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bulk of the trigonometrical and mathematical work, and we find that officers with engineer training are best for this. Although modern technique has reduced the work of map making, modern mobility and, of course, the range of modern aircraft, have enormously increased the area of the earth's surface for which maps may be required. Improvements in plotting and map reproduction have made it possible for up-to-date maps to be issued on a pretty lavish scale. In no theater, unless extremely close to home, is it possible to operate nowadays without a large map reproduction and distribution service involving large numbers of big modern lithograph and printing machines.

One other activity for which the engineers are responsible is movement control. Strictly speaking, of course, this is a non-engineer staff function, but we find that engineer officers, especially those with railway and docks experience, usefully fill a high proportion of movement control posts.

Also, the Army Postal Service has always been manned by the RE. This dates from the days when we ran the Signals.

Bacteriological Warfare

Translated and digested by the MILITARY REVIEW from an article by Major Ernst Wiesmann in "Allgemeine Schweizerische Militarzeitschrift" (Switzerland) August 1949.

WHEN and if bacteria are employed as combat means in total warfare, man and his domestic animals or plants will suffer a fatal blow. To be suitable for military purposes, however, microbes must fulfill a large number of conditions. For this reason, the different types that can be used are few in number. The following requirements are the most important:

1. The microbes must be "raised" and kept in readiness in large quantities.

2. The requirement, "kept in readiness," includes a certain degree of ability to survive on the part of the microscopic forms of life, even under unfavorable conditions.

3. It must be possible to bring the active agent into contact with the enemy in the proper form.

4. The incubation period of the disease that is to be induced must be as short as possible.

5. Pathogenic ability must be as great as possible. That is, all infected persons, if possible, must be made sick.

6. The sickness produced must come to a crisis as speedily as possible and must not be chronic.

7. The sickness produced must be as hard as possible to diagnose and its producer must be hard to determine.

8. Wherever possible, artificial immunization must not be possible and the producer should not respond to any specific chemical therapy.

9. It must be possible to immunize one's own forces against the sickness.

These requirements would seem to indicate that the possibilities of employing bacteriological warfare are rather limited. For example, requirements 1, 3, and 5 prevent the employment of the poliomyelitis virus; point 4 rules out the employment of the rabies virus, with an incubation period of 3 months, or of the tuberculosis bacillus; point 5 eliminates all producers of children's diseases; point 6 rules out tuberculosis bacillus or the producers of leprosy; point 8 eliminates the smallpox, tetanus, or diphtheria bacilli.

An attempt has always been made to associate bacteriological warfare with gas warfare, from the standpoint of their nature and employment. There is, however, a considerable difference between gas and bacteriological warfare, mainly because of the contagiousness of the latter. In the employment of gas, only those who come in contact with the gas become sick. In the employment of bacteria, a single infected individual might transmit the disease to a large community.

Usable Microorganisms

Microorganisms suitable for bacteriological warfare are listed in accordance with their method of infection as follows:

1. Contact infection. Here we may consider:

a. Anthrax bacillus b. Tetanus bacillus c. Bacillus of gaseous gangrene.	Highly pathogenic for man and domestic animals.

d. Strepto and straphylococcus.

e. Pathogenic fungi.

f. Brucella. Producers of Bang's disease in human beings and cattle (infectious abortion).

g. Tularemia bacilli. Producers of tularemia, a very contagious disease occurring chiefly in North America.

All of these germs are relatively resistant. Part of them occur normally in many places. Little is to be expected from this group. An intensive epidemic of anthrax would be a severe blow to an enemy, due to its effect on animals. It would not be of decisive influence, however, since it is possible to immunize against anthrax.

It seems that the disease-producers in this group might best be controlled by preventing sabotage, such as infecting bandaging materials or sterile medications intended for hypodermic injections.

2. Infections by means of intermediate hosts (insects). We may consider, here:

a. Yellow fever virus.

b. Dengue fever virus.

c. Malaria plasmodia.

d. The spirochete of relapsing fever.

e. Rickettsia.

This group differs from the first group only in that contact is brought about by an intermediate host. This group probably would not be of great importance since it is easy to break the chain of infection by destroying the intermediate hosts which are usually confined to limited geographical zones.

