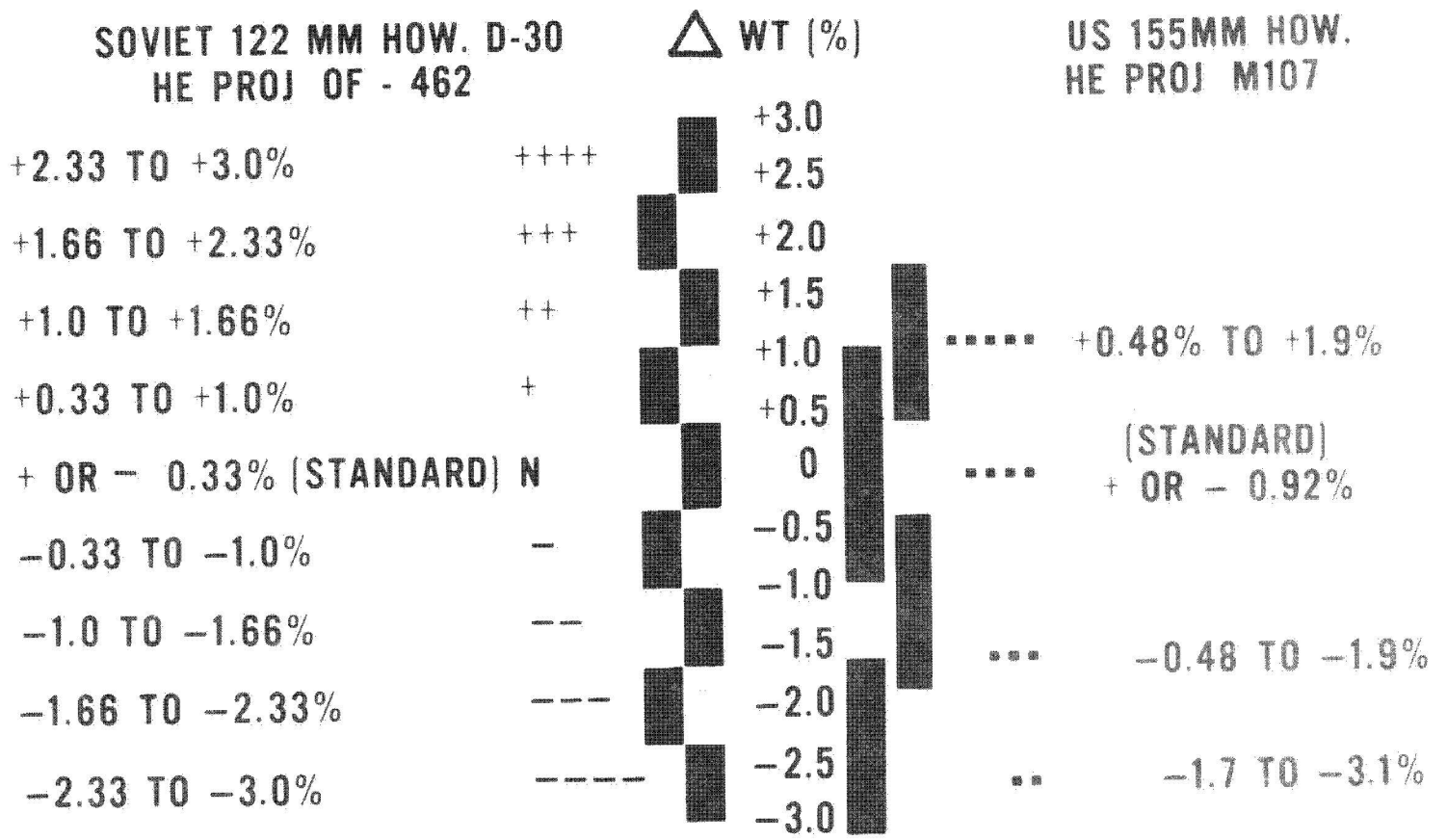

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Figure A-I-5. Soviet vs. US Army projectile markings and comparative weight zones (U).

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- "Hasty (or shortened) preparation of data."

The parameters that characterize these classifications were explained in para 3a, supra.

(4) (U) Transfer limits. Plus or minus 300 M in deflection and ±2000 meters in range [±1000 meters for high angle (upper register) fires] delimit transfer of fires within Warsaw Pact field artillery units.

(5) ~~(C)~~ Fire direction. Within the Warsaw Pact, technical fire direction is performed at the battery level. Technical fire direction at battalion level usually is confined to the preparation of firing data (that customarily is uncorrected for ballistic effects) incident to the firing of preplanned fires. Usually, each battery operates two battery FDCs, one at the CP-OP and the other at the gun position. Each FDC has a PUO-9 (fig A-I-6) FD set (with firing chart) that is operated by a computer (man) and a plotting board-type set used for graphically deriving coordinates, etc. that is operated by a second man. Either the reconnaissance officer or the chief of detail supervises the operation of the FDC at the CP-OP, and either the XO/assistant XO or the chief of firing battery supervises FDC operations at the gun position. The FDC at the battery (or battalion) CP-OP calculates target intersections, determines firing data for, and replots of, registrations and adjustments, and plots "set forward points" and determines firing data for the engagement of moving targets. Warsaw Pact fire direction, per se, is essentially a one-man and one-officer, rather than an officer-plus-team-of-men, operation; this is not considering a second man who operates the map (or plotting) board. Whereas a US artillery battalion manually operated fire direction center (besides the fire direction officer) utilizes a horizontal control chart and operator and a vertical control chart and operator, plus a computer (man) for each battery, Warsaw Pact units use one chart and one operator to plot all targets and derive all firing data that does not originate with an observer employing axial, small-T, or large-T procedures and, thereby, is transmitting fire commands and not sensings. If a battery loses the use of its second set of PUO-9 FD equipment or if the firing battery is deployed in two separate platoons (in which case the battery may desire to operate three FDCs), the second or third FDC can be operated using a plotting set or map board, an AK-3 map artillery protractor (fig A-I-4), firing tables, site tables, and graphically constructed range and deflection correction charts. At battalion level, two firing charts are usually employed. One chart, at the battalion CP-OP, is utilized by the battalion commander for fire direction. The second chart, at the battalion headquarters, is used by the staff to compute, or check the computation of, scheduled and on-call fires. It is possible to mass the battalion using only the battalion chart. Nevertheless,

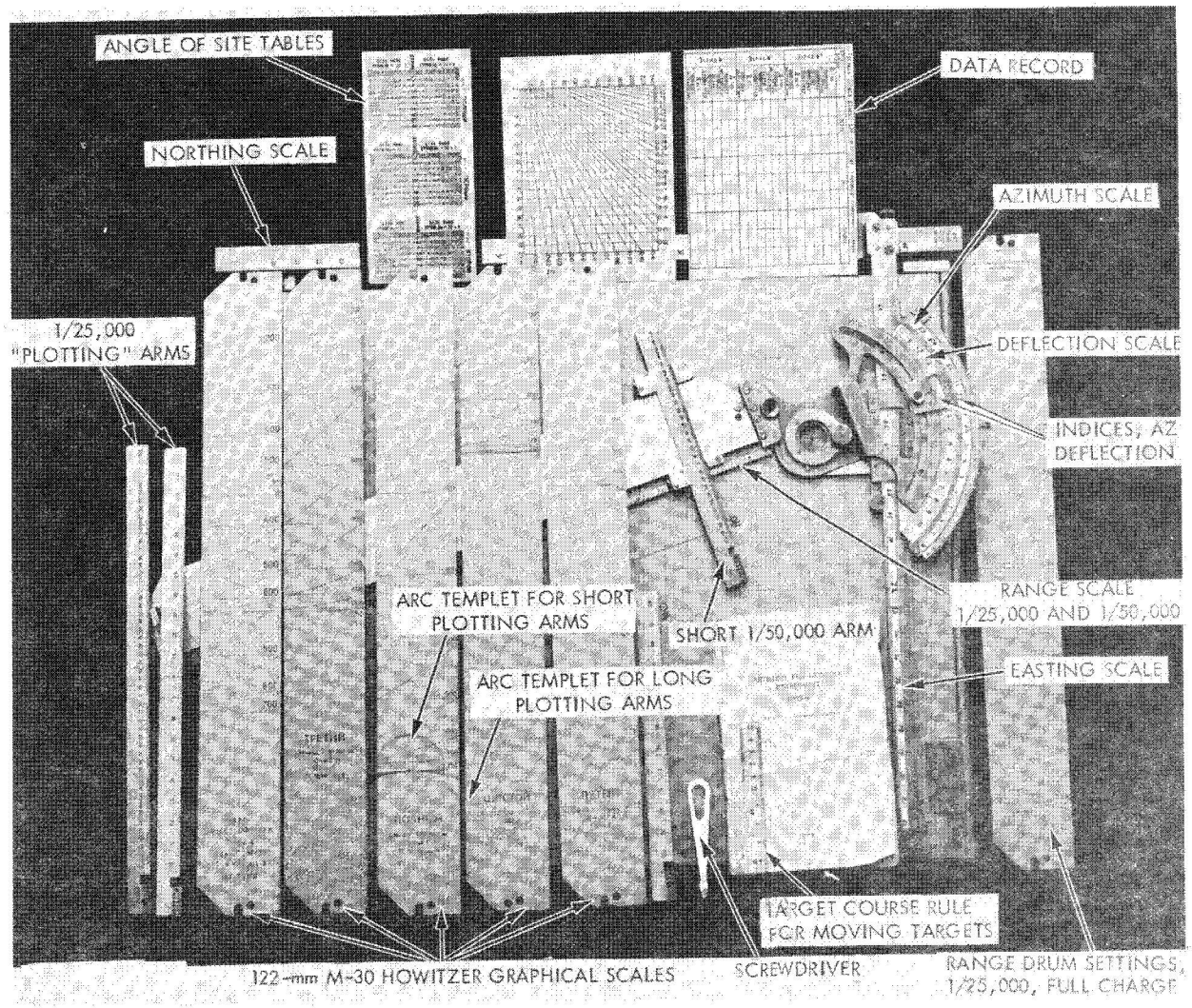

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Figure A-I-6. Display of components, Soviet PUO-9 fire direction set, less case (U).

although the battalion CO controls the massing of his battalion he customarily leaves the derivation of firing data (i.e., technical fire direction) to the FDO and computer at each battery. On balance, such methodology is little, if any, slower than the derivation of firing data by means of a centralized FDC (as is US Army practice) unless that FDC is computerized.

d. ~~(C)~~ Equipment Used in the Conduct of Unobserved Fire. This equipment includes the Soviet PUO-9 Fire Control Instrument (fig A-I-6) and the Artillery Protractor AK-3 (fig A-I-4). The PUO-9 essentially is the older PUO-3 that has been modernized by the inclusion of prefabricated graphical firing table scales that are readily attachable to the range arm. The cursor of the PUO-9 has a multipurpose ruler-like scale that is affixed at right angles to the range arm. In addition to deflection shifts, this scale (the "plotting arm") enables information on range, corrected elevation or range drum settings, and deflection correction to be read directly by the instrument operator. In fact, all required firing data except that pertaining to site and sheaf width may be read directly from the PUO-9. Site (angle of site plus complementary angle of site) and the necessary amount of sheaf opening or closure are obtained from special tables that are included with the kit. The PUO-9's plotting board is hinged in the center, thereby increasing portability. The older PUO-3, although serviceable, is characterized by the number of scales the user must inscribe upon the range arm and, especially, upon the cursor (slide).

(1) ~~(C)~~ The PUO-9 fire control instrument. This equipment (fig A-I-7) consists of a plotting board to which is fastened unnumbered vertical and horizontal coordinate scales, each equipped with a vernier. An angle-measuring arc with a movable centrally located swivel-type connection, to which the plotting (range) arm is affixed, is mounted on the movable (the easting) coordinate scale. A circular glass insert containing a "pinhole" is located at the center of rotation of the movable swivel joint that connects the range arm to the angle-measuring arc. Targets are plotted through this "pinhole" in the movable swivel joint. This instrument and its predecessor (the PUO-3) may be used not only as fire direction equipment but as plotting boards for flash bases and other operations in which intersections, resections, and/or polar coordinates are solved by graphical means. The PUO-3 equals the PUO-9 in performing graphical operations.

(a) (U) Coordinate and range scales. The PUO-9 is divided at scales of 1:25 000 or 1:50 000; only the range scale is so numbered. Either 1:25 000 or 1:50 000 scale firing charts or topographic maps may be utilized with the PUO-9. A range of 15 000 meters is the break point for using a scale of 1:50 000 rather than 1:25 000. Claimed accuracy for this instrument is a circular plotting error of 5 meters when using the 1:25 000 scale and 10 meters with the 1:50 000 scale.

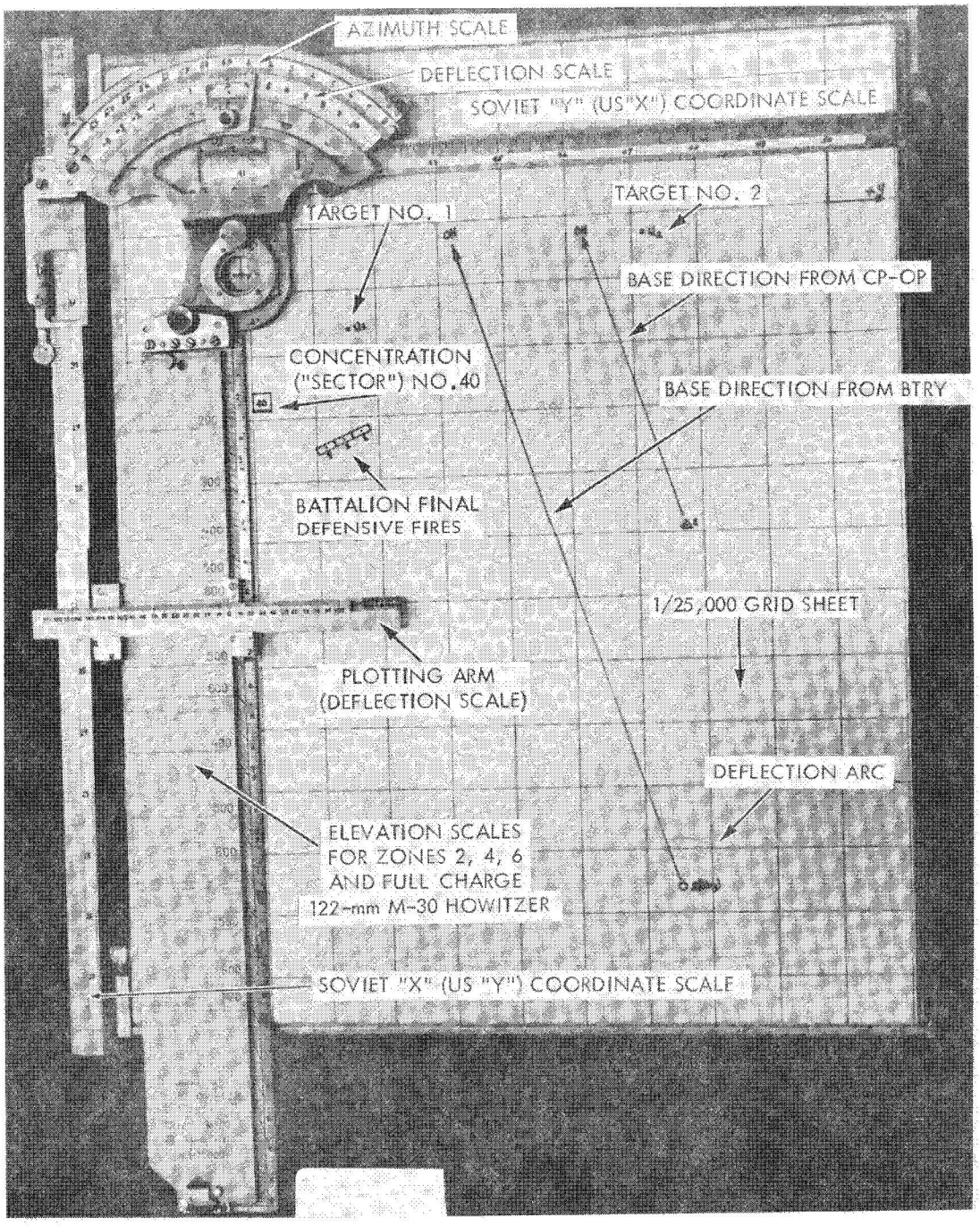

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Figure A-I-7. Soviet PUO-9 fire direction set with GFT scales for the 122-mm M-30 howitzer and a 1:25 000 US Army grid sheet mounted upon its map board (U).

(b) (U) Orientation. When this instrument is being used, the chart or map is so positioned (with either N, S, E, or W at the top of the plotting board) that the target area is located in the upper portion and the position area near the bottom of the board. By the use of one or more colored pencils in addition to an ordinary lead pencil, it is feasible to derive and annotate firing data in two or more quadrants.

(c) (U) Measurement of range and deflection. Unlike US practice, the origin of these measurements for the Soviets and their Warsaw Pact allies is the target and not the battery center. At first glance, a US artilleryman would consider the orientation of the board to be 180° out in azimuth and the range scale to be numbered in reverse. Nevertheless, angular and distance measurements obtained with either Soviet or US equipment result in the same readings.

(d) (U) Plotting. In addition to the battery position(s) and the main direction(s) (azimuth upon which the battery is laid), the CP-OP(s) and the lateral and forward OPs (to include their main directions) are plotted on the firing chart (fig A-I-8). When such data are available, the following are also plotted: The flash bases, the radar position, and the center of the sound base(s); all to include their base directions. Targets, reference points, and registration and checkpoints are plotted as they become available. Barrages and final defensive fires and the like are plotted to scale and appear as rectangles, squares, and, perhaps, lines which portray the actual dimensions and the orientation of such fires.

(e) (U) Operational times. The following times are prescribed for operation of the Soviet PUO-9:

- Preparation of the PUO-9 from an "on the march status" to "operating condition," to include its orientation and plotting of the gun position ---------- 3.0 min
- Preparation of range and deflection correction scales, each for three ranges ---------- 2.5 min
- Plotting and determining the range, deflection, and altitude for a target ---------- 20 seconds
- Determination of elevation, shift, and angle of site ---------- 40 seconds

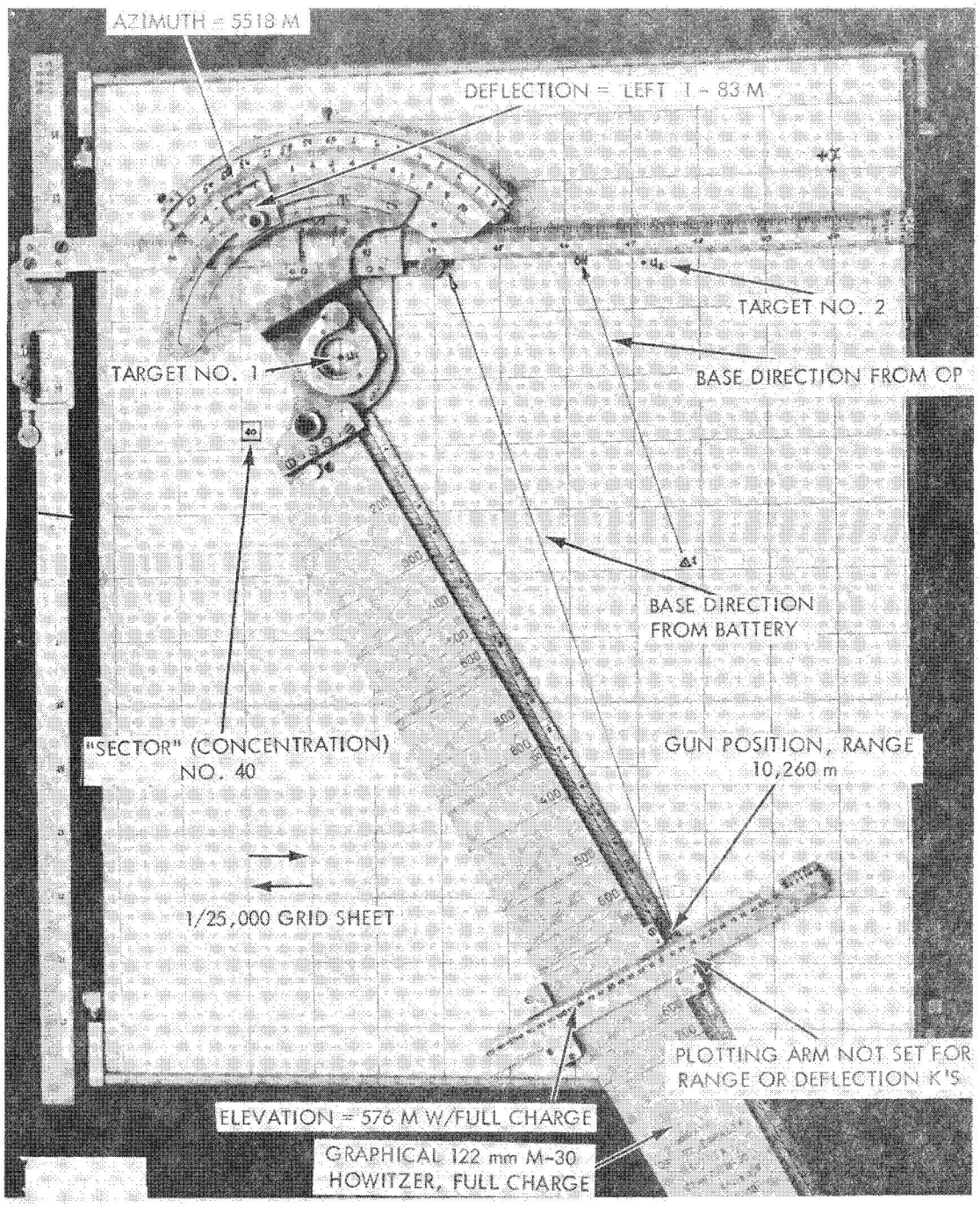

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Figure A-I-8. Soviet PUO-9 fire direction set with range arm positioned to derive firing data for target number 1 (U).

