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TECHNICAL MEMORANDUM
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SURVEY OF ALLIED TANK CASUALTIES IN WORLD WAR II

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BY
ALVIN D. COOX
AND
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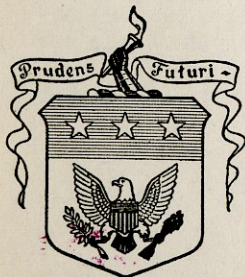
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SUBJECT: Request for Declassification of Document IAW EO 12065(U)

Commandant
US Army Military History Institute
ATTN: Sp5 Brown
Carlisle Barracks, PA 17013

The attached document, which you forwarded for declassification review on 17 October 1980, has been reviewed, and is declassified and returned herewith.

Sincerely,

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Chief, Declassification Opns Br
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TO: Recipients of ORO-T-117

SUBJECT: Corrigenda

1. Table I of ORO-T-117 is in error, relative to the breakdown of US and UK tank casualties in Western Europe. A corrected copy of this table has been prepared and is herewith distributed to all recipients of ORO-T-117.

2. None of the data in the very important Table II are in any way invalidated by the corrections in Table I.

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Technical Memorandum

← SURVEY OF ALLIED TANK CASUALTIES IN WORLD WAR. II

by

Alvin D. Coox
and

L. Van Loan Naisawald

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The authors wish to express their appreciation and thanks to a number of US and foreign agencies and sources for extremely valuable data and material. Cooperation was the keynote of relations with the personnel involved and contributed immeasurably to the successful completion of this paper.

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We are also particularly indebted to the personnel of our own library staff of the Operations Research Office, the Johns Hopkins University, Washington, D.C., for helpful contributions in time and material.

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SURVEY OF ALLIED TANK CASUALTIES IN WORLD WAR II

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SURVEY OF ALLIED TANK CASUALTIES IN WORLD WAR II

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SUMMARY

PROBLEM

The purpose of this study is to present a detailed analysis of Allied tank casualties in World War II.

FACTS

The present study analyzes every cause of tank casualties, based upon a sample of 12,140 Allied tanks. This sample was derived from US, British, Canadian, and French records, from every theater of operations.

DISCUSSION

An historical analysis of World War II records provides one method of assessing the effectiveness of tanks and of measuring their vulnerability. In this study a tank casualty was considered to be any tank unavailable for a firefight or for movement in a battle area. Immobilization, whether soon repairable or not, might result from an enemy weapon, friendly weapon, accident, mechanical failure, capture, self-destruction, bogging, or abandonment. No armored cars, tank destroyers, self-propelled artillery, or motor transport, were considered.

The incompleteness of the Allies' historical records of armored units in World War II obviated any attempt to separate tank casualties from gunfire into categories, e.g., "tank," "antitank," or "artillery." The following breakdown to all causes was devised:

1. Gunfire.
2. Land mines.
3. Hollow charge weapons.
4. Miscellaneous weapons, or combinations involving a weapon.
5. Non-weapon causes, e.g., mechanical failure or bogged down.
6. Mortared.
7. Unknown.

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CONCLUSIONS

In descending order of incidence, the following accounted for tank casualties in the sample studied:

1. Gunfire exacted the highest over-all percentage (54 percent) of tank casualties in all theaters.
2. Land mines immobilized a fairly consistent 20 percent in all theaters.
3. Mechanical, terrain, and other non-enemy weapon causes immobilized 13 percent of the sample studied. This figure is low. British and US Army data were concerned only with weapon damage. Canadian Army and US Marine Corps data appear to suggest a much more accurate figure of 25 to 40 percent.
4. Hollow charge weapons exacted the comparatively high toll of 7.5 percent, considering that this weapon was not in general use by the enemy in North Africa or the Pacific. An adjusted sample, to include only Western Europe and Italy, would give a somewhat more accurate over-all percentage. From a toll of 10 percent at the time of its introduction in early 1944, the Panzerfaust type of weapon went on to attain a peak of effectiveness in the spring of 1945 of from 25 to 35 percent of all tank casualties.
5. Miscellaneous weapons or combinations of enemy weapons accounted for 5.5 percent of the tank casualties in the total sample. Enemy air attack knocked out a negligible share of the percentage. The Pacific fighting accounted for a very large number of the tanks knocked out by two or more enemy weapons. The Japanese, lacking armor and massed artillery, resorted to such combinations as improvised mines, satchel charges, pole charges, and "Molotov cocktails."

Figures 14 through 19 indicate the following relationships between the type of Allied armored operations and the causes of tank casualties sustained in each phase:

1. Gunfire, both numerically and percentagewise, exacted the highest over-all toll of tank casualties. "Peaks" in the gunfire rates were usually accompanied by a downward trend in the mine casualty rate. As might be expected, gunfire hit these "peaks" in every period of heavy armored engagement.
 2. Hollow charge weapons fluctuated at a very low level of effectiveness before reaching peaks. In Italy, this peak
- 

reached 20 to 25 percent in the spring of 1945, after the crossing of the Po River. In Western Europe similar peaks were attained during the periods of the breakthrough from Normandy, the Ardennes, and the final offensive east of the Rhine River. Toward the end of the war the incidence of tanks immobilized by Panzerfaust weapons, during offensive and pursuit operations, reached the toll of 25 to 35 percent of all tank casualties. This development was influenced by the decrease in the numbers of tanks and antitank guns available; by terrain and localities more favorable to rocket type weapons; and by the increased numbers of Panzerfaust weapons available to the enemy.

3. Land mine warfare indicated an increased number of mines employed by the Axis powers. The variations in incidence of tanks immobilized by mines were closely related to the type of opposition encountered. In North Africa, the highest losses were suffered during offensive and breaching operations, e.g., El Alamein and the Mareth Line, and during retreats when Allied armor had to traverse uncharted mine fields. The difficult terrain in Italy, on the other hand, caused higher tolls during periods of normal pursuit through defiles and across streams. The lower mine losses during assaults on fortified lines may have been due to the fact that other weapons exacted a much higher toll, because of heavy concentrations of enemy armor and antitank guns. Operations in Western Europe showed that winter phases cost more mined tanks during operations against enemy defensive positions. The decreased tank casualties to mines in the final stages of the Western European campaign seemed to indicate that the enemy could not lay mines because so many of his troops were attempting to get out up to the very last minute. This would suggest that one of the advantages of speed in the pursuit is the decrease in mine casualties.

4. The Canadian sample provided the only detailed data from which conclusions may be drawn concerning the toll exacted by non-enemy causation. The figures show the very high proportion immobilized by this factor, in relation to all other causes, during offensive and pursuit operations; thus, during the breaching of the Gustav Line in Italy, terrain and mechanical failures accounted for twice the toll exacted by the usually highest causative agent--gunfire.

A study of the average range at which tanks were knocked out by guns or tanks, in all theaters, indicated a figure of 785 yards; the range for hollow charge attack averaged 50 yards for all theaters.

The site of hits upon tanks immobilized by gunfire was apportioned between the turret, 31 percent; the hull, 52 percent;

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and the suspension system, 17 percent. For hollow charge attack the equivalent sites were 44 percent on the turret, 48 percent on the hull, and 8 percent on the suspension system.

Of the sample hit by enemy gunfire, medium guns knocked out 90 percent; light guns, 6 percent; and heavy guns, 3 percent. The 75-mm and the 88-mm guns accounted for 86 percent of the total gunfire sample, i.e., 36 percent and 50 percent respectively.

Causes of burned tanks, in descending order of incidence, were: gunfire, 65 percent of which burned; hollow charge, 61 percent; mines, 21 percent.

Data on the repairability of tanks suggested the following percentages: mined tanks, 78 percent repairable; Panzerfaust weapons, 71 percent; and gunfire, 51 percent. Because of differing samples, no direct correlation could be established between the percentage burned and the percentage repairable.

Historical data for the establishment of exchange factors were available only for land mine correlations. Despite vigorous Allied countermasures, one British or Soviet tank was immobilized for approximately every 2000 Axis land mines originally laid at El Alamein and Targul Frumos, respectively. Another study, in the European Theater—the Aachen-Eschweiler operation—indicated a ten-fold increase in the toll exacted from US tanks.

Less complete data on German tank casualties indicated that the causes of immobilization, in descending order of incidence, were as follows: gunfire, 44 percent; self-destruction, 20.8 percent; abandonment, 18.4 percent; air attack, 8 percent; hollow charge, 4.5 percent; mechanical, 4.1 percent; and mines and miscellaneous weapons, 1 percent.

Limited data on Allied tank crew casualties indicated that an average of 2.0 to 2.5 crewmen per tank became casualties, including killed, wounded, and missing-in-action, to attack by gunfire, hollow charge, or mines. A breakdown of these figures by crew position revealed only slight differences. Tank commanders suffered the highest over-all casualty rate—57 percent—of those engaged. The gunners and cannoners followed with 51 percent, while the hull positions suffered somewhat less—bow gunners, 48 percent, and drivers, 47 percent. Thus, no one crew position was markedly "safer" than another. An important corollary to this conclusion emerged from another sample studied; namely, that casualties to tank personnel, wholly outside their vehicles, amounted to 40 percent of the total casualties sustained. Of this figure, 30 percent, or 11 percent of the total, became casualties while trying to escape from immobilized tanks.

While it is recognized that the writing and maintenance of historical records command a secondary role within combat units, it is felt that the best needs of the Army would be met if the records lent themselves to operational analysis. Col. C. P. Stacey, Director of the Historical Section of the Canadian Army, in an article appearing in the Canadian Army Journal in 1950, defined the problem succinctly: "A War diary can serve its purposes only if it is written up promptly, accurately, and frankly. It is essential that the unit should record its operations and activities in as great detail as possible and record them the same day on which they take place."

Historical and analytical guidance should go far to improve the existing type of records; thus, the work of the British Army's Operational Research Group teams with the 21 Army Group in World War II, and of the US Army's Operations Research Office teams with the Far East Command during the recent Korean fighting, has emphasized the military value of data collection and analysis under combat conditions.

(Note: Figures 1 through 8, which follow, graphically portray the major conclusions of the Summary and of the body of the text.)

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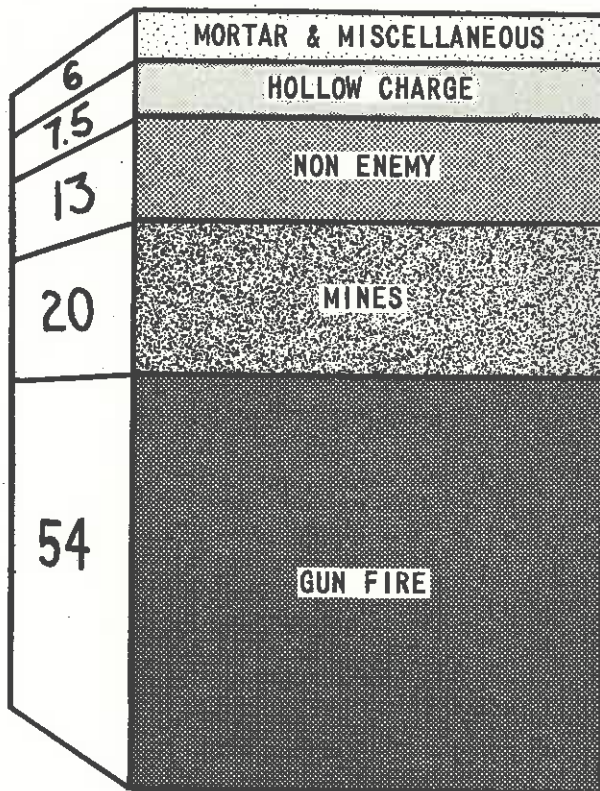
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TANK CASUALTIES



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Figure 1. An analysis of a sample of Allied tank casualties, showing the percentage of losses by cause.

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AVERAGE GUNFIRE RANGE

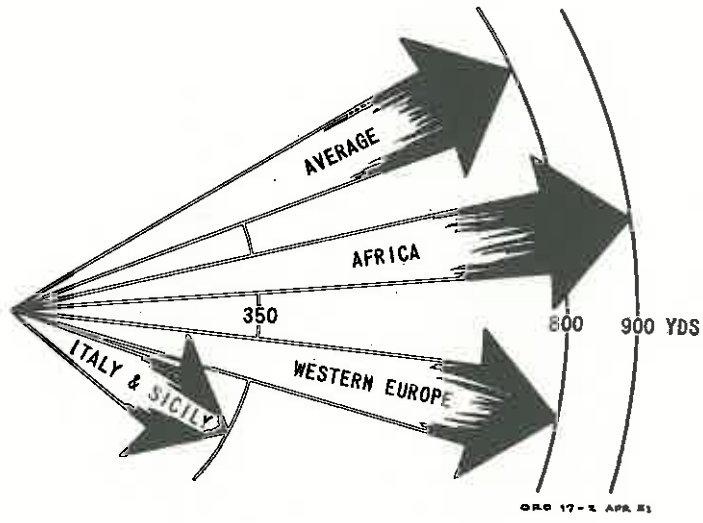


Figure 2. Average ranges at which tanks were immobilized by gunfire, as derived from data covering Allied experience in Western Europe, Africa, Italy, and Sicily.

**AVERAGE BAZOOKA RANGE
(all theaters)**

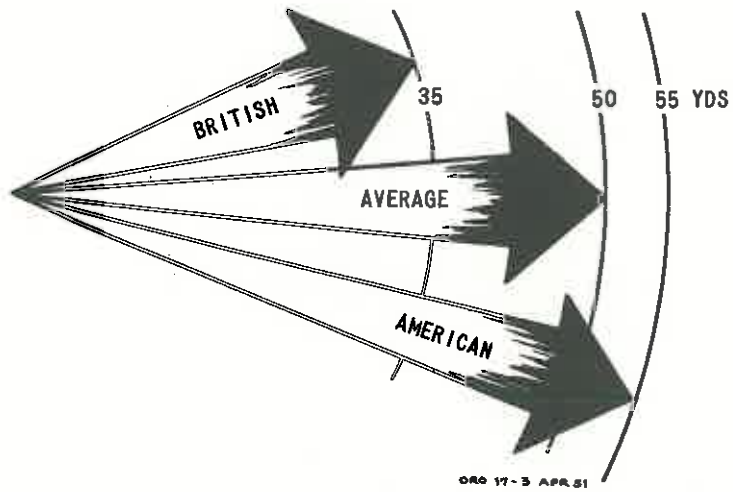


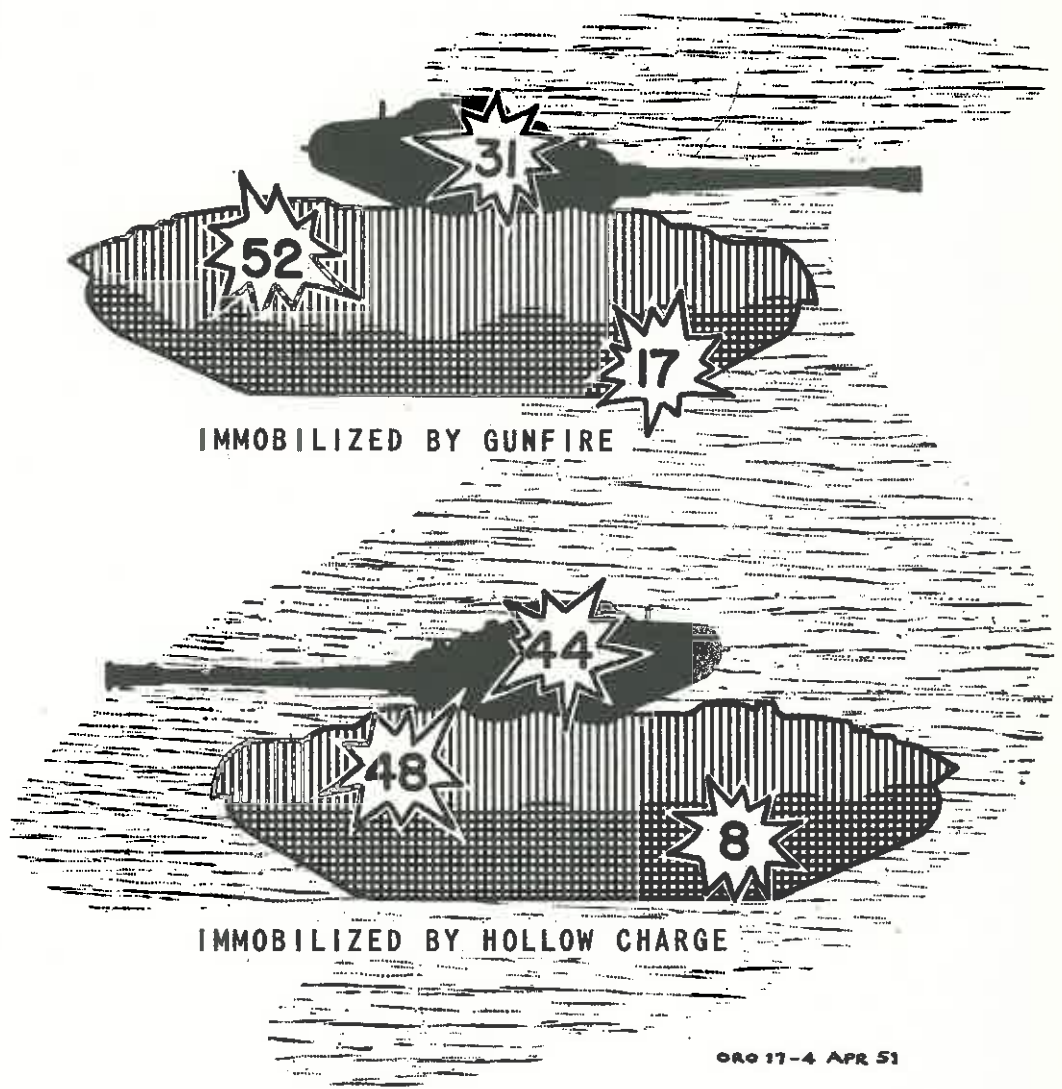
Figure 3. Average range at which tanks were immobilized by hollow charge weapons, as experienced in all theaters of war.

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SITE OF HITS



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Figure 4. Percentage of area hits inflicted by artillery and hollow charge weapons, taken from a sample of 150 allied tank casualties.

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CALIBER OF ENEMY GUNFIRE

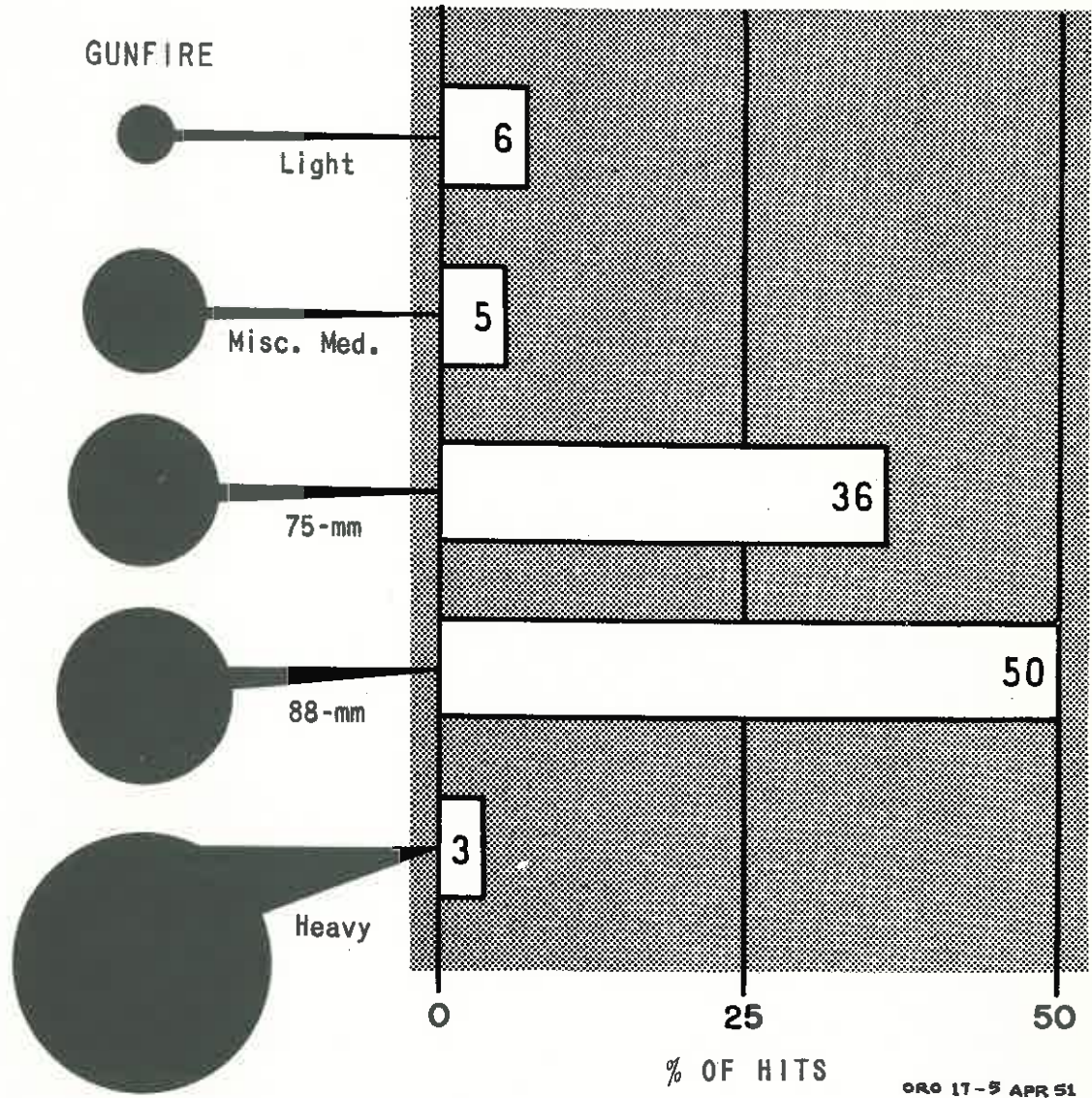
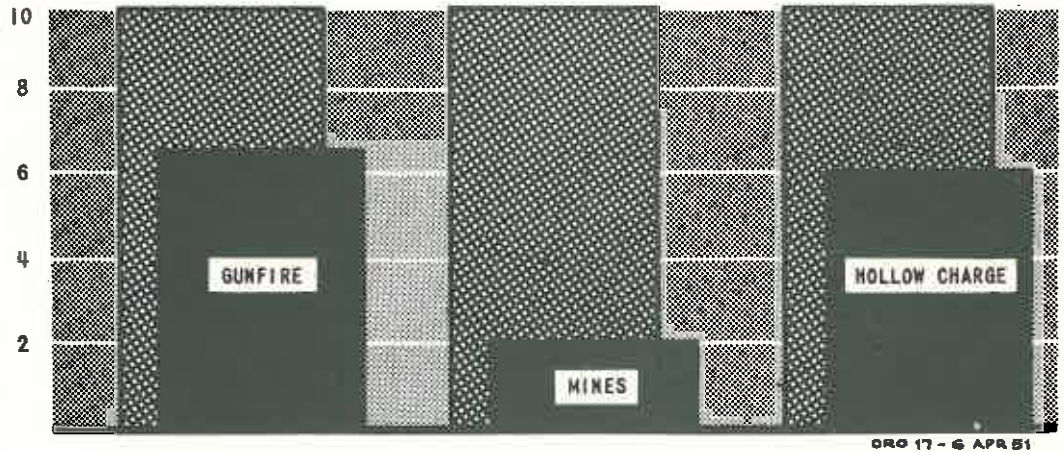


Figure 5. An analysis by percentage of the caliber of enemy guns inflicting critical hits.

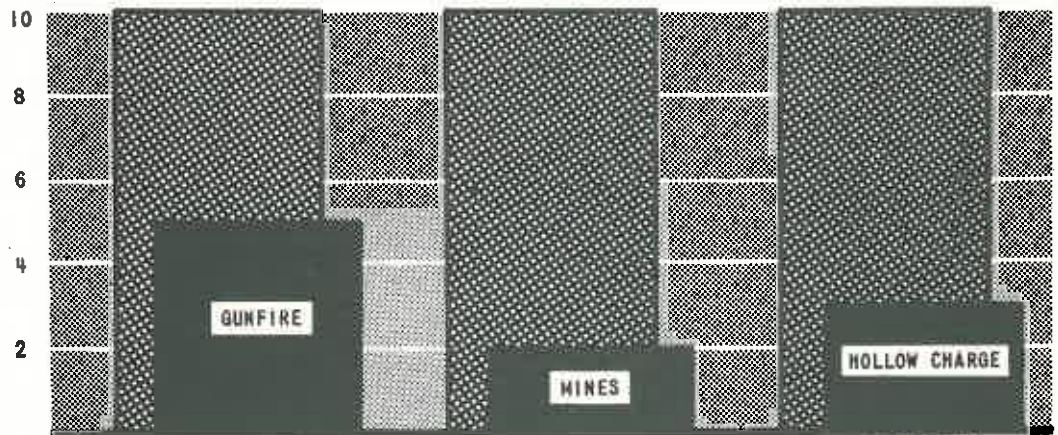
NUMBER OF
BURNED TANKS



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Figure 5a. SAMPLING OF TANKS WHICH BURNED INDICATING IN EACH SAMPLING THE TANKS IMMOBILIZED BY, GUNFIRE, MINES, AND HOLLOW CHARGE.

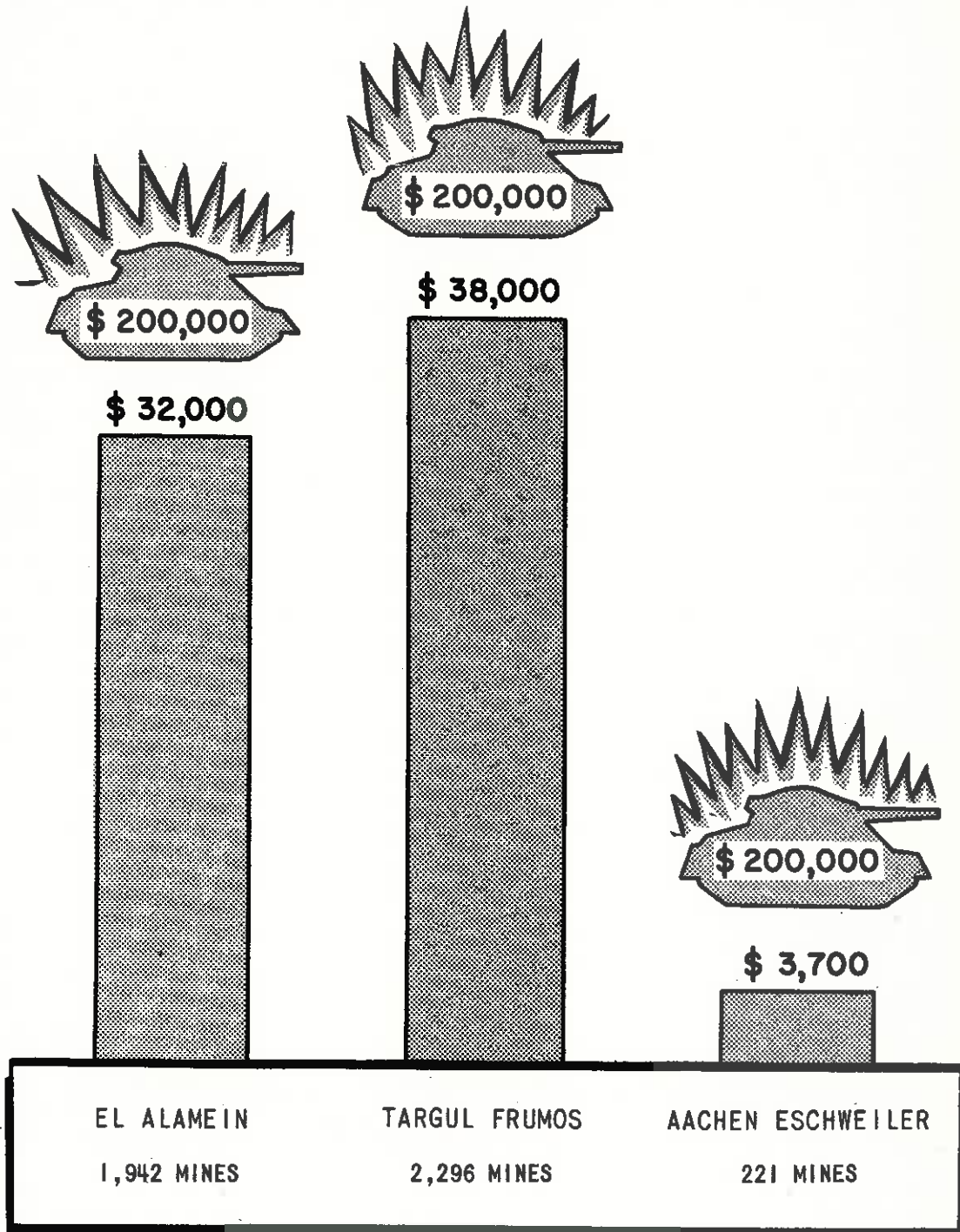
NUMBER OF
UNREPAIRABLE
TANKS



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Figure 5b. SAMPLING OF TANKS UNREPAIRABLE INDICATING IN EACH SAMPLING THE TANKS IMMOBILIZED BY, GUNFIRE, MINES, AND HOLLOW CHARGE.

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Figure 6. Mines vs Tanks (Exchange Rates)

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GERMAN TANK CASUALTIES

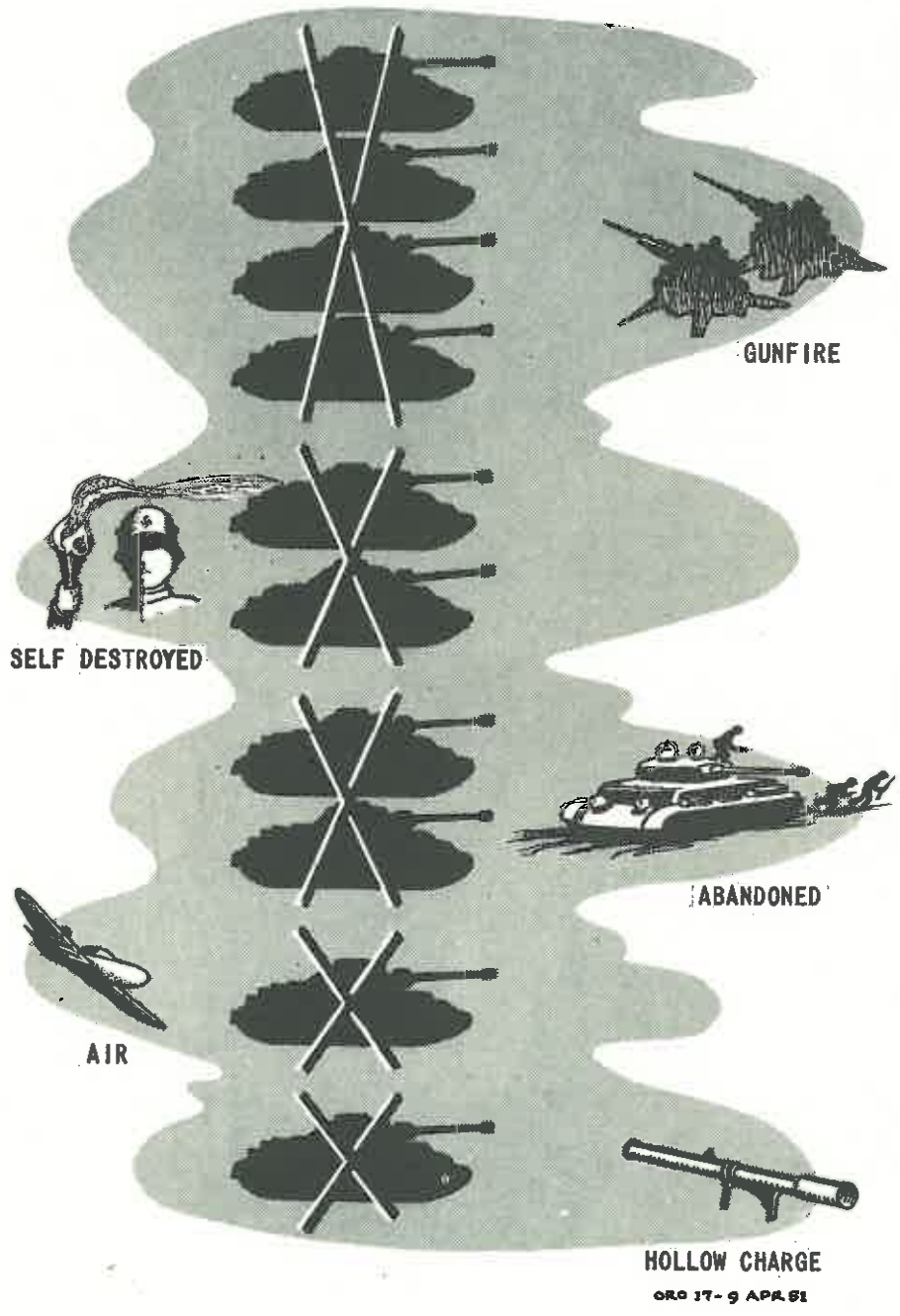
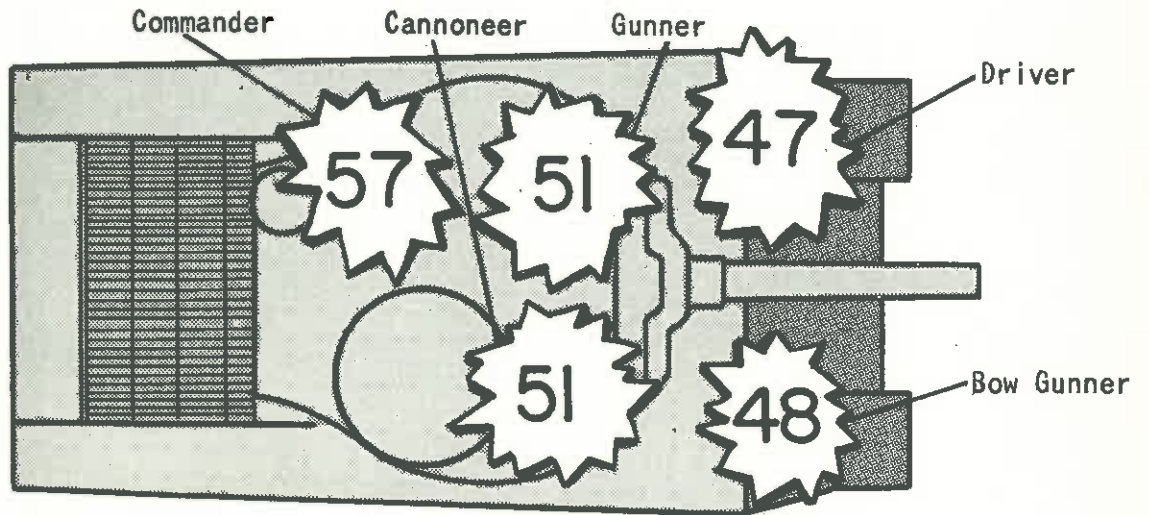


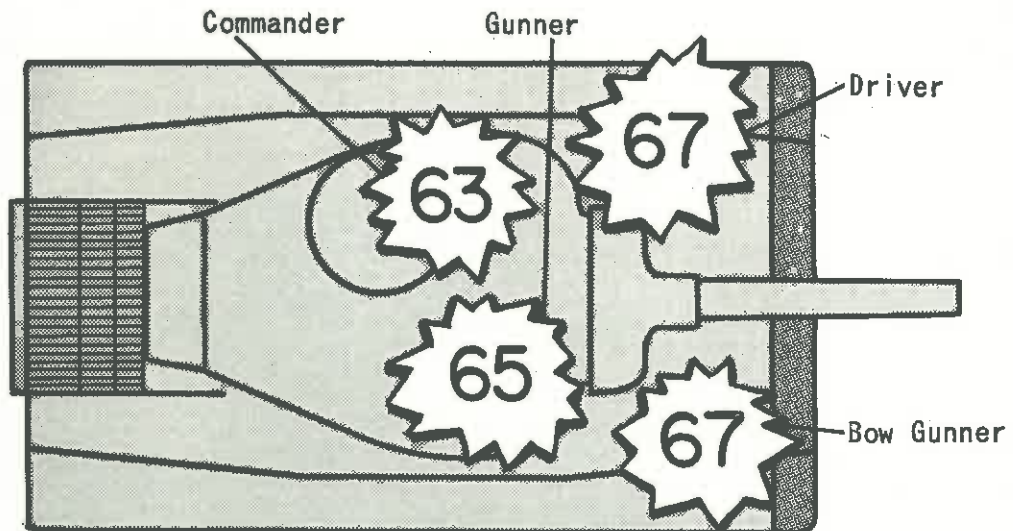
Figure 7. An analysis of German tank losses due to various causes inflicted by US, Canadian, British, and French forces.

