

THIS FILE IS MADE AVAILABLE THROUGH THE DECLASSIFICATION EFFORTS AND RESEARCH OF:

THE BLACK VAULT

THE BLACK VAULT IS THE LARGEST ONLINE FREEDOM OF INFORMATION ACT / GOVERNMENT RECORD CLEARING HOUSE IN THE WORLD. THE RESEARCH EFFORTS HERE ARE RESPONSIBLE FOR THE DECLASSIFICATION OF THOUSANDS OF DOCUMENTS THROUGHOUT THE U.S. GOVERNMENT, AND ALL CAN BE DOWNLOADED BY VISITING:

[HTTP://WWW.BLACKVAULT.COM](http://www.blackvault.com)

YOU ARE ENCOURAGED TO FORWARD THIS DOCUMENT TO YOUR FRIENDS, BUT PLEASE KEEP THIS IDENTIFYING IMAGE AT THE TOP OF THE .PDF SO OTHERS CAN DOWNLOAD MORE!

**German Experiences
in
Desert Warfare
during
World War II**



Volume I

U.S. Marine Corps

**DEPARTMENT OF THE NAVY
Headquarters United States Marine Corps
Washington, D.C. 20380-0001**

1 October 1990

FOREWORD

1. PURPOSE

Fleet Marine Force Reference Publication (FMFRP) 12-96-I, German Experiences in Desert Warfare during World War II, Vol I, provides lessons learned by the Germans during World War II desert operations.

2. SCOPE

The author of this manual, Generalmajor Alfred Toppe, drew on German World War II veterans to record the lessons learned from operations in North Africa.

3. BACKGROUND

a. Desert operations have much in common with operations in the other parts of the world. The unique aspects of desert operations stem primarily from heat and lack of moisture. While these two factors have significant consequences, most of the doctrine, tactics, techniques, and procedures used in operations in other parts of the world apply to desert operations. The challenge of desert operations is to adapt to a new environment.

b. FMFRP 12-96-I was originally published by the Historical Division, European Command in the years immediately following World War II. This document is rich in the details so important for those who must live and fight in the desert.

4. RECOMMENDATIONS

This manual will not be modified. However, comments on the manual are welcomed and will be used in revising other manuals on desert warfare. Submit comments to --

Commanding General
Marine Corps Combat Development Command (WF12)
Quantico, VA 22134-5001

5. CERTIFICATION

Reviewed and approved this date.

BY DIRECTION OF THE COMMANDANT OF THE MARINE CORPS



M. P. CAULFIELD

Major General, U.S. Marine Corps
Deputy Commander for Warfighting
Marine Corps Combat Development Command
Quantico, Virginia

DIST: 14012960100

The Author

Alfred TOPPE

Generalmajor

Date of Birth: 28 June 1904

Place of Birth: Zernin, Northern Germany

Alfred TOPPE joined the Army in 1923, entering the 14th Cavalry Regiment at Ludwigslust. After training in both Infantry and Cavalry Officer Candidate Schools from 1924-26, he received his commission as second lieutenant in December of the latter year and was assigned to the 1st Cavalry Regiment being promoted to first lieutenant in 1929. In 1934 he was detached for a two-year term at the Berlin War Academy, where he was promoted captain (Cavalry) in 1935. From 1936-39 TOPPE served as Quartermaster Training Officer of the XI Infantry Corps and then, after participating in General Staff training courses in 1940, was promoted major and assigned to the Paris headquarters of the Quartermaster General for France as First Assistant to the Chief Supply Officer. In 1942 he was promoted lieutenant colonel and assigned as Chief, Army Supply Department, Army High Command, where he was promoted colonel in 1943.

Following service as Chief of Staff, X Infantry Corps in Northern Russia from early 1944, TOPPE was transferred back to Army High Command as Army Quartermaster General in June of the same year, in which he remained until the war ended, and where he was promoted Generalmajor in October 1944.

CONTENTS

	Page
Critique to the Study "German Experiences in Desert Warfare in World War II" - by Franz Halder.	ix
Preface by Generalmajor Alfred Toppe	xi
List of Contributors	xiii
CHAPTER I Prior Planning.	1
1. Intelligence Planning	1
a. Desert Terrain and Climate	1
b. Scope of the Evaluation	3
c. Influence of Intelligence on Planning	3
d. Availability and Evaluation of Terrain Intelligence	3
e. Use of Historical Data for Planning Purposes	3
2. Operational Planning	4
a. General	4
b. Changes in Troop Organization and Equipment	6
c. Special Training	9
d. Acclimatization of the Troops	10
e. Development of Special Equipment	12
3. Logistical Planning	12
a. February to May 1941	13
b. June to December 1941	13
c. January to June 1942	13
d. July 1942 to May 1943	14
CHAPTER II Operations	16
4. General Description of the Zone of Operations	16
a. Mountain Ranges	17
b. Steep Terraces	18

5.	Order of Battle of Army and Luftwaffe Units . . .	22
6.	Reasons for Changes in Organization and Equipment . . .	28
7.	Descriptions of the More Important Battles . . .	28
Chapter III	Special Factors	56
8.	Dust	56
	a. Effects on Troops, Weapons and Equipment . . .	56
	b. Effect on Combat Operations	57
	c. Effect on Tactical Measures	58
	d. Effect on Aircraft and Their Crews	59
9.	Terrain	61
	a. Influence on Tactical Measures	61
	b. Influence on the Construction of Field Fortifications and the Use of Weapons . . .	64
	c. The Tactical Importance of the Recognition of Vehicle Tracks by Air Observation . . .	66
	d. The Use of Vehicle Tracks for Deception of the Enemy	67
	e. The Use of Wheeled and Track Vehicles . . .	67
	f. Influence of Desert Terrain on the Develop- ment of New Tactical Principles for the Use of Motorized Units.	67
	g. Influence of Rainfall on Mobility in Desert Terrain	70
10.	Water	71
	a. General	71
	b. Requirements for Troops and Vehicles, Economy Measures etc.	71
	c. Water and Motor Fuel Requirements	72
	d. Tactical Importance of the Presence of Water Sources	72
	e. Assignment of Engineer Troops for Water Supply Services	74
	f. Well Drilling Equipment	75
	g. Method of Distribution	75
	h. Pipelines	76

CONTENTS cont.

	Page
11. Heat	76
a. General	76
b. Effect on Unaccustomed Troops	76
c. Effect on Tank Crews	77
d. Measures Taken to Avoid the Noonday Heat	77
e. Special Equipment for Protection Against Temperature Variations	77
f. Types of Shelter	77
g. Comparison Between the Efficiency of Troops in the Tropics and in Temperate Climates	77
h. Effect on Materiel and Equipment	78
i. Effect on Visibility	78
j. Effect on Airplanes in Taking Off and Landing	78
CHAPTER IV Miscellaneous	79
12. Cartographic Service	79
a. General	79
b. Reliability and Methods of Use	79
13. Camouflage	80
14. Evaluation of the Enemy Situation Through Aerial Photographs	81
15. Visibility at Night	81
16. Choice of Camp Sites	82
17. Selection of Battle Sites	82
18. Time of Day Selected for Combat	82
19. Influence of the Desert Climate on Daily Service Routine	83
20. Special Problems of the Technical Services	83
21. Influence of Light, Shade and Sandstorms on Combat	83
22. Influence of Darkness on Radio Communications	84
23. Wind	84
24. Special Equipment and Procedures for Aircraft Crews	84
25. Dry Docks and Port Installations	86
26. Reinforcement of Sand Surfaces for Landings by Amphibious Craft	86

CONTENTS cont.

	Page
27. Changes in Ship Loading and Unloading Procedures	87
28. Materiel Loss and Replacement Estimates for Desert Warfare	87
29. Modifications in Supply Dump Procedures - Especially for POL	87
30. Diseases and Insects in the Desert	87
31. Desert Weather Service	89
CHAPTER V General Remarks and Experiences	90
32. Special Equipment for Desert Warfare	90
33. Research and Development Possibilities for Special Desert Equipment	92
34. Unusual Supply Problems	92
35. Comparison with Desert Warfare in Southern Russia	94
36. Troop Welfare in the Desert	95

Franz Halder
Generaloberst

Koenigstein/Taunus, 18 June 1952

Critique to the Study "German Experiences in Desert

Warfare in World War II" MS # P-129

by Generalmajor Alfred Toppe

In spite of the time limit imposed upon him, the topic leader, with the collaboration of the leading German experts on the African Campaign, has succeeded in answering the assigned questions. The esprit de corps and the justified pride of the African veterans were a decided factor that helped to make the contributions so good and comprehensive, that they could to a large extent be fitted into the attached study. This in no way detracts from the services of the topic leader. It was his initiative and organizational ability that resulted in this excellent study, despite the time restriction.

The German experiences in African desert warfare are made unique by the fact that the command and the troops were faced with a mission in no way either planned or prepared, and they entered it completely without prior prejudices. The experience gained, therefore, is free from outside theories and opinions, and was only achieved by struggling with an entirely new military situation; it thus has the value of originality. The value is, however, diminished by the fact that the experiences are in part negative and could not be developed further in a positive direction due to the lack of time and the limited means at hand.

The particular conditions in Africa under which they were gained will have to be kept in mind in any evaluation. The impossibility of securing a supply line across a body of water dominated by the enemy, the numerical and materiel inadequacy of the German and even more their allies and the increasing lack of Luftwaffe fighting and transport units --these are all negative aspects of the campaign. On the positive side belongs the tempo and performance of field forces, under the able leadership of Rommel, forces which were without doubt far above the average in initiative, spontaneity and soldierly zeal.

/s/ Franz Halder

Preface

Two and a half months was the total time allotted for the preparation of this study.

Prerequisite was that such German officers be induced to contribute who had had as broad as possible a view in the conduct of over-all operations, who possessed practical combat experience and, furthermore, had exact knowledge of as many factors as possible which exerted a determining influence on desert warfare. In addition to the contributors listed below a number of former members of the German Africa Corps also made contributions.

The organization of the study was based on the individual questions assigned. German manuals were not used. The presentation can therefore be evaluated on the basis of actual experiences.

A number of questions could not be answered exhaustively. The reason for this lies in the fact that no experience had been gathered in such areas or else operations took place in areas in which the typical attributes of a real desert were not present. The request attached to the major question "Special Equipment and Procedures for Aircraft Crews" that accounts by "individuals or groups" be added could not be fulfilled, because no authorities on this subject could be contacted in the short time available.

In describing the most important battles the procedure has been as follows: a broad survey has been included in Chapter II, Section 7, and then three battles have been treated in detail in Annexes 8 to 10.

The official documents contained in Field Marshal Rommel's notes have been utilized as a valuable source of information. In addition other map and photographic material of great value was also available, which can be found in Annexes 1 to 4. The material in Annexes 1, 2, and 4 can be considered unique.

List of Contributors

1. Bayerlein, Fritz, Generalleutnant, Chief of Staff of the German Africa Corps, 1941-1942.
2. Deichmann, Paul, General der Flieger, Chief of Staff of the Second Air Force.
3. Hudel, Helmut, Major, Commander 1st Battalion, 7th Armored Regiment in Tunisia.
4. Kesselring, Albert, Generalfeldmarschall, Commander in Chief, South, 1942-1943.
5. Kienow, Dr. Sigismund, Regierungsbaurat (official title in the construction engineering profession), military geologist with the German Africa Corps, 1941-1943.
6. Mueller, Gerhard, Generalmajor, Commander 5th Panzer Regiment, 1942.
7. Westphal, Siegfried, General der Kavallerie.
In North Africa 1941-1943 as
Operations Officer of Panzer Group, later Panzer Army Africa,
Chief of Staff of the German-Italian Panzer Army in Africa,
Commander, 164th Light Africa Division,
Chief of the Operations Branch of the German Commander in Chief South attached to the Comando Supremo,
Chief of Staff of Commander in Chief South.
8. Wagner, Dr. Wilhelm, medical officer with the 21st Panzer Division 1941-1942.
9. Zeissler, Hubert, Major, Commander of an artillery regiment, 1941-1943.

CHAPTER 1

Prior Planning

1. Intelligence Planning.

a. Desert Terrain and Climate. When the first German units were shipped to Africa in February 1941, the officers responsible for the operational planning had no data of any kind on the nature of the terrain and circumstances in the desert. The intelligence data furnished by the Italians was extremely meager and the Italian maps were so inaccurate and so incomplete that they were used only for lack of something better. For this reason the German command had to obtain all necessary information itself through reconnaissance. In the papers found in his estate, Field Marshall Rommel wrote:

It has probably never happened before in modern warfare that an operation of this type was undertaken with so little preparation. On 11 February, I reported to General Garibaldi, the commander in chief of the Italian forces and informed him of my mission. Initially, he showed no enthusiasm for my plan to organize defense positions in the region of the Bay of Sirte as a first measure. Using the poor and inaccurate Italian map material, I then proceeded to explain to General Garibaldi my ideas as to approximately how the war in Tripolitania should be conducted. Garibaldi, who was unable to give me any precise information about the terrain that would be involved, advised me to reconnoiter the terrain between Tripoli and the Bay of Sirte personally, and said that I could not possibly have any idea of the enormous difficulties this theater of war presented. Around midday I took off aboard a Type He 111 plane to reconnoiter the combat area. We saw the field-type fortifications and the deep antitank ditch east of Tripoli and then flew over a wide belt of dunes which presented a good natural barrier before the fortifications of Tripoli and would prove difficult to cross with wheeled or track vehicles. Then we flew across the mountainous country between Taruna and Homs, which appeared hardly suitable for operations by armored units in contrast to the patches of level terrain between Homs and Misurate.

Like a black band the Via Balbia road could be seen extending through the desolate country, in which no tree or shrub was visible as far as the eye could reach. We passed over Buerat, a small desert fort on the coast with barracks and a landing stage, and finally circled above the white houses of Sirte. Southeast and south of this

locality we saw Italian troops in their positions. With the exception of the salty swamps between Buerat and Sirte, which extended only a few kilometers southward, we found no features in any sector that would favor a defense, such as, for instance, a deep valley. This reconnaissance flight supported me in my plan to fortify Sirte and the terrain on either side of the coastal road and to concentrate the mobile units for mobile operations within the area of the defense sector in order to counterattack as soon as the enemy started an enveloping attack.

From the above it will be seen that Rommel himself had to gather the information on the terrain and on the peculiarities of the desert, which he required for the conduct of operations.

It was only at a later stage that the so-called "military-geographical description" was made available, which gave a general survey of the terrain but was based mainly on information gleaned from literary works, and contained none of the detail information required by the troops, so that they were of only small military value.

The military geological unit attached to the German Africa Corps commenced a systematic assembly of data and methodical reconnoitering immediately after arrival. The English maps captured by the German troops proved an excellent help. The results of the methodical reconnaissance were consolidated in what might be called a "traversability map" and in reports and made available to the command. Maps K 1-10 in Appendix 1 are specimens of the maps referred to. They contained the following details:

Terrain that could be traversed by any type of vehicle
in all parts and in all directions,
Terrain outside the Pistes* which was moderately or
poorly suited for vehicular traffic,
Terrain with many steep cliffs,
Salty swamps and depressions which were impassable
after rain,
Sanddunes, which were difficult for vehicular traffic,
Information on plant growth,
Broken terrain,
Impassable cliffs,
Cliffs that were less steep and that could be traversed
in numerous places,
Passes over the cliffs, with information as to whether
they could be used by wheeled or only by tracklaying
vehicles,

Trails, with information as to their usability for wheeled
or tracklaying vehicles.

* Tracks

The military geological unit compiling these maps consisted of two geologists and ten auxiliaries. However, they were inadequately equipped, so that it was only possible to reconnoiter the areas that happened to be tactically important at any given time. Occasional inaccuracies and deviations in the lines marking the limits of the traversable terrain on the maps were unavoidable.

Here, a word might be said about the work of the British Long Range Desert Group which, apart from its intelligence and sabotage missions, carried out reconnaissance far behind the Italo-German fronts in Lybia. The results obtained in this reconnaissance work formed the basis for the British maps on the Italian colony of Lybia which were incomparably better, so far as quality, accuracy and detail were concerned, than the Italian maps. They were considered a particularly valuable prize when captured.

b. Scope of the Evaluation. The above serves to show that in deserts the command must employ adequate personnel with adequate equipment, organized in specialized units if it wishes to obtain usable maps within a brief space of time.

After the winter of 1941, the Traversability Maps served as permanent data for the German command. The preparations for attack and for defense positions were based on them.

c. Influence of Intelligence on Planning. The available intelligence information was so inadequate in the spring of 1941 that it influenced the employment of the German forces in no way. As previously stated, Field Marshal Rommel had to gather the necessary information on the terrain and on the characteristics of the desert. On the basis of this information he performed his mission of halting the British advance and preventing the loss of the whole of Lybia.

d. Availability and Evaluation of Terrain Intelligence. The pamphlets MILITARY GEOGRAPHICAL DESCRIPTIONS for Lybia, Northeast Africa and Egypt were published by the Military-Geographical Branch of the Army High Command. Since they contained only information on cities, roads and oases, and a general survey of the entire region, they could serve the command only as a source of general orientation, for which purpose they proved valuable. They contained very few important tactical details. They were put out in such large numbers that they could be made available down to regimental staff level. At these lower levels their value was naturally restricted.

e. Use of Historical Data for Planning Purposes. With the exception of the experience gained by General Graziani's army during its advance on Egypt in the winter of 1940 no information taken from military history was used in planning the campaign. One lesson that this experience pointed out was that troops which are not motorized are valueless in desert warfare and can do nothing whatever against

a motorized enemy. General Graziani's army consisted almost exclusively of infantry units and it was tied down, enveloped and destroyed by the well motorized British forces because it was unable to conduct mobile operations.

The African Campaign took on such entirely new forms owing to the almost exclusive use of mobile troops by both sides in the desert, that it was not possible in planning to make use of any examples taken from military history. The methods of modern desert warfare were created by Field Marshal Rommel.

2. Operational Planning

a. General. Prior to World War II not a soul in the German armed forces imagined the possibility of it becoming necessary in any future war to conduct land warfare outside of Europe. This is why no particular attention was paid in the army to the military experience of this type gained during World War I, particularly in the former German colony, German East Africa. It was only in 1935 that a sub-section for colonial affairs was created in the Foreign Affairs Branch of the Reich Ministry of War. This sub-section was staffed with only one officer who had fought in German Southwest Africa.

Prior to the outbreak of war in 1939, no preparations of any sort had been made in the German army for any desert warfare that might possibly become necessary in the future. All preparatory work in the operational, organizational and training fields had been restricted exclusively to preparations for the conduct of war on the continent of Europe. This was why a suggestion submitted by the Mapping and Survey Branch of the Army General Staff in 1938 that the maps to be issued in the eventuality of mobilization should include maps of Denmark, Norway and Northern Africa was disapproved as entirely unnecessary by the appropriate representative of the Operational Branch under instructions from the chief of that branch.

It is an actual fact that early in 1941 the German troops reached the African theater of operations almost entirely unprepared for their new missions.

Up to the summer of 1940, the information available to the German Army General Staff on Northern Africa was restricted to the reports furnished by the German military attaché in Rome and reports from agents of the German counterintelligence service. From the autumn of 1940 on, the Special Detachment Dora, a detachment of the German counterintelligence branch, was in Libya. Its main mission was to keep the French territories in Africa under observation. Most of the data on which the German military attaché in Rome based his reports came from his liaison officer attached to the Governor General, who was

simultaneously Commander in Chief of all Forces in Italian North Africa, and on personal impressions gained while traveling. All positive information of a military nature on North Africa was taken from the manuals of the Foreign Armies Intelligence Branch (West) on the British, French and Italian armed forces.

Originally, Hitler had decided to leave Mussolini an entirely free hand in conducting operation in the Mediterranean theater, which was another reason for the small interest of the German General Staff in this subject. A change in this fundamental view of Hitler only took place in the summer of 1940, when it became evident, on the one hand, that Italy was apparently avoiding any decisive action in the Mediterranean theater while the British, on the other hand, were continually reinforcing their troops in Egypt, without their transportation being appreciably affected by the Italian navy. At the meeting between Hitler and Mussolini in October 1940, the dispatch of a German panzer corps to Libya was discussed, but no decision was reached. Following the discussion, a general of the armored force who was attached to the German Army High Command, was sent to Italian North Africa for an on-the-spot study of the possibilities of employing a German expeditionary corps there. Shortly after Italy rejected the support offered by Germany, quite obviously Mussolini did not want any German military support in North Africa. The 3rd Panzer Division, which in peacetime was garrisoned in the Berlin area, had been reorganized in all haste for employment in the tropics as a precautionary measure; it was now available for other employment. Later, when the British offensive, which gained huge initial successes, threatened to develop into a catastrophe for the Italian forces, Italy herself requested the dispatch of German forces to Libya.

The first unit to be transferred was the X Air Corps, which was sent to Sicily. So far as ground forces were concerned, the original plan was to send only a defense unit of brigade strength, which was to be specially organized for the purpose, but it soon became evident that such a weak unit would not be able to give Germany's ally any really effective support. In January 1941, Hitler therefore decided to make a special corps of two divisions available, the German Africa Corps.

Meanwhile a special staff for tropical warfare (Sonderstab Tropen) had been formed at the headquarters of the Commander of the Replacement Training Army in Berlin. It was composed of officers who had fought in the German colonies in World War I and was to assemble as speedily as possible all experience that could be helpful in the training, organization, equipment and employment of troops in desert warfare. However, the march of events was too fast, so that the first units of the German Africa Corps landed in Africa when the staff had just commenced its work in Libya.

What has been said above goes to show that the German Army High Command was taken almost completely by surprise when the necessity arose to dispatch troops for warfare in the desert. In any event,

the command had no time to make thorough preparations for this type of combat employment. For this reason all preparatory work that was possible in the short space of time available had to be restricted mainly to the following measures:

- (1) Medical examination of all troops to determine their fitness for service in the tropics, with the application of very severe standards.
- (2) Equipment of all soldiers with tropical clothing.
- (3) Adaptation of a training program for combat in open terrain.
- (4) Camouflage of all vehicles with a coat of desert-colored paint.
- (5) Organization of special units to handle water supply problems.
- (6) Familiarization of the troops with the hygienic measures necessary in tropical climates.
- (7) Orientation of the troops on the military-geographical conditions of the new theater of war and on the peculiarities of Germany's allies and enemies. In this respect it must be mentioned that initially only one military-geographical bulletin was available. It had been prepared in a hurry and was not accurate in all points. A manual of instructions for the tropics was being drafted in the summer of 1942.

It was not possible within Germany to accustom the troops to the intense heat to which they would be exposed, particularly at that time of the year, the winter of 1940. To a certain extent, the troops which had to wait any length of time in Italy for transportation to North Africa adapted themselves automatically to the heat.

b. Changes in Troop Organization and Equipment. The composition of the units employed in Africa was the same as the composition of units in Europe. The pressure of time alone made any reorganization impossible in 1941, and later experience showed that no specialized organization is necessary for divisions and other units that are to be employed in desert warfare. However, it is necessary to have a far higher ratio of tanks and antitank weapons, since these are the two decisive weapons in the desert. It goes without saying that all units employed in desert warfare must be motorized.

The following special units were newly activated for employment in the desert:

- (1) Water supply companies, under the command of engineer officers. They were assigned to the corps and operated under the Water

Supply Branch of the Corps Supply and Administration Officer. These companies had equipment for the drilling of deep wells as well as pumps, while some of them had installations for the distillation of water.

(2) Water supply transportation columns organized in the same way as ordinary supply transportation columns but employed solely in the transportation of water to the troops. They had no tank trucks or tank trailers as was customary with the British units but had to transport the water in 20-liter cans. This method of transportation proved extremely tiresome, quite apart from the considerable loading space required, which imposed an extra strain on the gas supply services.

(3) Astronomical observation teams, directed by professional astronomers who were awarded regular or assimilated officer rank. These teams worked under the special staff officer for surveying attached to the operations officer of the army and their function was to establish geographical points by astronomical means. They were rarely employed, since no serious orientation difficulties arose because most of the fighting took place in the coastal region and not in the desert proper.

The following changes proved necessary so far as equipment was concerned:

Long range artillery, long range antitank guns and tank guns decisively influence the course of battle in desert warfare, and it was therefore necessary to employ more long range weapons. No alterations of the weapons themselves were necessary.