In sum, the PUO-9 instrument can be set up complete with correction scales in 5.5 minutes. Then, from announcement of a target location to issuance of the fire order, the time per target is 1.0 minute. These times certainly are acceptable in any army, and it should be noted that the FD function when using the PUO-9 essentially is a one-man (not more than two man) operation. In addition, the instrument operator of the PUO-9 can accomplish all the functions executed in US artillery by the HCO, VCO, and the battery computer, thereby effecting a saving of manpower. The PUO-9 can be used to mass the fires of a battalion; nevertheless, this capability seldom is used because technical fire direction within Warsaw Pact countries essentially is a battery responsibility and is accomplished more rapidly on a one-PUO-9-to-one-battery basis.

(f) ~~(e)~~ The PRC type 59 field artillery fire control instrument. The PRC has developed and deployed a FDC set (fig A-I-9) that is based on the Soviet PUO-9. This PRC FD set has not been studied in any depth. Nevertheless, it is apparent the type 59 basically is a two-man, rather than a one-man, operation, as is the Soviet PUO-9. The type 59 incorporates a means of obtaining target intersections through the use of two range arms having arcs (fig A-I-10); it is apparent this feature primarily is intended to facilitate the engagement of moving, particularly waterborne, targets. This FD set also incorporates a mechanism for applying and/or determining range and deflection corrections (fig A-I-11) plus what appear to be devices for the rate of change in deflection and range when firing at moving targets. In addition, the type 59 obviously can derive firing data for massing the fires of a battalion with more facility than can the PUO-9. Whatever its overall capability and its net worth over the Soviet PUO-9 may turn out to be, the type 59 certainly is ingenious in concept and design.

(2) (U) Range and deflection correction charts. Although these are not equipment per se, ECC artillerymen also frequently construct, and make extensive use of, range and deflection correction charts. It is apparent these charts are utilized when operating a "second" firing chart, using the artillery protractor, at battalion or group headquarters in conjunction with the use of check charts, as a means of exchanging information pertaining to corrections between units, by observers to obtain a range coefficient (K-factor) for use in preparing initial data for observed fires, and by PUO-9 operators for targets that lie outside the transfer limits of the several sets of range and deflection corrections that may be entered upon the range arm-graphical range table scale of the PUO-9. A very simple, one-charge, two-registration point, range correction-only chart of the type used by an observer is shown in figure A-I-12.

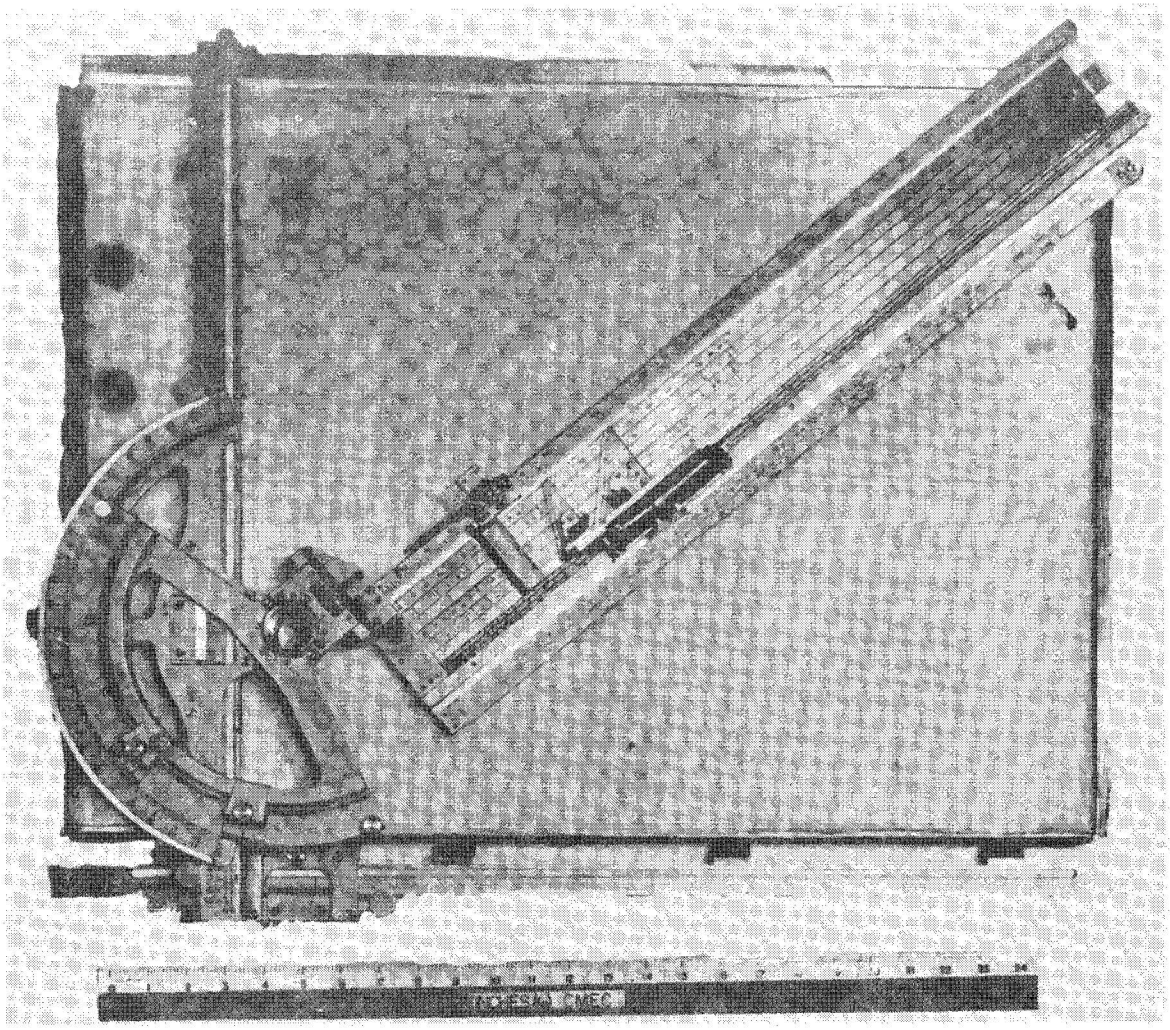

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Figure A-I-9. PRC type 59 fire direction set (U).

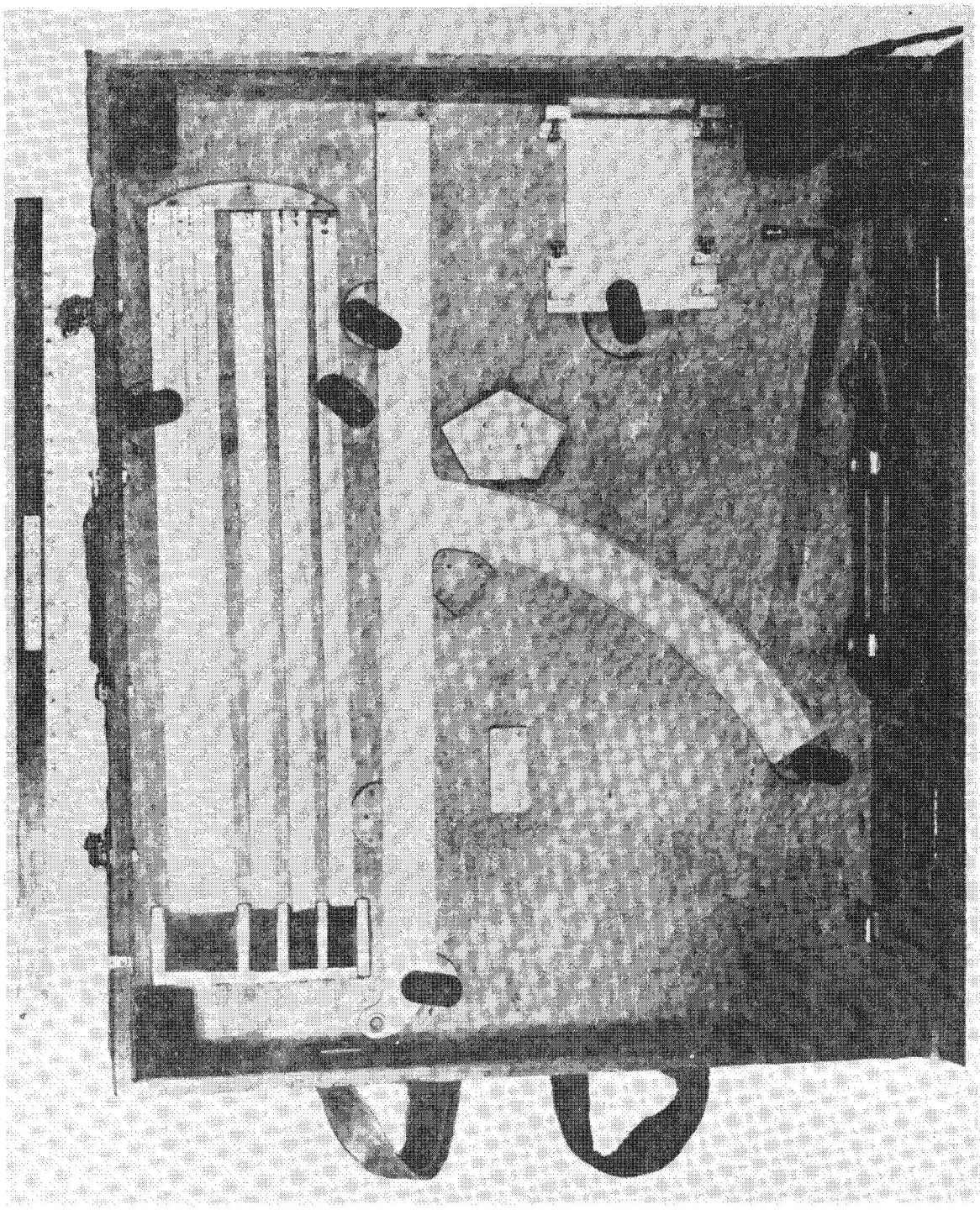

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Figure A-I-10. PRC type 59 fire direction set; at left are GFT scales for elevation and range drum settings; range scale with arc is right arm of intersecting device, and cursor is at top right (U).

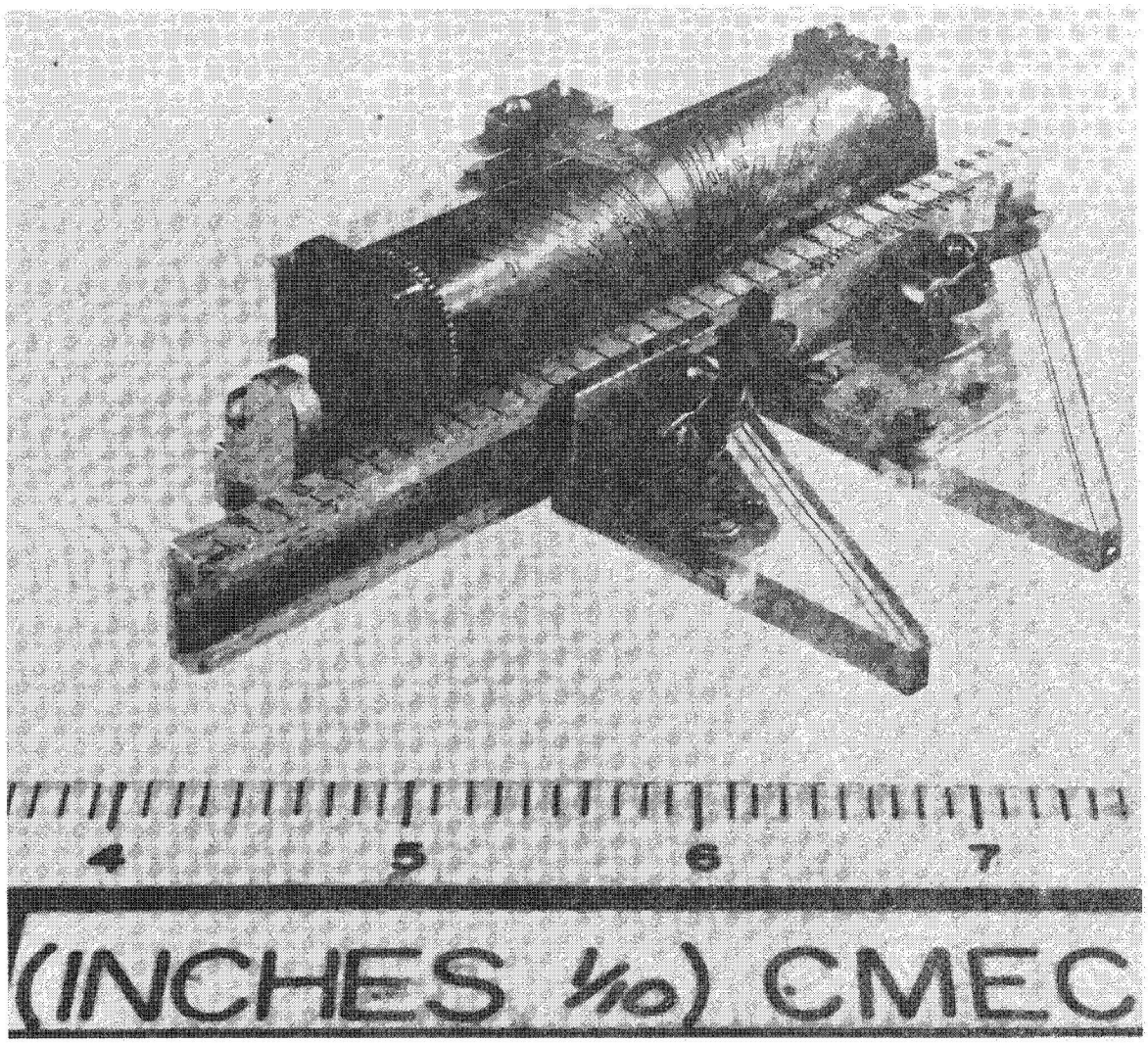

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Figure A-I-11. Correction mechanism on PRC type 59 fire direction set (U).

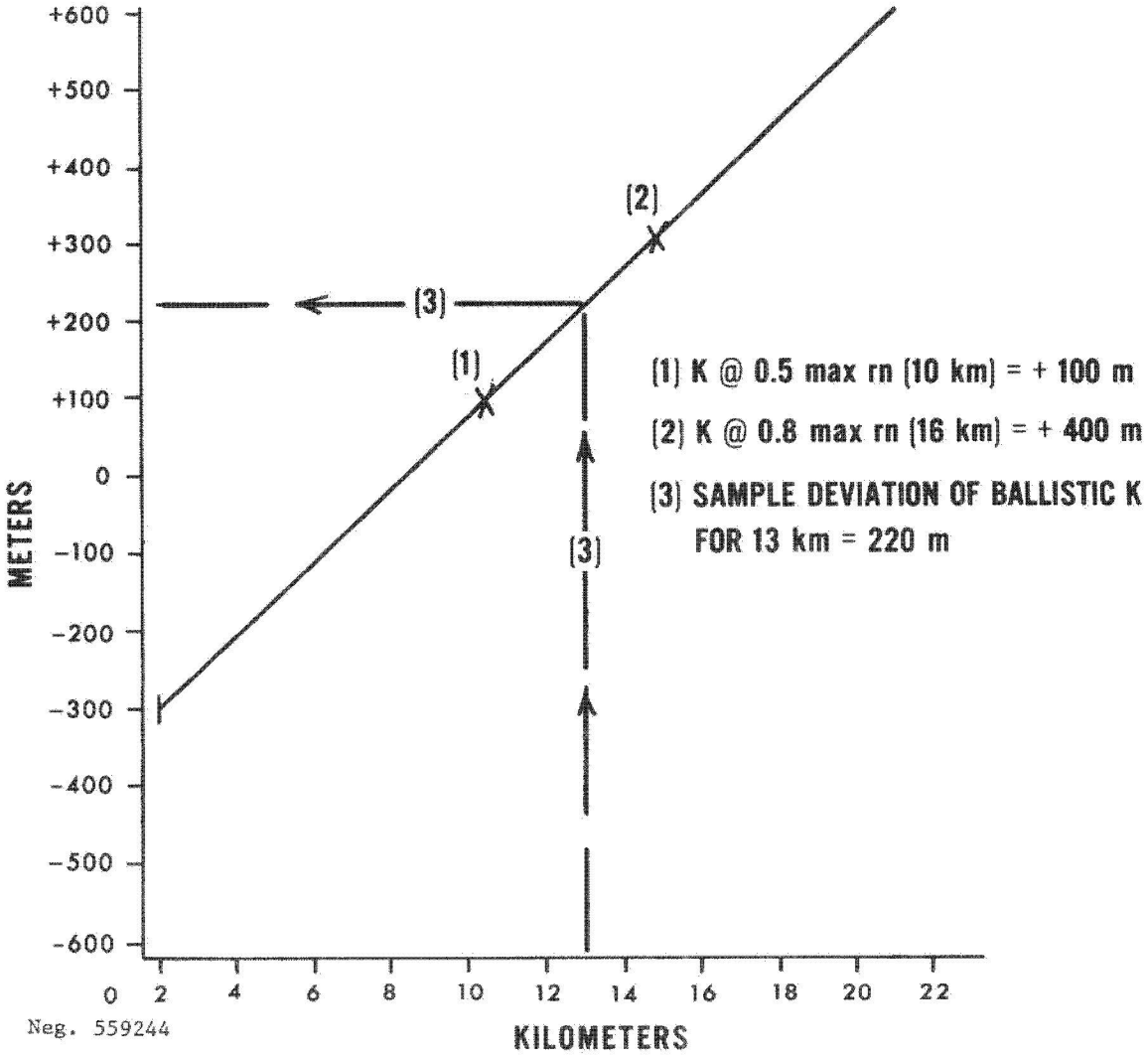

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Figure A-I-12. Sample of Soviet ballistic correction chart (U).

(3) ~~(C)~~ Soviet artillery corrector AP-7. No physical specimen or photographs of this item are available. The AP-7 is used to solve met effects data. During World War II, and possibly today, some US artillery battalions locally fabricated "paste-on scales" for various types of slide rules that permitted, to varying degrees of accuracy and timeliness, the solution of met messages. The AP-7 obviously is a much more sophisticated and efficient device than were the locally fabricated US "metro slide rules." The AP-7 (25 cm long x 12 cm high x 8 cm deep)

contains a "player piano-type" roll upon which graphical range table data that are pertinent to met effects for all charges (and ranges therein) are imprinted. This roll is positioned by a knob on the right end of the device. The top face of the device contains a window. A sliding cursor that is moved manually right and left across the window is mounted upon, and indexed to the midpoint of, a linear scale that is affixed to the base of the device. The left half of this scale represents minus, and the right half plus, values. A transparent horizontally inscribed reticle moves vertically between the "window" and the "range table data" that is visible through the "window." The AP-7 primarily is intended for the concurrent solution of met effects for nine (or more) locations; i.e., three ranges each along three different directions (nine or more data points involving three or more propelling charges).