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CREW CASUALTIES BY POSITION



MEDIUM TANK



LIGHT TANK

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Figure 8. Percentage of tank crew casualties broken down by crew position.



CAUSATION

GUNFIRE

Conventional tank and antitank artillery, as well as field artillery, accounted for a plurality of tank casualties inflicted in every theater of operations in World War II: 50 percent in Western Europe, 80 percent in North Africa, 45 percent in Italy, and 35 percent in the Pacific fighting. The over-all average for 10,500 known US, British, Canadian, and French tank casualties was about 55 percent for all theaters. (See Tables I and II.)

No clear-cut breakdown of the gunfire category was possible. The following list of the reported causes of tank casualties in one Army (US) and one Theater (ETO) serves to illustrate the wide divergence of nomenclature and the resultant difficulty in accurately evaluating reported data:

- | | |
|------------------------------------|--------------------------------|
| 1. Tank | 26. Antitank and Artillery |
| 2. Antitank | 27. HE |
| 3. Artillery | 28. AP |
| 4. Gunfire | 29. HE and AP |
| 5. Shellfire | 30. Mine + Artillery |
| 6. Tank or Assault Gun | 31. Mine + Antitank |
| 7. Assault Gun | 32. Railroad Gun |
| 8. Antitank and Bazooka | 33. Bugged + Artillery |
| 9. Direct Fire | 34. Bugged + Antitank |
| 10. Self-propelled Gun | 35. White Phosphorus |
| 11. Self-propelled Gun + Artillery | 36. 57-mm |
| 12. Tank or Antitank | 37. 75-mm SP |
| 13. Tank and Artillery | 38. 76-mm SP |
| 14. 75-mm | 39. 76-mm |
| 15. 88-mm Antitank | 40. 20-mm |
| 16. Antitank and Tank | 41. 240-mm |
| 17. 88-mm Tank | 42. 50-mm |
| 18. 75-mm Tank | 43. 105-mm SP |
| 19. 75-mm Antitank | 44. Antitank or SP |
| 20. 88-mm | 45. Tank + Antitank + Bazooka |
| 21. 40-mm | 46. Tank + Antitank + SP |
| 22. 105-mm | 47. Tank + Antitank + Infantry |
| 23. 155-mm | 48. Infantry |
| 24. Mortar | 49. High Velocity Fire |
| 25. Mortar and Artillery | 50. Small Arms |

In the case of gunfire, the tactics and available armament of the enemy played a great role, as did terrain. Thus in North Africa, where the Western Allies encountered their greatest armored opposition, gunfire and mines accounted for an overwhelming share

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TABLE 1

SAMPLING OF ALLIED TANK CASUALTIES TO ALL CAUSES - WORLD WAR II

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
THEATER OF OPERATIONS	TOTAL SAMPLE WITHIN THEATER	TOTAL NUMBER OF KNOWN CASUALTIES IN THEATER	TOTAL NUMBER OF UNKNOWN CASUALTIES IN THEATER	PERCENT OF KNOWN WITHIN (2)	PERCENT OF UNKNOWN WITHIN (2)	NUMBER MINED WITHIN (2)	NUMBER MINED AS PERCENT OF (3)	NUMBER HOLLOW CHARGE WITHIN (2)	NUMBER HOLLOW CHARGE AS PERCENT OF (3)	NUMBER GUNFIRE WITHIN (2)	NUMBER GUNFIRE AS PERCENT OF (3)	NUMBER MORTARED WITHIN (2)	NUMBER MORTARED AS PERCENT OF (3)	MISC ENEMY WEAPON WITHIN (2)	MISC ENEMY WEAPON AS PERCENT OF (3)	MISC NON-ENEMY WEAPON WITHIN (2)	MISC NON-ENEMY WEAPON AS PERCENT OF (3)
WESTERN EUROPE																	
US - 1944	2579	2065	514	80.1%	19.9%	375	18.2%	236	11.4%	1051	50.9%	16	0.8%	95	4.6%	292	14.1%
US - 1945	1678	1383	295	82.4%	17.6%	239	17.3%	176	10.5%	687	40.9%	9	0.5%	48	3.5%	224	16.2%
UK - 1944	1103	1048	55	95.0%	5.0%	293	28.0%	56	5.3%	621	59.2%	7	0.7%	50	4.8%	21	2.0%
UK - 1945	582	574	8	98.6%	1.4%	126	22.0%	123	21.4%	308	53.6%	0	.0%	17	3.0%	0	.0%
Canada - 1942	30	26	4	86.7%	13.3%	0	.0%	0	.0%	19	73.1%	0	.0%	2	7.7%	5	19.2%
Canada - 1944	473	294	179	62.2%	37.8%	37	12.6%	14	4.8%	161	54.8%	4	1.4%	12	4.1%	66	22.4%
Canada - 1945	342	301	41	88.0%	12.0%	37	12.3%	32	10.6%	99	32.9%	4	1.3%	17	5.6%	112	37.2%
NORTH AFRICA																	
US - 1942	72	37	35	51.4%	48.6%	1	2.7%	0	.0%	23	62.2%	0	.0%	1	2.7%	12	32.4%
US - 1943	205	81	124	39.5%	60.5%	18	22.2%	0	.0%	36	44.4%	0	.0%	13	16.0%	14	17.3%
UK - 1941	413	413	0	100.0%	.0%	30	7.3%	0	.0%	357	86.4%	1	0.2%	25	6.1%	0	.0%
UK - 1942	1123	1123	0	100.0%	.0%	188	16.7%	0	.0%	884	78.7%	1	0.1%	49	4.4%	1	0.1%
UK - 1943	182	182	0	100.0%	.0%	42	23.1%	0	.0%	140	76.9%	0	.0%	0	.0%	0	.0%
France - 1943	39	39	0	100.0%	.0%	9	23.1%	0	.0%	30	76.9%	*	*	0	.0%	**	**
SICILY																	
US - 1943	58	21	37	36.2%	63.8%	2	9.5%	0	.0%	10	47.6%	0	.0%	5	23.8%	4	19.0%
UK - 1943	31	31	0	100.0%	.0%	7	22.6%	0	.0%	23	74.2%	0	.0%	1	3.2%	0	.0%
Canada - 1943	20	20	0	100.0%	.0%	9	45.0%	0	.0%	6	30.0%	0	.0%	1	5.0%	4	20.0%
ITALY																	
US - 1943	55	44	11	80.0%	20.0%	8	18.2%	0	.0%	18	40.9%	0	.0%	1	2.3%	17	38.6%
US - 1944	471	407	64	86.4%	13.6%	87	21.4%	12	2.9%	180	44.2%	3	0.7%	22	5.4%	103	25.3%
US - 1945	159	137	22	86.2%	13.8%	42	30.7%	25	18.2%	26	19.0%	0	.0%	14	10.2%	30	21.9%
UK - 1943	128	109	19	85.2%	14.8%	39	35.8%	0	.0%	60	55.0%	1	0.9%	3	2.8%	6	5.5%
UK - 1944	652	521	131	79.9%	20.1%	118	22.6%	47	9.0%	309	59.3%	12	2.3%	17	3.3%	18	3.5%
UK - 1945	115	98	17	85.2%	14.8%	25	25.5%	12	12.2%	57	58.2%	0	.0%	4	4.1%	0	.0%
Canada - 1943	73	66	7	90.4%	9.6%	18	27.3%	0	.0%	21	31.8%	2	3.0%	3	4.6%	22	33.3%
Canada - 1944	631	488	143	77.3%	22.7%	72	14.8%	10	2.0%	146	29.9%	2	0.4%	12	2.5%	246	50.4%
Canada - 1945	15	13	2	86.7%	13.3%	3	23.1%	2	15.4%	3	23.1%	0	.0%	0	.0%	5	38.5%
BURMA																	
UK + India - 1945	102	95	7	93.1%	6.9%	19	20.0%	9	9.5%	64	67.4%	*	*	3†	3.2%†	**	**
PACIFIC																	
Guadalcanal (USMC) - 1942	5	5	0	100.0%	.0%	1	20.0%	0	.0%	3	60.0%	0	.0%	1	20.0%	0	.0%
Bougainville (USMC) - 1943	2	2	0	100.0%	.0%	0	.0%	0	.0%	2	100.0%	0	.0%	0	.0%	0	.0%
Tarawa (USMC) - 1943	33	33	0	100.0%	.0%	0	.0%	0	.0%	6	18.2%	2	6.1%	2	6.1%	23	69.7%
Saipan (USMC) - 1944	38	27	11	71.1%	28.9%	3	11.1%	0	.0%	2	7.4%	0	.0%	5	18.5%	17	63.0%
New Britain (USMC) - 1944	5	5	0	100.0%	.0%	1	20.0%	0	.0%	0	.0%	0	.0%	0	.0%	4	80.0%
Kwajalein & Solomons (USA) - 1944	9	9	0	100.0%	.0%	0	.0%	0	.0%	1	11.1%	0	.0%	0	.0%	8	88.9%
New Guinea (USMC) - 1944	3	3	0	100.0%	.0%	0	.0%	0	.0%	0	.0%	0	.0%	0	.0%	3	100.0%
Guam (USMC) - 1944	42	33	9	78.6%	21.4%	9	27.3%	0	.0%	12	36.4%	0	.0%	2	6.1%	10	30.3%
Tinian (USMC) - 1944	15	15	0	100.0%	.0%	5	33.3%	0	.0%	4	26.7%	0	.0%	6	40.0%	0	.0%
Philippine Islands (USA) - 1944-45	145	136	9	93.8%	6.2%	58	42.6%	0	.0%	40	29.4%	2	1.5%	25	18.4%	11	8.1%
Iwo Jima (USMC) - 1945	137	129	8	94.2%	5.8%	40	31.0%	0	.0%	44	34.1%	5	3.9%	10	7.8%	30	23.3%
Okinawa (USA) - 1945	239	239	0	100%	0	55	23.0%	0	0	93	38.9%	5	2.1%	67	28.0%	19	7.9%
Okinawa (USMC) - 1945	136	136	0	100%	0	42	30.9%	0	0	54	39.7%	1*	0.7%*	27	19.9%	12	8.8%
Okinawa (USMC + USA) - 1945	375	375	0	100.0%	.0%	97	25.9%	0	.0%	147	39.2%	6*	1.6%*	94	25.1%	31	8.3%

KEY: * = Unknown number included in gunfire sample † = Estimate ** = Unknown

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TABLE II
SAMPLING OF ALLIED TANK CASUALTIES TO ALL CAUSES - WORLD WAR II

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
THEATER OF OPERATIONS	TOTAL SAMPLE WITHIN THEATER	TOTAL NUMBER KNOWN CASUALTIES IN THEATER	TOTAL NUMBER UNKNOWN CASUALTIES IN THEATER	PERCENT OF KNOWN WITHIN (2)	PERCENT OF UNKNOWN WITHIN (2)	NUMBER MINED WITHIN (2)	NUMBER MINED AS PERCENT OF (3)	NUMBER HOLLOW CHARGE WITHIN (2)	NUMBER HOLLOW CHARGE AS PERCENT OF (3)	NUMBER GUNFIRE WITHIN (2)	NUMBER GUNFIRE AS PERCENT OF (3)	NUMBER MORTARED WITHIN (2)	NUMBER MORTARED AS PERCENT OF (3)	MISC ENEMY WEAPON WITHIN (2)	MISC ENEMY WEAPON AS PERCENT OF (3)	MISC NON-ENEMY WEAPON WITHIN (2)	MISC NON-ENEMY WEAPON AS PERCENT OF (3)
WESTERN EUROPE																	
US - 1944-45	4,257	3,448	809	81.0%	19.0%	614	17.8%	412	11.9%	1,738	50.4%	25	0.7%	143	4.1%	516	15.0%
UK - 1944-45	1,685	1,622	63	96.3%	3.7%	419	25.8%	179	11.0%	929	57.3%	7	0.4%	67	4.1%	21	1.3%
Canada - 1942, 1944-45	845	621	224	73.5%	26.5%	74	11.9%	46	7.4%	279	44.9%	8	1.3%	31	5.0%	183	29.5%
COMBINED TOTALS	6,787	5,691	1,096	83.9%	16.1%	1,107	19.5%	637	11.2%	2,946	51.8%	40	0.7%	241	4.2%	720	12.6%
NORTH AFRICA																	
US - 1942-43	277	118	159	42.6%	57.4%	19	16.1%	0	0.0%	59	50.0%	0	0.0%	14	11.9%	26	22.0%
UK - 1941-43	1,718	1,718	0	100.0%	0.0%	260	15.1%	0	0.0%	1,381	80.4%	2	0.1%	74	4.3%	1	0.1%
France - 1943	39	39	0	100.0%	0.0%	9	23.1%	0	0.0%	30	76.9%	*	*	0	0.0%	**	**
COMBINED TOTALS	2,034	1,875	159	92.2%	7.8%	288	15.4%	0	0.0%	1,470	78.4%	2	0.1%	88	4.7%	27	1.4%
SICILY																	
US - 1943	58	21	37	36.2%	63.8%	2	9.5%	0	0.0%	10	47.6%	0	0.0%	5	23.8%	4	19.0%
UK - 1943	31	31	0	100.0%	0.0%	7	22.6%	0	0.0%	23	74.2%	0	0.0%	1	3.2%	0	0.0%
Canada - 1943	20	20	0	100.0%	0.0%	9	45.0%	0	0.0%	6	30.0%	0	0.0%	1	5.0%	4	20.0%
COMBINED TOTALS	109	72	37	66.1%	33.9%	18	25.0%	0	0.0%	39	54.2%	0	0.0%	7	9.7%	8	11.1%
ITALY																	
US - 1943-45	685	588	97	85.8%	14.2%	137	23.3%	37	6.3%	224	38.1%	3	0.5%	37	6.3%	150	25.5%
UK - 1943-45	895	728	167	81.4%	18.6%	182	24.9%	59	8.1%	426	58.3%	13	1.8%	24	3.3%	24	3.3%
Canada - 1943-45	719	567	152	78.9%	21.1%	93	16.4%	12	2.1%	170	30.0%	4	0.7%	15	2.6%	273	48.1%
COMBINED TOTALS	2,299	1,883	416	81.9%	18.1%	412	21.9%	108	5.7%	820	43.5%	20	1.1%	76	4.0%	447	23.7%
BURMA																	
UK + India - 1945	102	95	7	93.1%	6.9%	19	20.0%	9	9.5%	64	67.4%	*	*	3†	3.2%†	**	**
PACIFIC																	
US Army - 1944-45	393	384	9	97.7%	2.3%	113	29.4%	0	0.0%	134	34.9%	7	1.8%	92	24.0%	38	9.9%
USMC - 1942-45	416	388	28	93.3%	6.7%	101	26.0%	0	0.0%	127	32.7%	8*	2.1%*	53	13.7%	99	25.5%
COMBINED USMC + USA	809	772	37	95.4%	4.6%	214	27.7%	0	0.0%	261	33.8%	15	1.9%	145	18.8%	137	17.7%
ALL THEATERS																	
US - 1942-45	6,086	4,947	1,139	81.3%	18.7%	986	19.9%	449	9.1%	2,292	46.3%	43	0.9%	344	7.0%	833	16.8%
UK - 1941-45	4,431	4,194	237	94.7%	5.3%	887	21.1%	247	5.9%	2,823	67.3%	22*	0.5%*	169†	4.0%	46	1.1%
Canada - 1942-45	1,584	1,208	376	76.3%	23.7%	176	14.6%	58	4.8%	455	37.7%	12	1.0%	47	3.9%	460	38.1%
France - 1943	39	39	0	100.0%	0.0%	9	23.1%	0	0.0%	30	76.9%	*	*	0	0.0%	**	**
GRAND TOTAL	12,140	10,388	1,752	85.6%	14.4%	2,058	19.8%	754	7.3%	5,600	53.9%	77*	0.7%*	560†	5.4%†	1,339	12.9%

KEY: * = Unknown number included in gunfire sample † = Estimate ** = Unknown

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of the tank casualties; hollow charge weapons were not yet in general use. The addition of those casualties inflicted by the multiple action of gunfire and mines, plus those in the unknown category (57 percent of the US sample alone), would raise the North African Theater gunfire total to about 85 percent.

In Italy, the picture is affected by the fact that, of a total sample of 2300 tank casualties, 20 percent were immobilized by causes unknown, and a further 25 percent by miscellaneous non-enemy causes such as bogging, accident, and mechanical failure. Based upon a weighted sample of 1450 tanks, gunfire accounted for at least 60 percent of tank casualties. The introduction of the Panzerfaust in large numbers, as well as the proportionally greater employment of mortars and land mines, combined to diminish the over-all gunfire percentage of this theater. Similar explanations hold true for Western Europe. The subtraction of the 15 percent unknown causation and the 15 percent miscellaneous non-enemy tank casualties would weight our sample down to 5,000 tanks, instead of 6,800. Based upon the latter figure, the gunfire percentage would be at least 60 percent. The very heavy German use of land mines (See Appendix C of this study) and the tremendous increase in the employment of the Panzerfaust and the Panzerschreck tended to reduce the toll exacted by gunfire alone.

The US Army and Marine Corps records for the Pacific fighting accord as to the percentages immobilized by gunfire: 35 percent and 33 percent respectively. Nevertheless, this low figure can be explained by the fact that 10 percent of the Army sample and 25 percent of the Marine sample were immobilized by non-enemy causes, such as drowning, bogging, mechanical failure, and accident. A further 20 percent were knocked out by miscellaneous enemy action, such as satchel charge, magnetic mine, etc. An accordingly weighted sample of 500 tank casualties would reveal a gunfire proportion approximating 50 percent.

On the basis of the preceding computations, a truer picture of the over-all percentage immobilized by gunfire alone in all theaters would be nearer to 65 percent of 8500 known cases, after making allowance for the 15 percent unknown and the 20 percent due to miscellaneous causes.

LAND MINES

World War II revealed the importance of land mines, which increased both in number and in types. It was not, however, until the large-scale tank battles in North Africa and the Western Desert that the true value and significance of mine warfare were fully demonstrated. Large and strategically placed antitank mine fields were used by both the Germans and the British Eighth

Army in the fighting in the area between El Alamein and the Qattara Depression, and westward to Tripoli along the coastal road. The first major US encounter with large-scale mine fields was in the Tunisian campaign.

The Axis employed increasing numbers of land mines as the tempo of the war slowed from the rapid advances of 1939-41 to the defensive phases of the following four years. German anti-tank mine production leaped from about 100 thousand per month in the first three years of war to over 3.5 million per month in 1944. Cumulative totals show that the Germans produced over 72 million land mines of all types from September 1939 through December 1944. Land mine consumption by the German field armies rose from about 150 thousand annually in 1939 and 1940 to over 14 million in 1944. German land mine consumption on all the fronts in World War II totalled about 25 millions. The difference between this figure and the total of land mines actually produced is largely explained by the following factors: training and demonstration uses; sales or "gifts" to co-belligerent or friendly powers; losses in land or sea transit by all causes; defective mines; non-combat use of mines for explosive purposes in the rear areas and in the zone of interior; reserve stocks. (See Appendix C).

These figures compare with a total US production of less than 25 million land mines. Excepting perhaps a dozen important situations in World War II--Bataan; Faïd-Sbeitla-Kasserine Pass; El Guettar; the Normandy beachhead; Strasbourg; the Ardennes; St Vith; and Metz--the US Army actually had no major requirement for sustained defensive warfare. Studies have indicated that the Germans suffered less than five percent of their tank casualties to Allied land mines, in Europe. (See Appendix E).

Of a sampling study of 10,388 known Allied tank casualties in all theaters of operation in World War II, a fairly consistent over-all percentage seems to have been exacted by land mines; e.g., 20 percent. Individual theaters exhibited particular conditions, especially favorable or unfavorable to the employment of mines, and with a consequent range of values extending between 10 percent and 45 percent. But, in every operation, Axis land mines were an ever-present "thorn in the side" of the Allied armored forces. A detailed discussion by theaters will be found at Appendix C.

HOLLOW CHARGE WEAPONS

Our first record of Allied tank casualties to Panzerfaust weapons occurs in January and February 1944, in Italy. Thereafter, in Italy, the role of hollow charge weapons fluctuated at a relatively low level before reaching a peak of 20-25 percent

in the spring of 1945, after the crossing of the river Po. The figure of 6 percent for this theater represents an averaging out of every phase of the Italian campaign, from Messina to the Alps. In western Europe, the tank casualty rate to hollow charge weapons averaged over 10 percent for the whole campaign. "Peaks" were reached during the period of the break-out from Normandy in the late summer of 1944; during the Ardennes battles of December 1944 and January 1945; and in the final offensive east of the Rhine, in the spring of 1945. These peaks, mounting in intensity, reached a climax after the Rhine crossing, when 25 to 35 percent of all tank casualties were inflicted by Panzerfaust weapons.

Colonel W. L. Roberts, who commanded a combat command of the 4th Armored Division, said on 21 April 1945: "Panzerfaust is the worst weapon we have encountered in this exploitation type of war. It will go through any US tank, and can be handled by even an inexperienced individual. It is the only weapon that is getting our tanks today."^{1/}

Another report, based upon French Tactical Liaison, discussed the mounting German employment of "antitank fox traps:"

"Antitank fox traps" have been encountered by the US 7th Armored Division in their sector on the south flank of the British Second Army. They are manned by bazooka teams who fire at tanks at very short ranges. The trap consists of a slit trench approximately 8-ft long, 4-ft deep, and 6-ft wide at the front, tapering to a narrower width at the rear. Logs and grass cover the top of the trench, with the result that the trap is extremely difficult to identify. There are two openings, apparently with removable covers at the front, from which the bazookas are fired. There is also an opening at the rear leading into an escape hatch. After firing at a tank, the bazooka team escapes either through the opening at the rear or the escape hatch. These traps are usually located close to roads with the escape trench running behind a nearby farm building or hedge. MG's are emplaced on either side of the road in support of the bazooka teams. When a column advances down the road, the bazooka team waits until the leading tanks are opposite the fox trap and then attempts to knock out the first two tanks. When the tanks have been hit, the MG's open fire on crews and other personnel who expose themselves, to learn what has stopped advance of the column. MG's do not fire on leading infantry or soft-skinned vehicles but wait until a tank has been stopped. "...The witness reported that stress was laid on the bazooka teams escaping without revealing

^{1/} Equipment, Army Ground Forces Report No. 894, 30 Apr. 45, HQ, ETO, War Department Observers Board. (SECRET).

themselves, and on the MG's not opening fire until a tank has been hit."^{2/}

The factors affecting the increased importance of Panzerfaust weapons include: a decrease in the number of German tanks and antitank guns available; terrain more favorable for launching the ground rockets; increased numbers of Panzerfaust weapons available, despite the interesting fact that many were thrown away before being used. The over-all figure of seven percent for tanks immobilized by hollow charge weapons in all theaters, based on a known sample of 10,500, is somewhat misleading, for there were no such casualties in Africa, Sicily, or the Pacific. An adjusted sample, to include only Italy and Europe, would give us a more accurate percentage for over-all hollow charge casualties: 10 percent of a sample of 7700 tank casualties. The addition of that fraction bazooka'd in the multiple-weapon category, or in the unknown listing, would further raise the over-all percentage to about 15 percent of the sample used.

MORTAR FIRE

Of the total known sample of 10,500 Allied tank casualties, it was found that only 80 tanks were mortared. This represented a fairly constant casualty rate of about one percent in every theater. Indeed, the highest proportion was in the Pacific, where two percent were mortared. The Italian theater was the next highest proportionally, closely followed by Western Europe. In North Africa, the open terrain and the emphasis upon flat-trajectory weapons largely explain the negligible role of the high-angle mortar.

MISCELLANEOUS (PLUS MULTIPLE), ENEMY WEAPON

To have included a tank knocked out, say, by "tank plus antitank plus bazooka" under each separate weapon category would have resulted in a record of incidence of hit rather than of tank casualty integers. Consequently, an attempt has been made to circumvent this problem by including under one separate category all tanks immobilized by more than one weapon. Also included in this tabulation was that numerically unimportant proportion of tanks knocked out by a wide variety of enemy weapons: rifle grenades, thermite, aerial bombs, hand grenades, demolitions, capture, tank traps, small arms fire, etc. A fairly consistent proportion of tanks was knocked out by multiple or miscellaneous enemy weapons in every theater of operations, i.e., five percent. Two major exceptions must be noted: in the Pacific fighting, the Japanese, lacking armor

^{2/} Armored Report No. 4, HQ, 12th Army Group, 24 Oct. 44.

and massed artillery, used a very considerable amount of satchel charges, "Molotov cocktails," grenades, and expensive, improvised mines, aerial bombs, sea mines, etc. This fact explains the figure of 20 percent for tank casualties suffered due to miscellaneous or multiple enemy action. The figure of 12 percent for the US forces' tank casualties to these causes in North Africa is largely attributable to such causation as: captured, aerial bombed, small arms, etc.; but the sample involved (14 tanks) is deemed to be too small to be statistically significant.

MISCELLANEOUS, NON-ENEMY WEAPON

The over-all average of 13 percent for Allied tanks immobilized by non-enemy causation is obviously much too low a representation of that factor. The most serious source of error is the general nature of the British data available for detailed analysis. These records were concerned solely with weapon damage, and hence were deficient in the type of data needed to round out the over-all picture. Of a total sample of 4500 British tanks, only one percent could be listed in the non-enemy weapon category. The records of the Canadian Army and of the US Marine Corps furnished the most detailed information, and are believed to be much more representative than their theater counterparts. The US Army percentages of non-enemy immobilization are believed to be minimum figures, due to the fact that much of our data were concerned mainly with tactical operations.

In the European theater, the Canadians suffered 30 percent of their tank casualties from swamping, accident, mechanical failure, bogging, etc. The larger US forces' sample, whose records were far less complete, indicated a minimum figure of 15 percent. There is independent evidence which leads us to believe that the Canadian percentage is a much closer approximation of the true US figure. Thus, a US Third Army study of 107 US M4 tank casualties indicated that 30 tanks, or 28 percent, "were destroyed by terrain obstacles or mechanical deficiencies."^{3/} Similarly, there is good reason to believe that tank casualties due to mechanical failure rise very sharply during periods of exploitation and pursuit, often at a ratio four to one over tank casualties due to enemy action alone. Thus, one fairly complete British sample of mechanical failures, for the period of 28 August to 7 September, 1944, indicated the following relationships:

^{3/} Examination of Causes for Rendering Tanks Inoperative, HQ, Third US Army, OCO, KRJ/rfe, 19 March 1945, submitted to Chief of Staff, Third US Army.

TABLE III^{1/}

BRITISH SAMPLING OF MECHANICAL FAILURES, WESTERN EUROPE

Unit ^{2/}	Number of Tank Casualties Due To:			
	Mechanical Causes (#)	(%)	Enemy Action (#)	Total (#)
Guards Armored Div. (Brit.)	59	92.2	5	64
8th Armored Brigade (Brit.)	57	74.0	20	77
11th Armored Div. (Brit.)	44	88.0	6	50
7th Armored Div. (Brit.)	38	76.0	12	50
1st Polish Armored Div.	50	62.5	30	80
4th Canadian Armored Div.	57	91.9	5	62
Total	305		78	383
Average per Armored Brigade	51	79.7	13	64
Average per Days in Pursuit	5.4	79.4	1.4	6.8
Average per 100 miles	16	79.6	4.1	20.1

^{1/} Based upon Tables I, II, III, of O.R.S. Report No. 18, "Tank Casualties During the Exploitation Phase after Crossing the Seine."

^{2/} All units equipped with Shermans, except the 7th Armored Division (Cromwells).

These figures reflect a very constant ratio of immobilization to the two causes, and are largely explicable by the fact that very little maintenance work can be performed during such operational phases, because of the distances involved, the times travelled, and the need to be ready for instant action. Excluding these data, the combined minimal proportion for the European theater was 13 percent of the total tank casualty sample.

The combined over-all figure for non-enemy weapon immobilization in the Italian theater would give a much fairer representation if the incomplete British data were excluded. A percentage of 35 percent, based upon a sample of 1200 Canadian and US tank casualties, is believed to be more typical than the figure of 24 percent given in Table II, Column 18.

The data for the Pacific fighting are considered to be quite representative, although the US Army figure of 10 percent is judged to be minimal. An average percentage of 18 is obtained from the combined Army and Marine Corps (25 percent) totals.

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Causation

Once again, the over-all percentage of 13 is "slanted" by the inadequate British and French data. By excluding the latter records, a much more accurate over-all percentage is obtained from the US and Canadian sample, totalling 6200 tank casualties; i.e., 21 percent. This figure, as we have seen, included tanks immobilized by drowning, accident, bogging, and mechanical failure.

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UNIT	DISABLED										REPAIRABLE																
	DIRECT FIRE					OTHER THAN SMALL ARMS					BAZOOKA					ARTILLERY & MORTAR					MINES						
	LT	MT	HT	TD	AC	‡	6x6	LT	MT	HT	TD	AC	‡	6x6	LT	MT	HT	TD	‡	6x6	LT	MT	HT	TD	AC	‡	6x6
Hq Co 6th Armd Div			1				1												1								
Hq Co CCA																			1								10
Hq Co CCB																											
146th Sig Co														1													
Hq Co Div Tns																											
Hq Btry, Div Arty																				1							
86th Cav Rcn Sq	6		2		18		2						1							1				3	4		1
9th Armd Inf Bn			1																								
44th Armd Inf Bn																											7
50th Armd Inf Bn				14			3																				
15th Tank Bn	2	12						2	4																		
68th Tank Bn	1	69	3				8			1																	
69th Tank Bn	1	15	1				1	1	2	10	1																
128th FA Bn																											
212th FA Bn	1	1	2																								
231st FA Bn																											
25th Engr Bn																											
128th Ord Bn																											2
603d TD Bn				4	2	6					2																
777th AAA AW Bn																											
TOTALS	11	87	24	4	15	18	5	5	14	1	2	1	3	1	9	80	192	5	45	27	12	29	10	6	1	17	3

GRAND TOTAL LT MT HT TD AC ‡ 6x6
 37 160 231 19 17 83 41

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Others Disabled but Repairable

3 — M7 Artillery 105 How
 4 — L4 Liaison Planes
 Other Vehicle types Omitted,
 Casualties Negligible.

(Figures from records of Separate Company
 and Battalion Motor Officers)

Disabled by Other Means
 9th Armd Inf Bn — 3 HT Rammed by Enemy Tks
 212th FA Bn — 1 HT Rammed by Enemy Tk
 25th Engr Bn — 2 6x6, Bombs
 603d TD Bn — 2TDs Rammed by Enemy Tks
 3 6x6, Bombs

Source: Combat Record of the 6th
 A.D. in the E.T.O.