In their 87.6-mm guns the British had a light artillery piece with a longer range than that of the German, but the German forces in Africa soon received 100 and 170-mm guns, which had a longer range than any of the British guns. In 1941 the guns of the German Type III tanks had a longer range than the guns of the British tanks, and this is the reason for the success of the German tanks in that year, but from May 1942 on the British employed American tanks of the Grant, Lee and Sherman types, which mounted guns with a considerably superior range of fire. In the Battle of Gazala these guns came as a disconcerting surprise for the German tank units and in the first phase of the battle the British were able to gain considerable successes.

Clothing and uniforms were entirely different from the clothing and uniforms worn in Europe. The army uniform was made from a water-tight linen cut in a style approximating the traditional uniforms of the former German colonial defense forces. These uniforms proved unsuitable both in style and material. The material was too stiff and did not give adequate protection against heat or cold. In the early mornings the material absorbed moisture from the dew, so that it became intolerable to wear the uniform. The British tropical uniforms,

in contrast, were made of pure wool and were excellent. Large quantities of the British uniforms were captured and worn by the troops of the German Africa Corps with the German insignia and proved excellent. This was true particularly of the trousers. The tropical uniform of the German airforce was also good. Apart from the fact that the color, a yellowish-brown, was more appropriate, they were made from a material which was of a lighter and better quality and were cut in a more appropriate style. Olive drab color proved unfavorable. In view of the normal camouflage difficulties in the desert, a yellowish-brown, which would have been a protective color, would have been best. High boots were unsuitable in every respect since in hot climates everything must be done to prevent soldiers wearing any apparel on the legs, which restricts the circulation of the blood. In this matter, the troops helped themselves by wearing only slacks, most of which came from captured British depots and which the troops wore over their boots. The German lace shoe with a cloth tongue proved suitable. The shorts issued to the troops could not be worn during combat since they left the bare legs exposed to injury by thorns and stones, and these injuries healed very slowly. The olive drab caps with wide vizors were excellent; the vizor, in particular, was indispensable for the infantryman and for the gunner as protection against the intense glare of the sun. The tropical helmets that were issued could be used only in the rear areas and were entirely useless in combat. The German troops wore no steel helmets in contrast to the British troops, whose steel helmets were more appropriate both in shape and weight, being lighter than the German helmets. The tropical coats issued, which were made from a thick woolen material, were good, but the English, which were fur-lined and reached only to the knees, were better. Owing to the stiff material from which it was made, the German tropical shirts were inferior to the British, which was made of so-called "Tropic" material. To protect the abdominal area of the body against colds, the wearing of belly bands was obligatory, which proved a wise measure. Tropical helmets and mosquito nets proved an unnecessary expenditure. The majority of the troops got rid of them immediately after debarking from the ships, since they were not able to take them along owing to insufficient transportation space.

The troops were also furnished wall tents, which had a special sun apron. An illustration of this type of tent, which proved admirably suitable, will be found as item 54 in appendix 2. With the exception of footwear, no leather was used in any article of apparel; it was replaced everywhere by thick linen.

The types of vehicles used were the same as those used in Europe. Vehicles with Diesel engines were not used in order to avoid the necessity of transporting two different types of fuel. However, experience showed that it would have been advisable to accept this disadvantage in order to facilitate transportation, since fuel oil could have been transported in bulk containers, such as tank trailers. The excellent coastal road would have allowed the use of such transportation.

Volkswagens were used in great numbers and proved excellent. For use under desert conditions the following alterations were made to adapt the standard model: Air intakes were placed inside the vehicles to reduce the amount of dust in the air taken in by the motor. In place of the standard tires, aircraft oversized tires were used, which proved exceptionally good on rocky terrain and in sandy stretches. On rocky ground they reduced jolting because of their low air pressure while on sandy tracks the wide treads of the tires prevented the vehicles from sinking into the sand and getting stuck. On the whole, however, the British motor vehicles, as a result of the extensive experience of the British in desert conditions, were superior to the German, being better adapted to the special conditions in respect to tires, power, higher ground clearance and lower bodies. Double tires proved unsuitable, particularly in areas where the surface was covered with stones, as the stones became compressed in large quantities in the space between the two tires. In the desert, motor vehicles must always carry something or other, such as rope ladders or grids, to place underneath the wheels if they get stuck in the sand.

To reduce the effects of sand and heat, additional airfilters for all types of vehicles were developed and used. They proved very valuable although it was not possible to eliminate the effects of sand on the motors altogether.

Troops employed under desert conditions should be furnished a certain number of aircraft compasses, which should be mounted on the windscreen next to the driver's seat. By means of a small magnet, deviations were excluded, so that the driver was able to drive in the direction ordered. The sun compasses, which were developed for the same purpose, did not meet requirements, since they were too complicated and failed to function properly around midday, between 1000 and 1400 hours. Pocket compasses were indispensable and had to be issued to each man individually, since the individual soldier plays a greater role in the desert than in any other theater of operations. The compass used by the British, in which the dial floated on oil, was better than the German and was preferred by the German troops when they managed to capture any.

The Germans failed to develop anything special as a protection against flies and other insects, which became particularly pestiferous in summer. Insecticides similar to FLIT were an urgent requirement for the combat units.

c. Special Training. It was not possible to give the troops, which were rushed to Africa suddenly and at short notice, any specialized training. All that was done was to have them attend a number of lectures by specialists in tropical medicine and by officers who had a vague knowledge of conditions from traveling. However, these lectures gave the troops wrong impressions of what they were to expect from the effects of heat, sand, insects and diseases instead of orienting them

properly. The instructions on hygiene in the tropics, on the other hand, were good. Even units that were transferred to Africa during the further course of the campaign there received no real specialized training owing to the fact that the orders for their transfer usually came so unexpectedly that there was no time for this purpose. However, in a suggestion submitted to the Army High Command by the army in Africa, the following training subjects were considered important:

- (1) Exercises of all types in marching and combat in open, sandy terrain.
- (2) Cover and camouflage in open terrain.
- (3) Aiming and firing of all weapons in open terrain and at extremely long ranges.
- (4) Recognition and designation of targets without instruments. The aiming and firing exercises were to be carried out by daylight, at night, in the glaring sun, during twilight, facing the sun, with the back to the sun, with the sun shining from one side, by moonlight and with artificial lighting.
- (5) Exercises during extreme heat.
- (6) Exercises of long duration with no billeting accommodations.
- (7) The construction of shelters in sandy terrain.
- (8) Practice in night driving and in driving over sandy terrain.
- (9) Nightmarching in level terrain.
- (10) Orientation by compass, by the stars, and so forth.
- (11) Driving by march compass.
- (12) Recovery of tanks and other vehicles in sandy terrain.
- (13) Laying and removing mines in sandy terrain.
- (14) Exercises in mobile warfare.

If it had been possible to train the troops in these subjects and to prepare them thoroughly, considerable losses could probably have been averted.

d. Acclimatization of the Troops. So far as the first divisions transferred to Africa were concerned, no measures were taken to accustom the troops to excessive heat. Some of the replacements sent

forward later had the opportunity of spending a certain period in South Italy or in the Balkans for acclimatization. The climate in these two regions is very similar to the climate in the coastal areas of North Africa. In the light of experience, however, a familiarization period is not considered absolutely essential, since the troop employed without a prior period of acclimatization proved no less efficient in combat than those who had lived for a time in southern Italy or in the Balkans. It was not the climate alone that caused the heavy losses that were suffered, but the poor food, and the hardships during combat combined with the effects of the climate; the troops had in no way been prepared for these circumstances.

It proved very unwise to transfer units or replacements to the desert in summer, during the hottest part of the year and the time when the flies proved most troublesome. A parachute brigade provides a typical example. The brigade was transferred from Europe in July 1942, the hottest time of the year, and employed in defense in the rocky wilderness around El Alamein. The unit consisted of handpicked men and within a very short while more than 50 per cent of them were sick from the combined effects of the heat, with its accompanying discomforts, and the inadequate diet. Shortly after the unit was committed, numerous cases of metabolic disorders set in, such as, dysentery, jaundice and festering sores which healed only very slowly. The causes were the brackish drinking water, which contained as much as one gram of salt per liter, and the inadequate diet, which consisted almost exclusively of canned foods. Blond and redhaired men with blue eyes and fair skins were particularly susceptible, while the brown and dark haired types soon recovered from the disorders which were almost inevitable in the beginning.

These points were not taken into account in the medical examination, the main emphasis being placed on sound teeth and a strong heart. The result was that the elite units, such as the paratroopers, suffered particularly heavy losses. Even prior acclimatization would not have protected them.

The following experience was gained in respect to the acclimatization of persons to hot climates: Men who had lived before in temperate zones stood the intense heat very well in the first year, during which they were far more efficient than the indigenous population and Europeans who had been living in the country for a long time. This proved to be the case when German troops were employed in Sicily, for instance, where summer temperatures are the same as those in the deserts of Africa. In the average case, the powers of resistance of the new arrival decline after the first year and his efficiency sinks below the level of that of the persons who have spent a longer time in the country. His efficiency only starts to improve gradually after a few years but never reaches the same standard as that of the first year. The following inferences can be drawn from this experience:

(1) No prior lengthy acclimatization should take place, since this would waste part of the first year of maximum efficiency.

(2) Only a brief transitional period should be allowed in a hot climate, during which the troops can be instructed in the manner of living under tropical and desert conditions and the best protective measures they should take without the added difficulty of enemy action.

(3) After approximately one year on active service in a hot climate, the troops should be rotated to some other theater of operations. The disadvantage that the experience gained by the men can only be exploited for a relatively short time must be accepted.

e. Development of Special Equipment. The following special types of equipment were developed:

(1) Special tropical clothing and uniforms, as dealt with in detail in Section 2, b.

(2) Special airfilters for motor vehicles, including tanks. This subject has also been discussed in Section 2, b.

(3) Special medical equipment for use in tropical climates, which subject is dealt with in Annex 5.

3. Logistical Planning

Logistical planning is an integral part of operational planning. (Section 2, a.) In this operation, plans for the supply services also had to be prepared at top speed. The main concern in these plans was to provide for the transportation of the supplies for the German troops by rail to Italian ports and by German or Italian ships from there to ports in North Africa. The selection of transportation media and supervision of the loading was the responsibility of a special branch, the Branch for Transportation to Africa. It operated under the command of the German General attached to Italian Headquarters, hitherto the German military attache in Rome. Unloading in African ports and further transportation to the troops was the responsibility of the Supply and Administration Officer of the Africa Corps, later of the Chief Supply and Administration Officer of the Panzergruppe* Afrika, which later again was redesignated the Panzer Army of Africa and finally the German-Italian Panzer Army.

Initially all bulk commodities, as well as all troops, were transported by sea, but when shipping losses mounted, personnel were transported by plane.

* An armored army with no rear zone administrative responsibilities.

In November 1941, Field Marshall Kesselring arrived in Italy as Commander of the Second Air Force. In coordinated action with the Italian navy and air force, his mission was to protect German and to prevent British transportation in the Mediterranean. It is said that shortly after his arrival, he sighed: "Now it is clear to me that in conducting a war across the sea, the proper delivery of the means of combat at their proper place is of far more importance than any worries as to whether the enemy should be attacked on the right or left flank!"

It was not possible with the means available to the supply command or with any improvised measures to secure adequate supply services for the armored forces in Africa. To keep open the supply lanes or to open these lanes was the responsibility of the operational command, which rested with the Italian Supreme Command. The Wehrmacht High Command had supported the Italian Supreme Command but had also occasionally interfered in the conduct of operations. It was imperative that this problem be solved if an adequate supply service was to be secured for the troops in Africa. As no solution was found, the supply service collapsed as a natural consequence after all improvised means had failed. The following dates and information concerning the functioning of the supply services has been furnished by the German General attached to the Italian Supreme Command during the period from February 1941 to May 1943:

a. February to May 1941

The transportation of troops and supplies across the Mediterranean functioned without interruption. The convoys reached Tripoli regularly and almost without losses. Immediately after its capture, Benghazi was used as a port of debarkation. At the request of the German command, Italian submarines were used as early as April 1941 to transport fuel for the most advanced elements of the Africa Corps. They discharged their cargo at Derna. Coastal shipping along the African coast was organized with small ships and sailing boats with auxiliary motors.

b. June to December 1941

British surface and submarine craft interfered with the transportation of German troops and supplies. The losses in shipping space and in materiel were considerable. To relieve the situation, air transportation groups were employed to move troops and materiel, while naval barges transported tanks and important spare parts. The use of Bardia as a port of debarkation close to the front was prevented by the British air force. In December, Italian battleships had to be used to protect the convoys.

c. January to June 1942

During this period transportation was favored by German superiority in the air, which was gained by the German Second Air

Force under Kesselring, and also by the fact that Malta was held down. The transportation of troops and supplies functioned smoothly and with very few losses. Enough supplies were moved forward to enable the German-Italian Army to launch an offensive with limited objectives, which advanced as far as the borders of Egypt in May-June. In addition, adequate supplies were stockpiled for a period of six to eight weeks against the eventuality of the air forces and naval vessels being employed in an operation to capture Malta.

d. July 1942 to May 1943

As a result of Rommel's advance into Egyptian territory after the capture of Tobruk (this advance was contrary to the plans of the Italian Supreme Command) the supplies deposited in the Benghazi and Tripoli areas for the front were practically useless since the distances were too great for transportation on land and coastal shipping was prevented by the British. The Second Air Force was compelled to transfer some of its units stationed in Sicily and Southern Italy to Africa and Greece in order to support the Panzer Army, which was fighting desperately at El Alamein. As a result, the Luftwaffe was so heavily engaged that it was unable even to screen Malta. The British forces on Malta regained their strength and employed new types of bombers equipped with radar and having a wider radius of action. They succeeded in bringing German convoy traffic to an almost complete standstill. The Italian battleships were in port at Tarent and La Spezia, unable to operate because of lack of fuel. Losses in materiel and fuel were so heavy that it was barely possible to obtain adequate supplies from Germany. The sea routes to Tripoli and Benghazi were completely severed. Air transportation from Crete now played the major role but quite naturally the volume was far too small to meet even the most urgent demands of the front. In addition, the Wehrmacht High Command moved an infantry division from Crete to Egypt. This division had no motorized vehicles whatever, so that it became an added strain on the transportation and supply services in Africa.

After the occupation of Tunis the distances across the sea were admittedly shorter. Nevertheless, in spite of the use of the military transport ships which had been constructed meanwhile and numerous ships of the smallest types, it was not possible to relieve the strained supply situation. Anglo-American power in the air was growing steadily and transportation capacities were sinking from day to day. Even a temporary increase of the quantities transported by air to 1000 tons failed to bring any relief. Once the German-Italian forces in Tunis were enveloped, the Anglo-American fighter planes had such complete mastery in the air, even over the Straits of Sicily, that it was hardly possible for even the smallest ships to reach Africa safely. Around 20 April, the German-Italian air transportation units were subjected to a crippling attack.

Thus, the point must be brought out that, as a result of the gradually developing Anglo-American supremacy at sea and in the air in the Mediterranean, North Africa was cut off from Europe. The German-Italian forces operating in Africa therefore could not be adequately reinforced or supplied. This lack of any possibility of maintaining supply traffic was not due to any failure on the part of the German or Italian headquarters responsible for the movement of supplies, but solely to the fact that the German-Italian operational command did not succeed in keeping the supply routes to Africa open. Any examination of the question why these routes were not kept open or could not be kept open, is beyond the scope of this study.

Plans for supplying the troops in the desert had provided for adequate supply transportation space and also an additional water supply service. Each division had the same transportation space, the same motor vehicle and weapons maintenance units, the administrative, medical and military police units as a division in Europe, plus a water distilling company. The corps supply services included an additional, special water supply company, filter and distilling units and geological teams, details of which can be found in Annex 3.

CHAPTER II

Operations

4. General Description of the Zone of Operations.

The zone of operations in the North African Campaign in Libya and Egypt consisted of a strip of land, sometimes as much as sixty kilometers wide, bounded on one side by the coast and on the other by the desert interior.

The ground surface was either firm gravel, sand-covered gravel, rocky, or mixed sand and gravel. Within this entire zone, large parts of which were level plain, the desert could be traversed by all types of vehicles. The only exceptions were patches of deep sand, and steep wadis, which could not always be ascertained from the map, and salty swamps, such as those at Marada, roughly forty kilometers south of Marsa el Brega. Natural defiles were formed by the serpentines of Derna and the Halfaya Pass at the border between Libya and Egypt. It was possible to create defiles by the use of mines.

Undulating, steppe-like terrain predominated (Annex 2, Photos B 1-5, Annex 4, serial photos L 1 and 2). It consisted of low mounds and long ridges, whose average height above the surrounding terrain was from four to twenty meters. At times they had gentle slopes and at times they rose steeply from broad, level valleys in which there were no watercourses. The summits were naked rock covered with loose rocks of varying size which made motor traffic difficult but not impossible. In the valleys the rocky bottom was covered by a layer of dust or clay of varying thickness. In dry weather this ground could be traversed without difficulty by vehicles with four-wheel drive and capable of cross-country travel, but not without raising dense clouds of dust. The steppe-like terrain had patches of camel's-thorn shrubs, around which the dust had blown to form small dunes (Annex 2, photos 14 and 15). Traffic followed the broad paths, called Trighs or Pistes, which connected the few settlements and water holes. (Annex 2, photos 1 and 2; Annex 4, aerial photo 2). This terrain extended from the coast to a line roughly thirty or forty kilometers inland. The coast itself was fringed by a belt of dunes behind which was a zone of salt swamps, called Sebchen, which were usually dry (Annex 4, aerial photos 19 and 20). This coastal zone was frequently used as a bivouac area for troops, since it offered good opportunities for digging in tents and vehicles and had good water supply facilities. The only parts of the coast at which there were no dunes were the cliff sections at Tobruk, Bardia and Sollum. There, the coastal sector was often intersected by deep wadis and was difficult to penetrate.

Towards the interior, the steppe-like zone gradually merged with the desert proper, which is practically devoid of any type of vegetation (Annex 4, aerial photo 3). On the whole, motoring was easier in the desert proper than in the steppe-like zone, although movement was

rendered difficult in parts by very rugged areas (Annex 2, photos 6-8; Annex 4, aerial photo 4-6). Instead of the rocky surface, patches with a deep covering of sand are encountered, which make rapid travel possible (Annex 2, photos 9 and 10). Here, the valley floors were clay pans, as flat as table tops, which were submerged in water during the rainy periods (Annex 2, photos 11 and 12). It is only at the foot of steep cliffs that a rocky bottom was found or a soft sandy bottom, into which the vehicles easily sank (Annex 4, aerial photo 14). This soft sand also covered the beds of the numerous wadis, by which the steep faces of the ridges are broken, so that it was often extremely difficult to surmount the obstacles presented, even by comparatively low steep ridges.

Farther south these patches of soft sand increased in size and seriously impeded operations by armored units (Annex 4, aerial photos 15-18). The dividing line between those parts of the desert in which mobility was good and those in which it was bad is in eastern Libya and western Egypt, between the 29th and 30th degree latitude. (Annex 1, map 2). South of the 29th degree latitude the vast dune-covered expanses began, and to cross it was considered quite a sporting feat.

We can thus see that the area suitable for military operations was confined to the relatively narrow strip along the coast and the southern, desert, zone which was more favorable for rapid movement on the whole than the northern, steppe-like zone, if the tarred coastal road is left out of consideration. (Annex 1, maps 2-10.)

Within the zone described, the following types of terrain obstacles were to be found:

a. Mountain ranges. Three mountain ranges played an important part in the war in Africa, namely

(1) The Cyrenaica Mountains (Annex 1, maps 4 and 5). At points these mountains reached a height of 875 meters above sea level; they intercepted the moisture carried inland by the north wind. The heavier rainfall here is the reason why, in this area, the chalky ground carried a growth of macchia in contrast to the desert or steppe-like areas. (Annex 2, photo 16.) These mountains rose in two high, steep terraces, which could be traversed at only a few points (Annex 2, photos 17 and 18) and were intersected by numerous deep valleys (Annex 2, photo 19), which made it impossible to conduct sizable operations except along roads. South of the topmost ridges, the mountains sloped down gradually to the desert terrain which was good for vehicular traffic. (Annex 2, photos 1, 2, 10.) For this reason the Cyrenaica region was vulnerable to attack from the south, a fact which Rommel recognized at once during his attack in the spring of 1941. For this reason he delivered his main attack against Mechili, a desert fort designed to protect the southern approaches to the Cyrenaica. The fact that it was so easy to bypass is the reason why the Cyrenaica

was never held with any degree of determination by either side during the entire campaign, although it could be called a natural fortress. During every retreat, every effort was made to pass through this region as rapidly as possible in order to avoid being intercepted.

(2) The Gebel Nefusa Mountains, (Annex 1, map 7), protruded like a barrier between the coastal plains of Tripoli and those of Misurata. South of Tripoli they rose to a height of 700 meters above sea level, the first 300 meters of which were a gigantic cliff (Annex 2, photos 20 and 21). In the southeast they descended in a gradual slope. In the northeast, towards the sea, the height was less than 200 meters above sea level at Homs. In the central parts, this mountain range was extremely rugged and motorized troops could only pass along the roads. The southeast slope was covered with a deep layer of wind-blown sandy loess, which made vehicular traffic difficult (Annex 2, photo 29). From the north, this mountain range formed an impregnable fortress. From the southeast, it was vulnerable to attack in spite of the mountainous and intersected nature of its approaches, since the attacking forces could find favorable assembly areas in the foothills and could approach under cover to the proximity of the defense positions. Possibilities for by-passing existed and were taken advantage of by the British in the attack in January 1943.

(3) The Matmata Mountains, a range in south Tunisia, had a steep drop of 100 to 200 meters in the east (Annex 1, map 8). In the west they sloped down gradually to a high plateau, which was sandy in parts, while in others the ground was good for motor traffic, so that it could be crossed by motorized columns in spite of occasional difficulties (Annex 4, aerial photo 17). The steep cliff-like wall in the east and north was interrupted by numerous wadis, through some of which an ascent to the high plateau was possible (Annex 4, aerial photos 7 and 8).

The Matmata Mountains narrowed down the coastal plains of southern Tunisia considerably, so that it was possible to organize a defense line at the narrowest point, at Mareth. However, the steep mountain-side was only a weak protection against flanking attacks, since it could be by-passed with little difficulty. Only if the German-Italian forces had been numerous enough to hold all passes and if they had had a mobile reserve available to repulse any enemy attempts at detouring the mountains, would this range have constituted an important factor in the defense.

b. Steep terraces. Most of the steep terraces in the steppe-like terrain were not high and followed a course parallel with the coast (Annex 2, photo 22; Annex 4, aerial photos 1 and 2) so that they hardly interfered with troop movements. In the numerous caves, overhanging cliffs and gorges, good opportunities could be found for troops shelters, for which purpose they were frequently used, since they were

the most effective protection against air attack that was to be found. Some of the steep terraces, and other similar terrain features, however, became of outstanding importance, namely,

(1) The northern rim of the Quattara Depression, on which the southern flank of the El Alamein line was based. (Annex 4, aerial photos 10 and 11). This rim towered about 300 meters above the floor of the depression, which was 80 meters below sea level. Within the sectors held by the German-Italian forces there were only three points at which motor traffic was possible, and even there difficulties were encountered because of the deep sand. Throughout the entire campaign no better protection for a flank was ever found than in the El Alamein line.

(2) The steep terrace at Sollum, between the Bardia-Capuzzo high plateau and the Sollum coastal plain (Annex 1, maps 3 and 11; Annex 4, aerial photo 9). There were two roads, with numerous serpentines, across the terrace, one from the Via Balbia - the tarred coastal road, the other from the Halfaya Pass road. During the period of positional warfare in the summer of 1941, the terrace was within the combat area.

(3) Large-sized wadis. These were found in the Cyrenaica region and in the eastern approaches to the Tripolitanian Gebel mountain and extended, as far as the Bay of Sirte (Annex 2, photos 24-29; Annex 4, aerial photos 12-14). Usually the bed of a wadi consisted of a layer of soft sand; less frequently the beds were salty swamps with a growth of camel's thorn. The banks were usually steep but not continuous, since they were cut by numerous cross-wadis. On the whole they could be considered as terrain obstacles, but as obstacles that could be overcome without difficulty unless obstinately defended.

