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FOREWORD

IN THE LIBYAN DESERT, where fighting has been continuous since 1940, fire power has been a decisive factor, and artillery has played an important role in its development. Guns have halted tanks and infantry; guns of all calibers—motor-drawn, self-propelled, portee, and mounted in tanks—have enabled large advances to be made by both sides. Although the primary purpose here is to describe the employment of the artillery's fire power, the broader picture of desert operations, especially insofar as they relate to German tactics, is included as having an important bearing on the whole subject.

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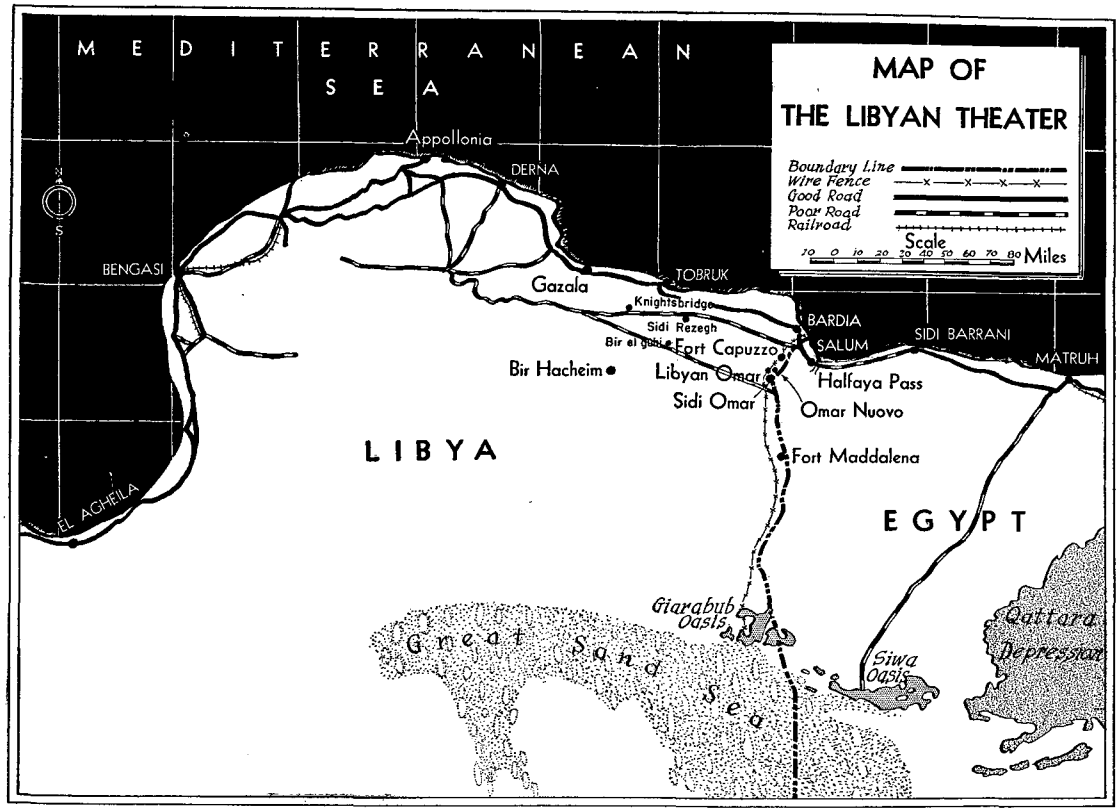

Figure 1.—Map of the Libyan theater

Section I. ORGANIZATION

1. GENERAL

Both the Axis and the United Nations have been gradually altering their regular organizations to conform to the conditions of the desert. Armored units can carry the fight to the enemy; infantry units, if well balanced, have been able to defend themselves against tank attacks from any direction or against simultaneous attacks from various directions. The traditional infantry-artillery team is able to assume only a defensive role. Independence from the regular supply echelons means greater mobility. Armored units carry more supplies than was contemplated by peacetime training; 7 days' supply is advocated by many officers, and the Germans are said to carry 14. Each unit sent into the desert needs to be as self-sustaining as possible. These are merely some of the factors which must be considered in forming any organization for desert warfare. Well-balanced, closely coordinated teams of armored forces, infantry, field artillery, engineers, antiaircraft, and air forces have been the organizations which have achieved the best results in desert fighting.

2. GERMAN

a. General

It would be an error to attempt to portray any set German organization for tactical purposes. The German

varies his organization and the relative strengths of different arms in any force to suit the particular terrain, the nature of the hostile defense, and the missions.

b. Armored Division

The following scheme of organization, subject to many modifications, appears to approximate the normal German armored division as used in the desert:

(1) Headquarters with immediate radio communication to subordinate units and to air reconnaissance and combat support.

(2) Reconnaissance unit.

(a) Armored car company [1] of about 25 armored cars, usually in the proportion of one 8-wheeled car to two 4-wheeled cars.

(b) Support group of motorized infantry including infantry-gun platoon, one antitank platoon, one engineer platoon, and one platoon of heavy machine guns.

(3) One tank regiment of two battalions, each of two Mark III and one Mark IV companies. Each battalion has from 65 to 80 tanks.

(4) One motorized artillery regiment of three battalions, each of three batteries of four guns each; two of these battalions are armed with 105-mm gun-howitzers, and one with 150-mm howitzers.

(5) One motorized infantry brigade, of one motorcycle battalion [2] and of two regiments of two battalions each.

(6) One antitank battalion of three companies of at least 10 guns each. The battalion usually includes some antitank guns on self-propelled mounts.

(7) One light antiaircraft battalion of three companies of twelve 20-mm AA/AT guns each.

---

[1] Some reconnaissance units have two armored car companies.

[2] It is believed that *Volkswagen* have been substituted for the motorcycles, which are unsuited for desert terrain. The *Volkswagen* as modified for army use is similar to the U. S. "peep." The *Volkswagen* weighs about 1,400 pounds and develops about 25 horsepower.

(8) One signal battalion; containing a most efficient radio intelligence interception detachment [3] whose interception of enemy messages has been of great value to the German forces.

(9) One engineer battalion, containing a tank engineer company whose task is the support of the tank regiment. This company has two platoons mounted on Mark I tanks, one on armored engineer vehicles, and one on trucks.

(10) Service units. The number and strength of the various services in Libya is not accurately known.[4] The Germans have an excellent tank recovery and maintenance system. Gasoline and ammunition supply vehicles accompany tanks units, and the replenishment system is well organized.

c. German 90th Light Division (Afrika Korps)

Throughout the Libyan campaigns the 90th Light Division has operated in the closest conjunction with the 15th and 21st Armored Divisions and has furnished the larger portion of the infantry component of the German "Afrika Korps." In its recently reorganized form, the strength of the division has been estimated at around 12,000 officers and men. The division has a tank battalion and probably between 2,000 and 3,000 motor vehicles.

A large number of auxiliary infantry weapons are included in this division. It would appear, indeed, that the rifle had been relegated to a role of subsidiary importance—a weapon solely for close combat. The backbone of the divisional artillery appears to be the 150-mm assault guns on partially armored self-propelled mounts. The mobility and armor of these weapons permit unusually heavy fire support for the infantry at every stage of battle.

The antitank armament of this division has been

[3] See paragraph 14 e, below.

[4] See paragraph 19, below.

strengthened beyond that of any other known German division.

3. ITALIAN

a. General

The Italians have mainly supplied the Axis forces in Libya with infantry and motorized units, but they have also employed two armored divisions.

b. Armored, or "Corazzata", Division

The Italian armored division at war strength is composed of 4,858 officers and men using 1,534 motor vehicles, 138 medium tanks. The organization is—

Division headquarters.
1 Bersaglieri regiment (2 motorcycle battalions).[5]
1 antitank battery of 47/32-mm AT guns (Mtz).
1 tank regiment of—
    4 battalions of light tanks (eventually medium);
    1 battalion of medium tanks (eventually heavy).
1 artillery regiment of—
    2 battalions of 75/27-guns, tractor-drawn.
2 20-mm antiaircraft batteries (Mtz).
1 mixed engineer company (engineers and signals).
Services:
    1 medical company,
    1 commissary company,
    1 gasoline and oil supply platoon.

[5] Because of the unsuitability of motorcycles for the desert, they may have been replaced by light cars. If used at all, motorcycles are probably employed in rear areas.

c. Artillery Regiment

The artillery regiment in the Italian armored, or corazzata, division consists of—

Headquarters.
Headquarters battery.
2 battalions of 75/27-mm guns (tractor-drawn) each with 12 guns and 6 machine guns.

Each battalion is composed of a headquarters, headquarters battery, three firing batteries, and a combat train. The war strength of the regiment is 55 officers and 1,180 enlisted men.

4. BRITISH

The United Nations forces in Libya principally come from all parts of the British Empire. The resulting heterogeneity presents difficulties in addition to those which are always a part of desert operations. However, the British have had more experience with desert fighting than most other powers.

In general, the British Imperial forces are organized in a manner that is similar to the U. S. Army. The one outstanding characteristic is the large amount of artillery present in the Libyan units. For detailed descriptions of the British organizations in Libya, reference may be made to other publications of the Military Intelligence Service.[6]

[6] See "The Libyan Campaign, November 1941 to January 1942," Campaign Study No. 1, August 25, 1942, pp. 35–38; "The British Capture of Bardia (December 1941–January 1942) A Successful Infantry-Tank Attack," Information Bulletin No. 21, July 25, 1942, pp. 33–40; "The Battle of the Omars," Information Bulletin No. 11, April 15, 1942, p. 2; "The Battle of Salum," Special Bulletin No. 36, November 17, 1941, pp. 8–11.

Section II. EQUIPMENT

5. GENERAL

No attempt is made here to discuss exhaustively the details of all the artillery equipment used in Libya; the more important items are described so that the exposition on tactics which follows can be readily understood.

6. GERMAN

a. Antitank Weapons

All German forces in the desert have a large number of antitank weapons. Antitank guns have accounted for most of the tanks which the Germans have destroyed. (The details of German antitank guns have been included in Appendix B, which may be consulted for available information on the more important German artillery pieces.)

b. 50-mm Antitank Gun (fig. 2)

Originally issued to the main units of the German Army in the spring of 1941, this 50-mm. antitank gun is steadily replacing the 37-mm antitank gun, which was formerly the standard German antitank weapon. Both high-explosive and armor-piercing projectiles are fired. The solid projectile fired by this gun weighs 4 pounds 9 ounces, and has pierced the armor of British infantry tanks and cruiser tanks, and of light and medium U. S.

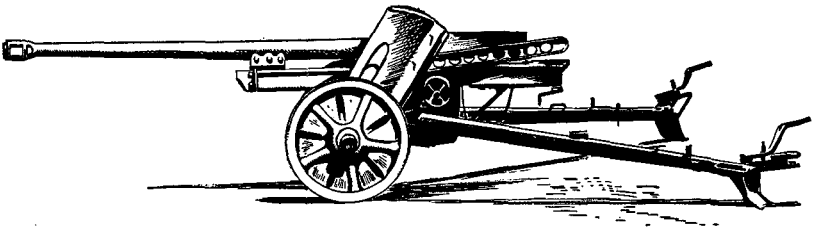

Figure 2.—German 50-mm antitank gun

tanks. The carriage is provided with an armor-plated shield and has a tubular split trail. This gun is towed on its own wheels and has a detachable third wheel, which attaches to the lunette when the gun crew moves the gun by hand.

Nature of weapon: high velocity antitank cannon.
Weight: 2,016 pounds.[1]
Length of barrel: 62 calibers.
Traverse: 60°.
Elevation: −13° to +22.5°.
Initial muzzle velocity: 2,953 to 3,280 feet per second (900 to 1,000 meters per second).
Rate of fire: 16 rounds per minute.
Weight of armor-piercing shell: 4 pounds 9 ounces.
Weight of high explosive shell: 3 pounds 15 ounces.

c. 50-mm Tank Gun (high velocity)

This gun is mounted in the new Mark III German tank. It has been very effective at ranges under 800 yards.

Weight: 421.5 pounds.
Length, over-all: 210 cm (12 feet 11 inches).
Length of chamber: 30.5 cm (12 inches).
Length of rifling: 162.2 cm (5 feet 4 inches).

[1] The gun mechanism alone weighs 698 pounds.

Muzzle velocity: 3,444 feet per second.
Weight of armor-piercing shell: 3.9 pounds.
Rifling: polygroove plane section; uniform twist of 1 in 35 calibers; 16 lands, 3.5 mm wide; grooves, 6 mm wide, .75 mm deep.

d. 28/20-mm Antitank Gun M41 (fig. 3)

The barrel of this semiautomatic gun is constructed on the Guerlich principle; that is, it tapers from 28 mm at the breech to 20 mm at the muzzle. The gun uses the so-called arrowhead type of ammunition. The life of the barrel is thought to be not over 400 rounds. This gun,

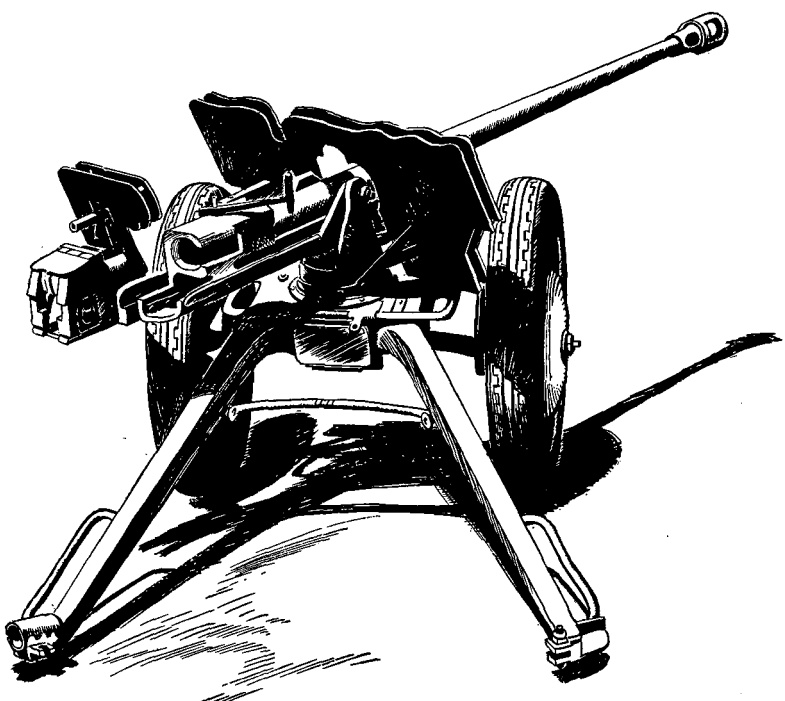

Figure 3.—German 28/20-mm antitank gun M41

which has a welded carriage with a split trail, is served by a 5-man crew. It is normally towed portee on a trailer equipped with ramps and may also be mounted on a truck split into a 5-man load for transport, or carried by air.

Weight: 501 pounds.
Muzzle velocity: 4,555 feet per second.
Caliber at breech: 28 mm.
Caliber at muzzle: 20 mm.

e. Dual-Purpose Weapons

More and more reports from the desert indicate the use of antiaircraft weapons for antitank purposes wherever such use has become necessary. The Germans have various dual-purpose weapons, the most famous in the desert and elsewhere being the 88-mm.

The German 20-mm AA/AT gun as used in the desert may be towed by a light tractor. There is a four-barrel type, called "Flakvierling" by the Germans.

In addition to the 88-mm, the Germans have two other types of dual-purpose guns which are used extensively. There is the 37-mm AA/AT gun, which is motor-drawn or self-propelled on a half-track vehicle, and the 47-mm AA/AT gun, which originated in Czechoslovakia.

f. 88-mm Dual-Purpose Gun (figs. 4 and 5)

(1) *Development.*—The German 88-mm dual-purpose gun was designed in 1934 as the standard semimobile antiaircraft gun. It is known that the plan of its designers was to construct a dual-purpose antiaircraft and antitank weapon. It was first used in 1936 during the Spanish Civil War, with considerable effect, on the lightly armored

vehicles of the Loyalist forces. The antitank purpose of the weapon was, however, veiled in some secrecy, and the German intentions in this regard did not become well known until the Polish campaign of 1939. The Germans produced large quantities of armor-piercing ammunition and designed a more mobile carriage. With these added improvements the gun was used successfully in the Battle of France, where it proved capable of dealing with the

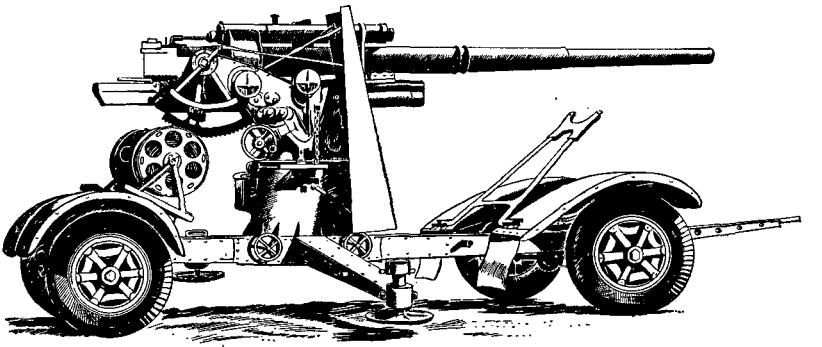

Figure 4.—German 88-mm dual-purpose gun on special trailer

heavier French tanks against which the standard German 37-mm (1.45 inch) antitank gun was comparatively ineffective.

Commencing in 1940, the Germans began to provide these guns with an armored shield in order to protect the personnel against small arms bullets and shell fragments, as well as smaller antitank gun projectiles. The Germans next provided the gun with a new mounting (designated Trailer 201) from which the gun could engage tanks without being taken off its wheels. Finally a self-propelled mounting has been produced from which the gun can be fired against ground targets but cannot be used in its original antiaircraft role.

It appears that this weapon has played an important role throughout the Russian campaign. However, far more exact information is available as to its use in Libya.