(a) ~~(C)~~ Operation. Assume the objective is to solve for met effects at 8000, 11 000, and 14 000 meters using 2d charge, reduced charge, and full charge, respectively; each on azimuths 5500, 6000, and 500 M. The method of operation divides itself into three steps; this in part is due to the AP-7 not vectoring the wind into its range and cross wind components. First, the operator solves for the range effect (less range wind effects) for 8000 meters using 2d charge, 11 000 meters using reduced charge, and 14 000 meters using full charge. He accomplishes this by setting the proper section of the range table data within the window, aligning the cursor on the zero (midpoint of the linear scale), and successively aligning the cursor with the Δ powder temperature, the Δ air pressure, Δ ballistic air temperature, Δ projectile weight, and ΔV_o data as presented in the range table data that are visible through the window. The movements of the cursor produce an algebraic summing-up of the various effects that is read from the scale; e.g., -256 meters. The operator continues to solve for range (less range wind) effects at 11 000 and 14 000 meters. Second, while the AP-7 operator is solving for the range (less range wind) effects, a second person vectors the ballistic wind by using a range table and a wind components chart. Third, after having solved for range (less range wind) effects for all ranges, the AP-7 operator receives the ballistic wind component (e.g., 6 m/s) for azimuth 5500 M, sets in his previously determined range effect for 8000 meters, and by moving his cursor to 6 m/s, reads the total range effect on the "summing" scale. He then proceeds to obtain the lateral effects (cross-wind plus drift) in a similar fashion. By reversing their signs, these "effects" become "corrections" to firing data. He repeats this procedure until he has obtained the range and lateral effects for all nine locations. The AP-7 used with the SCUD system has provisions for obtaining Coriolis effects; presumably, the "window shade-type" graphical firing table rolls in the AP-7s used with the longer ranged cannon also incorporate this feature.

(b) (U) Recording. The corrections obtained for these nine locations are plotted onto a graph. The left vertical axis of the graph is Δ range in meters, the right vertical axis is Δ deflection in M, and the horizontal axis is range in kilometers. Six "curves" are produced from these plots: Three "range" curves, one each for 5500, 6000, and 500 M, and three corresponding "deflection"curves.

(c) ~~(C)~~ Comment. In this era of rapid maneuver, with concurrent frequent changes of firing position, dependence in large part upon the use of map + met + VE for the delivery of surprise fire and the effecting of transfers of fire over wide frontages, the procurement of a device similar to the Soviet AP-7 should receive serious consideration.

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APPENDIX II.

TERMINAL EFFECTIVENESS OF SOVIET FIELD ARTILLERY SYSTEMS

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1. (U) General

This appendix presents examples of overall system effectiveness as computed for selected Soviet field artillery systems delivering counter-battery fire. (b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e) Because of lack of applicable vulnerability data, effects attainable against ammunition in the firing position area (and the secondary effects attainable from its detonation) are not assessed. These assessments are based upon computer simulation models which take into consideration not only weapon, munition, and target characteristics but errors in the delivery of fire. Effects are presented in terms of expected fraction of casualties (F/C) for personnel and expected fractional damage (F/D) for materiel.

2. (U) Definition of Terms

a. Expected Fraction of Casualties (F/C). This value is a measure of weapons system effectiveness against personnel under specified weapons system, target, and engagement conditions. It is the average fraction of personnel in the target area incapacitated by an expenditure of n rounds. Personnel are assumed to be randomly located with a uniform distribution in the target area.

b. Expected Fractional Damage (F/D). This value is a measure of weapons system effectiveness against materiel under specified weapons system, target, and engagement conditions. It is the average fraction of materiel target elements in the target area damaged by an expenditure of n rounds. Target elements are assumed to be randomly located with a uniform distribution within the target area. Expected fractional damage may also be interpreted as the probability of damaging a single target element in the target area.

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EXEMPTION CATEGORY: 1,2
DECLASSIFY ON: UPON NOTIFICATION
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c. K-Transfer. This is a method of delivery of either unobserved or surprise fires upon the basis of transferring fire from a point of known topographical location, upon which fire has been adjusted, to a target within transfer limits of that location. Warsaw Pact transfer limits are 300 Soviet mils (M) (320 ‰) right and left and 2000 meters over and short (1000 meters when firing in the upper register) of the registration (base or check) point. For counterbattery fire, K-transfer, when feasible, is the method of engagement preferred by Soviet artillerymen. The advantage of this method is that occasion-to-occasion errors in lay, deviations from expected ballistic performance, and local variations in meteorological effects are reduced.

d. Lethal Area. This is a measure of the effectiveness of a munition under specified conditions of burst parameters and target environment. Lethal areas may apply to both personnel and materiel. Although this measure is expressed in units of area (ft^2 or m^2), it cannot be interpreted as a physical area, per se. It is defined as the integral over the plane of the target of the differential area weighted by the probability of incapacitation in that area; viz.,

$$A_L = \int_A P_k(a)da$$

Where: A_L = lethal area

$P_k(a)$=probability of incapacitation or kill in da

da = differential area

In practice, lethal area is calculated as a finite sum of small weighted areas; viz.,

$$A_L = \sum_A P_k(a)\Delta a$$

Where: Δa is a small area in the target plane

3. (U) Method of Computation

a. Computer Programs. The data contained herein were computed by means of standardized JTCG/ME (Joint Technical Coordination Group for Munitions Effectiveness) computer programs.

b. Damage Matrices. These matrices were computed from munition fragmentation data by use of the Lethal Area Programs. A damage matrix is a rectangular array of smaller rectangular cells, usually 40 cells wide by 40 cells deep. A probability of incapacitation or damage is

associated with each cell, the value of which is a function of munition fragmentation characteristics, burst height, angle of fall, terminal velocity, and target characteristics; thus, a damage matrix describes the terminal effects of a particular combination of munition, munition arrival parameters, and target conditions.

c. Expected Fraction of Casualties and Expected Fractional Damage. These data were computed by the Matrix Evaluator Program. Using the weapon damage matrix from the lethal area program and weapons system dispersion and accuracy characteristics, the Matrix Evaluator Program constructs a damage matrix for a weapons formation; e.g., a battery or a battalion. Then, taking into consideration target location and accuracy errors, it computes the effects of the formation damage matrix on the target for any number of rounds (salvos or volleys).

(1) Casualty criterion. The criterion used for personnel in these computations is the Assault-5-minute Casualty Criterion. Under this criterion, personnel will be incapacitated within 5 minutes from the time of burst of the munition.

(2) Damage criterion. This criterion for the M102 howitzer and the LANCE missile system is termed firepower kill. Under this criterion, an individual weapons system (i.e., gun) will not be able to deliver fire until the damage it has sustained has been repaired by Ordnance personnel, such repair usually necessitating evacuation of the weapon to a repair facility.

4. ~~(C)~~ Method of Engagement

a. Amount of Fire Delivered. The weapons system-target situations modeled in this appendix are based upon known Soviet combat doctrine, except that the number of rounds delivered has been rounded off to the nearest full battery salvo (6 rd).

b. Number of Batteries. Typically, enemy batteries are engaged by several Soviet batteries; the number of batteries is dependent upon the type of target, the threat posed by it, the range, the results desired, the time allocated to (or available for) the engagement, and the number of batteries within range of the target and currently available to engage it. The effects of two or more units firing simultaneously from different directions (enfilading the target) are greater than those of a single unit firing the same total number of rounds.

c. Zoning and Sheaf Interval. Soviet artillery commonly zones the depth of the target when attacking unobserved or observed targets having an estimated depth greater than about 4 PE_r. Each battery fires, alternately at each of the three elevation settings; that is, upon the target center and at a range spread of either 2 or 4 PE_r over and short of the target center, depending upon the apparent depth of the target or the assumed accuracy of its location. The three batteries in a Soviet battalion zone the target so that at any given time each of the three elevation (range) settings is being fired upon by one battery. Because of the differential errors in lay in both direction (deflection) and elevation (range), plus variations in muzzle velocity, as well as the different directions of fire among the participating batteries, zoning (i.e., each battery firing at all three elevation settings) tends to produce a more uniform distribution of bursts over the target area and to disperse the fall of shot about the assumed target center in such manner as to provide a higher probability that the target is effectively engaged (that the subelements therein are struck). In addition to zoning the target in range, the sheaf interval (lateral spacing between bursts) also is increased (nominally by 2 M) when a target is not located precisely and/or presents an observed frontage in excess of about 120 meters. A target that is being attacked by only one battery (which is seldom) may present a frontage in excess of about 200 meters (dependent upon the accuracy of target location and the effective radius of burst). In such cases, the target frontage is divided by a factor of two or three and the target is engaged at two or more deflection settings using parallel sheaf. When only one or two guns in an enemy battery are observed and located it may be that these weapons are guns number 1 and 2 or 5 and 6 rather than 3 or 4 (the center pieces). When only one or two guns are located, the Soviets employ a technique that accounts for this possibility. When firing with a battalion the 1st battery (US=btry A) fires one-third sheaf width to the right and the 3d battery (US=btry C) one-third sheaf width to the left of the apparent target center; against a light battery (105 mm) this shift will approximate 35 meters and against a medium (155 mm), 50 meters. When but two batteries are employed, the same technique is used; e.g., 1st and 3d = one-third right and left of apparent target center, 1st and 2d = one-third right of target center and target center, etc. This shift in deflection on the part of one or two batteries is in addition to the usual 2 M opening of the sheaf and the 2 to 4 PE_r zoning of the target.

d. Ammunition Expenditure. The average number of rounds required to neutralize, destroy, or, in some cases, to suppress a target is prescribed by Soviet firing doctrine; these data are set forth in annotated tabular form in their manuals. Ammunition expenditure is dependent upon the type of system to be engaged (launcher or cannon, towed or SP, armored or unarmored); the threat posed (nuclear or nonnuclear capable); target posture (in the open or dug-in; close, open, or extended formation);

the gunnery technique employed (adjustment on the target), unobserved shift (K-transfer, or map + met + deviation in muzzle velocity, or methods of lesser accuracy), and unobserved shift plus subsequent observation and adjustment of the centers of impact of each battery; the type and caliber of weapon and the action of the munition used (impact, ricochet, or air burst); the result desired [destruction, neutralization, suppression (interdiction)]; probable accuracy of target location; the range to be fired; and factors of lesser import.

e. Delivery Techniques. Soviet field artillery delivers counterbattery fire using an admixture of methods of fire. When a nuclear capable launcher (such as LANCE) is to be engaged, the prescribed number of rounds are delivered in the shortest possible time; continuous volley (running) fire is employed. This same technique is used by MRL units delivering counterbattery fire. It also is used by cannon units firing upon nuclear capable cannon artillery, and it may be used when engaging self-propelled artillery, per se. Usually, however, in firing for either neutralization or destruction of cannon batteries, a technique known as "tempo of firing" is utilized to keep the enemy battery suppressed for a longer period (for an average of about 20 minutes). Depending upon the number of rounds to be delivered and the time during which the enemy battery is to be suppressed, battery volleys (continuous fire) are followed by periods of salvo fire having varying time intervals between rounds in successive salvos or series of salvos, by single rounds, and by periods during which firing is suspended. The object of this time-phased fire not only is to suppress and confuse personnel in the target area but to encourage them to change posture; e.g., to prepare to displace or to return to a normal operational state, this under the mistaken assumption the firing has ended or has abated to such an extent the element of risk becomes acceptable. Under this circumstance, a typical counterbattery mission against a nonnuclear capable battery may last from 15 to 25 minutes. For example, a counterbattery mission being fired by two Soviet battalions against a towed battery could consist of the following time-phased fires:

(1) Initial fire assault. Each of the six batteries initially fires one or more volleys at each of the three range settings (a total of 18 to 36 battery volleys) as rapidly as possible.

(2) Deliberate (salvo) fire. All or some of the batteries fire one or more salvos at each range setting. The density of fire varies greatly with time, both by changing the interval between rounds in succeeding zonings and the number of batteries firing. During this phase of the engagement, if effect is being observed, the center of impact of one or more batteries in each battalion is reported and the firing data (for those batteries) is corrected without suspending fire.

(3) Second fire assault. Repeat fire as described in (1) above but with a lesser number of volleys.

(4) Second salvo fire. Repeat fire as described in (2) above, usually with widely differing tempos (rates).

(5) Final (covering) fire assault. Repeat fire as described in (1) above. If fewer rounds are prescribed than would be fired in the foregoing arrangements, the second salvo fire could be reduced to one or two batteries firing interdictory fires and, if expenditure still is excessive, the second fire assault could be eliminated. From 10% to 20% of total expenditure may be allocated for suppression fires that are delivered whenever fire is suspended for more than 10 to 15 minutes during the course of the engagement and from 10% to 20% may be expended in those salvos that are observed to obtain refinement of the firing data of individual batteries. It should be noted that such effects as are attainable from the "tempo of firing" technique, the increase in accuracy obtainable from the observation of individual battery salvos and subsequent correction of their firing data, and the effects attainable from the destruction of ammunition and the secondary effects obtained from its detonation have not been assessed in the following examples. Certainly, some damage in addition to that indicated in the following examples is to be expected.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

A-II-7 thru A-II-9 are denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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APPENDIX III.

HIT PROBABILITIES AS CALCULATED FOR CERTAIN SOVIET AND CZECHOSLOVAK CANNON IN DIRECT FIRE

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1. ~~(C)~~ Calculated First-Round Hit Probabilities

Estimates of first-round hit probabilities have been calculated for the following ECC artillery pieces when engaged in the direct fire role:

- Soviet 85-mm field (antitank) gun SD-44.
- Soviet 100-mm antitank gun T-12/T-12A.
- Czechoslovak 100-mm field gun M-53.
- Soviet 122-mm field gun D-74.
- Soviet 122-mm howitzer D-30.
- Soviet 130-mm field gun M-46.

2. ~~(C)~~ Methodology

a. Targets. Accuracy of Soviet artillery in direct fire is conveniently measured by first-round hit probability against the standard NATO target (2.3x2.3 meters) or against the frontal silhouette of the US M60A1 tank.

b. Procedure. The methodology employed by FSTC for calculating first-round hit probabilities parallels that used by the US Army Materiel Systems Analysis Agency (AMSAA) in estimating the accuracy of tank firings. This involves the combination of a set of standard quasi-combat error sources with the individual characteristics of the gun and ammunition to obtain realistic dispersion data at the target location. Table A-III-1 presents a list of the error sources, considered together with assumed nominal values, for the Soviet smoothbore 100-mm T-12/T-12A antitank gun.

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Table A-III-1. Nominal Values of Error Sources, 100-mm T-12/T-12A Guns (U)

Error source	Nominal value	Vertical errors (≠)						Horizontal errors (≠)					
		APDS-FS			HEAT			APDS-FS			HEAT		
		Range (m)			Range (m)			Range (m)			Range (m)		
		1000	2000	3000	1000	2000	3000	1000	2000	3000	1000	2000	3000
Muzzle velocity	0.50%	0.022	0.046	0.072	0.068	0.153	0.261	--	--	--	--	--	--
Range error	10%	0.238	0.486	0.779	0.773	1.951	3.763	--	--	--	--	--	--
Jump	0.3 ≠	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Range wind	3.35 m/s	0.010	0.021	0.032	0.051	0.114	0.195	--	--	--	--	--	--
Cross wind	3.35 m/s	--	--	--	--	--	--	0.052	0.106	0.161	0.329	0.699	1.114
Air temperature	1.52%	0.001	0.004	0.010	0.012	0.058	0.157	--	--	--	--	--	--
Air density	1.65%	0.001	0.005	0.011	0.013	0.063	0.170	--	--	--	--	--	--
Cant	1°	--	--	--	--	--	--	0.038	0.083	0.129	0.118	0.270	0.461
Fire control	variable	0.143	0.149	0.159	0.158	0.226	0.377	0.150	0.150	0.150	0.150	0.150	0.150
Optical path	0.03 ≠	0.030	0.030	0.030	0.030	0.030	0.030	--	--	--	--	--	--
Zeroing (1200 m)													
muzzle velocity	0.50%	0.027	0.027	0.027	0.027	0.027	0.027	--	--	--	--	--	--
range error	1.5%	0.042	0.042	0.042	0.042	0.042	0.042	--	--	--	--	--	--
jump	0.3 ≠	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
range wind	3.35 m/s	0.012	0.012	0.012	0.012	0.012	0.012	--	--	--	--	--	--
cross wind	3.35 m/s	--	--	--	--	--	--	0.062	0.062	0.062	0.062	0.062	0.062
air temperature	0.95%	0.001	0.001	0.001	0.001	0.001	0.001	--	--	--	--	--	--
air density	0.96%	0.001	0.001	0.001	0.001	0.001	0.001	--	--	--	--	--	--
cant	1°	--	--	--	--	--	--	0.048	0.048	0.048	0.048	0.048	0.048
fire control	0.032 ≠	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
optical path	0.03 ≠	0.030	0.030	0.030	0.030	0.030	0.030	--	--	--	--	--	--
center impact	0.13 ≠	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
observed center	0.10 ≠	0.100	0.100	0.100	0.100	0.100	0.100	0.070	0.070	0.070	0.070	0.070	0.070
Round-to-round	variable	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Lay	variable	0.387	0.219	0.163	0.387	0.219	0.163	0.305	0.178	0.135	0.305	0.178	0.135

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c. Assumptions. Ranging has been assumed to be by eye in familiar terrain in which distances to local objects have previously been determined. The 10% range error used in the present work is based on a Soviet training document. In addition to the errors shown, both a fixed parallax error associated with the offset of the gunsight and a fixed deflection error associated with projectile drift have been used in the hit probability calculations. It should be noted, however, that many, if not all, Soviet antitank gun units apply corrections for parallax and drift as well as for surface meteorological conditions; hit probabilities in the presence of these corrections will be higher than those presented herein.

d. Ammunition. Shown in table A-III-2 are the diameter (D), mass (M), muzzle velocity (V_o), and the vertical and horizontal round-to-round dispersions (T_V and T_H) of the armor defeating ammunition used in the artillery pieces under consideration. The dispersion data are standard deviation values at a range of 1000 meters.

Table A-III-2. Antitank Ammunition (U)

Gun	Round	D (mm)	M (kg)	V_o (m/s)	T_V (mil)	T_H (mil)
SD-44 (85-mm gun)	AP-T	85	4.9	1050	0.60	0.70
T-12/T-12A* (100-mm gun)	APDS	42	3.8	1500	0.30	0.30
M-53 (100-mm gun)	AP-T	100	14.7	955	0.30	0.30
D-74 (122-mm gun)	AP-T	122	25.1	855	0.30	0.30
D-30 (122-mm how)	HEAT	122	21.6	680	0.60	0.60
M-46 (130-mm gun)	AP-T	130	33.5	930	0.30	0.30

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*Data estimated.

3. (~~C~~) Results

a. Effective Ranges. Horizontal distances at which the probability of a first round hit equals 0.50 (effective ranges) calculated for the several ECC artillery pieces considered are presented in table A-III-3.

Table A-III-3. Effective Ranges in Direct Fire (U)

Gun	Round	Effective range (m)	
		M60A1 tank	NATO target
SD-44 (85-mm gun)	AP-T	1125	914
T-12/T-12A (100-mm gun)	APDS	2000	1625
M-53 (100-mm gun)	AP-T	1450	1250
D-74 (122-mm gun)	AP-T	1325	1150
D-30 (122-mm how)	HEAT	950	775
M-46 (130-mm gun)	AP-T	1450	1250

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b. Hit Probability Versus Range. First-round hit probabilities as a function of range for the M60A1 tank and the NATO target are presented in figures A-III-1 and A-III-2, respectively. For any of the cannon considered, the hit probabilities associated with the tank target are seen to be significantly greater than those associated with the NATO target. This situation is directly attributable to the difference in the presented area of the two targets, the frontal silhouette of the M60A1 tank having an area approximately 50% greater than that of the standard NATO target.

