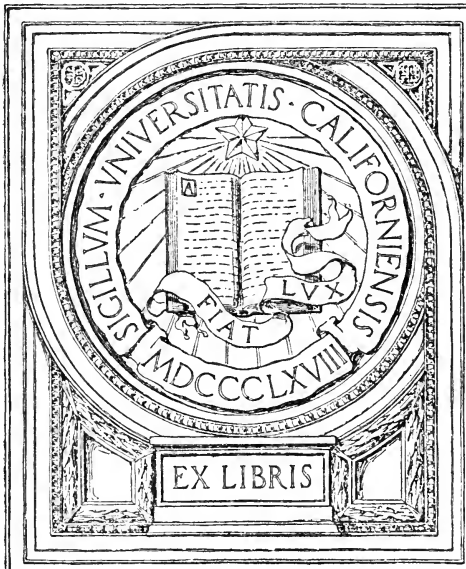
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PROGRAM OF TRAINING IN GAS DEFENSE

FOR

DIVISIONAL ANTI-GAS SCHOOLS

EDITED AT
ARMY WAR COLLEGE

OCTOBER, 1917

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WAR DEPARTMENT,
WASHINGTON, *October 23, 1917.*

The following pamphlet, "Program of Training in Gas Defense for Divisional Anti-Gas Schools," is published for the information of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

PROGRAM OF TRAINING IN GAS DEFENSE FOR DIVISIONAL ANTI-GAS SCHOOLS.

SYLLABUS OF TRAINING.

First day:

Theoretical.—Lecture on the general principles of gas warfare—

(*a*) History of the use of gas.
(*b*) Gas-cloud attacks.
(*c*) Gas-shell attacks.
(*d*) Various kinds of gas used.
(*e*) The effect of gas.
(*f*) Methods of protection.

} 45 minutes.

Practical—

(*a*) The mechanism of the mask.
(*b*) Gas mask drill (individually and in squads).
(*c*) Inspection of masks.

} 1¼ hours.

Second day:

Theoretical.—Lecture on signs of approaching gas—

(*a*) Three signs of cloud gas.
(*b*) Wind observations.
(*c*) Precautions to be taken during wind-dangerous period.
(*d*) Means of giving the alarm (cloud gas).
(*e*) Action to be taken in trenches.
(*f*) Signs of gas-shell attack.
(*g*) Means of giving the alarm (gas shells).
(*h*) Rules to be observed during any gas attack.

} 45 minutes.

Practical—

(*a*) Repeat gas-mask drill one-half hour.
(*b*) Exercise in gas house with lachrymatory gas.

} 1¼ hours.

Third day:

Theoretical.—Lecture on action to be taken after gas attack—

(*a*) Clearing of shelter, trenches, and shell craters (gas fans and fire pots).
(*b*) Cleaning of arms and ammunition.
(*c*) Protection of dug-outs and all arms.
} 45 minutes.

Practical—

(*a*) Repeat gas-mask drill one-fourth hour.
(*b*) Exercise in gas house with chlorine gas one hour.
} 1¼ hours.

Fourth day:

Theoretical.—Lecture on the effect of gases and treatment of gas cases, 30 minutes.

Practical—

(*a*) Gas-cloud attack.
(*b*) Use of gas fan and fire pot in clearing trenches.
(*c*) Demonstrate protection afforded in dug-outs by means of wet blankets.
} 1½ hours.

Fifth day:

Theoretical.—Lecture on organization of gas service in foreign forces—

(*a*) Anti-gas duties within an Infantry regiment.
(*b*) Standing orders.
(*c*) Collection of gas samples.
} 45 minutes.

Practical—

(*a*) Repeat gas-mask drill.
(*b*) Exercise in gas-shell attacks (lachrymatory gas), 1¼ hours. (Explosion of grenades.)

Sixth day:

For officers—

Written quiz covering instruction given during the week.

For enlisted men—

Verbal quiz and general exercises of the course.

Upon completion of this training all troops should be given one hour mask drill per week under their platoon commanders. This drill should include the mask drill proper and other drills and exercises while wearing the mask.

LECTURE NO. 1 (first day).

The use of gas, like many of the other weapons now in common use in the armies of Europe, such as the catapult, flame projector, trench knife, and sling, is an inheritance from the early ages amplified, improved, and made more destructive by the aid of modern science.

The first recorded effort to overcome the enemy by the generation of poisonous and suffocating gases seems to have been in the wars of the Athenians and Spartans (431 to 404 B. C.), when, in besieging the cities of Platea and Belium, the Spartans saturated wood with pitch and sulphur and burnt it under the walls of those cities in the hopes of choking the defenders and rendering the assault less difficult. They also melted pitch, charcoal, and sulphur together in cauldrons and blew the fumes over the defenders' lines by means of bellows.