(2) *Tactics.*—In November 1941, when General Auchinleck launched his major offensive, Marshall Rommel

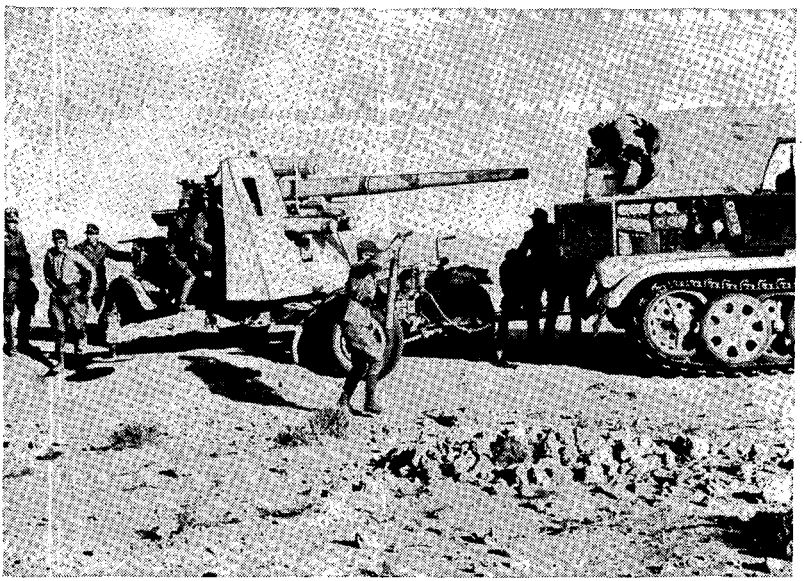

Figure 5.—German 88-mm dual-purpose gun in action

formed three tank-proof localities along his front line: at Bardia, at Salum, and in the vicinity of Halfaya Pass. Wherever these areas included 88-mm guns, the guns were used to provide the core of the all-around protection so necessary in the desert against tank attacks. These guns were supported by a large number of smaller antitank weapons. So well organized were these strong points that they were never seriously attacked, and only fell when the British pushed on to Bengasi and when the water and

food stocks of the strong points became exhausted. The British ascribe the long resistance by these strong points to the difficulty they found in coping with these dual-purpose weapons.

Rommel's offensive use of these weapons is of considerable interest. The antiaircraft guns appear to follow closely his armored vehicles. As soon as the front begins to stabilize, the 88-mm dual-purpose guns go into position and around them is then organized a "tank proof" locality.

The effectiveness of these weapons is clearly brought out by the following reports of observers formerly at the front in the desert battle around Tobruk:

One observer reports as follows:

At a point in the Knightsbridge area, the 4th British armored brigade faced some 35 German tanks of the Mark III and IV type drawn up in line and obviously inviting attack. These tanks were supported by a battalion of 12 antiaircraft guns. The commander of the 4th Brigade refused to attack at all because of the presence of these guns on the battlefield.

Slight firing occurred throughout the day. Towards evening the superior British tank force withdrew, and the German tanks attacked after nightfall in a new direction. Their 88-mm dual-purpose guns had checked the British all day and permitted Rommel to seize the initiative as soon as the British threat had vanished.

Another report reads as follows:

The greatest single tank destroyer is the German 88-mm dual-purpose gun. For example, on May 27th at 0800, Axis forces having enveloped Bir Hacheim, a German tank force of 60 tanks attacked the British 22nd Brigade some distance to the northeast. The British moved to attack this force with 50 light and medium

American tanks. It soon became apparent that this British force was inadequate and the Brigadier commanding ordered a second regiment of 50 tanks into action. In 10 minutes the 88-mm German dual-purpose guns destroyed 8 American medium tanks of this reinforcing regiment. All day thereafter, the British engaged the enemy half-heartedly and finally withdrew. Sixteen American medium tanks were lost in all. These 16 fell victims, without a single exception, to the 88-mm dual-purpose gun.

(3) *Fire-control methods.*—For field artillery tasks, and for use against armored vehicles, the following four methods of fire control are used: direct fire using a telescopic sight; predictor control; fire directed from an observation post (OP); and air burst HE.

(*a*) *Direct fire.*—This has been the most successful method against armored vehicles. Apart from the extreme mobility of the gun, the efficient telescopic sight has contributed largely to the success of the 88-mm gun in the antitank role.

The latest mark of telescopic sight used is the ZF. 20 E., which is a monocular type with a magnification of 4 and a field of view of 17.5°. The graticule of the sight is formed with two cross lines, interrupted at the center.

On the sight are a range drum graduated in 100-meter (109-yard) steps from 0 to 9,400 meters (10,340 yards), a target elevation drum in $\frac{1}{16}$° from 0° to 12°, and vertical and lateral deflection drums. The layer lays on the target through the sight, and the range is set on the range drum, which automatically applies the necessary target elevation to the sight. Corrections from observation of fire or laying off for a moving target are set on the appropriate deflection drums.

(*b*) *Predictor control.*—With a predictor control, the data for the first round is calculated in the same way as for an aerial target. Corrections for line, range, and fuze length are made from observation of fire and set on the respective scales on the predictor.

(*c*) *Fire directed from an OP.*—When the target is below the horizontal, or at ranges greater than 10,340 yards (that is, beyond the limit of the telescopic sight), fire is directed from an OP. The OP officer takes bearing, range, and elevation from his shooting map. From these he calculates the gun data with a range table and forwards the information to the gun position by telephone. A director is sometimes used for giving the original line to the guns. Corrections are ordered from observation of fire and set at the gun.

(*d*) *Air burst HE.*—Fire for effect with time fuze air-burst HE against troops in the open and against battery positions has also been reported. Ranging is carried out with a low height of burst. Fire for effect follows with the fuze length adjusted for the most effective height of burst.

(4) *Service of the piece.*—The 88-mm unit, which is under divisional control for tactical purposes, goes into action from the ammunition line. Here the ammunition trucks are left, and the battery commander, the chief of section, and the driver reconnoiter the assembly point, usually within 225 yards of the gun position, in march order, and the crew prepares it for action when the command is given at the assembly point.

The gun crew is composed of a gun commander and nine

men. The service of the gun for antitank fire is divided among them as follows:

Gun commander:	
No. 1	Lays for elevation
No. 2	Lays for line
No. 3	Loads and fires
Nos. 4, 5, 6, 7	Handle ammunition
No. 8	Sets range (vertical deflections)
No. 9	Sets lateral deflections

(5) *Characteristics.*—The German 88-mm dual-purpose gun, which was used in such effective fashion in the desert, was designed primarily as an antiaircraft weapon, but like many German antiaircraft guns, it may also be employed against ground targets as explained. The high muzzle velocity and the resultant striking power of this weapon make it particularly effective against armored targets and fortified gun positions, even at considerable ranges. Using HE and armor-piercing ammunition, it is employed with deadly effect against medium and heavy tanks.

(*a*) *Gun.*—The barrel is jacketed, with easily detachable breech rings, a supported, interchangeable A tube (the rifled part of the tube), and a removable guide ring. It is 16 feet long and has 32 rifling grooves. The breech is semiautomatic and self-cocking, opening when the barrel runs out after the shot has been fired, ejecting the cartridge case, and at the same time compressing the striker spring.

(*b*) *Carriage.*—The carriage consists of a mounting built into the platform of the chassis, the upper carriage with a protective armor shield, a buffer fitted into the barrel cradle, a hydropneumatic recuperator fitted above the barrel, two balancing springs to distribute the excess

weight of the barrel and cradle, and the traversing and elevating mechanism.

(*c*) *Sight.*—The standard German antiaircraft sight, modified to give range readings in meters rather than elevation angles, is normally used, but the armor shield also has a loop-hole for the wide-angle (emergency) sight. With the telescopic sight, the line of sights is parallel to the axis of the barrel when both deflection and range drums are set at zero. Since, however, the sight is 28 inches to the right of and 8 inches below the barrel, the aiming point must be taken low and to the right if direct hits are to be obtained.

The elevation field is determined by fixing an attachment on the sextant from −3° to +15°. The traverse field is limited by the striking of the upper carriage against the armor of the driver's seat. The traversing arc is 151° to the right and 181° to the left, or a total traverse of 332°.

(*d*) *Mobility.*—Two methods are still used to give the gun its well-known mobility: (1) some of the guns are mounted on the special trailer (No. 201) which is fitted with pneumatic tires and drawn by a half-track vehicle which carries the gun crew and a small supply of ammunition. Ground targets can be engaged while the gun is in this traveling position. (2) the newer development is the self-propelled mounting consisting of a 12-ton half-track vehicle, armored in front and carrying a small supply of ammunition. The gun mounted in this position is used only for engaging ground targets.

Rules on the selection of a firing position are as follows: the angle of impact should be not greater than 60°; the range should generally not exceed 2,000 yards; the gun

level must slope downward with the wheels nearer the target lower (the gun level varies from −3° to +15° from the horizontal of the muzzle); the position should be concealed and as near to the target as possible to insure maximum accuracy and surprise in opening fire; the lanes of approach and withdrawal must be as firm and level and as wide as possible.

The prime mover can knock down trees up to 3 inches in diameter, and the self-propelled carriage can level 5-inch trees. The minimum widths, which must be considered in choosing lanes of approach and withdrawal, are: with barrel at right angles, 20 feet; with side supports in rest position, 16 feet; and with side supports in march position, 10 feet. If narrow points have to be negotiated on the way to the firing position, the side supports are not put down until these points are passed, nor is the barrel swung free until there is sufficient room. At all times, however, the barrel, with its armored shield, is directed toward the enemy.

(*e*) *Summary.*—Following is a list of characteristics of the German 88-mm dual-purpose gun (on towed carriage):

Muzzle velocity	2,690 feet per second
Maximum ordinate	36,000 feet
Maximum horizontal range	16,200 yards
Effective range against tanks	3,000 yards
Effective ceiling	34,000 feet
Elevation	−3° to +85°
Traverse	360°
Weight of piece in firing position including outriggers.	11,354 pounds
Weight of tube	3,175 pounds
Caliber	88-mm

Length in calibers	56
Height of tube over outriggers	52 inches
Height of tube over earth	63 inches
Longest recoil	41 inches
Shortest recoil	28 inches
Weight of trailer	16,426 pounds
Tread	70 inches
Diameter of wheels	36 inches
Weight of projectile	21 pounds
Weight of propelling charge	20 pounds
Weight of bursting charge	1.5 pounds
Rate of fire	15 to 20 rounds per minute

g. 75-mm Sturmgeschütz (Assault Gun)

The Germans have mounted their 75-mm Kw. K.[2] (used also as the main armament of the Pz. Kw. IV) [3] on the chassis of their Pz. Kw. III. The turret is removed and replaced by a squat superstructure housing the gun. The gun compartment is roofed, but there is no rotating turret. The gun is fitted with a dial, not a telescopic sight. The gun commander has a scissors telescope. Two wireless receivers and one transmitter [4] are carried. There is no mounting for a machine gun. The armor is 55 mm (2.17 inches) at the front, 30 mm (1.18 inches) at the sides, and 12 mm (0.47 inches) on top. Inside this moving pillbox, a crew of four are required: the commander (on the left), the driver, gunner, and leader (on the right).

This gun is employed in independent battalions. It is possible that these assault guns have now become organic

[2] *Kraftwagen Kanone,* tank gun.
[3] *Panzer Kraftwagen,* armored vehicle, tank.
[4] Type B. UA2.

parts of the motorized and Panzer divisions, as well as part of the front-line infantry divisions. Normally only direct fire is used. It is believed that this low-velocity 75-mm gun is being replaced by a high-velocity 75-mm gun with a reported length of bore of about 43 calibers.

An assault gun of this type captured in the Middle East has been described as follows:

The gun and mount weigh about 20 tons. The gun itself is the short-barreled 75-mm tank gun originally mounted in the Mark IV tank. The range drum is graduated for HE up to 6,550 yards and for AP up to 1,640 yards. Elevation and traverse are hand-operated. The hull is that of the standard German Mark III tank with normal suspension system. The turret has been removed. The length is 17 feet 9 inches, height 6 feet 5 inches, and width 9 feet 7 inches. In general, the armor is 51 mm (2 inches) at the front and 32 mm (1.25 inches) on the sides and at the rear. An added 53-mm plate is fitted to the rear of the vertical plate, apparently between the driving and fighting compartments, and is braced to the front plate by two 31-mm plates, one on each side of the opening for the gun. The sides of the hull enclosing the driving compartment appear to be vulnerable to the British 40-mm antitank ranges. The engine is a Mayback V–12-type rated at 300 horsepower. The gears provide for six speeds, and steering is hydraulically controlled. The capacity of the gasoline tank is 71 gallons, which is consumed at the rate of about 0.9 miles per gallon at a cruising speed of 22 miles per hour. As in German tanks, this vehicle is equipped to carry extra gasoline in a rack on the rear of the vehicle, which should hold about 10

standard 5-gallon gasoline cans. The captured vehicle contained metal boxes for 44 rounds of ammunition, and 40 rounds were stacked on the floor at the loader's station. Ammunition is also carried in an armored half-track vehicle which tows an armored ammunition trailer. There was also a rack for 12 stick grenades, and the usual smoke-candle release mechanism for 5 candles was fitted to the rear. For communication there were two radio receivers and one transmitter. For observation a scissors telescope was provided. As spare parts the 11-mm sloping plates over the track guard carried two spare bogie wheels on the right side and one on the left side. Two

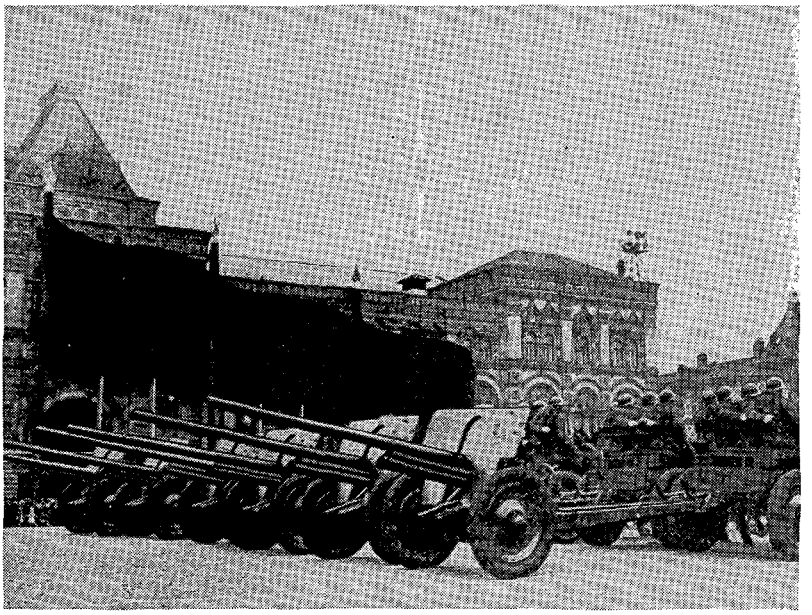

Figure 6.—Russian 76.2-mm guns. (The Germans have captured large quantities of this gun and have used them in Libya.)

spare torsion rods were also carried, one in each side of the hull above the bogies. Some other details are—

Length of bore: 23.5 calibers.
Muzzle velocity (estimated): 1,600 feet per second.
Elevation: 20°.
Depression: 5°.
Traverse: 20°.
Weight of projectiles: HE, 12 pounds 9 ounces; Smoke, 13 pounds 9 ounces; AP (with ballistic cap), 13 pounds 9 ounces; AP (hollow charge), not known.
Estimated penetration of AP: 55-mm (2.16 inches) with ballistic cap at 60° at 400 yards.

h. Russian 76.2-mm Gun (fig. 6)

It is reliably reported that the Russian 76.2-mm field gun is being used in Libya by the Germans for antitank purposes. Published photographs of this weapon indicate that it is a practical high velocity weapon.

7. ITALIAN [5]

a. 75/18 Gun-Howitzer, 1935 (fig. 7)

The characteristics of this piece are—

Muzzle velocity: 1,430 feet per second.
Maximum range: 10,200 yards.
Weight of shell: 13.9 pounds.
Elevation: 65°.
Depression: 10°.
Traverse: 50°.
Weight in action: 1.1 tons.
Method of transport: on wheels or carrier at 19 miles per hour.

b. 75/18 Self-Propelled Gun

The Italians have been mounting their guns on tank chassis. They have mounted their 75/18 gun-howitzer,

[5] See paragraph 9b.

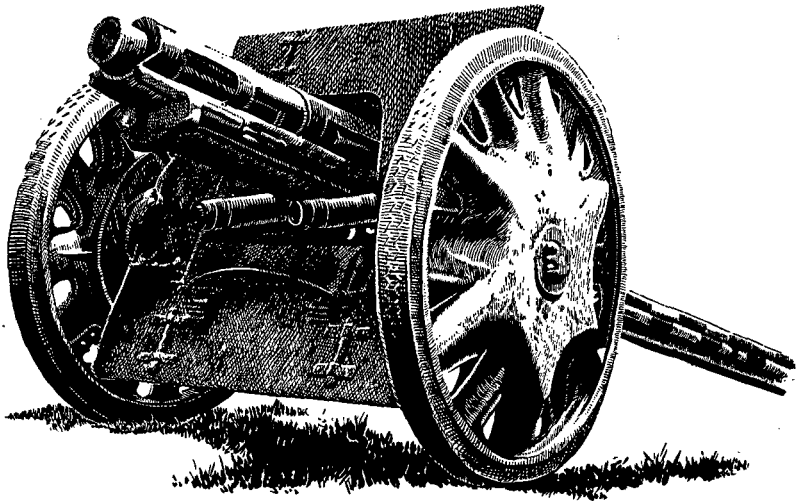

Figure 7.—Italian 75/18 gun-howitzer, model 1935

described above, on a turretless M 13/40 tank chassis. It is not thought that the gun as mounted in the tank has any great amount of independent traverse. The maximum range is reported to be about 6,500 yards, with an effective range of 4,300 yards. Both armor-piercing [6] and high-explosive [7] ammunition may be fired. The complete self-propelled equipment weighs about 14.5 tons. It has 45 mm laminated armor. Both key and voice radio are used, and the mobility of the gun is increased to about 18 miles per hour on roads and 12 miles per hour across country.

c. 75/27 Gun

This is the standard light field piece of the Italian Army. British users consider it to be satisfactory equip-

[6] Weight of projectile 14.1 pounds.
[7] Weight of projectile 15.9 pounds.

ment, giving no trouble in spite of constant use. But the gun has the following disadvantages: (1) light hitting power; (2) poor fragmentation effect; (3) at ranges above 6,600 yards, it is necessary to use a false angle of sight, slope the platform, and dig a hole for the trail. The characteristics of the gun are—

	Model 06	Models 11 and 12
Muzzle velocity	1,730 feet per second.	1,675 feet per second.
Maximum range	11,200 yards	9,075 yards.
Rate of fire (theory)	8 rounds per minute.	8 rounds per minute.
Rate of fire (practical)	4 rounds per minute.	4 rounds per minute.
Length of bore	27 calibers	27 calibers.
Weight in action	1 ton	1.06 tons.
Weight in draught	1.67 tons	1.87 tons.
Maximum elevation	16°	65°.
Maximum depression	−10°	−15°.
Traverse	7°	59°9′.

d. 75/34 Gun

While there is no report of this gun being used in Libya, a report of 1940 stated that it was expected to replace the 75/27 guns in mobile divisions.