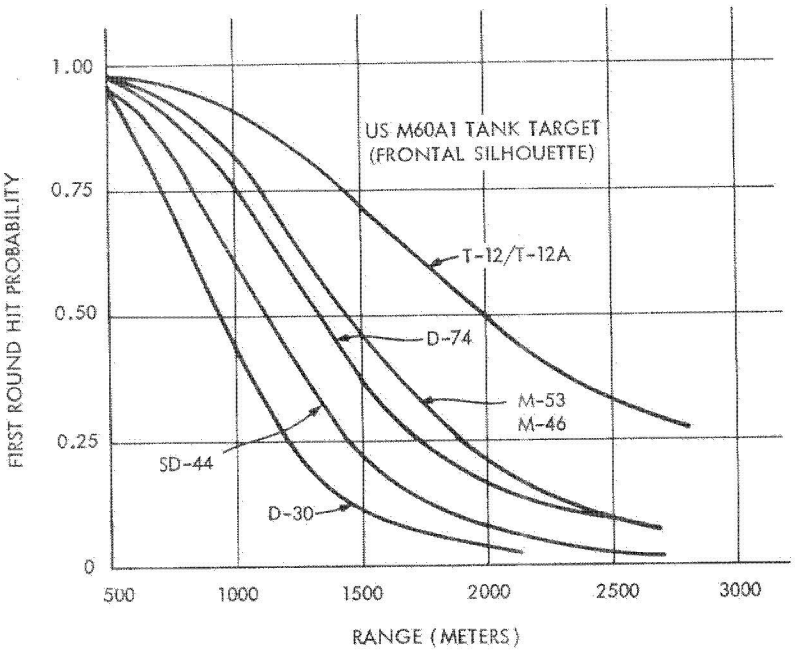

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Figure A-III-1. Probabilities of a first-round hit, various ECC field artillery weapons vs. the US M60A1 tank (U).

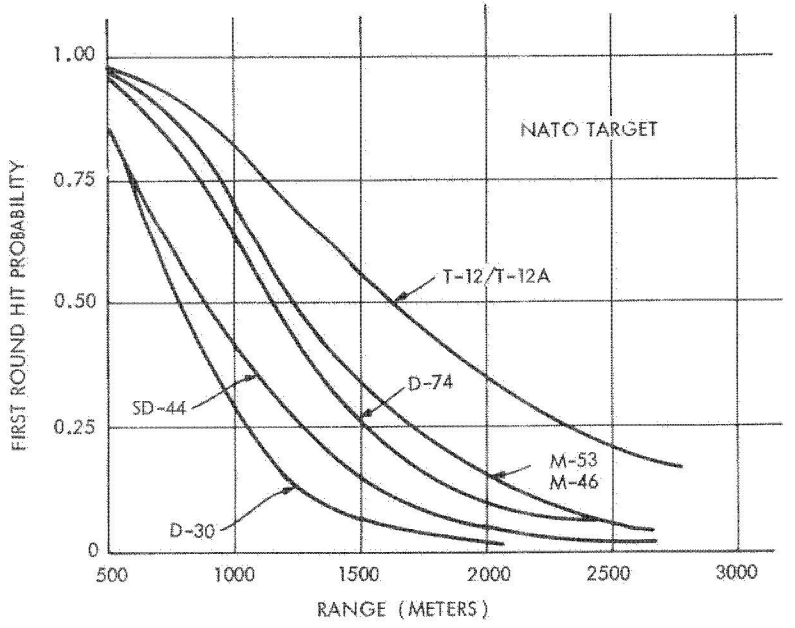

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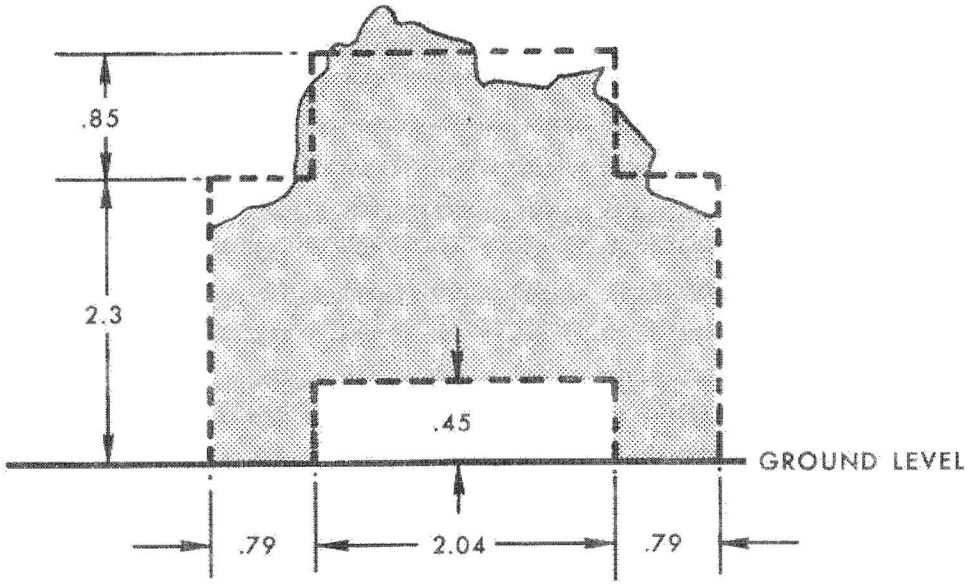
Figure A-III-2. Probabilities of a first-round hit, various ECC field artillery weapons vs. the standard NATO target (U).

c. Improvement in Capability. A trend analysis of various Soviet 100-mm antitank guns indicates, should the Soviets deploy a new 100-mm gun in the 1975-1980 time frame, that weapon probably will have an effective range of about 2000 meters vs. the standard 2.3x2.3-meters NATO target.

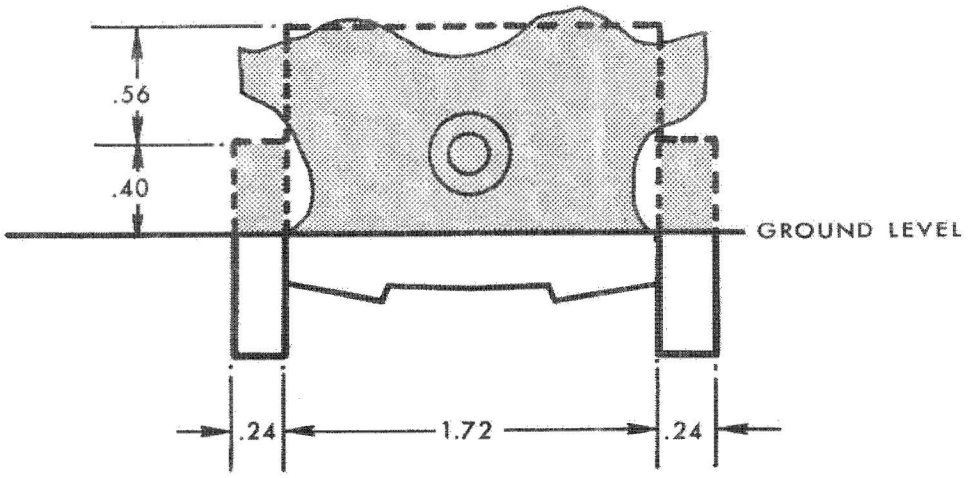
4. ~~(C)~~ Soviet 100-mm T-12A Antitank Gun Versus the US M60A1 Tank

a. The T-12 and T-12A Antitank Guns. The Soviet 100-mm T-12A antitank gun represents the greatest presently known antitank artillery threat to free world forces. This weapon is a high performance smoothbore gun that was first observed in 1972. The T-12A is known to fire both kinetic energy [armor piercing discarding sabot (APDS)] and chemical energy [high explosive antitank (HEAT)] rounds. Data shown in table A-III-2 are based on estimates of ammunition for the earlier T-12. There is a possibility these data may be conservative for the newer T-12A. More likely, the ballistic performance of these smoothbore antitank guns essentially is the same but that the T-12A exhibits considerably greater stability, less jump and muzzle whip, and a higher practical rate of effectively aimed fire. Such parameters should have little, if any, effect upon first-round hit probability, although these parameters, from a practical standpoint, will affect the accuracy of the second and subsequent rounds and shorten the time required for the engagement.

b. Methodology. The methodology employed in making these estimates parallels that used by AMSAA as indicated in paragraph 2b. Calculations for the T-12A are for its APDS and its HEAT projectiles at the M60A1 tank. Calculations for the M60A1 are for that tank firing its 730-m/s HE projectile at the dug-in T-12A guns, as prescribed by US armor doctrine. In making these calculations, we have assumed the M60A1 tank to be in a mobile, fully exposed posture and the T-12A antitank gun to be emplaced in a gun pit; i.e., both weapons are frontally presented to each other in the "engagement." The actual (solid lines) and assumed (broken lines) target silhouettes used in these calculations are graphically portrayed in figure A-III-3.



M60A1 SILHOUETTE



ALL MEASUREMENTS IN METERS

T-12A SILHOUETTE

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Figure A-III-3. Frontal silhouettes, US M60A1 tank and Soviet T-12A antitank gun (U).

c. Hit Probabilities. Effective ranges R_E (i.e., ranges at which the probability of a first-round hit is 0.5) are presented in table A-III-4.

Table A-III-4. Effective Ranges; Soviet T-12A Antitank Gun and US M60A1 Tank (U)

Weapon	Ammunition	R_E (m)
T-12A	APDS	2000
T-12A	HEAT	1300
M60A1	HE	600

~~(CONFIDENTIAL)~~

Calculated first-round hit probabilities, plotted as a function of range, are shown in figure A-III-4.

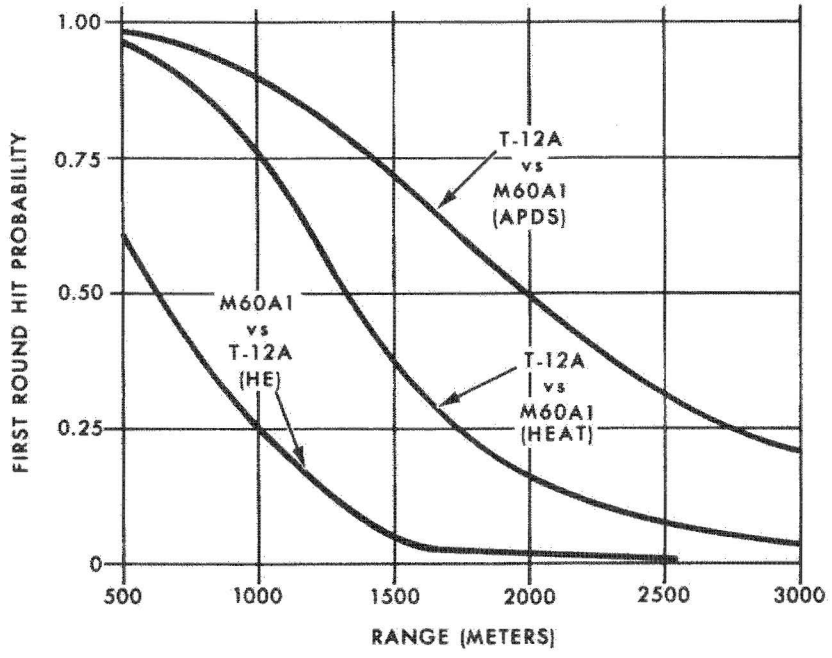

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Figure A-III-4. Comparative probabilities of a first-round hit, T-12A gun and US M60A1 tank; direct frontal engagement (U).

d. Analysis. Graphical data shown in figure A-III-4 reveal that the effective range of the T-12A when firing APDS ammunition against the M60A1 is more than three times greater than the M60A1 when firing HE ammunition at the dug-in T-12A. This result is due primarily to the higher muzzle velocity of the T-12A's APDS ammunition and to the smaller target silhouette presented by the T-12A. When firing its HEAT projectile, the T-12A's effective range vs. the M60A1 is more than two times greater than the M60A1 versus the T-12A. Also, in an actual combat situation, the differences in hit probabilities may be even greater than indicated when Soviet antitank units employ corrections for parallax, drift, powder temperature, density, and surface winds.

e. Armor Penetration. On the basis of comparison with test data on the Soviet 115-mm APDS-FS BM-6 projectile, fired from the T-62 tank, armor penetration for the T-12/T-12A APDS projectile were estimated. These data are presented in table A-III-5. Also included are current armor penetration values for the HEAT projectile.

Table A-III-5. Estimated Penetration of T-12A Ammunition (C)

Ammunition	Range (m)	Striking velocity (m/s)	Maximum armor penetration	
			0° obliquity	60° obliquity
APDS	1000	1357	225 mm (8.9 in)	112 mm (4.4 in)
	2000	1234	200 mm (7.9 in)	100 mm (3.9 in)
	3000	1122	170 mm (6.7 in)	85 mm (3.3 in)
HEAT	NA	NA	400 mm (16 in)	200 mm (7.9 in)

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The T-12A APDS ammunition can defeat the M60A1 tank at an estimated range of 1900 meters (0.5 probability of penetration). Owing to the uncertainty of both the BM-6 data and the design of the T-12A ammunition, these values of penetration have an estimated 90% confidence level of ±10%.

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APPENDIX IV.

SELECTED SOVIET FIELD ARTILLERY SELF-PROPELLED SUPPORT SYSTEMS

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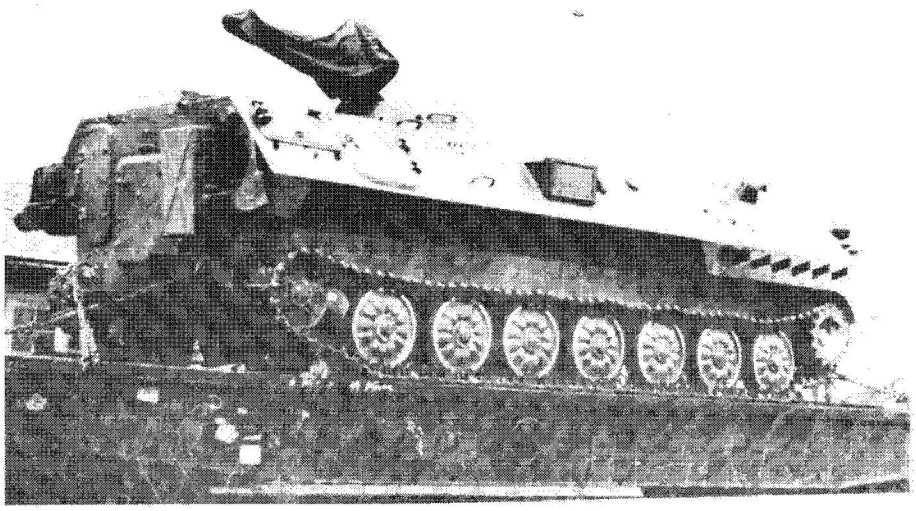
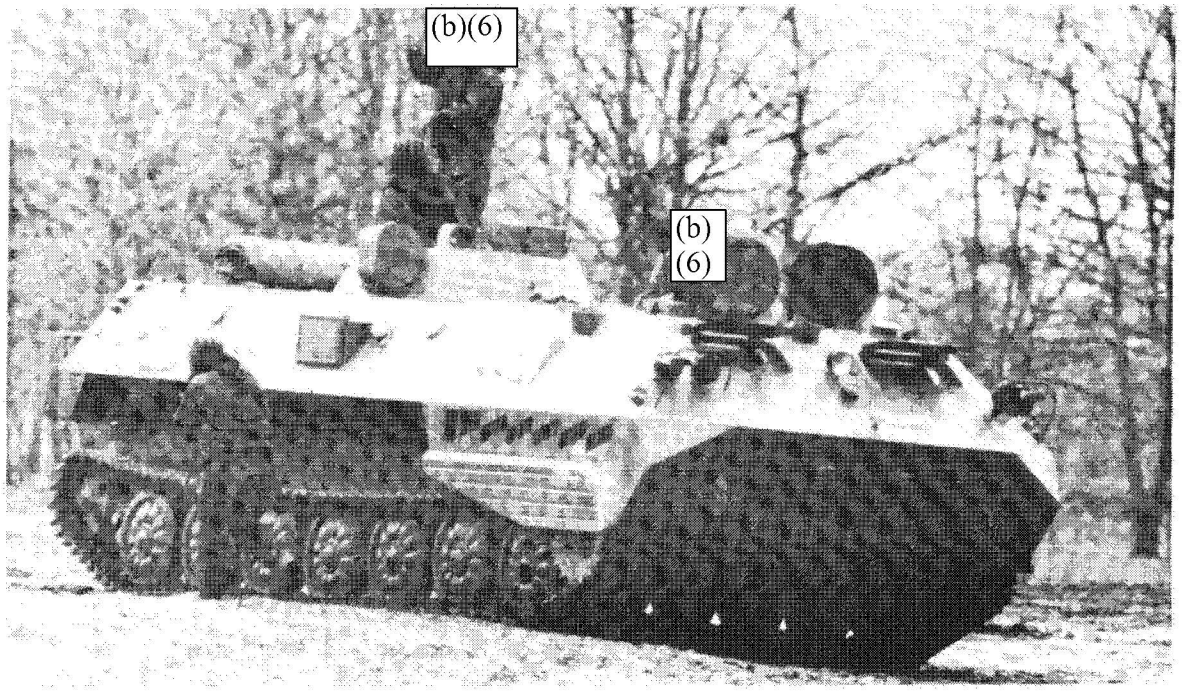
1. ~~(C)~~ Soviet Field Artillery Associated Armored Command and Reconnaissance Vehicles (M1974-Type ACRVs)

a. Present Status. Currently, there are three known variants of the artillery associated ACRV. These have been designated the ACRV M1974(1) through (3), respectively. Figures A-IV-1 through -4 show these variants and, for comparison, the 122-mm self-propelled gun M1974. The M1974(1) is postulated to be a fire direction center and command vehicle for those firing batteries that are equipped with either the 122-mm M1974 self-propelled gun or the 152-mm M1973 self-propelled gun. The M1974(2) provides battery and battalion commanders with a COP vehicle that facilitates the sustained support of mobile operations. The M1974(3) is utilized by the battalion chief of staff (US=bn XO) of self-propelled field artillery battalions. The M1974(3) probably incorporates a fire direction computer. One M1974(2) and one M1974(3) have been observed with each self-propelled gun battalion headquarters, an M1974(2) for the battalion commander, and an M1974(3) for the battalion chief of staff. Each self-propelled battery has two ACRVs; an M1974(1) for the gun position officer (US=btry XO) and an M1974(2) for the battery commander.



Neg. 554765 ~~(CONFIDENTIAL)~~

Figure A-IV-1. ACRV M1974-(1) (U).



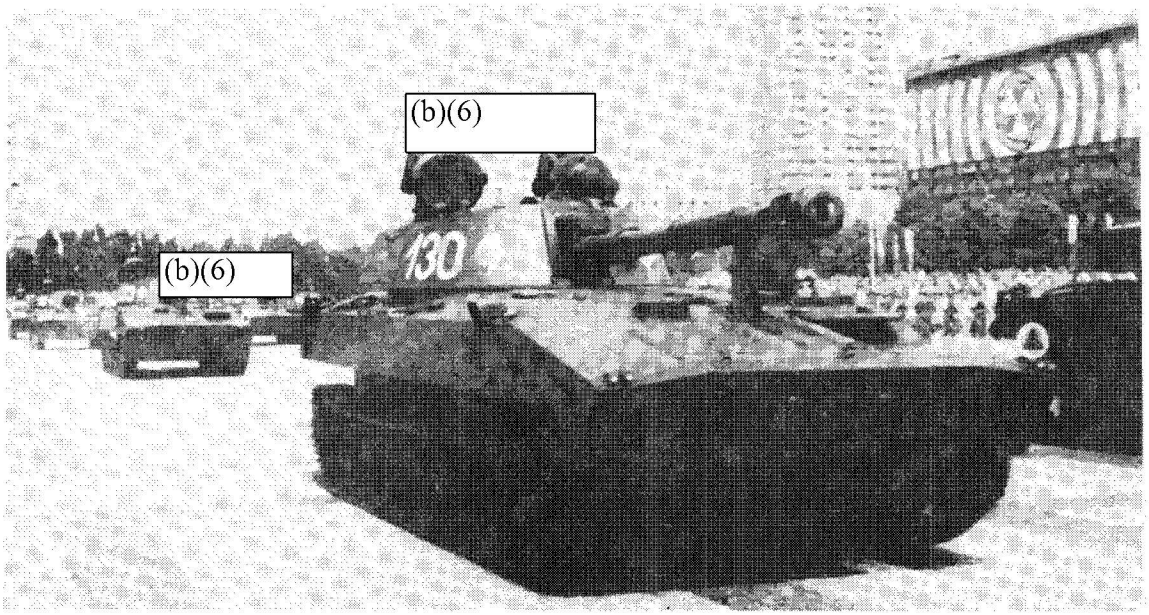
Neg. 553720 ~~(CONFIDENTIAL)~~

Figure A-IV-2. ACRV M1974-(2) (U).