"Greek fire" was used by the Byzantine Greeks under Constantine about 673 A. D., to destroy the Saracens, and Saracens in turn used it as a weapon of defense against the Christians during the Crusades. This Greek fire had the double advantage of being not only inflammable but also generating during the process of combustion clouds of dense, blinding smoke and gas of an asphyxiating character. (This gas—sulphurous dioxide—is one of the gases used to-day.) Its chemical composition was supposed to be a mixture of quicklime, petroleum, sulphur, and such other inflammable substance as pitch, resin, etc. Upon the addition of water the slaking process which the quicklime underwent generated enough heat to ignite the petroleum, which in turn ignited the resin, pitch, and sulphur. This flaming mixture was delivered against the enemy by means of fantastic syringes in the shape of dragons and other monsters with wide jaws.

The first use of gas in modern warfare was in an attack April 22, 1915, by the Germans at Ypres on a sector of trench where the French and Canadians met. The surprise was complete and the number of casualties enormous. On April 26 gas was liberated against two French battalions which were making an assault, and broke down the assault completely. Repeated gas attacks followed, and it soon became recognized that gas was an accepted weapon in modern warfare. These first gas attacks were of the gas-cloud type, but soon gas shells began to make their appearance and now gas shells are in use in all armies and are one of the most important weapons in modern warfare.

GAS-CLOUD ATTACK.

The gas-cloud attack is brought about by the liberation of gas from metal containers buried under the parapets of the front-line trenches. Tubes from these containers provided with a stop-cock attachment, are carried up over the parapet and through them the gas is liberated. These containers are usually placed in batteries of three or four at intervals of about 30 yards apart. The gas in them is in a liquid state, but upon being released by turning on the stop cock it volatilizes rapidly and escapes in the form of a dense vapor. This escape of the confined gas is accompanied by a low whistling sound which is frequently the only warning the opposing side has of the coming attack. The gases used in cloud attacks are heavier than air and when released under proper atmospheric conditions move—or, rather, appear to roll—along the ground, usually in the form of a dense greenish-yellow cloud, toward the lines of troops to be attacked, and when it reaches the trenches it settles down into all parts of them, penetrating the dugouts and bomb proofs and remaining sometimes for several days.

The success of the "gas cloud" is dependent on the atmospheric conditions. A calm night or day, with a gentle wind blowing in the right direction, is essential. A strong wind distributes the gas too quickly and diminishes its concentration, and a variable wind is not to be depended on. Gas attacks have been made with wind velocities varying from 3 to 15 miles per hour, i. e., from $1\frac{1}{2}$ to $7\frac{1}{2}$ yards per second. A wind between 4 and 8 miles is the most favorable. With such a wind gas would reach trenches 100 yards away in 22 seconds. Gentle rain has no effect on the gas but a heavy rain washes it down. Fogs have but little effect and may be taken advantage of to conceal the approach of a gas cloud.

While the gas cloud form of attack, if successful, can produce a number of casualties, its operation is uncertain and its approach can be anticipated if proper watchfulness is maintained. Efficient measures can be taken by trained troops to nullify its effects, and its military value therefore is probably not so great as when it is used in shells, bombs, hand grenades, etc.

GAS-SHELL ATTACK.

Gas used in shells has a much more definite military value than gas used in clouds. The gas shell has, in fact, become

one of the most important weapons in modern warfare and at present 20 per cent of all shells used on the western front are gas shells.

They fulfill a double purpose; they are excellent in forming a barrage to prevent the bringing up of supplies and reinforcements, and they are most excellent in silencing artillery positions. Their method of employment, as described to me recently by a French officer, was like this: A continued barrage fire was kept up behind a certain artillery position for 24 hours. Then a cloud fire was kept up on the artillery position itself for 12 hours. The infantry assault was then made and there was no fire at all from the artillery position. When this was taken, it was found that most of the men there were dead and those that survived were too weak to work the guns. The protective power of their masks had been exhausted by the long exposure to gas.

Gas is used in shells of both heavy and light field howitzers. The 5.9 Minenwerfer is the shell most used by the Germans.

These shells hold about 7 liters of a gas-producing liquid. They have a short ogival head and a long cylindrical body of thin steel, about one-fourth of an inch thick; closely fitted against the inside walls is a cylinder of sheet lead about one-eighth inch thick, which is filled with the gas-producing liquid and then tightly soldered. This load container fills nearly the whole cylindrical portion of the shell; just above it, but not resting on it, is the explosive, and above this, on the point of the shell, is a combination of time and impact fuze. The effect of the charge upon exploding is to tear open the head of the shell and the top of the lead container so as to allow the liquid to spill out and liberate the gas.