TABLE IV —BATTLE VEHICULAR CASUALTIES - For Period 18 July 44 - 8 May 1945
 (See Figure 9)

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UNIT	DESTROYED												NOT REPAIRABLE																	
	DIRECT FIRE OTHER THAN SMALL ARMS						BAZOOKA						ARTILLERY & MORTAR						MINES						OTHER MEANS					
	LT	MT	HT	TD	AC	↓	6x6	LT	MT	HT	AC	↓	6x6	LT	MT	HT	AC	↓	6x6	LT	MT	HT	TD	↓						
Hq Co 6th Armd Div						3																								
Hq Co CCA																														
Hq Co CCB						1																								
146 Sig Co						1	1																							
Hq Co Div Tna																														2-↓ Ton Capture
Hq Btrye Div Arty																														2-6x6 Burned, Small Arms
86th Cav Rcn Sq	9		3		16	20	7	2				1	4																1-↓ Ton Captured	
9th Armd Inf Bn			14		2							3		1															1-↓ Ton Captured	
44th Armd Inf Bn			7		3							3	4		1		24	11	3										3-6x6 Captured 5-↓ Ton Small Arms on Patrol	
50th Armd Inf Bn	1		13		1												1		2											
15th Tank Bn	8	26	2					3	18					3	2															
68th Tank Bn	1	29			1				5								5		2	3										
69th Tank Bn	2	25	1					1	12					1	1	1													1-6x6 Bomb 6-MTs Enemy Demolition 2-6x6 Captured	
128th Armd FA Bn			2				1					2						1	1											
212th Armd FA Bn			1						1								2			5										
231st Armd FA Bn			2	6		1														2										1-6x6 Burned, Small Arms
25th Armd Engr Bn				2		1														1	1								2-↓ Ton Captured	
128th Ord Maint Bn						1																								4
808d TD Bn					6	5	2													2	1									1-TD Captured, 1-6x6 Captured
777th AAA AW Bn										1										4										2
TOTALS	21	85	47	6	16	40	11	8	37	9	11	9	1	6	8	31	0	33	15	7	2	4	1	25						

GRAND TOTAL LT 40 MT 138 HT 91 TD 8 AC 17 ↓ 118 6x6 37

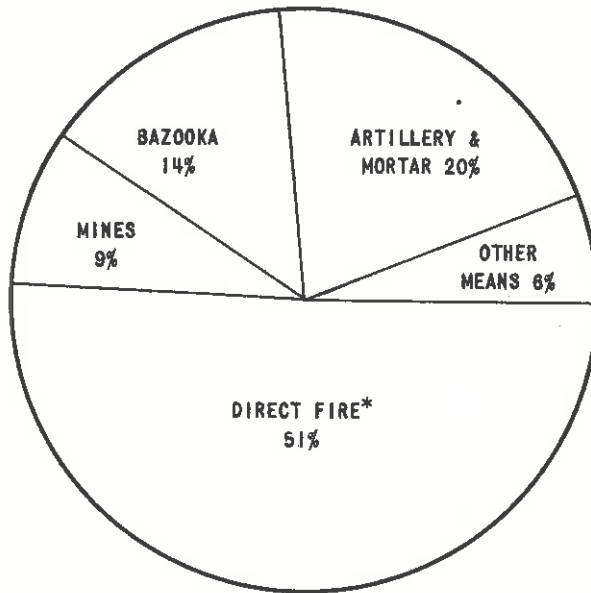
Others completely destroyed:
 3 - M7 Artillery 105 How
 4 - L4 Liaison Planes
 Other Vehicle Types Omitted,
 Casualties Negligible

Legend for Charts
 LT - Light Tank
 MT - Medium Tank
 HT - Halftrack
 TD - Tank Destroyed
 AC - Armored Car
 ↓ - ↓ Ton Truck
 6x6 - GMC 2½ Ton Truck

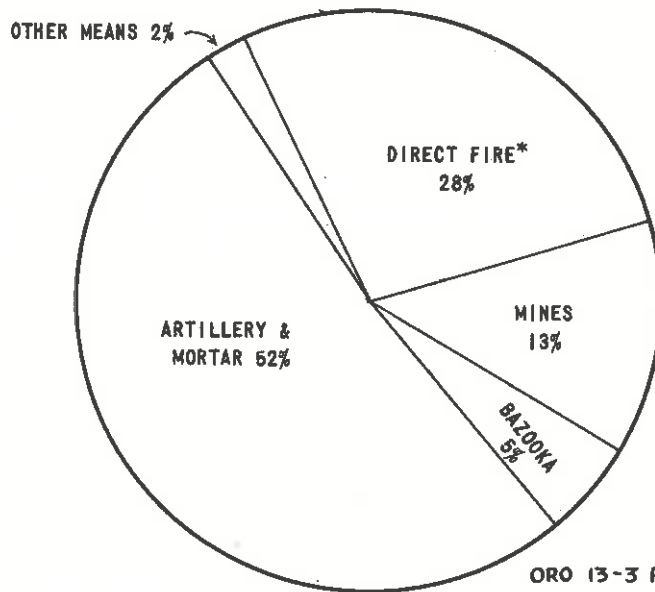
(Figures from record of Separate Company and Battalion Motor Officers)

Source: Combat Record of the 6th A.D. in the E.T.O.

TABLE V - BATTLE VEHICULAR CASUALTIES - For Period 18 July 44 - 8 May 1945
 (See Figure 9)



VEHICLES DESTROYED (449)



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VEHICLES DISABLED (588)

FIGURE 9.—BATTLE CASUALTIES 6th ARMORED DIVISION
JULY 18, 1944 - MAY 8, 1945

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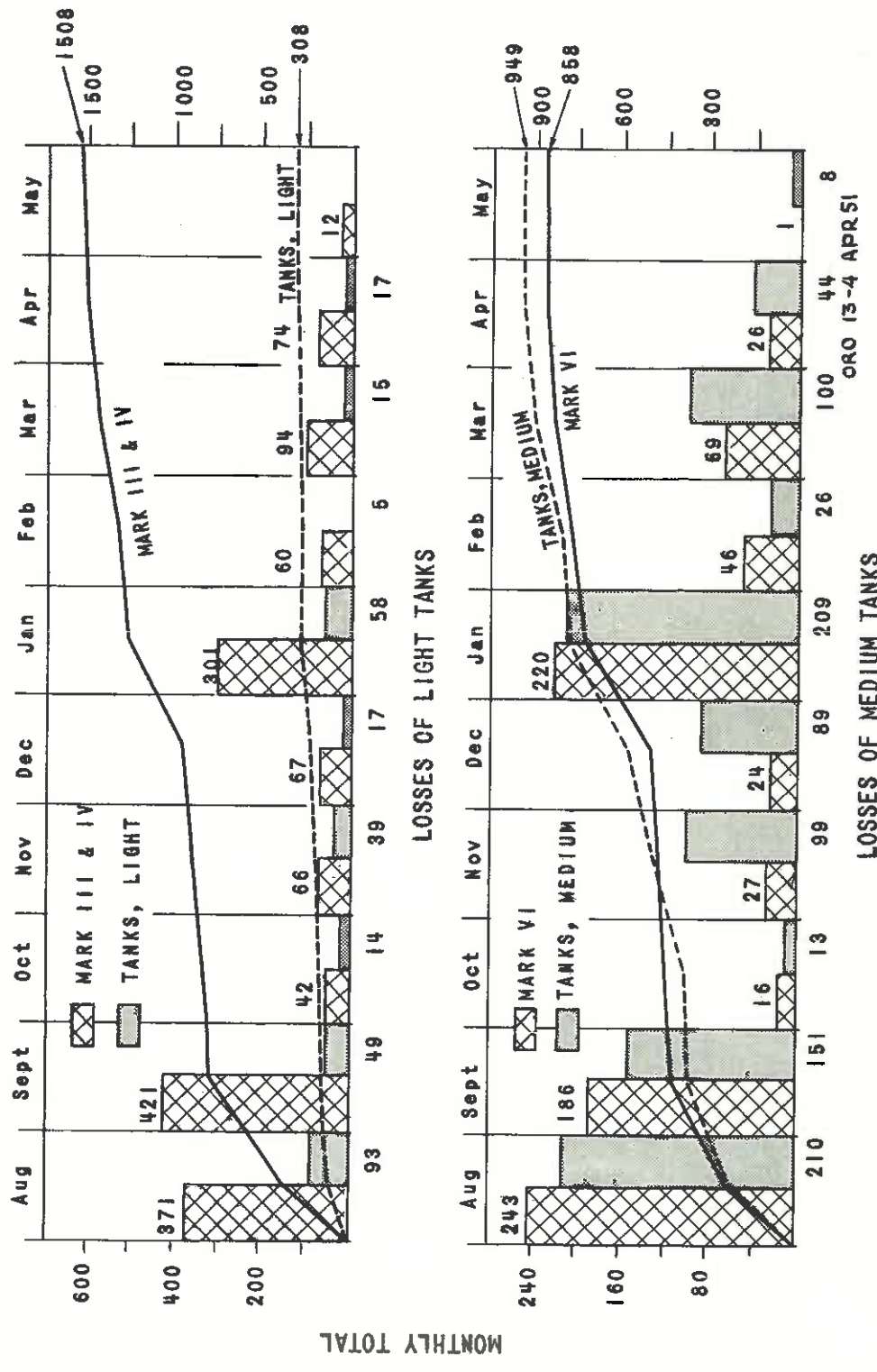


FIGURE 10. ---COMPARATIVE CHARTS - LOSSES OF MATERIEL US THIRD ARMY

SOURCE: After action report Third US Army - 1 Aug. 1944-9 MAY 1945 Vol. I The Operations

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RANGE

GUNFIRE

A study of 800 US, British, and Canadian tank casualties in Western Europe, the Mediterranean Theater, and North Africa, disclosed that the average range at which tanks were immobilized by gunfire was under 800 yards. A sample of 100 tank casualties in North Africa showed an average range of 900 yards; 60 tank casualties in Sicily and Italy—350 yards; 650 tank casualties in Western Europe—over 800 yards. These figures are explicable by the fact that in the western desert of North Africa, where the terrain favored ranges to the limits of visibility, tank fighting often resembled naval battles which boiled down to "slug fests" where light vessels (=light tanks and armored cars) were involved. A figure of 900 yards represents the averaging out of engagements at 1500 to 2000 yards as well as those at hub-to-hub range, e.g., Knightsbridge; Rommel's brilliant tank traps allowed his antitank guns to effect kills at short range. Martel^{4/} has explained the reasons for the Germans' electing to fight armor at longer ranges in the desert as follows:

The German armoured forces often attacked British unarmoured troops if they found them insufficiently protected by artillery and antitank guns, but they always avoided closing with our tanks in a running fight. When meeting British tanks in strength they preferred to take up a position which was well protected by artillery fire and with antitank guns on the flanks, and used the superior gunfire from stationary tanks to shoot at the British tanks at long range.*

The figure of 350 yards for Sicily and Italy reflects the effect of terrain in channelizing armor and restricting its mobility. Rivers, defiles, ravines, cities, narrow roads, vineyards: all conspired to reduce the scale of armored warfare, and to favor close-range fire of both antitank and tank weapons. In Western Europe, however, the opportunities for pursuit and for exploitation helped to raise the average range for closing hit to about 800 yards. For a discussion of the scale of German armored opposition in Western Europe, consult Appendix D.

It should be stressed that the data on range are almost always derived from "subjective" estimates given in after-action reports or "third-hand" summaries. The only exception is a portion of the British ETO sample, wherein operations research

^{4/} Lt. Gen. Sir G. leQ. Martel, Our Armoured Forces, London, 1945, P 143 (UNCLASSIFIED).

teams from the 21st Army Group actually examined tanks immobilized after the Rhine crossing. The over-all average of 800 yards range is also probably higher than the actual figure, if it were known, for a much larger sample, inasmuch as a further 75 tank casualties to gunfire were listed merely as "close," "fairly close," "point-blank," "various," etc.

HOLLOW CHARGE WEAPONS

The sample of tanks knocked out by hollow charge weapons included 150 US, British, and Canadian machines. The average closing range of hit was 50 yards. The sample for Italy was too small to justify firm conclusions, although the ranges involved were of the same order of magnitude as their European counterparts. The British tank casualties to Panzerfaust weapons were suffered at ranges of about 35 yards, while the US casualties were recorded at about 55 yards. The nature of much of the British armored fighting, in close, built-up, or inundated country, may explain part of this slight variance, but it is believed that there is a more valid explanation: the British data were derived from better and more carefully kept records than their US counterparts, which were largely estimates made after-the-fact and at third-hand. Consequently it is considered that the figure of 35 yards more nearly approximates the average range for the European Theater. Naturally, there are no data for the North African Theater, where the Panzerfaust was not yet in general use.

The figure of 35 yards is probably even somewhat higher than the actual range to be derived from a much larger sample, for at least another dozen "subjective" estimates could not be quantified; e.g., "close," "very close," "point-blank," etc. This contention is borne out by the results of British Operational Research Report No. 33, which concerned itself with The Use of Panzerfaust in the North West European Campaign. The study, based upon Allied tanks immobilized east of the Rhine, found that Panzerfausts scored hits at ranges from 10 to 100 yards, although the frequency of hit fell off rapidly beyond 40 yards. Based upon a sample of 80 hits, the following table was constructed by British O.R.S.:

TABLE VI

HOLLOW CHARGE HITS AGAINST AFV'S (RANGE IN YARDS)

	<u>0-20</u>	<u>21-40</u>	<u>41-60</u>	<u>61-80</u>	<u>81-100</u>	<u>100</u>
Frequency) of hits)	35	22	13	4	3	3

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Range

TABLE VII

HOLLOW CHARGE MISSES AGAINST AFV'S (RANGE IN YARDS)

	<u>0-20</u>	<u>21-40</u>	<u>41-60</u>	<u>61-80</u>	<u>81-100</u>	<u>100</u>
Frequency of Misses)	15	14	13	5	4	7

The preceding data thus accord well with the findings of the present study.

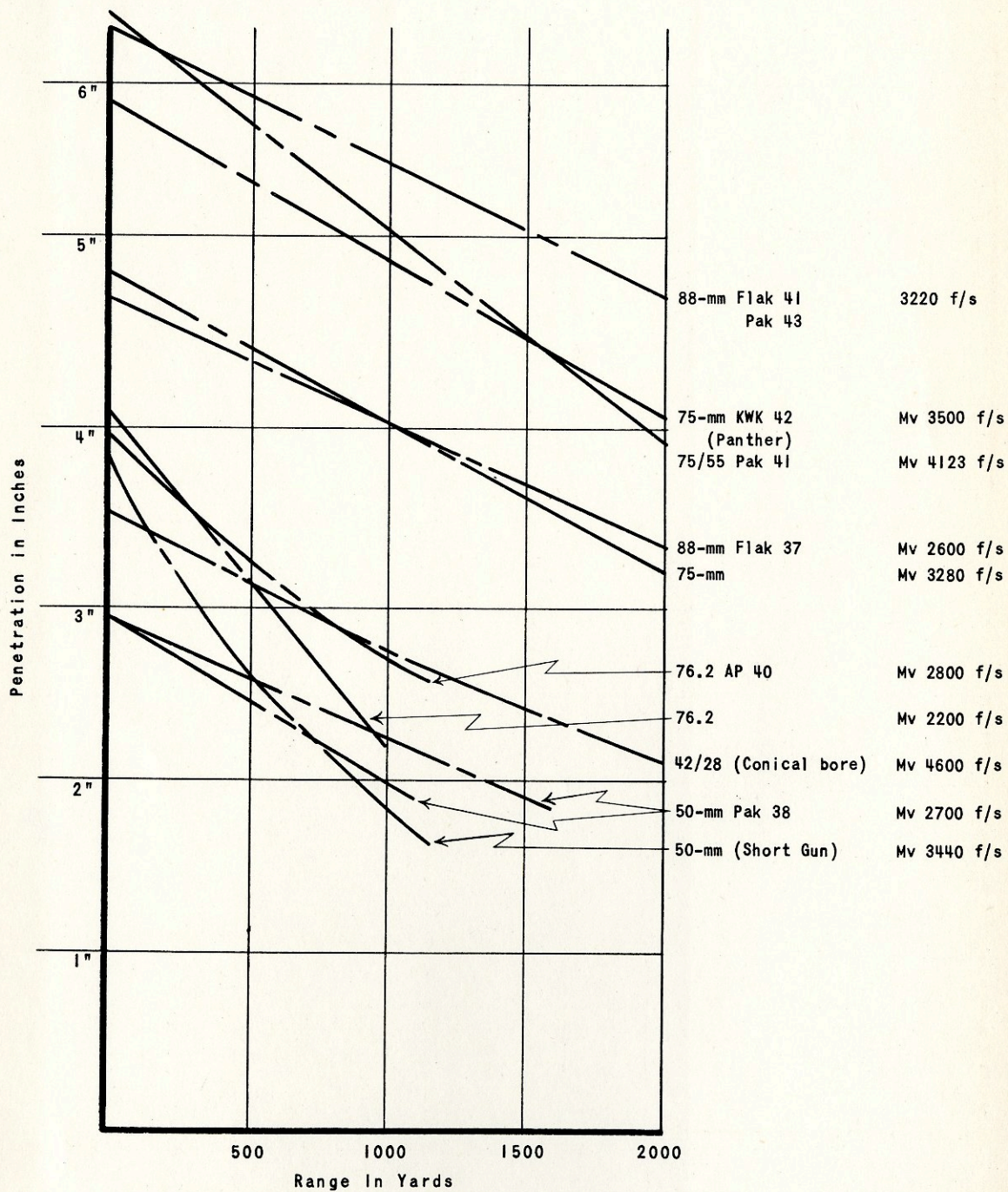
TABLE VIII
 AVERAGE RANGES AT WHICH TANKS WERE IMMOBILIZED
 (Sampling)

	Gunfire		Hollow Charge Weapons	
	Sample	Range (Yds)	Sample	Range (Yds)
US: ETO-First Army	330	796.4	62	53.6
ETO-Third, Seventh, Ninth Armies	119	713.7	21	93.1
ITALY	3	758.3	1	50.0
US: Total	452	774.4	84	63.4
UK: ETO	190	886.3	59	33.2
ITALY	51	348.1	2	75.0
SICILY	6	300.0	-	-
AFRICA	96	890.1	-	-
UK: Total	343	797.1	61	34.6
CANADA: ETO	5	432.0	1	50.0
ETO: US, UK, CANADA	644	804.8	143	51.4
All Theaters: US, UK, CANADA	800	782.0	146	51.3

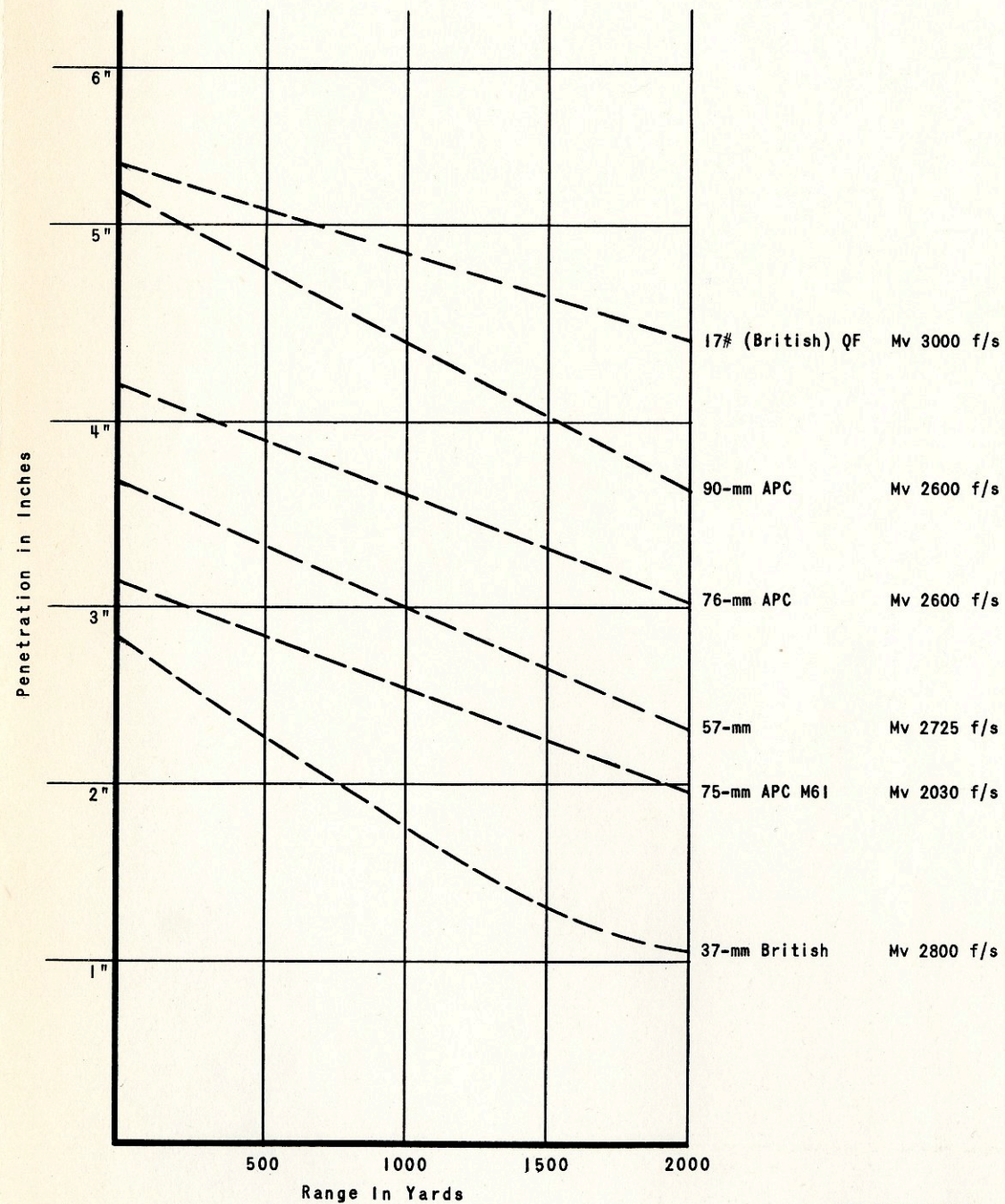
Figure 11. CHARACTERISTICS OF US, UNITED KINGDOM, AND GERMAN GUNS

Figure 11

a. GERMAN GUNS



b. US AND UNITED KINGDOM GUNS



Source: *Data on US Tanks Knocked out by Enemy Action*, Hq, Third US Army 8 April 1945 (DECLASSIFIED)

SITE OF HITS

GUNFIRE

Three US samples of tanks immobilized by gunfire showed that, of a total of 1100 vehicles, a consistent average of 31 percent of the hits were on the turret, 52 percent on the hull, and 17 percent on the suspension system. In this connection, a subjective analysis by a US technical officer^{5/} of the sites of hits on over 100 US tanks rendered inoperative by enemy gunfire, may serve to amplify the above data:

"The German gunners did not seem to have any particular aiming point, unless it was the final drive, and this was just a matter of picking a spot that allowed for a wide margin of error and still assured a hit. Due to the wide dispersal of the hits on American tanks, I am of the opinion that the German gunner fired at whatever part of the American tank that he could see. Most of the American tanks were destroyed by penetrations of the frontal armor, with the hits being well distributed between the front slope plates, final drive, front of turret, and the gun mantlet."

A final note on this subject was provided by a Third Army report, which stated that "on the side shots, the German is... shooting at the spot on the forward sponson in which ammunition was stored in early M₁ tanks."^{6/} Tabulations of the data concerning US gunfire casualties in the European Theater will be found in Table X and Figures 12 and 13.

British data, based upon a sample of 375 tank casualties due to gunfire, showed a very close correlation with the Americans in Europe: 33 percent of hits on the turret, 52 percent on the hull, and 16 percent on the suspension. The relationships for North Africa and Italy indicated that from 40 to 50 percent of all hits were on the turret, but it is considered that the excessively meager sample available that gave sites of hits (only 55 tanks, or two percent, of a total sample of 2600 in the two Theaters) permits no firm conclusions. Accordingly the combined British and US data for all theaters, a sample of 1500 tanks, differ little from the findings in

^{5/} Letter from Mr. Taylor S. Oldham to ORO, dated 23 Aug. 1950 (UNCLASSIFIED).

^{6/} Examination of Causes for Rendering Tanks Inoperative, HQ, Third US Army, OCO, KRDR/rfe, 19 Mar 1945, submitted to C/S, Third US Army. (CONFIDENTIAL).

Europe alone; e.g., 32 percent of all hits were on the turret, 51 percent on the hull, and 17 percent on the suspension system. A British Army Operations Research Group analysis of 139 tanks immobilized by gunfire in the period after the Rhine crossing disclosed the following tank "aspects."^{7/}

TABLE IX

DISTRIBUTION OF TANK HITS BY GUNFIRE

	<u>Aspect of the Tank</u>			
	<u>Front</u>	<u>Side</u>	<u>Rear</u>	<u>Roof</u>
Percentage of total hits	37%	60% ^{1/}	3%	0

^{1/} Average 30 percent per side surface.

A more complete discussion of the employment of flat-trajectory weapons is to be found in those sections dealing with gunfire elsewhere in this study.

HOLLOW CHARGE WEAPONS

The numerically most important data concerning the site of hits on Allied tanks immobilized by hollow charge weapons are available only for the European Theater (sample of 320 tanks); the Italian campaign furnished a negligible sample (only 5 tanks). The over-all combined findings showed that US and British tanks suffered 44 percent of hollow charge hits on the turret, 48 percent on the hull, and only 8 percent on the suspension system.

The US samples showed an average of 37 percent of hollow charge hits on the turret, 56 percent on the hull, and 8 percent on the suspension system. The British sample showed a higher incidence of hits on the turret--52 percent, and a lower incidence of hits on the hull--39 percent, while the suspension system hits remained the same--8 percent. A British AORG analysis of the "aspects" of 106 hits on British tanks immobilized by Panzerfaust weapons disclosed the following relationships:

^{7/} The Use of Panzerfaust in the Northwest European Campaign, O.R.S. Report No. 33 (SECRET). Also see M.O.R. Study No. 82, Report No. 19, A Survey of Tank Casualties, March 1947 (SECRET).

TABLE XI^{1/}

DISTRIBUTION OF TANK HITS FROM PANZERFAUST

	<u>Aspect of the Tanks</u>			
	<u>Front</u>	<u>Side</u>	<u>Rear</u>	<u>Roof</u>
Percentage of Total Hits:	31%	51% ^{2/}	9.5%	8.5%

1/ The Use of Panzerfaust in the Northwest European Campaign, O.R.S. Report No. 33. (SECRET).

2/ Average 25.5 percent per side.

A more complete discussion of the employment of hollow charge weapon usage in Western Europe is to be found in those sections pertaining to hollow charge weapons found elsewhere in this study.

TABLE X
 SITE OF HITS FROM GUNFIRE - BY THEATER
 (Sampling)

	TOTAL NUMBER OF HITS	TURRET		HULL		SUSPENSION	
		NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
US: ETO-FIRST ARMY	784	247	31.5	408	52.0	129	16.5
ETO-THIRD, SEVENTH, NINTH ARMIES	284	88	31.0	145	51.0	51	18.0
ITALY	23	7	30.4	9	39.1	7	30.4
US: Total	1091	342	31.4	562	51.5	187	17.1
UK: ETO	320	104	32.5	166	51.9	50	15.6
ITALY	24	10	41.7	12	50.0	2	8.3
AFRICA	31	15	48.4	4	12.9	12	38.7
UK: Total	375	129	34.4	182	48.5	64	17.1
ETO: US + UK	1388	439	31.6	719	51.8	230	16.6
ETO + ITALY + AFRICA: US + UK	1466	471	32.1	744	50.8	251	17.1

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TABLE XII							
SITE OF HITS FROM HOLLOW CHARGE WEAPONS - BY THEATER							
(Sampling)							
	TOTAL NUMBER OF HITS	TURRET		HULL		SUSPENSION	
		NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
US: ETO-FIRST ARMY	119	45	37.8	67	56.3	7	5.9
ETO-THIRD, SEVENTH, NINTH ARMIES	52	18	34.6	28	53.8	6	11.6
ITALY	1	0	0	1	100.0	0	0
US: Total	172	63	36.6	96	55.8	13	7.6
UK: ETO	145	76	52.4	57	39.3	12	8.3
ITALY	4	2	50.0	1	25.0	1	25.0
UK: Total	149	78	52.3	58	39.0	13	8.7
ETO: US + UK	316	139	44.0	152	48.1	25	7.9
ETO + ITALY: US + UK	321	141	43.9	154	48.0	26	8.1

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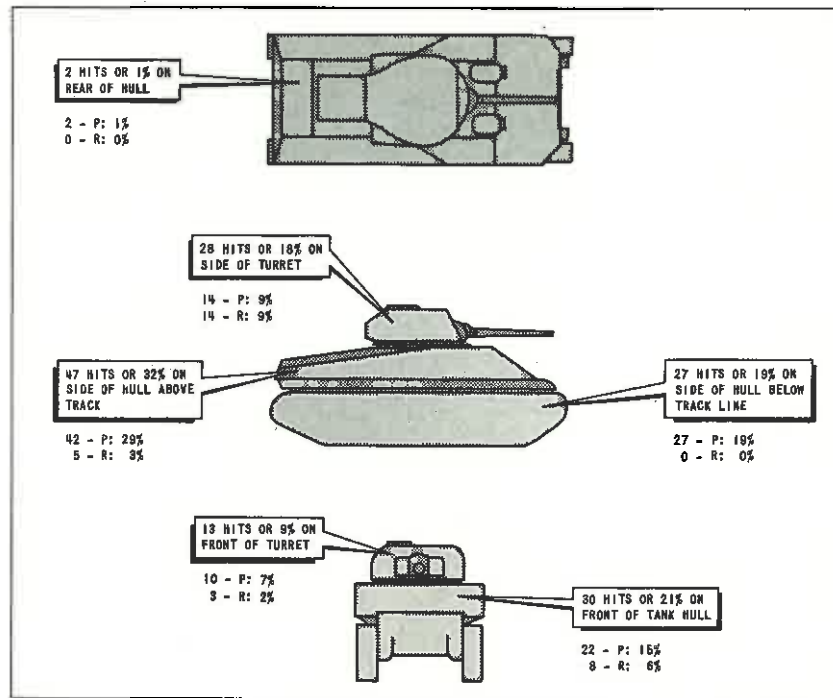


Figure 12. US M4 TANK CASUALTIES

107 TANKS CHECKED
(Total of 145 hits registered)

85 TANKS BURNED
42 BECAUSE OF HITS
43 BECAUSE OF CHARGE

72 TANKS DESTROYED BY GUNFIRE
3 HIT BY ROCKETS
17 HIT BY 88-MM AP
52 HIT BY 75-MM AP

5 DESTROYED BY MINES

30 DESTROYED BY OTHER THAN ENEMY ACTION

LEGEND: P - Penetration; R - Ricochet

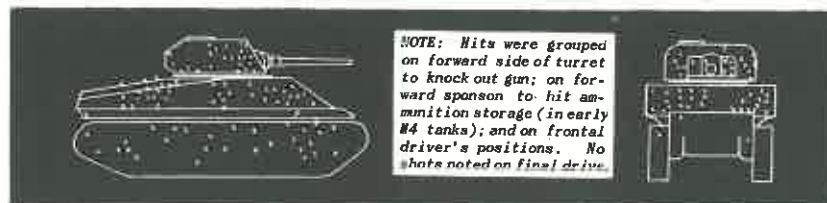


Figure 13. SITE OF HITS ON US M4 TANKS

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CALIBER OF ENEMY GUNFIRE

As may be seen from Tables XIII, XIV, XV, and XVI, data as to the caliber of enemy gunfire responsible for Allied tank casualties is extremely sparse. Of the total sample of 5,600 tanks shown under column 11, Table II, as gunfire casualties, caliber is given for only some 1,000 tanks.

A majority of the gunfire samples came from "third-hand" reports, i.e., war diaries, and after-action reports, in which such specific details are largely omitted. There has been incorporated within the total only one sample which is considered to be a technical analysis—a US First Army sampling of 373 tanks. A second technical sampling is referred to in Table XXV, but because of the impossibility of eliminating possible duplication, is omitted from the grand total.

Of a total sample of 1,000 tanks, 90 percent became casualties to medium-caliber gunfire, 3 percent to heavy-caliber fire, and 6 percent to light-caliber fire; 532 tanks were listed as victims of the 88-mm, or 50 percent of the total, while the 75-mm gun was second with 378, or 36 percent. These two weapons together thus accounted for 86 percent of the total casualties.

NORTH AFRICA

The sample of 150 tanks for North Africa, 1941-1943, reflects the meager data available for analytical purposes. Here the 88-mm gun exacted a toll of 74 percent. The 50-mm weapon was responsible for 10.7 percent of the total sample and the 75-mm trailed with 8 percent. The remaining sample was distributed among the 47-mm, 105-mm, and 210-mm guns.

It is believed that the percentage for the 50-mm gun should be higher for the over-all North African sample. General Martel stated that the principal German tank gun in the three battles of Libya was the 50-mm gun. As for the 75-mm gun, at that time it was a low-velocity gun and "did not do much harm to our [British] tanks...."^{8/}

As to antitank guns, the General stated that in the first two battles of Libya the principal weapons were the 37-mm and 50-mm guns. It was not until late 1941, in the third Libyan battle, that the enemy came up with considerable numbers of dual-purpose 88-mm guns.

^{8/} Martel, op.cit., pp 144, 148, 179.

SICILY AND ITALY

Of a total Allied gunfire sample of 860 tanks for these areas only 7.3 percent gave the caliber of the enemy weapon. The US gunfire sample of 234 listed the caliber in only three instances. Thus, the over-all totals and percentages largely reflect the British and Canadian records.

Here the 75-mm gun was given the largest score--52 percent of the total sample. Its companion in destruction, the 88-mm gun, received credit for 35 percent. The higher percentage to the 75-mm gun can perhaps be explained by the fact that the fortified lines in Italy, constructed by the Germans, were studded with dug-in turrets of Panther tanks mounting the long-barrel 75-mm gun.

EUROPEAN THEATER OF OPERATIONS

Of a total sample of 841 tanks in this theater, 48 percent were KO'd by 88-mm gunfire. The over-all total for the 75-mm gun credited it with 40 percent. Thus, together these two guns accounted for 88 percent of the sample. The US sample of 600 tanks for the European Theater is composed of two smaller samples, one of 373 from the US First Army, and a second sample of 226 from other US units. It was found in analyzing the two samples separately that the percentage of casualties to 88-mm fire ran 30 percent in the First Army sample as against 55 percent to 75-mm fire. However, in the second sample the percentage to 88-mm fire was 49 percent and 38 percent for 75-mm fire. It is believed that the US First Army sample presents a more correct picture. This sample was taken from detailed monthly tank casualty reports maintained by Headquarters, First Army.

The second sample of 226 was compiled from casualties reported by other units in their after-action reports or journals. In this type of report there exists a margin of error in accurately reporting details such as caliber of enemy weapons, even when such detail is included. To the average US soldier every heavy-caliber flat-trajectory weapon that fired at him was an "88", which feeling is reflected in this type of report. A former US tank officer, who made a detailed inspection in 1944-45 of approximately 100 US tanks has stated that the majority of those machines that he inspected were knocked out by the German 75-mm KwK42 gun.^{9/}

^{9/} Letter from Mr. Taylor S. Oldham to ORO, dated 23 Aug 1950 (UNCLASSIFIED).

A similar situation prevails in the British and Canadian samples for the European Theater. The sample of 120 British tanks used in Table XIII was taken from war diaries and indicates a preponderance of tank casualties to 88-mm fire. A second sample of 94 tanks taken from a British Army Operational Research Report^{10/} indicates an even heavier weighting in favor of the 75-mm gun. Again it is believed that the sample based on close personal examination of the tanks by technical personnel is the more accurate one.

The preponderance of the damage done by the 88-mm gun was undoubtedly caused when this gun was on its antitank or dual-purpose mount. German production figures clearly indicate that only a limited number of tanks mounting the 88-mm gun, or 8.0 percent of the total, were being produced in the summer of 1944. See Appendix D.