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555526 ~~(CONFIDENTIAL)~~

Figure A-IV-3. ACRV M1974-(3) (U).

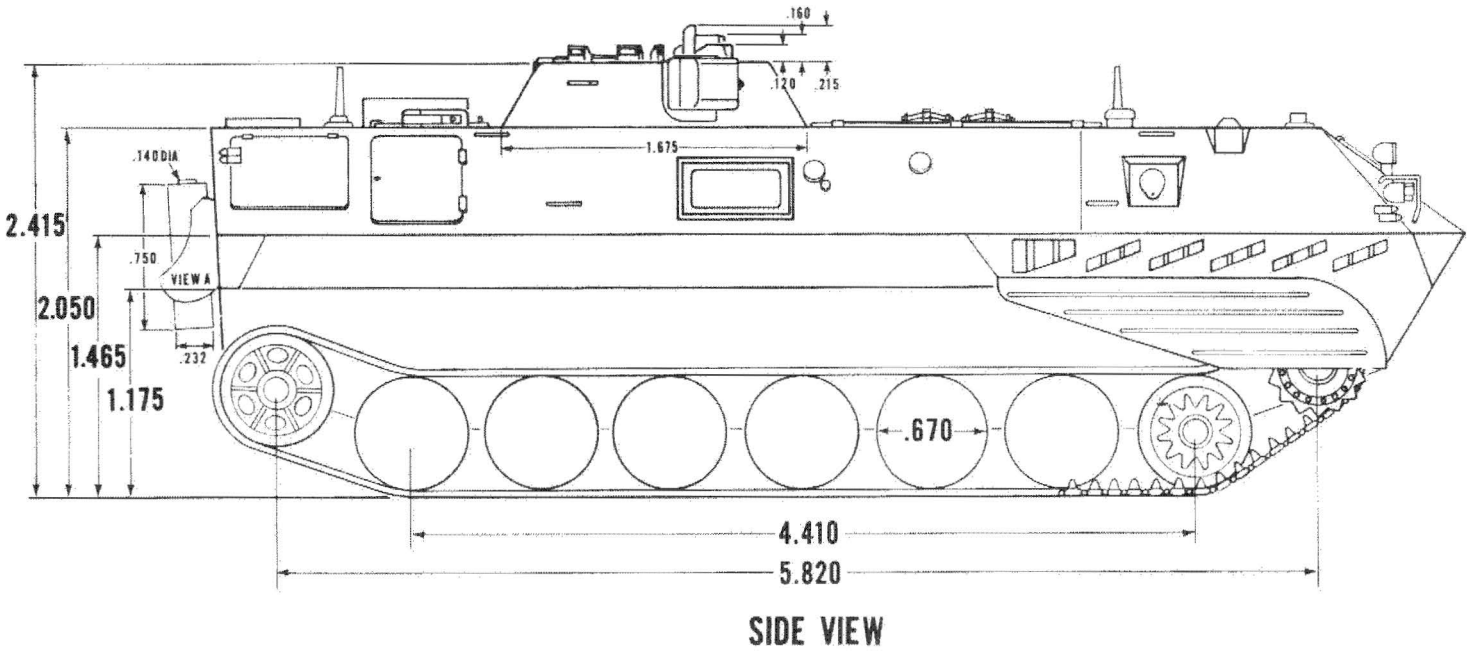


Neg. 552101 ~~(CONFIDENTIAL)~~

Figure A-IV-4. 122-mm self-propelled gun M1974 (U).

b. Commonality of ACRVs. The same basic chassis, suspension, engine, and transmission used for all three ACRV variants are believed to be used with the 122-mm self-propelled gun M1974. (See para II-I-18 for a complete discussion of the chassis, engine, and transmission used with the 122-mm self-propelled gun M1974).

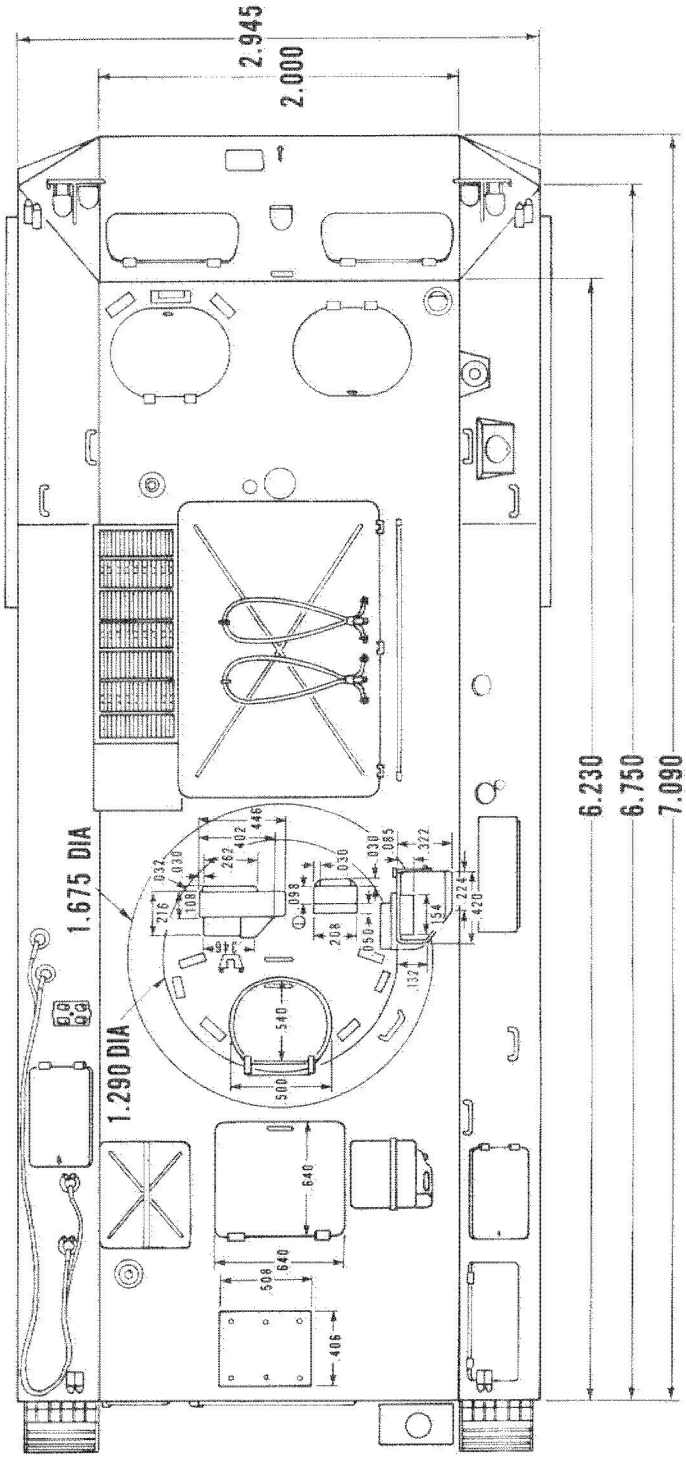
(1) General description. The ACRV M1974 is an amphibious, lightly armored, tracked vehicle that exhibits a generally rectangular configuration, with chamfered upper sides and front. A one-man truncated conical turret is located immediately in rear of the lateral centerline of the vehicle. The engine compartment is located directly in front of the turret. The rear hull plate of the vehicle is perpendicular. The transmission and drive sprockets are located at the front. The remaining running gear consists of a rear-mounted idler, seven torsion-bar-sprung roadwheels, and a single-pin bushed steel track. Figures A-IV-5 through -7 provide general mensuration. (See Vol 2, sec II, I, 122-mm Self-propelled Gun M1974, for a detailed discussion of the engine and transmission.)



Neg. 555513

(~~CONFIDENTIAL~~)

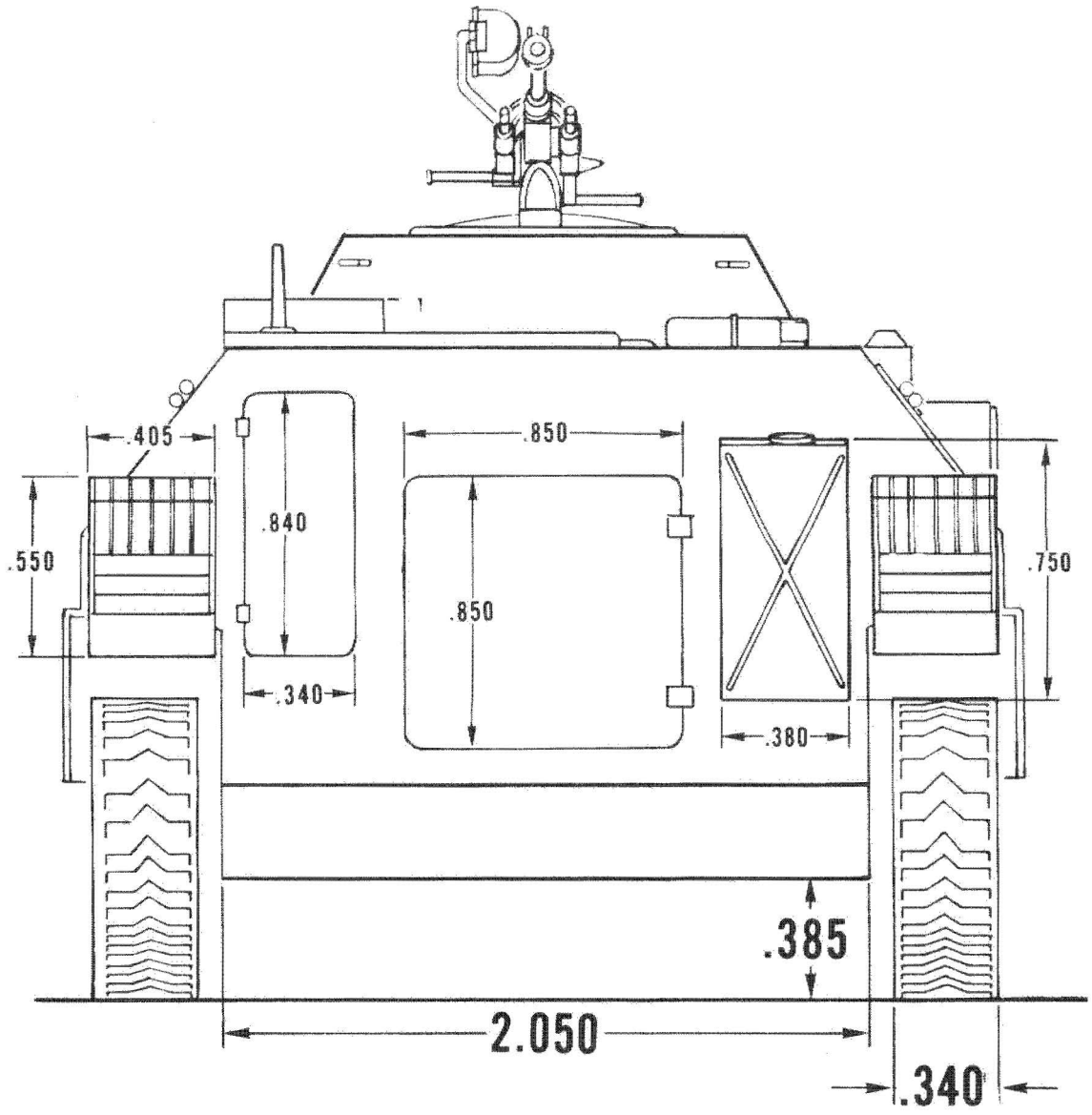
Figure A-IV-5. Mensuration ACRV M1974-(2), right side view (U).



((~~CONFIDENTIAL~~))

Figure A-IV-6. Mensuration ACRV M1974-(2), top view (U).

Neg. 555514



REAR VIEW

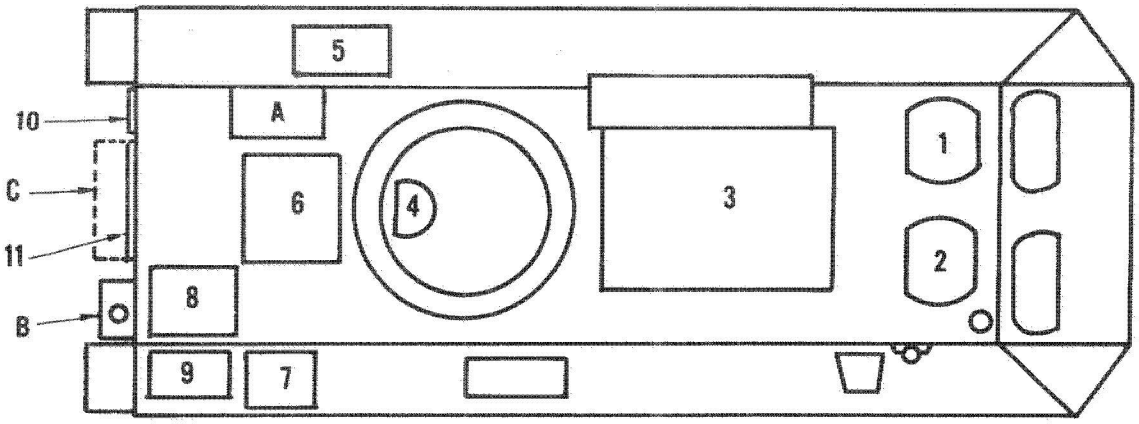
Neg. 555515 ~~(CONFIDENTIAL)~~

Figure A-IV-7. Mensuration ACRV M1974-(1), rear view (U).

(2) Hull.

(a) The lower halves of the hull sides are perpendicular to the ground until they clear the top of the tracks. They then angle upward and outward above the tracks to form sponsons. The upper halves of the hull sides then bevel inward at ≈ 37° until they reach the hull roof (fig A-IV-1).

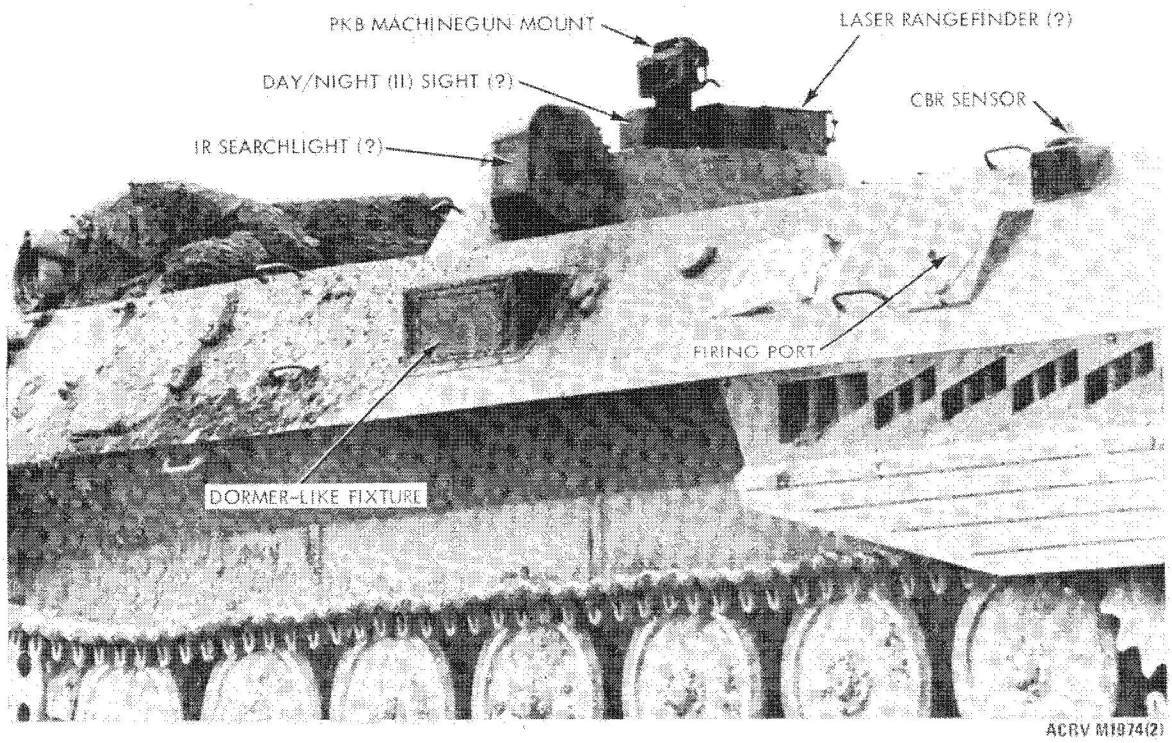
(b) The front of the hull has an asymmetrical blunt wedge-shaped appearance with the lower and upper glacis slanted at different angles (fig A-IV-2). A top-hinged wave-deflector plate is attached to the lower glacis. The upper glacis plate slopes rearward at an angle of approximately 54° and the lower glacis plate at an angle of approximately 30°. Paired IR driving lights and associated paired blackout lights are vertically centered on the outer edges of the glacis. A single headlight-type fixture is centered on the upper glacis between, and at the level of, the lower edges of two viewing windows (fig A-IV-2). These two windows [driver's on the left and commander's (?) on the right] are provided with top-hinged armored covers. The rear-hinged driver's hatch (hatch No. 1 in fig A-IV-8) is located in the forward left side of the hull roof. Three vision blocks are positioned at the forward edge of the driver's hatch. The right-hand front-hinged hatch (hatch No. 2) has several fixtures associated with it, including possible vision devices. The circular hooded fixture that is located on the forward right corner of the roof is a periscope having a rotatable head.



Neg. 524399 (UNCLASSIFIED)

Figure A-IV-8. ACRV M1974, top view identification of hatches and boxes (U).

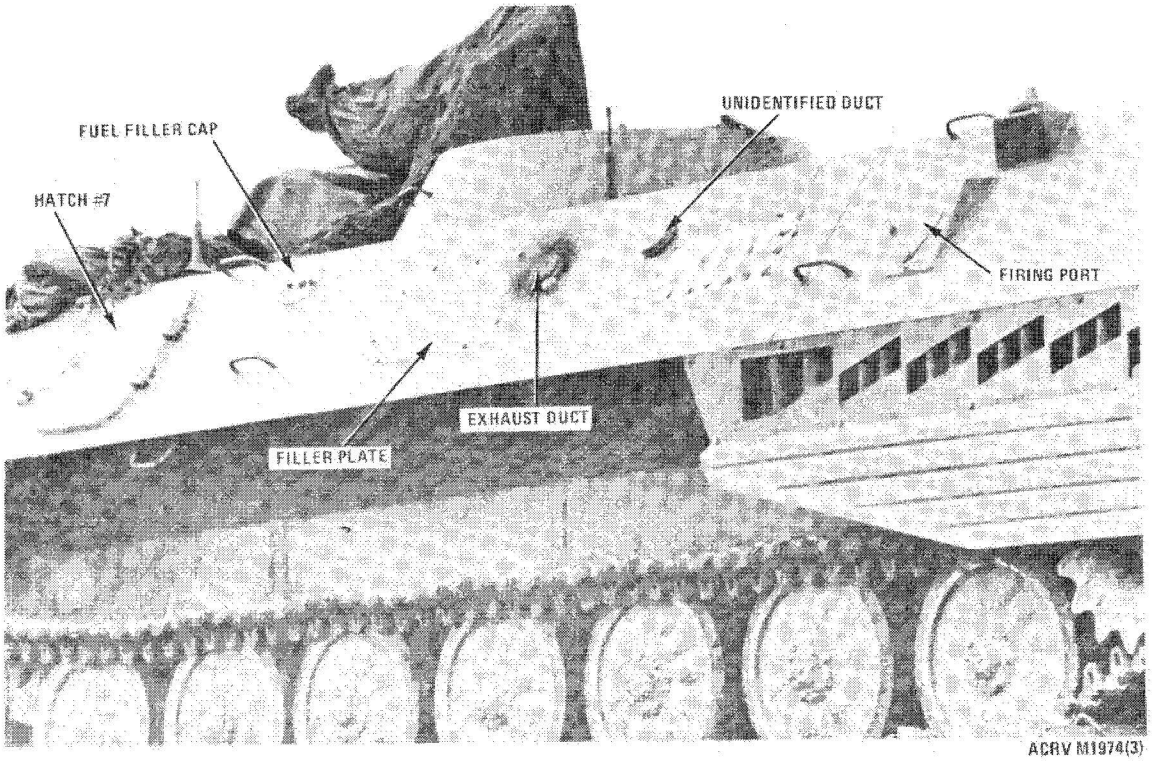
(c) A small box-like weapon firing port with a pear-shaped armored cover is positioned on the upper right hull side between the first and second roadwheels (fig A-IV-9). A CBR sensor is positioned above and forward of this firing port.