Hand grenades of various kinds, made of both glass and iron, and containing a quantity of gas-producing liquid, are used in trench warfare, and iron bombs, with a bursting charge of black powder and containing gas liquid, are also used in trench mortars.

Unlike cloud gas, gas shells can be used in wind blowing in any direction. The strength of the wind, however, has considerable influence on the effective use of the shells. A wind of 7 miles per hour or less is as high a wind as is practical for their effective use.

THE VARIOUS KINDS OF GASES.

(*a*) *Lachrymatory gases* (cause an intense inflammation of the eyes with temporary inability to see).

(*b*) *Asphyxiating gases* (extremely severe in their action, causing either rapid death or lingering death with much suffering).

(*c*) *Suffocating gases* (causing death by spasm of the glottis; they are usually combined with lachrymatory gases).

(*d*) *Paralysant gases* (causing instant death when in sufficient concentration).

The three latter classes are known as lethal gases. The asphyxiating gases, because of their weight, are the ones used in cloud-gas attack. The other gases, and the asphyxiating gases, also are used in shells.

A great variety of acids may be used for the production of gases, and chemists in all armies are constantly experimenting with a view to perfecting new and more potent combinations. The ones most commonly used now, however, for the suffocating and lachrymatory group are combinations of benzol and acetone with chlorine and bromine, such as cloracetone, bromacetone, and benzyl bromide. The principal acids used for asphyxiating purposes are chlorine, bromine, and phosgene. These acids are abundantly produced in commercial processes of manufacture, are easily obtained, and answer every purpose. They are, however, with the exception of phosgene easily neutralized by alkalies. In addition to these commoner acids many other acids have been used; some of them are hydrogene sulphide, sulphurous anhydride, various nitrous vapors, formol, arsene, and prussic acid.

THE EFFECT OF GASES.

Certain gases, such as prussic acid, produce instant death by paralyzing the central nervous system, but the majority of the gases have a special affinity for the mucous membranes, and their systemic effect depends on the amount of damage they do to those tissues. The lachrymatory gases have a special action on the membranes of the eye and upper air passages, and their effects though severe while they last are as a rule temporary. They cause a severe smarting pain and running of the eyes (tearing) and soon the lining of the eyelids become so swollen that vision is impossible. At the same time there is a dryness.

burning, and smarting of the nose and throat, with coughing and sometimes vomiting. In three or four hours those symptoms begin to disappear and gradually the soldier recovers.

The asphyxiating and suffocating gases are far more severe in their action. Their potency can be realized when it is known that a dilution of 1:+1,000 is fatal with chlorine and bromine, and a 1:+25,000 is fatal with phosgene. A dilution of 1:—100,000 or more has a marked effect. These gases act to a less degree on the membranes of the eye than the lachrymatory gases, but their action is particularly virulent on the membranes of the respiratory tract, which they cause to swell rapidly and finally destroy. The result is œdema of the lungs, accompanied by persistent coughing and spitting of blood, then great difficulty in breathing, the soldier becoming cyanosed and struggling for breath. Death may be almost instantaneous, or it may be postponed for several days, the sufferer in the meantime not being able to eat anything and undergoing great agony. Many of the cases in which recovery does take place develop later a chronic disease of the lungs.

METHOD OF PROTECTION.

The deadly character of gas attacks can be almost entirely obviated if the proper measures of protection are known and strictly enforced.

A perfect familiarity with the gas mask and its prompt application is the only certain means of defense. The development of the gas mask has kept pace with the development of gas as a weapon. From the first the principle of the mask has been to provide a filter through which the inspired air must pass, this filter to be made of chemicals which have a neutralizing effect on the gases. At first the mask was simply a pad of cotton or gauze soaked in a soda solution, and this afforded fairly good protection against chlorine. With the introduction of the lachrymatory and more poisonous gases, however, the simple pad proved inadequate and new types of mask were constantly appearing.

Three types are now in use in the European armies. The box respirator, the tube helmet, and the M. 2 French mask. Of these, the box respirator is by far the best. While cumbersome in appearance, it is really the most comfortable, and has the longest life against the greatest variety of gases.

PRACTICAL INSTRUCTION (First Day).

1. Explain the mechanism of the mask. Point out the way in which the inspired air passes through the bottom of the canister, the connecting tube, and the mouthpiece. Dwell on the fact that air reaching the lungs in any other way is poisonous when gas is present. For this reason the nose clip must be worn. Explain how the expired air escapes through the flutter valve.

Impress upon the soldier that the mask is of the utmost importance, and any failure to keep it in good condition and adjust it promptly and properly when the gas alarm is given may cost him his life.

GAS-MASK DRILL.

The detachment should be in line with the masks in the carry position. The haversack slung at the right side, sling passing over the right shoulder, flap buttons toward the body.