Muzzle velocity: 1,650 feet per second.
Maximum range: 13,500 yards.
Weight of shell: 14 pounds.
Weight in action: 1.25 tons.
Method of transport: towed on own wheels.

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e. 100/17 Howitzer, 1914

This howitzer has been used in Libya as organizational artillery with the Italian motorized and normal infantry divisions. The British have found it to be an accurate and satisfactory howitzer. However, it has a long unwieldly trail that has to be dug in for high elevation.

Muzzle velocity: 1,800 feet per second.
Maximum range: 8,400 yards.
Weight of shell: 28 pounds.
Rate of fire: 3 rounds per minute (practical).
Maximum elevation: 48°.
Maximum depression: 8°.

f. Captured Matériel

The information contained in this section has been obtained from British sources. These weapons have been captured, inspected, and used by the British. (See par. 9b.)

(1) *149/13 howitzer (149-mm, 13 calibers in length).*—This howitzer fires a heavy 80-pound shell accurately up to a range of 10,000 yards. The rate of fire is two to three rounds per minute.

(2) *105/28 gun (105-mm, 28 calibers in length).*—This weapon is considered to be the most valuable battalion artillery piece in the Italian Army. But very few have been captured. The gun fires a 35-pound shell a maximum range of 13,600 yards, at the rate of six rounds per minute.

(3) *75/46 (75-mm, 46 calibers in length) Ansaldo mobile AA gun.*—While this is primarily an antiaircraft gun, successful experiments in engaging ground targets have been carried out. The weapon is mechanically sound,

and practically no maintenance has been required. The muzzle velocity is probably about 2,500 feet per second, although it may be higher. The gun has a high rate of fire, and with a trained crew it is estimated that 20 rounds per minute can be fired. The silhouette is satisfactory

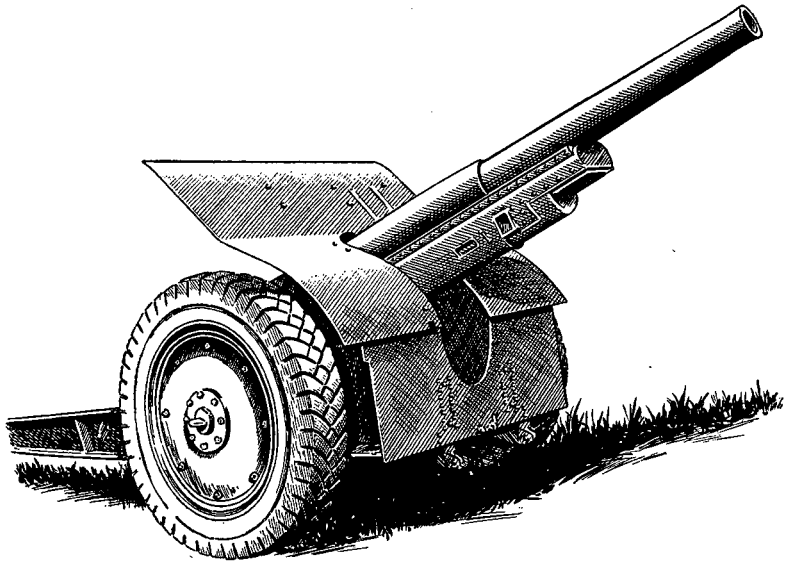

Figure 8.—Italian 105/28 gun.

and it is believed that it would be difficult to hit from a tank at 600 to 1,000 yards. The Italians camouflage the gun with light gray and dirty white colors, and from a range of 500 yards it is difficult to see, even on level ground. A speed of 25 miles per hour over good terrain and 10 miles per hour over rough terrain should be obtainable.

(4) *37/54 (37-mm, 54 calibers in length) light double-barrel AA gun.*—This is a tray-loaded twin antiair-

craft gun serviced by a detachment of seven men. The rate of fire is 250 rounds per minute—125 rounds per barrel per minute. It is considered to be a very effective light antiaircraft gun, although stoppages are frequent unless all the equipment is kept scrupulously clean and free of sand.

(5) *102/35 (102-mm, 35 calibers in length) AA and coast defense gun.*—This antiaircraft weapon has a muzzle velocity of approximately 2,476 feet per second, a maximum horizontal range of 14,500 yards, and a maximum vertical range of 31,000 feet. The breech mechanism is semiautomatic.

(6) *76/40 (76-mm, 40 calibers in length) dual-purpose AA-AT gun.*—This is a fixed weapon and is not expected to be satisfactory for antiaircraft work, but sufficient tests have not been made to give any details.

8. BRITISH

a. 2-pounder Antitank Gun

(1) *Characteristics.*—The Vickers–Armstrong 2-pounder antitank gun Mark I is a semiautomatic caliber 40-mm (1.58 inches) weapon with a muzzle velocity of 2,616 feet per second. It has a 5/16-inch armor-plate shield, which will keep out ordinary small arms fire but will not repel the armor-piercing bullets fired from tank machine guns. It is carried on two rubber-tired wheels, towed by a ¾-ton truck. For firing, it is lowered to three outriggers.

Nature of weapon: high velocity cannon.
Weight: 1,848 pounds.
Length: 11 feet, 2 inches (bore, 78.75 inches).

Traverse: 360° when placed on tripod.

Elevation: −13° to +15°.

Ammunition: fixed: armor-piercing with tracer, weighing 4.5 pounds complete, the projectile alone weighing 2 pounds 6 ounces; 14 rounds carried on the carriage and 98 in the truck.

Rate of fire: 22 rounds per minute.

Effective range for use against tanks: 300 yards.

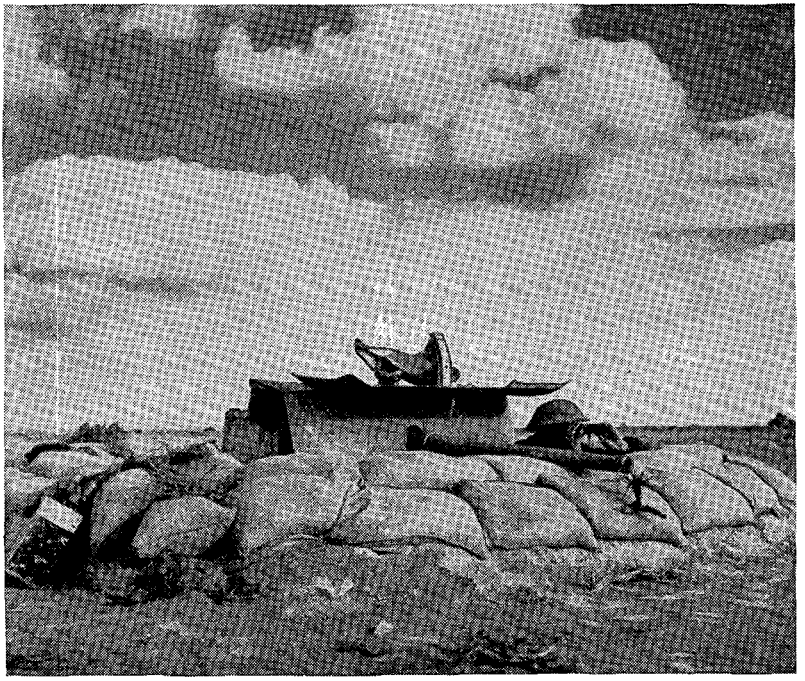

Figure 9.—British 2-pounder antitank gun in position in the Western Desert. (This photograph gives an indication of the height of the gunner's sight.)

(2) *Operation.*—The gunner's position is on the seat to the left of the gun. The vertical handwheel on the left controls elevation. The trigger control is attached to this handwheel. Traversing is accomplished by a hori-

zontal handwheel to the right of the gunner. For rapid traverse, a throw-out clutch at the right foot of the gunner allows the NCO gun commander to traverse the gun, pedestal, and gunner together by pressing on the shoulders of the gunner. The carriage gives the gunner every advantage. It is a fine gun to shoot on the practice range, but its extreme height is most noticeable. In country with thick underbrush there are some positions where such a carriage is advantageous, but in the desert the lower the carriage when firing, the better.[8]

Three independent sights are provided. The first, a simple ring and bead type, is used by the NCO gun commander for approximate setting. The other two sights are used by the gunner. The telescopic sight has a field of approximately 20°, and a magnification of about four times. There is a fixed vertical line and movable horizontal line with range marks at the left for 300, 600, 900, 1,200 and 1,500 yards. A small knob directly above the sight, provided with a click, permits movement of the horizontal line by increments of 100 yards. This operation is performed by the NCO gun commander after initial setting by the gunner in accordance with the oral instructions of the commander. Mounted on and above the telescopic sight is a forward bead sight and a rear notch-type sight, adjustable in elevation. Attached to the left side of the pedestal is a receptacle for a spare telescopic sight.

(3) *Portee.*[9]—In order to increase the mobility of the 2-pounder antitank gun, the British have been employing

[8] For examples of lower carriages, see the British 6-pounder carriage and the U. S. 37-mm antitank gun carriage.

[9] See paragraph 31d.

it portee on a 1½-ton truck. A recent development has been a type of light self-propelled or assault artillery in which the 2-pounder antitank gun is mounted on the Loyd carrier. The regular shield of the 2-pounder is utilized for protection against small arms fire from the front, and additional protection is provided by armor shields on the sides of the gun. The tires of the portee and of the gun are of the "run flat" type. To prevent rocking of the portee and to enable the crew to carry out their duties efficiently, the gun when used from the portee is not fired at an angle greater than 40° from astern. This requires perfect understanding between the gunner and the portee driver.

b. 6-pounder

The 6-pounder antitank gun has been designed by the British for use against enemy armored vehicles which are not vulnerable to the 2-pounder at distances of over 200 or 300 yards. A 57-mm gun, the 6-pounder will be able to engage tanks at much greater ranges than the older 2-pounder, although the latter will still be important to the antitank defense of individual formations and units. In order to facilitate the quick adoption of the proper gun for the circumstances, the carriage of the 6-pounder is so designed that the 2-pounder may be mounted alternatively. It is intended that the 6-pounder will be standard equipment in the divisional antitank organization.

Nature of weapon: high velocity antitank weapon.
Muzzle velocity: 2,700 feet per second.
Weight: 2,471 pounds.
Length: 15 feet 5 inches.

Traverse: 90°.
Elevation: −5° to +15°.
Ammunition: projectile weight, 6¼ pounds.
Effective range against tanks: 800 yards.

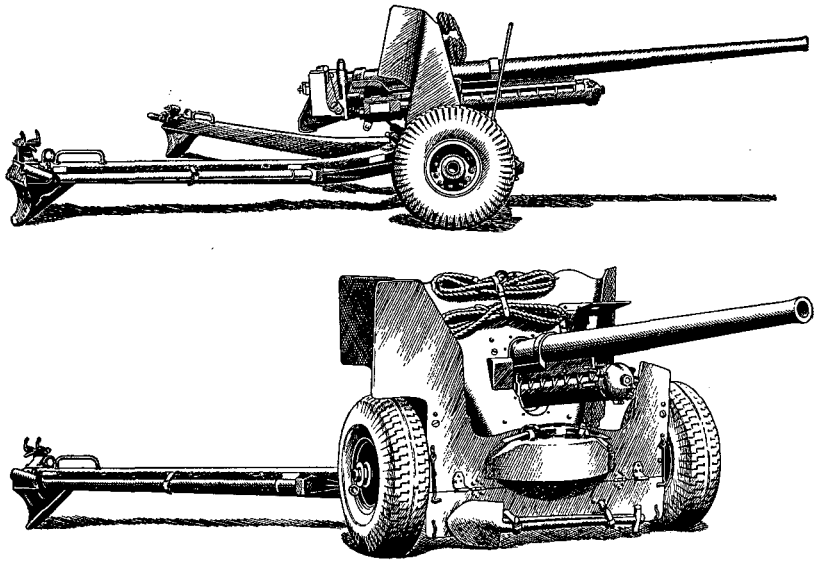

Figure 10.—British 6-pounder antitank gun (two views)

c. 25-pounder Field Gun-Howitzer

Fire from the British 25-pounder (3.45-inch) field gun-howitzer, the basic field piece of the British Army, has been extremely effective for two reasons: (1) the 25-pounder is an excellent field gun, and (2) British artillery was well-trained before the outbreak of war. German tanks when struck by 25-pounder armor-piercing shell at ranges less than 1,000 yards have sometimes been knocked out; some have had turrets completely blown off, and others have been set afire. Indirect 25-pounder

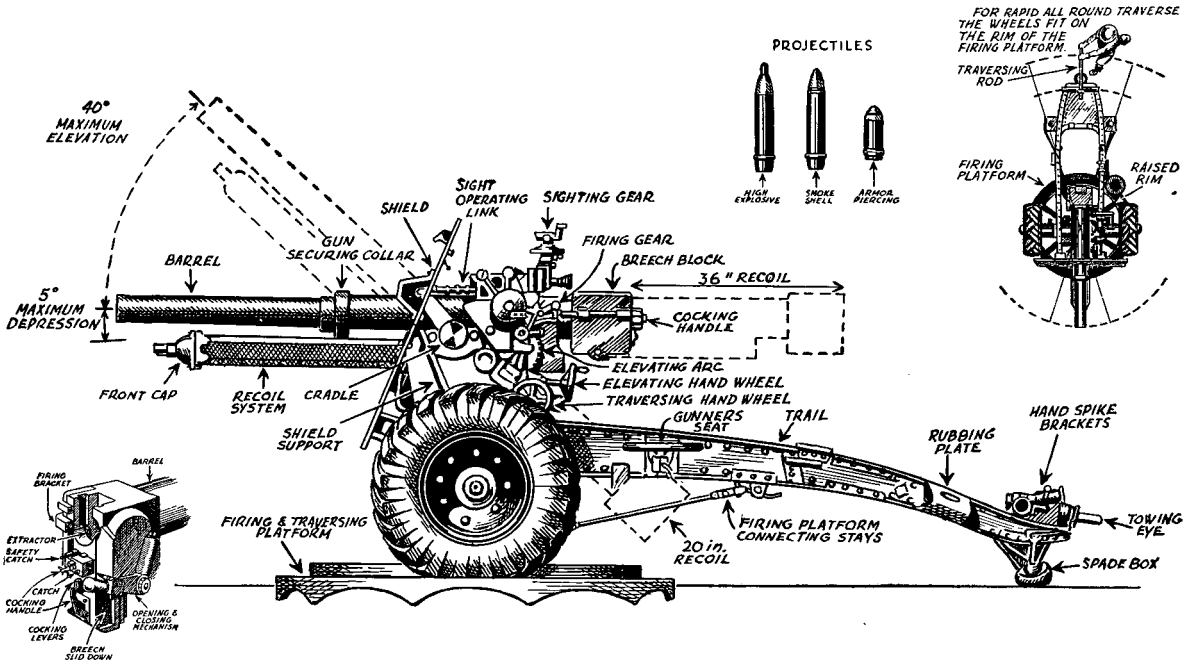

Figure 11.—Diagrammatic sketches of British 25-pounder field gun-howitzer, showing its characteristics (with British terminology)

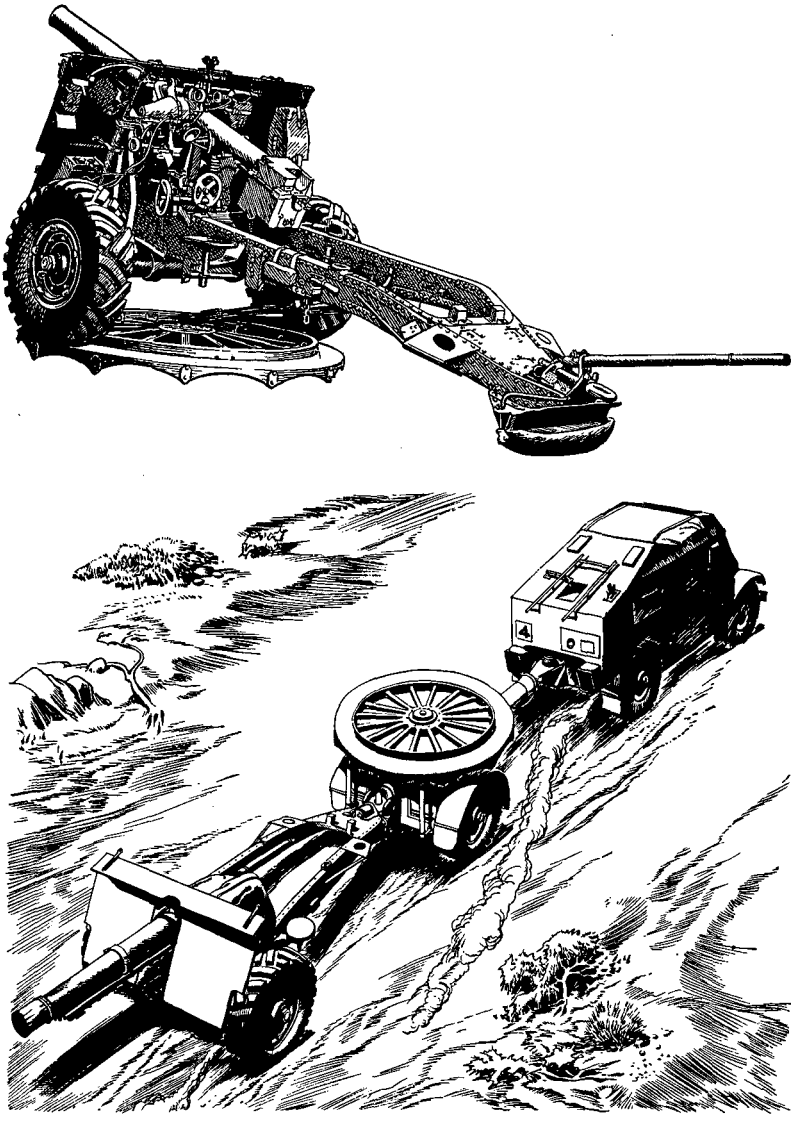

Figure 12.—British 25-pounder field gun-howitzer, showing the method by which it is transported

fire is, however, not effective for stopping tank attacks, but it can cause the tanks to "button up" their hatches. Reports of indirect fire's stopping tank attacks are believed to be erroneous interpretations of the repulse of reconnaissances in force.

The 25-pounder has been replacing both the 18-pounder and the 4.5-inch howitzer of the last war. The tube has a removable liner which can be changed in the field. The gun can be placed in firing order on its platform in 1 minute. The firing platform is in the form of a wheel which is carried either under the trail or on the back of the prime mover. To place the piece in action, the platform is lowered to the ground and the carriage is then manhandled or tractor-drawn over it and coupled to its center. To permit easy maneuvering of the trail, the spade has been imbedded in a "box" commonly called a "banana," which functions very effectively and prevents the trail from digging in. The muzzle velocities with its three normal charges are 650, 975, and 1,470 feet per second, and with supercharge 1,700 feet per second.