10/ Capt. H.B. Wright and Capt. R.D. Harkness, A Survey of Casualties Amongst Armoured Units in Northwest Europe, Medical Research Team, British 21 Army Group (No. 2 ORS) Jan. 1946. (SECRET).

TABLE XIII
SAMPLING OF ALLIED TANK CASUALTIES BY CALIBER - ALL THEATERS

CALIBER	TOTAL US	PERCENT OF TOTAL US	TOTAL UK	PERCENT OF TOTAL UK	TOTAL CANADA	PERCENT OF TOTAL CANADA	TOTAL ALLIED SAMPLE	PERCENT OF TOTAL ALLIED SAMPLE	TOTAL PERCENT	
LIGHT	20-mm	3			2	1.4	5	.5	6.3	
	37-mm	2			16	11.0	18	1.7		
	40-mm	3					3	.3		
	47-mm	8	1.3				8	.8		
	50-mm	2	.3	20	6.7	3	2.1	25		2.4
	57-mm	7	1.2					7		.6
MEDIUM	75-mm	292	47.8	64	21.6	22	15.1	378	35.9	90.3
	76-mm	12	2.0				12	1.1		
	77-mm	2	.3				2	.2		
	88-mm	225	36.8	207	69.7	100	69.0	582	50.5	
	105-mm	24	3.9	2	.7	1	.7	27	2.6	
	150-mm	14	2.3					14	1.3	
HEAVY	155-mm	5	.8			1	.7	6	.6	3.4
	170-mm	2	.3				2	.2		
	178-mm	7	1.2				7	.6		
	210-mm	1	.2	4	1.3			5	.5	
	240-mm	2	.3					2	.2	
	TOTAL	611	100.0	297	100.0	145	100.0	1053	100.0	

TABLE XIV
SAMPLING OF ALLIED TANK CASUALTIES IN THE ETO BY CALIBER

CALIBER	UNITED STATES						UNITED KINGDOM						CANADA		TOTALS	
	NO. OF FUSA TANKS	PERCENT OF FUSA SAMPLE	NO. OF TANKS IN US SAMPLE	PERCENT OF US SAMPLE	TOTAL US SAMPLE	PERCENT OF TOTAL US SAMPLE	NO. OF TANKS AORG SAMPLE	PERCENT OF AORG SAMPLE	NO. OF TANKS IN UK SAMPLE	PERCENT OF UK SAMPLE	TOTAL UK SAMPLE	PERCENT OF TOTAL UK SAMPLE	NO. OF TANKS	PERCENT OF SAMPLE	TOTAL ETO SAMPLE	PERCENT
20-mm	2	.5	1	.4	3	.5							2	1.6	5	.6
37-mm	2	.5			2	.3							16	13.0	18	2.1
40-mm			3	1.3	3	.5									3	.4
47-mm	3	.8			3	.5									3	.4
50-mm			1	.4	1	.2	1	1.1	3	2.5	3	2.5	1	.9	5	.6
57-mm	4	1.1	2	.9	6	1.0									6	.7
75-mm	204	54.7	86	38.1	290	48.4	68	72.3	34	28.6	34	28.6	9	7.3	333	39.6
76-mm	8	2.1	4	1.8	12	2.0									12	1.4
77-mm	1	.3			1	.2									1	.1
88-mm	113	30.3	111	49.1	224	37.4	24	25.5	81	68.1	81	68.1	95	77.2	400	47.6
105-mm	20	5.4	4	1.8	24	4.0	1	1.1	1	.8	1	.8			25	3.0
150-mm	4	1.1	9	4.0	13	2.2									13	1.5
155-mm	2	.5	3	1.3	5	.8									5	.6
170-mm	2	.5			2	.3									2	.2
178-mm	7	1.9			7	1.2									7	.8
210-mm	1	.3			1	.2									1	.1
240-mm			2	.9	2	.3									2	.2
	373	100.0	226	100.0	599	100.0	94	100.0	119	100.0	119	100.0	123	100.0	841	100.0

¹The two UK samples cannot be combined due to possibility of duplication.

TABLE XV
SAMPLING OF ALLIED TANK CASUALTIES, SICILY AND ITALY 1943-45 BY CALIBER

CALIBER	UNITED STATES		UNITED KINGDOM		CANADA		TOTAL ALLIED SAMPLE	PERCENT OF TOTAL
	NO. OF TANKS	PERCENT OF SAMPLE	NO. OF TANKS	PERCENT OF SAMPLE	NO. OF TANKS	PERCENT OF SAMPLE		
50-mm			2	5.3	2	9.1	4	6.3
57-mm	1	33.3					2	1.6
75-mm			20	52.6	13	59.1	33	52.4
88-mm	1	33.3	16	42.1	5	22.7	22	34.7
105-mm					1	4.5	1	1.6
150-mm	1	33.3			1	4.6	1	1.6
155-mm							1	1.6
TOTAL	3	100.0	38	100.0	22	100.0	63	100.0

TABLE XVI
SAMPLING OF ALLIED TANK CASUALTIES, NORTH AFRICA 1941-43 BY CALIBER

CALIBER	UNITED STATES		UNITED KINGDOM		TOTAL ALLIED SAMPLE	PERCENT OF TOTAL
	NO. OF TANKS	PERCENT OF SAMPLE	NO. OF TANKS	PERCENT OF SAMPLE		
47-mm	5	55.6			5	3.4
50-mm	1	11.1	15	10.7	16	10.7
75-mm	2	22.2	10	7.1	12	8.1
77-mm	1	11.1			1	.7
88-mm			110	78.6	110	73.7
105-mm			1	.7	1	.7
210-mm			4	2.9	4	2.7
TOTAL	9	100.0	140	100.0	149	100.0

FIRE DAMAGE AND REPAIRABILITY OF TANK CASUALTIES

The weakest of all the data available concerns the status of the burning and repairability of tanks. Ambiguities, innumerable omissions and patent errors cripple the historical records in almost every operation. Loose terminology frequently compounds the problem; thus, "K.O'd," "damaged," "hit," "lost," etc., may—or may not—indicate a tank's repairability. The echelon of repair, if any, is often found to be quite obscure. In addition, "burned" does not necessarily mean "unrepairable." Systematic evaluations, on the spot, were all too few, but provide a welcome leaven to the discouraging raw data. Subject to these very important reservations, it is believed that Tables XVII and XVIII give a general order of magnitude that may be of value in determining relationships.

Based upon differing samples, the over-all combined total for US, British and Canadian tank casualties showed by percentage of total known sample: burned—gunfire, 65 percent; mine, 21 percent; hollow charge, 61 percent; repairable—gunfire, 51 percent; mine, 78 percent; hollow charge, 71 percent.

The detailed tabulations are broken down in Tables XVII and XVIII. The great variances and discrepancies therein are largely explained by the factors discussed in the first paragraph of this section.^{11/}

^{11/} It is suggested that Tables XVII, XVIII, and XIX be studied in conjunction with the brief findings of M.O.R. Study No. 82, Report No. 19, Section VII, 17, and Appendix 1a, Tables 4 & 5, 27-28. (SECRET).

TABLE XVII					
TANK CASUALTIES WHICH BURNED - BY THEATER					
(Sampling)					
CAUSE	SAMPLE	NUMBER BURNED	PERCENT BURNED	NUMBER NOT BURNED	PERCENT NOT BURNED
NORTH AFRICA					
UK: Gunfire	208	125	60.0	83	40.0
Mine	31	5	16.1	26	83.9
SICILY & ITALY					
UK: Gunfire	153	123	80.4	30	19.6
Hollow chg.	12	10	83.3	2	16.7
Mine	28	13	46.4	15	53.6
Mortar	6	6	100.0	0	0.0
US: Gunfire	48	39	81.3	9	18.7
Hollow chg.	3	3	100.0		0.0
Mine	4	4	100.0		0.0
Mortar	1	1	100.0		0.0
Canada: Gunfire	60	56	93.3	4	6.7
Hollow chg.	2	2	100.0	0	0.0
Mine	5	3	60.0	2	40.0
Mortar	--	--		--	
TOTAL - SICILY & ITALY					
Gunfire	261	218	83.5	43	16.5
Hollow chg.	17	15	88.2	2	11.8
Mine	37	20	54.1	17	45.9
Mortar	7	7	100.0	0	0.0
ETO					
UK: Gunfire	235	190	80.9	45	19.1
Hollow chg.	43	38	88.4	5	11.6
Mine	19	7	36.8	12	63.2
Mortar	6	1	16.7	5	83.3
US: Gunfire	740	394	53.2	346	46.8
Hollow chg.	142	67	47.2	75	52.8
Mine	190	25	13.2	165	86.8
Mortar	10	2	20.0	8	80.0
Canada: Gunfire	54	48	88.9	6	11.1
Hollow chg.	13	11	84.6	2	15.4
Mine	2	1	50.0	1	50.0
Mortar	--	--		--	
TOTAL - ETO					
Gunfire	1029	632	61.4	397	38.6
Hollow chg.	198	116	58.6	82	41.4
Mine	211	33	15.6	178	84.4
Mortar	16	3	18.8	13	81.2

TABLE XVIII					
TANK CASUALTIES WHICH BURNED - ALL THEATERS					
CAUSE	SAMPLE	NUMBER BURNED	PERCENT BURNED	NUMBER NOT BURNED	PERCENT NOT BURNED
UK GF	596	438	73.5	158	26.5
US GF	788	433	54.9	355	45.1
Canada GF	114	104	91.2	10	8.8
TOTAL GF	1498	975	65.1	523	34.9
UK HC	55	48	87.3	7	12.7
US HC	145	70	48.3	75	51.7
Canada HC	15	13		2	
TOTAL HC	215	131	60.9	84	39.1
UK Mine	78	25	32.1	53	67.9
US Mine	194	29	14.9	165	85.1
Canada Mine	7	4	57.1	3	42.9
TOTAL Mine	279	58	20.8	221	79.2

TABLE XIX
REPAIRABILITY OF TANK CASUALTIES - ALL THEATERS
(Sampling)

	SAMPLE	NUMBER REPAIRABLE	PERCENT REPAIRABLE	NUMBER NON-REPAIRABLE	PERCENT NON-REPAIRABLE
TOTALS BY THEATER					
US: Italy - Gunfire	32	9	28.1	23	71.9
Mine	24	16	66.7	8	33.3
Mortar	1	0	0.0	1	100.0
Hollow chg.	3	2	66.7	1	33.3
ETO - Gunfire	722	337	46.7	385	53.3
Mine	210	159	75.7	51	24.3
Mortar	7	7	100.0	0	0.0
Hollow chg.	152	105	69.1	47	30.9
UK: N. Africa - Gunfire	242	129		113	
Mine	48	31	64.6	17	
Italy - Gunfire	94	51	54.3	43	45.7
Mine	42	30	71.4	12	28.6
Mortar	2	1	50.0	1	50.0
Hollow chg.	10	7	70.0	3	30.0
ETO - Gunfire	192	124	64.6	68	35.4
Mine	114	105	92.1	9	7.9
Mortar	6	6	100.0	0	0.0
Hollow chg.	35	28	80.0	7	20.0
TOTALS BY COUNTRY					
US: Gunfire	754	346	45.9	408	54.1
Mine	234	175	74.8	59	25.2
Mortar	8	7	87.5	1	12.5
Hollow chg.	155	107	69.0	48	31.0
UK: Gunfire	528	304	57.6	224	42.4
Mine	208	171	82.2	37	17.8
Mortar	8	7	87.5	1	12.5
Hollow chg.	45	35	77.8	10	22.2
GRAND TOTALS BY CAUSE					
Gunfire	1282	650	50.7	632	49.3
Mine	442	346	78.3	96	21.7
Mortar	16	14	87.5	2	12.5
Hollow chg.	200	142	71.0	58	29.0

PERSONNEL CASUALTIES

Two samples of casualties to tank crews were studied. The first sample is composed of some 275 medium and 50 light tank crews from the US First Army. The second and larger sample is composed of data on British crew casualties in North Africa, Sicily and Italy, and Northwest Europe. The US sample, though the smaller, lends itself to greater analysis. Sufficient data were available to make a causative breakdown of the casualties for both medium and light tanks by crew position. The records for the UK sample failed to give the casualties by position, thereby reducing that sample to one of over-all killed, wounded, and missing in action, by cause, for each theater.

As may be seen from Table XX, the First Army sample of 274 medium tanks revealed that the tank commander suffered the heaviest casualty rate, 57 percent. The driver had the lowest percentage for this sample, 47 percent. The remaining three crew positions all hovered near the 50 percent mark. The higher casualty rate among the commanders is no doubt due in part to the fact that it was frequently necessary for them to expose themselves, either partially or wholly, in fighting their vehicles. In so doing they become extremely vulnerable to the Germans' two main casualty-producing weapons—gunfire and bazooka attacks. This sample also shows that the casualty rate for these 274 medium tanks was 51 percent of all the crewmen involved.

The First Army light tank sample as shown by Table XXI did not reveal any appreciable difference in casualty rates for their four crew positions. As may be expected, however, the rates for each position ran about 15 percent higher than their medium tank counterparts. The over-all casualty rate for the crews of these 50 light tanks approximated 65 percent.

It should be recognized that these figures are based on data taken from reports on tank damage, and that personnel casualty data therein were incidental and subject to inaccuracies. Furthermore, the casualties studied here were inflicted only by the major weapons, of which gunfire caused 69 percent, in the medium tank sample. Therefore, the figure of 51 percent indicates that in this sample about 2.5 men per medium tank became casualties. This ratio is accordingly higher than various unofficial estimates which average about 1.5 to 2.0 per tank. For further studies on US tank crew casualties see First US Army, Report of Operations, 23 February to 8 May 1945, Annex 6, Appendix 4, pages 155-157. Also see Tables XXII and XXIII.

Due to insufficient data, an analysis by crew position for the British sample was impossible. However, as may be seen from

Table XXIV, percentages for the various types of causative agents were worked out for three theaters. The casualty rates for the Italian and Sicilian campaigns ran approximately three percent higher per category. A possible explanation of this may be the closer ranges involved. For additional information on British tank crew casualty data, see the Harkness and Wright study.^{12/}

The sample studies previously mentioned dealt with casualties to personnel while engaged in fighting their vehicles. One report, based on a sample of 333 British tanks, included a study of crew casualties occurring outside the vehicles. This investigation concluded that 40 percent of the casualties incurred by crewmen were sustained outside their tanks. Of this figure, 30 percent became casualties when escaping from knocked-out tanks. This amounted to 11 percent of the total casualty sample. It was further found that a high proportion of this type of casualty was fatal.^{13/}

Table XXV contains a small US sample of tank crew casualties, in and out of their tanks, though not by position or cause. A total of some 300 personnel casualties are involved. As may be seen, 64 percent became casualties while outside of tanks.

One US report contained observations by tank personnel of the effect of artillery fire, antitank fire, Panzerfaust weapons, and antitank mines, on crewmen. Some of the observations, taken from "Tank Personnel Casualty Reports," follow:

1. Effect of Antitank Mines on Tank Personnel.

Commanders have stated that the effect of AT mines on personnel riding in tanks has been very small. It is only in exceptional cases that any member of a tank is injured by a mine. There is considerable shock effect caused by the explosion of single AT mines, but it is not disabling for crew members. There have been a few cases where reinforced mines have been used that were the cause of casualties but apparently the preparation of such increased charges takes considerable time and effort and is not a common practice. In a few cases the explosion of AT mines has been delayed and has occurred under the rear part of the tracks. In two cases, these explosions are credited with causing fires in the

^{12/} Capt. H.B. Wright and Capt. R.D. Harkness, A Survey of Casualties Amongst Armoured Units in Northwest Europe, Medical Research Team, British 21 Army Group (No. 2, ORS) Jan. 1946 (SECRET).
^{13/} Ibid.

engine compartment which caused evacuation of the crew. No members of the crew were injured.

Where tanks have encountered AT mines that were protected by enemy fire, casualties have occurred in crews due to sniper or m.g. fire when the vehicle had to be evacuated. Whenever possible, the enemy brings fire on stalled tanks and attempts to destroy them by burning. Even when tanks are disabled out of range of flat-trajectory weapons, the enemy, when it is possible, will try to bring artillery fire on vehicles and attempt to burn them up, cause casualties among crew, or render recovery very difficult during the daylight hours.^{11/}

2. Effect of Artillery Fire on Tank Crews.

Commanders all agree that the effect of artillery fire on tanks is very slight. Direct hits are the exception and near-misses apparently have but little effect, other than some blast effect, on crews. Tank CO's, when riding with their heads and shoulders out of the turrets—which is normal—are sometimes wounded by shell fragments and jarred up considerably by the concussion, but unless actually hit, are able to proceed with little ill effect.

(760th Tank Battalion, CO): I was parked alongside of a stone wall and giving orders by radio to one of the commanding officers. A shell hit wall on far side and knocked out a big section of wall. I was in turret of tank with my head out. The concussion knocked me down to bottom of turret, but in a few moments I was all right even though jarred up a bit. Enemy artillery fire has not done us any harm even at times when we got direct hits on [our] tanks. The concussion is heavy on near hits, and sometimes knocks the men out, but very seldom causes any injury.

(Observer's Note): An enemy artillery concentration of not less than 30 rounds, estimated

^{11/} Col. G. B. Devore, Armored Command, AGF Board Report No. 165, NATO, 5 July 1944. (DECLASSIFIED).

to be about 105-mm caliber, was observed falling on an area where 10 medium tanks were dispersed for a temporary bivouac. Shells fell very close to a number of the tanks, which had all hatches fastened and crews inside. No direct hits were observed and no casualties were suffered either at that time or later on when a similar concentration was fired on same group of tanks.

3. Use of Time Fire. There has been little use made of time fire supporting attacks of tanks. CO's state that it is better to have vision and take their chances on injury from shelling than it is to "button up" and be blind. Enemy has made little use of time fire against tanks.

4. Effect of Antitank Fire on Personnel. Penetrations of the tank by A/T projectiles usually result in about two casualties, one killed and one wounded. When tanks have been penetrated by A/T fire, members of crew who have not been killed or wounded or knocked unconscious usually manage to escape even though tank is set on fire. Where complete crews are lost, unit CO's attribute casualties to flash ammunition fires which spring up so rapidly that wounded or shocked members cannot evacuate themselves or be evacuated before overcome by the flames. Also it is believed that in a number of cases exits may have been blocked by wounded members of crew and thus prevented escape of other members.

(Cronk): Crews usually get out when a tank burns unless they have been injured.

(Brusse): Penetrations usually kill or injure one or two crew members and rest escape even if tank burns.

(Davis): Usually one or two men injured or killed when tank is penetrated. I have not had any men burned to death and have been lucky

in not having very many men killed or seriously injured. Several men have been burned out but not badly. We have had a number of tank CO's wounded in shoulders and neck from various causes. They all ride with their heads out of the turrets.^{15/}

5. Rhine to Elbe Campaign: Panzerfaust Weapons. Resistance encountered was mainly at defended road blocks and in towns. Bazookas and Panzersausts caused most of the trouble. Most of the casualties suffered by the 736th Tank Battalion occurred outside the tanks. Germans would disable tank by Panzerfaust or Bazooka fire, forcing the crews to abandon the tank. When the crews attempted to abandon the tanks they would be shot with machine pistols or MG's... If crews are well drilled in abandoning tank, losses inside tanks will be very low. Need for pistols and shoulder holsters for whole crew.^{16/}

^{15/} Ibid.

^{16/} Quotation from letter, Subject: Visit of Col. Black to 736th Tank Battalion, HQ, 9th US Army, OC Armored Section, 25 Apr. 1945. (DECLASSIFIED).

TABLE XX
 SAMPLING OF US FIRST ARMY CREW CASUALTIES - BY POSITION AND CAUSE
 BASED ON 274 MEDIUM TANKS
 (1370 Crewmen)

POSITION	GUNFIRE			MINE			BAZOOKA			MORTAR			GUNFIRE + MINE			GUNFIRE + BAZOOKA			UN-HURT	TOTALS				TOTAL CASUALTIES	CASUALTIES AS PERCENT OF NO. OF INDIVIDUALS BY POSITION	PERCENT TOTAL CREWMEN (1370)		
	K	W	M	K	W	M	K	W	M	K	W	M	K	W	M	K	W	M		K	W	M	PER-CENT				PER-CENT	PER-CENT
																								K	W	M		
Commander	25	71	10	0	8	0	0	0	1	0	0	0	0	0	0	2	3	1	118	26	23.1	108	69.2	12	7.7	156	56.9	11.4
Gunner	32	55	10	0	4	0	5	28	1	0	0	1	1	2	0	134	38	27.1	90	64.3	12	8.6	140	51.1	10.2			
Cannoneer	23	67	13	2	2	0	5	22	1	0	0	0	1	0	4	134	30	21.4	95	67.9	15	10.7	140	51.1	10.2			
Driver	22	57	10	3	12	0	5	12	0	0	0	1	1	0	4	146	31	24.2	86	67.2	11	8.6	128	46.7	9.3			
Bow Gunner	23	56	6	2	13	0	10	12	3	0	1	0	0	1	5	142	36	27.3	87	65.9	9	6.8	132	48.2	9.6			
TOTALS																674	171	24.6	466	66.9	59	8.5	696	50.8				

TABLE XXI
 SAMPLING OF US FIRST ARMY CREW CASUALTIES -- BY POSITION AND CAUSE
 BASED ON 48 LIGHT TANKS (192 CREWMEN)

POSITION	GUNFIRE		MINE		BAZOOKA		MORTAR		GUNFIRE + MINE		GUNFIRE + BAZOOKA		UN-HURT	TOTALS				TOTAL CASUALTIES	CASUALTIES AS PERCENT OF NO. OF INDIVIDUALS BY POSITION	PERCENT TOTAL CREWMAN			
	K	W	K	W	K	W	K	W	K	W	K	W		K	W	M	PER-CENT				PER-CENT		
Commander	10	9	0	2	0	2	4	0	1	0	0	0	0	18	13	17	43.3	0	0	0	30	62.5	15.6
Gunner	8	13	0	2	1	2	2	0	1	0	0	1	17	12	18	38.7	18	58.1	1	31	64.6	16.1	
Driver	9	10	0	2	3	0	1	5	0	1	0	0	16	13	19	40.6	19	59.4	0	32	66.7	16.7	
Bow Gunner	10	6	0	1	6	0	2	3	0	1	1	0	16	14	18	43.8	18	56.2	0	32	66.7	16.7	
TOTALS													67	52	72	41.6	72	57.6	1	125	65.1		

TABLE XXII
BREAKDOWN OF US FIRST ARMY - CREW CASUALTIES
(Sampling)¹

	MINE		BAZOOKA		GUNFIRE		MORTAR		GUNFIRE & MINE		GUNFIRE & BAZOOKA		TOTAL	
	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
KILLED														
Commander	0	0.0	10	6.3	35	6.3	2	22.2	0	0.0	2	8.0	49	6.0
Driver	5	7.9	6	3.8	31	5.6	1	11.1	1	9.1	0	0.0	44	5.4
Gunner	0	0.0	7	4.4	40	7.2	1	11.1	1	9.1	1	4.0	50	6.1
Bow Gunner	3	4.8	12	7.6	33	5.9	1	11.1	0	0.0	1	4.0	50	6.1
Cannoneer	2	3.2	5	3.2	23	4.1	0	0.0	0	0.0	0	0.0	30	3.7
Sub Total:	10	15.9	40	25.3	162	29.2	5	55.6	2	18.2	4	16.0	223	27.2
WOUNDED														
Commander	10	15.9	28	17.7	80	14.4	1	11.1	3	27.3	3	12.0	125	15.3
Driver	15	23.8	17	10.8	67	12.1	0	0.0	2	18.2	4	16.0	105	12.8
Gunner	6	9.5	30	19.0	68	12.3	1	11.1	0	0.0	3	12.0	108	13.2
Bow Gunner	19	30.2	15	9.5	62	11.2	2	22.2	2	18.2	5	20.0	105	12.6
Cannoneer	2	3.2	22	13.9	67	12.1	0	0.0	0	0.0	4	16.0	95	11.7
Sub Total:	52	82.5	112	70.9	344	62.0	4	44.4	7	63.6	19	76.0	538	65.4
MISSING IN ACTION														
Commander	0	0.0	1	0.6	10	1.8	0	0.0	0	0.0	1	4.0	12	1.5
Driver	0	0.0	0	0.0	10	1.8	0	0.0	0	0.0	1	4.0	11	1.3
Gunner	1	1.6	1	0.6	10	1.8	0	0.0	1	9.1	0	0.0	13	1.6
Bow Gunner	0	0.0	3	1.9	6	1.1	0	0.0	0	0.0	0	0.0	9	1.1
Cannoneer	0	0.0	1	0.6	13	2.3	0	0.0	1	9.1	0	0.0	15	1.8
Sub Total:	1	1.6	6	3.8	49	8.8	0	0.0	2	18.2	2	8.0	60	7.3
TOTAL	63	7.7	158	19.3	555	67.6	9	1.1	11	1.3	25	3.0	821	100.0

¹1821 known casualties based upon sample of 48 Light and 274 Medium Tanks.

TABLE XXIII
US FIRST ARMY CREW CASUALTIES - COMBINED TOTALS
(Light and Medium Tanks)
(Sampling)²

	MINE		BAZOOKA		GUNFIRE		MORTAR		GUNFIRE & MINE		GUNFIRE & BAZOOKA		TOTAL (K, W, MIA)	
	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT	NO.	PERCENT
Commander	10	5.4	39	21.0	125	67.2	3	1.6	3	1.6	6	3.2	186	22.7
Driver	20	12.5	23	14.4	108	67.5	1	0.6	3	1.9	5	3.1	160	19.5
Gunner	7	4.1	38	22.2	118	69.0	2	1.2	2	1.2	4	2.3	171	20.8
Bow Gunner	22	13.4	30	18.3	101	61.6	3	1.8	2	1.2	6	3.7	164	20.0
Cannoneer	4	2.9	28	20.0	103	73.6	0	0.0	1	0.7	4	2.8	140	17.0
TOTALS	63	7.7	158	19.3	555	67.8	9	1.1	11	1.1	25	3.0	821	100.0

¹ 821 known casualties based upon sample of 48 Light and 274 Medium Tanks.

TABLE XXIV
UK CASUALTIES AS PERCENT OF TOTAL CREWS IN THOSE TANKS WHOSE CASUALTIES ARE KNOWN
(Sampling)

	(1) Italy		(2) Sicily		(3) Italy & Sicily		(4) Africa		(5) ETO		Averages (3+4+5)	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Gunfire Killed	15.7	13.3	15.6	12.6	13.3	12.5	13.3					
Wounded	23.2	4.4	22.6	13.7	17.8	19.5	17.8					
MIA	1.3	42.2	11.8	4.8	3.7	3.0	3.7					35.1
PW	0.4	-	0.4	0.2	0.2	0.2	0.3					0.3
Tank Sample	253	9	262	435	1032	335	1032					
Mine Killed	6.8	6.7	6.8	2.7	4.8	3.6	4.8					
Wounded	20.0	53.3	21.7	18.4	13.2	5.9	13.2					19.3
MIA	-	-	-	2.0	1.3	1.2	1.3					
PW	-	-	-	-	-	-	-					
Tank Sample	56	3	59	51	293	183	293					
Bazooka Killed	14.9	-	14.9	-	12.9	11.9	12.9					
Wounded	20.5	-	20.5	-	18.8	17.8	18.8					
MIA	3.6	-	3.6	-	2.5	1.9	2.5					36.2
PW	5.6	-	5.6	-	2.0	-	2.0					
Tank Sample	39	-	39	-	113	74	113					
Mortar Killed	4.4	-	4.4	-	5.7	8.0	5.7					
Wounded	35.6	-	35.6	-	32.9	28.0	32.9					38.6
MIA	-	-	-	-	-	-	-					
PW	-	-	-	-	-	-	-					
Tank Sample	9	-	9	-	14	5	14					
Total Tank Sample	357	12	369	486	1452	597	1452					

TABLE XXV					
US CREW CASUALTIES - IN AND OUT OF TANKS					
(Sampling)					
Tanks Lost:	Medium	753d Tk Bn	756th Tk Bn	760th Tk Bn	Total
		9	23	21	53
	Light		3		3
	TOTAL	9	26	21	56
Personnel					
IN tanks					
	Killed	7	11	2	20
	Wounded	14	17	29	60
	Missing in Action		21	5	26
	TOTAL	21	49	36	106
OUTSIDE tanks					
	Killed	13	12	4	29
	Wounded	72	44	27	143
	Dead of Wounds	5	4		9
	Missing in Action	12			12
	TOTAL	102	60	31	193

[REDACTED]

TANK TARGET ANALYSIS

Table XXVI was furnished by US Army Field Forces Board No. 2, Fort Knox, Ky., and represents a weighted series of percentages based upon the subjective reports of 100 officer and non-commissioned tank commanders as to the targets they engaged in all theaters. The figure is self-explanatory, but we should note that US armor, in World War II, seems never to have devoted itself to fighting enemy armor in more than one out of four times of engagement.

The over-all percentage of tank vs. tank battles, as a ratio of total targets, averaged about 15 percent. Building, fortifications, and personnel each seems to have attracted the greater attention of the tank. It must be stressed that the scale of armored opposition never approached that of the Eastern Front, as Appendix D suggests.

TABLE XXVI

TANK TARGET ANALYSIS - WORLD WAR II

Type Target	Highest Percentage Per Theater (%)	Average All Theaters (%)
Buildings	28.0 (I-S)	17.3
Personnel	23.9 (POA)	15.5
Tanks	24.4 (NA)	14.2
A/T Guns & Artillery	18.8 (I-S)	12.8
Fortifications & Caves	36.4 (SWPA)	21.2
Wheeled Vehicles	12.6 (ETO)	8.2
All Other (Smoke, Flash, Brush, Trees, etc.)	15.6 (NA)	10.8
		100.0%



APPENDIX A

OPERATIONAL CHARTS



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APPENDIX A

OPERATIONAL CHARTS

Figures 14 and 15 represent graphically a sampling of US, British, and Canadian tank casualties to all known causes in the European, Italian, and North African Theaters of Operations.

Figure 14 indicates a numerical breakdown of the US, British, and Canadian samples in the European Theater of Operations. Figure 15 represents the same samples charted by cause in percentages per month.

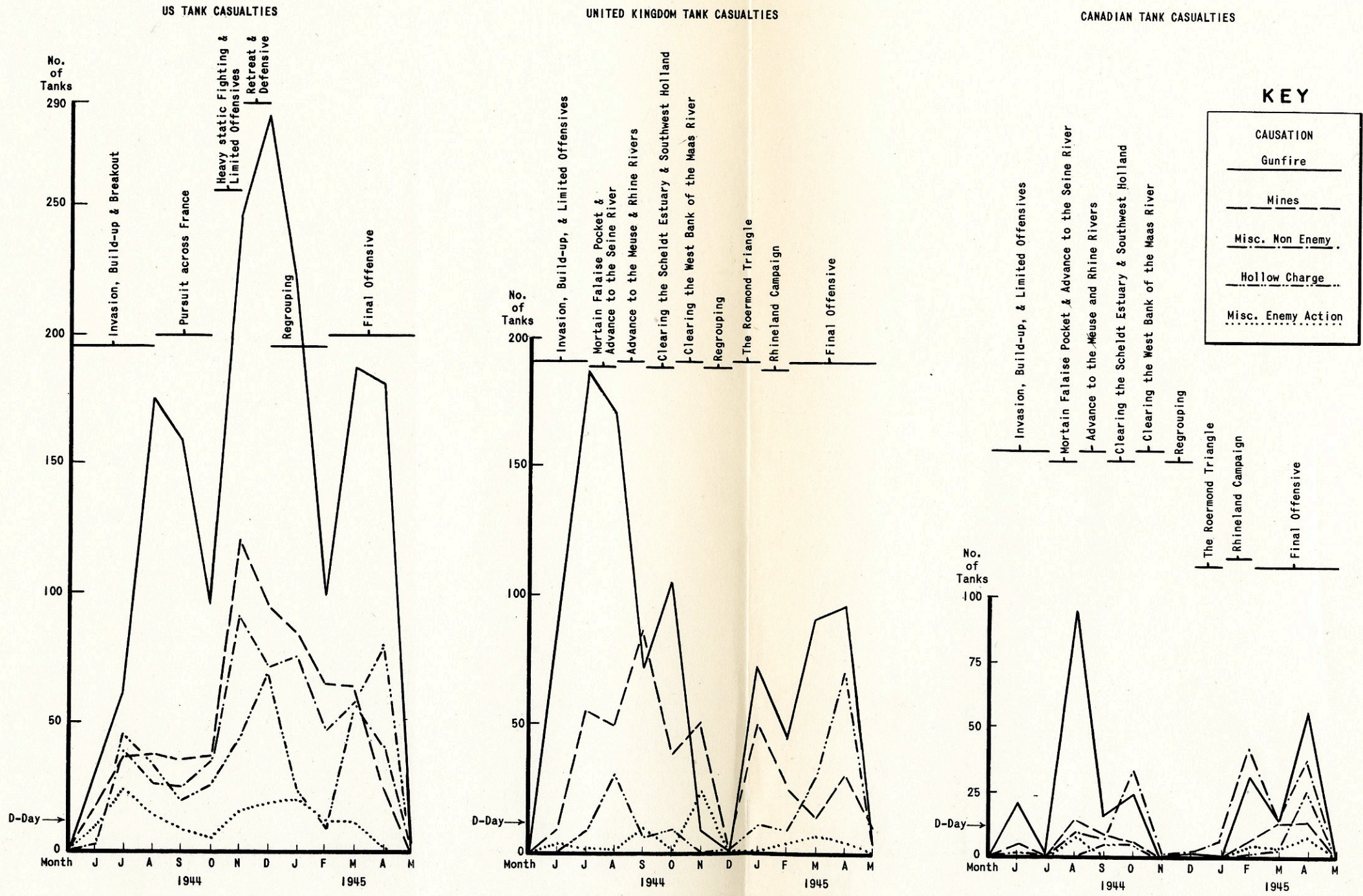
Figures 16, 17, 18, and 19 treat graphically the Italian and North African samples.

When sufficient data were available, representations of miscellaneous enemy causes, and of non-enemy causes were also included.

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Figure 14. SAMPLING OF ALLIED TANK CASUALTIES
(Causation by Numbers of Tanks)
ETO 1944-1945

Figure 14



Note: Due to type of records used for computing British sampling it was impossible to obtain data as to misc. non-enemy casualties.

Note: Data as to misc-enemy causation was too small to chart.