3. Infection by means of water and food substances. Here we have, mainly:

a. Typhus and paratyphus bacilla. b. Weil's leptospira.	Incubation period about 10 days; severe period of sickness of long duration; long period of convalescence.

c. Enteritis producers. Short period of incubation; short period of sickness.

d. Cholera vibro. Short period of incubation.

e. Botulinus toxin. Short period of incubation; extreme intensity; usually fatal.

These producers of sickness are well suited for the infection of streams, reservoirs, and food supplies. If this could be successfully accomplished, considerable initial success would be attained in the infected area.

All the diseases of group 3 are diagnosed with relative ease by medical authorities. As a rule, determining the source of infection should not be too difficult. Further infection would then be avoided by adequate heating of all foods or beverages.

In a way, botulinus toxin presents unusual characteristics. It is one of the most powerful poisons known. Five one-hundredth of a milligram absorbed by the stomach or intestines is definitely fatal to a human being. The period of incubation is from 24 to 48 hours at most. Like most living producers of disease, this poison possesses low resistance. It is rendered inactive by short exposure to sunlight and other environmental factors, and it is completely destroyed by 2 minutes of continuous heating at a temperature of 212° Fahrenheit.

As might be expected, the possibility always exists of increasing effects by employing a mixture of different germs or substances. In this case, the doctor or diagnostician would have much more difficulty in making a diagnosis and, consequently, in taking proper preventative measures.

4. Infection through the air. The greatest consideration should be given this group. since it possesses many and varied possibilities. The following diseases may be employed in this manner:

a. Anthrax bacilli.

b. Plague bacilli.

c. Glanders bacilli.

d. Tularemia.

e. Rickettsia.

f. Influenza virus.

g. Psitacosis virus.

h. Brucella.

i. Bacilli of haemorrhagic septicaemia Pasteurellia.

j. Foot and mouth disease virus.

k. Virus of equine encephalomyelitis.

l. Cattle-plague virus.

m. Hog-cholera virus.

It is obvious, of course, that considerable harm and losses could be caused by the concentrated employment of these disease producers. From the technical standpoint, the only question is how they might be employed.

To begin with, the microbes must be "raised" in large, special plants (analogous to munition plants) and produced in large quantities. From storage depots, they would be transported by the air force to the enemy's country and there sprayed over the intended areas. This could be done by attempting to unite the smallest of the microbes, especially the viruses, with fine particles of dust or water, and then dropping them in this form. An effort would be made to keep the microbes suspended in the air as long as possible and capable, even after having fallen to the ground, of being picked up again by the wind, to be drawn in with the breath. It goes without saying that weather conditions must be considered in a "bacteriological attack" by air. In moist air, such as fog, the microorganisms are able to remain in the atmosphere longer than in dry weather. Also, in damp weather, both human beings and animals are generally more susceptible to infection.

Combating Germ Warfare

No realist will have faith in international agreements to outlaw the use of bacteria in war. Hence, the danger must be squarely faced and steps taken to meet i

Combating bacteriological warfare begins in the intelligence and espionage services. Wherever possible, it must be learned in advance whether certain nations are preparing for such warfare and what germs they plan to employ. On the basis of such findings, the medical service organizations must make proper preparations.

After hostile operations begin, steps must be taken to prevent the dropping of bacteria from the air, or at least to make such action difficult. These are tasks which can be fulfilled only by the general air defense. An adversary who possesses air superiority cannot be prevented from employing bacteria as a combat means.

After bacteria has been used in combat, there will be nothing else to do but to combat epidemics, just as in peacetime.

1. Prophylaxis. In addition to general hygienic measures which improve health and give the body the greatest possible resistance, specific immunization must be carried out. The troops, civilian population, and domestic animals must be made immune to those diseases or sicknesses against which reasonable protection by vaccination is possible.

The diseases against which satisfactory immunization is possible are few. The following requirements must be met before artificial immunizations are successful:

a. They must give sufficient protection.

b. They must be easily administered.

c. They must be safe.

d. All men and animals that might later become infected must be inoculated.

Since it will be impossible to protect ourselves against all eventualities, we shall of necessity be forced to count on early diagnosis of the diseases and must locate as soon as possible the source of the infection.

2. Diagnosis. It is extremely important to be able to discover and identify the producers of infection as early as possible. It would be well if this could be done before the occurrence of the first sickness. This will not be possible, however, in most cases. In all cases, the cause of a disease must be accurately determined. Only when we can identify an infection from the standpoint of its cause and ability to spread will we be able to combat it effectively and halt its progress.