Nature of weapon: field gun-howitzer.
Weight: 3,968 pounds.
Length: 25 feet 11 inches, including trailer (barrel, 92.5 inches).
Traverse: 360° on firing platform, 8° without platform.
Elevation: −5° to +40°.
Maximum range: 12,500 yards.
Ammunition: projectiles: armor-piercing (20 pounds), HE (25 pounds), and smoke (base-ejection type, 21.8 pounds); charges: three and a supercharge for HE.
Rate of fire: 8 rounds per minute (rapid) and 3 rounds per minute for prolonged firing.

d. 4.5-inch Gun and 5.5-inch Gun-Howitzer

(1) *General.*—The 60-pounder has been replaced by the 4.5-inch gun; the 6-inch howitzer is being replaced by the 5.5-inch gun-howitzer as the latter becomes available. The two new weapons are mounted on the same type of carriage, which has a split trail and is simple and easy to use in going into and out of action. While the guns are being fired, the three points of support are the center of the axle and the two trail spades. When the trails are closed, a simple locking mechanism automatically locks in traveling position the carriage proper, the traveling axle, and the trails. Although the trunnions are well to the rear and equilibrators are provided, the recoil mechanism is variable. In addition, the carriage has a quick-release elevating mechanism which permits the tube to be placed in the horizontal position for loading while the elevating rack remains properly laid for the desired target.

(2) *4.5-inch gun.*—This gun fires a 55-pound shell and has a muzzle velocity of 2,265 feet per second.

Nature of weapon: medium gun.
Weight: 16,048 pounds.
Length: 16 feet.
Traverse: 60°.
Elevation: −5° to +45°.
Maximum range: 20,500 yards.
Ammunition: HE.
Rate of fire: 2 rounds per minute (rapid) and 1 round per minute for prolonged firing.

(3) *5.5-inch gun-howitzer.*—This medium gun-howitzer fires a 100-pound shell and has a muzzle velocity of from 1,235 to 1,675 feet per second.

Nature of weapon: medium gun-howitzer.
Weight: 12,768 pounds.
Length: 24 feet 8 inches.
Traverse: 60°.
Elevation: −5° to +45°.
Maximum range: 16,000 yards.
Ammunition: BL type HE shell.
Rate of fire: 2 rounds per minute (rapid) and 1 round per minute for prolonged firing.

e. 6-inch Howitzer

This is a medium howitzer with muzzle velocity of from 1,235 to 1,352 feet per second. It is made of steel (wire construction) and has a calibrated sight. The breech mechanism is of the Asbury single-motion type, having a parallel breech screw of the Welin pattern.

Nature of weapon: medium howitzer.
Weight: 10,088 pounds.
Length: 17 feet 6 inches.
Traverse: 8°.
Elevation: +45°.
Maximum range: 11,400 yards.
Ammunition: Separate, HE, two marks of shell weighing 100 pounds and 98½ pounds, respectively, the propellant charges being contained in serge cloth bags.
Rate of fire: 2 rounds per minute (rapid) and 1 round per minute for prolonged firing.

9. USE OF ENEMY EQUIPMENT

a. General

In the fast moving situation in the desert, where the tide of battle changes quickly, considerable effort has been made to use captured enemy matériel in boomerang

fashion. There have been many instances of captured enemy guns being manned by their captors.

The four-gun 75-mm battery captured in Omar Nuovo was manned by the regimental headquarters personnel of one regiment and the lost infantrymen of another division. They fired over a 1,000 rounds back at the Italians and took part in the bombardment of Libyan Omar.

Extensive use was made of captured machine guns, antiaircraft weapons, artillery, tanks, and motor vehicles captured from time to time throughout the operations in Syria. Considerable use was made of captured weapons in the British defense of Tobruk.

b. Use of Captured Italian Weapons

The British have captured large amounts of enemy matériel, particularly Italian. The use of all these captured field artillery weapons has been limited by a lack of spare parts, the recoil systems, both spring and hydropneumatic, having suffered particularly. The carriages of the 100-mm and 149-mm howitzers are old models, and the best performance from these weapons can be expected only when they are mounted on modern carriages. None of these weapons is considered suitable for mobile operations in the desert, but within the limitations noted in paragraph 7f, above, they are satisfactory under static conditions. Although some of the Italian weapons have not proved satisfactory enough to be used by the British, the weapons which have been utilized have been listed separately in paragraph 7f, above, to indicate the type, and, incidentally, the value of captured matériel. Some have been used with interchangeable British ammunition and parts and others with Italian ammunition.

10. AMMUNITION

A direct hit at close ranges from a 105-mm gun or a 25-pounder has usually knocked out the tank or the crew, regardless of the point of impact. High-explosive shells are always useful against personnel in the open and in light shelters. Flashless powder is highly desirable, especially for medium and heavy artillery, which are the favorite targets of dive bombers, strafing fire, and enemy batteries. Weapons have been difficult to detect at a distance when using this type of propellant. The use of separate-loading ammunition places any weapon at a disadvantage during action against armored vehicles.

The Germans give much attention to the effect of the tropical sun on their munitions and weapons. All ammunition other than small arms ammunition is especially packed for the Tropics. All munition cases are so marked. Normal charges for tropical use are calculated at an average temperature of 77° Fahrenheit.

Caissons have been found to be one of the best means of stowing ammunition, because they both protect the ammunition and make it readily available and mobile.

Protection is needed because of the vulnerability of shells and fuzes piled on the ground. The explosion of stacked ammunition set afire by an aircraft cannon wiped out in one instance two Bofors crews. It is true that stacked ammunition can be dug in for protection against shell fire and air attack. However, the mobile operations of the desert give little time for digging protective pits for ammunition—in fact, there is hardly ever sufficient time to dig slit trenches for personnel. Protection at the guns cannot be given by trucks, because they are too conspicu-

ous and vulnerable to be allowed to remain at gun positions as ammunition carriers. Dumped ammunition can seldom if ever be saved in the sudden moves of armored action. Caissons are the British solution to all these difficulties.

The British use artillery trailers between the 25-pounder gun and its prime mover. Two trailers are also coupled behind a prime mover to form the ammunition section. Each trailer can carry 32 rounds of 25-pounder ammunition and fuzes, plus some extra space for a small amount of supplies. These loaded trailers are dropped near the gun positions and give some protection against air attack and shelling, serving the same purpose as horse artillery caissons.

Section III. TACTICS

11. INTRODUCTION

This section on the tactical employment of artillery in the North African campaigns is influenced by two considerations: a. *The Task-Force Principle.* The development of the task-force principle underlines the importance of the coordinated tactical action of all arms. Therefore, while the main focus here is on artillery action, this will always be referred to the general operations in which artillery plays its part.

b. *Special Conditions of Desert Warfare.* The terrain and climate of this theater have imposed certain limitations and set certain problems, some of which involve or affect the use of artillery.

12. RECONNAISSANCE

a. General

Both large and small units operate over wide desert expanses. The lack of cover necessitates great dispersion, which in turn requires each unit to provide its own close-in defense—a situation emphasizing the need of reconnaissance.

Constant use is made of both ground and air reconnaissance units. Even the side which is weaker in air strength carries on air reconnaissance. Forward ground reconnaissance is usually executed by armored cars. Fre-

quently German armored car patrols are supported by tanks, in a ratio of one tank to two armored cars, to provide sufficient fire power to overcome hostile patrols and outposts and thus extend the depth of observation. Once contact is gained by the Germans with an armored force, it is kept under observation even though the German armored units may have withdrawn. As a result, German armored units have been able to avoid battle when conditions were not favorable, to make night attacks against bivouacs, and even to surround hostile bivouacs during the night with antitank weapons and destroy the armored vehicles from close range in the morning.

b. Methods of Observation

Although the desert is not completely flat, suitable vantage points for observation posts are never very high. This lack of height, together with the heat waves rising from the hot sand and rocks, sometimes reduces visibility in the desert. Mid-day is the least satisfactory period for observing fire.

Both sides endeavor to gain what high ground does exist in the desert. It has been noted that the German infantry in Libya, as elsewhere, have launched attacks for the purpose of obtaining observation posts for their artillery. In one instance such an attack was made to gain ground only 3 feet higher than the surrounding terrain.[1] Similarly, German artillery officers have been

[1] This conforms with modern German tactical doctrine. In "Tactical Handbook for the Troop Commander" by General Friedrich von Cochenhausen, the general doctrine on artillery and infantry cooperation is stated: "The infantry must seize and hold the terrain most suitable for artillery observation posts. The movable artillery observation posts accompanying foremost infantry units are the only guarantee for intimate cooperation."

known to ride on top of tanks in order to gain height for observation.

In both German and British armored divisions the artillery has its own armored vehicles for observation posts. However, even artillery with unarmored troops utilizes methods similar to those of the armored divisions. Forward observers are well out in front with those covering forces, armored cars, or carriers which are deployed for reconnaissance and outpost duty. Often these mobile OP's must be with the armored-car screen, and they are then in an armored car or scout car. Many British officers have spoken highly of the U. S. M–3 Scout Car for this work. Its chief advantage is that it accommodates the entire OP party, whereas the armored car has room for only three persons. Armored cars or scout cars are assigned to and maintained by artillery units. Enough cars must be provided so that all radio sets allotted to a battalion can be mounted in such vehicles; these can then be used by forward observers. The advisability of providing more than a few such cars has been quickly realized, because they wear out soon and have a high casualty rate. Unless the OP is the same type of vehicle as that used by the supported troops, the enemy will concentrate its fire power on the OP vehicle.

The British have found it to be impossible to assign tanks to artillery for OP purposes. But they do have arrangements whereby each regiment of tanks modifies and, on occasion, reserves for artillery observers a certain number of tanks.

A problem of observation was revealed in one fast-moving situation which occurred during the winter of

1941–1942. The battery commander was traveling with the tank regimental commander. Two observers, one per troop,[2] were directing fire while traveling with the forward elements of the regiment. When contact was actually made, the observers had their tanks stay on the flanks and drop back slightly from the front in order to avoid becoming directly engaged. All control was by radio and the observer had his own radio operating in the artillery net, separate from the tank radio which operated in the tank net. Because of the limited number of frequencies available, it was necessary for all artillery units in a battery to be on the same frequency. The effect of this single frequency was unfortunate, for only one troop could be fired by one observer at a time, and a great deal of confusion occurred. When all control by observers breaks down, artillery support deteriorates into direct laying by individual pieces.

In addition to the armored OP's, gun towers have been used to gain height for observing fire. These OP ladders are used both as dummies to draw fire and for observation. They are mounted on trucks or may be removed quickly and set up at an OP. The British observing towers are generally about 25 feet high. The Germans have a two-piece telescoping tube mounted on the side of their armored OP, which can be cranked up into observing position. To employ these gun towers effectively there must be a number of them—at least one to each four guns. These, like the tanks and the slight rises in the ground, aid in overcoming the flatness of the desert.

Other difficulties arise in the desert which only keen eyes and training can surmount. There is the real prob-

[2] British *troop* is equivalent to U. S. *battery*.

lem which a forward artillery observer has in identifying his own bursts among the dust and heat waves when other units are also firing. Judging distance in the desert is as difficult as on the ocean. Lack of familiarity with the size and appearance of armored vehicles at various ranges is a frequent cause for misjudging distance. The fact that the enemy opens fire does not inevitably mean that the enemy is within range, for he can misjudge distance also. But it is even more important to remember that all tanks are not equipped with the same type of gun. German tanks armed with 75-mm guns can open effective firing at a range of 2,000 yards. Antitank guns with a smaller range waste ammunition by returning fire and, what is worse, give away their own positions.

13. SELECTION AND OCCUPATION OF POSITIONS

a. Introduction

Suitability of position for accomplishing the mission assigned, and also cover and camouflage, are sought by the artillerymen in the desert as elsewhere. Since cover is practically impossible to obtain in most desert positions, the main concern in selecting a gun position is the suitability of the soil for digging pits and the possibility of arranging for mutual support with other units.

b. Terrain

Both sides make excellent use of those few accidents of the ground which occur in desert terrain. Maximum use is made of folds of the ground both to advance and to conceal tanks, artillery, and antitank weapons. Artillery and antitank guns have frequently been cleverly con-

cealed in ground where the terrain was unfavorable for tank action.

Quick concealment from both the ground and air is obtained by digging gun pits and using light-colored camouflage nets. Gun pits which have no parapet, being flush with the surface of the ground, are more easily concealed than those which have. When possible, therefore, both Axis and United Nations troops distribute the soil and refrain from building a parapet. Gun pits are dug to permit all-around fire.

Often a diamond formation with sides of about 800 yards is employed for a regiment of four batteries. This enables the batteries to be mutually supporting. The guns within each battery are sited in semicircular fashion, 60 to 70 yards apart.

On going into action, the British consider the priority of tasks to be:

(a) Concealment from ground and air;
(b) Digging of slit trenches;
(c) Digging of gun pits, command posts, etc.

Rapidly occupied positions may not be the best available. Therefore, reconnaissance for more satisfactory gun positions is always carried out in such circumstances, and a move is made as soon as possible. In the event of a severe shelling, batteries move to alternate positions if the new positions will still give the necessary mutual support.

c. Dispersion

Both dive-bombing and strafing aviation seek out artillery units for attack, as they are profitable targets. To

defend against such attacks, either cover or dispersion is necessary. Since sufficient cover is not usually available, the dispersion of vehicles has been great—200 yards between vehicles being normal. Units spread out in this fashion offer no target for air attacks. When the enemy air force has been inactive, the distance between vehicles is sometimes reduced. This is done to insure better defense against tank attacks and to obtain more control over units. A New Zealand division, while in defense of the Sidi Rezegh—Belhamed area, reduced the distance between its vehicles because of the small amount of cover available, and vehicles at 50- to 60-yard intervals did not suffer undue casualties during artillery bombardments. Undoubtedly casualties would have been severe if there had been an enemy air attack on that occasion.

d. Camouflage

In the desert every gun is dug into a pit if time permits, and covered with a net; every tent is set in a pit and camouflaged; and even each tank has a canvas top placed over it to make it look like a truck. All vehicles are painted with nonglare sand-color paint, and all glass is smeared with oil or a glycerine solution, and then dirt is thrown on these surfaces. Only a narrow unsmeared slit on the windshield is left to obtain vision. Wheel tracks are everywhere and cannot be disguised or obliterated.

A liberal application of dull yellow paint—the color of the sand—has been found to be the best method of rendering both artillery pieces and motor trucks less visible in the desert. The outlines of a piece are broken by the use of scrub and sand mats. The barrel and cradle are sometimes painted a dull sandy color, except for a 1-foot

diagonal stripe of light brown or green to break up the pattern of the gun. Motor vehicles carry camouflage nets, which are stretched taut from a central position on the roof of the vehicle at an angle of not more than 45°, and then pegged to the ground and covered with threaded screen and bleached canvas, or with pieces of sandbags 50 to 70 percent of which are painted dull yellowish white. The vehicles themselves are painted cream white, broken by irregular patches of light brown or green. The object is to neutralize dark shadows by an equivalent amount of dull white. Germans and British have adopted this sand color as camouflage. During recent operations German

Figure 13.—British 6-inch howitzer in a dug-in position

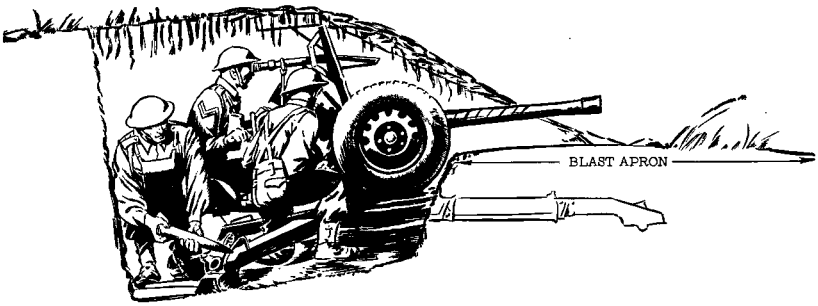

Figure 14.—Diagram of one method of camouflaging and emplacing a British antitank weapon

tanks were painted black, evidently to aid their antitank gunners in quick daytime identifications while also serving as night camouflage.

As a security measure and to prevent unauthorized persons gaining information regarding the identification of units and movement of troops, by observing motor transport movements, the practice of marking vehicles with unit designations has been discontinued. A code system, employing color and combinations of colors with numbers to indicate various tactical organizations has been adopted.

14. COMMUNICATION

a. General

Distance is the principal problem encountered in desert communications. Radio is used extensively, as wire is laid only when there is time—an element often lacking in desert operations. Radio presents a unique problem of security, because radio communication is like shouting

from place to place—all who will can listen. This has necessitated the development of various codes and devices for the secret transmission of data by radio.

b. Visual Signals

Although visual signals are not used extensively for transmitting artillery data, flag signals are employed by both sides for short messages and for identification, especially in small tank units. Recently, the Germans had radio sets in a ratio of one set to three tanks. The three operated as a unit, flag signals being used to control the tanks which had no radio. Great use has also been made of pyrotechnic signals. Recently, two signals were used by the Germans to identify their tanks to German aircraft: a Very signal of three white stars, and an orange-colored smoke. Large flags have sometimes been used for the same purpose. Rockets have been used in profusion at night, apparently both to rally forces which were scattered when dark fell, and to confuse and harass the enemy. It is not known what method the Germans use to identify tanks to friendly antitank and artillery weapons. When the British used the method of approaching friendly troops with turrent guns pointing to the rear, the Germans were quick to adopt the same method for purposes of deception, in order to approach close to hostile weapons.

c. Wire

Although the speed of operations in the desert may on occasion preclude the use of telephone lines, a greater degree of security and dependability is achieved by using wire. Almost all lines are laid on the ground. Motor

vehicles traveling across the desert constantly are running over the wires. The results of bruising of wire are not so serious in the desert, since ordinary field wire operates better over the desert surface than it would over damp or moist ground. Also, laying and picking up wire are much less difficult in the desert than in swampy or wooded country. Of course, overhead wire circuits are more desirable when the situation becomes at all static. Communication over long field lines in most cases is good in the desert.