Neg. 555362 ~~(CONFIDENTIAL)~~

Figure A-IV-9. ACRV M1974-(2), right side view (U).

(d) On the right upper hull side, just forward of the turret are two small dome-shaped ducts. The rearward duct (located even with the rear of the engine compartment hatch) appears to be an exhaust, possibly for expelling the dust separated by the first stage of the engine air cleaner (fig A-IV-10). The forwardmost duct (located centrally with respect to the engine compartment) probably is an air intake of unknown purpose.



Neg. 555357 ~~(CONFIDENTIAL)~~

Figure A-IV-10. ACRV M1974-(3), right side view (U).

(e) The rectangular engine compartment hatch (hatch No. 3, fig A-IV-8) is constructed of a "X"-stamped, rigidized metal, with rounded corners, and is hinged on the right side (fig A-IV-11). Two short cable loops, used to attach the self-recovery log to the tracks, are affixed to the right edge of hatch No. 3. A circular, flap-covered exhaust stack is centered on the roof immediately forward of the engine compartment hatch. Recently, this duct has been modified by the attachment of a rectangular duct that angles from the exhaust stack horizontally across the roof, terminating at the right edge of the vehicle (fig A-IV-12). The duct is presumed to have been installed to redirect the exhaust smoke and heat, thereby reducing obscuration of the ACRV's turret mounted optics. A radiator air intake grill is located on the left side of the roof adjacent to the engine compartment cover (fig A-IV-13).

A-IV-10 is denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555361 ~~(CONFIDENTIAL)~~

Figure A-IV-13. ACRV M1974-(3), left side overhead view (U).

(f) From the trailing edge of the engine compartment rearward, the following items, except as noted, are common to all three ACRV variants.

1. Centered on the upper right hull side is a box-like fixture that resembles a shed-type dormer window (fig A-IV-9). This fixture is absent on the M1974(3) variant, having been replaced by a flat plate bolted flush with the hull (fig A-IV-10). This fixture houses high-frequency equipment of unknown purpose; this equipment allegedly is designated "system of high frequency PB2.248.010." A series of bolts encircling the perpendicular face of this fixture may indicate the presence of a removable plate allowing access to the equipment inside.

2. Side-hinged, rectangular access hatches (hatches No. 5 and No. 7, fig A-IV-8 and -13) are located on both the right and left upper hull sides.

3. Two smaller rectangular access hatches are located on the right rear of the vehicle, one on the roof (hatch No. 8) and the other on the upper right side (hatch No. 9) (fig A-IV-9). Both hatches are hinged near the juncture of the roof and upper right side.

These hatches provide access to an auxiliary power source located inside the vehicles. A flap-covered exhaust stack for this power source is located on the upper right corner of the vehicle's rear plate (fig A-IV-14).

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555359 ~~(CONFIDENTIAL)~~

Figure A-IV-14. ACRV M1974-(3), rear view (U).

4. A rear-hinged square hatch (hatch No. 6, fig A-IV-8 and -13) is centered on the roof to the rear of the turret. This hatch has often been observed open when personnel are on and/or adjacent to the vehicle; possibly it is used by the crew for vehicle access and/or ventilation.

5. A square shallow box (Box A, fig A-IV-13 and -15) is located on the rear left hull roof. This box is dismountable and appears to be the approximate size and shape of the case for the PUO-9 fire direction set.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555365 ~~(CONFIDENTIAL)~~

Figure A-IV-15. ACRV M1974-(3), rear overhead view (U).

(g) Common to the rear hull of all variants are the following features (fig A-IV-7 and -14).

1. A centrally located, right-hand-hinged, square, personnel access door (hatch No. 11, fig A-IV-8 and -14) is positioned in the rear hull plate. Contained in this rear door are a centrally located pear-shaped firing port and a vision slot in the upper right corner.

2. A large externally mounted rectangular box (Box B) (fig A-IV-8) is affixed to the right rear hull. This box is believed to store reels of telephone wire.

3. A narrow, rectangular, left-hinged, access hatch (hatch No. 10) (fig A-IV-8 and -14) is located in the rear hull between the square central access door and the left edge of the hull. This hatch may be associated with radio communications gear.

(h) Miscellaneous features common to all three variants are as follows (fig A-IV-12, -13, and -16): Four positions for installing antenna bases, one each on the left front, left rear, and right rear hull roof, and the fourth on the hull roof to the right front of the turret; two engine fuel access plates located one on either side of the upper hull adjacent to the turret; and a fuel can located on the right side of the rear deck. Although the M1974(3) has not been observed with this fuel can mounted externally, the can is believed to be present as it probably contains fuel for the auxiliary generator.

(3) Shrouds and propulsion vanes (fig A-IV-14 and -17). The ACRV M1974 is an amphibious vehicle. Propulsion while afloat is provided by the movement of the vehicle's tracks. To assist in the more efficient operation of the vehicle while afloat, several special fixtures have been incorporated into its design.

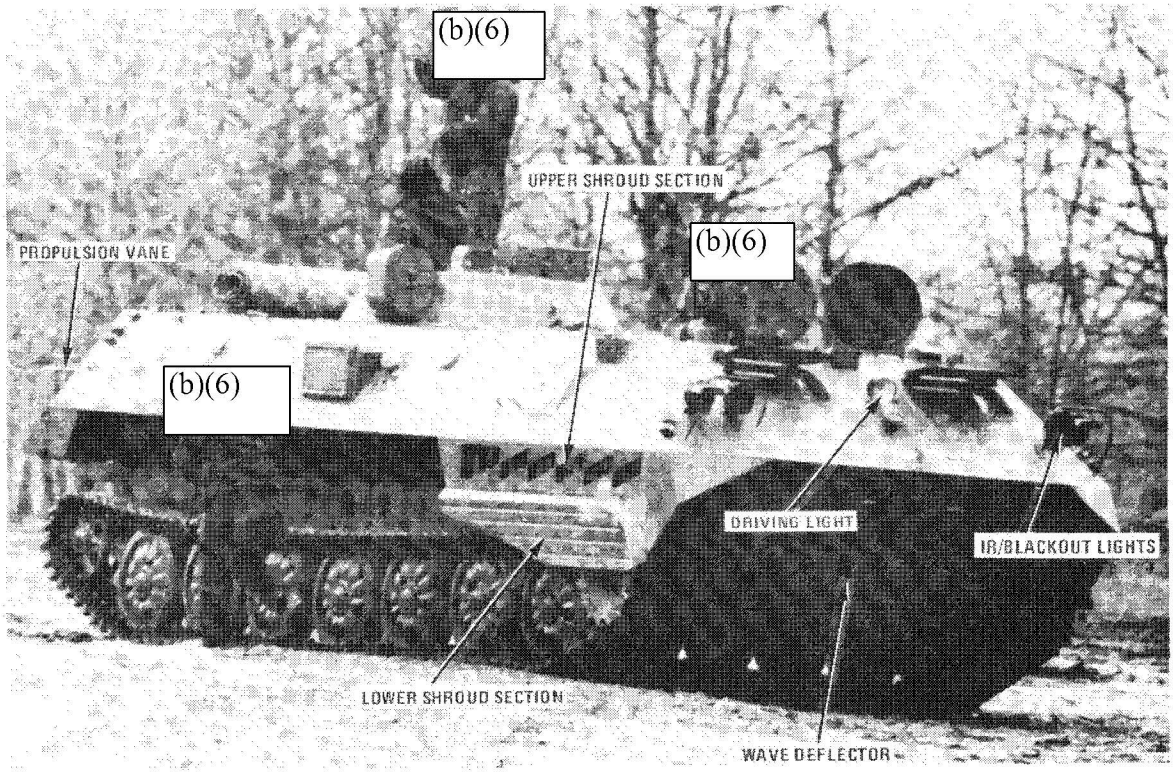
(a) Attached to the forward third of the hull sides are detachable, two-piece-track shrouds. It should be noted that the shrouds on the ACRV variants are different than those used on the 122-mm self-propelled gun M1974 (see Vol 2, sec II, I). The upper section is attached to the lower forward sponsons. This section contains five diagonal louvered slots and a rearmost triangular louvered slot. It is estimated that these louvered slots assist in the directional stability of the vehicle in addition to its propulsion. A lower shroud section is attached to the upper section.

(b) Hinged propulsion vanes are positioned upon the hull rear over the tracks. The upper halves of these fixtures are louvered horizontally, while the lower halves are louvered vertically. When not being used for swimming, these hinged fixtures are swung upward and secured.

(c) A top-hinged wave deflector (fig A-IV-17) is attached to the lower glacis plate. During land travel, this deflector lies against the lower glacis plate; prior to entering the water, the wave deflector is raised and secured in its upward position.

A-IV-15 is denied in full

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)



Neg. 555358 ~~(CONFIDENTIAL)~~

Figure A-IV-17. ACRV M1974-(2), right front view (U).

c. Differences Between ACRVs.

(1) Turrets. The turrets on these three variants resemble each other in general configuration but differ in detail. They are all shaped like truncated cones and appear to be of the same height and diameter. Although it is believed that they can all rotate, only the M1974(2) variant has been confirmed to have this capability. The fixtures associated with these turrets differ in the following respects.

(a) The turrets of the M1974(1) and (3) are very similar (fig A-IV-10 and -16). They both mount a 12.7-mm M38/46 heavy machinegun on a pedestal attached to a rotatable hatch ring. Within this ring is a single D-shaped hatch. This hatch (hatch No. 4) opens away from the machinegun pedestal. The hatch and machinegun rotate as a single unit. On the forward turret roof of the M1974(1), directly opposite the turret hatch ring, is a retractable, domed, circular fixture believed to be a periscopic sight. The M1974(1) variant's turret is also equipped with four periscopic vision blocks (TNPO-170) between the turret-hatch ring and the periscopic sight (fig A-IV-16). These vision blocks have not been observed on the M1974(3) variant. In lieu of these devices, metal plates have been affixed flush with the turret roof, sealing the holes where these devices are installed on the M1974(1) variant.

(b) Although its basic configuration is identical to that of the other two variants, the M1974(2) variant's turret differs considerably in its attached fixtures (fig A-IV-8, -9, -12, and -18). A small, rear-hinged, D-shaped hatch (hatch No. 4) (fig A-IV-8) is centered on the top rear of the turret. Encircling this hatch are six (three to a side) vision blocks; a seventh vision block may be incorporated into the rear of the hatch fixture. Attached to the right front side of the turret is a roughly square, armored fixture with a hinged cover on the forward side. Although the purpose of this device has not been confirmed, it possibly is a searchlight and, if a searchlight, probably a xenon light. Mounted forward and left of center on the top of the turret is a rectangular fixture that is believed to be a rangefinder (probably a laser). To the right of this device is another smaller rectangular optical head believed to be a possible day/night image intensifier periscope. Between and slightly to the rear of these two optics is a pintle mount for a 7.62-mm PKB machinegun. A few M1974(2) variants (fig A-IV-12) have been seen with an unidentified circular device mounted on top, to the right of the turret between the searchlight and the hatch. The purpose of this device is unknown. On these versions the two forwardmost vision blocks on this side have been eliminated.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 555363 ~~(CONFIDENTIAL)~~

Figure A-IV-18. ACRV M1974-(2), overhead view (U).

(2) Rear hull roof. The structures on the rear hull roof of the variants differ in the following details.

(a) The rear roof of the M1974(1) variant includes a slightly elevated, horizontally oriented, large rectangular plate (fig A-IV-16). Attached to the vehicle roof by three large bolts, this plate has a small rectangular section cut out of its forward left corner to accommodate the antenna mount. The two tie-down straps attached to this plate are used to secure the vehicle's tarpaulin during travel.

(b) The M1974(2), in lieu of the large rectangular plate on the M1974(1), has a smaller rectangular plate (fig A-IV-18) bolted to

the rear deck. This may be used for the attachment of storage boxes and miscellaneous vehicle equipment.

(c) Figure A-IV-15 shows four rectangular blocks lying upon the rear roof. These blocks, which have the general appearance of track chocks, are believed to be the same as those inserted beneath the rear hull plate in figure A-IV-16. These blocks may provide for lateral, and some degree of fore and aft, trim when swimming.

(d) The M1974(3) normally has a third antenna mast (fig A-IV-3) mounted upon the right rear roof just forward of the auxiliary generator compartment. Both of the other variants appear to have removable plates in this location.

(3) Rear hull. With the following exceptions, all three variants have similarly configured rear hulls (fig A-IV-16).

(a) The M1974(3) has a small rectangular (Box C) (fig A-IV-8 and -14) attached to the top center of the rear hull above the square personnel door (No. 11). The contents of this box are unknown.

(b) The M1974(3), and some M1974(2), also has an antenna mast base attached to the lower left portion of the rear hull immediately below the rectangular access hatch (No. 10) in the left side of the hull. This base is used with the large (10 meters high) telescopic antenna carried at the center of the left upper hull.

(4) Hull front and sides. The following features differ from the normal configuration (fig A-IV-10 and -15).

(a) The M1974(3) has no large dormer-like rectangular fixture attached to the center right upper hull. In lieu of this fixture, which is present on both of the other variants, a plate is attached flush to the hull.

(b) Attached to the center left upper hull side of the M1974(3) and some M1974(2)s is a large telescoping antenna mast. This mast, when in use, is mounted on the antenna base attached either to the lower left rear of the hull below the rear rectangular access hatch, or on the hatch itself.

d. Power Train. The engine, radiator, transmission, and final drive of the ACRVs is believed to be the same as that of the 122-mm M1974 self-propelled gun except that the 176.5-kW YaMZ-238V engine in the ACRV is not turbocharged. Assuming a 15-tonne weight for the ACRV

would provide a power-to-weight ratio of 11.8 kW (16 hp) per tonne. This power-to-weight ratio and the use of a mechanical transmission will provide mobility capabilities equal to those of the current and near-term armored vehicles that are supported by this system. (See para II-I-18-e for a complete description of the power train.)

e. Auxiliary Generator. To provide the ACRV and all of its electronic equipment with adequate electrical power during static operations, an auxiliary power source has been provided (fig A-IV-13). This unidentified engine is provided with two hatches (one in the hull side and one in the roof). The exhaust is located in the upper right corner of the rear hull plate.

f. Protection. Although the ACRVs are armored vehicles, the armor is believed to be sufficient only to protect the personnel and equipment from small arms and nominal fragmentation (85% probability). NBC protection is believed to be provided by a collective protection system that provides filtration of radioactive dust, chemical, and biological agents plus the use of over pressurization to prevent the contamination of the interior of the vehicle via air seepage (85% probability).

g. Firing Ports. Two firing ports provide the crew with protected firing positions for their small arms. One firing port is located in the right front hull side and the other in the rear door.

h. Crew Size. The ACRVs are manned by crews of five to seven persons (80% probability). The composition of the crews will vary with the mission of each variant. It is highly probable that the crewmen supplement one another in the performance of the various duties. It is also probable that the crews of the M1974(2) and (3) are augmented by personnel carried on other vehicles. Possible crew assignments may be as follows:

(1) M1974(1):

- Driver/mechanic.
- Firing position commander.
- Land navigation system operator.
- Chief of firing battery.
- Fire direction set operator (computer).
- Radio telephone operator.
- Instrument operator.

[1]Any additional personnel in the headquarters platoon would probably ride in other battery vehicles, because it does not appear that the ACRV variants could carry more than about seven men.

(2) M1974(2):

- Driver/mechanic.
- Battalion (battery) commander.
- Land navigation system operator.
- Rangefinder operator.
- Reconnaissance NCO.
- Instrument operator.
- Fire direction set operator.

Note: There are three other personnel normally associated with the COP, the reconnaissance officer and two scouts. Therefore, it appears that this combination could vary, with possibly a 0.25-tonne vehicle to support the additional personnel.

(3) M1974(3):

- Driver/mechanic.
- Bn COFS.
- Land navigation system operator.
- Staff officer (fire plans, etc.).
- Chief computer operator.
- Computer operator.
- RT operator.

[1]Any additional personnel in the headquarters platoon would probably ride in other battery vehicles, because it does not appear that the ACRV variants could carry more than about seven men.

i. Nomenclature. The Soviet designations of these ACRVs M1974 are not known. It is possible that each variant has a separate designation, or that each is simply known as the "Komandnaya Mashina" (command vehicle). Soviet open press articles have referred to such vehicles and stated their mission as follows: "The mobile artillery observation post (APNP) is an armored full tracked vehicle used as a command or forward observation post of artillery chast' or podrazdeleniye to conduct reconnaissance and direct artillery fire."

j. Summary.

(1) M1974(1) ACRV. This vehicle, employed primarily in the firing battery position, is postulated to be equipped with the communication, fire control, and fire direction equipment required to perform all of the functions necessary to operations in the battery position area. This vehicle is estimated to be equipped with most, if not all, of the following items:

- Land navigation system (with integral gyrocompass).
- Gyrocompass capable of being tripod mounted.
- CBR collective protective system.
- Periscopic goniometer (aiming circle) capable of being tripod mounted.
- At least two, probably three, radio transceivers with crew interconnections.
- Data link equipment with digital readout (considered probable).
- Fire direction equipment, including plotting boards, PUO-9 fire direction set, stopwatch, and related items.
- 12.7-mm M38/46 machinegun.
- Small survey set (tapes, pins, etc.).
- Crew intercommunication equipment.
- Telephones and field wire.
- Manuals, SOI, forms, etc.

(2) M1974(2) ACRV. This vehicle is used by battery and battalion commanders in the discharge of their COP and reconnaissance responsibilities. This vehicle is estimated to be equipped with most, if not all, of the following items:

- Land navigation system (with integral gyrocompass).

- Gyrocompass capable of being tripod mounted.
- CBR collective protective system.
- Goniometer (aiming circle), for backup and off-vehicle use.
- Laser and/or optical correlation-type rangefinder(s) (possibly this item can be dismounted and used off-vehicle).
- Stereoscopic rangefinder, Model DS 1.0 or optical correlation-type rangefinder (for backup and off-vehicle use).
- Night observation devices; image intensifiers(s) or passive imaging IR.
- Fire direction equipment, including plotting boards, PUO-9 fire direction set, several stopwatches, and related equipment. This equipment is dismountable and usable in an off-vehicle mode and sufficient for the manning of a lateral OP for combined observation.
- 7.62-mm PKB or 12.7-mm M38/46 machinegun.
- Manuals, SOI, forms, etc.
- At least two, probably three, radio transceivers with appropriate crew interconnections, portable sets for lateral and/or forward OPs, and field wire and telephones for lateral OP.
- Possible data link equipment with digital readout.
- Crew intercommunication equipment.
- Outside telescoping field antenna (not observed on all).

(3) M1974(3) ACRV. To date this vehicle has been observed only in the battalion headquarters of self-propelled gun battalions. It

is postulated that this vehicle provides equal mobility and improved communications for one or more battalion staff functions, probably those of the battalion Chief of Staff whose functions roughly equate to the combined functions of the US Army's battalion XO, S-3, and FDO. This vehicle consistently displays three antenna mounts. The third mount is located on the starboard deck just forward of the top hatch on the auxiliary power compartment. This vehicle is postulated to be used by the battalion staff in the execution of its operational functions. Equipment mounted in this model is expected to include most, if not all, of the following items:

- Land navigation system (possible, not probable).
- CBR collective protective system.
- Fire direction computer (probable).
- Fire direction equipment, including plotting boards, PUO-9 fire direction set, and related items.
- Crew intercommunication equipment.
- At least three, probably four, radio transceivers with crew interconnections.
- High-speed data link equipment (probable).
- Outside telescoping field antenna (10-meter height capability).
- 12.7-mm M38/46 machinegun.
- Manuals, SOI, forms, etc.
- Telephones and field wire.