During the German-Italian retreat from El Alamein to Tunis, only one defense position was based on a wadi, namely the Buerat line, which extended along the Zem-Zem wadi south of the Via Balbia (Annex 1, map 15; Annex 2, photos 26 and 27; Annex 4, aerial photos 12 and 13). However, after careful deliberation, the line was developed east of the wadi in order to prevent an approach by the enemy under cover and not on the low-lying west bank, since the west bank was dominated by the higher opposite bank.

The Buerat line could be by-passed easily. It was therefore evacuated by the infantry before the attack began and held only for a short while in a delaying action by mobile units.

(4) Dune terrain. Large sandy areas were found close to the coast, near larger wadis, and in the desert proper, where the ergs* present barriers that were impenetrable for traffic:

*Large areas of shifting sand dunes. (Translator)

Big dunes along the coast, which interfered with traffic, were found around Agedabia, on the shores of the Bay of Sirte (Annex 4, aerial photo 20), south of Misurata, and in the neighborhood of Tripoli (Annex 2, photo 30), thus mostly in western Libya. They impeded traffic seriously off the roads and even the roads were affected, since the dunes shifted constantly. After severe storms the roads became so deeply covered with sand that they had to be cleared. For this reason, a constant road maintenance service was necessary where the roads crossed dune areas.

A large area of dunes was also found north of the El Fareh wadi, between El Agheila and Marada along the shores of the Bay of Sirte (Annex 1, map 6; Annex 4, aerial photos 18 and 21). It protected the German Marsa el Brega position against flanking attacks and forced the British to make a wide detour through the region south of the El Fareh wadi, where vehicular traffic was possible.

The big dunes of the desert proper were all south of the zone of operations and only a section of them along the border between Libya and Egypt played a role of some tactical importance, since they afforded protection for the south flank of the German Alamein positions. The dunes in the desert proper were not crescent-shaped like the dunes along the coast, but formed continuous ridges anywhere between four and fifty meters high, which extend usually from north to south. (Ridge dunes, Annex 4, aerial photos 22 and 23.) A number of these ridges could be so driven by the wind to form a labyrinthian confusion of dune ridges with completely encircled hollows in which the firm ground could be seen (Annex 4, aerial photo 24). This enormous ocean of dunes formed what might be called a collection of honeycomb dunes. In order to cross them it was necessary to have the very best cross-country vehicles available and to drive at top speed at the first dune, break through its crest and on driving down the opposite slope, to gather speed for the next dune. While driving, the vehicle was enveloped in a dense cloud of dust, which reduced visibility to practically nil. In this way, one to two kilometers might possibly be covered per day. Serious losses in personnel and materiel were unavoidable.

The Great Eastern Erg, a similar large dune area, extended from south Tunisia to south Algeria close to the western border of Libya (Annex 1, maps 1 and 8). If adequate German manpower had been available to extend the Mareth position across the Matmata Mountains and Fort Le Boeuf to this dune area, the flank would have been as well protected as was the case in the Alamein line.

(5) Salt swamps. These swamps developed at those points where the water in the subsoil of the desert rose to the surface. Owing to the constant evaporation which takes place, the salts carried by the water were deposited and the resultant brine formed either a lake or, when mixed with sand and clay, a patch of thick tough mud on which salt marsh vegetation could take root. (Annex 2, photos 34

and 35; Annex 4, aerial photos 21-23 and 25-27.) Once a person was caught in a salt swamp it was impossible for him to escape without help. Photos 36-9 in Annex 2 show how vehicles which were sunk in salt marshes could be recovered. However, this method was successful only on terrain which was not too swampy. In really soft swampy ground, the vehicle had to be pulled out by another vehicle, which was often extremely difficult and could only be done if the latter was on firm ground and had a very strong engine. Most of the salt marshes were crossed by fords, which were known to the natives. Many of the fords could carry vehicular traffic, so that any salt marshes within a defensive position should always be kept under observation and all fords crossing it must be carefully reconnoitered with the aid of native guides. Frequently, the salt marshes dried out completely and then presented no obstacle at all (Annex 2, photo 33).

The biggest salt marsh in the Libyan and Egyptian desert was the Quattara Depression, the surface of which was 80 meters below sea level. This depression and its northern rim protected the flank of the El Alamein line. The swamp itself was skirted by a zone of soft sand varying between one and two kilometers in width, on which a few vehicles could travel with some difficulty (Annex 4, aerial photos 10 and 11). All other ground outside of the actual swamp but within the Quattara Depression was also soft and difficult to cross with vehicles. The salt marsh which was within the German zone of operations in the Marsa el Brega line was considerably smaller (Annex 1, map 6). Nevertheless, in conjunction with the sandy patches and dune areas, it provided good protection against frontal attack in spite of the fact that it had numerous fords. The salt marshes of southern Tunisia, called Schotts, were of more importance. The Dscherid Schott was the feature which led to the decision to construct the Gabes line, which served as a rear line for the Mareth line (Annex 1, maps 9 and 10). In most parts, the Dscherid Schott was considered an impassable obstacle (Annex 4, aerial photo 26), but its eastern part, the so-called El Fedjad Schott, had numerous good fords which could be crossed without difficulty by vehicles.

Both Benghazi and Tripoli had good ports with very ample capacities for shipping and landing, for which reason the former was used as the main supply base. The capacities in the ports of Derna and Bardia, as well as the naval port of Tobruk, had much smaller capacities.

There was no continuous railroad in Libya. The two railroads, each about thirty kilometers in length, in Tripolitania and in the Cyrenaica were of no importance from the military point of view.

The only permanent signal communications system consisted of an open-wire telephone line, on poles, from Tripoli to Bardia. The distances were extremely great and the line made only limited communication traffic possible. Furthermore, it was frequently interrupted by the frequent air attacks against the Via Balbia.

The water supply facilities along the Via Balbia were adequate. The water holes in the desert, usually with a small supply of brackish water, were generally known only to the natives and were not indicated on maps.

During the main part of the year the air was very hot but dry, the hottest months being June, July and August. The highest temperatures registered around midday were about 114° Fahrenheit. At night, even in summer, temperatures dropped to about 5° Fahrenheit. In winter, from November to January, the nights were quite cold, temperatures dropping to around 5° and rising again during the daytime to about 85° Fahrenheit. Rain fell only in winter, but was then sometimes very heavy, starting suddenly and swamping extensive areas, sometimes stopping all traffic, even on roads, for protracted periods. The only other moisture was the very heavy dew at daybreak and in the evenings.

The outstanding weather feature was the sandstorms, which are called Ghiblis. These sandstorms recurred pretty regularly every four weeks in all seasons of the year. They usually lasted three days and since they reduced visibility to nothing, they brought all operations by ground and air forces to a standstill. During these sandstorms the range of vision was often reduced to less than three meters, so that orientation was impossible.

Owing to the wind from the sea, the climate in the coastal regions is almost always healthy. In spite of the enormous number of flies, there were few cases of malaria. On the other hand, the troops proved extremely susceptible to jaundice and dysentery.

5. Order of Battle of Army and Luftwaffe Units.

Army: The first units to be transferred to Africa between February and May 1941 were the corps headquarters of the Africa Corps and headquarters units (the corps signal battalion and several supply units) together with the 5th Light Division, which was later reorganized to form the 21st Panzer Division, and the 15th Panzer Division.

During the summer months, a number of so-called oasis companies, a few battalions and some coastal batteries were moved in, with an Africa Division Headquarters which was to control them. In the autumn of 1941, these units were consolidated to form a division, later designated the 90th Light Africa Division.

Thus, the German combat troops in Africa at the end of 1941 consisted of two armored and one light division. The two armored divisions remained under the command of the German Africa Corps. In the summer of 1941, this corps and the other army units in Africa were placed under the command of the newly created Panzergruppe Afrika.

On 21 January 1942, this headquarters was redesignated Headquarters of the Panzer Army of Africa, which designation was changed again in the autumn of 1942 to Headquarters of the German-Italian Panzer Army.

In the summer of 1942 the 164th Light Africa Division and the Parachute Instruction Brigade were transferred to Africa. As they were transported by plane, and since the sea transportation capacities were steadily sinking, these units never received their vehicles, so that they remained non-mobile to a great extent, a fact which was to have very adverse effects on the withdrawal from El Alamein.

In 1942, about eighteen batteries which were not included in any of the divisions and consisted of Army Headquarters batteries, coastal batteries and new batteries of captured guns, were consolidated as Army Headquarters Artillery. This artillery was organized in two regiments and was placed under the command of the Commander of Artillery in Africa. In addition, the reconnaissance battalions of the 15th and 21st Panzer Divisions and the 580th Reconnaissance Battalion (a GHQ unit) were consolidated to form a reconnaissance brigade under the immediate control of the army headquarters. The army also had the 900th Engineer Battalion, formerly a GHQ unit, available as a headquarters unit.

At the end of 1942 the ground forces employed in combat therefore consisted of the following:

- 2 armored divisions
- 2 light divisions
- 1 parachute brigade
- 1 reconnaissance brigade
- 2 regiments of headquarters artillery
- 1 engineer battalion
- the 283th Special Unit, a reinforced battalion originally organized as an elite battle group for employment in the Middle East.

The above list does not include the numerous units available to the army for logistical support.

The divisions were organized as follows:

a. Armored Divisions:

Divisional headquarters

- 2 armored infantry regiments of each 2 battalions
- 1 tank regiment of two battalions with a T/O of 100 tanks each
- 1 artillery regiment of two light and one heavy battalion
(9 batteries with 24 light field howitzers, 8 heavy field howitzers and 4 100-mm guns)

1 antitank battalion of three companies each with three
three guns with prime movers

1 engineer battalion of two companies

1 signal battalion with one telephone and one radio
company

Supply and transportation units.

Total strength of each panzer division: 12,000.

b. Light Division:

Divisional Headquarters

3 infantry regiments of two battalions each

1 artillery regiment of two light and one heavy
battalion (24 light and 12 heavy field howitzers)

1 antitank battalion of three companies (armament as
for panzer division)

1 engineer battalion of two companies

1 signal battalion (as for panzer division)
supply and transportation units

Total strength of the light division: 12,000

c. Parachute Instruction Brigade

Brigade Headquarters

4 battalions

1 engineer company

1 light artillery battalion

1 mixed signal company.

Total strength of the Parachute Instruction Brigade:
5,000

In addition to the above, the following units were landed in
Tunis and employed in combat from November 1942 to the end of the
campaign:

Considerable parts of the 10th Panzer Division

1 battle group of regimental strength of the Hermann Goering Parachute Panzer Division

Considerable parts of three infantry divisions, a number of GHQ armored battalions and the German Arab Legion, which latter was a unit of regimental strength.

Thus, the ground forces employed in combat in the African theater of operations were equivalent to

3 armored divisions at full strength

2 light divisions at full strength

2 infantry divisions at full strength

1 parachute brigade.

Air Forces. The fact must be stressed at the outset, that the air force units stationed in Africa were kept at a low level of strength in order to avoid further complicating the already difficult supply situation.

Additional air support was given by air force units stationed at Italian or Greek air bases which were transferred occasionally for temporary periods to Africa.

We must differentiate between three phases in respect to the organization and composition of air force units stationed in Africa, namely,

Phase a. February - November 1941

Phase b. December 1941 - December 1942

Phase c. January - May 1943

Phase a.:

Command: Air Force Commander in Africa. The commander was subordinate to the X Air Corps (stationed in Athens and later on Crete) and was in tactical support of the Africa Corps (later the Panzer Army of Africa).

Flying forces in Africa:

1 long-range reconnaissance squadron (F-121 type planes)

2 squadrons of the 14th Close Range Reconnaissance Group

1 fighter group, later replaced by the

77th Fighter Wing of three groups

2 groups of the 3rd Dive Bomber Wing

1 destroyer plane group 1 desert rescue squadron

Antiaircraft artillery:

1 regiment of four battalions, tactically assigned to the

Africa Corps (later Panzer gruppe Afrika).

Air Signal troops:

1 air signal battalion

Logistical support troops:

1 team detailed by the Luftwaffe General in Italy.

Phase b.:

Command: Air Force Commander in Africa. The commander was subordinate to the 2nd Air Force and was assigned tactical support of the Panzergruppe Afrika (later Panzer Army in Africa).

Flying units in Africa: as in a., above.

Antiaircraft artillery:

Organized in the summer of 1942 to form the 19th Flak Division and tactically assigned to the Panzer Army

Air Signal troops: as in a., above

Logistical support troops

From 1942 on: Airforce Administrative Command, Africa, controlled by the Luftwaffe General in Italy.

Phase c.:

Command: Air Corps Africa, with Air Commanders 1 and 2.

The Air Corps Africa was subordinate to the 2nd Air Force and was required to cooperate as follows:

Air Corps Africa with Army Group Africa

Air Commander 1 with the 5th Panzer Army

Air Commander 2 with the German-Italian Panzer Army (later redesignated the 1st Italian Army)

Flying units in Africa:

2 Fighter wings (53rd and 77th)

1 dive bomber wing of 2 groups

1 destroyer plane group

2 antitank plane squadrons

reconnaissance units as in a., above.

Antiaircraft artillery:

19th Flak Division, tactically assigned to the German-Italian Panzer Army (later redesignated the 1st Italian Army).

20th Flak Division, tactically assigned to the 5th Panzer Army

Air Signal troops:

1 reinforced air signal battalion

Logistical support troops:

Air Force Administration Headquarters Tunis with three air base areas.

The order of battle in Annex 3 shows the status as of January 1942, but does not reveal the number and types of weapons available. The organization and the main items of armament were the same as in Europe with the exception of the additional supply units assigned for service in the desert, namely, the water supply service units, the meteorological survey teams, and so forth. It must be emphasized in respect to the tables of organization that the units at no time had the stated authorized strengths. The actual strengths were constantly subject to fluctuations according to the losses suffered and the replacements received.

Thus, the combat efficiency, which also depended on the shipment of replacements in personnel and materiel, also fluctuated.

6. Reasons for Changes in Organization and Equipment

Initially, the German units were transferred to Africa with their normal tables of organization and equipment. Changes which were effected immediately in respect to equipment were as follows:

a. All vehicles were immediately fitted with new special dust-filters.

b. Special units, namely, water supply companies, water transportation columns and geological teams, were organized immediately to take care of water supply and transportation problems. However, owing to the steadily increasing transportation difficulties, large parts of these units remained in Italy until the campaign was over.

c. All vehicles were camouflaged by a coat of desert-colored paint.

d. Uniforms and other clothing. The troops were issued tropical shirts; khaki-colored linen jackets, breeches, and shorts; lace boots and lace shoes, both cotton-lined; linen caps with vizors; tropical helmets; belly bands; woolen overcoats.

In 1941 the following additional changes became necessary:

a. The antitank battalions arrived in Africa with 37-mm antitank guns. In the summer of 1941, these were exchanged for 50-mm guns, which were exchanged again in early 1942 for captured Russian 76.2-mm antitank guns. This was necessary because of the increased effectiveness of weapons used on both sides.

b. From early 1942 on, all infantry units were also assigned antitank guns, since tank warfare is the deciding factor in desert warfare, where the antitank gun becomes of even greater importance to the infantry than the machine gun. The aim of furnishing each battalion eighteen 76.2-mm antitank guns was never achieved.

c. Types I and II tanks, some of which were armed with machine guns and some with 20-mm guns were withdrawn after the summer of 1941 and replaced by Type III tanks, which had 50-mm guns. These again were replaced after the winter of 1941/42 by Type IV tanks, which had 75-mm guns.

d. The replacement of all motorcycles by Volkswagens. Even the half-track motorcycles that were used for a while proved unsatisfactory.

7. Description of the More Important Battles

a. 31 March to 19 April 1941: The first counter-attack to reconquer the Cyrenaica.

Contrary to the views of General Garibaldi, Commander in Chief of the Italian forces in Africa, Rommel, who had arrived in the theater of operations on 11 February 1941 as commander of the German Africa Corps, was of the opinion that waiting would worsen the situation. The British forces were still in a long drawn out column and were momentarily in a precarious condition, which fact had to be exploited immediately. Rommel was able to substantiate his opinions by reconnaissance and, therefore, his views prevailed. Immediately after the 5th Light Division commenced landing at Tripoli on 11 February 1941 and moving up to the front, Rommel commenced a series of reconnaissance thrusts west of Agheila on 24 March, which he followed up on 31 March by an attack with limited objectives in the direction of Agedabia. The sole object of this attack was to drive back the British troops in the advanced positions of Agedabia. Since these British troops retreated immediately, Agedabia itself was attacked and taken on 1 April, the enemy withdrawing toward Benghazi. The attack toward Benghazi, which then followed, was also successful and on 4 April that city and the port were taken by German forces.

In view of the obvious weakness of the enemy, who had been taken by surprise by the German attack, it seemed advisable to continue the advance. Rommel decided not to continue the pursuit through the Cyrenaica, but to launch an enveloping attack through the desert, in order, if possible, to prevent the retreat of considerable enemy forces. For this reason he pushed forward the bulk of the 5th Light Division south of Benghazi straight through the desert towards Mechili and Derna, with weaker forces moving by way of Msus in a flanking drive. This move also succeeded and on 6 April more than 2000 prisoners were taken at Mechili, Derna being captured on the same day.

On 9 April the pursuing columns reached the Libya-Egyptian border at Bardia, so that all territory lost in Libya had been recovered. Only the Tobruk fortress remained in British hands. It was enveloped with weak forces by 11 April. Two attempts to take it in raids on 13 and 14 April and a third attempt in a properly prepared attack on 30 April failed. The forces available were inadequate for this task.

Rommel now had to decide whether to break off the siege of Tobruk and to withdraw to the elevated terrain of Ain el Gazala or to maintain the siege with the disadvantage that he would have to establish a second front in a line level with Sidi Omar-Sollum-Bardia. He decided on the second solution. Chiefly Italian troops, namely, the X and XXI Corps, with a total of four infantry divisions, which were to be increased to five at a later stage, were to maintain the siege of Tobruk. The Sidi-Omar-Sollum front was held only in strong points in order to release the bulk of the German forces for mobile employment in the open field.

Summary.

(1) The units which took part in the actual offensive operations were as follows:

The 5th Light Division, which at that time consisted of three battalions; one tank regiment; one reconnaissance, one light artillery, one antitank, one engineer, and one signal battalion.

(2) The important factors that brought about this speedy and thorough success were the following:

(a) The momentary weakness of the British forces, whose supply transportation had not yet been able to catch up fully with the rapid advance.

(b) German supremacy in the air.

(c) The direct attack through the desert, which the enemy had not expected.

(3) A special feature of these operations was the advance through the desert from south of Benghazi toward Mechili and Derna, which advance was ordered by Rommel in spite of the serious misgivings of most of the commanders serving under him. The actions brought out the necessity of having the commanders of mobile units far ahead in the unit column in desert warfare and of employing all means, including liaison planes, to maintain contact within the pursuing force. There is no other possible way of remaining close on the heels of the retreating enemy.

(4) Logistical requirements were not given the proper consideration. This is the reason why some of the units failed in the desert. But, on the other hand, Rommel could not afford to wait for the arrival of further fuel transports, as he would then have lost contact with the enemy.

(5) Here, for the first time, the units had to cross a long stretch of desert, some of them 300 kilometers and more, and while doing so had to gather the experience they lacked. This experience included recognition of the necessity to carry along ample supplies of fuel and water and the difficulties of orientation. In the desert it is hardly possible to establish one's position by the sun, since the sun is usually almost directly overhead. The available maps, which were reprints of Italian maps, were inadequate. Practically no reference points existed, so that all orientation had to be done by compass. Furthermore, the eyes of the troops had to become accustomed to the glare of the sun, which made contours unclear, so that it was extremely difficult to recognize objects, for instance, to differentiate between tanks and trucks.

(6) Together with the fact that any movement causes immense clouds of dust, the above factor was originally exploited by Rommel, who had his supply and baggage trains move in tank formation

in order to mislead the enemy. Later, this came to the notice of the enemy, so that later attempts to employ this ruse were unsuccessful.

(7) At that stage, the German forces suffered little from enemy air attacks.

(8) Here, for the first time, the 88-mm antiaircraft gun proved an effective antitank weapon. Later it became indispensable for this purpose.

b. May-June 1941: Battles for the positions on the border.

The British left Rommel no peace and in these months seized the initiative several times in attempts to take from the Germans the border positions, which commanded the outpost area, and particularly in attempts to take the Halfaya Pass. In the mountain range extending from the coast to the interior of the desert, a distance of more than 30 kilometers, the Halfaya Pass was the only point at which tanks could cross.

On 15 May, the British succeeded in recapturing Sollum, Capuzzo, and the Halfaya Pass. In an immediate counterattack Rommel succeeded two days later in retaking Sollum and Capuzzo, while the Halfaya Pass remained in British hands. However, on 27 May the pass was finally retaken in an attack in which the 15th Panzer Division, which had meanwhile reached the front, also took part.

On 15 June, after careful preparations, the British launched a major offensive which aimed at retaking the border positions and advancing on Tobruk. They by-passed the German border positions and pushed forward almost as far as Bardia. The situation was critical. However, on 17 June, Rommel, again employing the 15th Panzer Division, succeeded in defeating the enemy by concentrating his forces in an attack on the west flank of the enemy, who had advanced northwards. The enemy forces were compelled to withdraw southward to avoid the encirclement of some of their units.

The more important features of these operations are as follows:

(1) The pursuit phase was now over, and the actions described are those of attack and defense.

(2) Stronger forces were employed on both sides, than hitherto. On the German side, both divisions, the 5th Light and the 15th Panzer -- minus certain elements tied down on the Tobruk front -- were fully employed, as well as one Italian division. Without the 15th Panzer Division, the German forces would not have been able to hold their own, particularly in the battle from 15th to 17th June.

(3) Whereas the fighting during the pursuit in March and April took place on either side of the Via Balbia, all the actions just described took place in the desert.

(4) The German side no longer had absolute mastery of the air; British bombing units were taking part in the fighting in concentrated attacks for the first time.

In these skirmishes and battles the 15th Panzer Division gained its first experience in desert warfare. The fields in which experience was gained were the same as those described for the 5th Light Division in section a.

New features in the operations were as follows:

(1) For the first time, all German units were exposed to lively enemy activity in the air, a feature they were to experience daily from now on. At first, several instances occurred where severe losses were suffered owing to the bunching up of vehicles and troops. It was weeks before the troops learned to counter this new combat factor by a wide dispersal of units in breadth and depth, a particularly important requirement in the desert, where no cover whatever is to be found. (The minimum distance between vehicles should be 50 and if possible 100 meters.) It also proved necessary to dig in immediately all vehicles that were halted for any considerable time. They were to be dug into the ground to at least a depth that protected the axles in order to lessen the effects of bomb fragments. In the same measure it was necessary to camouflage the vehicles. This was only possible with the use of camouflage nets, so that it was extremely difficult. Furthermore, it was now necessary for each and every man to dig a fox-hole as protection during air raids.

(2) The danger of radio stations being intercepted and located made it imperative to have all radio instruments and particularly central radio stations removed at least one kilometer from headquarters sites in order not to have the functioning of staff headquarters interfered with. The resultant delay in the transmission of orders and reports had to be accepted as an unavoidable disadvantage. By the use of messengers with motor vehicles, this delay had to be reduced as far as possible.

During the time discussed above, consolidating measures were also taken in the envelopment of Tobruk. The intention to withdraw all German troops from the besieging force could not be carried out, particularly at Ras el Mdauar, on the southern front, where two German battalions remained in position until the autumn of 1941.

(3) The danger of enemy tanks breaking through the front made it necessary to develop all-around defense positions protected by antitank mines. Rommel issued a bulletin describing the development

of such positions, each held by a reinforced company, in a system of strong points. Above all, this system was adopted along the border, where the Italian "Savona" Division was employed in addition to five German oasis companies.

c. July to mid-November 1941: The siege of Tobruk and preparations for the attack on the fortress.

It was clear to Rommel that Tobruk had to be taken as soon as possible and it was obvious that the enemy would do everything possible to prevent this happening. Speed was therefore necessary. The following factors made it difficult for Rommel to take the steps which he recognized as essential:

(1) The necessity of awaiting the arrival of further troops, infantry and particularly heavy artillery, and large supplies of ammunition from Europe, since the available forces were inadequate.