The wide dispersion of guns has made necessary the use of an enunciator [3] system between the executive and the individual sections of the firing batteries. Such a system permits the executive to coordinate and command his guns in such a manner as to control rapidly the guns for effective concentrated fire.

d. Radio

Radio is the most important means of communication in the desert. During the summer of 1941 one British armored division conducted its entire communication network by radio. Every command vehicle had a receiving set. Each artillery troop has three No. 11 [4] sets

[3] The British use the Tannoy system. It is a miniature public address system, now reported to be standard issue for British artillery units.

[4] These British radio sets have the following characteristics:

	Voice range	Frequency	Weight	Approximate U. S. Army equivalent
No. 9	8 to 10 miles	1,875 to 5,000 kc/s	200 pounds	Radio set S. C. R. 284.
No. 10	Not a standard set; details unknown.			
No. 11	4 miles with loop antenna; 8 miles with pole antenna. (Special devices are used for increasing the range.)	4,200 to 7,500 kc/s	83 pounds	Radio set S. C. R. 288.

using one principal frequency, and, for emergency use, one switch in "frequency."

Each troop of this armored division was part of a mobile column, which furnished No. 9 command sets. Switch frequencies were in the overlap band of No. 10 and No. 11 sets, permitting use of No. 9 in displacement by a half-troop in case no extra infantry No. 11 set was available for the purpose. Artillery troops normally operated with two OP's using No. 11 sets. A third OP could be manned for emergency use by diverting a set from the infantry of the mobile columns.

Only one radio set could be provided to each gun position. This may have been caused by the fact that British radio sets are heavy and cannot be removed from the vehicle in which they are mounted. The range of the No. 11 set—voice, 15 miles—has been considered adequate for all troops used during the summer of 1941.

e. Codes

During active operations all messages below the division are usually sent in the clear. Christian names of tank and unit commanders and prearranged code names for places are used. Although there is little intentional enemy interference with artillery communications, there are active and efficient Axis radio-interception intelligence units.

The use of plain language even when accompanied by code names and enciphered place names enables radio interception to be employed effectively. By keeping a careful record of all names, key words, and numbers, both the Italians and the Germans have been able to bring their order-of-battle information up to date by a

process of sifting and cross indexing. Officers' names, either family name or given name, are the principle keys used in identifying intercepted messages. Captured German documents indicate that the careful compilation of names made by the Germans has enabled them to work out British code names. In addition to names, references to the personnel arm, such as "Gunner Smith," or "Rifleman Jones," have helped the Axis forces to identify said units.

One of the most interesting methods of enabling map references to be sent in the clear with security is the "thrust line" method used by the Germans. (This method is similar to the code described in FM 18–5, "Organization and Tactics of Tank Destroyer Units," June 16, 1942, paragraph 231 b (2) (e).) It consists of a line drawn upon a map which theoretically may run in any direction but which actually usually extends in the proposed direction of advance or down the axis of a reconnaissance unit.

The line, which begins at a fixed point and continues indefinitely in the required direction, is usually divided into centimeters for convenience. To give a map reference, a perpendicular is dropped from the reference point to the thrust line. Measurements are then taken from the point of origin to the point where the perpendicular cuts the thrust line, then along the perpendicular to the reference point. Since the point may lie on either side of the thrust line, the second figure must be prefaced by either "right" or "left", as one looks toward the enemy.

A typical reference would be "6 right 3." (See fig. 15.) The figures are always in centimeters; therefore, the actual distance on the ground will vary with the scale of the map

used. The scale may start with an arbitrary figure, and have dummy figures interspersed, or it may start with the number of the thrust line when there are several in a given area. These devices make the code difficult to break rapidly.

Instruments have been found consisting of a transparent ruler graduated in millimeters, with a shorter ruler simi-

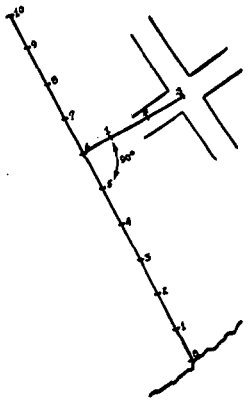

Figure 15.—The "thrust line"

larly graduated and fixed to slide up and down at right angles to the longer ruler. Practiced operators can give references very quickly.

15. GERMAN TACTICS

a. General

No strict pattern is apparent in German operations. The Germans have in most instances employed a balanced and highly coordinated team of all arms and services, whatever the size of the force. Although their procedure

has thus been elastic to suit the tactical situation, they have been found to proceed in general along the following lines.

b. Effect of Terrain

The Germans make full use of the freedom of maneuver which desert terrain affords and generally have not accepted battle under unfavorable conditions. Maximum use is made of the artillery and all auxiliary arms, both ground and air.

The lack of terrain obstacles and the supply difficulties have resulted in a modification of the German use of armored units in the desert as compared with their previous use in Poland and in Western Europe. In Libya, with the exception of isolated fortified localities such as Tobruk and Halfaya, no long defensive lines exist which can be probed to find a weak spot for penetration and exploitation. Nevertheless the cardinal principle of concentrating tank strength has been followed. On those occasions when the German forces advanced in several columns, the tanks were usually concentrated in one column. The object of the tank column is to destroy the enemy force, using maneuver to defeat him in detail whenever possible.

c. Formations

Various methods of advance have been used by German armored units. Usually the formation is in considerable depth. A battalion (65 to 80 tanks) frequently uses a "V" formation with two companies leading and one in reserve, or an inverted "V" with one company leading

and two in reserve. Companies are usually in line, with tanks in column of threes at about 50-yard intervals and three to five tank lengths in depth.

A German tank battalion in tactical formation moves in short rushes, taking advantage of the terrain. Frequently the whole regiment advances in mass formation with lines of tanks at regular intervals of about 50 yards, advancing in waves. The relatively close formation is more readily controlled than a widely dispersed one. Field artillery and antitank weapons are kept up close, although their location is not apparent until they go into action, usually on the flanks of the tank column. The Germans have in the past been able to bring effective artillery and antitank fire to bear on the British before the British could effectively fire upon them. In addition, RAF planes, because of the pilots' inability to distinguish between their own and German tanks, have not attacked German tank formations in the forward areas.

d. Offensive Tactics

In the desert frontal attacks have not often been used, an effort being made more often to attack from one or both flanks. German tanks usually open fire at 1,500 to 2,000 yards, which is beyond the effective range of the hostile weapons that they have thus far encountered. When contact is made, the speed of advance is slowed down unless the movement is a quick thrust to force the withdrawal of weaker hostile forces. The 75-mm and 50-mm guns are used to keep hostile tanks out of range.

(1) *Usual German objectives.*—The object of the Germans is to knock out quickly as many of the antitank guns and foremost field guns as may be visible. When the

German tank commander has decided to attack a position, his first objective has often been the British 25-pounders. By reconnaissance in tanks he first locates the British battery positions and makes his plans. This plan in principle always appears to be the same. He decides which battery to attack and he arranges to attack it from enfilade. His attack is made with 105-mm guns, the 88-mm dual-purpose guns, and both Mark III and IV tanks. The 105-mm guns fire from covered positions; their observation posts are in tanks. The 88-mm dual-purpose guns are towed. These guns use direct fire from their trailers after attaining defiladed positions at ranges varying from 2,000 to 2,500 yards. The Mark IV tanks assume positions in defilade and fire over open sights at ranges varying from 2,000 to 2,500 yards. The high velocity 75-mm gun in the Mark IV tank and the 88-mm dual-purpose gun have far higher muzzle velocities than any artillery that the British have had in the desert.

(2) *German Mark III tanks.*—The Mark III tank is used as the main striking force in attack. It has the dominant role in tank-versus-tank combat. Its heavy armor and powerful 50-mm gun give it a decided advantage over all types of tanks which it has thus far encountered in the desert. The 75-mm gun in the Mark IV tank is not an antitank gun but a close-support weapon. Its maximum range is 7,000 yards. Frequently these tanks use direct laying from a defiladed position in which, owing to the location of the gun in the turret, they offer a very small target. At other times the fire is massed, with indirect laying, and is adjusted by forward or flank observers in tanks. Tanks rarely fire while moving,

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although in at least one instance they were used to fire a rolling barrage at from 3,000 to 4,000 yards while advancing slowly. This forced the opposing tanks to close up doors and turrets.

The first wave of Mark III tanks overrun the gun positions. The second wave of Mark III tanks is closely followed by the motorized infantry, which detrucks only when forced to and cleans up the position with small-arms fire, assisted by tanks which accompany it. After the artillery has neutralized the tanks, the support infantry is attacked. Such attacks have nearly always neutralized the artillery, either by destroying it when the attack was driven home, or by forcing it to withdraw before the tank attack was launched. A successful defense against such attacks has been made only when a tank force was available to launch a counterattack from concealed positions against the flank of the German tank attack.

(3) *The German Mark IV tanks used as artillery.*—In the attack the Germans maneuver to some position where their Mark IV tanks[5] can take up a position in

[5] The German Mark IV tank weighs 22 tons and carries 5 men. It has a maximum speed of 31 mph and is armed with one 75-mm gun and two light machine guns. Recent reports indicate that the Germans are modifying the design of this tank by fitting it with an improved 75-mm (2.95-inch) gun known as the "Kw. 40" and by adding hollow frontal armor. The Mark IV has hitherto been equipped with a low velocity 75-mm gun, and the tendency has therefore been to employ this tank as a close-support weapon. As a consequence of the mounting of an antitank gun—and the possible fitting of hollow frontal armor—it is to be expected that the Mark IV will in the future be, and may already have been, more boldly employed as a striking force in tank-versus-tank engagements. The German designation of this new equipment is *Sturmgeschütz lange 7.5-cm Kanone* (*Stu. G. lg. 7.5-cm K*).

defilade. The Germans meanwhile make a reconnaissance, probing the enemy from all directions to test his strength, and to induce the defenders to disclose their positions by opening fire. During this period, observation posts keep close watch, and any guns which disclose their positions are marked down for destruction when the main attack begins. Then, from their defiladed positions, the Mark IV's attack by fire all antitank guns or light artillery which are visible and within range. Light artillery, antitank guns, and machine guns with the same mission are pushed forward among and to the flanks of the tanks. Observers and occasionally infantry are pushed further forward.

Each German tank battalion has one company of 10 Mark IV tanks, which are employed in 2 principal roles: as highly mobile artillery, and as a component of a fast-moving column. Often field artillery cannot be immediately available in armored engagements; the Mark IV tank with its 75-mm gun together with the artillery of the armored division provides German armored formations with the necessary heavy fire power for a breakthrough.

The maximum range of the 75-mm gun is reported to be 9,000 yards. This relatively long range dictates to troops equipped with light antitank guns the time and place of a battle. In addition, the speed of the Mark IV tank is sufficient to enable it to take part in a rapid advance with the Mark III tanks. The Germans have used these tanks as sniper guns, as artillery against forward British columns, and as heavy concealed weapons in the ambushes into which German armored cars have tried to draw the British cars. In a defensive situation the

Mark IV is able to engage British troops from outside the range of the antitank guns, avoiding at the same time, by their mobility, the British artillery fire.

(4) *Field artillery support.*—The 105-mm mobile batteries and the 75-mm guns of the Mark IV tank furnish the principal artillery support for the German Mark III tank, which is the main attacking tank. Sometimes the 88-mm dual-purpose gun is used in conjunction with the Mark III tank.

Some reports indicate that the direction of this supporting fire is carried out by a system of air bursts, since air bursts have been immediately followed by HE concentrations. The fire of 75-mm and 105-mm guns using HE shells has not been reported to be extremely effective. Casualties caused to personnel and tanks by these weapons have been reported to be the result of a new flare—a 75-mm shell which envelopes the tank in flames regardless of what portion of the tank is hit. One whole tank regiment was reported destroyed by this type of projectile. Although the casualties caused from these weapons may be slight, all reports agree that they have a high nuisance value to tanks because of the blinding effect of the smoke and dust. The 88-mm is effective; tanks hit squarely by this gun are destroyed.

The Germans stress the use of ricochet artillery fire against personnel as follows:

> The much greater effect of ricocheting projectiles as compared with those bursting on impact has been confirmed by the testimony of numerous prisoners.[6] Against all living targets not covered from above, more ricochet fire than hitherto will be employed therefore. Ricochet fire may also be employed against concealed

[6] The use of slit trenches is universal among all forces in the desert.

targets if it can be observed from the burst, the noise of the explosion, or the flash of the exploding shell that a sufficient number (40 to 50 percent) of ricochets, are occurring. Ricochets can be distinguished from projectiles which enter the ground by their sharper detonation sound, and by the brighter flash, visible even in daytime. This is particularly the case with shallow ricochets, which are easily mistaken for impact detonations. Projectiles which penetrate the ground make no, or very little, report and flash on exploding.

e. German Method of Forcing Gaps through Mine Fields

A heavy artillery concentration is placed on the point to be forced and upon the defending troops in the vicinity. After the defenders' resistance is lowered by the concentration, a comparatively small number of foot troops advance to the gap under cover of smoke or of dust raised by the concentration; they locate the mines by prodding the ground with bayonets or with mine detectors; the mines are then removed. Casualties are replaced from a reserve unit that is held immediately in rear. This method was used in forcing a gap through the mine field that was part of the defenses of Tobruk; the preliminary concentration lasted for two hours. After a gap is forced and marked, infantry followed by tanks or tanks followed by infantry attack through the gap. Infantry preceded the tanks in the battle of Tobruk.

f. Defensive Tactics

When an armored force is encountered, all tanks may take up a firing position in defilade, immediately reinforced by towed and self-propelled antitank guns and artillery. If the tanks are forced to retire, they withdraw under cover of antitank weapons and artillery. Usually

the Mark III tanks withdraw first, the Mark IV assisting in covering the withdrawal with high explosive and smoke. When such withdrawals have been followed by the enemy, the well-concealed German antitank guns and artillery have caused such serious damage to the pursuing tanks that the pursuit has generally been stopped. Sometimes the tanks will withdraw through the antitank and artillery positions and then maneuver to strike the hostile armored force on its flank.

16. BRITISH TACTICS

a. The Approach

The action of artillery with British armored forces during the approach has differed little from its action with infantry formations. The armored regiments move in open order in a formation usually like that in figure 16.

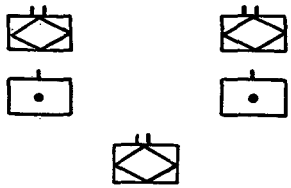

Figure 16.—Open order formation of a British armored regiment

The artillery regimental commander rides in a vehicle near the tank brigade commander; the artillery battalion commander rides near the squadron commander, usually in the same tank with the squadron second-in-command. Battery commanders are with their batteries; observers are in vehicles *on the flank* of the leading elements, or *in the rear*, so as to have observation in all directions. All communication is by radio, as shown by figure 17.

Artillery regimental and battalion commanders each have two radio sets, one for use in the tank net, the other for use in the artillery net. Each artillery observer has direct radio communication with his battery, but the battalion commander can cut in on either of the battery frequencies if he desires.

Some artillery observers accompany the leading ar-

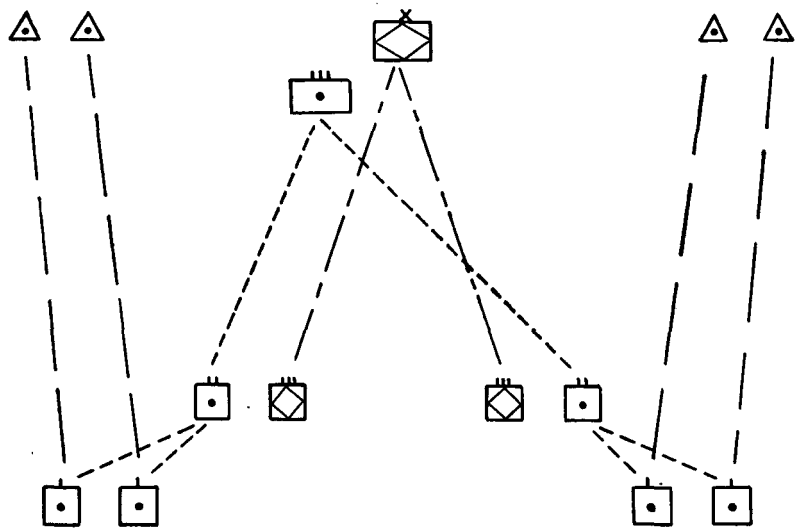

Figure 17.—British radio net

mored cars, which are used by both sides for reconnaissance purposes. Only sufficient guns accompany these armored cars as are necessary to support them in the fighting required to secure the needed information. In addition, a certain proportion of antitank guns are used for protection.

b. The Attack

1. *General.*—It has been found that an attack by tanks against an even hastily organized position in which there

are a reasonable quantity of antitank and field guns succeeds only at disproportionate cost, unless the enemy guns are knocked out or neutralized first. When the British spot Axis guns, they engage them by direct fire from 25-pounders. As many as possible are knocked out.

(2) *Role of the artillery.*—Normally, at the beginning of combat the artillery regimental commander attaches his battalions to tank regiments, and does not try to control their fire.

Artillery battalion commanders usually keep one battery within 1,500 yards of the rear of the supported tank regiment, and the other several thousand yards in rear. As soon as the forward battery is committed to action, the rear battery is ordered forward to leap-frog the forward battery. This method provides for continuous support during an advance.

The artillery observers do not always use armored OP's. It was discovered that isolated armored vehicles received concentrated fire as the enemy approached, whereas an isolated unarmored truck was often disregarded by the enemy during the initial stages of the action. Hence observers in tanks or other armored OP's stay within the armored formation, and those in trucks get out on the flank where they can see better and avoid the long-range fire which the Germans usually commence at 2,500 yards (or more) as the two opposing forces approach each other. The observer calls for two rounds, 100 yards apart, at a given range and at a measured compass direction. From these he shifts fire on to the target. He continues to observe and adjust the fire by this method until the Germans are so close that he has

to withdraw; in these final stages the batteries usually employ direct fire.

In the meantime the firing battery is laid in the following manner: the battery march is in a diamond formation, with a pilot vehicle containing the executive on the flank (see fig. 18).

When the call for fire comes from the observer, the battery forms a line, the base piece is laid reciprocally by the executive and referred to the pole on his vehicle.

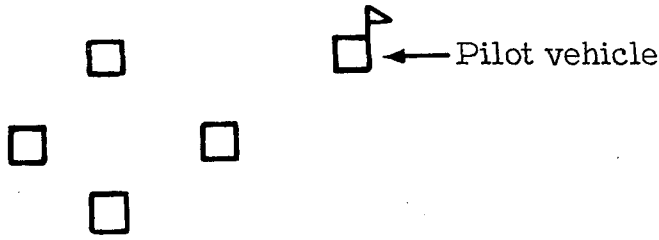

Figure 18.—Diagram of a British artillery battery on the march

While the base piece is firing the two initial rounds, the other sections go into position and are laid with a prismatic compass. This enbables the battery to get off its initial rounds quickly with rough data.

c. The Defense

In the desert, mechanized attacks may come at any time and from any direction as in a naval action. This has, of course, necessitated special formations for defense. Division "X" has been reported to have the best defense organization. This division, with a grand total of about 12,650 men, consists of —

3 infantry brigades of about 3,000 men each; total, 9,000 men.
3 artillery regiments of about 600 men each; total, 1,800 men.