Figure 15. SAMPLING OF ALLIED TANK CASUALTIES
 (Causation Expressed in Monthly Percentages)
 ETO 1944-1945

Figure 15

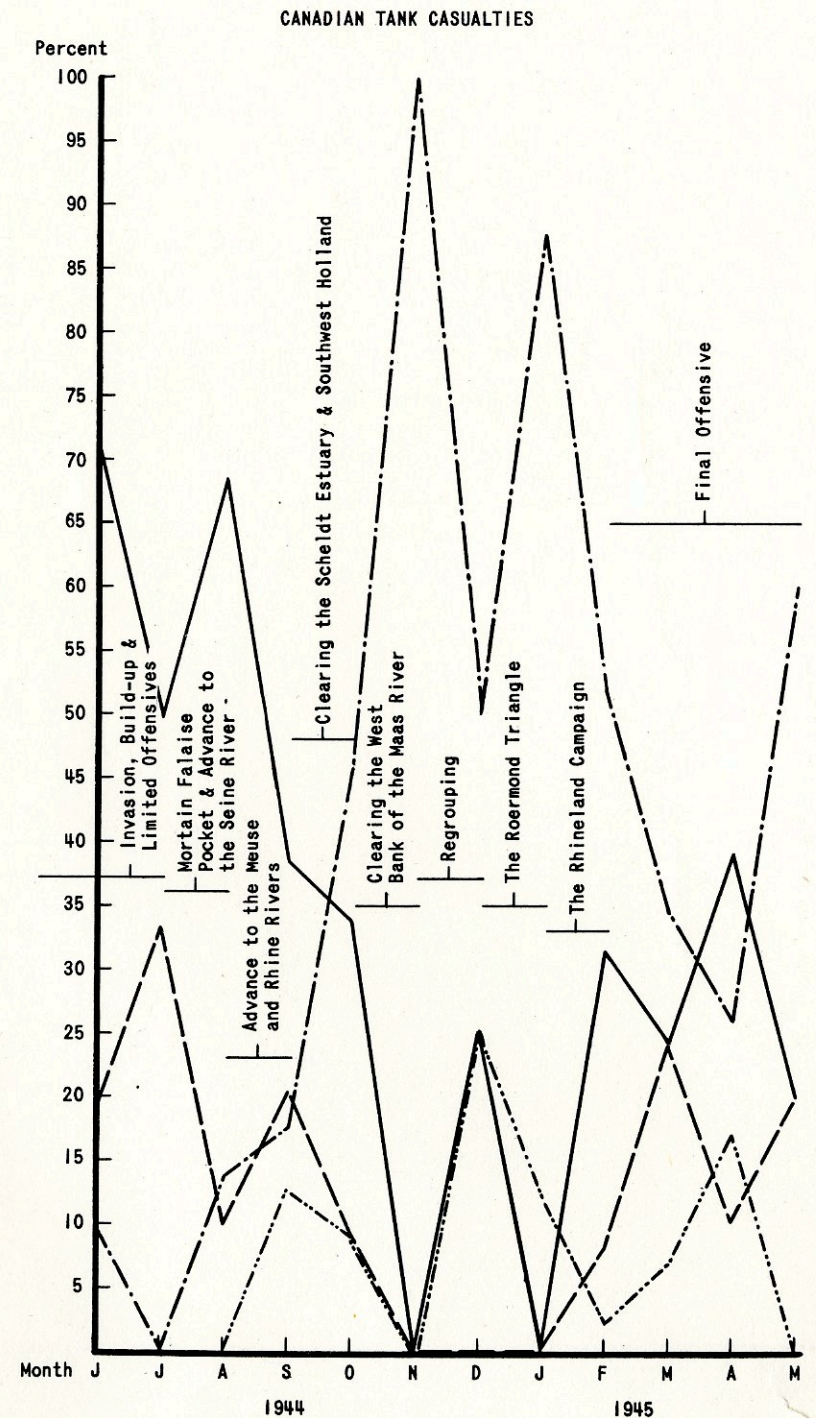
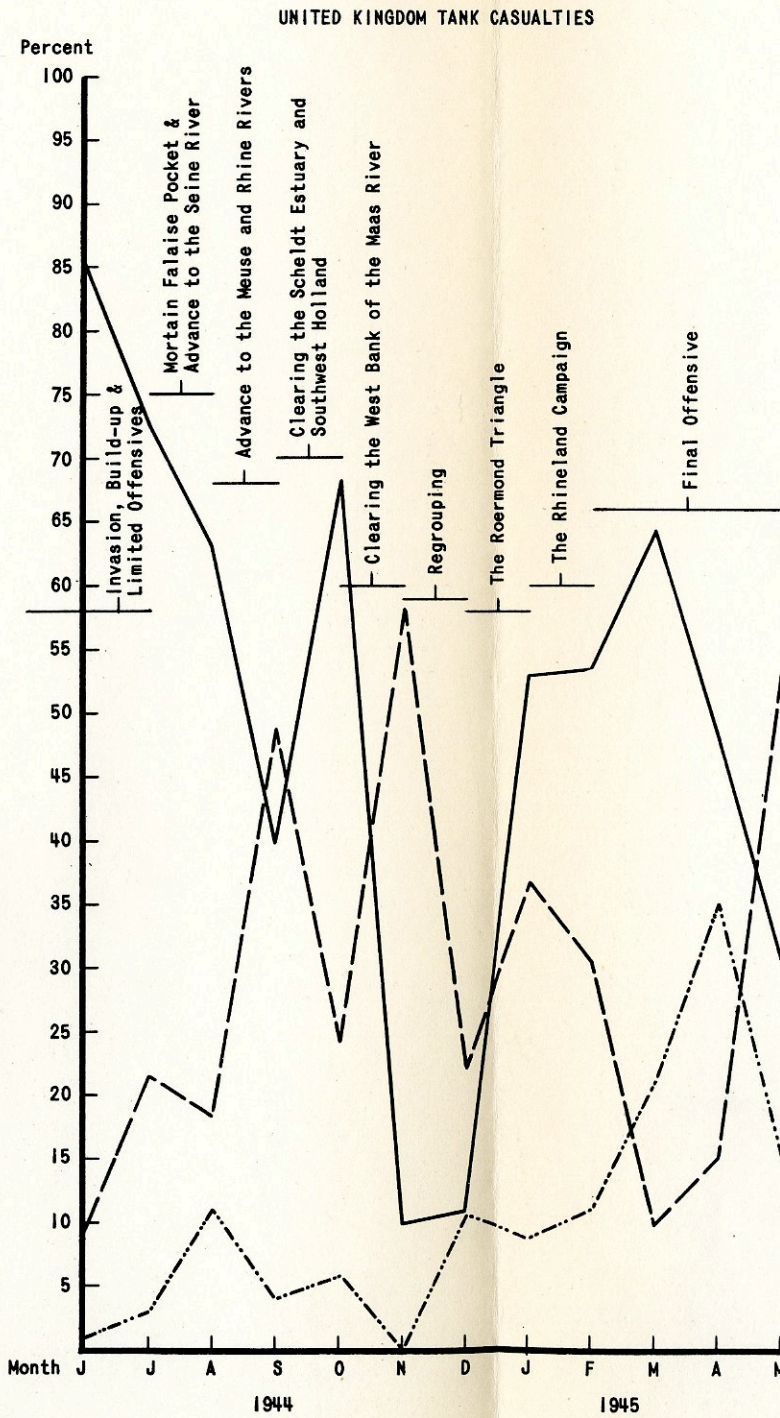
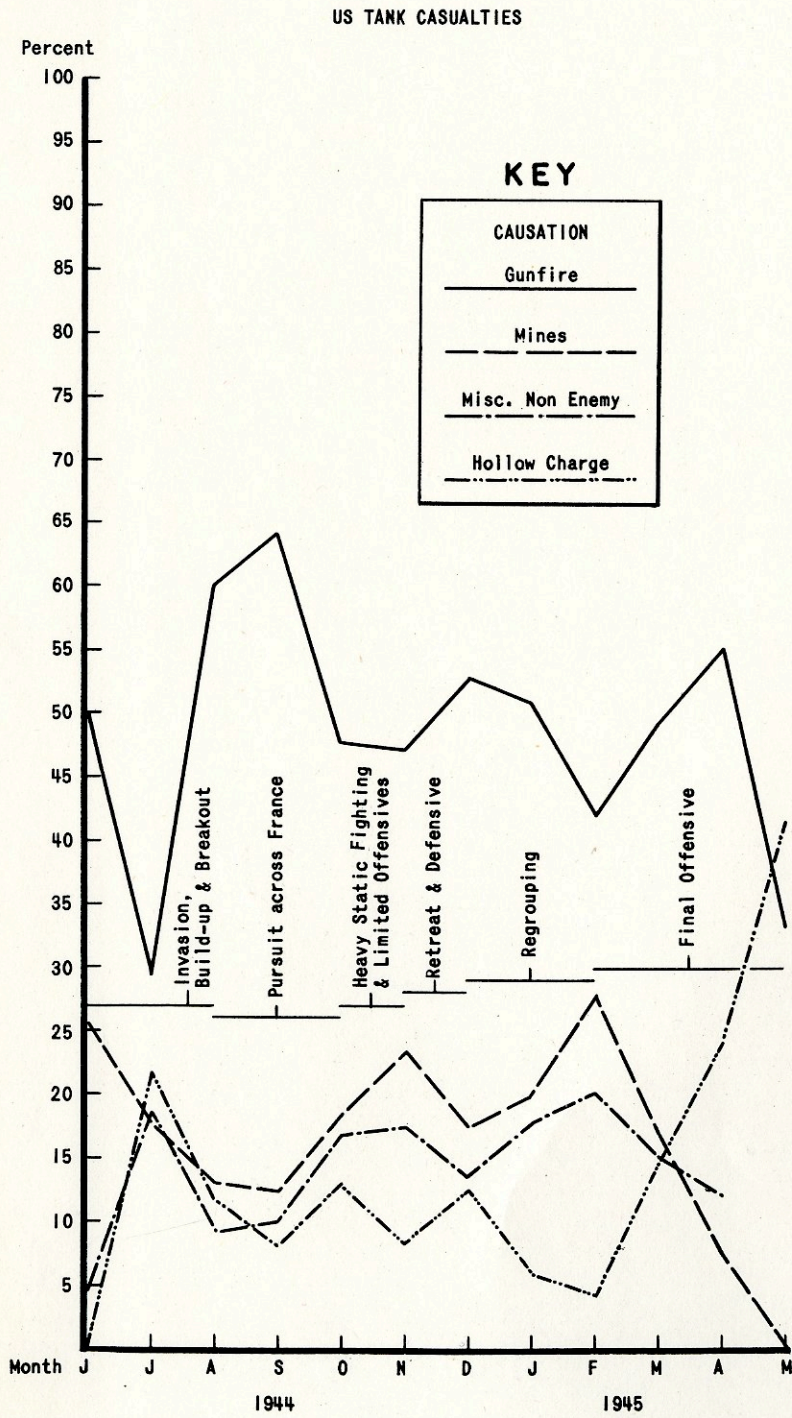


Figure 16. SAMPLING OF ALLIED TANK CASUALTIES
(Causation by Numbers of Tanks)
Italy 1943-1945

Figure 16

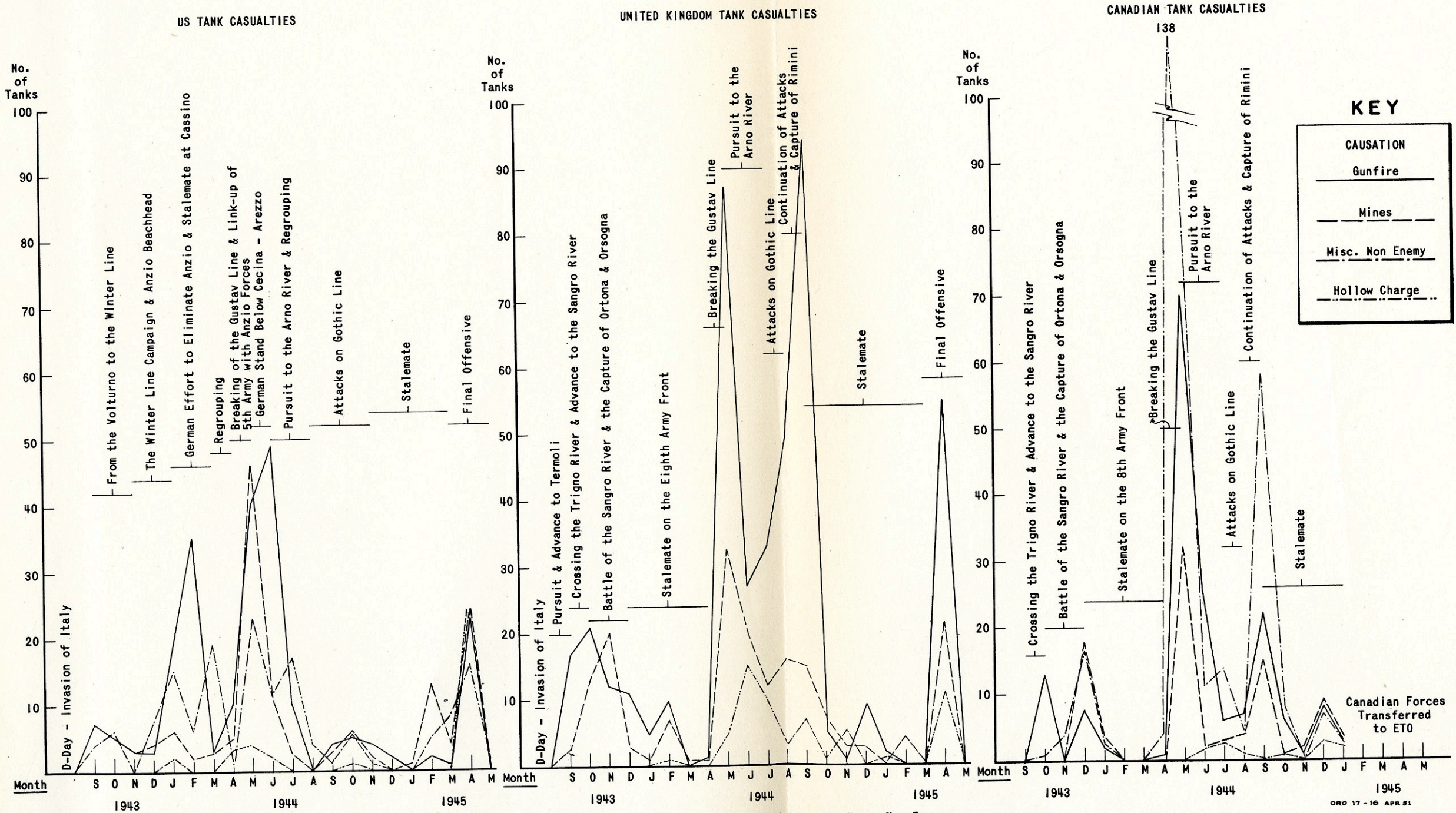
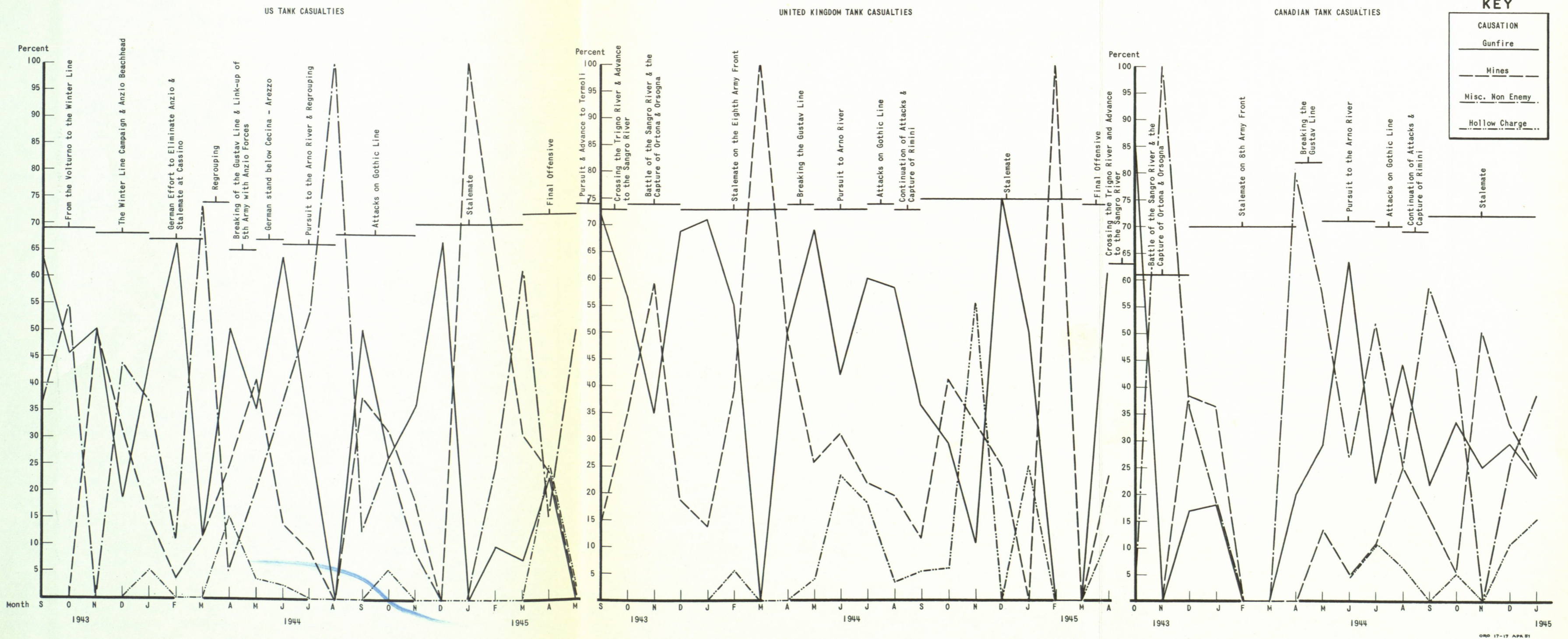


Figure 17. SAMPLING OF ALLIED TANK CASUALTIES
(Causation Expressed in Monthly Percentages)
Italy 1943-1945

Figure 17

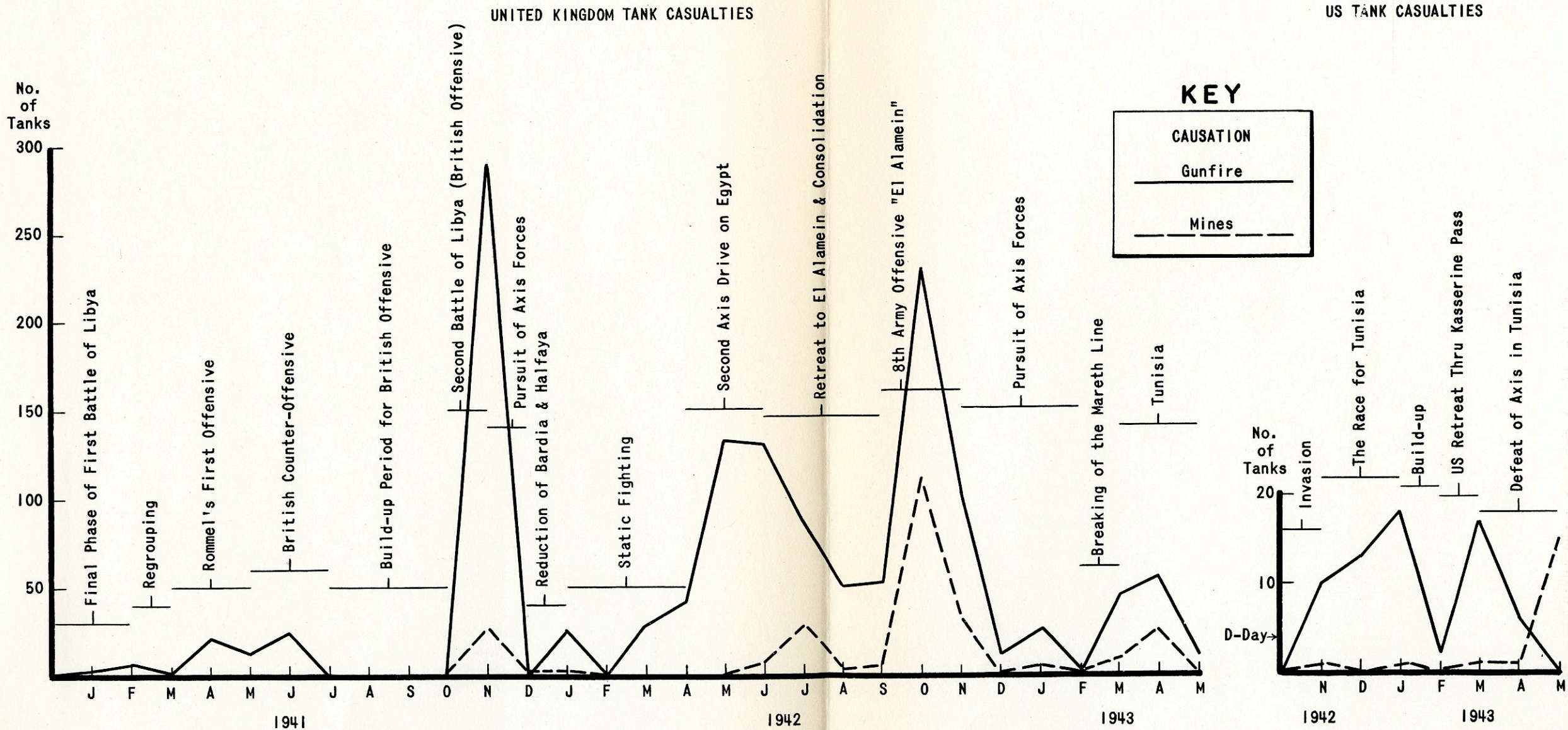


KEY

CAUSATION
Gunfire
Mines
Misc. Non Enemy
Hollow Charge

Figure 18. SAMPLING OF ALLIED TANK CASUALTIES
(Causation by Numbers of Tanks)
North Africa 1941-1943

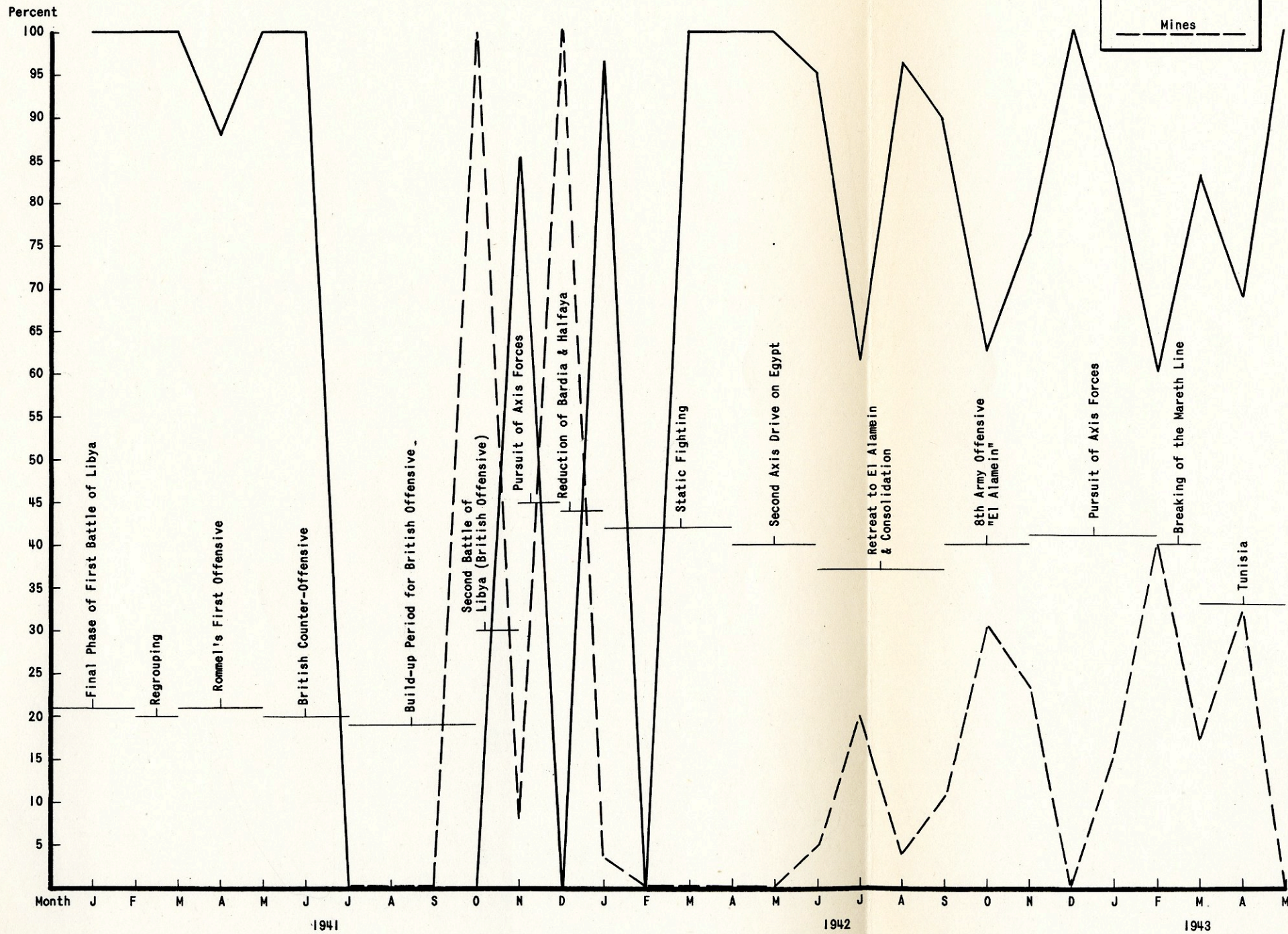
Figure 18



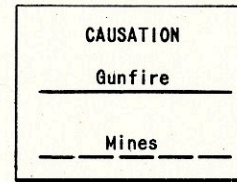
Note: Casualty data on miscellaneous enemy and non-enemy causes omitted because of inadequate records.
As hollow charge weapons were not in general use in North Africa, this line was omitted.

Figure 19. SAMPLING OF ALLIED TANK CASUALTIES
(Causation Expressed in Monthly Percentages)
North Africa 1941-1943

UNITED KINGDOM TANK CASUALTIES



KEY



US TANK CASUALTIES

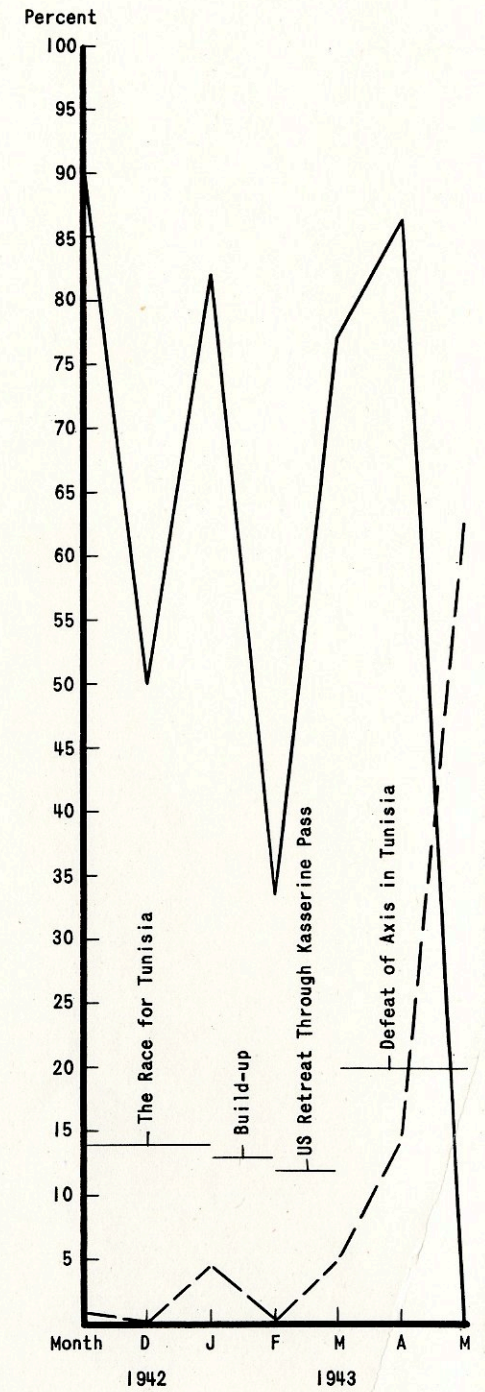


Figure 19



APPENDIX B

FRENCH TANK CASUALTY DATA



APPENDIX B

FRENCH TANK CASUALTY DATA^{18/}

GENERAL

Over-all French tank casualty data are not included in any French Army study, nor are there any statistics as to specific causes of immobilization of armored vehicles.

HISTORICAL DATA

Campaign of 1939-1940. The following data represent losses of tank battalions which belonged to the Reserve Generale: four armored divisions, five light mechanized divisions, mechanized cavalry divisions, reconnaissance groups, and territorial units. Tanks, hit but salvaged and repaired by the field echelons in a very short time, were screened out. Tank losses for the indicated period of time by number and percentage were as follows:

TABLE XXVII

FRENCH TANK CASUALTY DATA, 1939-1940

<u>Cause</u>	<u>#</u>	<u>%</u>
Artillery (cannon and tank)	1669	95.4
Mines	45	2.6
Aircraft	35	2.0
Total	1749 ^{1/}	

^{1/} Includes 151 obsolete tanks.

In the campaign of 1939-1940, approximately 4071 tanks of all types were actually engaged, and 3413 of them were modern tanks. About

^{18/} Abstract of data provided by the Service Historique de l'Armee: "Notice relative aux destructions d'engins blindes au cours de la guerre 1939-1945," and "Fiche: Annexe a l'etude sur les pertes en chars au cours de la campagne 1939-1940..." (SECRET) Received by Office of the Army Attache, American Embassy, Paris, France, 20 Dec 1950, in reply to an ORO request of 4 Aug 1950.

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250 modern tanks were put back in combat condition after the Armistice, in the Free Zone. The difference represents those tanks that met with accidents, broke down, were abandoned, or were set afire by their crews to avoid capture. No data exist as to those tanks repaired in factories and parks between 10 May and 25 June 1940, or those salvaged on the battlefield, repaired, and sent back into battle. Nothing has yet been found to make it possible to calculate the depot replacements, especially of Somua (cavalry) tanks.

Tunisian Campaign. See Tables I and II of the present study.

Italian Campaign. Definite information is lacking on this campaign.

Western Europe, 1944-1945. French tank casualties in the final campaigns of 1944 and 1945 in Europe were as follows: 549 light and medium tanks, 95 tank destroyers, and 134 combat cars. No tank was put out of action by enemy air action. The tanks immobilized by mines could be repaired in a few hours. The "real" losses were due to artillery and hollow charge weapons, but in very small proportions from the latter weapon.

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APPENDIX C

LAND MINE WARFARE DATA

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APPENDIX C

LAND MINE WARFARE DATA

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PART I

ALLIED TANK CASUALTIES TO MINES - ALL THEATERS

NORTH AFRICAN THEATER OF OPERATIONS

A total of 1718 British tank casualties were noted in Africa, during the period of 1941-1943, of which 15 percent were mined losses. This figure represents the averaging out of a steadily increasing mine toll: 7 percent in 1941, 17 percent in 1942, and 23 percent in 1943. To each of these figures should be added about 2 percent, which would represent the mined portion included within the separate category entitled "miscellaneous enemy" or multiple weapon damage, i.e., mine plus gunfire, etc. The resultant figure accords well with the US sample of 16 percent mined, of a known total of 118, and the French loss of 23 percent of a smaller sample of 39 in Tunisia.

The Western Desert of North Africa afforded special advantages for major mine employment. Long stretches of undulating sand, broken by rare natural features of escarpments, depressions, and salt marshes, accentuated the need for channelizing enemy armored thrusts in western Egypt, Cyrenaica, Libya, and Tunisia. Nor was the laying of mines the problem it was in other terrains. (See studies in Part II, Appendix C).

MEDITERRANEAN THEATER OF OPERATIONS

Mines caused many of the Allied tank casualties suffered in Italy during the operations prior to the crossing of the Po River. As the Campaign progressed into and across the valley of the Po, bazookas, antitank guns, and tanks knocked out increasing numbers of Allied tanks. The over-all figure of 22 percent for Allied armor mined in Italy represents the average of losses throughout the various phases of the fighting. The US mine casualties averaged 23 percent from a known sample of 588; the British, 25 percent from a known sample of 728; the Canadians, 16 percent from a known sample of 567 tanks. The inclusion of those tanks which suffered multiple enemy weapon hits, plus the inclusion of that portion of the unknown causation sample which was mined, might be expected to raise the over-all figure to about 30 percent for the Italian theater. This percentage closely approximates the over-all

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figure of 25 percent mined in the Sicilian operation, based upon a much smaller sample of 72 Allied tanks.

The Italian terrain tended to channelize armor's movement and room for maneuver, which in turn facilitated defensive utilization of mine fields. Ravines, trails, rocky slopes, terraces, defiles and river lines--all were mined, more or less methodically, in the slow German retreat throughout the comparatively narrow peninsula, and largely explains the greater number of mine casualties suffered in this theater than in Northwest Europe.

EUROPEAN THEATER OF OPERATIONS

Tanks mined, as a percentage of total tank casualties in the theater, totaled 20 percent for the US, British, and Canadian forces "sampling" which respectively suffered 18 percent, 26 percent, and 12 percent of their tank casualties to mines alone. The total known sample comprised 6800 tanks, broken down as 63 percent US, 25 percent UK, 12 percent Canadian. It should be noted that mines exacted an increasing toll until early 1945.

Thus General Martel has said that land mines were but little used early in World War II: "It was not thought that mines would be used in any large numbers in the initial stages in Europe [1939-40] as mobile warfare precludes the use of extensive minefields. Actually they were hardly used in France at all. It was thought better to use ditches and other artificial obstacles to stop tanks."^{19/} Our records show no Canadian tanks mined at Dieppe. As will be seen from Figures 1 - 4, the Axis began to employ land mines in huge numbers in 1944 and 1945 in Europe. The addition of those mined tanks included in the multiple-weapon category, plus that mined portion that probably exists in the large "unknowns" (27 percent for Canada, 20 percent for the US forces, and 4 percent for the British) would doubtlessly increase the over-all mined figure to about 30 percent for the three armies. This percentage represents Allied tank casualties incurred in every type of fighting engaged in during the European campaign: amphibious, offensive, defensive, and pursuit phases.