(2) The steadily decreasing capacities for seaborne transportation as the result of the mounting losses of ships.

As early as in July it became evident that it would definitely not be possible to commence any systematic attack before mid-September. At an early stage it was realized that this deadline would have to be extended to October, then to November and finally to December. Gradually, the hopes dwindled that the attack could be launched before the expected British offensive commenced.

The summer months were spent in executing the following measures:

(1) Reinforcement of the enveloping forces by artillery and through development of the terrain.

(2) Improvement of training.

(3) The movement of large quantities of ammunition and fuel to Benghazi and farther east.

(4) Improvement of the medical services, which had hitherto perforce been neglected.

(5) Overhauling and maintenance of arms, equipment and vehicles.

The following is to be said about the activity during these months:

(1) All attempts to reduce frontage and thereby strengthen the enveloping line failed since the Italian troops, by whom the greater part of the line was held, were not able to withstand counterattacks by the British.

(2) The reinforcement of the artillery forces was pressed forward vigorously; for this purpose a special artillery commander was assigned. Flash and sound ranging proved indispensable in the location of the enemy batteries.

(3) Again and again the order had to be stressed that all units employed were to dig themselves in as deep as possible in order to reduce losses.

(4) Demonstration exercises took place to improve the standard of training, with particular emphasis on combined infantry-artillery-tank, artillery-tank-airforce action and the practical application of the all-around defense strong point system.

(5) It was only from Tripoli and Benghazi that ammunition and fuel supplies could be moved forward to the front. The lack of any rail connections proved a serious disadvantage. Investigations showed that to construct a railroad to meet even the most modest demands, at least 60,000 tons of shipping space for locomotives, cars, rails, understructures, and so forth, would be required, and a period of about twelve months for the Tripoli-Benghazi section and an additional three months for the extension to Derna would be needed.

Ammunition and fuel had to be stored in the open, both in the vicinity of the ports and near the front, since tank installations and shelters were non-existent. This made wide dispersal and the burying and camouflage of all supplies at the storage depots all the more important. These precautions were frequently disregarded so that unnecessary losses occurred.

(6) Warm clothing after sundown was particularly important in the desert, and especially so for new arrivals, as a precaution against dysentery and skin diseases, since the difference between the daytime temperatures and those at night was extreme. After sunset it was absolutely essential for every man to wear trousers and a belly band. Experience showed, in fact, that it was advisable to wear the latter day and night.

An appropriate diet was essential to prevent jaundice, which occurred frequently. A large proportion of the cases of jaundice which occurred in 1941 were due to the fact that the rations issued included large quantities of pulses and conserved meat with a high fat content. Above all, food with a high Vitamin B and C content proved necessary and on the whole, the food had to be light. Vitamin C tablets could not take the place of fresh vegetables. Owing to inadequate air transportation space, it was usually only possible to fly in fresh vegetables and fruit for airforce personnel in Africa.

(7) In weapons maintenance, protection of the inside parts of the weapons against sand proved a particularly important

point. For this reason, all bolts and moving parts of the weapons were wrapped in sailcloth, besides the use of the standard muzzle covers. All weapons had to be cleaned very carefully, but after cleaning oiled only very thinly; otherwise the dust would eat its way into the surfaces. No special means to protect the weapons against dust were available. What has been said about the care of weapons applies in equal measure to the care of other equipment and motor vehicles.

(8) A high standard of training in the use and care of weapons, equipment and vehicles was particularly important in desert warfare and the work of the higher echelon ordnance technicians handling weapons, equipment and vehicles was of great significance in maintaining the combat efficiency of the troops in this respect.

In an overseas theater of operations, extensive maintenance services with well-equipped workshops for the repair and maintenance of weapons, tanks and other motor vehicles were just as indispensable as stocks of all types of spare parts, particularly for tanks.

It was also during the summer that Italian forces constructed the road to by-pass Tobruk, which was roughly sixty kilometers long. This road was metalled and tarred, and its construction which took three and a half months in the heat of summer, must be regarded as an outstanding performance. On the whole, the German troops, who were unaccustomed to the heat also came through the summer with very few losses.

On 14 and 15 September, Rommel launched an operation for reconnaissance in force in the direction of Bir el Habata, in the Egyptian desert, from the border positions. The operation was directed by the headquarters of the German Africa Corps, and was carried out by the 21st Panzer Division, which had been organized from the 5th Light Division. This operation, which was designated SOMMERNACHTSTRAUM must be considered a failure, since it failed in its purpose of discovering how far the British were in their preparations for their offensive. No opponent was contacted, as the British reconnaissance forces had recognized the German intentions and had withdrawn in good time. On the other hand, the 21st Panzer Division suffered considerable losses in a number of air attacks owing to the fact that it lost three and a half hours on Egyptian terrain in re-fueling, as the fuel trucks first had to be moved forward. These losses could have been avoided if sufficient fuel had been carried along in cans and if the fuel column had accompanied the combat units. Further losses were sustained while moving back through German minefields, the locality of which was not known precisely to the various units.

d. Mid-November 1941 to mid-January 1942: Repelling the British autumn offensive and the retreat to the Gulf of Sirte.

The British offensive opened on 18 November 1941. At strategic level it had been expected, but nevertheless it came as a tactical

surprise. This was because, from the end of October on, the German air reconnaissance hardly ever succeeded in penetrating into Egypt and because the enemy had concealed all general preparations and signal traffic with extreme skill.

Excluding the Tobruk garrison (1 1/2 divisions and 1 armored brigade) the ground forces of the enemy, which had meanwhile been consolidated to form the British Eighth Army, consisted of

- XIII and XXX Corps Headquarters
- 3 motorized divisions
- 1 armored division
- 1 armored brigade

with a total of about 700 tanks.

Apart from the 5th Italian Division and one German division and the GHQ artillery besieging Tobruk, Rommel had available for operational employment

- 2 German armored divisions with roughly 360 serviceable tanks
- 1 Italian armored division with roughly 150 inferior tanks
- 1 Italian motorized division, the efficiency of which was also limited.

The XXX British Corps, with the bulk of the available armor, advanced through Maddalena in order to relieve Tobruk while the XIII British Corps enveloped the border positions from the south.

The 21st Panzer Division, which was echeloned forward in the direction of Bir el Gubi had the mission of halting the British advance, but met with no success in its efforts. For a long while the situation remained unclear to Rommel because the division reported too infrequently and because its reports were confusing. On 23 November it seemed that the situation would improve when Rommel succeeded at Sidi Rezegh in battering the XXX British Corps so badly that the commander of the Eighth British Army seriously considered breaking off the offensive. Overestimating the scope of his success, Rommel then decided on an enveloping pursuit on the next day. On 24 November he advanced with the Africa Corps in the direction of Maddalena, then wheeled north and arrived back at the Tobruk front on 28 November. Here, the situation had developed unfavorably in the meantime, since the enveloping forces had not been able in the long run to beat off the repeated attempts of the enveloped British forces to fight their way out. The enveloping ring had been breached already on 22 November at el Duda, although the breach was locally restricted. The Africa Corps now only had roughly 100 serviceable tanks available and was no longer strong enough to restore the situation, so that it became

necessary to raise the siege on 7 December. The difficult maneuver of swinging the Italian Division, the Africa Division and the artillery forces westward was performed successfully and a new front was established in the Ain el Gazala line. This position had to be abandoned on 16 December because it was in danger of being enveloped from the south.

For tactical reasons, Rommel thought it impossible to hold the Cyrenaica, which protruded northward and provided ideal opportunities for the enemy to by-pass it, although the Italian command, for political reasons, demanded that he do so. He therefore decided to withdraw toward Benghazi-Agedabia.

This movement was carried out in the following manner:

(1) The Africa Division was dispatched through the Cyrenaica in order to take possession of the important town of Agedabia before the arrival there of an enemy column reported to be advancing westward through the desert.

(2) The Italian division was also moved through the Cyrenaica to the rear on vehicles of the supply transportation columns.

(3) The Africa Corps and the motorized Italian division at Mechili were to advance straight through the desert to Benghazi.

The motorized units carried out the movement successfully, but the available transportation space was unfortunately inadequate to move all Italian infantry forces to the rear.

At Christmas the Panzer group was ahead of Agedabia. On the last day of the year the Africa Corps, which was echeloned to the right, was once again clearly successful in a defensive action against the pursuing enemy forces and destroyed a large number of enemy tanks.

Two additional factors alleviated the situation for the armored group. One factor was the considerable reinforcement of the German air forces through the transfer of the Second Air Force Command, with the II Air Corps from the East Front to Italy and Sicily, which transfer had commenced toward the end of November. As a result, the hitherto overwhelming superiority of the British in the air was somewhat reduced. The second factor was the fact that the extremely tense supply situation was relieved by the arrival of two big convoys at Tripoli with supplies of all sorts, replacement tanks and two tank companies and artillery which were organic to the units in Africa. This was the first supply shipment to arrive between 16 September and 15 December 1941, during which period not a single ship had reached African ports.

In spite of the relieved situation, Rommel decided not to await the enemy attack in the Agedabia area and in early January retired to

the Marada-Marsa el Brega line, where he hoped that his right flank would be better protected by the salt marshes.

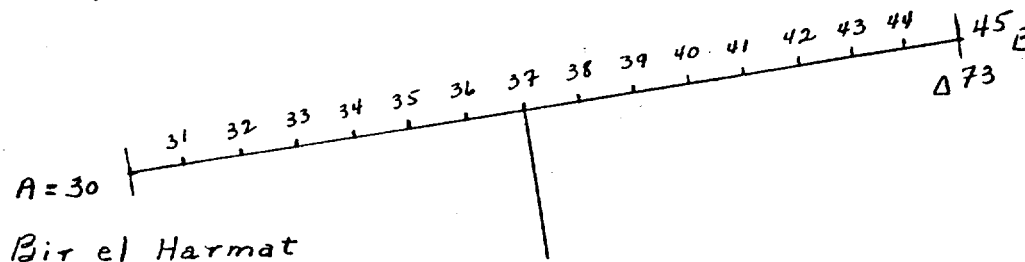
The more important lessons learned in the battle that has been described above in broad outline are as follows:

(1) The old maxim that reports should be sent in as frequently as possible was frequently not observed, although orders had been given that a brief radio report was to be sent in every two hours, with the provision that the single word "unchanged" or a statement of position would be sufficient.

(2) Similarly, not all of the units reacted automatically to any development by carrying out new reconnaissance.

(3) The use of the "directional line" with the aid of a few natural reference points in reporting and in issuing orders proved an excellent system, particularly under desert conditions. This system is as follows:

A directional line is drawn between two points on the map, from Point A to Point B. Starting at Point A, this line is marked and numbered consecutively at intervals of one centimeter. Positions can now be reported by this line; for instance, 3 right of 37 would mean a point 3 centimeters east of 37 on the map, as shown below.



The starting number for the consecutive numbering of the centimeter marking can be fixed as desired. Brief orders can be signalled in clear text with the aid of the directional line. It goes without saying that the line must be changed frequently.

(4) Another point that had adverse effects was the fact that not all unit commanders or their General Staff officers were at all times precisely informed on the supply situation of their units. At all times every unit commander and his assistants must know exactly how much fuel and ammunition of the more important types his unit has available, what quantities of supplies are to be expected within the next twenty-four hours and what percentage of the most important weapons are ready for action. This knowledge is indispensable as a basis for all command decisions.

(5) Under desert conditions the frequent penetrations by armored forces and the open terrain expose the higher level staffs to danger to a far greater extent than is the case in any other theater of operations, so that all staffs must be protected by close defense antitank weapons. For this reason the Panzergruppe and the Africa Corps had organized so-called combat detachments consisting of tanks, antitank and antiaircraft guns in battalion and company strength, which also proved very useful as a tactical reserve.

(6) One feature peculiar to the desert operations in 1941/42 was the constant threat to the southern flank of the side that happened to be on the defensive, the northern flank generally being well-protected since it extended to the coast. This danger to the German right flank made it necessary to have strong mobile forces, with ample supplies of fuel, echeloned far to the right in order to avoid being forced to abandon a position by-passed by the enemy.

(7) In desert warfare, retrograde movements will usually be restricted to roads and will be difficult owing to the lack of natural obstacles favoring new defense lines. Only if a firm control is maintained during retrograde movements over great distances will it be possible to prevent the retreat continuing beyond the intended point and the danger of disintegration. For this purpose it is also necessary to compel the rear echelons, such as the transportation columns and so forth, to halt at intervals.

(8) Owing to the dust that is caused by any movement on the ground, it is difficult to differentiate between friend and foe from the air. For this reason bombing stop lines must be established and clearly defined with due allowance for safety factors.

e. Mid-January to the end of May 1942: The counter-offensive to retake the Cyrenaica; preparations for the attack on Tobruk.

On 10 January 1942, the Panzer Group reached the Marada-Marsa el Brega line, where new defense positions were to be established. However, the remaining units, particularly the Italian troops, had been so far reduced in numbers during the previous fighting, that they would hardly be able to hold the sixty kilometers of frontage against any major attack by the enemy for longer than twenty-four hours. A careful examination of the situation revealed that the enemy forces were still echeloned far to the rear, so that they were in a critical situation similar to that they had been in the previous year. The coastal road remained closed to them until 17 January, when Rommel approved the surrender of the troops holding the Halfaya Pass since their supplies of ammunition and foods were exhausted. A careful examination of the strength ratios showed that at the moment the German and Italian forces were even superior to the hostile forces at the front. Now was the moment to take preventive action, to interrupt the assembly of the enemy forces through a counterattack and to delay his preparations for the continuation of the offensive.

Rommel therefore decided to launch an attack with limited objectives in order to decide on further action as the situation developed.

The attack was scheduled for the morning of 21 January. Various deceptive measures were taken to conceal the German intentions, including strict secrecy concerning the intended attack. Thus, regimental commanders were informed only one day before the attack was to start. Also all vehicular traffic in the direction of the front was to cease during daylight from the fourth day preceding the attack. From then on vehicular traffic toward the front was firmly restricted to the nights. These measures proved fully successful.

The attack was carried out as follows:

The 90th Light Division, hitherto the Africa Division, was to break through the enemy lines on either side of the coastal road and to advance toward Agedabia. The motorized Italian corps was to follow immediately and was then to advance south of the Via Balbia while the Africa Corps was to start out from an assembly area thirty kilometers south of the Via Balbia in an enveloping pursuit designed to prevent the retreat of as many as possible of the enemy forces. The breakthrough by the 90th Light Division succeeded as planned, but Army Headquarters, to which the command had been upgraded on 21 January 1942, received no reports from the Africa Corps for a long time. The corps had run into a patch of deep sand, so that it could only move forward with difficulty. The intended envelopment thus failed.

On 22 January Agedabia was taken. In the following days two attempts to pocket sizeable enemy forces in the Antelat-Saunnu area failed as the German forces were too weak and their intention had been recognized at an early stage. However, large quantities of materiel were captured in a surprise raid on Msus.

The Italian Supreme Command approved an advance as far as Agedabia but not beyond that point. It feared reverses that might again endanger the Italian infantry divisions because of their lack of mobility. The employment of these divisions forward of the Marada-Marsa el Brega line was therefore not permitted. Rommel nevertheless persisted in his intention to take advantage of the opportunity of the moment. He advanced through the desert at the head of a specially organized battle group and on the evening of 29 January captured the Benina quarter of the city of Benghazi. There he received Mussolini's belated approval of this advance. On 30 January, Benghazi was captured and a brigade taken prisoner. In the following days, the pursuit was continued straight through the Cyrenaica. Derna was taken on 4 February.

The condition of the troops and the lack of fuel prohibited any attempt at attacking Tobruk so that, from 7 February on, the units were compelled to organize themselves in defense positions, with the north flank based on the Bay of Bomba in front of the British positions at Ain el Gazala.

Since it was now to be expected that the exhaustion of the troops on both sides would lead to a period of comparative quiet, Rommel flew to Rome and Germany in order to learn the intentions of the Italian Supreme Command and of the Wehrmacht High Command with regard to the conduct of war in the Mediterranean, in 1943. He found that practically no plans existed and that the Italians were even very averse to any offensive operations before autumn.

In April Rommel therefore again took the initiative on his own responsibility. His opinion was that it was necessary to take anticipatory action against a new offensive by the enemy, which he expected in June, probably with even stronger forces than before. It was vitally important to capture both Tobruk and Malta, the latter of which, as a naval and air base, interfered with German seaborne supply traffic to an extent that could not be tolerated. However, since the German air force could support only one of these operations at a time, it would be necessary for them to take place in succession. He considered it desirable to attack Malta first and then Tobruk. However, if the preparations for the capture of Malta required too much time, he thought it best to attack Tobruk first so that, after that town had been taken and the border line from Sidi Omar-Bardia reached, all air force strength could be concentrated against Malta.* Rommel's suggestion was that the attack on Tobruk should open in the second half of May.

After some argument, this suggestion was approved and it was decided that Tobruk was to be attacked first owing to the fact that it would take longer to prepare for the attack on Malta. The supply situation was exceptionally favorable in May, so that adequate quantities of fuel were available in Africa by the intended date of the attack, 26 May. To a considerable extent the ammunition situation was also relieved.

Important lessons learned in this phase of the campaign:

(1) In pursuit actions, success depends not so much on the strength of the pursuing force as on speedy action, and thus to a considerable degree on the personality of the commander involved. Relatively small units under young and energetic commanders (colonels) proved most effective.

(2) It is highly important to assign air liaison staffs to the pursuit forces. These staffs must be equipped with radios, so that they can direct the close support air units to worthwhile targets and above all so that they can constantly report the lines reached to units in the air, and thus prevent the air forces from bombing their own forces on the ground.

(3) To envelop enemy forces is more difficult in the desert than elsewhere, since natural obstacles, such as rivers and so forth, through which manpower can be spared, do not exist.

* An advance into the interior of Egypt was thus not discussed.

(4) It is not to be expected that any attempt to take the enemy by surprise through the use of deceptive measures that have once proved successful, such as air attacks on the enemy headquarters, will meet with success.

(5) Terrain reconnaissance cannot be carried out too carefully.

f. Late May-July 1942: The battle of Tobruk and the pursuits to El Alamein.

The operational plan underlying Rommel's new offensive was as follows:

(1) Frontal attacks by the X and XXI Italian Infantry Corps, which had been consolidated temporarily to form Armee Abteilung Cruewell,* to commence on the afternoon of 26 May in order to tie down the enemy forces in the Gazala position.

(2) Advance of the five mobile units under the personal command of Rommel in a move around the right flank of the enemy at Bir el Hacheim in order to wheel in on the rear of the enemy on the 27th and complete the envelopment by 28 May. Counting from the right, the five units were disposed as follows: 90th Light Division, German Africa Corps with the 15th and 21st Panzer Divisions, the Italian motorized corps with the "Ariete" Armored and the "Trieste" Motorized Divisions.

(3) After the elimination of the bulk of the British Eighth Army's forces in the field, attack on Tobruk.

These plans miscarried for the following reasons: The two Italian infantry corps were too weak to tie down the strong enemy forces effectively. Initially, the enemy was admittedly taken by surprise by the forces that by-passed his south flank. Then, however, the attacking column spread out fanwise as the result of the 90th Light Division turning northeast and the German Africa Corps north, while the Italian motorized corps, pivoting on the inner flank, was forced to move toward Bir el Hacheim and also reduced the speed of its advance. This fanlike disposition of the attacking forces greatly facilitated the defense.

On the evening of 27 May, the attacking mobile force, which had split into three groups, was in a critical situation and in serious danger of itself being encircled. Furthermore, up to 29 May, Rommel to a great extent was unable to exercise his command, having become

* A temporary organization commanded by a corps commander with a corps type staff.

separated from most of his radio stations. Supplies had to be routed around Hacheim and, as convoy forces were lacking, large amounts of materiel and numerous vehicles were lost.

Nevertheless, in spite of this unfavorable development, Rommel steadily persisted in his intention to take Tobruk. He concentrated his forces once again, established a defensive front facing east and, from 1 to 6 June succeeded in eliminating a number of enemy strong points south and west of the enemy position one after the other. In this way, and in coordinated action with Armee Abteilung Cruewell, he succeeded by 31 June in opening up a direct supply route which, however, was under fire during the daytime in most parts.

Having thus eased the situation behind the center of the enemy front, he proceeded to eliminate Bir el Hacheim, a bastion in his rear. This point was well-fortified with field-type positions and was tenaciously defended and it was not taken until 12 June. Now the German Africa Corps advanced northward on Acroma, where it destroyed considerable armored forces by 14 June and threatened to cut off the two divisions in position in the northern sector. One of these divisions fought its way out eastward, while the other cut its way through the Italian forces by way of Bir el Hacheim toward the south. Now at last the road was open to Tobruk, which the British were determined to defend. A new deceptive ruse of Rommel's now proved successful. In the afternoon on 19 June he moved his German Africa Corps eastward past Tobruk on the south, moved it back during the dark and on the morning of 20 June attacked the fortress from the southeast. On the following day the fortress with its garrison of 25,000 and enormous stocks of supplies was compelled to capitulate. On 23 June Rommel crossed the border with the bulk of his forces, the 90th Light Division already having advanced to Sidi Barani.

Thus, the operational objective had been gained and the time had arrived to release the bulk of the air forces for operations against Malta. The Italian Supreme Command and Field Marshall Kesselring, Commander of the Second Air Force, still had the intention of now directing their attention to Malta, but Rommel believed that he now had an opportunity that would never recur of pushing ahead to the Nile. He was supported by the German High Command in this opinion and succeeded in getting his way. The attack on Malta was postponed and the main mission of the air forces was to continue supporting the pursuit in the direction of the Nile.

On 28 June, Mersa Matruh was captured and on 30 June Rommel arrived with his thoroughly exhausted troops and only fifty serviceable tanks before the Alamein position, which was better fortified than any position hitherto encountered. Two attempts to break through the newly established British front there failed on 1 and 10 July, whereas serious crises resulted from numerous counterattacks by the British between 15 July and the end of the month, the British directing their attacks chiefly against sectors of the front that were held by Italian troops.

Supply traffic again diminished considerably, so that for this reason alone, if for no other, any new offensive was out of the question. It was found that Tobruk, as a naval base, had far smaller off-loading capacities than had been expected.

In order to hold the front of about seventy kilometers, new units had to be transferred to Africa and the 164th Light Africa Division, the Parachute Instruction Brigade and the Italian Folgore Parachute Division were brought across by air and sent into action. Transportation of the Italian infantry divisions from Libya took a great deal of time.

The more important lessons to be learned from this phase of the campaign were the following:

(1) Once again, several tactical surprise actions had been successful, because methods were changed each time. On the other hand, the "dust deception" ruse was no longer effective. Rommel had had airplane propellers installed in a number of vehicles for the purpose of creating clouds of dust. These vehicles had been organized into a dust producing platoon from which he expected good deceptive results which, however, did not materialize.

(2) It is dangerous for a force to leave a major strong point in its rear unguarded even temporarily. If the forces available are inadequate to envelop the strong point, strong reconnaissance forces capable of combat should at least be left to keep it under observation and if possible to contain it.

(3) The British minefields, the extent and distribution of which was unknown to the German command, and the mined zones in the Ain el Gazala position frequently compelled the command to make tactically disadvantageous changes in its plans. They also proved a good substitute for terrain obstacles, of which there is a lack in deserts.

(4) Attack columns must be held together tightly and units should only be detached for some separate purpose in cases of extreme urgency.

(5) Commanders at higher levels should not change their positions too frequently, even if the attack is progressing favorably. The commander definitely must designate some specific spot as his command post and must maintain that post as a fixed point, even if the situation is unclear.

(6) In air attacks on enveloped strong points or bases it is necessary to designate the targets to be bombed with minute precision in order not to endanger the attacking ground forces. This is particularly difficult under desert conditions.

(7) Supply columns are defenseless and require protection in convoys when the situation is unclear or confused. Otherwise they are apt to fall prey to the enemy reconnaissance.

(8) In defense positions, the tanks also should be dug in at once. This should be done in such a manner that they can drive out of the positions immediately if necessary. The space between the tank and the surrounding ground in the trench provides good protection for personnel against enemy fire and bombs.

g. August-early November 1942: The battles around Alamein.