2 antitank regiments of about 500 men each; total, 1,000 men.
1 tank battalion of 250 men.
Supply and repair echelons of about 500 men.
AA personnel of about 100 men.
Motor vehicles numbering about 3,000.

In moving this unit three general methods were used;

Armored cars 5 miles ahead of Brigade.

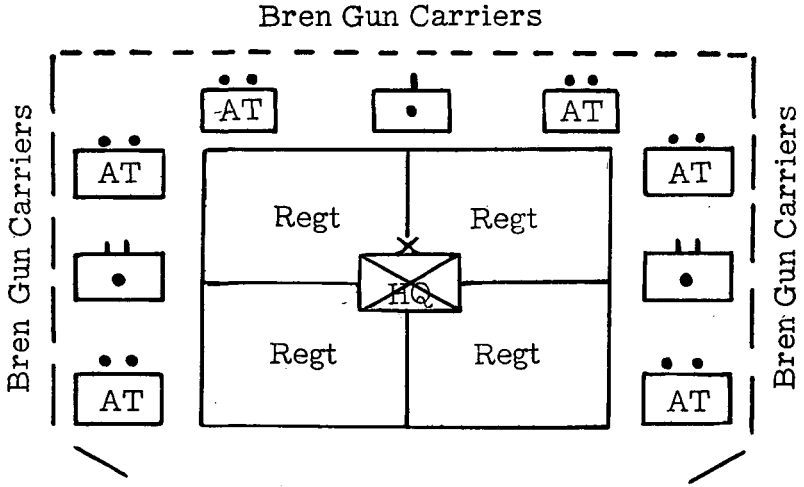

Figure 19.—Diagram of a British brigade on the march

the brigades in column, two brigades in front and one in rear, and one brigade in front and two in line in rear.

The position illustrated in figure 19 is that used for the halt with brigades closed up to 500 yards. On the march the distance between brigades is approximately 1 mile. A separate brigade is organized as shown in figure 20.

It is interesting to note that vehicles are formed in

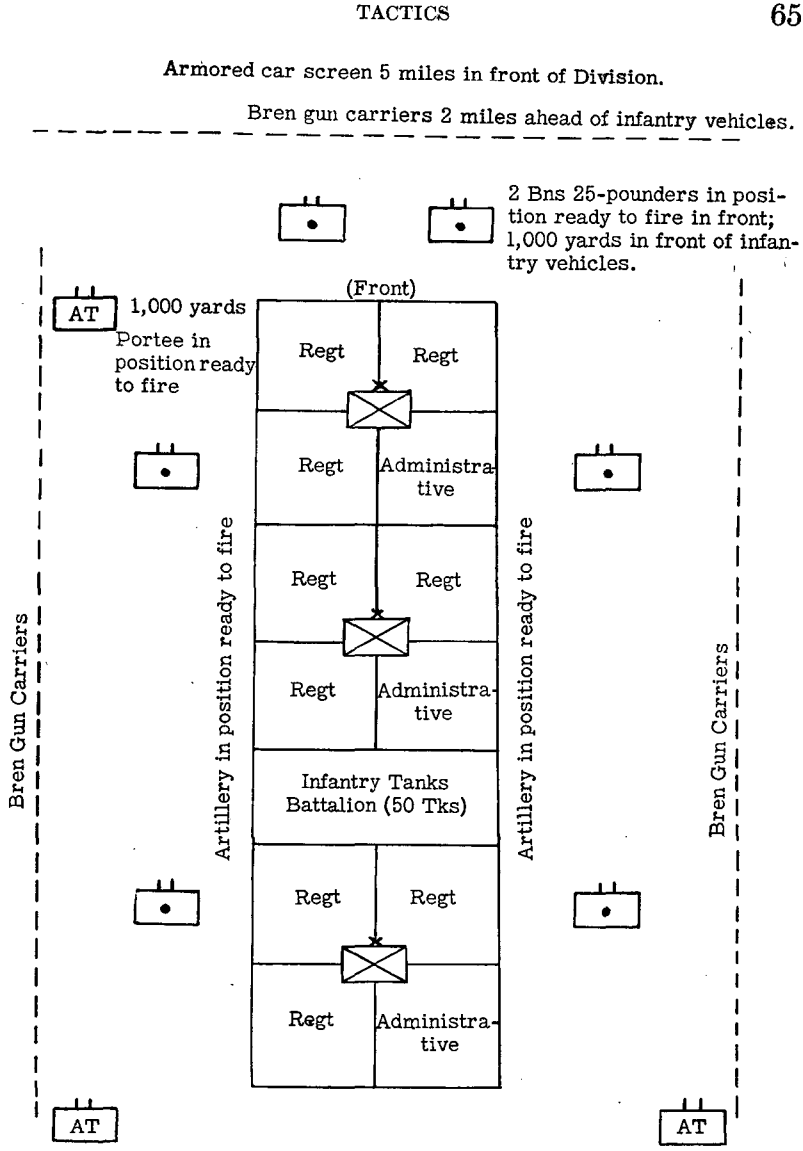

Figure 20.—Diagram of a British division organized for perimeter defense

lines by organizations and moved forward in that manner. Intervals between vehicles and in park are approximately 100 yards; distances from the front of one line to the next are approximately 150 yards.

In case of an attack the division (see fig. 19) or brigade on the march halts and the defense is offered with the proper weapons. Antiaircraft defense is offered by three battalions of three batteries of four (Bofors 20 mm) guns each (a total of 36), distributed through the divisional area. Bren machine guns on the basis of five per artillery and infantry battalion are mounted ready for immediate use at any time. Artillery is used at the earliest possible time in an effort to break up the attacking enemy formations before they are within effective tank or infantry ranges.

The experience of one infantry brigade has illustrated well the possibilities of artillery in the defense. The commander of this infantry brigade pushes forward a "Hard Hitting Packet" (four 2-pdr guns portee, four Vickers .303 MG's in carriers, two 3-inch mortars in carriers) to assist the armored car screen when it reports heavy armored forces to be approaching. He moves the brigade itself forward to a favorable position in which to receive an attack. The advance group usually meets the enemy and fights a rear guard action back to the perimeter, into which they move in their assigned positions. All the while this is going on, the brigade artillery, controlled by mobile OP's, keeps the advancing tanks under fire. In this brigade the commander has made six armored cars into mobile observation posts with radio sets which can contact the artillery Hq and have artillery observers in each. With these mobile OP's the enemy tanks cannot

get away from effective artillery fire, for the mobile OP's go where necessary to observe the fire. This brigade has never yet been without observed fire even during the hardest engagements. These cars work around the flanks, and, as a result, the enemy cannot refuel or form up within range of the artillery without bringing down effective fire on himself. Armored cars are not afraid of tanks, as they can always outrun them.

In one instance, some time after the advance screen joined the perimeter, the Germans delivered a minor tank attack from the northeast. The brigade beat this off, burning out four tanks. One, however, came so close that it was captured by an officer who charged it in a ½-ton truck with a sticky-type bomb. The crew surrendered, and he brought it in to the Brigade Hq, crew and all. There were no more tank attacks that day, but the artillery continued its shelling.

During the night of November 23/24 the brigade received orders to withdraw 7 or 8 miles to the south and establish a defended perimeter. Stragglers of another brigade commenced drifting back; so the commander waited until dawn and sent out armored car patrols to bring in as many as they could find. At 0730 the brigade commenced moving south, and at 0900 its leading unit arrived in the designated area. There was much miscellaneous transport in the area which had to be moved before the perimeter was established. This was a day (November 24) of a big breakthrough in the south, and there was considerable confusion.

The brigade remained in position all day and was engaged by the German 21st Armored Division, and on

the night of November 24/25 the Germans encircled the entire perimeter. The attack began in earnest at 0700 of the 25th with artillery fire from two medium batteries, one to the east and the other to the northeast.

The armored cars which had withdrawn into the perimeter at dark were out again at dawn (0615), and they soon reported armored formations in strength to the northeast and also to the south of the perimeter. At that time it was known that the Italian armored forces with other mobile troops, but with no German tanks, were in the Bir el Gubi area 6 or 7 miles west of the brigade.

By 0730 the medium batteries were augmented by three field batteries firing from positions to the north, east, and southeast.

The first heavy attack, made up of approximately 60 tanks supported by motorized infantry and heavy mortars, came from the east. This force included a number of heavy tanks, German Mark IV's, which "fire everything they have as they move, making quite a show as they advance."[7]

The attack was made in two waves on a front of about 1,000 yards, the light tanks forward and the heavier ones in the second wave. It lasted exactly 1 hour, and, after failing to penetrate the perimeter in a number of places and suffering heavy losses, the tanks withdrew and reformed to the north. During the enemy attack, artillery fire was intensified and the brigade artillery answered them, firing primarily on armor; but some guns were spared for the soft column [8] which usually functions close

[7] Comment of an eye witness.

[8] *Soft column* is used to describe unarmored and less well protected vehicles for example, supply and infantry transport vehicles.

in the rear of the German armored column.

A second and heavier attack was launched from the north at 1000 hours. The violence of this attack was such that for about half an hour it was feared the Germans would penetrate the perimeter. The ground attack was intensified by air bombing. This brigade was attacked by dive bombers and fighters during the early morning from November 19th to December 6th, and by two or three large formation assaults during the day, but dispersion and slit trenches made air attack comparatively ineffective against personnel. However, the brigade did have 145 vehicles burned out during this period, the majority by the air. This brigade digs slit trenches whenever it halts, if even for an hour, and its vehicles are always dispersed by at least 200 yards. A slit trench for a temporary halt need be just deep enough so that the body of a man is below the surface of the ground.

The attack slowed down at 1030, when the remaining tanks moved widely around to the west, still constantly under the brigade artillery fire. During this movement smoke screens were laid by the tanks themselves, but the brigade's mobile OP's moved around the screen and kept them under observed fire.

It appeared as if a third attack was imminent, but before this could be launched, an armored brigade arrived with 40 American light tanks. These were not sufficient in number or sufficiently armored or armed to counterattack the numerically superior and heavier armored German tanks, and it was therefore decided that should a third attack materialize, the armored brigade would counterattack into their flank. But this third attack did not materialize,

probably as a result of the welcome reinforcement of the American tanks.

The artillery battle continued all the rest of the day. Toward sunset the enemy's soft column (motorized infantry and supply units), approximately 2,000 vehicles which were well within gun range, started withdrawing, with the infantry brigade's artillery continually shelling them until they moved out of range. During the withdrawal the Germans interposed their tanks between their soft columns and this infantry brigade.

d. Withdrawal

If a withdrawal has to take place, it is conducted under cover of artillery fire. Orders are issued sufficiently early for a plan of withdrawal of the artillery to be made. If they are given too late, there is grave danger of batteries being unnecessarily overrun. Antitank guns are required to protect the flanks and the rearmost units of the force, especially those of the field artillery engaged in delaying the enemy advance. Antitank guns may have to be used from their portees, but this is avoided, if possible, in order to obtain better positions. In any withdrawal, a rallying point, beyond which no vehicle will pass, is established and announced to all ranks.

e. Counterbattery

(1) *General.*—Organized counterbattery work has not occurred during the highly mobile stages of the fighting on the desert. Counterbattery operations have been used most effectively by the British during the more or less static situations which have developed around such key

points as the Omars,[9] Salum,[10] Halfaya Pass, Bardia,[11] and Tobruk. Special counterbattery officers are trained and employed by the British for this work, which often entails the aid of flash spotting. Whenever used, the effect of the heavy shell of the British 6-inch howitzer, both on the morale of the enemy artillery and as a destructive agent, has been most noticeable.

At Salum the most effective counterbattery method used by the Germans was that of employing dive-bombardment aviation under divisional control for critical targets.

(2) *Flash and sound ranging.*—The British flash spotters did some useful work by locating many isolated 105-mm, Italian 75/46, and antitank guns at the Battle of the Omars.[12] They were hampered, however, by poor observation. On the whole, because of the fluid nature of the operations in the desert, small use has been made of flash and sound ranging.

f. Naval Bombardment

Bardia, Tobruk, and Bengasi have been the scenes of considerable British naval bombardments. Observation has been conducted largely by airplanes. To enable such observation to be effective, there has to be complete air superiority or strong fighter protection.

The open country of the desert and the mobile nature of the fighting require considerable effort to be expended to maintain communication so that the ships can fire

[9] See "The Battle of the Omars," Information Bulletin No. 11, page 38.

[10] See "The Battle of Salum," MID Special Bulletin No. 36, page 39.

[11] See "The British Capture of Bardia (December 1941–January 1942) A Successful Infantry-Tank Attack," Information Bulletin No. 21.

[12] See "The Battle of the Omars," Information Bulletin No. 11.

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where and when the troops require it. A naval liaison officer is stationed at army headquarters to direct calls for assistance. However, in highly mobile operations, the exact situation was seldom known even at corps headquarters in time for a naval bombardment to be arranged. Under such circumstances it was found necessary for the naval liaison officer to be at division headquarters. But even more satisfactory results were obtained when this officer was with the forward brigade commander.

A forward army artillery observer works with a naval assistant to observe the naval firing. This forward artillery observer (termed FOO—forward observation officer—by the British) is usually a field artillery captain trained in the observation of the fire of bombardment ships. He calls for fire on his own initiative or on order from his unit commander. He observes the ship's fire, and when the bombarding ship is at anchor and the ground is difficult, he himself may control the fire instead of only observing it. Similarly an artillery officer is embarked in every bombarding ship. This officer's primary duty is to interpret calls for fire received from the forward artillery observer and to place at the disposal of the ships' officers his understanding of the military situation, his knowledge of procedure, and his training. Targets were on some occasions indicated to the ships by army artillery using smoke shells. An army liaison officer on board the ship provides a picture of the operation in progress to the naval commander.

When ships come close to shore, as they must for the purpose of bombarding land installations, an air attack on the ships can be expected from an alert enemy. This makes any naval bombardment a hazardous operation.

To reduce the vulnerability of the ships to these dangerous air attacks, bombardments have in most cases occurred at night. Although strong fighter protection or complete local air superiority can make enemy airplanes less dangerous, a naval bombardment still remains a risky enterprise because of the havoc that can be wrought on the warships by enemy submarines, torpedo boats, and coastal batteries.

The main value of naval bombardments has been the demoralization caused in the enemy ranks. Bombardment with 15-inch naval shells has a paralyzing moral effect on the enemy. U. S. observers have reported after conversations with Italian prisoners that the explosions of the big projectiles has a tremendous psychological effect on those being shelled. Used in conjunction with army artillery, the results can be devastating to the enemy's esprit de corps and heartening to friendly forces.

17. ANTITANK OPERATIONS

a. Organization

Since the number of guns in use in Cyrenaica has been inadequate, all available are used or emplaced before the close of each operation. The antitank weapons, which are considered artillery by the British, are under the command of the division artillery commander in the British forces, and he is responsible for so placing his artillery and antitank guns that they will be mutually supporting. For any action the artillery commander issues the necessary orders allotting the antitank weapons to both artillery and infantry units.

Antitank artillery regiments of 2-pounders consist of 3 battalions of 2 batteries of 8 guns each, totaling 48 guns.

They are organized exactly in the same manner as the artillery units except for the number of personnel assigned. A few 6-pounder [13] and 18-pounder [14] batteries are being used. The 6-pounder guns are mounted portee, and the 18-pounders are truck-drawn. These units are also organized in the same fashion as the artillery batteries. The trucks used for the 2-pounders and 6-pounders portee are in general of the 1½-ton type.

The minimum amount of antitank guns required with units necessarily depends on the type of country; the more open the country, the larger the number of guns needed. In the desert where there are no natural tank obstacles an attack may come from any direction. Headquarters and rear echelons must be protected. The large frontages covered and the wide dispersion necessary to minimize the effects of air attack make this problem of protecting rear elements a difficult one.

In the western desert there have been in use no antitank warning systems, but the British make use of armored car patrols to prevent any surprises, and, as a rule, when one weapon fires, all prepare for action. OP's to the front and flank warn by visual signals of the approach of enemy armor.

b. Positions

In some cases one battery of twelve 2-pounder antitank guns is detailed to protect each infantry regiment. Each attached supporting battery of artillery is often given one troop of four antitank 2-pounder guns. Organic artillery has the support of one antitank troop per artillery battery.

[13] The 6-pounder is a new 57-mm. gun which is scheduled to replace the 2-pounder because of the latter's inadequate range.

[14] The 18-pounder is an old type gun.

These 2-pounder antitank units are not usually grouped or held in reserve at any point but are actually placed in positions from 100 to 300 yards from the unit protected.

British artillery regiments are armed with 25-pounders which, although not so designed, have formed the basis of the antitank defense. This has been necessary, because the 2-pounder antitank gun has not proved effective. The 25-pounders are sited to give protection in depth, and, where the terrain permits, to give all-around protection to the position.

Antitank guns are placed to cover the 25-pounders in front, in intervals, and on the flanks. A proportion of them may have to be kept on wheels to counter a threat from an unexpected direction. The fewer the total number of antitank guns, the larger will be the proportion kept in mobile reserve. But positions which guns may have to occupy will in most cases be reconnoitered and prepared beforehand.

Despite the fact that the British have usually operated with one and sometimes two 48-gun antitank regiments to the division, they have still found the number to be too small, and consequently have had their choice of positions affected by the necessity of choosing terrain which could allow them the maximum use of their inadequate number of antitank guns. Unless otherwise dictated by the terrain, it is considered better to place the few antitank guns in comparatively small localities for all-around defense rather than to attempt a complete defense in depth over a wide area. The batteries of 25-pounders are used to provide depth to the defense. Antitank weapons are often placed from 100 to 300 yards on the flank of a battalion in action. For all-around

defense of an organization, they are placed from 500 to 1,000 yards in front or on the flank of a battalion with instructions to move close to the battalion position when tanks approach within 1,000 yards of their positions.

c. Principles of Employment—German Tank Tactics

Since the antitank gunners have a formidable and important job to perform, knowledge of the enemy's capabilities makes it easier to accomplish. German tank crews are trained to try to gain the opportunity to register hits at 90° impact (i. e., get the target head-on or broadside). They attempt to put their own tank in such a position that it presents both front and side at an angle to opposing guns. Stationary firing is preferred, although they have fired on the move to force opposing tanks to close down, or to intimidate outposts and hostile gun crews. Artillery and antitank weapon crews have suffered many casualties from German machine-gun fire delivered from moving tanks. When antitank guns have held their fire until German tanks approached to within 600 yards, the crews have frequently been knocked out by machine-gun fire which penetrated their shields. If the ground permits, the German tanks move rapidly by bounds, firing between bounds when halted in hull-down positions.

d. Principles of Employment—British Tactics

All British antitank guns except 18-pounders (75-mm guns) are mounted portee on vehicles and equipped with

ramps for unloading. These weapons have on occasion been fired from their vehicles.[15]

(1) *Guns mounted on vehicles.*—In using these weapons mounted portee, the gun is usually dismounted during firing, and the vehicles are removed under cover. The firing of guns mounted portee is unpopular, but when it is done, the vehicle is backed up to a point just below the reverse slope of a hill and the gun pushed up sufficiently to clear the crest. The driver of the truck must manipulate his truck on orders from the gunner in order to point the gun or place it in proper firing position.