2. ~~(C)~~ SMALL FRED (BMP-A Variant M1975)

a. Description. A second variant of the BMP-A probably is a surveillance radar (85%) and has been designated SMALL FRED. This vehicle (fig A-IV-19) is reportedly known as PRP [pere dnighnoy razvedynated'nyy punkt (mobile reconnaissance point)]. The SMALL FRED is amphibious and has the same basic mobility characteristics as the ACRV variants. It has a Model UTD 20 15.9-liter, 215-kW (293-hp) engine. The weight of

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

Neg. 553889 ~~(CONFIDENTIAL)~~

Figure A-IV-19. SMALL FRED (BMP-A variant M1975) (U).

the SMALL FRED is estimated to be approximately 13.3 tonnes, thus the kW/t ratio is approximately 16:1 and ground pressure is approximately 63 kg/cm^2. This system is believed to be organic to each self-propelled 122-mm and 152-mm cannon battalion, one to each battalion. The Soviets are known to utilize this type radar to engage moving targets.

b. Components Removed From the BMP-A. In the construction of the M1975 BMP-A variant, the following items have been removed from the BMP-A:

- The BMP's turret, including the 73-mm gun.
- The firing ports on the hull sponson sides, with their associated unity periscopes and exhaust scavaging ports.
- The upper deck of the hull from the engine cooling radiators rearward.

c. Components Added to the BMP-A. The following new items appear on the M1975 variant:

- A large two-man turret, about one-third greater in diameter than that of the BMP-A. This turret appears to mount a 7.62-mm PKT machinegun. Two forward opening hatches are located in the top of the turret. A large periscope head is located forward of each turret hatch. These heads appear sufficiently large to house devices such as a passive image intensifier for night observation, a laser rangefinder or illuminator, or a passive-type sight for the machinegun. A rectangular object about 0.3x0.3x0.45 meters is attached to the right front quarter of the turret's outer wall. This object may contain some sort of optical device.

- From the engine cooling radiators rearward, a new top deck, the edges of which are chamfered near the sponson.

- A rearward opening hatch and an associated periscope mount in the top deck to the left rear of the turret.

- An additional antenna mount is positioned at the right rear of the vehicle.

- Three shovels, a pick, a sledge, and two towing cables are attached to the sides of the sponsons.

- This vehicle has what appears to be an ≈82-mm mortar or rocket launcher tube mounted on the port side of the rear deck. The purpose of this mounting may be target illumination.

d. BMP-A Components That Are Repositioned on the M1975 Variant. The following items have been relocated on the M1975:

- The air intake snorkel for the CBR equipment has been relocated to a position in the rear, and to the right, of the turret.

- The antenna mount on the left rear of the top deck of the BMP-A has been moved about 1.2 meters (4 ft) to the right.

3. ~~(C)~~ BIG FRED

BIG FRED (fig A-IV-20) probably is a countermortar/battery radar that is mounted on the MT-L series chassis, specifically the MTLB version which affords armored protection for the crew. The MTLB is full-tracked, amphibious, and utilizes the same engine (YAMZ-238), minus turbocharger, as the ACRV variants and the 122-mm self-propelled gun M1974. The MT-L series vehicle is believed to be widely used within the Soviet Army as a prime mover and cargo carrier. One BIG FRED is deployed to Soviet artillery regiment and brigade level with priority of initial issue to front 152-mm self-propelled gun regiments. The radar antenna is larger than that of SMALL FRED, but is similarly mounted.

(b)(1),(b)(3):10 USC 130c,1.4 (a),1.4 (c),1.4 (e)

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Figure A-IV-20. BIG FRED (top view) (U).

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APPENDIX V.

USE OF PROBABLE ERRORS IN RANGE AND DEFLECTION VERSUS CIRCULAR ERROR PROBABLE IN CANNON SYSTEMS

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1. (U) Dispersion Patterns

The distribution of vertically free-falling bodies that exhibit the same physical parameters (mass, shape, etc.) is circular. Guided missiles also tend to exhibit a circular pattern of dispersion. Free-flight rockets exhibit an elliptical pattern: At the shorter ranges the major axis of the ellipse is parallel to the flight path; beyond mid-range the pattern becomes circular; and as maximum range is approached the major axis of the ellipse becomes perpendicular to the flight path of the rocket (the minor axis being parallel to the flight path). Gun-fired RAP exhibit an increase in PE_d when compared with non-RAP, but such increases are relatively minor. Non-RAP (conventionally fired) projectiles exhibit elliptical patterns of dispersion, the major (range) axis of which always remains parallel to the direction of fire and is several times greater than the minor (deflection) axis.

2. (U) Dispersion of Cannon Fired Projectiles

The round-to-round dispersion (precision) of projectiles fired from cannon is stated in terms of probable errors in range (PE_r), in deflection (PE_d), in the vertical plane at the point of maximum deviation (PE_v), and in "airburst probable errors": PE in time to burst (PE_{tb}), PE in height of burst (PE_{hob}), and PE in range to burst (PE_{rb}). In executing direct fire against targets that present a vertical posture and are located within about two times grazing range, PE_v and PE_d rather than PE_r and PE_d are the parameters of interest. At ranges greater than about two times grazing range, the adjustment probably should be conducted as an axial adjustment in which the target is bracketed in range, in which case PE_r rather than PE_v becomes the parameter of interest. When firing time-fuzed projectiles, PE_{hob} may be used in determining either a suitable mean height of burst above the target or, conversely, the percentage (or number) of airbursts that may be expected when the mean height of burst above target is prescribed; e.g., US=20 meters or USSR=2 Soviet mils ($\approx$ 10 to 15 meters at ranges to which time fire nominally is delivered). In the delivery of indirect fire, PE_r and PE_d and (when firing time-fuzed projectiles) airburst probable errors are the quantities of interest. As is described in the US Army's FM 6-40 and foreign gunnery manuals, 12 PE_r and 12 PE_d establish the horizontal limits that contain 100% of the rounds fired (except for "flyers";

e.g., an erratic round occasioned by a thrown rotating band). For practical purposes, 8 PE_r and 8 PE_d are considered to delimit the dispersion pattern, because these limits not only encompass 99.3% of the projectiles fired but also are more facile for use in the conduct of observed fire; i.e., the use of 8 PE_r permits a division of 8, 4, 2, 1. The distribution within the 4 PE_r over and short, and the 4 PE_d left and right of the main point of impact is 25%, 16%, 7%, and 2% of the number of rounds making up the pattern. The same distribution applies to the airburst probable errors. The values for PE, expressed in meters, vary with the range being fired and the propelling charge being used (i.e., velocity). The <u>total</u> pattern of dispersion is elliptical; nevertheless, the pattern as delineated by 12 PE_rx12 PE_d or 8 PE_rx8 PE_d is rectangular. Using the 12 PE pattern description, the area of the actual pattern probably is most accurately defined by π (6 PE_rx6 PE_d). The total area of the 8 PE pattern always should be considered as rectangular (i.e., 8 PE_rx8 PE_d), although the area as described by the firing of only 100 or so rounds probably tends to be somewhat biased toward that lesser area that is defined by π (axb). Nevertheless, the area that describes any <u>percentage</u> of the fall of shot (e.g., 50%, 82%, etc.) <u>always</u> must be described as rectangular when the PE method is used. It must be remembered also that while 1 PE_r over and short of the MPI contains 50% of the total distribution of the projectiles in <u>range</u>, and 1 PE_d left and right of the MPI contains 50% of the distribution in <u>deflection</u>, an area described by 3.117 PE_rx3.117 PE_d (i.e., 1.559 PE over and short x 1.559 PE left and right of the MPI) is necessary to encompass 50% of the projectiles constituting the dispersion pattern. This value of 3.117 PE can be derived as follows:

- The limits, in PE, that contain 50% of the projectiles within the dispersion pattern are established by $\sqrt{0.5}$, i.e., 0.70711.
- Since normal probability tables depict but half of the pattern of dispersion (6 PE) rather than 100% (12 PE), $\frac{0.70711}{2} = 0.35356$.
- The probability tables show, through interpolation, that 0.35356 = $\approx$1.559 PE based on $\frac{12\ PE}{2}$. Therefore $\approx$1.559x2=3.117 PE.
- Therefore, the area of the rectangle (in m^2) that encompasses 50% of the fall of shot = 3.117 PE_rx3.117 PE_d.

It should be particularly noted that, with regard to cannon-fired projectiles, the value of PE_r always is several times that of PE_d. Examples of this relationship are set forth in table A-V-1. It should also be noted that the ratio of PE_r and PE_d in any particular cannon generally decreases as the range is increased, and that between various type of weapons, the ratio increases from howitzers to gun-howitzers to guns (i.e., increases with velocity). Further, a comparison of the ratios of PE_r to PE_d in the 122-mm MRL reveals that, at 77.5% of maximum range, its dispersion pattern actually is circular.

Table A-V-1. Relationships of PE_r to PE_d in Various Soviet Cannon Systems Firing Full Charge (U)

Weapon, max rg (m)	Percent of max rg	PE_r (m)	PE_d (m)	Ratio (r to d)
122-mm D-30 howitzer,				
15 300	33	11	3.5	3.1:1
	66	18	5.1	3.5:1
	99	27	10.0	2.7:1
Max deviation in high angle..		--	--	2.0:1
152-mm ML-20 gun-howitzer,				
17 230	33	29	4.0	7.3:1
	66	48	8.0	6.0:1
	99	69	12.0	5.7:1
Max deviation in high angle..		--	--	6.8:1
130-mm M-46 gun, 27 490	33	25	2.2	11.4:1
	66	30	4.3	7.0:1
	99	89	13.0	6.8:1
180-mm S-23 gun, 30 390				
w/o RAP	33	34	2.7	12.6:1
	66	61	5.6	10.9:1
	99	110	11.0	10.0:1
40 800 w/RAP	99	221	26	8.5:1
At 99% max rg of conventional projectile				
(30 086 m)	73.7	144	14	10.3:1
122-mm BM-21 MRL, 20 380	33	195	37	5.3:1
	66	105	77	1.4:1
	99	78	147	0.5:1
	77.5	93	93	1.0:1

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3. (U) Circular Error Probable (CEP)

The value of this measure (CEP) is the radius of a circle that contains 50% of the projectiles within the dispersion pattern of a weapon.

a. CEP Vis-a-Vis a Single Cannon. CEP, per se, is an inappropriate measure to apply in considering those probabilities pertaining to a single field artillery cannon; e.g., the ratios of PE_r to PE_d in table A-V-1 vary from 2.0 to 12.6. The norm of all the ratios presented in that table is about 7, and the norm for ratios at 66% and greater ranges for those systems that could be nuclear-capable is about 8.5. Conversion of a rectangle with dimensions of 8.5x1.0 into an ellipse with these same axes results in a loss in area of ≈21%; however, the conversion of such a rectangle into a circle is futile.

- Converting to a circle, the area of which is the same as that of the rectangle, disregards the 8.5:1.0 relationship of range to deflection probable error in the foregoing example; i.e., a circle of that radius will not encompass 50% of the fall of shot.

- Converting to a circle the diameter of which is equal to that of the long side of the rectangle produces an area several times larger than the area contained in the rectangle; i.e., the relatively excellent precision of a cannon in deflection is disregarded (except for a relatively narrow band along its Y-axis, the left and right halves of the circle are devoid of projectiles).

- Converting to a circle the radius of which encompasses 50% of the fall of shot within the dispersion pattern is but a modification of the foregoing. Nevertheless, this practice has been followed by a number of operations analysts, particularly those assessing the nuclear capabilities of missiles, free-flight rockets, and cannon. Rather than delineating the dimensions of each target, these analysts either assume the target to be circular or they select an aim point for the target without considering the effective depth and effective width of the actual dimensions of the target [these dimensions result from the orientation of the target with respect to the direction of fire (the angle of bias)]; the analysts then calculate the single shot hit probability for that target. Although the practice of using CEP (rather than PE_r and PE_d) facilitates computation, it results in a great disservice to the precision of cannon vis-a-vis that of rockets and, in some instances, missiles.

b. Computation of CEP. Two formulae generally are used to compute CEP. The first of these is:

$$CEP = 0.8728\ (PE_r+PE_d).$$

This formula is said to be applicable when PE_d is greater than $0.2\ PE_r$. It should be noted that the only cannon system in table A-V-1 to which this formula applies is the 122-mm D-30 howitzer, and, further, that this formula should be well suited to the 122-mm BM-21 MRL. The second formula, said to be applicable when PE_d is less than $0.2\ PE_r$, should be applicable to all the cannon in table A-V-1 except for the 122-mm howitzer. This formula is:

$$CEP = PE_r+0.2365\ PE_d.$$

Example 1 portrays some of the relationships between the results obtained when using the second of these formulae and that obtained from computation of the area of that rectangle containing 50% of the fall of shot within the dispersion pattern. For simplicity, the weapon system portrayed is firing HE-FQ, but to a range that may be associated with the delivery of a nuclear projectile.

Example 1. US M109A1 firing the M107 HE projectile to 85% of maximum range:

- 0.85x18 100 meters (max range) = 15 385 meters = selection of charge 8.
- From FT 155-AM-1, table G, charge 8: through interpolation, PE_r=49.8 and PE_d=8.4; PE_d=0.169 of PE_r (i.e., PE_r is 5.92xPE_d).
- Using the PE method, the area of the rectangle that encompasses 50% of the dispersion pattern = 3.117 PE_rx3.117 PE_d (see para 2, preceding); (3.117x49.8)x(3.117x8.4) = 4064 m^2.
- Using the CEP method, CEP=PE_r+0.2365 PE_d. CEP=49.8 m+0.2364 (8.4 m)=51.8 m (radius), and the area within the CEP=π (51.8^2)=3.1416 (2683.2)=8430 m^2.

- In this example the area computed by use of the applicable formula for CEP is more than two times larger than that area which also contains 50% of the projectiles in the dispersion pattern; furthermore, the depth of the rectangle that actually contains 50% of the projectile is 5.95 times larger than is its frontage (width); i.e., while the area computed by the CEP method also may contain 50% of the projectiles, it contains a most inappropriately selected 50%.

Continuing this example, it may be assumed that a 10-meter-wide by 50-meter-long bridge is a target located at a range of 15 385 meters. Considering precision only, the problem is to determine the single-shot hit probability (SSHP) according to both the PE and the CEP methods when, first, the longitudinal axis of that bridge is parallel to the direction of fire, and, second, the target forms an angle of bias of 45° (800 ₥) to the direction of fire.

- Using PE method, the SSHP for the longitudinally oriented bridge is as follows:

  Range distance in PE (t) $= \frac{0.5(50)}{49.8} = 0.502$

  Probability in range (P_r)=(0.1324)x2=0.2648

  Deflection $t = \frac{0.5(10)}{8.4} = 0.5951$

  SSHP = (0.2648)x(0.3120)=0.0826 or 8.26%.

  Further, assurance graphs (such as those contained in FM 6-40) reveal that for a 90% assurance of at least 1 hit, an expenditure of 27 rd is necessary.

- Continuing to use the PE method, the SSHP for the same bridge when oriented at 45° to the direction of fire is derived as follows:

  At 45° bias, the dimensions of the target (50x10 m) change to an apparent length (effective depth) of 14.14 meters and an effective width of 35.36 meters;

  i.e., effective depth $= \frac{0.5 \text{ width}}{\cos 45^\circ} = \frac{0.5(10)}{0.7011} =$

  14.14 meters and effective width =

$$\frac{\text{target area}}{\text{effective depth}} = \frac{500}{14.14} = 35.36 \text{ meters}$$

(14.1 meters and 35.4 meters will be used). Therefore,

$$\text{Range } t = \frac{0.5(14.1)}{49.8} = 0.141$$

$$P_r = (0.0384)x2 = 0.0768$$

$$\text{Deflection } t = \frac{0.5(35.4)}{8.4} = 2.107$$

$$P_d = (0.4224)x2 = 0.8448$$

SSHP = (0.0768)x(0.8448) = 0.0649 or 6.49%.

At 6.49% SSHP, a 90% assurance of at least 1 hit necessitates the expenditure of 34 rounds.

When using the CEP method, one must assume that the errors in range and deflection are equal; i.e., that the CEP is the radius of a circle that contains 50% of the fall of shot. A CEP of 51.8 meters is equivalent to a standard deviation of 44 meters, according to the formula for a circular normal (Rayleigh) distribution; i.e., CEP = 1.1774 σ. The probability that a target 50 meters deep and 10 meters wide will be hit by a single round is the product of the lengthwise and widthwise marginal probabilities; viz:

$$P_h = P(-5 \leq x \leq 5) \times P(-25 \leq y \leq 25).$$

Assuming that the mean point of impact (MPI) is the center of the target:

$$P(-5 \leq x \leq 5) = F(Z = \frac{5}{\sigma}) - F(Z = \frac{-5}{\sigma})$$

where F(Z) is the cumulative normal distribution evaluated at Z.

$P(-5 \leq x \leq 5) = F(Z=0.1136) - F(Z=0.1136) =$
$0.5452 - 0.04548 = 0.0904.$

$P(-25 \leq y \leq 25) = F(Z=0.5682) - F(Z=0.5682) = 0.7151 - 0.2849 = 0.4302$

$P(x)P(y) = 0.0904 \times 0.4302 = 0.0389$, or 3.89%.

- A SSHP of 0.0389 necessitates the expenditure of 57 rd for a 90% assurance of at least 1 hit.

- In using the CEP method, since the distribution is assumed to be circular, the probability of hitting a target remains the same for any orientation of that target about its center.

- Note that the SSHP derived by the PE method in the foregoing example is about 2.1 and 1.7 times greater than the SSHP derived by the CEP method, that the number of rounds necessary to attain a 90% assurance of at least 1 hit bear these same ratios, and that the CEP method is not capable of accounting for any angle of bias that may be present in the target.

Example 2. 122-mm BM-21 MRL firing to 77.5% of maximum range, at which range PE_r and PE_d have equal values.

- 0.775x20 380 m=15 795 m, at which range PE_r and PE_d both equal 93 meters.

- By the PE method, the area containing 50% of the projectiles within the pattern of dispersion is delimited by:

  $3.117\ PE_r \times 3.117\ PE_d$=rectangular area
  $(3.117 \times 93) \times (3.117 \times 93) = 84\ 031\ m^2$.

- By the CEP method the appropriate formula is:

  $0.8728\ (PE_r + PE_d) = CEP$
  $0.8728\ (93+93) =$
  $0.8728\ (186) = 162.34$ meters (radius).

  $Area = \pi r^2 = 3.14159 \times 162.34^2 = 82\ 794\ m^2$.

  $82\ 794\ m^2$ vs. $84\ 031\ m^2$ exhibits acceptable correlation; nevertheless, it should be noted that the range selected is optimal (i.e., $PE_r = PE_d$). Although the area computed by the CEP method may contain 50% of the fall of shot, it should be

noted that this is not the "same 50%" of the projectiles contained in the area computed by the PE method.

Continuing example 2, it may be assumed that the range is changed to 20 176 meters (99% of maximum range), at which PE_r=78 and PE_d=147 meters for a ratio of 0.531.

- Using the PE method, the area containing 50% of the projectile within the dispersion pattern is delimited by 3.117 PE_r and 3.117 PE_d.

  $(3.117 \times 78) \times (3.117 \times 147) = \underline{111\ 400\ m^2}$.

- By the CEP method:

  $0.8728\ (PE_r + PE_d) = CEP$
  $0.8728\ (78+147) = 196.38$ meters=CEP
  Area of 50% of the pattern=$\pi(196.38)^2 = \underline{121\ 155\ m^2}$.

- The area of 121 155 m^2 that is derived by the CEP method shows only a fair correlation to the PE method, although the ratio of the width to the depth of the pattern representing 50% of the fall of shot is but 2:1. The foregoing demonstrates that the more diverse the ratio between PE_r and PE_d, the less valid is the CEP method.

Example 3. 180-mm Soviet gun firing conventional shell HE-FQ to 90% maximum range; i.e., to 27 350 meters. At this range, PE_r=94 meters, PE_d=8.8 meters, and PE_d to PE_r=9.36% for a ratio of PE_r to PE_d of 10.68:1.

- By the PE method:

  Area of the 50% zone=$(3.117 \times 94) \times (3.117 \times 8.8) = \underline{8037\ m^2}$.

- By the CEP method the appropriate formula is:

  $PE_r + 0.2365\ PE_d = CEP$
  $94 + 0.2365\ (8.8) = 96.08$ meters=CEP
  Area of 50% zone=$\pi r^2 = \pi(96.08)^2 = \underline{29\ 001\ m^2}$.