At the beginning of August the strengths on both sides were about equal. Neither the Eight British Army nor the German forces had any appreciable measure of superiority.

It was clear to Rommel that time was working against him and that as soon as the enemy had brought forward sufficient reinforcements he would launch a powerful counteroffensive.

He therefore did everything possible to improve the German positions, with particular stress on the use of mines, including air bombs which were buried and prepared for electrical detonation. He even had what he called "mine gardens" laid in the outpost area and had all battalion command posts surrounded by minefields. In distributing the forces in the northern half of the defense line, which he considered the most endangered and which was in the zone of the Italian XXI Corps, he placed Italian battalions and battalions of the 164th Light African Division alternately.

As soon as the supply situation permitted, Rommel intended making another effort from the other end of the line to break through to Alexandria. However, for the moment this was not possible, especially because of the fuel situation. Toward the end of the month sufficient supplies of fuel would at last be available if a large tanker, which had left Europe, managed to reach Tobruk. It was on this hope that Rommel, supported by the Italian Supreme Command and by Kesselring, based his plan to break through the southern part of the front, which was held by weaker forces than the rest of the British line, on the night of 30-31 August and advance by way of Alam el Halfa to Alexandria.

The breakthrough, which was to take place at night at two points and in two waves, with the German Africa Corps on the right and the 90th Light African Division on the left, followed by the Italian motorized corps as the second wave, was delayed until after daybreak. The commander of the 21st Panzer Division was killed and the commanders of the German Africa Corps and of the 90th Division were both wounded. When this blow was followed in the morning by the news that the tanker, which had arrived in Tobruk, had been torpedoed and sunk, Rommel intended breaking off the operation. However, the chief of staff of the

German Africa Corps induced him to continue the attack, which was making good headway. Field Marshal Kesselring also very emphatically favored continuation of the attack. The attack actually soon began to move forward but already in the evening of 31 August the shortage of gas began to make itself seriously felt. Furthermore, a sandstorm which had been blowing continuously, stopped after several hours and enemy air attacks commenced with an intensity that had not been experienced before. At this stage the five German and Italian divisions were behind the enemy front, where they were unable to move for several days. They were attacked by the enemy air forces daily between 0700-1700 and 2200-0500 and suffered very heavy losses in personnel and materiel. Kesselring had promised to deliver 400 tons of fuel per day by air if necessary, but only a fraction of this quantity reached the troops. The reason for this was that the transporting planes consumed most of the fuel themselves on the long trip. It was only on 3 September that sufficient fuel was available to commence moving back to the jump-off positions, which were reached on 6 September.

The following weeks were utilized mainly to further improve the defense positions. The three German and three Italian mobile divisions (the Italian Littoria Armored Division had arrived meanwhile), were organized in three tactical reserve groups, one German and one Italian division to each group, and held ready for action. Toward the end of September heavy air attacks were launched by the enemy against German airfields and the ground installations of the German air force, which fact could be taken as a sign of an impending offensive.

The offensive commenced at 2300 during the night of 23 October which was a dark, moonless night.

In this offensive, the British Eighth Army employed

- 3 armored divisions
- 7 motorized infantry divisions
- 7 tank regiments, which operated independently.

For the defense, Rommel had available

- German forces: 2 Panzer divisions
- 2 light divisions
- 1 parachute division

- Italian forces: 2 tank divisions
- 1 motorized division
- 1 parachute brigade
- 4 infantry divisions

The British had 1200 tanks, among which were some of the latest Grant models. Rommel had 200 German and 250 Italian tanks; the latter of very little value in combat.

The Allied superiority in the air was more pronounced than ever before, reaching a ratio of 10:1 at times in heavier type bombing aircraft.

In artillery and ammunition supplies the enemy likewise was overwhelmingly superior.

The British attack opened on the northern part of the front, with the point of main effort shifting southward later, and by 29 October the defenders had been forced to throw their last tactical reserves into the battle.

The first attack was on the Italian strong points, and after taking these, the British enveloped the points still held by German forces.

The "mine gardens" referred to previously did not have the desired effect, because many of the mines had been detonated by the artillery fire or during bombing attacks.

Although every inch of ground was hotly contested, a few kilometers being lost each day at the utmost, it was impossible to hold the field permanently. Rommel therefore found himself forced to withdraw if he did not want to risk complete destruction at Alamein. Consequently, he commenced withdrawing at the last possible moment on 3 November, contrary to Hitler's express orders. By that time the enemy had broken through the German lines on a front of twenty kilometers. The 90th Light Africa Division had been moved to the rear previously in order to take up support positions at Fuka, where no defense line had been prepared owing to the lack of forces. The bulk of the Italian forces were captured because no vehicles were available to render them mobile, as had been done with the Parachute Instruction Division and the 164th Division. A great part of the German divisions succeeded in escaping capture.

From this phase of the campaign the more important lessons to be learned were:

(1) The fact that the decision to attack on 30 and 31 August was based on a very insecure supply situation and the hope that the 5000 tons of fuel would arrive, was risky, but to persist in this decision, after it was learned that the fuel tanker was sunk, resulted in dire consequences.

(2) Once again it was proved that only fully motorized units can be used in the desert.

(3) The defense would have been more successful if some of the mines laid within the main battle zone had been used in the rear to compel the enemy to change the direction of his drive frequently.

In this way, the effectiveness of the main defensive weapon would not have been spent so soon.

(4) In transporting fuel by air, due allowance must be made for the fuel which the transporting planes themselves will consume.

h. November 1942-January 1943: The retreat to the border between Libya and Tunisia.

The retreating troops, consisting almost exclusively now of German forces, particularly of the German Africa Corps and the 90th Light African Division, did not succeed in establishing a new line of resistance at Fuka, and even Mersa Matruh had to be abandoned on 8 November because of the danger of its being by-passed. Whereas the German forces had been under constant attack from the air by day and by night, these attacks gradually decreased temporarily because of the effects of heavy rains on the British airfields in the Nile Delta. A halt of one day was called at Sidi Barani, where considerable elements of the Parachute Instruction Brigade rejoined the army. They had set out to march through the desert on foot but had captured vehicles in a successful raid on British supply columns, so that they were again mobile.

Thanks to the precautionary measures that had been taken to build up an effective antiaircraft defense there, the Halfaya Pass, which would have presented difficulties owing to the enemy superiority in the air, was crossed without serious losses.

The idea of defending Tobruk was weighed but rejected almost immediately as it would have amounted to voluntarily accepting a siege. The retrograde movement continued, the Cyrenaica being abandoned up to the Marada-Marsa el Brega line, which was reached by the first combat units on 18 November. Here, at last, there was an opportunity to reorganize the units. Rommel expected a long stay at this point, since the enemy required time to close up his units from the rear and to move forward his supply bases.

On 28 November, Rommel flew to Hitler's headquarters, where he unsuccessfully suggested that the African theater of operations be abandoned. After his return from this trip, he decided to construct a rear position at Buerat. On 8 December work on this position commenced. German units which required a period of rehabilitation, namely, the 164th Light African Division and the Parachute Instruction Brigade were employed for this purpose as well as rear elements of the German Africa Corps and native labor, all under the direction of the commander of the 164th Light African Division. One of the main features planned by Rommel in this line was an antitank ditch in front of the positions, but owing to the lack of time and the inadequate labor forces available, only parts of this ditch were completed.

On 10 December Rommel found himself compelled to abandon the Marada-Marsa el Brega line, since he feared that it would be by-passed. For the same reason he abandoned the Buerat positions on 18 January 1943. At no point did he have sufficient armored reserves with an adequate supply of fuel to counter any attempts the enemy might make to outflank him.

Altogether, fuel supplies had become the major problem of this retreat. As no ships at all arrived in African ports, with the exception of a few military transporters with a gross tonnage of 400 tons, the army was entirely dependent on air transportation so far as fuel supplies were concerned. On one single day 200 tons were delivered in this way, but on all other days the performances were far lower, rarely being more than eighty tons and on one day only two tons arrived. At any rate, the promised performance of three to four hundred tons daily to be delivered by air was never achieved because of weather conditions and enemy activity. The fuel shortage was so serious that it was not even possible to take advantage of very favorable opportunities which presented themselves frequently to damage the pursuing enemy forces, since every drop of fuel had to be hoarded. Things even got so bad that, in order to conserve fuel supplies, one motor vehicle was used to tow several others. This could usually be done along the coastal road, which was fairly level in most parts.

On 23 January Tripoli was abandoned and the retreat continued toward the Tunisian border, which was reached by the end of the month.

Important experience gained in this phase of the African Campaign includes the following points:

(1) Before the battle began, Army Headquarters should have combed out the transportation columns of the German Africa Corps and the 90th Division rigorously. These services were, admittedly, extremely limited anyway, but a number of vehicles could have been obtained in this way to form a transportation reserve separate from the supply transportation services, and this reserve would have been available for the transportation of the infantry.

(2) In the face of enemy superiority in the air, it is impossible to maintain supplies for large units by air.

(3) The rule that during a retreat all dispensable elements must be set moving to the rear under a central command ahead of time, but must be directed firmly from point to point, also applies in desert warfare.

(4) It proved even more difficult than in the previous year to intercept stragglers, since there were no natural features in the terrain that facilitated the establishment of straggler intercept lines.

(5) Even during the retreat the lack of engineer forces was seriously felt.

(6) The mining of air fields by scattering mines indiscriminately proved to be effective for a shorter time than had been expected.

(7) The Allied air forces made the mistake of attacking at regular times of the day. They commenced flying their sorties at about 0800 each day, ceased about 1200 and then continued from 1400 to 1700 hours. The German troops were able to take advantage of the intervals to increase the speed of their march.

i. November 1942 to March 1943: The occupation of Tunisia and the battles fought in Tunisia.

Extraordinarily heavy convoy traffic in the direction of the Straits of Gibraltar was observed on 6 November 1942. The Italian Supreme Command in Rome as well as Field Marshall Kesselring, Commander-in-Chief South and Commander of the Second Air Force, immediately feared that the Allies were going to land in force in French Northern Africa, a view which the Wehrmacht High Command, however, did not share. In fact, Goering, as Commander-in-Chief of the Luftwaffe, forbade the employment of strong air forces against the ship movements, which Kesselring had intended.

When the Allied forces landed in Morocco and Algeria on 8 November, they were met by French troops alone. The German and Italian control organs of the Armistice Commission were only a few hundred strong and were valueless for combat purposes.

It was only on 10 November that the Wehrmacht High Command ordered the Commander-in-Chief, South,* who now for the first time was to take a part in ground operations, to occupy Tunisia. The only forces in Italy at that time were individual units of Rommel's Army, which were awaiting transportation to Africa. No integrated body of troops was available. For this reason the occupation of Tunisia bore the imprint of an improvisational measure from the very outset. The first unit to be moved there was a guard battalion of the Luftwaffe, which was transported by air. This unit was followed by a fighter group and Italian elements.

On 15 November, General der Panzertruppe Nehring** assumed command over all units employed in Tunisia as Commander of Tunisia. He

*Kesselring was given this title as the representative and coordinating head of German forces employed in the Mediterranean theater of war. Up to this point he had command authority only over the air forces and in a restricted degree over the small naval combat units employed in the Mediterranean.

**Commander of the German Africa Corps from February to September 1942, initially as deputy and then as successor to General Cruewell.

succeeded in gradually extending the occupation, which at first had been confined to the immediate surroundings of Tunis, so that by the end of November, Sfax and Gabes, in the south, were also occupied.

After the transfer of additional German units, the advance units of the British First Army, operating in the north, were pushed back to Tabarka and Medjez el Bab. The port of Bizerta was surrendered by the French without any resistance.

On 8 December 1942, Generaloberst von Arnim, as commander of the newly created Fifth Panzer Army, assumed command over all army forces in Tunisia. Owing to the beginning of the rain period, the Allied forces in Morocco and Algeria were unable to move their units eastward, so that it was possible to consolidate the position in Tunisia by the end of the year and to establish an admittedly thin line of resistance against the British in the north, French forces in the center, and a US Corps in the south, in a general line east of Tabarka-Medjez el Bab-Fonduk-Faid-Maknassy. In the battles which took place on this front in early 1943, particularly in the central sector, a number of local successes were gained.

Early in February, Rommel arrived with his army in the Mareth Line. This was a line of French fortifications at the former border which had been stripped at the demand of Italy after the defeat of France in 1940. The Mareth Line offered several advantages. It was only 95 kilometers long, was protected by a continuous line of anti-tank obstacles and its south flank was securely anchored on the almost impassable Matmata hills, so that it would only be possible to dislodge the German-Italian Armored Army by an enveloping movement entailing a wide detour. On the other hand, there was the disadvantage that the supply route to Tunis, which was more than 400 kilometers long, could easily be cut by advancing US forces, since the 100 kilometer section between Maknassy and Schott el Djerid was not protected owing to lack of forces.

To remove this threat to his rear, Rommel, on 14 February 1943, attacked at Faid, employing the bulk of his forces in the attack, some of them advancing by way of Gafsa, while the enemy forces were contained by elements at Fonduk. In this attack he had available units of the Africa Corps, including the 21st Panzer Division, and the 10th Panzer Division, which had been made available to him temporarily by the Fifth Panzer Army. Rommel succeeded in breaking through at Faid and in advancing to Tebessa through the Kasserine Pass, which he held for ten days. The American troops, which were still unaccustomed to combat, suffered considerable losses, and for the time being the threat to the rear communications was removed. However, he no longer had sufficient forces for the drive on El Kef which Hitler and Goering desired.

Since the German-Italian Armored Army under Rommel and the Fifth Panzer Army under von Arnim had now come into immediate tactical

contact, a reorganization of the chain of command became urgently necessary. On 1 March 1943 the Army Group Africa was created and Rommel appointed as its commander. This army group was assigned the Fifth Panzer Army and the First Italian Army, the latter under the command of General Messer. Hitherto, the First Italian Army had been a part of Rommel's army. The African Air Corps, which also had just been created, was to cooperate with the army group.

On 6 March the Africa Corps launched what was to be its last attack in Africa. The plan of this attack was to strike the British Eighth Army on the flank while it was preparing for its new offensive. The armored units carrying out the attack were to operate from the Mareth Line. However, the general commanding the forces in this attack had no experience in this theater of operations and the attack was halted by the heavy antitank defense of the enemy and as a result of the clear superiority of the enemy in the air. Heavy losses were suffered. Rommel had seriously doubted the chances of success from the beginning, but was unable to escape the necessity of gaining time.

At the express order of Hitler, Rommel left the African theater of operations on 9 March 1943, Generaloberst von Arnim succeeding him as commander of the army group, while General von Vaerst assumed command over the Fifth Panzer Army.

On 16 March the British Eighth Army commenced its preparatory attacks against the Mareth Line, following up with the main attack in the night of 19 March. After crossing the antitank ditch, which was accomplished with difficulty, the enemy, with strong air support, succeeded in expanding the penetration. Nevertheless, a German counterattack on 22 March succeeded in recovering the greater part of the ground that had been lost. Then, however, on 26 March, Montgomery, employing two divisions, succeeded in breaking through the flank position so that the Italian First Army had no choice but to withdraw to the Akarit wadi, where the line was thirty kilometers long and well protected on both flanks.

The following are the main points of the experience gained in this phase of the campaign:

- (1) It took some time before the command and troops of newly arriving units in Africa accepted and adapted themselves to the conclusions that had to be drawn from the overwhelming Allied air superiority. One of these conclusions is that, in the face of enemy air superiority, the employment of massed armored units is doomed to failure.

- (2) Once again the value of speedy action was proved by the seizure of Tunisia, which took place solely with improvised means.

(3) The hopes centered on the short supply route from Sicily to Tunis did not materialize. The chance no longer existed of forcing the enemy to dissipate his air reconnaissance and air combat forces by using a number of sea routes. The enemy was now able to concentrate his air attacks against the one existing sea and land route of supply. For this reason, the supply situation, which was eased temporarily in early 1943, worsened steadily. From the end of March 1943 on transportation by large ships, which was the only way in which requirements could have been met, ceased almost completely.

k. April-May 1943: The final battles in Tunisia.

The attack by the British Eighth Army against the German-Italian positions at the Akarit wadi began at daybreak on 6 April. Although the defenders were taken by surprise, the attack failed to penetrate. However, the increasing number of Italians who deserted showed how the morale was declining. In the German units the shortage of ammunition for the artillery and special weapons was becoming more and more serious.

An attack by the US Corps in the direction of Gafsa-Fonduk resulted in a breakthrough at Gafsa and, in view of the threat to the rear that now developed, made the evacuation of the Akarit wadi position unavoidable.

In the rear of the Akarit wadi position was an extensive section of hilly country, which offered no good protection for the west flank, so that it was now necessary to retire to the Pont du Fahs - Enfidaville line, about 180 kilometers to the rear, and to abandon the intervening terrain to the enemy almost without a fight. On 13 April, the Italian First Army moved into this line, which was about fifty kilometers long, and in doing so for the first time made contact with the Fifth Panzer Army, which was holding the 120 kilometers of front extending from the coast in the north to Pont du Fahs.

In May, event followed event in rapid sequence. On 3 May the British First Army penetrated as far as Mateur which necessitated withdrawal of the north flank of the German-Italian front to the area immediately west of Bizerta.

In the decisive and final attack, the enemy moved in two divisions of the British Eighth Army and directed his point of main effort at the center of the sector held by the Fifth Panzer Army, which he penetrated, with strong air support, at 1530 on 5 May. Tunis was captured by the Allied forces on the same day, Bizerta on 7 May. The southern flank, which was held by the Italian First Army, was not under such heavy pressure and was still intact when the western sector collapsed.

On 12 May all resistance by isolated groups ceased. Crowded together on the Cap Bon peninsular, more than 250,000 men, more than half of whom were German, were taken prisoner.

The Commander-in-Chief, South, had intended consolidating all staffs and withdrawing all specialists, such as gunners, radio specialists, tank crews, armorer artificers and so forth, in order to fly them to Europe and thus prevent the capture of at least the more important personnel. He was supported in this intention by the Italian Supreme Command but was prevented from putting it into effect by the Deputy Chief of the Wehrmacht Operations Staff, who intervened in April.

The following points in this final phase of the campaign in Africa deserve mention:

(1) The smaller the area becomes which is available to the defending forces, the more concentrated will be the effects of the force attacking with superior power, particularly in the present age of long-range weapons. A superior air force can almost completely paralyze all movements on the ground.

(2) The brief descriptions of the individual phases of the campaign given in sections a to k show that the time chosen for attack varied. Rommel preferred moonlit nights, while Montgomery chose a dark night at Alamein, for instance, but on the whole usually commenced his offensives at various times of the morning.

For the side that lacks air superiority, moonlit nights are particularly advantageous for attack, provided the troops have been adequately trained.

(3) The side that is weaker in air strength must restrict all movements of troops and supplies to the night, as otherwise raids by enemy fighter bombers along the roads would cause too heavy losses and might even bring all movements to a complete standstill for a considerable period of time. Movement at night requires careful planning and organization. Even for vehicles traveling alone it is advisable during the daytime to avoid main roads.

So far as the German side is concerned, the reasons for the defeat in Africa are to be found in the poor balance between ground forces, air forces and naval forces. This poor balance resulted in the temporarily inadequate support rendered to the ground forces in November-December 1941 and the permanently inadequate support from the autumn of 1942 on, which was insufficient in spite of the self-sacrificing efforts that were made.

It also resulted in the constant lack of adequate air and naval protection for supply transportation from Europe to Africa, the volume

of which was adequate only once, in April-May 1942. This again resulted in the ground forces always being short of supplies and later in their being handicapped by an acute lack of supplies of all kinds, particularly fuel and ammunition.

In operations in an overseas theater of war in particular, a well-considered balance between the three branches of the armed forces is of decisive importance. Attempts should never be made to offset deficiency of strength in the one branch by an increased use of another, which in the present case was the army.

CHAPTER III

Special Factors

8. Dust

a. Effect on Troops, Weapons and Equipment

Men in the desert are constantly exposed to the effect of dust. This bothers the fighting man all the more because he has to endure it in conjunction with heat and the lack of water. There is no universal remedy against dust in the desert. Dust is a betrayer, which enables one to perceive every movement for great distances, even by individual vehicles, both from the ground and the air.

Every footstep on the surface of the desert throws up dust and sand; moreover the almost perpetual winds carry along dust with them, generally in the form of dust columns as high as a house, which form themselves into whirlwinds and wind-spouts. In the beginning the German troops in the desert suffered considerably from dust and had to fight against mental depression. However, they quickly became accustomed to it, so that their fighting power was not affected to any appreciable extent. The dust there does not cause any injury to health, since it does not contain any angular or sharp-edged particles which might lead to lung diseases. The eye inflammations caused by dust did not have any serious consequences. It proved helpful to wear dust goggles, especially in the large clouds of dust produced by moving columns of motor vehicles. Therefore, every soldier in the desert was equipped with a pair of dust goggles.

The effect of dust on weapons and equipment, including motor vehicles, is considerable in the desert. Dust had the greatest effect on motor vehicles, because the dusty air which was sucked into the cylinders attacked the cylinders and pistons and caused these parts to wear out quickly. Special air filters reduced the wear, but could not prevent it altogether. In general purpose cars (Volkswagen) the air intake openings were installed in the interior of the car in order to give the engine purer air. In tanks the air was sucked out of the battle compartment. In spite of this, the average lifetime of a Volkswagen engine in the desert was only 12-14,000 kilometers in comparison with 50-70,000 kilometers in other theaters of war. In the desert it was necessary to change tank engines after about 3500 kilometers, while they would last for 7-8000 kilometers in Europe. To be sure, this was due not only to the effect of dust but also to a considerable degree to the necessity of driving long distances across country in low gears. The other parts of motor vehicles (such as the brakes, chassis, and all parts which could be penetrated by dust) also suffered considerably more wear and tear than under normal conditions. It is not possible to give any figures on this point. What is certain is that motor vehicles in the desert need substantially more lubrication than in other theaters of war. No special greases and lubricants were used.

The barrels of guns, as well as all unprotected moving parts, were especially affected by dust. The wear on barrels, therefore, was considerably higher than in a European theater of war. Machine guns, sub-machine guns and other small arms were the weapons most endangered, because inasmuch as they were used on the surface of the ground they were especially exposed to the effects of dust. It was, therefore, necessary to protect all the movable parts of guns and equipment, especially the breechblocks, by such expedients as wrapping them up when not in use, covering them with shelter halves or by other means. The barrels of artillery pieces and rifles had to be provided with muzzle protectors whenever they were not being fired. In view of the effects of dust, special importance was attached to the care of weapons and equipment, as well as to cleaning them frequently. Improvised dust-proofing devices have been discussed in detail in the former German field manual Combat in Deserts and Steppes and therefore no further mention will be made of them in this place.

b. Effect on Combat Operations

The generation of dust made it practically impossible to conceal marching columns. Dust clouds could be seen even at great distances and enabled one to recognize the size of the columns and sometimes even the type of vehicles (wheeled or track-laying). On the other hand, the effect of dust was also taken advantage of for purposes of camouflage and deception. Dust was often created artificially in the desert chiefly for purposes of deception. Rommel was the first to recognize the possibilities of this method, and he employed it up to the summer of 1942. However, even he often fell a victim to enemy deception measures. For details concerning the use of dust for purposes of deception and camouflage see Annex 6, Camouflage in the Desert.

We shall quote the following passage from the diary of Field Marshal Rommel concerning the importance and effect of dust:

"On 13 March 1941 I transferred my headquarters to Sirte so that I could be closer to the front. In order to save time I attempted to reach this area by airplane. In the area of Tauroga a sandstorm came up. The pilot of the airplane turned around, although I tried to get him to fly on. The trip was then continued by car. We were now forced to admit that we had had really no idea of the tremendous force of such a sandstorm. Huge clouds of a reddish hue obscured our vision and the car crawled slowly along the coastal road. Often the wind was so strong that one could not drive at all. Sand dripped down the car windows like water. It was only with difficulty that we could breathe through a handkerchief held in front of the face and perspiration poured from our bodies in the unendurable heat. That was the ghibli. In the silence I made my apologies to the pilot of my airplane. One Luftwaffe officer actually crashed with his airplane in the sandstorm that day.