Although firing guns mounted portee is frowned upon, reports indicate that some officers consider firing from portees to be necessary under the following conditions: (1) when on patrol with armored cars; (2) when on escort or convoy duty with supply echelons, headquarters, or brigade columns advancing across the desert to the attack. In such circumstances the object is to keep the enemy as far as possible from his prey and so enable the convoy to proceed without loss. Full use is made of the mobility of the portees, the opening range varying according to the thickness of the armor carried by the enemy raiding columns. Firing while the portee is in motion and opening fire on a moving target at over 1,500 yards or a standing target at over 2,000 yards are considered a waste of 2-pounder ammunition. Bren guns mounted on the portees are used to force the enemy to close down his hatches and so reduce his visibility.

[15] One observer reported that not a single case was known of dismounting an antitank gun during the period November 17 to 30, 1941, which was the intensive opening phase of the British 2d offensive. Firing portee has become increasing unpopular, however, and is no longer recommended.

Although the use of the antitank guns on portees is an improvisation, it has had some success. During the Italian retreat from Bengasi to Tripoli on February 6/7, 1941 the British sent three columns a distance of 150 miles in 30 hours to cut off the retreat. In the battle which resulted the antitank guns on improvised mounts

Figure 21.—British 2-pounder antitank gun photographed in April, 1940, during exercises in the Libyan theater. (The picture shows the gun on its special desert carrier.)

encountered the Italian tanks, and 100 out of a total of 130 brand new M 13 Italian tanks were destroyed. One 1½-ton truck carrying an antitank gun pointed to the rear went up and down the Italian column and claimed to have destroyed 25 tanks.

(2) *Direct laying at short range.*—Usually 2-pounder antitank batteries are directed not to use direct laying on tanks until the tanks are within 800 yards of their posi-

tions. For 25-pounders, direct fire is held until the enemy vehicles are within 1,000 yards. Opening fire at 600 yards has been found to be too short, because the enemy machine guns are then within effective range. At 800 yards the antitank gun is still comparatively as accurate as at 600

Figure 22.—British 2-pounder antitank gun being camouflaged in its gun pit. (The portee may be seen in the background.)

yards, whereas the machine gun has lost considerable accuracy and is likely to penetrate the gun shields. In one case near Sidi Omar in Libya, a battalion commander of 25-pounder guns, seeing a tank attack coming issued instructions for withholding fire until he gave the order. When the Axis tanks had approached to within 800 yards,

commands for direct laying were given. The result was a bag of 10 tanks.

(3) *Guns placed well forward.*—All artillery and antitank weapons are placed well forward in either defensive or offensive situations. This permits the guns not only to support the infantry but to break up the leading wave of German medium (Mark III) tanks. In battle, 18-pounders go into action on the flanks of the battle position and well forward. These 18-pounder antitank guns are truck-drawn and are of course kept mobile during an advance. All are fully manned and placed in position ready to fire when a halt is made.

The antitank guns are employed more often in pairs or bunches than as battalions or batteries. They are scattered about—often in pairs, and staggered, an effort being made to prevent a single strong sortie of enemy tanks knocking out all the guns. Positions taken are usually those which command a field of fire covering known danger areas. Wadis, large and small, are usually avenues of approach for hostile troops and are therefore given particular attention when siting guns.

(4) *Emplacements.*—Certain antitank guns have a very strong muzzle blast. In the desert terrain of the Middle East the force of this blast throws up a cloud of dust and sand that quickly reveals the position to enemy observers and often completely obscures the field of fire. Consequently, it is necessary to provide such guns with a blast screen. To eliminate this difficulty, the device shown in figure 21 has been used. It consists simply of a net of fine wire mesh, supported on pegs extending about 1 inch above the surface of the ground. The wire mesh should be so painted as to blend into the surrounding terrain.

Other provisions for eliminating the dust include covering the critical areas with concrete or cement, paving the areas with stone, or treating them with oil. These areas are camouflaged whenever the guns are not firing. Precautions are also taken to make the inside of the emplace-

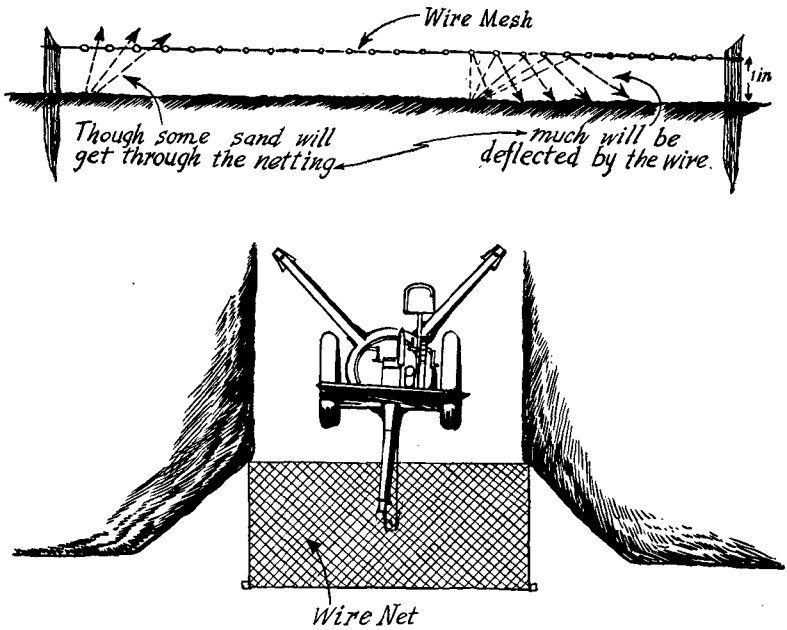

Figure 23.—Antitank gun emplacement

ments as dustproof as possible in order to prevent dust from being sucked up in the rush of air following the discharge.

Alternate positions are provided and all emplacements are constructed to permit easy removal of the guns. These provisions have been found indispensable, for the fire of the weapon will inevitably betray even a well constructed position.

When the terrain permits, the gun is defiladed from the enemy by emplacement on a reverse slope, or, if the country is flat, behind a natural or artificial mound. If an artificial mound is constructed, it should be as low as possible. The arc of fire is usually large; 180° is normal. The guns are given overhead camouflage where possible, but the coverings are constructed so that they can be easily removed when there is need to close station rapidly. Basically it is considered that the emplacement should be an open pit of minimum dimensions.

e. The Main Role: To Form a Secure Base

Every force, of whatever size, requires a secure base from which to attack if its intentions are offensive, or within which to maneuver for a counterstroke if its intentions are defensive. This problem is important in the desert where attacks can come from any direction.

On a large scale this secure base is called a "defensive position" by the British; on a small scale they termed it a "pivot of maneuver." The terms are really similar, the only difference being that the "defensive position" is made up of a number of "pivots of maneuvers."

The framework of the pivot of maneuver consists of the antitank gun positions, and the formation of this framework is the chief role of the artillery whether in attack or in defense. Every gun, field or antitank, is included in the framework. The framework also is strengthened temporarily by the inclusion of tanks in hull-down positions particularly in the case of a pivot of maneuver formed by an armored brigade. The field artillery performs a secondary role as well—that of producing bombarding or harassing or covering fire. The more exposed

sites are allotted to the antitank guns. Every gun section has nearby infantry protection, the two forming together a definite defense area. The escort is armed with machine guns whenever possible.

(1) *The Framework.*—The actual form of framework, of course, varies with the ground. The main position is formed around the field artillery. Regiments are placed with their batteries in depth so that attacks from any direction will meet with an equal reception. A diamond formation often is considered the best solution. The positions of the guns are laid out so that the zones of fire interlock and at the same time so that the whole gun area can be covered with fire. Dead ground within the position is covered by antitank guns, normally drawn from those included in the composition of the field artillery regiments.

An outpost position in front of the main position toward the enemy is often required to prevent observation of the main positions. These outposts are formed of antitank guns, normally drawn from the infantry antitank companies, with the close escort of infantry, as mentioned above. The outpost dispositions are in depth, the front edge being placed on or just over the crest in front of the main position; and the antitank dispositions are coordinated with those of the main positions so that the whole area forms one complete net. The field artillery may be unable to carry out its secondary role (covering fire) if this outpost position is not provided.

A reserve of mobile antitank guns is held within the position. From this reserve, guns can be sent to give close support to batteries attacking from the "pivot," to extend the flanks of the outpost position if an enemy threat

develops from an unexpected direction, or to strengthen the outpost line or the main position if the force is thrown temporarily on the defensive.

(2) *In the attack.*—The British consider that there are only two legitimate tasks for antitank guns in the attack; (a) to form the framework after a successful attack, and (b) to protect the flanks of attacking infantry tanks.

The antitank gun mounted on its portee is not a tank, and any attempt to use it as such by requiring it to accompany the leading waves of a tank or infantry attack inevitably results in severe losses. Every effort is made to place antitank guns in position at the objective as soon as it is captured.

The commander of the antitank guns detailed for consolidating the objective when captured is therefore given a free hand to move his guns as he thinks fit. Often it proves best to move the guns in bounds as the attack progresses. The antitank commander himself accompanies the commander of the unit that he is supporting, and on arrival at the objective makes a plan of the framework of the consolidation defense. If an enemy tank counterattack is launched before the consolidation framework is made, the antitank commander places his guns on or near the objective as soon as possible, and then uses them from the portees, taking advantage of any cover that can be found. Speed is essential, and it is for that reason only that he uses his guns as if they were tanks. If the consolidation framework has time to get into position, its object is to destroy counterattacking tanks. In this case, therefore, the antitank guns are used on the ground, concealed to the utmost, and dug in as thoroughly as time will permit. They are taught not to reveal their positions

prematurely by opening fire at long range. Their fire is held until the enemy tanks are within the range [16] at which their armor will be pierced by the 2-pounder. Nearby infantry protection is provided with the guns, and snipers are placed to pick off enemy forward artillery observers who push in close with the object of spotting the antitank guns.

In protecting the flanks of attacking tanks or infantry, the object of the antitank artillery is to keep the enemy at a distance. Then the gun is used from its portee and opens fire at longer ranges. But since it is seldom possible to forecast the direction of an enemy attack, the guns are not normally committed to any positions at the outset. The antitank commander therefore keeps his guns mobile, and, together with representatives of his sub-units, carries out continuous reconnaissance of the area for which he is responsible, noting especially any ground in which hull-down positions are available. If an enemy flank attack develops, he moves his guns to meet it, either dropping into position on the ground to lie in wait when the enemy has to pass a defile, or fighting portee and using his mobility to prevent the enemy from closing the range.

(3) *In the defense.*—In the defense, the antitank gun has one object—to kill tanks. The enemy will, of course, do all that he can to spot and knock out the guns of a defense before he launches his tanks. Every effort is made, therefore, to prevent the positions from being disclosed until the enemy tanks advance to the attack and are within range of the antitank guns. The range must be short enough to enable the shell to pierce the armor.

[16] 800 yards against Mark III, 500 yards against Mark IV.

Harassing and bombardment tasks are carried out by the 25-pounder guns that are situated in covered positions.

The efforts to avoid observation are directed toward concealment and protection. Scrub ground, or other rough ground, is chosen wherever possible, and digging is done with great care. Movement of all personnel is rigidly controlled.

Guns are placed so as to give effect to the principle of concentration of fire. This is necessary, as the German tanks usually attack in a mass, which cannot be engaged effectively by single guns.

Guns are, therefore, normally sited by troops. The four guns of the 2-pounder troop are spread over an area of about 400 yards square, and they must, of course, be mutually supporting. The four guns of the 25-pounder troops also adopt this formation if employed in a purely antitank role; but if the troop has a secondary role (covering fire) as well, it adopts a more concentrated formation in order to obtain fire control. For this purpose an arrangement roughly the shape of a half-moon, with intervals of about 70 yards between guns, has been found satisfactory. Depth within the field artillery regiment is obtained by siting the troops in diamond formation, 800 yards between troops, all troops being mutually supporting.

f. Effect of Artillery on Tanks

The following is the German teaching on the effect of field artillery on the tanks which they have encountered in the desert:

Armor of 60-mm or less is penetrated at ranges up to 600 meters by the 105-mm gun-howitzer 18 with angle of impact from normal

to 30° using charge 5 or 6. The 105-mm gun, model 18, penetrates all thicknesses of armor encountered at ranges up to 1,500 meters with medium charge and armor-piercing shell. Direct hits from the 150-mm howitzer, model 18, with HE percussion fuze (instantaneous) projectiles have set enemy tanks on fire, or put them out of action by destruction of the drive mechanism. Thus, when engaging tanks with the heavy field howitzer, the bursts should not be largely *over* as when firing armor-piercing shells, but should be evenly distributed, some *over*, some *short*. Concentrations of artillery fire have been very effective against tank assembly points.

18. SMOKE

Smoke, although not used extensively, has been employed occasionally in Libyan operations, and in these smoke operations the artillery has been one method of releasing smoke.

Conditions naturally vary, but observers report that smoke can often be used effectively. Some difficulties with the use of smoke are caused by desert winds, which are sometimes quite variable. Different sizes of whirlwinds which veer and change direction constantly make it difficult to estimate the wind when laying a smoke screen. Smoke has, however, many possibilities in connection with operations by armored formations.

a. Characteristics

Three main factors affect the use of smoke in the desert as elsewhere:

(1) The force and direction of the wind.

(2) Turbulence (which is the gustiness of the wind) and the effect of the bright sun on air currents.

(3) Humidity.

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These factors do not remain constant, the force and direction of the wind being particularly liable to sudden change. Moreover, air eddies caused by the configuration of the ground may make the force and direction of the wind different at the spot where shells land and at the gun position. It is therefore impossible to specify particular weather conditions in which smoke will be effective. A decision on this point is reached usually by a method of trial and error, for which time must be allowed.

In desert areas high-explosive shell produces a substantial cloud of dust, and it may therefore often be practical to mix HE with smoke and so produce a satisfactory screen when conditions are not entirely suitable for the use of smoke alone. This fact also makes it possible to economize in the use of smoke shell and bombs, only limited quantities of which are usually carried.

b. Tactical Employment

All antitank guns depend on direct observation to obtain fire effect. If they can be deprived of their observation, their fire is automatically neutralized. In this fact lies the greatest value of smoke, particularly to armored divisions.

In attacks smoke has been used for the following purposes:

(1) To conceal local preparatory moves by supporting weapons such as antitank guns, machine guns, and mortars.

(2) To screen a forward movement preparatory to assault.

(3) To screen tanks from the observation of antitank

guns and artillery observation posts on the flanks of the attack.

(4) To provide a smoke barrage on the front of the attack.

(5) To indicate the objectives to tanks.

Smoke screens required during the preparatory stages of the attack and during the advance to the objective are usually provided by the artillery. Assistance is sometimes given by infantry mortars when other tasks and the range permit. For a smoke barrage on the front of the attack, a crossing wind is necessary, and particular attention is paid to timing to insure that the attacking tanks are not placed in the dilemma of having either to wait for the barrage to lift, or to pass through it with the risk of being silhouetted against it on the far side.

In any attack some guns are either not located or not destroyed. In such situations some advantage has been obtained by smoke clouds laid down over the whole area,[17] for the lack of visibility usually hampers the guns more than the tanks. This smoke is not used to form a screen, for it is considered more effective to form a pall of smoke over the enemy defensive area.

In defense situations smoke is used to blind attacking enemy tanks. When used for this purpose, a smoke screen is put down beyond the effective antitank range. Otherwise it will merely assist the enemy by depriving the antitank guns of essential observation. The provision of a smoke screen of this kind usually is a task for the artillery.

[17] Neutralization by high explosive is used, of course, when the approximate positions of these guns are known.

German tanks in a hull-down position at over 2,000 yards' range are not only difficult targets, but also beyond the effective range of antitank guns. Much of the Axis fire is by direct laying. In many cases, therefore, the best method of dealing with Axis fire has been by a smoke screen. Care is then taken that this smoke screen is well clear of the British front lines, for if it is too close, it will merely serve as cover for the German advance.

While the smoke is in place, Axis unarmored troops are attacked by fire. Observation posts well out to a flank are found to be necessary, and every opportunity is taken to disorganize and cause casualties to the enemy while he is assembling for the attack.

Another use of smoke in the defense has been the blinding of the enemy's close-support tanks and other supporting weapons by interposing a smoke screen between them and the enemy assault tanks. This task may be within the power of both the defenders' close-support tanks and artillery. When smoke was used for this purpose care was taken to avoid assisting the enemy by providing him with cover behind which he could move forward infantry detachments in support of his assaulting tanks.

For covering a disengagment or a withdrawal, all types of smoke-producing weapons are used, smoke screens at the longer ranges being put down by the artillery, medium range screens by close-support tanks, and short range screens by the use of special dischargers and 2-inch bomb throwers. Tanks capable of producing tail smoke have also been used effectively for this purpose by both the Germans and the British.

19. SUPPLY METHODS

The outstanding characteristic of supply in the desert is the vulnerability of supply lines caused in large part by the fluidity of operations. The British have relied on supply dumps to a greater extent than the Germans, who use supply trains. The artillery plays an important role in the defense of both dumps and columns.

Supply trains are close up to maintain the momentum of the attack by supplying fuel and ammunition as required. Recovery crews go into battle with their units.

The Germans usually advance to the line of departure under cover of darkness in the early morning hours. They may give battle early in the morning, pause about midday for refueling and maintenance, and give battle again before dark. Return to bivouac is made after dark; hence the location of his bivouac area is difficult to discover. Whenever possible, tank attacks are made with the sun low behind the German tanks. Movement in the advance is fast—at least 20 miles per hour. The normal distance between halts, if no combat occurs, is about 40 miles. Refueling, replenishing of ammunition, and maintenance are carried out under the protection of artillery, antitank weapons, infantry, and overhead fighter protection. These operations are accomplished in full view of the enemy.