The Americans have constructed a special device for detecting the presence of disease germs in the air. Large quantities of air are forced through a filter in the device. The germs are caught in the filter and subsequently identified.

The speediest possible diagnosis is essential. In virus diseases, especially, enormous and sometimes insuperable difficulties stand in the way.

Any attempt to establish schematic measures to be taken against epidemics will always be difficult. In fact, so many accompanying circumstances exert an influence that only a person who is well acquainted with the matter is able to proceed with any degree of success. Such a person constantly finds himself confronted with unusual situations, because, in the final analysis, he is fighting against a living agent. As everywhere, the problem to pick out the significant points from a host of equally striking ones and to make use of the correct and most effective measures at the right time and in the right place.

Even in time of war, it will usually be necessary to proceed as follows, in fighting infections:

a. The source of the infection must be eliminated.

b. The infectional chain must be broken at some accessible point.

c. When the measures indicated in a and b cannot be carried out, an attempt must be made to get away from the source of the infection. All sound individuals must be forced to leave the infected area.

d. Specific healing means must be made available.

e. As far as possible, steps must be taken toward immunization.

Hardly a single one of the above requirements can be satisfactorily met with respect to the pathogenic agents mentioned above. Where such infectious substances are extensively employed, considerable reaction must be expected. Even abandoning an area cannot be carried out easily. First, we do not know off-hand the extent of the area that is actually infected. Secondly, we do not know but that another and, perhaps, quite different germ is already present in the new area. Lastly, there always exists the great danger of spreading the germs through individuals who are infected but who have not yet become sick.

Germs Against Plants

Since infectious diseases also occur in plants, the possibility exists of attacking edible plant life. Relatively little would be attained in warfare directed against plants, however, for the following reasons:

1. Epidemics among plants are much harder to induce than among animals.

2. Even under the most favorable ex-

ternal circumstances, the time required for the development of a great plant epidemic is much too long—at least 1 year—to be of decisive significance in war.

In new methods, however, we no longer have to employ living organisms. Instead, we use destructive chemical substances.

In the United States, several hundred different substances of vegetable hormone-like nature have been successfully created. Employed in small dosages, these substances promote the growth of plants. In larger dosages, however, they kill vegetable life and render it impossible for any vegetation to grow in the infected area for years. A certain amount of practical experience has been gained in the employment of these substances. Efforts have been made to produce substances for the extermination of weeds and the effects of these substances have been beyond all expectations.

These hormone-like substances could easily be sprayed by planes. Technically, it would be possible to render land areas as large as Western Europe or the Ukraine completely barren for years. Aside from an active air defense, we know of no specific means of combating this threat.

Military Possibilities

From all this, it should be evident that it is impossible to conduct war with bacteria alone, and that germs in themselves are not decisive. Where forms of life are employed which are not capable of directing their own activity, since they have no will in the human sense, many imponderables enter into the picture. This being the case, bacteria can be used only as an accompanying weapon, but they should not be disregarded.

It is not entirely easy, even for one acquainted with the subject, to foresee clearly the methods of employment and the effects to be expected in a future conflict.

The method of conducting operations in a given theater is dependent, to a certain degree, on the goal to be attained. There should, nevertheless, be no doubt but that future wars will be total and three-dimensional. The so-called rear areas will be involved from the very outset, and it can well be imagined that the large centers of population will be attacked not only with explosives but also with disease germs. Under such conditions, epidemic substances will find particularly favorable soil. In addition, invisible forms of life possess the added advantage that it is difficult to prove their planned employment.

On the contrary, however, microbes will hardly be employed in ground fighting, or in mobile warfare conducted by ground forces as we have known it. Germs will be employed where it is desired to create prolonged and widespread panic and disorder, or where it is desired to bring about a climax.

Summary

In preparing for bacteriological war, the following steps must be taken:

1. Teams and equipment must be ready that will permit rapid identification of germs.

2. Immunizing and curative serum must be ready in such quantities that care for the army as well as the civilian population will be insured.

3. Specific remedies must be on hand in sufficient quantities.

4. Scientific instructions for the fastest possible suppression of an epidemic must be issued on its outbreak.

As in all war operations, the minimum of technical installations must be in existence. But in addition, the human mind must be armed and ready.

Even if pestilences break out and deaths multiply, we must fight all the harder. Persistence has always paid off. So far, every epidemic has sooner or later come to an end.