"On 4 April 1941 I got underway with my combat staff at 0300 in order to bring the artillery battalions into their positions before daybreak. In the complete darkness we did not find the columns. On the next morning we repeated our attempt and were finally able to locate the artillery. Among other things, we ran into the rear of a British outpost area without knowing it. Although we only had three vehicles, of which only one was fitted with a machine gun, we drove up to the enemy at high speed while raising a great deal of dust. This apparently made the Englishmen nervous and they evacuated their position in great haste, leaving weapons and materiel behind."

Attention is also drawn to the various references to the effect of dust on combat operations in the description of the most important battles in the desert (see Chapter II, Section 7).

c. Effect on Tactical Measures

During the first attack on Tobruk dust had the following effects, concerning which we quote the following passage from Marshall Rommel's diary:

"The "Brescia" and "Trento" Divisions were supposed to attack Tobruk from the west and to raise a great deal of dust in the process in order to deceive and pin down the enemy. During this time the main attack group was supposed to swing around south of Tobruk in a wide arc through the desert and attack from the southeast. The dust which was thrown up deceived the enemy so thoroughly that he guessed that the attack would come from the west and paid no attention to the enveloping movement. When the enveloping group had reached its jump-off positions, their columns were struck by heavy British artillery fire. However, the air was soon full of heat vibrations and gusts of sand blew into the faces of the enemy. Good visibility soon vanished completely.

"On 11 April the encirclement of the fortress of Tobruk was completed. The "Brescia" Division opened the attack. A great deal of sand was blowing and the British artillery could therefore not be expected to direct any aimed fire.

"At about 1300 several enemy tanks moved past Ras el Madanier toward our lines. Because of the tremendous amount of dust, which moreover was being blown toward our positions, it could not be seen whether they were followed by any additional tanks and whether it was really a major attack. Therefore, I immediately committed all the antitank guns which were available in this area. It actually was a major attack and we succeeded in knocking out several tanks and halting the enemy advance.

"Around 1800 on 30 April a new attack was opened against Ras el Madauer. Numerous Stukas cooperated with us. Soon the hill was hidden in thick clouds of smoke and dust. The visibility of the enemy was reduced to zero. It was impossible for them to deliver any aimed fire. Our attack led to a complete victory."

During the advance of the German Africa Corps from the Alamein position into the British rear area the effects of sand varied:

After the Africa Corps had replenished its supply of motor fuel and ammunition in the morning of 1 September, it began to move about 1300. At first the attack made good progress in the violent sandstorm, which blew into the faces of the enemy. Unfortunately, the Italian divisions were very far off and were unable to take advantage of the camouflage provided by the dust clouds in their advance. The vehicles and tanks toiled laboriously through the deep sand drifts which covered the attack area. A fitful sandstorm raged all day and prevented the British air force from attacking in strong formations. When the sandstorm abated during the evening, the spearheads of our attack were engaged in stubborn combat with a strongly fortified enemy defense position and the attack came to a halt. Incidentally reference might also be made here to the statements given in Chapter II, Section 7.

The intervals which the advancing units were ordered to keep from each other in order to avoid dust varied according to whether the dust cloud was being blown in the direction of the advance or to the side. Moreover, since these desert expanses were in general easily traversed by all kinds of motor vehicles, it was possible to drive with gaps between the separate vehicles, thus reducing the effect of dust on the driver and his visibility. In general we used intervals of fifty meters, both in depth and width. During the night this interval had to be shortened for the sake of visibility in order to maintain contact with the man in front.

The generation of dust through the recoil of the powder gases in artillery firing, therefore, was of no special importance for the detection of artillery positions, because the combat zone was always enveloped in dust clouds anyhow. The discharges of guns of especially flat trajectory with a low barrel elevation -- antitank guns -- could be observed and recognized with particular ease by the enemy because of their characteristic dust clouds. Naturally, they also prevented the gun crews from observing the effects of their own fire.

d. Effect on Aircraft and Their Crews

Sand and dust had no appreciable immediate effect on airplanes and their engines, since sand filters were attached to the intake valves. Dust had no effect on the efficiency of the engine, but nevertheless one had to expect more rapid wear and tear on the engine,

because very fine dust particles were not entirely kept out by the air filter. Even the special precautions taken during refueling did not always provide hundred percent security.

Very heavy sandstorms made flights practically impossible because of the extremely poor visibility when taking off. However, they were comparatively rare. The ghibli brought sand out of the interior at heights of as much as 5000 meters; it was still easily visible 100 kilometers out to sea, and indeed occasionally was even carried as far as the European continent. This greatly hampered horizontal visibility, especially against the sun. Sometimes visibility was reduced to below ten meters. On the other hand, vertical visibility was only slightly impeded. It was only in exceptional cases that direct observation and aerial photography furnished satisfactory results about target details. In all airfields which consisted merely of sand it was difficult, and sometimes dangerous, for several airplanes to take off and land together. When there was no wind the dust remained hanging over the ground for an endlessly long time, so that in spite of extensive improvisations, formation take-offs failed in their purpose. Landings had even more unfavorable effects, since machines with empty fuel tanks simply had to land, in case they could not reach an alternate airport. When the wind was blowing, airplanes took off with a slight cross wind, so that the dust raised by the take-off would be blown to one side and not disturb the pilot behind. Difficulties also arose in dropping bombs on point targets, since the dust thrown up by the first bomb made it impossible to sight the target accurately. Although the breathing, sight and other functions of the men in the machine were hardly disturbed by sand, the radio equipment was more sensitive. Many radio failures could be traced to this cause. The most widely different methods were adopted to reduce the ill effects of dust in the airfields.

- (1) By selecting surfaces that were somewhat grassy or crusty even if they possessed other disadvantages.
- (2) By laying out abnormally large airfields or several airfields located close together.
- (3) By reinforcing the surface of airfields with asphalt or mats.

Nevertheless, dust and sand also had certain advantages for observers and scouts. They made it easier for the latter to detect every movement, even on trails and airfields. However, inexperienced crews often overestimated the strength of the enemy.

The tracks visible in the desert sand also enabled one to recognize where enemy troops had passed, as well as the strength and objective of the movement.

Besides the sand filters attached to the intake valves no protective devices were installed either in the engine or in the airplane itself. On the ground it was possible to protect airplanes, engines and machine parts against sand only to a limited extent by the use of awnings. Repairs were made in repair tents.

Summing up, it can be said that the Army and the Luftwaffe in general protected themselves successfully against dust in the desert by the most widely different means and by taking particular care of weapons, equipment and machinery. In general, weapons failed because of dust sooner than engines. These failures, however, were not of vital importance.

9. Terrain

a. Influence on Tactical Measures

A general description of the terrain was already given in Chapter II, Section 4. From this it is apparent that with the exception of places with deep sand and rugged valleys the desert in the combat zone of the German troops was in general passable for both wheeled and track-laying vehicles.

The influence of terrain on tactical operations is just as decisive in the desert as in other theaters of war. It is only more difficult to take advantage of the peculiarities of the terrain for one's own intentions, since due to the lack of forests, cultivated areas, villages, etc. it is seldom possible for troops to approach and assemble under cover. However, even in the desert there are the most widely different opportunities to take advantage of the terrain and, for example, to conceal troop assemblies in ravines and valleys from ground observation and — to a limited extent — even from air observation.

In both attack and defense the important thing was always to have reconnoitered the terrain carefully in advance.

In attack, importance was attached to choosing ground which could be easily traversed by motor vehicles, and, quite especially, which offered a covered approach, at least in parts, through the utilization of terrain contours. The fact that the desert surface was very easily traversed by motor vehicles made it easy to advance in light formations with few casualties, as well as to make all kinds of enveloping movements. In actual practice there were only a few limitations on freedom of movement. Thus, it was also easily possible to shift the direction of an attack. During an attack the tank battle always occupied the foreground. The attempt was made to compensate for the lack of good observation posts by sending out forward observers. Difficulties arose for the attacker if he was compelled to use the southern portion of the desert proper, which in places was covered with soft soil (see Annex 4, aerial photograph 15). In its attack of 30 August 1942 from the Alamein position, the Africa Corps had to contend with these difficulties. Above all, many motor vehicles became stuck in the passes which led from the ridge of hills to the depressions and thus offered welcome targets to the enemy air forces. The failure of this attack can be attributed in part to the unfavorable ground, together with the overwhelming air superiority of the enemy, the weakness of our own forces and the lack of motor fuel.

In defense, terrain was preferred which offered an opportunity to prepare reverse slope positions echeloned in depth. Moreover, the efforts of the troops to "crown the heights," which was dictated by the desire to see farther into the country lying ahead, had to be constantly combated. It was naturally also desired to have terrain in front and on the flanks which was not easily traversed by motor vehicles, but this wish could seldom be fulfilled. The following positions offered the most favorable opportunities for defense in the North African desert:

(1) The El Alamein Position: Here, although it was necessary to defend a strip of open desert and steppes sixty kilometers long by field fortifications, there were no possibilities for envelopment movements by major formations, since the position was blocked off on both flanks. In the north it was protected by the Mediterranean. In the south it had direct flank protection in the form of the northern edge of the Quattara Depression, (Senke), which has only three, easily guarded passes, namely, the one directly west of the Alamein position at Munquar Abu Dweis, then along the trail between Mersa Matruh and the Quara Oasis, and along the trail between the Quara Oasis and the Siwa Oasis.

Of these only the first was actually guarded by mine fields and troops; the two others, however, were utilized by the small sabotage teams of the Long Range Desert Group to penetrate our rear area.

Furthermore, the sandy soil of the Quattara Depression itself, which was filled with salt marshes, hampered movements by major units. Farther to the south the great sandy desert served as a barrier to the hinterland. The only passage between the steep edge of the Quattara Depression and the sandy desert led through the Siwa Oasis, which was fortified as a strong point.

(2) Farther to the west the Marsa el Brega position (see Annex 1, Map 6) was the first to offer good opportunities for defense again. Here the area of steppes and desert south of the coast contains many salt marshes and dunes, so that only narrow zones have to be guarded by field fortifications. The open desert begins south of the El Faregh wadi and extends to the area north of the Marada Oasis. The attacker, therefore, is forced to make a wide detour.

(3) The Tarhuna-Homs position east and south of Tripoli is flanked by the Djebel Nefusa in Tripolitania and takes advantage of the mountainous terrain, which is not easily covered by motor vehicles (see Annex 1, Map 7). Since the mountains descend steeply to the west but gently to the east, it can be more easily defended from attacks from the west.

(4) The two positions farthest west, which are the ones most favored by nature, lie in Southern Tunisia in the area of Mareth and Gabes (see Annex 1, Map 8). The former takes advantage of the heights

of Matmata Mountains and is protected against extensive envelopment in the south by the Great Eastern Erg (region of sand dunes). There is open terrain there in the form of a twenty-five kilometer strip between the coast and the Djebel Matmata, eighty kilometers wide between the southern end of Matmata Mountains and the great sandy desert. The Mareth position could be enveloped along this strip eighty kilometers wide, as first became evident during the fighting around the Mareth position.

The Akarit position situated north of Gabes is partially protected along its front and in its southwestern flank by salt marshes, which cannot be traversed by major units, and in the northeast by the sea. During the fighting here the British broke into this position at the places which were not protected by salt marshes and forced the defenders to surrender.

Between the five positions named above there were also three more defense lines which were used by either the Germans or the British during the hostilities. These positions are without any protecting obstacles and were only established as the result of the combat situation at the time, when the area behind them had to be held by the defender for tactical reasons. These were the following:

The Sollum position. It had no frontal obstacles. All strong points had to be dug into the ground. The northern flank was protected by the sea, the southern flank was open and could be easily enveloped. This position was chosen out of necessity, since the Germans intended to hold Tobruk and since this position was the key to the coastal highway and the important Halfaya Pass. Mobile units were organized behind the defense front in order to repel any enemy attempts at envelopment by mobile operations. During the British offensive in the winter of 1941 the front of this position was pinned down and enveloped in the south by strong British forces.

The Gazala position west of Tobruk was selected by the British as an outpost area for the fortress of Tobruk. It had no frontal obstacles, was protected in the north by the sea, and was open in the south. In May 1942 Rommel surrounded this position in a wide enveloping movement. (see Annex 9).

The Buerat position east of Tripoli had one weak frontal obstacle (Wadi Zem-Zem). The northern flank was protected by the sea; in the southern flank were several wadis which could be easily overcome by an attacker. Occupation of this position was ordered by the Wehrmacht High Command for the purpose of defending the eastern outpost area of Tripoli. It was enveloped by Montgomery during the British offensive in January 1943.

The three positions mentioned above were thus of slight value for the defense. The terrain situated between all these eight positions is unsuitable for a lasting defense, because everywhere it contains more

or less extensive areas of open desert and steppes. A defense in these areas, therefore, can only be conducted along mobile lines.

The fact alone that for a distance of 3800 kilometers there are only five natural defense positions of any use shows the great superiority of the attacker in desert warfare.

b. Influence on the Construction of Field Fortifications and the Use of Weapons

The German troops constructed only field-type fortifications in the desert. In building them an effort was made to keep the upper slope at ground level in order to prevent the enemy from recognizing them too soon. Special difficulties arose in constructing positions for antitank guns and heavy antiaircraft guns (high superstructures). They had to be emplaced on the reverse slope. In places where this was not possible the expedient was adopted of keeping these weapons in readiness in some place in the rear and not bringing them up to the position until they were urgently needed.

No experience was gained in the construction of permanent fortifications. However, it should be pointed out that the Italians laid out the fortifications of Tobruk so cleverly that they met with Rommel's unqualified appreciation. Their emplacements, which were level with the ground, were later introduced into the German Army as "Tobruk positions" and used both in Italy and on the Western Front.

From a purely technical point of view it is extremely difficult to prepare field fortifications in the North African steppes and desert (see Annex 1, Map 11). Wherever the ground in the steppes is stony it is very hard, because there is a layer of so-called "surface chalk" on the surface which has been formed in the following way: the rain water absorbed during the winter rises to the surface again during the summer and evaporates. During this process the dissolved matter, such as chalk, silicic acid, etc., is separated again and cements the top layers into a firm crust, having a thickness of from fifty centimeters to two meters. Under this surface chalk layer there is a so-called "lixiviation stratum," which is especially soft and therefore easier to work. In constructing field fortifications it is first necessary to laboriously blast away the surface chalk layer. Work of this kind can only be done if sufficient time is available. If a temporary defense system is being established, one has to be content with erecting positions built out of such stones as may be laying around, or else use steep slopes or ravines and fissures in order to get at the lixiviation stratum quickly.

The surface chalk layer is of maximum depth in the steppe area, which extends about thirty kilometers from the coast to the interior. In the desert proper its thickness and firmness diminish, and it is finally replaced by a gravelly crust a few centimeters thick which is of only slight importance for the construction of field fortifications.

Naturally, foxholes and shelters can be dug in the loose loam or clay of the depressions (see Annex 4, aerial photographs 29 and 30). However, because of the complete lack of timber, construction work presents difficulties, so that it is necessary to limit one's self to bare essentials. The use of sandbags and filled gasoline containers is of great importance.

Difficulties with underground water have to be expected in the salt marshes, in which there is salt water to a depth of about one meter, even when the surface is dry.

It is impossible to lay mine fields in rocky soil; in ground consisting of loam, clay and sand it is necessary to bear in mind that the mines will be exposed within a few weeks because of the action of the wind, or else be clearly visible.

Experience has shown that the effects of artillery and machine-gun fire are substantially more intense on rocky ground than on soft ground. Shells fired with percussion fuzes do not penetrate the ground and therefore can have an especially strong fragmentation effect. If solid projectiles are fired, the effect is increased by the frequent ricochets.

If it is at all possible to construct fortifications — this requires time and a great deal of materiel — they provide especially good protection. As an example it might be mentioned that on some occasions the Africa Corps used dried-up cisterns (indicated on the maps by the word "Bir") dating from Roman times as command posts, ammunition dumps and shelters for the troops. These cisterns had a small influx hole in the upper chalk layer, beneath which were large square caves of about 100 square meters and larger in area, which extended through the lixiviation stratum. The roofs consisted merely of a layer of surface chalk one or two meters thick and were not supported for a length of thirty-five meters. They held out against heavy artillery bombardments and air raids.

How difficult it is to capture well-constructed fortifications, if they are resolutely defended, became evident during the siege of Tobruk from April to November 1941, in the engagements around the desert fortress of Bir el Hacheim, south of Tobruk, in June 1942, and on the El Alamein front from July to October 1942.

The most important fortresses of the North African desert were Tobruk, Bardia and Mersa Matruh, as well as the Alamein position, which was constructed like a fortress. The three former fortresses served to protect coastal harbors, the latter was a barrier erected at the gateway to Egypt. All desert fortresses are built in such a way that their works cannot be seen from the ground, that is, they are built level with the ground, have low wire obstacles, communication trenches which are mostly of concrete, and strong antitank ditches. At the fortress of Tobruk the outer ring consisted of two lines of strong positions which

were not built like bunkers with embrasures but were completely sunk in the ground. In some places the works in the outer line were surrounded by an antitank ditch. This antitank ditch was partly covered with light boards and a thin layer of sand and stones, so that its outline could not be perceived even at a very close distance. The average length of one work was eighty meters. The work itself consisted of several shelters, well protected with concrete, which together could accommodate a crew of thirty to forty men. The different shelters were connected by a communication trench with combat positions for machine guns, antitank guns and mortars at their points of intersection. Like the antitank ditch, the communication trench, which was about two and a half meters deep, was also covered over with boards and a thin layer of earth, which could be easily opened at any desired point. The works were surrounded with strong wire obstacles and the individual positions were connected by barbed wire obstacles. The second line, which was about 200-300 meters behind the first, was of similar design.

The desert terrain had a great influence on the selection and use of the various weapons. It was found that one cannot have too many tanks in the desert, for because of the almost unlimited possibilities for using and deploying tanks they bear the brunt of desert warfare. An abundant supply of antitank guns is necessary, since in view of the almost endless distances, reconnaissance naturally assumes special importance.

All guns should have the longest possible range, since the enemy can be seen even at a great distance and it is necessary to get him accurately within your sights before he has you covered. Since there is very little cover and only a few reverse slope positions in the desert, it is advisable for the most part to use only weapons and vehicles (including tanks) with a low superstructure. With tanks it is especially important to have one which is fast, maneuverable and equipped with a long-range gun. Then the question of whether the armor plate is of greater or lesser thickness is of no vital importance.

In the course of time mines acquired tremendous importance in the desert. They were generally used for furnishing unobstructed terrain with artificial obstacles. All fortresses, strong points and fortifications were protected by mine fields. In the course of the fighting the employment of mines in the desert developed into a real art on both sides.

c. The Tactical Importance of the Recognition of Vehicle Tracks by Air Observation

The tracks of motor vehicles in the desert can be easily recognized in aerial photographs (see Annex 4, aerial photograph 28). Together with other observations they were constantly evaluated for the following purposes:

To ascertain troop assemblies and concentrations.
To ascertain enemy supply routes.
To determine whether terrain in enemy territory was passable for motor vehicles.

It was, therefore, very often possible to detect enemy movements in the flanks and rear of friendly territory, especially the movements of the British long-range reconnaissance detachments which were operating in the area of the German-Italian front.

d. The Use of Vehicle Tracks for Deception of the Enemy

An attempt was made to do this during the first few months of the African campaign, but it was later abandoned because the expenditure of motor fuel was disproportionate to the results achieved.

e. The Use of Wheeled and Track Vehicles

The only track vehicles used in the desert were tanks, or else guns mounted on tank chassis, and antitank guns. The armored personnel carriers and artillery prime movers were half-track vehicles.

Wheeled vehicles, the same types as were also used in Europe, were employed for all other purposes, especially to transport troops, equipment and supply goods, as well as to tow guns in an emergency.

Whereas track and half-track vehicles were able to traverse all kinds of desert terrain, wheeled vehicles frequently had difficulties, especially in getting over sand dunes or steep slopes. It would be desirable to use only track-laying or half-track vehicles in desert operations. Then there would be no difficulties whatsoever in moving troops, weapons, equipment and supplies, except in getting over salt marshes.

Instructions concerning driving in the desert are contained in the German field manual Combat in Desert and Steppes. These instructions were written on the basis of the experience gained by German troops in the desert and can be described as very useful.

f. Influence of Desert Terrain on the Development of New Tactical Principles for the Use of Motorized Units

Since desert warfare is determined by the terrain and has to be carried out on a mobile basis, mobile engagements will be decided almost exclusively by motorized units. Combat in this open, unobstructed terrain must be carried on after the manner of a naval battle. Above all, it is essential to recognize the enemy's intentions quickly and react immediately to them. This is only possible if the chain of command is short. The commanders, therefore, must be stationed in the immediate

vicinity of, or right among, the combat troops and should not be hampered in their decisions by orders from headquarters which are far from the front. In desert warfare a unit commanded from a rear headquarters runs the risk of being encircled and annihilated.

To a large extent, Rommel's victories were based on the fact that he realized these tactical necessities of desert warfare and consistently acted accordingly, while the British adhered strictly to orders which they had received a long time previously and which were no longer applicable to the existing situation. Rommel's successes diminished as he became more and more bound by orders from higher headquarters in Germany and Italy.

Open country permits a rapid concentration of forces at the decisive point.

Long-range weapons of all types are of decisive importance.

The troops engaged in the operations should carry along supplies for as long a time as possible, since it is often impossible to send supplies after them because the lines of communication are threatened. Supplies must often be sent to the troops by the convoy system.

Field Marshal Rommel expressed his own views concerning the influence of the desert terrain on the development of a new system of tactics for motorized units as follows:

"The North African desert was probably the theater where war was waged in its most modern form. On both sides the brunt of the fighting was borne by completely motorized units, for use of which there were highly favorable opportunities in this level, unobstructed terrain."

Here it was possible to really apply the basic principles for the conduct of tank warfare as they had been taught in theory before the war, and more especially to amplify them. Here out-and-out tank battles were fought between division-size armored units. Although the war slowed down into infantry and position warfare from time to time, its most important phases -- the British winter offensive of 1941/42 and the German summer offensive of 1942 -- demonstrated the principle of full mobility. In desert warfare non-motorized troops can only hold their own against a motorized or armored opponent in elaborately prepared positions. If such a position is breached or outflanked, a retreat means delivering up such troops to the enemy. The most they can do is to resist in their positions to the last cartridge. During the withdrawal from Cyrenaica in the winter of 1941/42 practically all the Italian infantry and many German infantry units had to be moved out by shuttle traffic of a few truck columns, or else march on foot. Only sacrifices by the motorized units made it possible to cover the retreat of the German and Italian infantry units. Moreover, Marshal Graziani's failures in the winter of 1941/42 were largely due to the fact that a

large part of the non-motorized Italian army was helplessly exposed in the open desert to attacks by inferior numbers of completely motorized British troops. The weak Italian motorized forces could not engage the British with any prospect of success.

From the nature of warfare in the Libyan and Egyptian deserts, it is possible to derive principles that differ from those applicable in other theaters of war.

Enemy units encircled in a pocket can be destroyed under the following circumstances:

- (1) Non-motorized enemy forces, or forces that must give support to other troops that lack mobility.
- (2) Enemy forces that are clumsily employed, or forces whose commander has decided to sacrifice them in order to rescue other forces.
- (3) Forces whose strength is already broken, so that signs of disorganization and panic are visible among them.

The following points are worthy of mention:

- (1) A commander should strive to concentrate his own forces with respect to time and space, while he tries to scatter his opponents and to defeat them one at a time. The terrain offers unlimited possibilities for such action.
- (2) Supply routes in the open desert are unusually vulnerable. A commander should protect his own supply routes with all available forces and try to destroy or cut off those of the enemy. Operations across the enemy's line of communications can often force him to break off an attack at another point, since the supply system is essential for combat and therefore must be protected above all else.
- (3) The armored troops are the backbone of the motorized army. Everything depends on the tank; the other units are there merely to support it. Therefore, the battle of attrition against the enemy armored units must be fought as much as possible by one's own tank-destroyer units. One's armored troops should deliver the final thrust.
- (4) Reconnaissance data should reach the command in the shortest possible time, and the command should make its decisions and convert them into action as quickly as possible. The commander who reacts most quickly wins the battle.
- (5) It is the speed of one's own movements and the organizational unity of the troops which decide the battle and deserve special attention, since the desert terrain places hardly any obstacles in the way of swift movements.