Appendix A

Effective Ranges of German Antitank Weapons (Translation of a Captured Document)

93

Translation of a Captured German Document Showing Performance of Tank Destroyer Guns against the British Tank "Matilda"

Gun	Type of antitank ammunition	Front	Side	Remarks
20-mm tank	Shell			No penetration except for chance hits in observation slots and guns.
	HE Shell			Harassing effect on observation slits and gun mountings in the case of frontal fire.
37-mm antitank	Shell			Harassing effect on gun mountings and bogies from 500 m and nearer, as above.
37-mm tank	HE Shell			
	Shell 40	Up to 150 m	Up to 150 m	
50-mm tank	Shell	Up to 440 m	Up to 450 m	Only on turret and upper armor structure. Penetrationpr oduced, but, owing to the shape of the projectile, little accuracy. At range under 400 meters, exceedingly good penetration and high accuracy. At this range it is superior to the plain shell.
50-mm tank	Shell 40	Up to 700 m	Up to 700 m	
50-mm antitank	Shell	Up to 600 m	Up to 600 m	Only upper armored structure and turret, harassing effect on bogies.
75-mm tank	Shell			
	HE Shell			Harassing effect on bogies, tracks, and gun mounting.

HE shells of all calibers should be used with weapons and ranges that are not intended to produce penetration. They frequently effect damage to the tank and produce a demoralizing effect on the crew.

Notes by Military Intelligence Service:

1. "Matilda" is the British Medium Tank Mark II, which has armor 2.75 inches thick, though its sides are only 1 inch thick. It weighs 28 tons and carries a crew of four. See War Department FM 30–41, "Miliatry Intelligence, Identification of British Armored Vehicles," May 27, 1941, p. 28.
2. 20-mm equals 0.787 inch.
3. 37-mm equals 1.457 inches.
4. 50-mm equals 1.968 inches.
5. 75-mm equals 2.953 inches.
6. 500 m equals 546.83 yards.
7. 150 m equals 164.05 yards.
8. 450 m equals 492.15 yards.
9. 700 m equals 765.53 yards.
10. 600 m equals 656.20 yards.
11. 400 m equals 437.37 yards.
12. The figures given in the columns "Front" and "Side" mean that below the range given approximately 30 to 50 percent of the rounds that hit the mark will penetrate the cabin or produce a harassing effect. The ranges are to be considered as effective ranges for engagement. In the case of those weapons and types of ammunition from which penetration cannot be expected, the column "Remarks" indicates to what extent a certain harassing effect or even disablement can be produced.

Appendix B

German Artillery—Tables of Characteristics

German Artillery—Tables of Characteristics

Name	20-mm Flak 30	20-mm Flak 38	28/20-mm PAK* 41	37-mm PAK	47-mm Czech [1]	50-mm tank mounted gun [2]	50-mm Model 38 [3]
Weapon	AA gun	4-barreled AA	AT gun	AT gun	AT gun		AT gun
Weight (pounds)	141	3,346 [4]	501	970		421.5	2,016 [5]
Length of barrel	51.2"		50" [6]				10' 2"
Traverse	360°	360°		60°	30°		60°
Elevation	−12° to +90°	−10° to +100°		−8° to +25°	−10° to +30°		−13° to +22½°
Max range (yds)	5,230	5,230			1,500 meters		
Muzzle velocity (ft/sec)	2,950 HE 2,625 AP	2,950 HE 2,720 AP	4555+	2,706 2,500	3,000	3,444	3,000 [7]
Trail (type)	Single-axle [8]	Split	See note [30]	Split			
Max range vert (ft)	12,000	12,465					
Rate of fire (rpm)	120	700–800	8/10	15		16	16
Caliber	20		20	37			
Length in calibers	65			50			
Max ordinate (ft)							
Ammunition	AP; HE; incendiary		Special [9]	AP; HE	AP; HE	AP; HE	AP; HE
Wt of projectile (lbs)	11 oz	5.2 oz=AP 4.1 oz=HE	635 grams	1.68	3.75	3.9=AP	4.56=AP 3.9=HE
Wt of propelling charge							
Wt of bursting charge							
Transport			Portee on trailer [10]		Self-propelled		
Penetration at 100 yds	40-mm [11]		76.2-mm [12]				

Penetration at 200 yds	18-mm [13]		60-mm [14]			63-mm [15]	
Penetration at 220 yds			50-mm [11]		60 mm.		79 mm [15]
Penetration at 300 yds							
Penetration at 400 yds							
Penetration at 600 yds				37 mm [16]			71 mm [15]
Penetration at 880 yds				25 mm [17]			
Penetration at 3,850 yds							63 mm [15]
Methods of fire	Trailer removed [18]						

*PAK=Panzerabwehrkanone—tank defense cannon.

See footnotes on page 103.

German Artillery—Tables of Characteristics (*Continued*)

Name	75-mm tank mounted gun [19]	75-mm Flak L/60	75-mm in Mark IV tank	75-mm LMW 18 Inf [20]	75-mm L Inf GL/13	75-mm Geb K 15 Mt
Weapon		AA	Gun	How	How	Gun
Weight (tons)		3. 09			0. 37	0. 62
Length of barrel						
Traverse		360°		12°	50°	7°
Elevation		−5° to +85°		−10° to +72°	−5° to +43°	−9° to +50°
Max range (yds)		17, 800		3, 860	5, 600	7, 250
Muzzle velocity (ft/sec)	1, 600	2, 780	1, 600	715	1, 000	1, 270 [21]
Trail (type)						
Max range vert (ft)		37, 000				
Rate of fire (rpm)		20				
Caliber	75	75	75	75	75	75
Length in calibers		60		12	13	10. 7
Max ordinate (ft)						
Ammunition	AP; HE; Sm		AP; HE; Sm			
Wt of projectile (lbs)	15. 13	14. 3	15. 13	13. 2	14	12
Wt of propelling charge						
Wt of bursting charge						
Transport				Motor, pack, air	Motor, pack, horse	7 loads [22]
Penetration at 100 yds						
Penetration at 200 yds						
Penetration at 220 yds						
Penetration at 300 yds						
Penetration at 400 yds	55 mm [15]		55 mm [15]			
Penetration at 600 yds						
Penetration at 880 yds						
Penetration at 3,850 yds						
Methods of fire						

See footnotes on page 103.

German Artillery—Tables of Characteristics (*Continued*)

Name	75-mm Sturmgeschütz	88-mm dual-purpose [23]	105-mm LFH 18	105-mm K 18 [24]	150-mm S Inf G	150-mm K 18
Weapon		A A / A T gun	Gun	Gun	33 inf how [25]	Gun
Weight (tons)		5	1.9	5.5	1.5	5
Length of barrel						
Traverse	20°	360°	56°	60°	6°	60°
Elevation	−5° to +20°	−3° to +85°	−6½° to +40½°	−3° to +50°	40°	−4° to +45°
Max range (yds)	9,000	16,200	11,640	19,700 [26]	6,000	27,200
Muzzle velocity (ft/sec)	1,600	2,690	1,540	2,650		2,920
Trail (type)						
Max range vert (ft)						
Rate of fire (rpm)		15 to 20				
Caliber	75	88	105	105	105	105
Length in calibers	23.5	56	22.8	40	15	55
Max ordinate (ft)		36,000				
Ammunition	AP; HE; Sm		AP; HE; Sm			
Wt of projectile (lbs)	14	21	32.6	35	80	99
Wt of propelling charge		20				
Wt of bursting charge		1.5				
Transport	Self-propelled [27]		Motor, horse	Tractor drawn	Horse [28] or S P M	Tractor in two loads
Penetration at 100 yds						
Penetration at 200 yds						
Penetration at 220 yds						
Penetration at 300 yds						
Penetration at 400 yds	55 mm	100 mm [11]				
Penetration at 600 yds						
Penetration at 880 yds						
Penetration at 3,850 yds		70 mm				
Methods of fire						

See footnotes on page 103.

German Artillery—Tables of Characteristics (*Continued*)

Name	150-mm SFH 18	210-mm Mörser 18	210-mm	240-mm K	380-mm	7.62-cm (3.00″) Russian field gun
Weapon	How	How	Gun	Gun	Gun	AT
Weight (tons)	4½	12	24			900 (lbs)
Length of barrel						
Traverse	60°	360°	360°	360°		60°
Elevation	−3° to +50°	72°	−4° to +45°			−50° to +75°
Max range (yds)	16,400	18,300	32,600	35,000	46,000	15,260
Muzzle velocity (ft/sec)	1,970	1,815	2,880	2,780		2,316 3,428 [29]
Trail (type)						
Max range vert (ft)						
Rate of fire (rpm)						
Caliber	150	210	210	240		
Length in calibers	22	25–30	50	46		50
Max ordinate (ft)						
Ammunition						
Wt of projectile (lbs)	95.7	264	264	396	1,650	14.33
Wt of propelling charge						
Wt of bursting charge						
Transport	Tractor	Half-track tractor in 2 loads	3 loads	3 heavy vehicles CC		
Penetration at 100 yds						
Penetration at 200 yds						
Penetration at 220 yds						
Penetration at 300 yds						
Penetration at 400 yds						
Penetration at 600 yds						
Penetration at 880 yds						

Penetration at 3,850 yds						
Methods of fire						

[1] Identified as mounted on Mk I tank with special superstructure.
[2] Mounted on Mk III tank.
[3] Uses split trail carriage.
[4] On submounting; 2,798 pounds on static ring with 16 full magazines.
[5] The total weight of the gun mechanism is 698 pounds.
[6] Length of rifling only.
[7] Reported variously as 1,200 m/sec and 2,935–3,280 ft/sec.
[8] Trailer 51. This trailer can be motor-, horse-, or handdrawn. The gun and its mounting may be split into two loads for hauling over difficult terrain.
[9] Arrowhead (special type) ammunition.
[10] This weapon, which is normally towed portee on a trailer equipped with ramps, may also be mounted on a truck, split into a 5-man load, or carried by air.
[11] Homo-hard plate.
[12] Machineable plate.
[13] Armor plate (30 mm=1.18″).
[14] Facehardened plate at 30°.
[15] Homogeneous tank armor at 30°.
[16] N C plate.
[17] N C plate at 30°.
[18] In an emergency it can be fired from trailer.
[19] Mounted on Mk IV tank and as assault gun in a turretless Mk III.
[20] Different types may now be known as "L Inf G 18" or "L Geb 18" depending on whether or not the type is used as an infantry or a mountain gun, respectively.
[21] Using supercharge.
[22] Heaviest load is 150 kilograms.
[23] Includes weight of outriggers.
[24] May be known as 10-cm Kanone 18.
[25] Reported to be used mounted on Mk II tank, which is thought to be more satisfactory than a mounting on Mk I tanks.
[26] Maximum range of 24,000 has been claimed for the equipment.
[27] Mounted on Mk III tank with turret removed.
[28] On Mk I or Mk II tank chassis with superstructure rebuilt.
[29] Reputed.
[30] Trailer 52.

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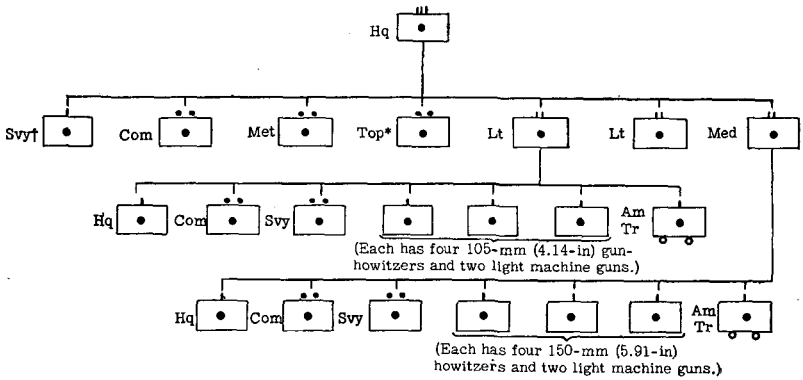
Appendix C

German Artillery—Organizational Charts

GERMAN ARTILLERY REGIMENT



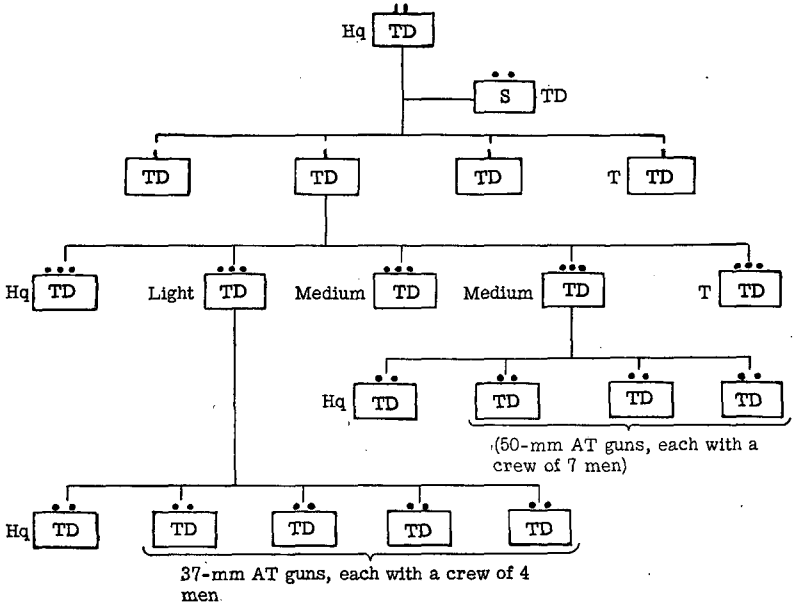
Strength.--79 officers, 1,969 enlisted men

Fire power.--105-mm (4.14-in) gun howitzers . . 24
150-mm (5.91-in) howitzers. 12
Light machine guns. 18

† Attached to artillery regiments of armored, but not of motorized, divisions.

* This is essentially a Map Printing Section.

GERMAN TANK DESTROYER BATTALION



Strength (approx).--21 officers, 578 enlisted men

Fire-power.—37-mm (1.45-in) AT guns 12
50-mm (1.97-in) AT guns 18
Light machine guns 18

Vehicles.—Motorcycles 64
Tractors 44
Other MT vehicles. 68

Appendix D

Italian Artillery—Table of Characteristics

Italian Artillery—Table of Characteristics

Name	Caliber (inches)	Muzzle velocity (foot-seconds)	Max range (yards)	Rate of fire (RPM)		Remarks
				Theoretical	Practical	
37/54-mm AA gun Breda	1. 46	2, 620	7,700 13,500 ft	125	75	6-rd loading tray; twin-barreled model also in use; mobile platform; barrel, 54 cals; fires HE with time fuze and HE tracer with percussion fuze; a very effective gun.
45-mm mortar Brixia (Model 35).	1. 77	272	587		30	Tripod mount; weight in action 34 lbs; 1-lb bomb; standard light mortar.
47/32-mm AT gun	1. 85	2, 050	7,600		12–14	Barrel, 32 cals; 60° traverse; penetrates 1¼-in armor at 90° at 800 yds; also used as infantry support gun.
65/17-mm infantry gun	2. 58	1, 130	7,100			
70-mm infantry gun	2. 76	1, 160	7,100			Weight, 850 lbs.
75-mm infantry gun (1934).	2. 97	1, 180				
75/13-mm mountain howitzer.	2. 97	1, 240	9,000			On wheels or 7-load pack; weight, 1,350 lbs.
75/18-mm gun-howitzer (Models 34 and 35).	2. 97	1, 430	10,200			Model 34: 1,760 lbs; mountain artillery. Model 35: 2,420 lbs; towed or self-propelled

75/27-mm gun-howitzer (Model 06).	2. 97	1, 730	11,200	8	4	Weight in action, 1 ton; elevation −10° to +16°; models 11 and 12 have smaller MV and range, greater elevation and traverse. See par. 7c.
75/34-mm field gun	2. 97	1, 650	13,500			Weight, 2,750 lbs; towed; expected to become standard in mobile division, replacing 75/27.
75/46-mm AA gun (Model 34).	2. 97	2, 350	14,100 27,200 ft			Mobile gun.
75/50-mm AA gun	2. 97	3, 200	17,000 27,500 ft			Tractor-drawn.
76/40-mm AA gun	2. 99	2, 620	9,000 15,750 ft	125	70	Water-cooled jacket; elevation −10° to +90°.
77/28-mm field gun	3. 03	1, 710	7,700			Weight, 2,200 lbs.
81-mm mortar (Model 35).	3. 19	836	4,429 (light bomb) 1,640 (heavy bomb)			Weight, 129 lbs, bomb wt, 7½ lbs; a new improved model has been introduced. A 15-lb bomb is sometimes used.
90/50-mm multipurpose gun.	3. 55	2, 755	19,000 39,400 ft			Weight, 5¾ tons; tractor-drawn.
100/17-mm mountain howitzer (Models 16 and 34).	3. 94	1, 800	10,000	6	4	Carried in 3 loads.
102/35-mm AA gun	4. 02	2, 477	14,425 31,100 ft		10–12	
105/28-mm field gun	4. 14	1, 850	14, 800			
105/32-mm field gun	4. 14		17, 500			
105/40-mm field gun	4. 14		18, 500			Weight, 9,900 lbs.
149/12-mm howitzer	5. 87	985	7, 200			
149/13-mm howitzer (Model 14).	5. 87	1, 130	9, 560			
149/35-mm gun	5. 87	2, 200	19, 100			Weight, 15,400 lbs.
149/40-mm gun	5. 87		24, 000			
152/13-mm howitzer	5. 98	1, 240	10, 400			Weight, 7,920 lbs.
152/45-mm gun	5. 98	2, 730	21, 200			Weight, 36,820 lbs.
210/8-mm mortar	8. 27	1, 130	9, 200			Weight, 17,600 lbs.

Italian Artillery—Table of Characteristics (*Continued*)

Name	Caliber (inches)	Muzzle velocity (foot-seconds)	Max range (yards)	Rate of fire (RPM)		Remarks
				Theoretical	Practical	
210/22-mm howitzer (Model 35).	8. 27	1, 730	17, 500	-------	-------	Weight, 34,320 lbs.
280/16-mm coast defense howitzer.	11. 03	-------	12, 760	-------	-------	
305/17-mm howitzer (Model 17).	12. 0	1, 790	19, 200	-------	-------	
305/50-mm coast defense gun.	12. 0	-------	23, 650	-------	-------	
381/40-mm railway gun	15. 0	2, 500	26, 200	-------	-------	

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