The number of German tanks encountered in the West, however, never equalled the scale of armored fighting on the Eastern Front, where battles involving several thousand tanks on each side were not unknown. For a more complete discussion of the quantitative problem of German armored opposition, see Appendix D. The frequency of attack by different types of Axis mines in Western Europe was tabulated by a British medical research team attached to the 21st Army Group; the sample comprised 77 mined British tanks. (See Table XXVIII)

^{19/} Lt Gen Sir G. leQ. Martel, Our Armoured Forces, London, 1945, p 53 (UNCLASSIFIED).

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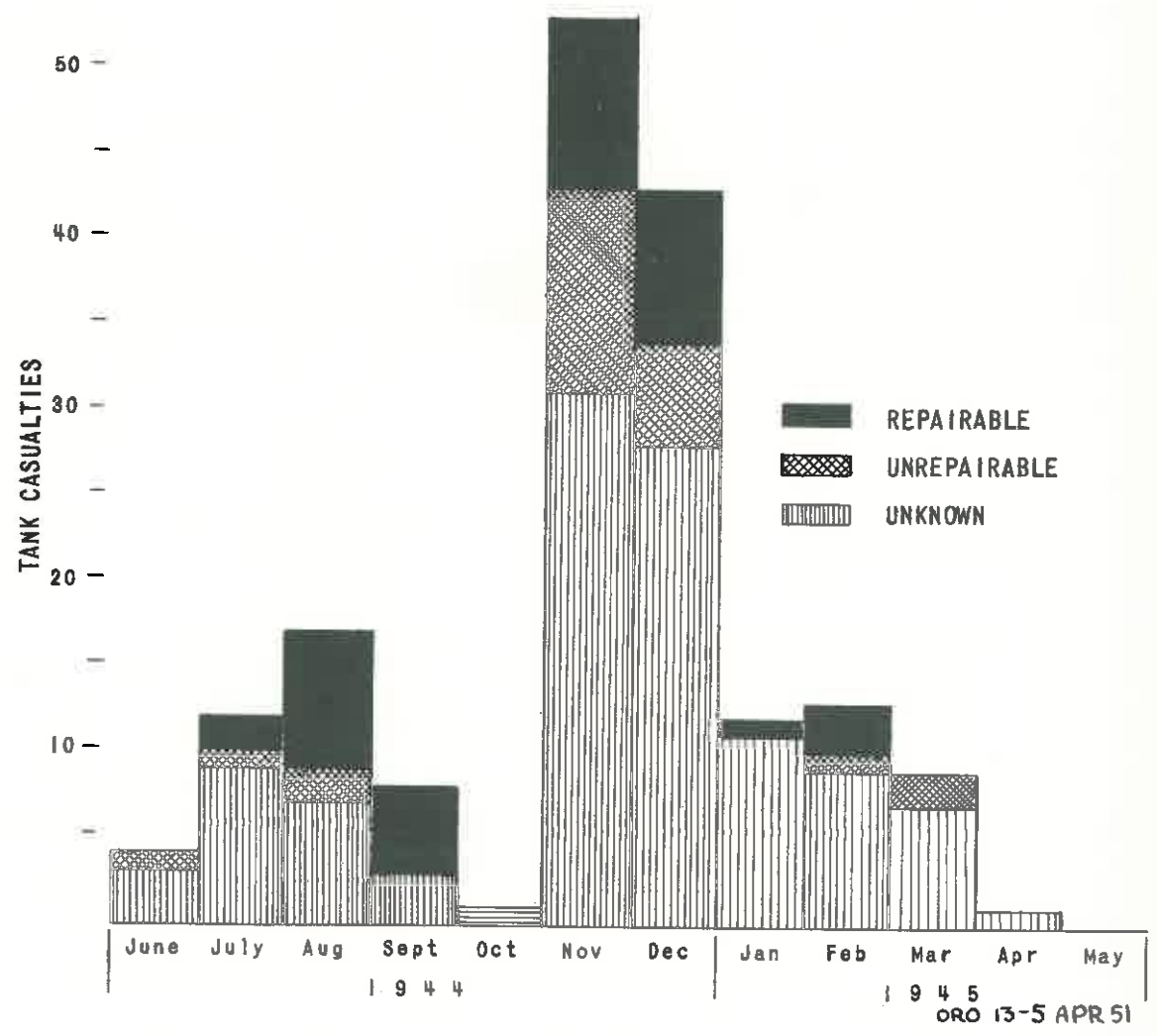
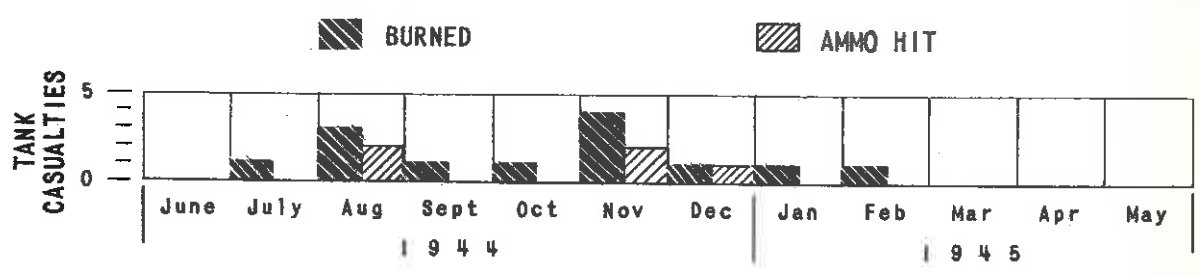


FIGURE 20. --US FIRST ARMY TANK CASUALTIES TO MINES (Monthly).

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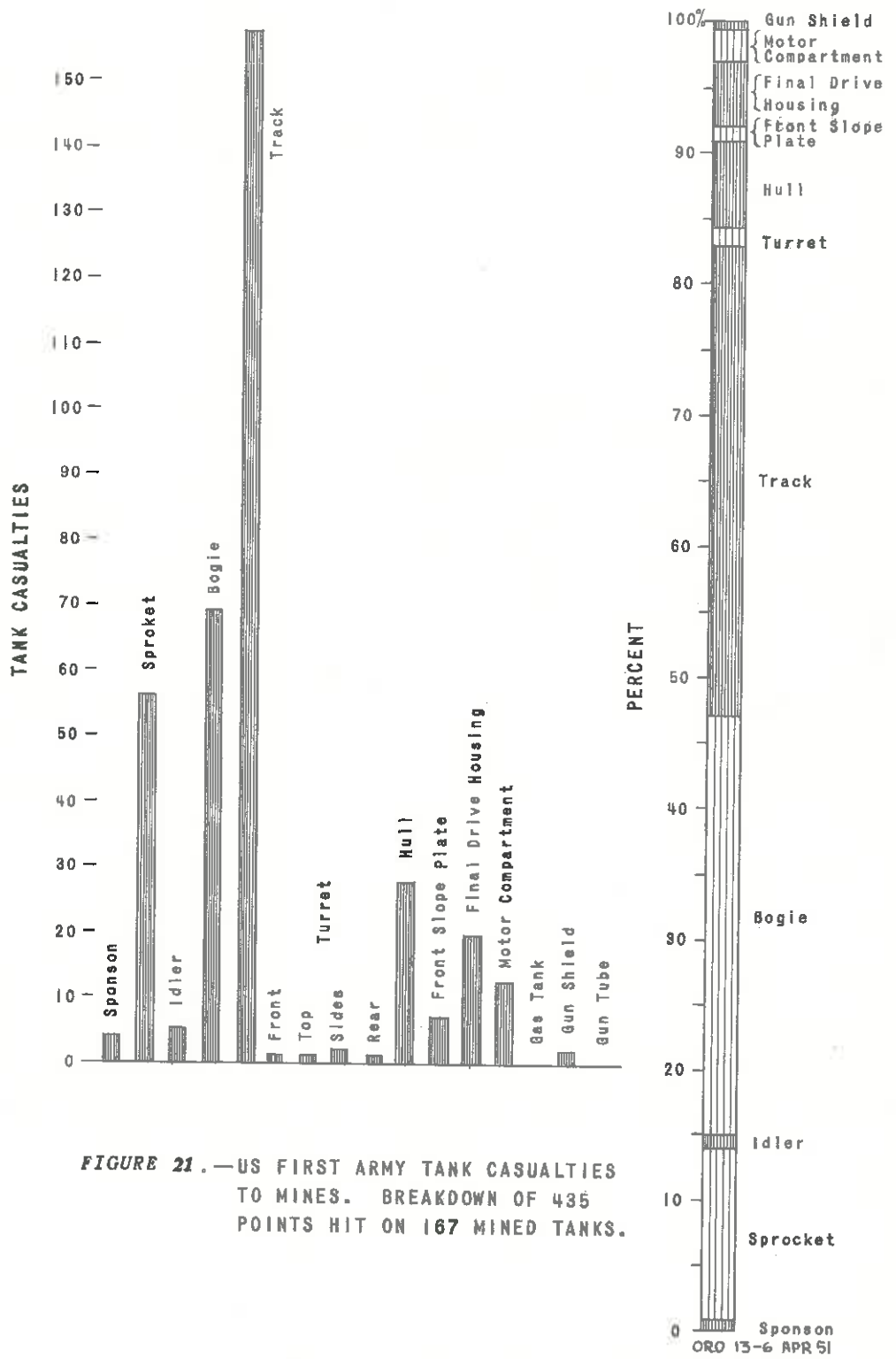


FIGURE 21.—US FIRST ARMY TANK CASUALTIES TO MINES. BREAKDOWN OF 435 POINTS HIT ON 167 MINED TANKS.

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NOTES TO FIGURE 21.

US FIRST ARMY, DISTRIBUTION OF HITS, MINED TANK CASUALTIES

The 167 tanks hit by mines had 435 different recorded hits. The 435 hits were distributed as follows:

Suspension:	361/435 = 83.2%
Hull:	39/435 = 15.8%
Turret:	5/435 = 1 %

Less than 10 percent of the mined tanks burned, and only 3 percent had their ammunition hit. Less than 15 percent of the mined tanks were recorded as having been penetrated by the mines, with 3 percent of this total representing combined artillery-mine penetration.

Most of the tanks mined suffered damage or penetration at more than one point of the vehicle involved. The suspension suffered 83 percent of the hits, 1 percent on the turret, and the remaining 16 percent on the hull. Only two tanks were hit in the turret--in five places.

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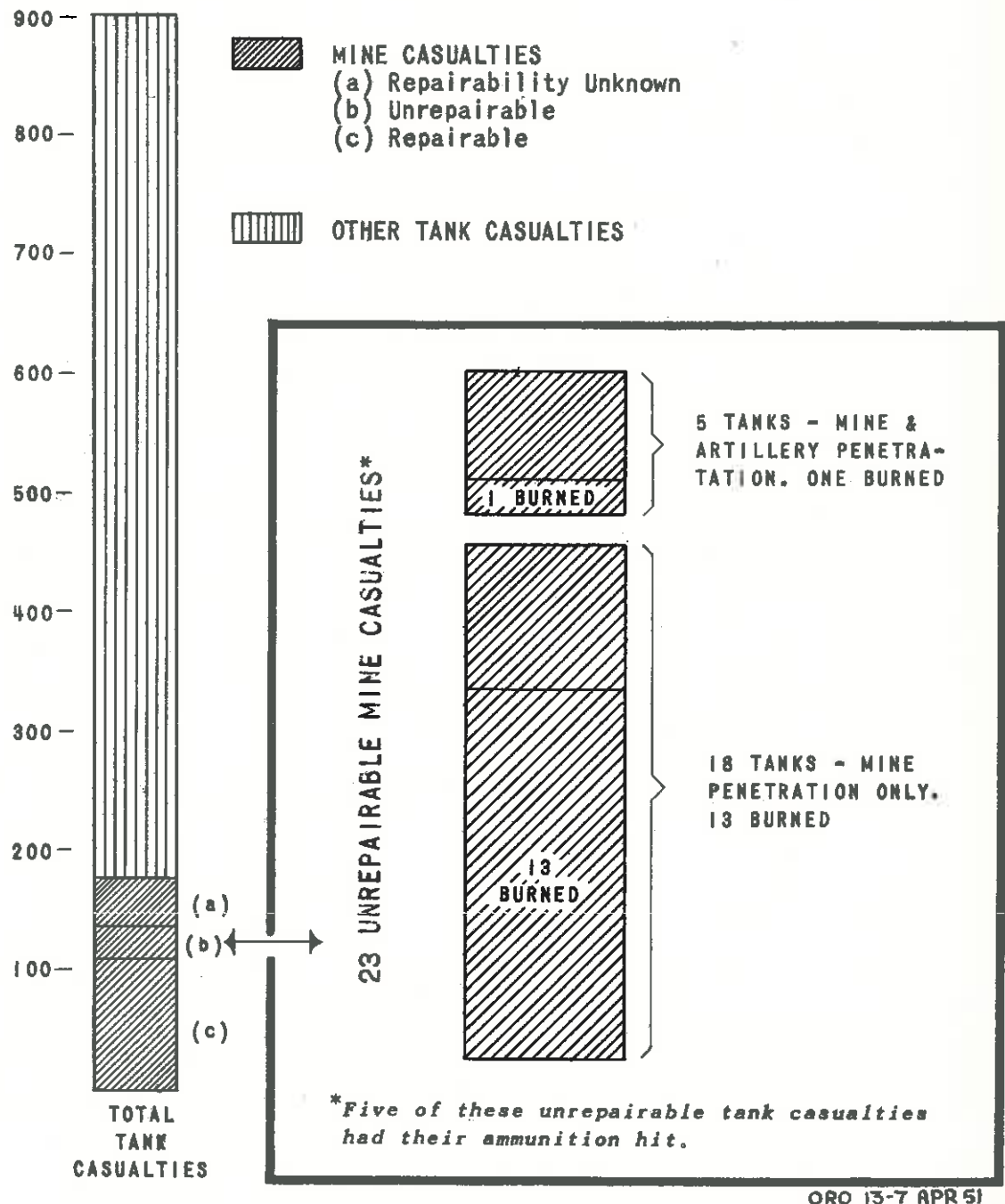


FIGURE 22. — US FIRST ARMY TANK CASUALTIES (SAMPLING)

TABLE XXVIII^{1/}

SAMPLING OF BRITISH TANK CASUALTIES TO MINES,
WESTERN EUROPE

<u>Type Mines</u>	<u>No. of Attacks</u>	<u>% All Attacks</u>
Riegel Mine 43	18	23
Teller Mines	2	3
Riegel or Teller	4	5
Other (Hungarian Box, etc.)	3	4
Unknown	50	65

1/ Capt H. B. Wright and Capt R. D. Harkness, A Survey of Casualties Amongst Armoured Units in Northwest Europe, Jan 1946 (SECRET)

Relative to the decreased losses to antitank mines after the crossing of the Rhine River, the following explanation has been given:^{20/}

"Except for a few cases of mined roads and verges (e.g., Riesenbeck; Hahrenberg; the verges between Elmenhorst and Talkan), there were few German A/T mines. The view was generally expressed that this was because the Germans were in their own land and would not endanger their own civilians. This may have been a deterrent but it must be remembered that in the previous pursuit from the Seine to Brussels and Antwerp equally few mines were met. The more likely explanation would seem to be that in a fast pursuit the enemy cannot lay mines because so many of their troops are up to the last minute trying to withdraw. In this view lack of mines is one of the advantages gained from speed in the pursuit."

SOUTHEAST ASIA COMMAND

The sample of tank casualties of the 225th Indian Brigade was incurred during the period February - May 1945, when they were pushing 400 miles from the Irrawaddy to Rangoon. The British

20/ M.O.R.U. Report No. 32, Report on the Armoured Pursuit after the Crossing of the Rhine. Par. 13: Mined Belts of Ground. (SECRET)

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possessed great superiority in armor and heavy armor and heavy weapons over the Japanese. The latter were therefore obliged to improvise unorthodox antitank weapons which in the case of mines included such expedients as aerial-bomb mines and picric charges. Generally, there was no European parallel to these improvisations of limited success. Therefore, the case of the Burma campaign may be considered to have been atypical and special.

The percentage of tanks mined, as a proportion of total known losses was 20 percent. It should be noted that actual damage caused to all tanks was considerably less than that caused by comparable hits in Europe.

PACIFIC THEATER OF OPERATIONS

Tank casualties to mines were highest in the island fighting of the Far East. Of a total sample of 775 US Army and Marine tank casualties, about 30 percent were from mines. In addition, a very large proportion of the 20 percent of casualties to miscellaneous and multiple enemy weapons were the result of satchel charge and "Molotov cocktail" attacks upon mined tanks. Therefore, it may be safely assumed that the over-all percentage of mined tanks in the Pacific approximated 40 percent. The Army's mined tank casualties in the Philippines (43 percent plus a large fraction of the 25 percent unknown multiple weapon damage) made that operation the most costly to land mines. The separate averages of the US Army and the Marines for the Pacific fighting accorded well: about 30 percent mined, from almost identical samples of 385 known tank casualties.

Employment of armor in Pacific island fighting presented special aspects. Armored opposition was negligible. The extremely difficult terrain and restricted compass for operations were especially important factors in the type of fighting engaged in. Tank losses of any sort were important, due to the critical problem with regard to replacement tanks, of which there was a very limited number available.

Replacement of armored personnel was a difficult problem, especially in the case of key men, e.g., the tank commander and the gunner. Sufficient key personnel were not available through normal replacement channels.

M5A1 light tanks were seldom employed, being inadequate both in armor and armament to meet the type of opposition encountered. Mines of various sizes were encountered in large numbers. Japanese soldiers, whether as individuals or in small groups, were prompt to attack, with satchel charges and "Molotov cocktails", any tanks

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within range, especially those immobilized by mines, terrain, or damage. Evacuation of personnel from stricken tanks was another problem.

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PART II

LAND MINE EXCHANGE RATES - THREE SPECIAL STUDIES

INTRODUCTION

Certain historical data exist, from which an attempt has been made to derive input-output relationships between the numbers of Axis land mines laid and the toll of Allied tank casualties exacted. The results of these investigations are given in Studies 1, 2, and 3, which represent, respectively, typical examples from three different theaters of war.

Study 1 represents a study of the British vs. the Axis at El Alamein in 1942; Study 2 presents the Soviets vs. the Axis at Targul Frumos, Rumania, in 1944; and Study 3 presents the Americans vs. the Germans in the Aachen-Eschweiler operations in 1944. The conclusions follow the presentation of the studies.

An attempt was made to establish similar exchange rates for the German campaign in Poland, 1939. Insufficient data exist to make this study possible. It is known that in the period of 1 - 24 September 1939, the Germans laid 42,000 antitank mines in Poland. We do not have any information, unfortunately, as to how many of the Poles' six hundred $2\frac{1}{2}$ -ton Tanketka TK-3 tanks, and two or three hundred 7-TP 10-ton modifications of the Vickers Armstrong 6-ton type B, were immobilized by the German land mines; we can therefore derive no exchange ratios therefrom.^{26/}

STUDY 1. THE BATTLES FOR EGYPT, 1942

After the Axis armies were checked at Alam el Halfa in early September 1942, they prepared reinforced field works, covered by six belts of antitank and antipersonnel mine fields. The position at El Alamein included, in its northern section, a second line of defended localities behind the main forward mine fields. The two lines were connected with each other by transverse mine fields, with the intention of luring the British

^{26/} Available German data based upon document relating to mine consumption, OKH, Gen. St.d.H./Gen.Q.(Qu 1), 27 Sep 1939 (CONFIDENTIAL); Polish data derived from conversation with Major M. G. Bekker, 13 Feb 1951; and from Tanks and Armored Vehicles, by Lt Col R. J. Icks, NY, 1945, pp 238 and 252.

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attacking forces, via prepared channels, into deceptively attractive clear areas entirely surrounded by mines, where the Germans could open fire from all sides. Thus a belt was prepared, between five and eight thousand yards deep, covered with mines and defended posts, stretching from the sea to the Deir el Mreir, a deep depression lying southwest of the end of the Ruweisat ridge. North of El Mreir there was a peculiar mine field in the shape of a shallow S-bend running roughly east to west at right angles to the main positions and extending for some distance behind them; this was presumably intended as a cover for the right flank of the northern sector of the front, if the British proved able to penetrate the southern sector. Behind the main defenses in the north, a third line of positions, starting east of Sidi Abd el Rahman, and running south for about eight miles, was still in course of preparation but already well advanced. The defenses had been less systematically developed to the south of El Mreir, but since the capture of the British mine fields there in September, that part of the line presented a formidable obstacle. There were two mine field barriers, based on the old British mine field and the original enemy mine field, with a gap between them. The going on the southern flank was bad for the British, and from Qaret el Himeimat the enemy had excellent observation.

To sum up, the Axis position at El Alamein had been developed for three months. It was well dug in, and well covered by wire and mines. At least half the mines were British, lifted from the enormous fields at Mersa Matruh and elsewhere. The defenses had considerable depth (3,000-5,000 yards in most places), but there were no antitank ditches or concrete pill boxes. The British armored forces required gaps in the mine fields 40 yards wide, as in soft ground the leading vehicles churned up the sand so badly that those following needed space to avoid the worst areas. But the engineers settled for 16-yard gaps breached first, and widened later. 1a/

1a/ See article by Brigadier G. R. McMeekan, "The Assault at Alamein," The Royal Engineers Journal, Dec. 1949, LXIII, pp 319-20 (UNCLASSIFIED).

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FACTS

TABLE XXIX

GERMAN MINE-LAYING, EGYPT, 10 JULY-1 NOVEMBER 1942^{1/}

<u>Period</u>	<u>AT Mines Laid</u>	<u>AP Mines Laid</u>	<u>Aerial Bombs Laid</u>	<u>Totals Laid</u>
July 10- Aug. 31	<u>2/</u>	<u>2/</u>	874	178,903
Sept. 1- Oct. 5	49,067	3,135	177	52,379
Oct. 5- Nov. 1	63,700	25,300	<u>85</u>	<u>89,085</u>
			1,136	320,367

^{1/} Source: Minenübersicht Ägypten, el Alamein-Stellung, 1942.
^{2/} Only totals are available.

TABLE XXX

BRITISH TANK CASUALTIES, EGYPT, 30 AUGUST-4 NOVEMBER 1942

<u>Period</u>	<u>Own Tank Casualties All Causes</u>	<u>Own Forces Engaged</u>
30 Aug.- 7 Sept.	68	300 Mediums 80 Light Tanks 230 Armored Cars <u>100 Reserve Tanks</u>
	68	710
23 Oct.- 4 Nov.	337 Repairable 193 Non-repairable	267 M4 (Sherman) 128 M3 (Grant) 128 Stewarts 105 Crusaders (6-pdr.) 255 Crusaders (2-pdr.) 35 Crusaders (close support) <u>196 Valentines</u>
	530	1114

61
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A total of 598 British tanks were immobilized (repairable and non-repairable, due to battle causes) in large-scale armored battles that covered 21 of the 114 days with which this study is concerned. Most of the period between and before the battles was relatively static, with only patrols and skirmishes to produce minor tank casualties. The latter figures, not available, are in any case deemed to be negligible, in terms of this study.

We may consider the totals of Axis antitank land mines laid to have been: 10 July - 31 August 1942, 142,433^{21/} AT mines and 874 aerial bombs; 1 September - 1 November 1942, 112,767 AT mines and 262 aerial bombs, or a total of 256,336.

Studies of British tank casualties to mines in Africa indicate an over-all casualty factor of about 22 percent at the time of El Alamein. Therefore we may assume that at least 132 of the 598 British tanks immobilized in the period were mine casualties. The exchange ratio of German mines laid (before sweeping, etc.) per British tank knocked out = 1942:1. This ratio would be even more favorable to the Germans, if British losses of motor transport, motorcycles, and other vehicles were considered. Such figures are not available, however.

In the absence of an exact scale of costs for Italian, German and other Axis land mines employed at El Alamein, the current cost factors (1950) for the equivalent US antitank mine, HE, M6A1 will be applied. The costs of the medium tanks engaged at El Alamein will be equated with the estimated mass production cost of the US medium tank T42.

Thus,

$$256,326 \times \$16.60 = \$4,255,000$$

$$\text{and } 132 \times \$195,300 = \$25,779,600$$

$$\text{or } \$4,255,000 : \$25,779,600$$

(Total mine investment : Cost of tanks lost to mines).

$$\text{Therefore, } \frac{\text{Mine investment}}{1 \text{ tank mined}} = \frac{\$32,235}{\$195,300} = 1:6.1$$

^{21/} This estimate is based upon a ratio of 5 AT mines;: 1 anti-personnel mine, and is based on the known total of 178,029 mines laid in the period. Note that antipersonnel mines were not then used in the quantity encountered later in World War II.

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Appendix C

It should be noted that the dollar loss for mined tanks is conditioned by the fact that only 25 percent are assumed to have been non-repairable. But the temporary loss of the tanks tactically cannot be assessed in terms of dollars; repair costs, expensive as they may have been, cannot compare with such intangibles, which win or lose battles and campaigns.

STUDY 2. TARGUL FRUMOS, 1944

Limited information is available on the important tank battles that took place near Targul Frumos, west of Jassy, in May 1944. Under Manteuffel the following units held defensive positions, to thwart a tank-led Soviet thrust toward the Ploesti oil fields:

Panzer Grenadier Division Grossdeutschland
3rd SS Panzer Division "T"
24th Panzer Division
Part of 1st Rumanian Guards Division
Part of Royal Rumanian I Army Corps

It is known that the 6th Rumanian Infantry Division, an element of the Rumanian I Corps, laid 16,000 antitank and 13,730 antipersonnel mines, through May 20. Since the major battles ended on May 6, an exchange rate can be attempted, which, however, represents a proportion even less favorable to the Axis than was probably the case. Nor does the rate consider the toll of Soviet motor transport and other vehicular casualties exacted by mines; these figures were not available.

We do know, however, that in the sector of the 6th Rumanian Infantry Division the Soviets attacked with 20-25 tanks on May 2. Seven tanks (or 35 percent of the attacking force) were immobilized by Axis mines.

From the above facts, we observe that

$$\frac{\text{Total mines laid}}{\text{Tanks mined}} = \frac{16,000}{7}$$

$$\text{or } \frac{\text{Mines laid}}{1 \text{ tank mined}} = \frac{2286}{1}$$

In the absence of a yardstick of costs of Soviet armored vehicles, the above exchange rate will be equated in terms of costs of US mines and tanks, as of the current 1950 index. The US T-43 Heavy Tank will be equated with the Soviet JS-III Heavy Tank; the US land mine (antitank), with the Axis version.^{22/}

^{22/} T-43: \$174,000 (estimated cost, in production).
Mine, Antitank, HE, M6A1: \$16.60 (estimate).

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Thus, the total Axis mine investment would be about \$265,600: \$1,218,000, for the total of tanks mined.

Or, \$37,947 : \$174,000 = 1:4.8.

(Mine investment per 1 tank knocked out.)

STUDY 3. THE AACHEN - ROER OFFENSIVES, 2 OCTOBER - 30 NOVEMBER 1944

During October and November 1944, the German LXXXI Army Corps defended the region from Geilenkirchen to Aachen, and eastward to the Roer and Inde.

The terrain in this sector is flat, open ground. The whole area is dotted with villages located a mile or so apart, which the Germans turned into formidable, mutually-supporting strongpoints. A good network of roads covered the zone, though severe rains and hard usage reduced their effectiveness.

The LXXXI Corps attempted to deny any American advance in this area by manning the defenses of the West Wall, which lay within its sector. These defenses consisted of an endless chain of pill boxes and emplacements, augmented by extensive antitank obstacles to canalize attacks against the stronger defenses. In early October the LXXXI Corps was in position within the West Wall. The October fighting saw the Germans try to prevent a breach in the defense line.

When the American First Army broke through, the LXXXI Corps fell back slowly, defending each town and village. Machine guns, artillery, and tanks were emplaced within houses with good fields of fire. The defenders relied heavily on land mines and artillery to stop further advance. In the region of the First-Ninth Army boundary, US units ran into one of the most heavily mined areas experienced in the war up to that time. After-action reports refer to the abundance of covering artillery and antitank weapons employed by the LXXXI Corps.

United States armor which fought against the LXXXI Corps, and for which data on tank losses is available, included:

- 2nd Armored Division
- 3rd Armored Division
- 743rd Tank Battalion
- 745th Tank Battalion
- 746th Tank Battalion
- 747th Tank Battalion
- 750th Tank Battalion
- 759th Tank Battalion
- 70th Tank Battalion

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FACTS

TABLE XXXI

U.S. TANK CASUALTIES, THE AACHEN-ROER OFFENSIVES^{1/}

1 - 31 October

<u>UNIT</u>	<u>TOTAL CASUALTIES</u>	<u>MINED TANKS</u>	<u>UNKNOWN CAUSATION</u>
66th Arm'd Regt (CC-A)	20	4	2
67th Arm'd Regt (CC-B)	53	?	51
32nd Arm'd Regt (CC-A)	1	0	0
33rd Arm'd Regt (CC-B)	2	0	0
82nd Rcn Sqd	2	2	0
743rd Tank Battalion	36	3 (1 to US mine)	0
745th Battalion	<u>25</u>	<u>3</u>	<u>7</u>
	139	12	60

1 - 30 November

<u>UNIT</u>	<u>TOTAL CASUALTIES</u>	<u>MINED TANKS</u>	<u>UNKNOWN CAUSATION</u>
66th Arm'd Regt (CC-A)	10	?	10
67th Arm'd Regt (CC-B), (less 3rd Bn)	47	?	47
3rd Bn, 67th Arm'd Regt	16	5	0
32nd Arm'd Regt (CC-A)	21	6	0
33rd Arm'd Regt (CC-B)	51	12	0
743rd Tank Battalion	25	8 (2 to US mines)	0
745th Tank Battalion	30	2	3
746th Tank Battalion	10	3	2

^{1/} The term tank casualty is used to mean any tank (not including tank destroyers or assault guns) which was put out of action for the remainder of the day's operation as a result of enemy action or becoming bogged down by terrain. Mechanical failure is not here included as a cause of tank casualties.

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Appendix C

TABLE XXXI (cont.)

U.S. TANK CASUALTIES, THE AACHEN-ROER OFFENSIVES

1 - 30 November

<u>UNIT</u>	<u>TOTAL CASUALTIES</u>	<u>MINED TANKS</u>	<u>UNKNOWN CAUSATION</u>
747th Tank Battalion	18	6	0
750th Tank Battalion	54	25	2
759th Tank Battalion	1	1	0
70th Tank Battalion	<u>3</u>	<u>3</u>	<u>0</u>
	286	71	64

Totals for October and November

Total tank casualties (known and unknown causes)	425
Total tank casualties to enemy mines	80 or 18.8 percent

TABLE XXXII

MINES LAID BY GERMAN LXXXI CORPS,

OCTOBER - NOVEMBER 1944

<u>PERIOD</u>	<u>AT MINES LAID</u>	<u>AP MINES LAID</u>	<u>TOTAL LAID</u>
October 1944	10,234	10,633	20,867
November 1944	<u>7,416</u>	<u>8,534</u>	<u>15,950</u>
	17,650	19,167	36,817

From the foregoing facts, we observe that

$$\frac{\text{Total AT mines laid}}{\text{tanks mined}} = \frac{17,650}{80}$$

or

$$\frac{\text{Mines laid}}{\text{1 tank mined}} = \frac{220.6}{1}$$

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Appendix C

Using as a yardstick of cost the estimated 1950 mass production figure of a US medium tank T42 as \$195,300, and \$16.60 for a US antitank mine, HE, M6A1, we may set up the following equations.

$$80 \times \$195,300 = \$15,624,000$$

and

$$17,650 \times \$16.60 = \$292,990$$

$$\text{or} \quad \$292,990 : \$15,624,000$$

(Total mine investment : Cost of tanks lost to mines)

$$\text{Therefore:} \quad \frac{\text{Mine investment}}{\text{1 tank mined}} = \frac{\$3,663}{\$195,300}$$

or

1:53

(Mine investment per 1 tank knocked out.)

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CONCLUSIONS

On the basis of the preceding studies, whatever the limitations in their completeness, we must conclude that the "orthodox" antitank mines of World War II "paid off" for the Axis. Despite vigorous Allied countermeasures, one British or Soviet tank was immobilized for every 1900 - 2300 land mines originally laid, in the two engagements examined in Studies 1 and 2. This figure accords with the conclusion of the British AORG, based upon theoretical studies, that "nearly 2000 enemy mines were required to cause the loss of one British tank, on the assumption that equal numbers of mines went to each mile of the German front line."^{23/}

Study 3 is an example of US armored operations in one of the most heavily mined areas encountered by the US Army in Europe. The terrain favored canalization into avenues of armored attack. The Germans mined the approaches to every village, and covered these approaches by a very heavy, mutually supporting antitank fire. There is little evidence of concerted mine sweeping by the Americans, whose attempts at detection with the new nonmetallic mine detector did not perform satisfactorily. The Germans laid glass Topfmines very heavily in November 1944, and US tank casualties showed a marked increase that month. These factors appear to account for the ten-fold increase in effectiveness of land mines in the Aachen-Eschweiler operations, reflected by the exchange ratio as compared with those observed in Studies 1 and 2. Experience at the Sangro river crossing and in certain North African battles accentuates the conclusion that land mines may be a serious menace to a particular operation, and thus may pay off even more dramatically for the defense.

Even if a proportion of the tanks mined in the three engagements studied were repairable, at a certain cost, the mines laid made a "profit" for the Axis. Had the antivehicular mines laid in World War II been less easily detectable^{24/} and truly lethal against tanks, the exchange rates would have become more advantageous to the Axis, even if a mere parity of incidence of hits were

^{23/} Internal Memorandum No. 16, The Comparative Performance of German Antitank Weapons during World War II. May 1950. (UNCLASSIFIED).

^{24/} At El Alamein, for example, visual detection was often possible, when the wind had blown the surface sand away from the shallowly laid mines.

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maintained with the actuations effected in the battles noted. If available, records of motor transport and of other vehicles immobilized by mines would have similarly accentuated the mine-laying "profit" to the defense.

Transcending a reckoning in materiel alone are the factors of psychological and tactical delay presented by mine fields laid in depth. An American observer in the European Theater has reported that "the presence of enemy mines tended to lower the morale of US troops," since the shock effect caused by the detonation of antitank mines was considerable. The British AORG have attempted to quantify the factor of tactical delay.^{25/} Within a sample of 97 British tank regiments engaged in North Africa, Italy, and northwest Europe, 22 instances were recorded in which the times given for delays due to mine fields averaged 15.3 hours per regiment per incident. In addition, there were 20 occasions when regiments were delayed or stopped in their advance by mines, and on four of these occasions the delay was stated to be considerable. Research done for the present study indicated a further 21 incidents of US delay by antitank mines, 13 of which (the majority in Italy) caused abandonment of the advance or its delay for 1-24 hours.