(6) It is of great importance to conceal one's intentions. Deception maneuvers should be encouraged by all means, not least in order to make the enemy commander uncertain and induce him to resort to caution and delay.

(7) When the enemy has been thoroughly beaten, the attempt can be made to exploit one's success by overtaking and destroying major elements of his defeated units. Here, too, speed in exploiting the unobstructed desert terrain is everything. It is necessary to reorganize one's forces for the pursuit as rapidly as possible, as well as to reorganize the supply system quickly for the offensive units.

g. Influence of Rainfall on Mobility in Desert Terrain

In the steppes, heavy rainfalls occur only a few days in the year and in the desert proper even more rarely. A few hours after the rain has commenced the wadis begin to fill with water. The water rises quickly and converts the otherwise dry valleys into raging torrents. In the first winter of the African campaign the troops lost equipment and even men as the result of this natural phenomenon. In spite of the fact that the troops had been warned and were required to evacuate the wadis, there were still numerous living quarters in the valleys during the first big rainfall. The water began to rise during the night and washed away tents and motor vehicles.

The strong effect of the rain could be attributed above all to the fact that the troops were stationed in the mountainous area between Tobruk and Bardia, which was full of numerous steep slopes and deep wadis. In the area of El Alamein (winter 1942/43) the effects of the rains, which commenced at the beginning of October, were substantially slighter, because the terrain was more level and the troops had gained experience in the meantime.

After a rainfall the water collects in depressions and lowlands and renders them impassable (see Annex 2, photographs 40 and 41). In the steppes near the coast large connected areas became impassable for traffic for this reason. It was even impossible to drive over the trails, since most of them followed the depressions. After one or two days the water evaporated and the difficulty was removed.

In the desert proper rain had less effect on the surface. The water collected quickly in clay pits and changed them into lakes which lasted for several days -- in some places even for several weeks (see Annex 2, photographs 42 and 43). However, they only filled the deepest parts of the depressions, while the border areas, where the troops generally pitched camp, remained dry. On the whole, rain had only a slight effect on the passability of terrain in the desert proper.

Rainfalls had considerable influence on military operations during the retreat from the Alamein position in 1942. Near Fuka one panzer unit became stuck fast, so that the tanks had to be blown up. However,

the rain bothered the British even more. They could not carry out their pursuits because of the mud, while the German troops continued their retreat along the coastal highway without interruption.

10. Water

a. General

The water supply for the German troops in Africa was never a troublesome problem. It therefore did not influence or hamper operational decisions either. The chief reason for this was that there were always enough wells available. In the Africa Corps the entire water supply for the German troops was centralized and was under the supervision of the corps surgeon.

b. Requirements for Troops and Vehicles, Economy Measures, etc.

During active operations four to five liters were provided as a minimum supply for one man per day. This quantity was only issued to the field kitchen, which used it for cooking and for making tea and coffee. Pure water was never issued as drinking water. During quiet periods unlimited amounts of water were issued to the troops whenever possible.

The amount of water required daily by a battalion with an actual strength of 600 men -- not including water for motor vehicle radiators -- was about 3000 liters. The amount of water required by the medical units was fixed at twice as much per man per day, i.e. about eight or ten liters. The amount of water required for the radiators of motor vehicles varied according to the type of engine and fluctuated between three and ten liters per vehicle per day. The figures for the water rations were generally the same at all times of the year.

There were no important effects caused by evaporation. No appreciable losses occurred because of evaporation, since the water was poured directly into covered containers or tanks at the standpipes and remained in them until it was used.

The problem of keeping water cool remained unsolved.

There is no data available concerning the relation between water requirements and evaporation at different times of the year and in different temperatures.

In combat units serving in the desert the water consumption was generally so limited that the men even had to go without washing almost entirely. Each man usually received a canteen (three fourths of a liter) in the morning filled with coffee or tea, which had to last the whole day. Normally no water was used to clean vehicles and equipment.

c. Water and Motor Fuel Requirements

In all combat operations our chief concern was about motor fuel and not about the water supply. Only the garrison of Halfaya suffered severely from the lack of water after its well had been destroyed by gun fire.

d. Tactical Importance of the Presence of Water Sources

Even in the operations of advance detachments the motor fuel supply was of more importance than the water supply. This is especially remarkable if one compares the required quantities. For example, a tank needs an average of fifty liters of motor fuel for 100 kilometers, whereas the three crew members need only an average of twelve to fifteen liters of water per day. Added to this is the radiator water, averaging about seven liters. In a daily run of 100 kilometers, therefore, each vehicle requires fifty liters of motor fuel and twenty-two liters of water.

No great lack of water developed, for the reason that the fighting was always in the coastal area. In numerous places in the coastal dunes there are sufficient supplies of fresh water to take care of the needs of the troops. Above a stratum of salt underground water there is a more or less thick stratum of fresh water which is constantly increased during the winter by rainfall and which does not evaporate in summer as much as is the case in areas farther from the coast. (see Annex 1, Map 14). This water is collected by laying out an extensive network of drainage ditches and by careful pumping (see Annex 2, photographs 44 and 45). If too much is removed, the salt water underneath forces its way in and renders the installation useless.

There are water sources of this kind in the sand dunes along the entire western coast of Egypt from Sollum to El Alamein (see Annex 1, Map 12). In addition there are a number of wells in the solid rock in the coastal plains which yield fresh water.

East of Sollum and extending as far as Ain el Gazala there is a strip of steep coastline which has no continuous ridges of sand dunes and therefore contains only a few water sources of this kind (see Annex 1, Map 13). Here it was necessary to dig for water in the bottoms of the wadis which opened on the sea, but only small quantities could be found and it was of poor quality (see Annex 2, Photograph 46). The water supply situation of the German troops, therefore, was at its worst during the siege of Tobruk and during the defense of the Sollum front. During this time the troops were given water which was barely palatable and which contained one gram of cooking salt per liter. At some times it was only agreeable to the taste if used in hot coffee. The result was a great increase in the number of intestinal diseases.

Farther to the east the water supply becomes better as one approaches Cyrenaica (see Annex 1, Map 13). Here there are several large and efficient water sources which assure an ample supply for fairly large numbers of troops. In Cyrenaica itself there are many abundant springs in the chalky formations of the soil which can meet any requirements with respect to water. The coastal area from Benghazi contains numerous deep wells and surface wells and is therefore adequately supplied with water.

West of Agedabia the coast becomes flat again and is inclosed by broad ridges of sand dunes which contain an adequate number of water sources. Finally, in the surroundings of Tripoli there is an extensive stratum of underground water, which is one reason why this region is relatively so thickly settled. Water is pumped here mostly by wind-mills.

All these water sources are limited to a narrow strip of the coast. Outside of this strip there are no springs or wells whatsoever which could be of any use for supplying major troop units. There are merely cisterns, most of which no longer contain any water (see Annex 2, photograph 47). There are only a few modern cisterns which produce water until into the summer (see Annex 2, photographs 48 and 49). From August to November even these cisterns are generally empty.

Occasionally there are water sources indicated in the maps in rubble-filled wadis situated below steep slopes. Usually wells have also been dug there, but they are always dry. If new wells are dug, only damp sand will be found. These wells are dug by the men in camel caravans, who obtain the necessary water for their animals by this artifice (see Annex 2, photograph 50). Water sources of this type are worthless for supplying a military unit.

Large amounts of water are first found again in the chains of oases along the Nineteenth Parallel, which includes the Siwa, Giarabub, Gialo and Marada Oases (see Annex 1, Map 12). The artesian wells found here (see Annex 2, photograph 51) have their source in an underground river which is fed from the rain water falling in the Sudan and which flows northward underneath the desert. Since the above-mentioned oases are situated below sea level, it cannot be assumed that the underground river flows any farther to the north. It is also impossible, therefore, to obtain any fresh water by deep borings in the area north of the oasis chain.

The above account shows that the only reliable place for obtaining water was along the strip of coast where it was naturally available. If military operations had been carried out in the interior of the desert, water would undoubtedly have been the decisive factor which would have determined the strength of the troops and their radius of action. As it was, however, it was always possible to make use of the water sources which were most favorably situated with respect to the front, although it was sometimes necessary to transport the water as far as 100 kilometers. In view of our bad situation with respect to motor fuel this

was certainly a considerable burden. For drinking purposes on the Alamein front the new expedient was adopted of making use of a temporary lake formed of rain water in the southern part of the front with the aid of filtering equipment.

Of the large oasis only Siwa and Giarabub acquired any major tactical importance. The Siwa Oasis enabled us to close off the only passage between the steep side of the range and the sandy desert during the fighting on the Alamein front and thus protect our flank. The Giarabub Oasis was used by the British as a strong point and base for their attack against the encircling ring around the fortress of Tobruk in November 1942.

e. Assignment of Engineer Troops for Water Supply Services

Engineers were only used for obtaining water in the beginning, and the work was then assigned to the water companies.

The water supply company of the German Africa Corps had the following equipment:

(1) Several centrifugal pumps with a lifting height of at least ten meters, driven by mobile power generators.

(2) Several mobile water purification units.

(3) A motor-driven water filter with a diaphragm for the purpose of obtaining sterile water (not to be confused with chemically pure water). All the above equipment was used in all the units of the German Army and therefore was not designed for Africa alone.

(4) After late summer 1942 water distillation plants for the purpose of obtaining drinking water from sea water were also added.

(5) A laboratory, the chemist of which had to pass on the wells and analyze the water in them.*

Water was divided into the following categories according to quality:

No I Water — Could be used for all purposes.

No II Water — Could be used for cooking.

No III Water — Could be used for motor vehicles, washing, etc.

* It should be borne in mind that too large a concentration of magnesium sulphate in the water may lead to intestinal irritations and thus intestinal diseases. (Author's note)

f. Well-Drilling Equipment

On the whole, no experience was gained concerning well drilling. The Abyssinian wells, with which the troops were likewise equipped, did not prove suitable for this purpose.

Some of the water supply companies were equipped with heavy mobile deep-boring equipment, Salzgitter type (Meissel percussion drills). Their size and efficiency are not known. They were not actually put to use and probably would not have been successful. If the fighting had shifted to the area south of the Nineteenth Parallel, we would have been in the region of the static underground water stratum and probably could have used the heavy boring equipment here to advantage. It probably would have taken several weeks to make a boring of this kind.

The Benoto drill, a drilling scoop attached to a heavy drop-weight, on the under side of which were sharp movable steel claws, proved useful for operations in the coastal region (see Annex 2, photographs 52 and 53). The drop-weight fell freely onto the ground, whereupon the claws dug into the earth and then closed automatically. When the drop-weight was raised, the earth held in the claws was brought up with it and then disposed of when the claws were opened. The drill was named after its French inventor and was manufactured in Germany on a royalty basis (both heavy and light models). With the heavy Benoto drill it was possible to dig wells fifteen to twenty meters deep in one day in loamy or gravelly soil, for which it was especially well adapted. However, it was impossible to drill below the underground water level with it, because the force of its fall was greatly broken by the water. The small Benoto drill (see Annex 2, photographs 52 and 53) was chiefly used for test borings. It drilled a hole about ten meters deep and seventy centimeters in diameter in one day. The principle according to which it was built was good, but unfortunately the construction was imperfect, so that there were often operating difficulties. In particular the wire cables were too weak and were subjected to much wear and tear at the guide pulleys. Nor were the claws able to stand up under the heavy strain. If these faults were eliminated, this drill might prove a very useful tool in desert warfare.

The water distilling company was equipped with six water distillers mounted on trucks. This unit was employed only in special cases, since its fuel consumption was disproportionately high (one liter of fuel was required to obtain ten liters of water). During the German advance toward Egypt this unit performed very important service, since all the wells had been contaminated by the British during their retreat with neat's-foot oil.

g. Method of Distribution

As a matter of principle, all water was issued in canisters from the mobile water purification unit, which served as an intermediate container. At the end of the water purification unit was a hose fitted with twelve faucets, which made it possible to fill twelve canisters at

the same time. As a matter of principle, all water -- both drinking water and radiator water -- was carried in canisters. Bakery companies were not issued any fresh water, since by baking with sea water it was possible to save salt.

The standpipes were manned by teams from the water supply companies. The water was distributed according to a table prepared by the quartermaster according to the personnel strength and vehicles of the various units. The water was taken away by the supply vehicles of the units.

h. Pipelines

If a position is occupied for a fairly long time, it is advisable to lay water pipes, since this saves considerable transport space. Aluminum pipes are to be recommended, since they can be laid quickly and connected with each other by a bayonet catch. Of course, strict supervision of the pipeline and standpipes is urgently necessary. When moving into the Alamein position we made use of a British pipeline. In spite of strict orders, it was impossible to prevent it from being illicitly tapped. The available water supply was therefore soon exhausted.

ll. Heat

a. General

Even the very high temperatures during the hot seasons of the year were unable to impair the efficiency of the German troops to any noticeable extent. This is shown particularly well by Rommel's summer offensive from May to July 1942. The achievements of the troops refuted the former opinion of the Italians that European troops could not stand up under high temperatures. Even the British showed no regard for the heat; they attacked at Sollum in June 1941 and were planning a new offensive for June 1942. The most important thing for standing up successfully under hardships of this kind are the toughness of the troops and the good example set by their leaders of all ranks, who as a matter of course should share all deprivations with their subordinates.

Experience has shown that men under thirty-five are best able to adapt themselves to a hot climate. Acclimatization is easier in the open country than in cities.

b. Effect on Unaccustomed Troops

Newly arrived units had low fighting power and many losses through sickness. The heat paralyzed the men's will-power and thus also their powers of resistance. The diseases themselves were probably more a direct result of the diet (bad water, canned food) and hardships than of the heat. The sudden temperature drop in the evenings, causing abdominal colds, was also an important element.

c. Effect on Tank Crews

In tanks the heat -- measuring forty-five degrees on the gyrostatic thermometer (113° Fahrenheit) -- was naturally much greater. It became unendurable in combat when the hatches had to be closed because of artillery fire and when the engines and ventilating system had to be shut off during pauses in the action because of the lack of fuel. The German tank crews held out under even these temperatures.

d. Measures Taken to Avoid the Noonday Heat

In combat it was generally impossible to make any allowances for even the greatest heat. During quiet periods in position warfare there was always a noonday rest period of at least three hours. Cold rations were issued to the troops at noon and hot rations at night.

e. Special Equipment for Protection Against Temperature Variations

Measures were taken against temperature variations by requiring warm clothing and belly bands to be worn after sundown. Each soldier had three blankets, of which one had to serve as a ground sheet for protection against the night dampness. For wounded men four blankets were required (two for covering and two underneath).

f. Types of Shelter

In combat the troops had no shelter whatsoever. They either spent the night in their position, or else in or underneath their vehicle.

Wall tents for four men with a double top awning were used chiefly as shelter (see Annex 2, photograph 54). They proved thoroughly useful and met all the requirements of desert warfare. At the beginning of the campaign, low one-man tents, likewise provided with an awning, were issued, but later there was not a sufficient number of them available. There were also larger tents for ten or twelve men. However, these could be used for the most part only in rear areas, since it was practically impossible to camouflage them.

The Italian field hospital tents also proved highly successful.

g. Comparison Between the Efficiency of Troops in the Tropics and in Temperate Climates

After the men had become accustomed to desert warfare and after those who could not adapt themselves to it had been eliminated, the efficiency of the troops in combat operations was not inferior to that of troops serving in temperate climates. Even the drivers achieved normal efficiency, since the wind stream cooled them off and refreshed them. In all kinds of physical labor, on the other hand, the heat greatly reduced efficiency. In this respect the Italian troops were

superior to the Germans. For this reason they did most of the road construction work and mine laying. The detour road around Tobruk, for example, was built by Italian labor units. It constituted an outstanding achievement which German troops could not have accomplished in the same time.

h. Effect on Materiel and Equipment

The heat had no effect on guns, because they became so heated during firing that this more or less neutralized the outside temperature. No damage to war materiel and items of equipment was reported, or was to be expected.

i. Effect on Visibility

In the interior of the desert about ten kilometers from the coast the vibration of the air makes accurate observation practically impossible for a distance of more than one kilometer. All objects at a distance of one kilometer and more appear to move, and it is hardly possible to decide whether a dark spot on the horizon is an approaching motor vehicle or a destroyed vehicle. At still greater distances all contours become so blurred that one always thinks that one is surrounded by a sheet of water, from which certain elevations stand out as "islands." In the beginning of the war in the desert, during the first attack on Cyrenaica, several units fell victim to this deception. They tried to drive around what they thought was a "lake" and therefore did not reach their appointed objectives.

On the other hand, the vibration of the air protected small detachments in the desert from being discovered by the enemy from the ground.

Surveying work suffered to an extraordinary extent from the vibration. It was only in the morning hours (until around 1000) that satisfactory work could be done with aiming circles or theodolites.

j. Effect on Airplanes in Taking Off and Landing

For the Luftwaffe great heat often had a considerable effect on take-offs and landings. The density of the air was so reduced that the length of the take-off and landing strips had to be increased by as much as fifty percent. Landing operations could be indirectly disturbed by strong air reflections in the heated ground layer, thus causing errors in the estimation of altitude.

If airplanes stand for a long time in strong sunlight, the polished metal parts in the cabin, especially the glassed-in cockpit, become so hot that they cannot be touched. Therefore, the cabins have to be covered with tarpaulins. For the same reason strong sunlight entering the cabin during flight is also disagreeable for the pilots. Curtains relieved this difficulty, but hampered visibility.

Chapter IV - Miscellaneous

12. Cartographic Service

a. General

In Libya the German Army was initially solely dependent on the hastily reprinted Italian map (scale 1:200,000), since at first good German maps were available only on the scales of 1:1,000,000, and 1:500,000, which were mainly destined for use by the Luftwaffe.

The Italian maps were poor and often, at distances of more than 20 kilometers from the coast, they were several kilometers off. In compensation, there were captured British maps, which included Libya and Egypt. They were excellent and as a result very much prized. Later they were reprinted.

The French maps, used for the first time in Tunisia, were serviceable, but were later replaced by German maps.

In 1941 the Luftwaffe received a special map on a scale of 1:400,000, and in conic projection, which fully met requirements.

For general reference Annex 1, maps 1-16 should be consulted.

b. Reliability and Methods of Use

Sufficient maps were available for the following regions:

Tripolitania (area around Tripoli): Italian map, 1:50,000
Cyrenaica: Italian map, 1:50,000
Egypt (Western Desert): British map, 1:100,000
Southern Tunisia: French map, 1:100,000 and 1:200,000

The lack of good maps made itself felt especially in defensive operations. New photographs were accordingly taken of the area of the Marsa el Brega position and of the Buerat position in cooperation with the Luftwaffe, the cartographic detachment of the Africa observation battery, the cartographic section of the Army High Command and the Military Geologic Office (see Annex 1, maps 6 and 15). The following method was used: The survey battery drew up a net of artillery points (A.P.) by use of traverses which were emplaced at the triangulation points (T.P.). The A.P. were clearly identified by means of ground panels. Then the Luftwaffe took a series of aerial mosaics with 30 percent overlapping. The results were transferred from the aerial photographs to the A.P. diagrams by the Military Geologic Office. This work was more difficult than appears at first, especially since only a simple stereoscope was available for the purpose. Correct evaluation of the form of the terrain and of the condition of the ground on the basis of the aerial photographs required a great deal of experience. Errors occasioned by the angle at which the photograph was taken, the distortion at the edges of the picture, etc., had to be compensated for as well as possible.

After the rough drafts had been finished, clean copies were made by the cartographic section and these were reproduced by the printing section. In this way maps were produced in a short time which fully met the requirements of the forces. They gave an accurate picture of the tactical conditions of the terrain, permitted orientation and contained correctly surveyed artillery points (see Annex 1, map 15).

An important supplement in respect to tactics was constituted by the road maps made by the Military Geologic Office (see Annex 1, maps 1-10).

The Italian, British and French maps were redrawn and reprinted by the Mapping and Surveying Service and then distributed to the forces by the cartographic centers in Africa.

The maps were always available in adequate quantities, with the exception of temporary scarcities brought about by the difficulties of supply.

The maps and documentary material of the Military Geographic Branch were used by all headquarters down to regiment. They were used for the initial basic orientation in the conduct of operations and as such were indispensable. In addition, they contained a great deal of important information, especially in their description of road conditions. However, since only such documentation as was available at the beginning of the war could be used, there were gaps which only reconnaissance could fill in.

The colored hachures indicating the passability of terrain or at least the limitations on its passability, were important.

13. Camouflage

Camouflage is very difficult in the desert and in many cases impossible. During the day it was impossible to camouflage the movements of troops and columns from air observation. In the neighborhood of the front the troops could only with difficulty be camouflaged from ground observation. The unavoidable dust clouds raised betrayed any movement.

Nevertheless concentration of troops can be camouflaged, if great care is used. Depressions in the terrain will have to be exploited for this purpose; all vehicles will have to be covered with camouflage nets and vegetation (camelsthorn) attached to the nets. In the open desert all vehicles will have to be dug in as deep as possible. It goes without saying that the vehicles will have to be placed at as great a distance from each other as possible.

Although in most cases it will not be possible to camouflage the presence of vehicles and weapons, skillful camouflage can conceal the type of these vehicles (the arm of the service.) It would be altogether wrong to resign oneself and take the viewpoint that camouflage in the desert is useless.

What has been said above is also valid for the troops in position.

Another means of camouflage, although on a small scale, is to seek out shifting shadows.

For details on camouflage, see Annex 6. In addition, Annex 2 (photographs) and Annex 4 (aerial photographs) should be consulted.

14. Evaluation of the Enemy Situation Through Aerial Photographs

The main emphasis in aerial photography, in addition to determining the traffic on the Suez Canal, in the ports, on the roads, important paths, in the villages and on the airfields, was to provide details on the troops and positions of the enemy.

In order to check on our own camouflage, from time to time the German positions were photographed from the air.

Little by little it was possible to improve the methods of evaluating the results of the aerial photography.

As the enemy's air superiority increased, however, the possibility of taking aerial photographs diminished more and more.

Aerial photographs are indispensable (see Annex 4, aerial photographs 27 to 30). The evaluation was done by the Luftwaffe Photographic Section in the usual manner. In regard to evaluation of the aerial photographs to judge road and terrain conditions, see Annex 4, aerial photographs 1-26.

In taking the aerial photographs dark yellow filters were necessary. Developing required the addition of hardening material, since otherwise the coating of the film melted and there was the danger that microbes would damage it. Dust-proof vehicles were used for the developing of the film. Relief maps were also produced, but the need for them was not great, since the differences in altitude in the Libyan and Egyptian deserts is inconsiderable.

15. Visibility at Night

In the North African desert the nights are much darker than in more northern latitudes. It was often difficult to find a tent in one's own camp at night, because it was impossible to orient oneself. As a result it was also impossible for the enemy to detect troop movements taking place at night, unless there was moonlight or parachute flares were dropped by the air forces.

During the daytime, on the other hand, it was possible to see very far in the desert.

On nights when there was a moon the visibility was approximately as good as that prevailing in Central Europe at the fall of dusk.

16. Choice of Camp Sites

This subject is taken up in detail in Chapter III, Section 9 (Terrain) and in Annex 6 (Camouflage).

In the main, camp sites were selected for good protection from air attacks. Preference was given to depressions in the steep sides of the djebels, the banks of wadis and the dune districts (see Annex 2, Photograph 55.) Only the latter offered an opportunity to dig in vehicles and tents and to camouflage them.

17. Selection of Battle Sites

In attack the German Army preferred easily passable, open desert for a battle site, because it made it possible for the armored forces to exploit their mobility and their combat tactics, which were superior to those of the British.

In defense the positions selected depended to a large extent on the terrain. They had to be difficult of access and provide flank protection, otherwise on the whole they were useless for defense. Regarding selection of positions see Chapter III, Section 9 (Terrain).

18. Time of Day Selected for Combat

Marshal Rommel preferred to start fighting on moonlit nights or at dawn. The fighting often lasted until dark, unless it was broken off sooner for tactical reasons. There were no lulls in combat, even during the very great heat prevailing around noon.