- Since the 29 000 m^2 obtained by the CEP method is 3.61 times greater than the area obtained by the PE method, it is readily apparent that the CEP method is wholly inappropriate for application to long-range cannon systems such as the Soviet 180-mm gun or the US 175-mm gun.

To continue example 3, the foregoing data may be applied to a fenced installation 100 meters wide by 50 meters deep that has been determined to be an army-level special weapons storage depot. Two orientations are assumed for this target; first, a 0° angle of bias (the 100-meter-target width is frontally presented); and second, a bias of 30°. Considering that PE_r is 94 meters and PE_d is 8.8 meters:

- First, with the 100x50-meter target oriented frontally (0° bias):

$$\text{Range } t = \frac{1/2 \times 50}{94} = 0.266$$

$P_r = (0.0715) \times 2 = 0.1430$ or 14.3%

$$\text{Deflection } t = \frac{1/2 \times 100}{8.8} = 5.682$$

$P_d = (0.4999) \times 2 = 0.9998$ or 99.98%

SSHP = (0.1430) x (0.9998) = 0.1430 or 14.3%.

- Second, the 100-meter-wide by 50-meter-deep target is at a 30° angle of bias (θ):

To account for effect of angle θ:

$$\frac{1/2 \text{ depth}}{1/2 \text{ effective depth}} = \cos 30°$$

$$\frac{25}{\cos 30°} = \frac{\text{effective depth}}{2} = 57.735 \text{ meters.}$$

$$\frac{\text{area}}{57.735} = \text{effective width}$$

$$\frac{5000}{57.735} = 86.60 \text{ meters effective width.}$$

Computing SSHP:

$$\text{Range } t = \frac{1/2 \times 57.74}{94} = 0.3071$$

$P_r = (.0822) \times 2 = 0.1644$ or 16.4%

$$\text{Deflection } t = \frac{1/2 \times 86.60}{8.8} = 4.920$$

$P_d = (0.4996) \times 2 = 0.9984$ or 99.8%

SSHP = $(0.1644) \times (0.9984) = 0.1641$ or 16.4%.

- Computing the SSHP by the CEP method, CEP being 96.08 meters:

  $P_h = P(-50 \leq x \leq 50) \times P(-25 \leq y \leq 25)$.

  MPI being at the center of the target:

  $$P(-50 \leq x \leq 50) = F(Z = \frac{50}{\sigma}) - F(Z = \frac{-50}{\sigma})$$

  where F(Z) is the cumulative normal distribution evaluated at Z.

  $P(-50 \leq x \leq 50) = F(Z=0.6127) - F(Z=-0.6127) = 0.4600$

  $P(-25 \leq y \leq 25) = F(Z=0.3064) - F(Z=0.3064) = 0.2406$

  $P(x)\ P(y) = 0.4600 \times 0.2406 = 0.1107$, or 11.1%,

  which, by the nature of CEP, holds for all possible orientations of the target.

- Recapitulation: The SSHP for the 100-meter-wide by 50-meter-deep target set forth in example 3 is, when using the PE method, 14.3% at 0° angle of bias and 16.4% at 30° angle of bias. The SSHP for this target by the CEP method is 11.1%. The SSHP as determined by the PE method is about 1.3 times greater for this target at 0° target bias and about 1.5 times greater at the 30° target bias than the result obtained by the CEP method.

Table A-V-2 summarizes the results obtained from examples 1 through 3. This table also sets forth ratios that characterize the comparative error inherent to the CEP method. These results demonstrate that the CEP methods, when applied to single cannon systems (field artillery pieces), lack validity (i.e., the results are fallacious). With respect to single FA cannon, the use of the CEP method to compute the SSHP, the ammunition expenditure necessary to obtain one or more target hits, and/or comparative probable effects does not reflect probabilities that are realistic. Moreover, the CEP method does not account for the orientation of the target relative to the direction of fire. In short, use of CEP with respect to single cannon does a great disservice to the capabilities inherent in a single cannon system to perform a precision destruction mission or to deliver a special munition.

c. CEP Vis-a-Vis a Cannon Battery. As demonstrated in the foregoing examples, the application of CEP to a single cannon is precluded because in cannon PE_r and PE_d do not approximate a ratio of 1:1. This 1:1 relationship is not necessarily precluded when a battery of cannon fires at an area target. The width of the battery front (or the intervals between pieces), the ability to open or close the sheaf, etc. all permit a ratio between the depth and width of the pattern of the fall of shot from a battery volley to approximate a 1:1 ratio (e.g., 0.5:1 to 1.5:1). Such degrees of correlation permit the assumption that a battery volley or salvo can be characterized by its MPI. It therefore follows that, with regard to a battery (not a single piece), CEP may be defined as the radius of a circle that contains 50% of all battery volley MPI, the mean of the pattern of distribution of these MPI representing the target center. One such CEP contains 50% of these battery volley MPI, two CEP includes 93.75%, three CEP includes 99.81%, and four CEP is assumed to contain 100% (3.78 CEP=100%). Application of this battery volley MPI-type CEP permits determination of the probability of the next effects pattern covering some selected percentage of the target area or the probability that the MPI of the next volley will impact within a circle of a particular radius. Although such determinations are of decided value in deriving probabilities for subsequently fired effects patterns of battery volleys (or salvos), such determinations are inapplicable to single cannon, which are the delivery means used for nuclear and precision destruction missions.

Table A-V-2. Recapitulation of Results Derived from Examples 1 Through 3 (U)

Example/ Description	Range (m)	Probable errors (m)			Area, 50% of fall of shot (m^2)			Single shot hit probability			
					Method			Target bias (θ in deg)	PE (%)	CEP (%)	Ratio (PE/ CEP)
		PE_r	PE_d	Ratio (PE_r/ PE_d)	PE	CEP	Ratio CEP/PE				
1. 155-mm M109A1, Ch 8 vs. 10-m-wide x 50-m-deep target	15 385	49.8	8.4	5.93	4 064	8 430	2.07	0	8.26	3.89	2.12
								45	6.49	3.89	1.69
2. 122-mm MRL, w/o spoiler ring	15 795	93	93	1.00	84 031	82 794	0.985	-	-	-	-
	20 176	78	147	0.53	111 400	121 155	1.088	-	-	-	-
3. 180-mm S-23 gun, full chg vs. 100-m-wide x 50-m-deep target	27 350	94	8.8	10.7	8 037	29 001	3.61	0	14.3	11.1	1.29
								30	16.4	11.1	1.48

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LIST OF ABBREVIATIONS

ACRV	armored command and reconnaissance vehicle
ACV	armored combat vehicle
alt	altitude
APC	armored personnel carrier
atch	attach(ed)
APDS	armor piercing discarding sabot (at shot)
ARVN	South Vietnamese Army
ASP	ammunition supply point
at, AT	antitank
BC	battery commander
BD	base direction (Soviet); also ''main'' or ''principal'' direction
bde	brigade
bn	battalion
BP	base point
btry	battery
C	change in angle of elevation necessary to effect a 100-meter change in range (also carbon and Celsius)
CEP	circular error probable
CG	center of gravity
CI	center of impact of fall of shot
ck pt	check point
CP	command post
CP-OP (or COP)	command post-observation post
DB	double base (propellant)
def	deflection
DEGN	dinitrodiglycol
div	division
DNT	dinitrotoluene
DS	direct support
ECC	Eurasian Communist countries
EDNA	Haleite
EFC	equivalent full charge (rounds); a measurement of tube wear and fatigue life
elev	elevation
f	fork, 4 probable errors
FA	field artillery
FDC	fire direction center
FDO	fire direction officer
FD	fire direction; fuze delay
FEBA	forward edge of the battle area

FO	forward observer
FROG	free rocket over ground (Soviet Honest John-like rocket)
FQ	fuze quick
g	gravity, gram
gp	group
GS	general support
GSR	general support reinforcing
GT	gun-target (line)
ha	hectare (100x100 meters, 2.47 acres)
HB	high burst
HCO	horizontal control operator
HE	high explosive
HMX	commonly termed: Cyclotetramethylenetetranitramine, hemocydonite, octogen, or octogine
ICM	improved conventional munitions
I_{sp}	specific impulse
K	coefficient of correction; K-factor; Kelvin
K_{Ic}	the fracture toughness of a material
KNO_3	saltpeter, potassium nitrate
L/D	length to diameter ratio
⋕	US artillery mil (1/6400 of a circle, 3.375'; 17.778 ⋕ = 1°)
M	Soviet artillery mil (1/6000 of a circle, 3.60'; 16.667 M = 1°); also model
max	maximum
MDT	mean downtime
met	meteorological
min	minimum
MMV	A transfer of fire made by using map data as corrected by met data plus deviation from standard V_o
MPI	Mean point of impact [of the dispersion pattern (fall of shot)]
MRL	multiple rocket launcher
MRLS	multiple rocket launcher system
MTBF	mean time between failures
MTTR	mean time to repair
NVA	North Vietnamese Army
N	nitrogen
NC	nitrocellulose
NG	nitroglycerine
obsn	observation
obsr	observer

OP	observation post
OT	observer-target (line)
PD	point detonating
PE_d	probable error, deflection
PE_{hob}	probable error, height of burst
PE_v	probable error, vertical (height)
PE_r	probable error, range
PETN	pentaerythritol tetranitrate; nitropentaerythrite
PETN/TNT	pentolite
pgnd	propaganda
PIBD	point initiating base detonating
PRC	People's Republic of China
QE	quadrant elevation
r	OT range
R	GT range
$\frac{r}{R}$	range coefficient
RAM-D	reliability, availability, maintainability, and durability
RAP	rocket assisted projectile
rd/min	rounds per minute
RDX	cyclonite
reinf	reinforce(ing)
regt	regiment(s)
rkt	rocket
rg	range
RP	registration point, reference point, release point
RSCP	division rear services command post (Warsaw Pact term)
RVGK	reserve of the supreme high command (Soviet term)
SCP	survey control point
SEA	Southeast Asia
si	site; i.e., angle of sight plus complementary angle of site
SOI	signal operating instructions
SOP	standing operating procedure
SSHP	single shot hit probability
SSI	standing signal instructions
SQ	superquick (fuze)
T	type; also see "angle T" in glossary
TA	target acquisition
tgt	target
TNT	trinitrotoluene
TOT	time on target; simultaneous attack of one target by several artillery units

trig	trigonometric, triangulation
US	United States
uhf	ultrahigh frequency
USSR	Union of Soviet Socialist Republics (Soviet Union)
V_o	Initial or muzzle velocity
VC	Viet Cong
VCO	vertical control operator
VE (ΔV_o)	velocity error; deviation from expected V_o
VT	proximity fuze
XO	executive officer
θ	theta; angle of incidence of longitudinal axis of a projectile to the horizontal. θ on the ascending leg and $-\theta$ on the descending leg of the trajectory

UNITS OF MEASURE

A	ampere
ac	alternating current
AM	amplitude modulation
Bhn	Brinell hardness number
C	Celsius; also Centigrade
°C	degree Celsius; degree Centigrade
cal	calorie
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
d	day
dc	direct current
dm^3	cubic decimeter
°F	degree Fahrenheit
FM	frequency modulation
ft	foot
ft^2	square foot
ft^3	cubic foot
ft-lb	foot-pound
ft/min	foot per minute
ft/s	foot per second
G	gauss
g	gram; gravity
gal	gallon
GHz	gigahertz, gigacycle per second

gr	grain
h	hour
ha	hectare
hf	high frequency
hp	horsepower
Hz	hertz (cycles per second)
in	inch
in^2	square inch
in^3	cubic inch
in-lb	inch-pound
J	joule (N·m)
K	kelvin [no degree symbol (°)]
k	kilo (10^3)
kg	kilogram
kHz	kilohertz (kilocycles per second)
km	kilometer (0.624 miles)
km^2	square kilometer
km^3	cubic kilometer
km/h	kilometer per hour
l	liter (i.e., dm^3)
lb	pound(s)
M	mega (10^6)
m	meter, also milli (10^{-3})
m^2	square meter
m^3	cubic meter
mbar	millibar
mi	mile (statute)
mi^2	square mile
mi/h	mile per hour
min	minute (time)
mm	millimeter
mm^2	square millimeter
mm^3	cubic millimeter
mo	month
ms	millisecond
μs	microsecond
N	newton ($kg \cdot m/s^2$)
N/m^2	newton per square meter
oz	ounce (avoirdupois)
Pa	pascal ($N \cdot m^2$)
pt	pint
qt	quart
R	roentgen
rad	radian
r/min	revolutions per minute
rms	root mean square

r/s	revolutions per second
s	second (time)
s-ft	second-foot
sr	steradian
t	tonne (2204.6 lb)
ton	ton (2000 lb)
uhf	ultrahigh frequency
V	volt
vhf	very high frequency
yd	yard
yr	year

GLOSSARY

accuracy (of delivery)	A measure of the ability to place projectiles on or about the point of aim (target). Accuracy is considered to have two components; i.e., miss distance between point of aim and the mean point of impact (MPI), together with the extent of the pattern of dispersion.
angle T	Angle of intersection of the gun-target (GT) and observer-target (OT) lines.
burst rate of fire	As applied to field artillery systems, the capability of a system to fire a particular number of rounds in a short period of time, e.g., 4 rd/11 s. This capability may necessitate that fuzes be set, propelling charges cut, and the first round be loaded prior to commencing fire.
C	Carbon
circular error probable (CEP)	The radius, in meters, of a circle within which there is a 50% probability the projectile will impact. CEP=0.8728 (PE_r+PE_d) when PE_d is greater than 0.2 PE_r, or, when PE_d is less than 0.2 PE_r, CEP = PE_r+0.2365 PE_d.
effective range	In this study that range at which the probability of a first round hit is 50% vs. a target of stated size.
fork	4 probable errors.
grazing range	Range at which the height of the trajectory does not exceed the height of the target.
K-transfer	A transfer of fires made, within prescribed limits, using corrections obtained from a registration.

lower register . . . . . Low angle fire; fire at elevations less than that required to attain maximum range; commonly, elevations of 45° or less.

MMV (transfer) . . . . . A transfer of fire made by using map data that are corrected for met effects plus any deviation from the expected initial (muzzle) velocity (V_o).

N . . . . . Nitrogen

precision . . . . . Round-to-round dispersion (a natural phenomena in external ballistics).

probable error . . . . . The error which is exceeded as often as it is not exceeded; a measure of precision (i.e., dispersion). Although some 11.5 PE_r and 11.5 PE_d contain 100% of the dispersion pattern, 8 PE commonly is used since 99.44% of the rounds fired are contained therein.

range coefficient . . . . . $\frac{r}{R}$ factor; $\frac{\text{OT range}}{\text{GT range}}$

S-factor . . . . . Deflection change in mils at the gun between two rounds which bracket the target and are 100 meters apart on the OT line.

sector . . . . . Soviet command and control group that supervised and coordinated the operations of two or more fronts during World War II.

sheaf . . . . . Lateral distribution of bursts from two or more pieces fired together.

shift . . . . . Change in deflection and range from base point (US) or base direction (Soviet) necessary to lay a piece on a particular target.

standard deviation (σ) . . . . . 1 PE = 0.6745 σ

strain	The unit change, due to force, in the length of a body referred to its original length. The ratio of the stress to the corresponding strain in the modulus of elasticity (ASTM Standard E6-66).
target location error	Error in location of the target center (deviation from its actual location on the ground).
upper register	High angle fire; firing conducted at elevations in excess of those necessary to attain maximum range.
yield strength (0.1%)	The stress at which a material exhibits a limiting deviation of 0.1% from the modulus of elasticity (proportionality of stress to strain). The 0.1% deviation is expressed in terms of strain (ASTM Standard E6-66).

LIST OF SYMBOLS

Compass

°	degree
'	minute
"	second

Electrical

↕	reaction goes both up and down

Mathematical

:	is to; ratio
÷	divided by
::	proportion; as
>	greater than
≥	greater than or equal to
<	less than
≤	equal to or less than
≠	not equal to
≈	nearly equal to
=	equal to
~	difference to
√	root
$\sqrt[2]{}$	square root
$\sqrt[3]{}$	cube root
π	pi
ε	base (2.718) of natural system of logarithms; epsilon
+	plus
−	minus
±	plus or minus
x	multiplied by
%	percent
∫	integral
∂ or σ	differential; variation
→	approaches limit of
∝	variation; varies as
Σ	summation of; sum; sigma

US VERSUS SOVIET TERMINOLOGY

US Term	Soviet Term
Angle T	target offset
axial (type of adjustment)	small displacement
base deflection	base direction
base piece	main gun
Coordinates, rectangular:	
x (Easting)	y (Easting)
y (Northing)	x (Northing)
z (altitude or vertical coordinate)	z (altitude or vertical coordinate)
deflection, followed by mils; i.e., def 2800	angle meter, followed by shift; i.e., right (or +) 01-76 (176 M)
direct fire	Case I gunnery (or firing)
elevation	sight
fuze	detonator
GT range (R)	gun-target range
gun positions (types):	
direct fire	open position
indirect fire or defiladed	closed, hidden, or concealed position
high angle fire	mortar fire
indirect fire	Case II gunnery (or firing)
large (or big)-T (type of adjustment)	large displacement
map data corrected by: VE, met, and registration corrections (or surveyed data)	deliberate preparation of data
"Partial," "old," "estimated" data, or map data uncorrected	hasty preparation of data (any data less precise than K-transfer or MMV data)
map features	local objects
measured angle	shift at OP from main direction to target
OT range (r)	observer-target range
panoramic sight	angle meter

preplanned battalion concentration within which each battery has a separate target center (such as in final defensive fires)	sector (plus a number)
range coefficient $\left(\frac{r}{R}\right)$	range coefficient
reference point	contour point
S-factor	shu
sheaf	sheaf
converged or closed	concentrated
open	wide
parallel	parallel
shift from base deflection	shift from base direction
site	level
up	up
down	down
small-T (type of adjustment)	medium displacement
time fire	grenade fire

STUDIES PERTINENT TO EURASIAN COMMUNIST FIELD ARTILLERY*

Attention is invited to the following studies. Readers seeking additional information in a particular subject area or more detailed technical characteristics of an artillery associated item of equipment should find that one or more of these studies address their requirements.

DDI-1100-2-75 (w/C1 and 2), Soviet Ground Force Organizational Guide, June 1975 (UNCLASSIFIED).

DST-1150S-028-76, Army Mobility (Current and Projected), Warsaw Pact, March 1976 (UNCLASSIFIED).

ST-CS-07-30-75, Ground Forces Materiel Readiness (Procedures and Methods), USSR, February 1975 (UNCLASSIFIED).

AST-1800S-100-75, USSR Ground Forces R&D Overview, 1975, November 1975 (UNCLASSIFIED).

DST-1740S-005-76 (w/C1), Ground-Based Sensors (Except Radar)--ECC, September 1976 (UNCLASSIFIED).

DST-1130S-120-75, Multiple Rocket Launcher Systems (Current and Projected), Eurasian Communist Countries, June 1975 (UNCLASSIFIED).

DST-1110S-011-75, Mortar Systems (Current and Projected)--Foreign, August 1975 (UNCLASSIFIED).

DST-1850W-022-76, Characteristics and Properties of Propellants Used in Rockets, Guns, and Small Arms; Foreign, May 1976 (UNCLASSIFIED).

DST-1160S-126-77, Antipersonnel and Armor-Defeating Ammunition Guide--Eurasian Communist Countries, January 1977 (UNCLASSIFIED).

DST-1120S-013-76, Combat Vehicle Systems (Current and Projected), Eurasian Communist Countries, May 1976 (UNCLASSIFIED).

ST-CS-07-140-72, Methods and Equipment for Artillery Survey--Foreign, December 1971 (UNCLASSIFIED).

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*All titles are UNCLASSIFIED.

ST-CS-05-09-75, Radar (Battlefield-Associated) Eurasian Communist Countries, December 1975 (UNCLASSIFIED).

ST-HB-05-02 C72, VOL 1, Military Communications Equipment Handbook--Eurasian Communist Countries; Volume 1, Soviet Communication Equipment, January 1975 (UNCLASSIFIED).

AST-1731S-100-76, Soviet Radioelectronic Combat Capability, November 1976 (UNCLASSIFIED).

DST-2610S-526-76, Automated Support to Warsaw Pact Command and Control, June 1976 (UNCLASSIFIED).

AST-1100W-100-75, Brief Directory of Soviet Design-Documentation Terminology, September 1975 (UNCLASSIFIED).

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