Field Marshal Alexander testified at a conference held at Marble Arch (Egypt) in 1943 that the hundreds of thousands of land mines laid by the Germans along their path of retreat in Africa had held up the Eighth Army materially. One has but to peruse the battle dispatches of this Army to note how frequent were the delays in "timetables" of attack and of exploitation, before mine fields laid in depth. Rommel, the man behind this mine laying program, never forgot this experience. When he commanded German anti-invasion forces in 1944, he proposed to lay 50 to 100 million mines and, after surrounding all strongholds with deep mine fields, to fill up the country between them with mines, wherever it was "tankable."

A factor not betrayed by exchange rates alone--the magnitude of the task of sweeping discovered or suspected mine fields--is suggested by the following figures recorded by the 6th US Armored Division (1944-45):

25/ See note 23.

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Miles of roads swept for mines:

France	221
Belgium	113
Luxembourg	87
Germany	<u>128</u>
Total	549

Over-all figures of the cost in man-hours to clear the enemy mine fields in France, Belgium, and Germany, have been provided in the final report of the Chief of Engineers, for the European Theater of Operations, through 1945:

TABLE XXXIII

MAN-HOURS OF LABOR CONSUMED BY ALLIES IN
CLEARING ENEMY MINE FIELDS, ETC, 1944-1945

	<u>MILITARY</u>	<u>POW</u>	<u>CIVILIAN</u>	<u>TOTALS</u>
France	313,569	22,608	24,532	360,709
Belgium	1,232	0	0	1,232
Germany	<u>402</u>	<u>0</u>	<u>0</u>	<u>402</u>
	315,203	22,608	24,532	362,343

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ANNEX 1

GERMAN LAND MINE EMPLOYMENT

An extract of questions and answers from an Army Ground Forces Board Report^{27/} reveals pertinent comments by engineer members of various US Armies engaged in combat in the European Theater, concerning their experience with German land mine employment:

...

Question 2. "To what extent were the Germans able to lay mines in their retreat? Did they mainly rely on filling gaps in existing fields as they withdrew? Were fields employed of a hasty or deliberate type? Were many nuisance mines and booby traps used by the Germans before the Western Front became relatively stabilized? How did the stabilization of the Front affect the German employment of mines?"

Seventh Army: "Character of fields indicate that the enemy retreated behind previously prepared fields.

"Gaps are scarce in German fields. Fields on both sides of the road are made continuous by the construction of mined road blocks.

"Fields were of a deliberate type, well marked and camouflaged. Hasty type fields were principally employed in conjunction with the road block. Many mines laid by the Germans particularly in roads were removed by them to permit his use of

27/ Answers To Questions Submitted by the Engineer School, AGF Board Report No. 699, 5 Mar 1945.

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more roads in his retreat and by so doing decreased his loss by our air power.

"Yes, many nuisance (unpatterned) mines were found particularly in the St. Die, Baccarat, Bruyeres area. Booby traps and antipersonnel mines are SOP for all German mine fields.

"Front not stabilized."

Third Army: "While moving across France, no mines were encountered in many places where they could have been employed effectively. The Germans did not rely on filling gaps in existing fields as they withdrew. During our drive across France, practically all fields encountered were of a hasty type. The Germans rarely employed nuisance mines or booby traps before the Western Front became relatively stabilized. After stabilization, the Germans laid many deliberate minefields with antipersonnel mines interspersed among antitank mines. They also frequently laid antitank and antipersonnel mines at feasible bridge sites."

Ninth Army: "The Germans while hastily retreating from Normandy to the Siegfried Line, did not have time to install deliberate minefields; those mines encountered were placed in and around hastily prepared road blocks. Very few nuisance mines and booby traps were encountered. In an orderly withdrawal, the Germans rely mainly on filling gaps in existing fields. Since the Western Front has become somewhat stabilized, the Germans are installing very extensive deliberate fields with numerous booby traps and booby trapped antitank mines. In general, the type and density of German minefields depends on the time available."

...

Question 6. "In the current German salient, what barrier tactics and obstacles were used by the Germans to protect their flanks?"

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Annex 1, Appendix C

Third Army: "In the recent German salient, the Germans mined natural approaches and also used blown bridges and culverts, abatis, and improvised road blocks to protect their flanks. Warning devices such as percussion mines and signal flare devices were also employed."

Question 7. "How prevalent are S mines modified for instantaneous or knee firing?"

Seventh Army: "Modified 'S' mines - not prevalent."

Third Army: "S mines modified for instantaneous or knee firing are prevalent in some areas and are not found in others. It is estimated that these mines are at present prevalent on about one-third of this Army's front."

Ninth Army: "Approximately eight to ten percent of S-mines discovered have been modified for instantaneous or knee firing."

A captured German Army Service leaflet^{28/} reveals the type of instructions issued for the advice of German commanders in the field:

Minefields. Calculation of requirements should be based on a density of at least three, preferably five A/T mines per meter frontage (depending on available supplies).

Wrong procedure: Uniform distribution of the mines over a wide front with only two or even one mine per meter.

Correct procedure: Concentration at the decisive points, i.e. two or more minefields behind each other.

Mixture of A/T and antipersonnel mines is to be used in all types of minefields in front of MIR. Within main zone of resistance, only minefields of one or the other type may be used. Additional demands for antipersonnel

28/ Principles of Reconnaissance and Construction of Tank Obstacles.
(German) 1 Aug 1944 From the files of G-3, US Sixth Army Group.

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Annex I, Appendix C

mines should be taken into account. Dummy minefields are effective only in connection with real minefields. Dummy mines are particularly successful in irregular minefields.

The laying of mines is permitted exclusively to engineers, organic engineer trained personnel of other branches, and mine-laying platoons. Experience shows that the laying of mines by non-engineers does more harm than good.

...

Captured documents dated late January 1945 indicate that certain changes in laying of minefields may be expected in the near future.^{29/} Based upon experience, the following suggestions were submitted to German Engineer units:

More stress on mining roads and narrow passes, and fewer attempts to lay fields in open terrain. This will result in a far greater economy in mines, and in most cases be more effective in delaying enemy movements.

Echeloning of minefields in depth rather than extending them on a wide front.

Laying of tank mines in front of MLR has proven ineffective, particularly on the Russian Front. On the Western Front, A/T minefields were only found of value when coordinated with other A/T obstacles, such as road blocks.

More stress on arming tank mines with T Mi Z 43 and on using anti-lifting devices, in order to render clearing of fields more difficult. More extensive use of mixed minefields.

Better camouflage of mines.

Preparing of unarmed minefields whenever possible, in order to permit passing of German traffic over mined areas. Safeties to be removed by last unit clearing area.

^{29/} Recent Developments in the German Technique of Laying Minefields.
Armored Report No. 8, Hq, 12th Army Group, 10 Apr 1945 (US Third Army).

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Annex 1, Appendix C

More irregular minefield patterns. Avoidance of parallel guide ropes, and of repetitive patterns. ... The completed field presents a picture of utter irregularity, yet can be easily detected once the scheme is known.

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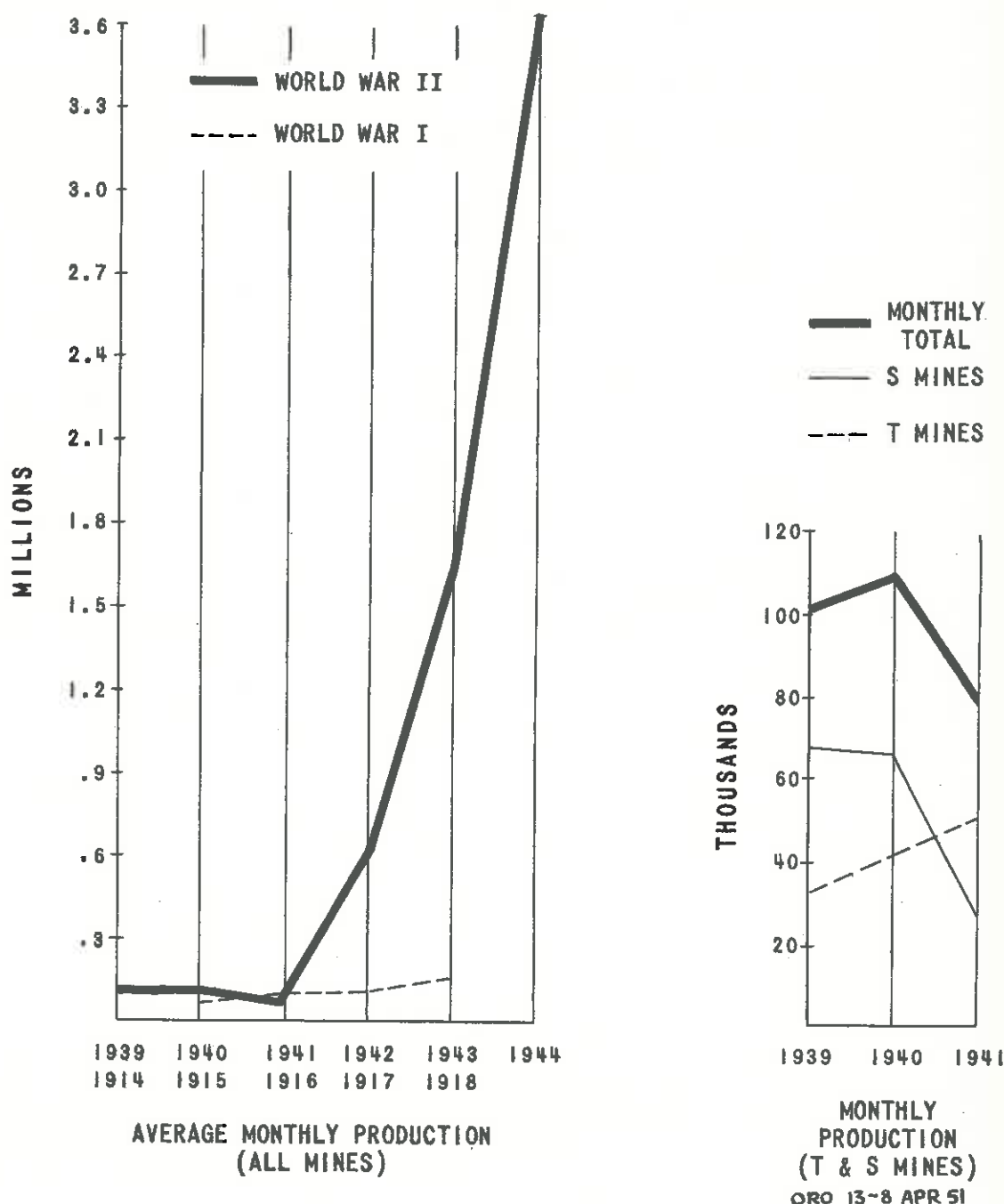


FIGURE 29.--GERMAN LAND MINE PRODUCTION (MONTHLY)

SOURCE: Heeres Munitions, Waffenstab, Heeres Waffenamt.

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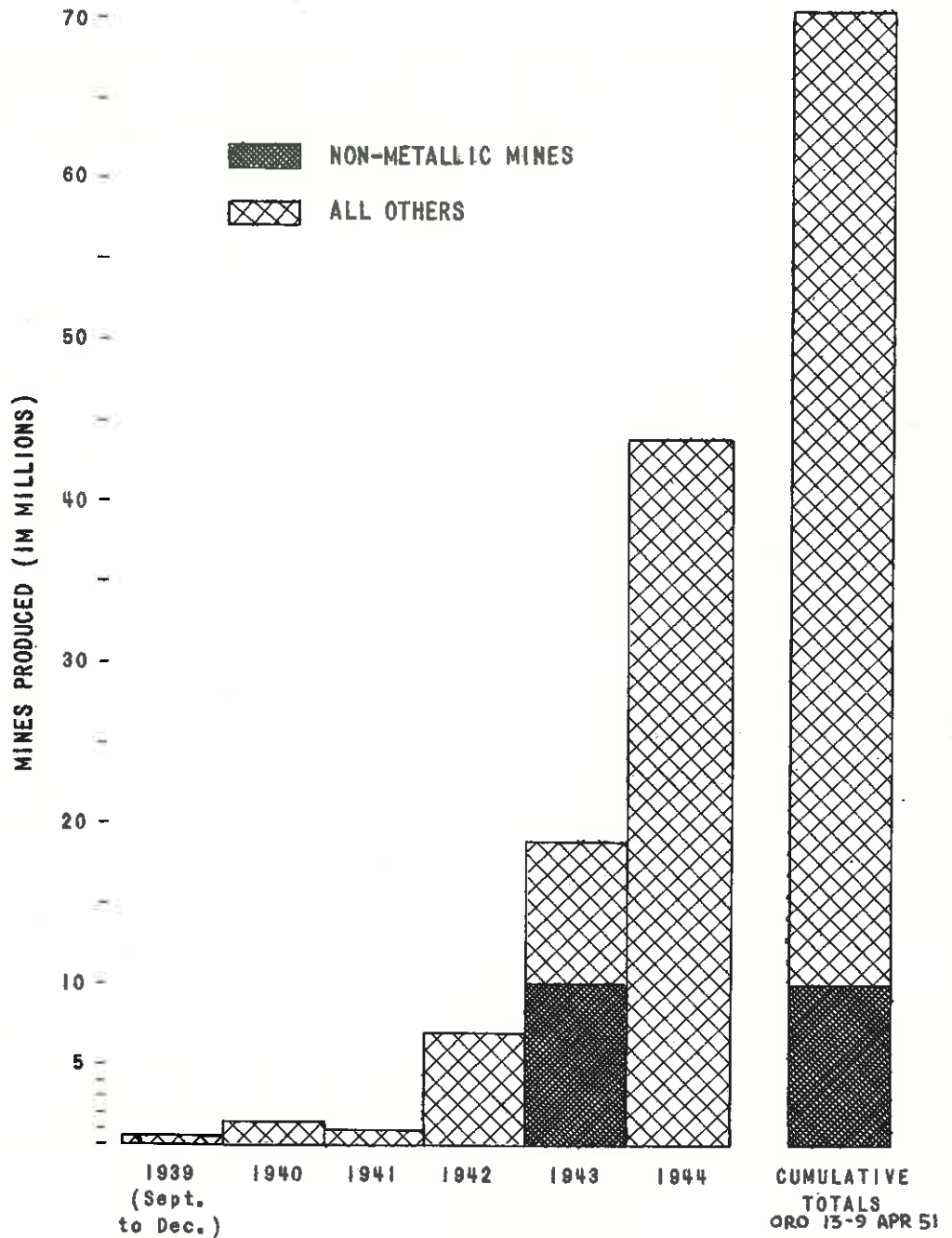


FIGURE 24. — GERMAN LAND MINE PRODUCTION, ANNUAL AND CUMULATIVE FIGURES, WORLD WAR II

SOURCE: *Speer Documents*. Vol. 212. Jan. 27, 1945. (Berlin).

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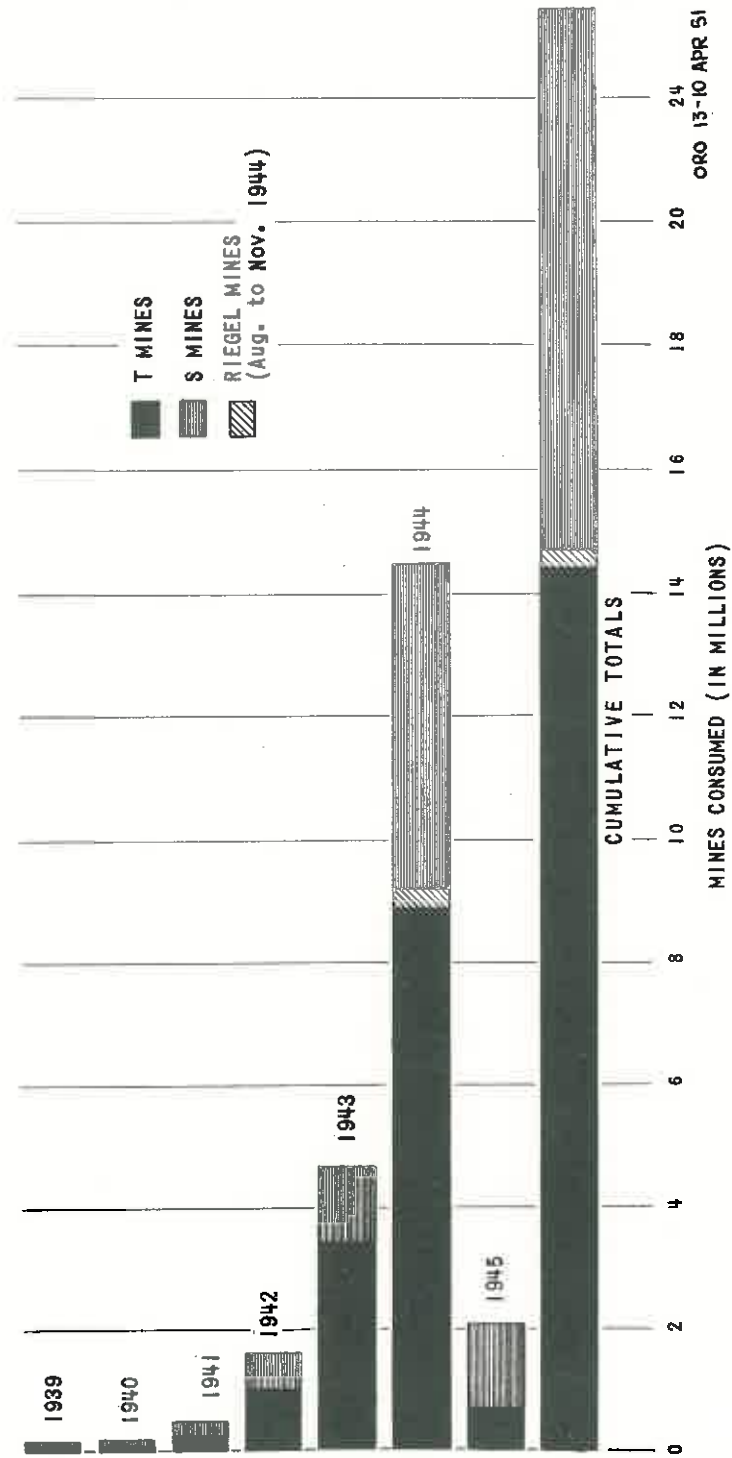


FIGURE 25 . — ANNUAL GERMAN MINE CONSUMPTION (FRONT), SEPT. 1939 - FEB. 1945.

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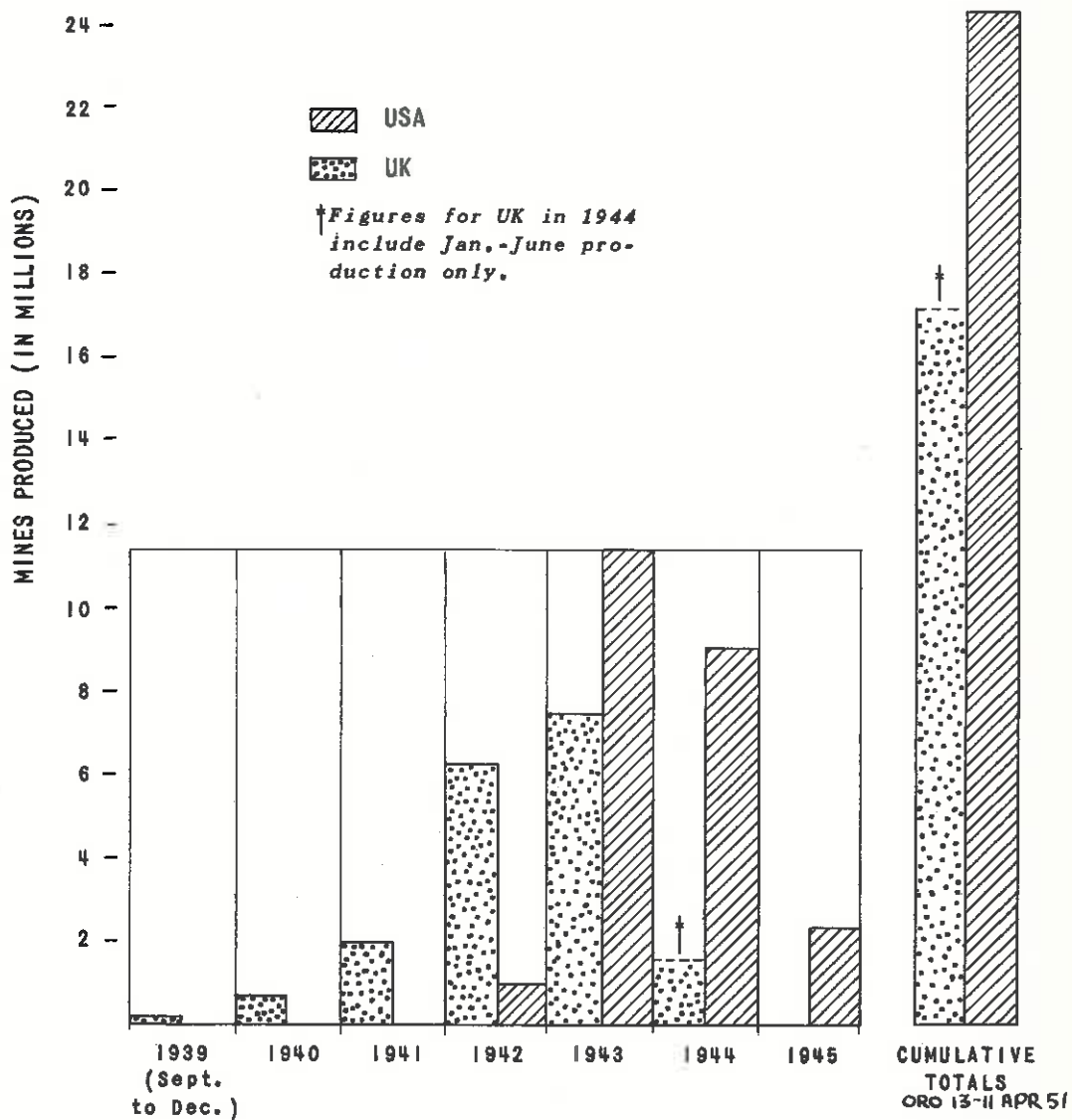


FIGURE 26.—LAND MINE PRODUCTION, ANNUAL AND CUMULATIVE FIGURES, WORLD WAR II. USA AND UNITED KINGDOM

SOURCE: *The Munitions Industries of Foreign Powers.* (1949).

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APPENDIX D

TANK PRODUCTION DATA



TABLE XXXIV
TANK PRODUCTION - WORLD WAR II

	1940	1941	1942	1943	1944	1945	TOTALS	
Germany	1,890 ¹	3,790	6,180	12,063	19,002	3,932 [Jan-March]	44,967	Incl. SP
UK	1,711 ²	4,844	8,611	7,476	2,474	?	(23,405) ⁵ [1940-44]	Incl. SP
USSR	?	?	18,500?	24,000?	30,000?	?	?	Tanks only
USA	-	3,923	13,884	29,497	17,565	11,583	86,452 ⁴	Tanks only
Japan	?	1,024	1,165	786	342	94	3,411	Tanks only
Italy		3,186 ³		?	?	?	?	Tanks only

¹Incl. 274 produced, Sept-Dec 1939.

²Incl. 314 produced in 1939.

³1939-late 1942.

⁴Note: US furnished 27,777 tanks to UK (Lend-lease) and 7,056 tanks to USSR.

⁵UK furnished 3,800 tanks to USSR. Canada furnished 1,220 tanks to USSR.

Sources: *The Munitions Industry of Foreign Powers, Appendix A, US Intelligence Division, Jan 1949 (SECRET).*

Soviet Arms and Soviet Power, Gen A. Guillaume (French Army), Washington, D. C. 1949.

The Effects of Strategic Bombing on the German War Economy, US Strategic Bombing Survey, III, 31 Oct 1945.

APPENDIX D

GERMAN TANK LOSSES AND PRODUCTION 1944^{30/}

One of the most awkward problems for the war historian, dealing with the operations of 1944, is to explain why the German Army was so desperately short of equipment at a time when German war factories were reaching the peak of their output. This is particularly the case with regard to tanks.

On January 1st 1944, according to figures given by Speer and accepted by USSBS, the armoured strength of the Wehrmacht was:

Tanks	- 8,622
Assault Guns	- 2,410

Total: 11,032

Speer does not break these figures down further into categories, but an analysis of the acceptance and wastage figures of the Inspectorate of Panzer troops at OKH (JN6) shows that on January 1st 1944 the holdings of the main types of armour were (or should have been):

	MK. VI	- 437
	MK. V	- 1,386
	MK. IV	- 1,558
*	75m. AG.	- 2,439

Total: 5,820

(* Because of the shortage of MK. IVs these assault guns mounted on MK. IV or MK.III chassis were being issued to the MK. IV Battalions of Pz. Divs. and also to the A/TK Battalions of these divs.)

If these figures are correct there were:

- (1) Sufficient Tiger Tanks to equip 10 Heavy Panzer Battalions (Their W.E. was 45 Tigers per battalion).

^{30/} The above reproduced paper is an extract from unpublished notes by the Australian war historian, Chester Wilmot, 16 May 1950
(UNCLASSIFIED)

- (2) Sufficient Panthers and MK. IVs to equip fully about 15 of the 33 Panzer divisions then in existence.
 (Their W.E. was: 98 MK.V 93 MK.IV per divn.)

During the first five months of 1944 production more than kept pace with losses, for the output was:

Tanks - 3,571
 Assault Guns - 2,550

Total: 6,121

Over the same period the profit and loss recorded by JN6 was:

	<u>Acceptance:</u>	<u>Wastage:</u>	<u>Net Gain:</u>
MK. VI	478	217	261
MK.V	1,468	620	848
MK.IV	1,463	973	490
Total	<u>3,409</u>	<u>1,810</u>	<u>1,599</u>
75 AG.	1,803	1,309	494
Overall Total:	<u>5,212</u>	<u>3,119</u>	<u>2,093</u>

Thus by June 1st for these types alone the holdings has increased since January thus:

	<u>Jan.1st</u>	<u>June 1st</u>
MK.VI	437	698
MK.V	1,386	2,234
MK.IV	1,558	2,048
75 AG.	2,439	2,933
Total	<u>5,820</u>	<u>7,913</u>

(The holdings on June 1st were sufficient to bring the Panzer divisions up to two-thirds of their W.E.)

The USSBS Report says that during this period the total strength of the Panzer units rose from 11,000 to 14,000. It gives production (including S.P.G.) as 7,272. That means that its calculation of losses was about 4,300, which may be correct if S.P.G. and Assault Guns other than 75mm are included, as

presumably they are, since its production figures include them.

Strength in the West.

Geyr von Schweppenburg says that the "number of tanks available to the German armies in France on D-Day was between 2,000 and 2,400." This figure presumably includes assault guns for Blumentritt says: "On June 6th there were 9 Panzer Divisions in France. Between them they had 1,000 to 1,200 tanks, no more, and about 900 to 1,000 assault guns." We do not know the actual strength of each of the Panzer divisions, independent tank battalions and assault gun brigades but a fair estimate of the D-Day strength (based on the strength of those units for which we have the figures) seems to be 1,200 tanks and 800 assault guns. To these we must add the armour which 9th and 10th SS Panzer Divisions brought back with them from Poland - approximately 130 tanks and 100 assault guns.

After D-Day losses rose steeply and for June-September (inclusive) far outstripped production.

	<u>Acceptance:</u>	<u>Wastage:</u>	<u>Net loss:</u>
MK. VI	376	509	133
MK. V	1,435	1,474	39
MK. IV	1,080	1,915	835
	<u>2,891</u>	<u>3,898</u>	<u>1,007</u>
75 AG.	<u>1,691</u>	<u>2,233</u>	<u>542</u>
Total:	<u>4,582</u>	<u>6,131</u>	<u>1,549</u>

Thus in these four months the Wehrmacht had lost as many Panzers as it had lost in the whole of 1943--but production had so greatly increased that three-quarters of these losses had been replaced--at least that is what the JN6 figures show. But in the West during this period there had been a catastrophic decline in the strength of the Panzer divisions and other armoured units. On September 27th Model reported that in Army Group B he had only "239 tanks and assault guns." At the same time Army Group G probably had 250 tanks and assault guns--certainly no more. Thus there were in the West at the end of September a maximum of 500 tanks and assault guns. That means that only one-quarter of its losses since D-Day had been replaced even though the factories had produced enough tanks and assault guns to replace three-quarters of the losses on all fronts.

Indeed the West was so starved, even during the crisis of September, that Army Group B, which had "about 100 tanks" on the 7th, reported that it had only 239 on the 27th. Obviously, if there had been more tanks available they would have been sent to the West then.

What is the answer? The possibilities are:

(1) One's first inclination is to doubt the USSBS production figures, but these are confirmed by the Acceptance figures of JN6 and, in the case of Tigers by the records of the Henschel works which made them. Thus:

	<u>Production</u>		<u>Acceptance</u>
1944	USSBS	Henschel	O.K.H.
Jan.-June	622	620	585
July-Dec.	380	380	344

(The discrepancy between the first two columns and the third is easily accounted for by time-lag in acceptances, owing to disorganization of transport, rejects, losses at factory due to bombing.)

(2) The second possibility is that the figure of over-all losses is too low, but there is no firm evidence to suggest that a very large percentage of losses went unrecorded at this time—probably 10%—15% were missed but hardly more.

The USSBS Report (p. 169) says that "in the five months after D-Day, 10,000 Panzer vehicles were destroyed in battle or abandoned in retreats." The JN6 figure for this period (i.e. to the end of October) is 7011. However, this discrepancy can be accounted for by the fact that the JN6 figure covers only Marks IV, V and VI and 75 mm AGs. The USSBS Figure presumably includes all fighting armour including S.P.Gs.

(3) The third possible solution is that throughout the summer the Eastern Front was given absolute priority and absorbed all—or very nearly all—the replacements.

In June, for instance, total tank losses (according to JN6) were 507: total acceptances came to 777. How many of this surplus 270 went to the West? On July 15th Rommel reported that so far he had received "17 tanks to replace about 225 destroyed." These, plus some 36 Tigers which were sent to France with a new heavy tank battalion, were evidently all that Rommel received from the June surplus, for when II SS Panzer Corps came back from Poland at the end of June it did not pick up any fresh tanks en route

to the West.

The answer seems to be that for the first two months after D-Day the West was starved because it appeared to Hitler that the Allied bridgehead was being contained with the forces already on the spot—and anyway it was merely a 100-mile front. On the other hand the demands of the Eastern Front were more vast and more urgent. Because of the great distances the wear and tear on tanks and engines was very much greater and the battle was so much more open that more armour was needed. In addition, the Russians were advancing and the Western Allies were not. As late as the start of August Hitler still regarded the campaign in France as a holding action. Indeed, the apparent success of the German Command in the West in the defensive battles of June and July paved the way for its utter defeat in August. The Panzer divisions had been exhausted in the bocage and had not the strength to counter the breakout.

Hitler's natural inclination to give priority to the East was reinforced when Guderian, who had been Inspector of Panzer Troops, became Chief of Staff at O.K.H. on July 20th. (In support of this view, see von Kluge's last letter—Aug. 18th—and Ebenbach's interrogation.) Since he was now concerned exclusively with the East and since he still exercised control over the Inspectorate of Panzer Troops, it was natural that he directed to the Eastern Front the bulk of the tanks that became available.

By the time Hitler woke up to the danger in the West the new tanks had already been sent to the East and were heavily engaged. With the railway network already disorganized by bombing, there was no chance of carrying out a major strategic switch of armoured forces.

The demands of the Eastern front in June and July must have seemed much the more urgent. In these months the losses of tanks and 75 mm AGs on all fronts came to 2669. Of these at least 2,000 must have been on the Russian front. In the same period output of these types was 2,464—of which perhaps 150 all told went to France. This means that losses in the East were replaced tank for tank during June and July, while the West received replacements for less than a third of its losses—if that.

In August and September losses were up and output was down. Of the 3,462 tanks and 75 mm assault guns written off by JN6, replacements were received for only 2,118. Of these not more than 500 had been sent to the West by the end of September. On a strict numerical calculation this was the West's share for only a quarter of the Panzer-type divisions were there, but this allocation ignored the fact that during the previous four months,

while at least 85% of the tank losses in the East had been replaced, the Panzer forces in the West had been reduced to skeletons, and had received replacements for less than 25% of their tank and assault gun losses. The result was that at the end of September, when there were some 500 tanks and assault guns in the West and another 200-250 in Italy, the total holdings of MK, VIs, Vs and IVs and 75mm AGs was, according to JN6, 6364. If this is correct, it means that more than 5,000 tanks and 75mm AGs were in the East giving this front a ten to one advantage over the West in armour.

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APPENDIX E

GERMAN TANK CASUALTY DATA



APPENDIX E

GERMAN TANK CASUALTY DATS

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APPENDIX E

GERMAN TANK CASUALTY DATA

During static periods of the European campaign, there was little opportunity for obtaining battlefield data concerning those tanks repaired or salvaged by the Germans. British author Alan Morehead says: "The Germans had an excellent tank recovery organization. Their huge tracked and wheeled tank-transporters were actually going into battle with the tanks themselves. Even while the fighting was still on, the men in the transporters were prepared to dash into battle, hook on to damaged vehicles and drag them out to a point where they could start repairs right away."^{31/}

On the other hand, periods of exploitation and pursuit furnish a fairly representative tank casualty picture, inasmuch as the proportion of damaged or immobilized tanks recovered was necessarily small. An attempt was made in the Office of the Chief of Military History, US Army, to tabulate German tank casualties incurred on the Eastern Front, on the basis of the document holdings of the German Military Documents Section, The Adjutant General's Office, Department of the Army. The findings were largely negative, as may be seen in Annex 1, this Appendix.

In the course of the tabulation of data for the study of Allied tank casualties, material on German tank casualties was more or less incidentally gathered, for whatever value it might later prove to be. It is now felt that the sampling of 1207 such tank casualties provides sufficient basis for certain preliminary conclusions, as seen in Table XXXV, which follows:

^{31/} Alan Morehead, A Year of Battle, p 61, London, 1943.