In general the Germans carried out no night attacks. On the other hand, at the end of October 1942 the British carried out their large-scale attacks on the German positions at Alamein exclusively at night. They used parachute flares to illuminate the battle field and tracer ammunition to show their troops the direction of the attack and the sector boundaries. The British Commander in Chief, Montgomery, preferred night combat. The German and Italian troops used the night for marches into their assembly areas, for large-scale shifts of forces and for surprise. These night regroupings could almost always be carried out unnoticed by the enemy and, especially during the winter battles of 1941-42, they came as a big surprise to the British.

19. Influence of the Desert Climate on Daily Service Routine

The daily routine in the desert did not substantially differ from that in other theaters of war. When not in combat the troops were as far as possible given a lengthy rest period during the great heat around noon. The maintenance troops (workshop companies) were also given a noon rest period. Supply traffic could not afford to take these rests.

20. Special Problems of the Technical Services

The German technical services were faced by the following special problems through the fighting in the desert:

a. They had to keep the motor vehicles, which because of the conditions in the desert and the long supply routes was exposed to extraordinary wear and tear, in running order. For this purpose an increased number of repair shops were available. It is probable, however, that the problem would not have been solved had the stock not been replenished by captured British material from time to time.

b. The water supply had to be safeguarded. The troops specially assigned to this task (see Chapter III, Section 10) did their work very well.

c. A detour had to be built around the besieged fortress of Tobruk. This task was undertaken by Italian Labor forces and very well carried out.

d. The Capuzzo-Mersa-Matruh-Alamein railroad had to be operated.

The above statements may give the impression that the technical problems encountered in the desert are less difficult than those in other theaters of war. This is not the case, however. On the contrary, many of the tasks which were necessary were so difficult that they were abandoned in advance. Among others, these included the extension of the railroad beyond Capuzzo and at least up to Tobruk and the procurement of steam locomotives, as well as the construction of a fortified defense position with bunkers at the Alamein front.

21. Influence of Light, Shade and Sandstorms on Combat

The intensive sunlight had a dazzling effect which was particularly disturbing when the light was reflected by bright dunes. It was therefore absolutely necessary to wear sunglasses. In the afternoon it was impossible to tell vehicles from tanks at a distance of 1-2 kilometers and up. Favorable times of day were the early morning and the afternoon hours from 1600 to 2000 hours.

In the desert range estimation cannot be depended upon. In most cases the distance will be underestimated. It was therefore advisable to use a range finder. During sandstorms visibility was nil; moreover, visibility was influenced by sand driven by the strong winds (from 5 meters per second). From the air this produced an effect like local ground fog. During a sandstorm fighting was impossible.

There were isolated instances for mirages.

Adaptation to the visibility conditions prevailing in the desert was relatively soon made.

22. Influence of Darkness on Radio Communications

Frequently, radio communication with Europe was interrupted for hours at a time during the nights because of pronounced fading.

23. Wind

The wind constantly blowing near the coast was regarded as very welcome by the ground troops. It made it much easier to tolerate the heat.

For the Luftwaffe the fact that the general direction of the wind was interrupted by periodic land and sea winds on the coast (during the day from sea to land, during the night from land to sea) was of importance. Because of the temperature differences between the water and the desert the winds on the coast are stronger than on the European continent. They increase with their altitude. Inland the wind is weaker. Very often the direction of the wind is constant, especially on the coast.

During sandstorms the wind went up to 150 kilometers per hour at the height of the storm above 3000 meters. On the ground the gusts blew at the maximum rate of 60 to 80 kilometers per hour.

No data can be given on the wind velocity at various altitudes for comparison with velocities elsewhere because no material is available on this.

24. Special Equipment and Procedures for Aircraft Crews

It was always advisable to try for an emergency landing because the emergency equipment for desert landings, the armament, the radio and the equipment for protection from the sun and the cold nights was ample. Aircraft which had made an emergency landing were easier to locate from the air than those that had crashed. The terrain was everywhere favorable for an emergency landing even for aircraft with stationary landing gear. Even a belly landing was preferable to bailing out. There is no case of crews having been lost in the desert. The "desert emergency squadron" played an important part in this. However, German aircraft were rather seldom employed in the interior of the desert.

The briefing of crews on the native population and its customs was kept to a minimum and was generally limited to the crews of single motored aircraft (fighters, Stukas, close-reconnaissance planes). The crews of long distance reconnaissance planes and multi-engined bombers, and the parachutists to be dropped behind the Tunesian front, were briefed on the basis of the experience gained. It was possible to keep the briefing short because the Arabs throughout had a friendly and helpful attitude. The sympathetic attitude of the Germans, which was soon known in the desert, was calculated to encourage friendliness. Small gifts and visits to the sheiks helped.

The crews were systematically briefed about the emergency measures to be taken to survive in the desert on the basis of cases that had actually occurred.

On this occasion the following questions were discussed:

Where are there oases, who occupies them and what is their capacity?

Where are the other water holes?

What is the attitude of the local sheik?

Should one assume that he is in touch with the Allies?

Where are the nearest enemy forces?

Rewards in gold were given for the rescue of German soldiers. It was difficult to live off the land since the natives had only just enough for themselves. As a last resort the hunting-gun included in the special equipment was available. Because of the scarcity of game success in hunting depended largely on the skill of the crew. Water was obtained by spreading tarpaulins during the night to catch the morning dew.

Distress signals consisted of signal ammunition and smoke signals, which had to be used at the right moment when the crew of a plane overhead was able to see them. Large aircraft carried an emergency radio transmitter. In addition, if necessary, fuel and oil were to be set afire.

The crews had been told to remain near their planes, if possible. Only if they were close to an inhabited place were they to start marching immediately.

The aircraft had special equipment for the desert. This consisted of the following items:

2 liters of bottled water;

Emergency rations (hard sausage, hard biscuits, coca-cola, Dextro-Energen*, Pervitin, cognac);

*Grape-sugar tablets.

Gasoline stove;

One-man tent, sleeping bag, rubber mattress, linen cloth to protect the head from the sun;

"Storm" matches, flashlight with a portable generator, sun reflector, first-aid kit;

Emergency compass, signal pistol with ammunition, red cloth strips;

Three-barreled hunting gun with ammunition, in dust-proof packing, hunting knife;

Foreign currency;

Emergency radio transmitter.

Blood transfusion sets were not included.

The search for missing aircraft was undertaken by the desert emergency squadron. It consisted of 9 to 12 Storch planes and a number of personnel carriers able to cross desert terrain. The planes patrolled the terrain in question constantly.

British prisoners of war stated that their men had small compasses camouflaged as uniform buttons and handkerchiefs printed with the map of North Africa and Southern Europe. This was undoubtedly a very good idea.

25. Dry Docks and Port Installations

The information contained in Chapter I, Section 1 should be consulted in regard to the practicability and usefulness of the available signal communications material. In the whole of Italian North Africa there was not a single dry dock, except for small vessels. The port installations of Tripolis, Benghazi and Tobruk were good, if one considers the conditions prevailing in the colonies. From the technical viewpoint there were no difficulties in unloading supplies. Difficulties appeared only after the port and unloading installations had been bombed. Besides the above mentioned three large ports there were also some smaller unloading points, but they played little or no role in large-scale supply traffic. In Egypt itself only Marsa Matruk was used as an unloading port. However the capacity available was not used in full because of the proximity of the enemy and the bombings from the air.

26. Reinforcement of Sand Surfaces for Landings by Amphibious Craft

The Germans had no experience in reinforcing the sand surfaces on the coast and in the desert for landings by amphibious craft and landing fields. The Luftwaffe used Italian and British airfields. The maintenance and improvement of roads was in the hands of the Italians. The British had steel matting for their airfields.

Except during the rainy season the surface of the desert was so hard that reinforcement of roads and airfields was unnecessary (see Annex 4, aerial photographs 1-12). Even the asphalt via Balbia and the Egyptian coast road only had a foundation of broken lime stone without an intermediate layer.

Except for the ports mentioned in Section 25 no advanced supply bases were established or used on the open coast. This was unnecessary because not even the normal ports near the enemy lines could be used fully. As a result no steps were taken to reinforce the beaches for landings by amphibious craft. The whole of the coast consisted of sandy beaches where the special landing craft of the German Navy, later imitated by the Italian Navy, were able to land. Basically the difficulties which arose were caused by the sea, which made a landing impossible when the wind blew from the shore.

27. Changes in Ship Loading and Unloading Procedures

The loading and unloading of ships was not influenced by the desert climate. Moreover, in the coastal ports, as has been mentioned, the desert climate did not prevail. In comparison with the interior, it was much milder. In the main, native Arabs were used to unload the ships. The limited unloading capacity in comparison with European standards was due to the performance of these people, which is basically lower, and the difficulty of getting them to go back to work after air attack alarms and bombing raids.

During the hottest hours loading and unloading was interrupted, when the situation permitted.

28. Materiel Loss and Replacement Estimates for Desert Warfare

It has not been possible to check the accuracy of the German estimates on materiel loss and replacement, because a large part of the needs of the forces was covered by captured equipment, the amount of which was not listed.

29. Modifications in Supply Dump Procedures - Especially for POL

There were no essential changes in stocking and distribution of fuel. They were unnecessary. Fuel was conserved in German Wehrmacht jerry cans, which proved effective even in desert warfare.

30. Diseases and Insects in the Desert

In 1941 there were a great number of jaundice and dysentery cases. The reason was bowel irritation provoked by the drinking of bad water. Quick treatment with sulfa drugs afforded relief. (The tales that the health of some people was gravely damaged by sand fleas and scorpions are pure fiction.)

Health of the troops requires constant control, which should go hand in hand with thorough instruction. The battalion and other medical officers do not suffice for this purpose. It is accordingly advisable to assign a sanitation officer to every company and battery to do this work in close cooperation with the competent medical officer.

The sanitation officer would have to give special attention to the following protective measures:

He will have to see that the soldiers wear warm clothes after sundown and that they do not drink unboiled water. Excretory matter should be buried after each movement of the bowels (the "spade system" is preferable to the latrine system.) Whenever the situation permits the soldiers should observe a siesta. Fly control should be organized (mosquito nets were used only in the latrines.) Vitamin C should be taken regularly. In specified districts atabrine tablets should be taken to prevent malaria. If necessary, the water supply should be controlled (but only in the case of detached units.) There should be a hygienic consultant for every two divisions. He should be provided with a mobile bacteriological laboratory.

There should be a mobile medical company in each division. The company should have 250 beds available. The German hospitals had the so-called Olympia beds, which proved very useful.

The equipment of a medical company should include one light X-ray instrument and three sets of blood transfusion instruments with plasma.

The corps and/or army medical officer will have to have available two surgical hospitals (with 300-400 beds) and two medical companies for every two to three divisions. This is in addition to the medical companies of the divisions.

See Annex 5 for medical equipment for use in the desert.

In respect to insects, there are flies wherever there are people. At first the troops had no effective means to combat them. It was only during the final phase of the African campaign that the newly developed means (for instance, a preparation called DDT) could be issued. There was no way of preventing infectious diseases such as dysentery and contagious jaundice from spreading. The only preventive measure that could be taken was the order to bury all fecal matters immediately. Infringements were severely punished. In contrast to flies, which were everywhere, mosquitoes (anopheles) were present only in the oases and their immediate vicinity. Since these insects fly only at night, use of mosquito nets is an absolute necessity in these areas. Atabrine tablets were used to prevent the malaria transmitted by mosquitoes. Orders specified that one atabrine tablet a day was to be taken. Since the units did not often stay in oases for long, malaria cases were few.

See Chapter III, Section 10 for treatment of water.

31. Desert Weather Service

It was the mission of the desert weather service to conduct weather observation and to keep the Luftwaffe posted on the basis of the results of these observations. The information was transmitted by a special radio frequency to a collecting station and retransmitted from there.

The mission was carried out by small mobile teams consisting of one or two meteorologists, three or four weather technicians and several radio operators. A special vehicle contained the weather service equipment, the radio apparatus (100-watt transmitter and receiver). The work methods were as follows:

The synoptic system was used with ground weather reports from the numerous ground observation stations distributed over the coastal area and also from the Italian desert oases. Radio weather observing stations in Derna sent up two balloons every day. At the front several pilot balloon spottings were made especially early in the morning and in the afternoon (single station pilot-balloon spotting was done, although it would have been better to use double stations.) According to the velocity of the wind at a height of 200-500 meters it was easy to tell, while the temperature was still low and the wind was weak, whether there would be sandstorms and at what time they would start. Often errors occurred in the wind tests through local causes or because of a rapid change in the atmospheric pressure, so that the estimate of sandstorms by means of pilot balloons sent up early in the morning was unreliable. Severe sandstorms will have to be predicted by means of the weather map, with special attention being given to the variations in atmospheric pressure. Small variations in pressure effect considerable changes in the wind at these low latitudes.

In addition the Luftwaffe transmitted further information over a special radio network. It transmitted individual weather reports but the main emphasis was on providing fully worked out weather analyses and surveys and predictions organized by districts.

There was a special encoding table for weather reports.

CHAPTER V

General Remarks and Experiences

32. Special Equipment for Desert Warfare

The proposals, made on the basis of experiences gathered in the desert, for the improvement and modification of equipment were carefully considered by the agencies in the zone of the interior and followed through to the extent that the limited time available permitted. The developments described below are of special importance in desert warfare.

- a. Decrease of the sensitivity to dust of vehicular and airplane fuel and of especially sensitive weapons.
- b. Experimentation in the production of a dehydrated fuel for vehicles which is also fully effective in salt water solution. Such a dehydrated fuel greatly alleviates the supply problem and would remove the danger of air attacks on fuel dumps to a large extent.
- c. Production of radar equipment to identify enemy forces which could not be seen by ground observation.
- d. Production of equipment for cooling drinking water or keeping it cool.
- e. Procurement of effective smoke producing equipment, which would be capable of sucking up large quantities of desert sand and then releasing it.
- f. Motor vehicles: The mass production of a cross-country truck for supply purposes with a three to three and a half ton capacity has high priority. The truck will have to possess low range four-wheel drive, and a lock off on the differential. It will need low pressure balloon tires. The advisability of utilizing air-cooled motors is uncertain. The Steyr Works developed an air-cooled heavy command car, which, however, was not used until shortly before the conclusion of the African campaign, so that it could not be adequately tested. Insofar as an evaluation is possible, it seemed to have been in good order.

Special attention must be accorded the springs. The spiral springs used in German command cars, Types 15 and 17 did not prove practical. The springs broke easily and caused a bottleneck in supply. Leaf springs were better, but they also had to be strongly constructed.

All desert vehicles have to be provided with spades, boards or rope ladders so that they can be dug out when they get stuck and put in action again.

Desert conditions require a sturdy motor vehicle which does not weigh too much, has not got a complicated motor and has deeply indented tires. Well-equipped replacement dumps and field workshops are a prerequisite. Both must be mobile and capable of producing results rapidly.

Camouflage (paint) of all vehicles proved advantageous.

g. It is advisable to provide all passenger cars and some of the trucks with compasses, which should be so built that they can be easily seen from the driver's seat. The compasses must be compensated by magnets (suitable examples are manufactured by the Askania Works in Berlin-Friedenau.)

h. Tents. The field forces must be completely outfitted with tents (double roof and dustproof where possible). The roof can be flat (see Annex 2, Photos 54 and 55.)

i. Drills. The development of a dry drill similar to the Benoto (see Chapter III, Section 10 f and Annex 2, photos 52 and 53) which can reach water sources very quickly would be very useful. Mobile deep drills should also be at hand, such as are produced in Germany by the Craelius factory.

j. Distilling equipment. Since there is a lot more salt water in the desert than fresh water, the field forces can often be supplied even when no fresh water is available, by having distilling equipment at their disposal. For that reason it is important to have such equipment. They should be sparing of fuel and be mounted on cross-country vehicles so that they can be taken along by motorized troops. Capacity should be great enough to provide each man with four to five liters of water daily.

k. Surveying equipment. Ordinary theodolites are adequate for surveying purposes. Still it is a good idea to provide them with special protection against dust. A military unit is advisable, which can quickly produce reliable maps in cooperation with the air force and can carry out terrain reconnaissance. One can recommend for the last-mentioned mission an organization which is a combination of the English Long Range Desert Group and the German Military Geology Office.

l. Tanks and prime movers. The periscopes of the tanks were often damaged. The motors of the Type IV tank (long), which were put into operation as of autumn, 1941, were very efficient. Depending on the condition of the terrain in which operations had taken place a general overhauling was necessary after about 10,000-15,000 kilometers. The motors of the Tiger tank, later used in Tunisia, were too weak and too sensitive.

The cross-country mobility of the prime movers could have been improved upon. They were not up to the demands imposed by a thick ground covering of sand.

33. Research and Development Possibilities for Special Desert Equipment

German industrial capacity was capable of satisfying all demands for equipment necessary for desert warfare. It was not prepared for these demands when they came, however. Since technical developments always require considerable time, it was not possible in the comparatively short period during which fighting went on in Africa to technically perfect new objects. Distribution to the forces did not impose difficulties as a smooth-working distribution organization was available.

34. Unusual Supply Problems

The basic difficulties for the smooth-functioning supply of German forces in Africa have already been described in Chapter I, Section 3.

Overseas theaters of war require many unloading ports which are usable and as near to the front as possible. Prerequisite is at least partial domination of the sea and air lanes. Rail connections between unloading ports and the front are very essential. In any event there must be adequate parking space for the supply trains. It can never be too large, when one considers that all supplies must be sent overland from the harbors to the front. Supply dumps near the front are also necessary, which must be regularly kept well stocked.

It is very important that the commander of the army and his chief of staff are daily oriented in detail on the supply situation. When waging war in another section of the world, the supply situation must be calculated very accurately as it exerts an even greater influence on the decisions of the command than elsewhere. On the other hand the commander should not become overly dependent on the supply situation, but he must expect a great effort to be made that supplies get from unloading ports to the front. Only what has already been unloaded can be included in calculations. Supplies still on their way cannot be counted.

Tactical considerations will determine the portion of the available ship's tonnage to be used for the transport of men and for that of supplies. This must be directed by an over-all authority and is just as true for air transportation. The latter can only be of temporary assistance and otherwise must be regarded as a secondary transportation means. The army in the desert, itself, must determine what is to be sent over.

In unloading, care must be taken because of the danger from air raids that the ships be emptied as quickly as possible, after which the supplies, especially fuel and ammunition, should be immediately moved from the danger zone into the interior.

Strong antiaircraft protection and fighter escorts are indispensable at the unloading ports as well as barriers against torpedoes and submarines.

Fuel and ammunition must be stored at widely-scattered points, where it should be buried and well camouflaged. Burial is absolutely necessary as protection against the heat. Careful surveillance of the camouflage, especially in rear areas, is important.

Rommel's supply columns were not assigned a maximum daily speed or travel time. They were simply given the mission of travelling as rapidly and as long as possible, because a shortage of column space always existed.

There was always a lack of fuel. After it was unloaded, it was transferred to drums and then issued at the fuel dumps near the front in jerry cans. Underground tank installations are of course desirable, but they did not exist in North Africa at the time.

The average loss of weapons and equipment in the desert was about 25 percent higher than in an European theater of war. Accurate figures are, however, not available (see Chapter IV, Section 28.)

Nutrition

Assimilation of food and production of body heat are about 10 to 15 percent lower in hot areas than in Europe. Therefore, under normal conditions, the total nutritional needs are less than in Europe. Heavy physical exertion requires about the same food intake as at home. Too much meat, especially canned meat, was rejected by the men.

A fundamental alteration of nutritional standards soon makes itself felt. Vegetables and fruit are more popular than meat. Too great a meat consumption considerably increases the body's need for water. The high caloric count of fat is in contradiction to the above-mentioned low production of body heat in hot regions. Increased intake of vegetable products, especially marmalade, are necessary to equalize the low fat requirements.

Fresh meat is preferable if refrigeration facilities are available. Smoked meat, especially hard sausage which is not too fatty, finds a ready audience. Eggs should never be eaten raw. Legumes should not be served too often. Because of the danger of infection with intestinal diseases, greens should be thoroughly washed with a solution of permanganate of potassium.

All sorts of dried fruits proved very satisfactory.

The consumption of concentrated alcoholic beverages should be carefully avoided. The best principle is "No alcohol before sunset." The furnishing of lemon and other citric juices is the best means of avoiding Vitamin C deficiency.

As wide a variety as possible should be attempted in the menu, as the troops came to dislike foods that were served constantly.

Refrigeration of foods (meat and fresh vegetables) is achieved by means of so-called cooling units manipulated by aggregates, which can be set up in trucks. The Luftwaffe also had refrigeration planes.

The "Field Cookbook for Improvised Cooking and Baking in the Colonies" was drawn up as a cooking aid.

The crews of armored vehicles and of planes needed extra rations because of the increased pressure exerted upon them.

Clothing

Clothing of 100 percent pure wool is most practical. In general long trousers which could be tightly closed at the bottom (slacks) were preferred to breeches worn with high laced boots. The slacks, such as were worn by the Luftwaffe, should be broad and cut on a comfortable bias. This is also true as regards the jacket, the most practical model for which is the Italian Sahariana. A warm cloth coat is indispensable in the cool seasons and nights. Woolen scarves become necessary in winter. Shoes should be constructed of a light leather with a linen inlay and thick, firm soles.

Tents should be painted a striped and speckled green and brown on one side and be the color of ochre on the other.

Camouflage nets with knotted strips of many-colored cloth attached to them are the best for sending to the front. Such camouflage nets are practical for all larger motor vehicles.

35. Comparisons with Desert Warfare in Southern Russia

The southern Russian steppes (Kirghis and Kalmuk steppes) have much the same rainfall as the ring of steppes in North Africa, 100-200 mm a year. However, since the temperature is on the average lower, evaporation is less. In Southern Russia, therefore, the surface of the ground is not covered with a firm crust (surface lime), the vegetation is denser and watercourses with water exist the whole year round, although, with few exceptions, they do not reach the sea but instead filter down through the sand or end in salt lakes. From the military point of view the differences have the following effect:

a. Water supply is easier; although it is not as easy as in cultivated regions, it nevertheless does not present serious difficulties as long as an organization for reaching it and distributing it exists.

b. In dry weather passability is at least as good as that in the open North African desert. During rainy weather, however, it is worse, since districts with a rocky sub-surface are lacking or are to be found only in mountainous areas.

c. The building of field positions is easier, since the ground is composed of clay or loam almost everywhere.

Like the North African desert, the South Russian steppes are better suited for attack than for defense. The biggest difficulties are encountered during the severe winter, especially when the enemy troops are accustomed to a harsh climate.

The conditions arising from the dust are in general the same as those prevailing in the pure steppe terrain in Southern Russia.

36. Troop Welfare in the Desert

In the desert, as on no other theater of war, life was hard for officers and men alike. Life in the rear areas, as it is known in Europe, was possible only in the few supply centers in the rear, and then it was only a small imitation.

Because of the close contact of the troops with each other, all officers had to give an example of soldierly bearing and good moral living. Any extravagance on the part of an officer is noticed by the men and scrutinized with a magnifying glass. On the other hand, life in the desert offers an excellent opportunity to create a very high level of community spirit. This brings about a feeling of solidarity in all ranks and prompts them to do their utmost.

It is especially the desert, where no diversions exist, that requires that every superior be carefully concerned about the welfare of his personnel. The fact that there are no outside attractions makes it easier for him--if that should be necessary.

An oppressive feeling of immense loneliness overcomes everyone more or less frequently in the desert, a feeling that one is cut off from everything that one holds dear. The commander must recognize such moods and depressions and offer sincere encouragement so that the pressure will disappear.

Even more important than rations for the well-being of soldiers in the desert is the maintenance of regular communications with the zone of the interior. The word "Mail" occupies a place of high priority in desert warfare. All officers and agencies must, therefore, be concerned with assuring a rapid distribution of mail to the very front lines.

A good newspaper that carries up-to-the-minute news and gives space to the problems which absorb the soldier at the front is also indispensable. Movies and theatrical performances at the front belong to the variations in the monotony of his life which can be offered the soldier even in the desert.

The normal service time in the desert for a German soldier was six months. Regular rotation could, however, often not be provided in Africa between 1941 and 1943 with the result that many soldiers had to serve in the desert for twelve and even eighteen months. If relief is not possible after six months for one reason or another, the men must be granted three week's leave. Otherwise lasting damage to their health can easily result.

Proper leadership, training and welfare of the troops can lead to extraordinary successes especially in the seclusion of a desert theater. Feldmarschall Rommel has proven this.