TABLE XXXV GERMAN TANK LOSSES BY CAUSATION - 1944-1945 (Sampling)		
CAUSE OF IMMOBILIZATION	NO. OF TANKS	PERCENT OF TOTAL KNOWN
GUNFIRE:		
75-mm or 76-mm AP	66	12.5
75-mm HE + AP	2	0.4
90-mm AP	6	1.1
Tank	125	23.6
Tank + Artillery	100	18.9
TD	24	4.5
TD + Artillery	7	1.3
Artillery	14	2.6
AP	127	24.0
APC	7	1.3
AP (TD)	2	0.4
HE	19	3.5
57-mm AT	3	0.6
SP	1	0.2
"Gunfire"	26	4.9
	TOTAL 529	43.8
HOLLOW CHARGE WEAPONS:		
Hollow Charge Weapons	TOTAL 53	4.4
AIR:		
Rocket	35	38.5
Cannon	4	4.4
Bomb	7	7.7
"Fighters"	7	7.7
"Air"	38	41.7
	TOTAL 91	7.5
MINE:		
Mine	TOTAL 3	0.2
MISCELLANEOUS, ENEMY ACTION:		
Multiple Action: AP + HC	5	55.6
Grenade	1	11.1
Captured	3	33.3
	TOTAL 9	0.7
MISCELLANEOUS, NON-ENEMY ACTION:		
Mechanical or Terrain	49	9.4
Abandoned (lacked parts, gas, recovery; under attack, etc.)	222	42.5
Self-destruction	251	48.1
	TOTAL 522	43.2

DISCUSSION

Gunfire. It is interesting to compare the figure of 44 percent for the German tank casualty sample to gunfire with that of the Allies in the same theater of 52 percent. The difference lies in the very heavy percentage of German tanks abandoned or self-destroyed. In the interrogations of Guderian, von Geyr, Dietrich, and Hausser, no mention was made of the latter two causative categories. See the section following, which gives the Germans' own estimates of tank losses. A Ninth US Army estimate of German tanks destroyed by all ground force action more nearly approximated the figure of Allied gunfire casualties in Europe, e.g., 53.5 percent based upon a sample of 8190 tanks claimed. Mr. Chester Wilmot, the Australian war historian, in an unclassified letter to A. D. Coox (O.R.O.) under date of 15 Feb 1951, notes that:

In the last year of the war there was a very high percentage of mechanical failures, due partly to flaws in production, partly to bad driving--itself the result of inadequate training, and partly to the breakdown of railways which compelled tanks to travel on their tracks. My own impression is that "availability" so far as the Germans were concerned, was affected more by mechanical unserviceability than by battle losses. The Germans tended to handle their armour with a rather brutal stupidity.

For a sampling of sites of hits upon German tanks, see Figures 27-30, at the end of this Appendix.

Hollow Charge Weapons. The number of German tanks immobilized by hollow charge weapons ran about one third the percentage for Allied tanks in Western Europe--4.5 percent instead of 11 percent. The Germans, of course, were fighting a generally defensive campaign, and threw more man-portable rocket weapons into the fray. For the views of Guderian, Dietrich, Hausser, and von Geyr, see section on "German Comments On Their Own Tank Casualties."

Land Mines. Less than one percent of the German tank casualty sample was mined. This is in contrast to the percentage of Allied tanks mined in the same theater which was 20 percent. Actually, the Allies had but infrequent occasion to engage in the type of defensive warfare that would necessitate mine-laying, e.g., the Normandy beachhead (Caen), Strasbourg, the Ardennes, and Metz. See the section on "American Employment of Land Mines." We have previously seen the comparative ease of repairability of tanks damaged by mines but it is remarkable how the Germans' excellent system generally facilitated swift salvage and repair. Consequently, our forces encountered few enemy tanks immobilized by our land

mines. Guderian estimates that only five percent of German tank casualties were suffered to land mines.

Air Action. About eight percent of the German tank casualty sample was immobilized by Allied air action, of which rocket attack appeared to outnumber cannon and bomb strikes by about four to one. A claim sheet issued by the Ninth US Army, based upon a sample of 8190 German tank casualties, attributed 22 percent to air action but, as we shall see, much of the discrepancy is attributable to the difficulty of distinguishing between tanks immobilized by direct and indirect air attack. Von Geyr thought that enemy air-tank cooperation was a very deadly and much feared combination, but could give no approximate figures. Dietrich estimated the tank casualties to air attack as 10 percent of the total, Hausser's estimate being 20 percent. See the section treating "German Estimates...."

Miscellaneous Causes. Of the German tank casualty sample, 44 percent was immobilized by miscellaneous causes, of which non-enemy causes accounted for over 98 percent. Mechanical or terrain causes knocked out about 10 percent of the miscellaneous total. This compares with Dietrich's figure of 30 percent; Hausser's of 15 percent (or 20-30 percent during long route marches); and Guderian's much higher figure for the Eastern Front of 60-70 percent.^{32/} We consider that our own figure for mechanical and terrain immobilization is definitely too low to be representative, a fact that is explicable by the very nature of the records at our disposal. About 90 percent of our data came from Allied combat records, which had little opportunity to note or examine "non-enemy" causes of German tank immobilization, as opposed to destruction.

Of the miscellaneous causes, 43 percent of the German tank casualties were in the abandoned category, either because of lack of fuel, parts, or recovery facilities, or because of direct, or indirect action (largely air attack).^{33/} Another 48 percent of the miscellaneous sample was self-destroyed. None of the German generals interrogated said anything about these two large factors of tank casualty causation! See Annex 2 of this Appendix.

It is interesting to note that the Ninth US Army's estimate of German tanks immobilized by miscellaneous causes, i. e., self-destroyed or abandoned, plus those immobilized by aerial attacks totaled 46.5 percent (24.5 percent plus 22 percent respectively, of a sample of 8190 tanks). This estimate accords well with our own combined total of 50.7 percent, (7.5 percent plus 43.2 percent respectively.)

^{32/} Also ORS Report No. 17, Analysis of German Tank Casualties in France.

^{33/} For elaboration, see ibid.

ANNEX 1

OFFICE OF THE CHIEF OF MILITARY HISTORY

CSHIS

11 May 1950

MEMORANDUM FOR THE CHIEF, APPLIED STUDIES DIVISION

SUBJECT: Statistical Analysis of Tank Losses by Causes in German-Soviet War.

1. An exhaustive search has been conducted in the document holdings of GMDS to establish whether or not the German Army maintained a system for recording their tank losses in World War II broken down as to causes such as artillery fire, mines, the airplane bombs, bazookas, etc. The research covered the daily War Diaries, the Periodic, and other Operational Reports on a representative cross section of German combat units ranging from division to army group. Research was also conducted in the available records of OKH, OKW, and the Fuehrer headquarters.

2. Where tank losses are dealt with they are usually shown as "total" or "repairable." The tank status reports normally show the number in line, in repair in the operational area, or in repair in rear area shops. The cause of tank destruction or damage is not usually indicated unless circumstances were extraordinary. The battle losses are chiefly due to artillery fire. However, there is a report by Guderian to Hitler in 1944 in which he does not discuss percentage rates, but states that the main reason for tank losses can be ascribed to the lack of recovery gear. It appears that in the over-all production effort the Germans cut down on the rate of production of tank transporters, and this was later reflected in inability to get damaged tanks out of the combat area.

CONCLUSIONS:

a. The combat units reported their losses chiefly in numbers with the causes not mentioned, or only as incidental parts of their report.

b. On the highest echelons the statistics appear to be largely the number of tanks in operational use, the number in production, the number en route to the armies, the forecast of future production.

c. While there is evidence to support the conclusion that the Germans kept a statistical analysis of reasons for tank losses, there is really no evidence that they did not. The document holdings in this field are so scattered and so fragmentary as to make any conclusion we might make rather dubious.

...

JOHN R. ULMER
Lt. Colonel, GSC
Chief, Foreign Studies Branch

ANNEX 2

GERMAN ESTIMATES AND COMMENTS ON THEIR OWN TANK CASUALTIES

On 24 May 1945, at the Seventh Army Interrogation Center, a number of questions were directed toward prisoner-of-war German Generals Guderian, von Geyr, Dietrich, Hausser, and others. In answer to the following questions: "To what do you attribute German tank losses by percentages; air, antitank, and mechanical? Which was most feared by the tank crews?" the following statements were made:

Gen Guderian: "60-70 percent through mechanical failures (Eastern Front); 15 percent A/T; 5 percent artillery; 5 percent mines; and 5 percent others." (Note: figures are only a very rough approximation; source was very hesitant about answering this question.)

Gen von Geyr: Source could not give any approximate figures. He thinks air-tank cooperation the most deadly combination. Air attacks are very effective and most feared by tank crews.

Gen Dietrich: "Mechanical failures, 30 percent; air, 10 percent; A/T, 15 percent; tanks, 45 percent. Losses due to artillery were negligible. Most feared by crews: Allied tanks and TD's."

Gen Hausser: "During long movements to the zone of action, 20-30 percent of all tanks en route fall out due to mechanical failures. Considering the remainder as 100 percent, 15 percent are lost through mechanical failures; 20 percent through air attacks; 50 percent through A/T defense; and 15 percent are knocked out by artillery. Tanks and TD's are feared most by German tank crews."

Another source, a German tank man with eight years of experience, in answer to the question: "What was feared most by the tank crews?" gave the following answer:

"M-36 TD's and bazookas." Prisoner of war stated that usually more Panthers were disabled by overland moves (motor troubles) than in actual battles.

From comments on enemy equipment made by a US source^{34/} the following statement was extracted:

34/ Notes on Separate Tank Battalions. No. 2, Hq, 12th Army Group, Armored Section, 13 Aug 1944.

Most of the enemy tanks destroyed in this battle sector were destroyed by our US aircraft. Both rockets and Cal.50 have been used to destroy these tanks. By firing Cal.50 on the ground ahead or behind the tank, the bullets ricochet through the thin floor plate and start the tank afire. They believe that this method of combatting enemy tanks is most effective and they would like to see it used more often.

In another instance, a prisoner of war at the Namur (Belgium) cage was interviewed on the subject of white phosphorus used against Allied tanks and stated he did not know of a tank being set afire by white phosphorus. He believed that if this happened, it was due to an overheated engine and gas fumes in the engine compartment being set afire by the hot air being drawn in from the burning white phosphorus.

Note: Other prisoners-of-war had previously stated that many German tanks had been set afire by white phosphorus shells bursting on the engine compartment, and that German tankers feared white phosphorus more than airplanes.^{35/}

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ANNEX 3

SOVIET DATA ON GERMAN TANK CASUALTIES

The French General A. Guillaume, in his book entitled Soviet Arms and Soviet Power, employs official Soviet sources throughout. On this basis, it may be of interest to tabulate the Soviet claims, by cause, of a sample of some 3454 German tank casualties knocked out on the Eastern Front:

TABLE XXXVI

SOVIET CLAIMS OF GERMAN TANK LOSSES

(Sampling)

Cause	# Claimed	% Total Claimed
AT Guns and Artillery	2601	75.3
Tanks	435	12.6
AT Rifles (or Molotov cocktails)	18	0.5
Air (Stormovik)	400	11.6
Total	<u>3454</u>	<u>100 %</u>

No details are given as to those German tanks claimed immobilized by mines, self-destruction, abandonment, terrain, or mechanical failure, or other means. Captured tanks are also excluded from this sample.

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ANNEX 4

US EMPLOYMENT OF LAND MINES

From an Army Ground Forces Board Report^{36/} comes a number of questions and answers which shed further light on the US employment of land mines during World War II:

...

Question 3: Did US troops reinforce their positions by use of mines as the situation became more stable? If so, what technique did the Germans employ to enforce a breach in this barrier for the current Belgian salient?

Seventh Army: "Since the assumption of our present mission our troops have laid the following:"

MLA1	11,036	MkV (Br)	10,974
MLA1 (BT)	226	MkV (BT)	175
T6E1	9,975	Not specified	45,967
T6E1 (BT)	60		

Anti-Personnel Mines:

M-2	91	Flares	102
M-2 w/trip	1,800	Bangalore (trip)	8
M-3	174	W.P. Grenades	10
M-3 w/trip	1,595	W.P. Grenades (trip)	82
M-3 w/pressure	4	Grenades	3
Artillery shells	9	Grenades w/trip	190
Frag Grenades	2	Improvised (TNT)	32
Frag Grenades w/trip	34	Improvised (TNT)w/tp	103
Not specified	155		
Not specified w/trip	183		

Third Army: "As the front became more stable, our troops reinforced their positions by use of mines when operational plans and the situation indicated the advisability of their use."

Ninth Army: "When the situation became stable, our troops installed mines, initially, for local protection only. After the Germans launched their attack in Belgium, extensive deliberate minefields were installed in the Ninth Army sector, with many booby-trapped mines interspersed. Approximately 200,000 mines were installed along a 45-mile front. The Germans did not attempt an advance through the fields described above."

^{36/} Answers to Questions Submitted by the Engineers' School, AGF Board Report, ETO, No. 699. 5 Mar 1945.

Question 4: "In our retreat before the German breakthrough, were we able to employ nuisance mines, antipersonnel mines and booby traps to any appreciable extent? Were we able to lay any hasty mine belts? What other obstacles were employed to impede the German advance?"

Third Army: "Since Third Army was not involved in the retreat before German breakthrough, no first-hand information is available as to employment of nuisance mines, antipersonnel mines and booby traps at that time. However, it can be stated that after arrival of Third Army on the scene that extensive minefields were employed by Third Army in area of breakthrough during attacks by Third Army to stop breakthrough."

Question 5: "Does it appear that our troops have made adequate use of mine technique in the advance and withdrawal? Have they shown proficiency in mine technique and barrier practice? Did responsible commanders make the maximum possible use of this proficiency?"

Seventh Army: "In spite of experience of the units of this army in enemy mine warfare in Tunisia, Sicily, Italy and France, there is evidence that they do not comprehend the use of mines as defensive weapons. Our experienced units have become extremely efficient in mine removal. In the laying, marking, and recording of minefields there is much to be desired, though these subjects have been covered in all mine schools. Since this same lack of training and experience appears in the organization of fixed positions, it is possible that this may be attributed to an absence of a defensive frame of mind on the part of our troops or not sufficient emphasis on this phase of training."

Question 8: "Are M6 and M7 mines being used to any extent in the European Theater?"

Seventh Army: "M-7 no. M-6 yes - 25,000 received and laid. This mine in short supply here. M1A1 issued in lieu of M-6 did not prove entirely satisfactory."

Third Army: "M-6 and M-7 mines are not available in this Theater."

Ninth Army: "Neither M-6 or M-7 mines have been available for use by Ninth Army troops."

ANNEX 5

ANTITANK AND ANTIPERSONNEL MINES

From an Army Ground Forces Report^{37/} come a number of interesting comments from Army and Corps Engineering Officers:

...

Question 103: "To what extent have US antitank and antipersonnel mines been employed and what types have been used?"

Col H. S. Miller, Engineer, XIX Corps: "This Corps has employed all issue types available and a few captured ones. We have used fewer booby traps due to the fact that we were on the offensive. The two Corps groups have laid a total of 75,360 AT mines and have removed or destroyed 460,000 enemy AT mines. The three main places where we laid mines were at Sittard, the Roer River near Julich, and in the Hurtgen Forest. We employed mostly MLAL. The most difficult mine field problem was that of adequate reports. Units would leave hasty mine fields that had been placed without recording to protect overnight bivouacs."

Col F. S. Blinn, Engineer, XIII Corps: "The defense of the Roer River line between Brachelen and just north of Julich, was accomplished in depth by mines, road blocks, outpost lines and a warning-flare system. The defense in depth was formed by three phase lines, each with a "switch position" to protect Corps northern flank. Main weapons for each phase line and switch position were British MkV and Am MLAL A/T mines, which were augmented by AP mines (British M1 and US M2) placed on enemy approaches to and borders of mine fields laid."

Barrier reports compiled from recent and interim reports in Office of Corps of Engineers were utilized in locating and determining limits of enemy fields. In many instances their fields were joined end-to-end to other enemy fields by

37/ Answers to Questions Submitted by the OCE, AGF Board Report No. 1010, 12 Jun 1945 (DECLASSIFIED)

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the MkV and M1A1 laid by the divisions. The use in the American fields and road blocks of AP mines was restricted to the extreme forward fields, in which the procedures outlined in FM 5-30 and FM 5-31 were followed.

"Along the actual river line warning flares and AP mines were laid. This was carefully coordinated with infantry units who patrolled east bank, and were only activated at night. The actual number of antipersonnel mines cannot be computed since the records and sketches have been forwarded or disposed of. Complete files to facilitate removal of the 200-odd fields, of approximately 90,000 A/T mines, 3,000 AP, 1,000 flares, are available to troops at Ninth US Army headquarters.

"In addition to the hasty and deliberate fields as mentioned previously, numerous road bridges were prepared for demolition in event of attack, which Engineer guards . . . were to perform on orders by telephone and messenger.

"Approximately one A/T mine in ten was a "double mine," (one on top of another), in the forward belts. Rear belts were standard hasty pattern with road breaches to make our own use of the roads possible. Mines to cover gaps were piled in a safe spot near gap and marked. Guards or patrols secured the breaches.

"The AP mines were interspersed in deliberate fields or in purely AP belts, in a ratio of one AP to each 10-15 mines. Activated A/T mines were in the same ratio, placed in each deliberate section. The AP mines were so placed in each deliberate section that a walking man could not shuffle through the field from any angle and fail to set off one mine.

"All fields were marked in accordance with instructions contained in FM 5-30 and FM 5-31, and additional instructions regarding expedition of reports were required by this Headquarters."

Col. W. A. Carter, Engineer, First US Army:
"A/T mines and antipersonnel mines were used extensively for defense during the Ardennes Battle

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in December 1944 and January 1945. During rapid advance across France and Belgium and across the Rhine River into Germany, they were used primarily as hasty local defense measures, which were removed when the advance resumed. Types of mines used were AT, M1A1, HE-AT, Contact, MkV (British), and AP Mine M-3. Several casualties resulted from sensitiveness of the British MkV AT mine.

"During the month of December 1944 and in January 1945, extensive standard, hasty and deliberate mine fields were laid along the US First Army front. Large deliberate fields were laid on west bank of Roer River by Division and Corps of Engineers units. One standard deliberate field laid by 329th Engineer Combat Battalion, 104th Infantry Division, was laid in Lucherberg-Inden (Germany) area. This field which was 440 yards long and included 2,000 yards of dummy field, contained 5,104 AT mines. In the Butgenbach-Waimes (Belgium) area large deliberate fields were laid to block enemy in their westward advance. All fields were laid in accordance with standard mine field technique and were reported as being very effective against enemy armor. "Daisy" chain mine roadblocks were extensively used in December 1944, and January 1945. Their effectiveness in stopping advance enemy reconnaissance vehicles was excellent."

Question 104: "Have the mines, AT, HE, M-6 and M-7 been used? If so, which is most suitable for front line use?"

Answer: Col Miller said no M-6 and M-7 mines were available; Col Carter said these mines have not been used by US First Army.

...

ANNEX 6

BAZOOKAS AND PANZERFAUST

Investigation of an interview report from the Seventh Army Interrogation Center^{38/} reveals interesting comments relative to the German use of bazookas and Panzerfaust weapons. An extract from these comments follows:

...

Question 3: "What are your views on effectively combatting infantry A/T measures in the use of the Panzerfaust?"

Answer:^{39/} General Guderian thinks the Panzerfaust an excellent weapon, easy to transport, cheap and easy to manufacture on a mass production basis, and easy to handle in a foxhole. Its disadvantages, as seen by General Guderian, are its short range and the jet flame.

Both Dietrich and Hausser think that although invented as a result of the A/T gun shortage, the Panzerfaust has proven itself to a point where it can no longer be regarded as a pure "emergency weapon." As General Dietrich puts it, even if he could obtain as many A/T guns as he wanted, he would not like to omit the Panzerfaust in organizing A/T defenses.

General von Geyr regards Panzerfaust as an emergency weapon par excellence. His answer, in full: "Faute de mieux, on se couche avec sa femme..."

...

38/ Observations on Armor Employment. Seventh Army Interrogation Center, 24 May 1945 (SECRET)

39/ Answers in Reply to Questionnaire, Hq, Seventh Army, Office of the Armored Officer, 18 May 1945. Sources: Col Gen Guderian, OKH, former C/S German Ground Forces; Lt Gen von Geyr, Inspector, Armored Units; SS Col Gen Dietrich, CG Sixth SS Panzer Army; SS Col Gen Hausser, former CG, AGp "G".

ANNEX 7

HEADQUARTERS
THIRD UNITED STATES ARMY
Office of the Ordnance Officer
APO 403

KRD/rfe
19 March 1945

SUBJECT: Examination of Causes for Rendering Tanks Inoperative.

TO : Chief of Staff, Third US Army

...

3. 100 German Mark III and IV tanks examined.

59 - Tanks or 59% were destroyed by enemy
gunfire as follows:

- 8 - Hit by rockets
- 4 - Hit by 90-mm AP
- 47 - Hit by 75-mm or 76-mm AP
- 1 - Tank destroyed by mine.
- 40 - Tanks or 40% were destroyed by terrain
obstacles or mechanical deficiencies.

Of the 59 tanks destroyed by gunfire, 20 or 34% burned.

For details of location of hits on tanks see Figure 28.

4. 30 German Mark V and VI tanks examined.

30 - Tanks or 83% were destroyed by enemy gunfire
as follows:

- 9 - Hit by rockets
- 2 - Hit by 90-mm AP
- 19 - Hit by 75-mm or 76-mm AP
- No tanks destroyed by mines.

6 - Tanks or 17% were destroyed by terrain
obstacles or mechanical deficiencies.

Of the 30 tanks destroyed by gunfire, 12 tanks or 40%
burned.

For details of location of hits on tanks, see Figure 30.

5. Discussion: The value of mobility over heavy armament, is borne out by the fact that 83 percent of the Mark V and VI German tanks were destroyed by gunfire as compared to 67 percent for American M4 and 59 percent for German Mark III and IV. The minor importance of shoulder rocket guns is evidenced by the low percentage of tanks destroyed by their use, both American and German. The American tank appears to be more susceptible to fire when hit than the German. The recognizable groups of hits as shown in Figures 28 and 30 show that the German and American gunner is shooting for the driver and assistant driver on his front shots. The American aims more for final drive than the German. On the side shots, the German is still shooting at the spot on the forward sponson in which ammunition was stored in early M4 tanks. It is evident from this study that either the American 75-mm gun or the 76-mm gun is capable of destroying any German tank.

For the Army Ordnance Officer:

K. R. DANIEL
Lt Col, Ord^TDept
Asst Ordnance Officer

4 Incl:

- Incl 1 - Statistics, Mk III & IV German Tanks
- Incl 2 - Plot of All Hits, Mk III & IV German Tanks
- Incl 3 - Statistics, Mk V & VI German Tanks
- Incl 4 - Plot of All Hits, Mk V & VI German Tanks

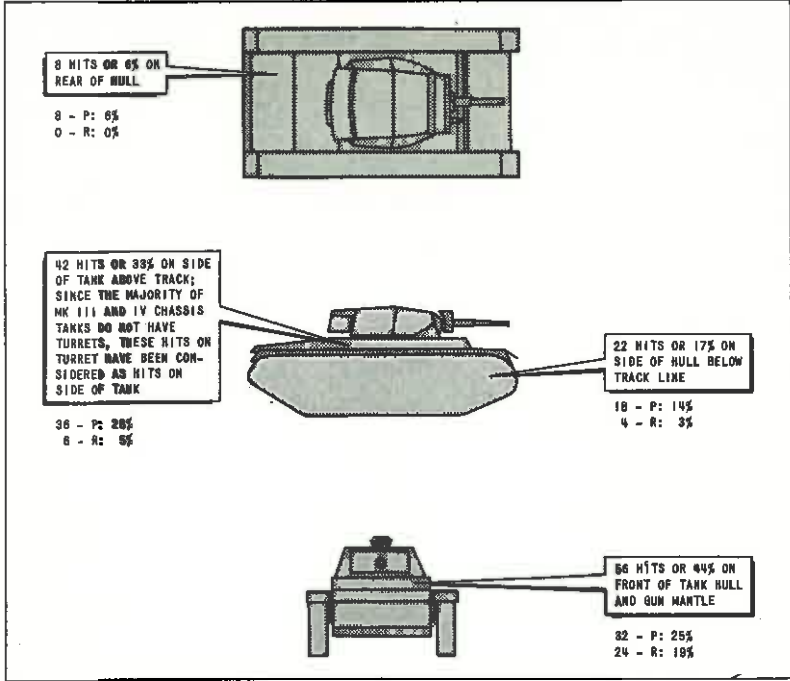


Figure 27. GERMAN MARK III AND IV TANK CASUALTIES

100 TANKS CHECKED
(Total of 128 Hits Registered)

60 TANKS BURNED
20 BECAUSE OF HITS
40 BECAUSE OF CHARGE

1 MINE

59 DESTROYED BY GUNFIRE
8 HIT BY ROCKETS
4 HIT BY 90-MM AP
47 HIT BY 75-MM OR 76-MM AP

40 TANKS DESTROYED BY OTHER THAN ENEMY ACTION

LEGEND: P - Penetration; R - Ricochet



Figure 28. SITE OF HITS ON GERMAN MARK III AND IV TANKS

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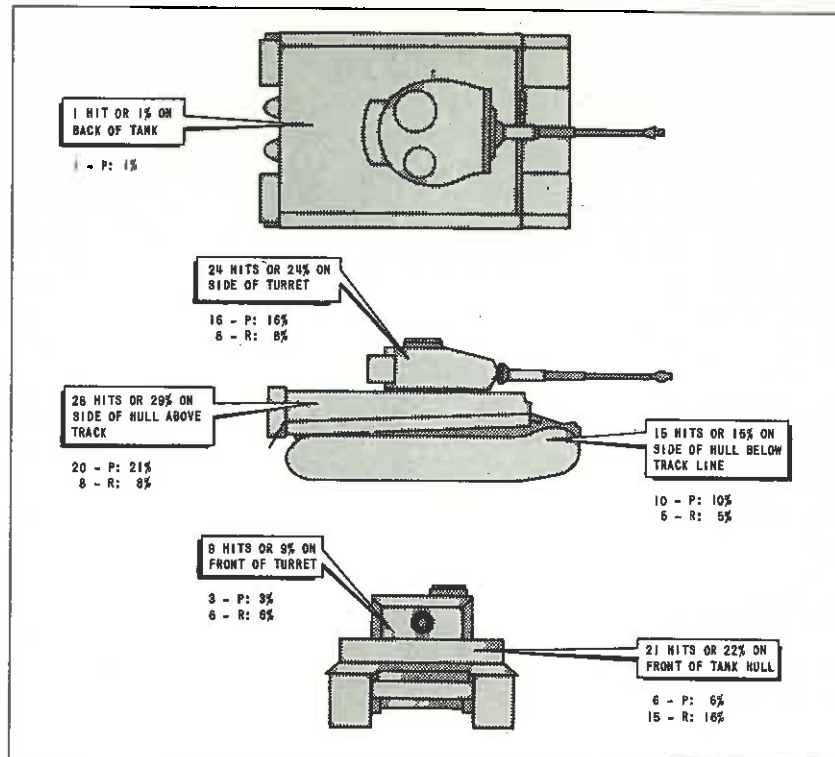


Figure 29. GERMAN MARK V AND VI TANK CASUALTIES.

ORO 17-22 APR51

36 TANKS CHECKED
(Total of 98 hits registered)

31 TANKS BURNED
12 BURNED BECAUSE OF HITS
19 BURNED BECAUSE OF DEMOLITION CHARGE

30 TANKS DESTROYED BY GUNFIRE
9 HIT BY ROCKETS
2 HIT BY 90-MM AP
19 HIT BY 75-MM OR 76-MM AP

6 TANKS DESTROYED BY OTHER THAN ENEMY ACTION

LEGEND: P - Penetration; R - Ricochet



Figure 30. SITE OF HITS ON GERMAN MARK V AND VI TANKS.

ORO 17-23 APR51

SECRET



APPENDIX F

LIST OF ALLIED ARMORED UNITS STUDIED - BY THEATER



APPENDIX B

LIST OF ALLIED ARMORED UNITS STUDIED -- BY THEATER

NORTH AFRICAN THEATER OF OPERATIONS

United States of America

1st Armored Division

1st Armored Regiment

13th Armored Regiment

2nd Armored Division

67th Armored Regiment

70th Tank Battalion

United Kingdom

The Queen's Bays

3rd King's Own Hussars

8th King's Royal Irish Hussars

9th Queen's Royal Lancers

10th Royal Hussars

The Royal Wiltshire Yeomanry

The Warwickshire Yeomanry

The Nottinghamshire Yeomanry

The Staffordshire Yeomanry

The Yorkshire Dragoons

2nd Royal Gloucestershire Hussars

3rd County of London Yeomanry

United Kingdom (continued)

4th County of London Yeomanry

1st, 2nd, 3rd, 5th, 6th, 8th, 40th, 41st, 42nd, 44th,
45th, 46th, 47th, and 50th Battalions of the Royal Tank
Regiment.

MEDITERRANEAN THEATER OF OPERATIONS (Sicily & Italy)

United States of America

91st Cavalry Reconnaissance Squadron

70th Tank Battalion

191st Tank Battalion

751st, 752nd, 753rd, 755th, 756th, 757th, 758th, 760th
Tank Battalions.

1st Armored Division

1st Armored Regiment

1st Tank Battalion

4th Tank Battalion

2nd Armored Division

66th Armored Regiment

67th Armored Regiment

United Kingdom

The Queen's Bays

The Royal Scots Greys

3rd King's Own Hussars

4th Queen's Own Hussars

7th Queen's Own Hussars

United Kingdom (continued)

9th Queen's Royal Lancers

16th/5th Lancers

17th/21st Lancers

The Royal Wiltshire Yeomanry

The Warwickshire Yeomanry

1st Derbyshire Yeomanry

2nd Lothians and Border Yeomanry

3rd County of London Yeomanry

North Irish Horse

1st, 2nd, 5th, 6th, 8th, 12th, 40th, 44th, 46th,
48th, 50th, 51st, 142nd, and 145th Battalions of

The Royal Tank Regiment

Canada

1st Canadian Armoured Brigade

2nd Canadian Armoured Brigade

2nd Canadian Armoured Regiment

5th Canadian Armoured Regiment

9th Canadian Armoured Regiment

11th Canadian Armoured Regiment

12th Canadian Armoured Regiment

14th Canadian Armoured Regiment

EUROPEAN THEATER OF OPERATIONS

United States of America

2nd Armored Division

United States of America (continued)

66th Armored Regiment

67th Armored Regiment

3rd Armored Division

32nd Armored Regiment

33rd Armored Regiment

4th Armored Division

8th Tank Battalion

35th Tank Battalion

37th Tank Battalion

5th Armored Division

10th Tank Battalion

34th Tank Battalion

81st Tank Battalion

6th Armored Division

15th Tank Battalion

68th Tank Battalion

69th Tank Battalion

7th Armored Division

17th Tank Battalion

31st Tank Battalion

40th Tank Battalion

8th Armored Division

18th Tank Battalion

36th Tank Battalion

United States of America (continued)

80th Tank Battalion

9th Armored Division

2nd Tank Battalion

14th Tank Battalion

19th Tank Battalion

10th Armored Division

3rd Tank Battalion

11th Tank Battalion

21st Tank Battalion

11th Armored Division

22nd Tank Battalion

41st Tank Battalion

42nd Tank Battalion

12th Armored Division

23rd Tank Battalion

43rd Tank Battalion

714th Tank Battalion

13th Armored Division

24th Tank Battalion

45th Tank Battalion

46th Tank Battalion

14th Armored Division

25th Tank Battalion

47th Tank Battalion

Unites States of America (continued)

48th Tank Battalion
16th Armored Division
5th Tank Battalion
16th Tank Battalion
26th Tank Battalion
20th Armored Division
9th Tank Battalion
20th Tank Battalion
27th Tank Battalion
70th, 191st, 701st, 702nd, 707th, 709th, 712th,
714th, 717th, 735th, 736th, 737th, 738th, 739th,
740th, 741st, 743rd, 744th, 745th, 746th,
747th, 748th, 749th, 750th, 753rd, 756th,
759th, 761st, 771st, 772nd, 774th, 777th,
778th, 781st, 782nd, 784th, 786th Tank Battalions

United Kingdom

7th Armoured Division
5th Royal Inniskilling Dragoon Guards
8th King's Royal Irish Hussars
1st and 5th Battalions Royal Tank Regiment
11th Armoured Division
15th/19th Hussars
23rd Hussars
2nd Fife and Forfar Yeomanry

United Kingdom (continued)

3rd Battalion Royal Tank Regiment

Guards Armoured Division

2nd Battalion Grenadier Guards

1st Battalion Coldstream Guards

2nd Battalion Irish Guards

2nd Battalion Welsh Guards

4th Armoured Brigade

The Royal Scots Greys

3rd County of London Yeomanry

4th County of London Yeomanry

44th Battalion Royal Tank Regiment

8th Armoured Brigade

4th/7th Royal Dragoon Guards

13th/18th Royal Hussars

The Nottinghamshire Yeomanry

The Staffordshire Yeomanry

1st Lothians and Border Yeomanry

1st Fife and Forfar Yeomanry

3rd County of London Yeomanry

4th County of London Yeomanry

1st Northamptonshire Yeomanry

2nd Northamptonshire Yeomanry

1st East Riding Yeomanry

4th Battalion Grenadier Guards

United Kingdom (continued)

4th Battalion Coldstream Guards
5th Battalion Coldstream Guards
3rd Battalion Scots Guards
107th Regiment Royal Armoured Corps
141st Regiment Royal Armoured Corps
144th Regiment Royal Armoured Corps
147th Regiment Royal Armoured Corps
153rd Regiment Royal Armoured Corps
7th, 9th, and 148th Battalions of the Royal
Tank Regiment

Canada

2nd Canadian Armoured Regiment
5th Canadian Armoured Regiment
6th Canadian Armoured Regiment
9th Canadian Armoured Regiment
10th Canadian Armoured Regiment
11th Canadian Armoured Regiment
12th Canadian Armoured Regiment
14th Canadian Armoured Regiment
21st Canadian Armoured Regiment
22nd Canadian Armoured Regiment
28th Canadian Armoured Regiment
3rd Canadian Armoured Reconnaissance Regiment
29th Canadian Armoured Reconnaissance Regiment
1st Polish Armoured Division

PACIFIC THEATER

US Army

44th Tank Battalion

754th Tank Battalion

763rd Tank Battalion

767th Tank Battalion

603rd Light Tank Company

US Marine Corps

1st Marine Tank Battalion

2nd Marine Tank Battalion

3rd Marine Tank Battalion

4th Marine Tank Battalion

5th Marine Tank Battalion

6th Marine Tank Battalion


SOUTHEAST ASIA COMMAND (Burma)

United Kingdom

225th Indian Armoured Brigade



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