Practice "A."—Adjustment of the respirator box in the "Alert" position.

On the command "Gas alert" hang the haversack around the neck with the press buttons next the body. With the right hand seize the satchel by the leather tab, with the left hand seize the sling by the brass button, and clip this into the leather tab. Undo the press buttons closing the flap, tuck in the slack of the sling into the left-hand compartment, so that it lies under the mask.

The length of whipcord will then be withdrawn from the right-hand compartment, passed through the ring on the right of the satchel, and carried around the waist to the ring on the left, where it is fastened. The press button closing the flap will be left undone, but the flap will be put in condition to keep the respirator from wet.

Practice "B."—Drill by numbers to obtain correct adjustment of the mask.

1. On the command "One" press down both thumbs between the satchel and the body and open the satchel flap. Immediately seize the mask with the right hand, the metal breathing tube just outside the mask being in the palm of the hand, and the thumb and first finger grasping the wire frame of the nose clip.

2. On the command "Two" bring the mask smartly out of the satchel and hold it in both hands with all the fingers outside around the binding, and the two thumbs inside, pointing toward

and upward under the elastic. At the same time throw the chin well forward ready to enter the mask opposite the nose clip.

3. On the command "Three" bring the mask forward, digging the chin into it, and with the same motion bring the elastic bands back over the crown of the head to the full extent of the retaining tape, using the thumbs.

4. On the command "Four" seize the metal breathing tube outside the mask, thumb on the right, fingers on the left—all pointing toward the face. Push the rubber mouthpiece well into the mouth and pull it forward until the rim of the mouthpiece lies between the teeth and the lips and the two rubber grips are held by the teeth.

5. On the command "Five" adjust the nose clip to the nose, using the thumb and first three fingers of the right hand. Come smartly to attention.

At the completion of this exercise, the instructor inspects each man and corrects any faults of adjustments. It is very important to see that the mask fits the face properly and that the length of the sling in the alert position is such that the man can move his head about freely without exerting traction on the rubber tube.

NOTE.—(*a*) If, after wearing for a long time, the pressure of the nose clip becomes unbearable, it may be relieved for a few moments by taking off the pressure without removing clip.

(*b*) *Removing masks.*—It must be seen that when masks are removed this is done without strain on the face piece or elastic. On the command "Take off masks" insert the fingers of the left hand under the mask at the chin, bend the head forward, at the same time removing the mask with an upward motion of the left hand.

(*c*) After all drills the mouthpiece must be disinfected, the mask wiped dry, folded correctly, and put away in such a way that the rubber valve is not bent.

Repeat practices "A" and "B" several times and note progress made. Then start "judging the time." With the mask in the "Gas alert" position the command "Gas" will be given and each man will proceed to adjust his mask in the manner prescribed in practice "B." When adjusted he will take one step forward and his time will be recorded. All men must be drilled until they can make a perfect adjustment in six seconds.

Practice "C."—The purpose of practice "C" is to teach the men the procedure to be gone through when a sudden gas-shell attack is made.

On the command "Gas shells" pass the left arm back through the sling, throwing the haversack to the front of the body, under the flap buttons and adjust the mask as in Practice "B," allowing the haversack to hang by the rubber tube. While doing this, men must be taught to hold their breath. After the mask is adjusted, breathing can be resumed and the haversack fastened in the alert position. The complete adjustment should be made in seven seconds.

At the end of every drill period entry will be made on the record card in the haversack of the approximate time of actual breathing through the respirator. This record must be kept accurately, so that the life of the mask can be ascertained.

Repeat Practices "A," "B," and "C" a few times.

Practice "D."—Drill to teach cleaning of eyepieces.

On the command "Clean eyepieces" the right eyepiece will be gripped between the thumb and first finger of the left hand. The first finger of the right hand will then be pushed gently into the flap of the mask behind the right eyepiece, which will be cleaned with a gentle circular motion.

The left eyepiece will be cleaned in a similar way.

Practice "*E.*"—Drill to teach method of giving orders.

It is first explained to a squad that the nose clip must not be removed to talk, and that before each sentence is spoken a long breath must be taken and the mouthpiece removed sideways from the mouth by turning the metal tube outside the mask to one side. After speaking the mouthpiece is replaced.

The squad should then be numbered off, extended to four paces, and orders passed along the line.

Officers and noncommissioned officers will be specially drilled in Practice "E."

Long orders must be broken into short phrases so that each part may be shouted out before a new breath must be taken.

Practice "*F.*"—Drill to teach method of clearing mask from gas which may have leaked in and is affecting the eyes.

On the command "Empty masks," press the mask close to the face, forcing out foul air around the sides, and then fill again with air from the lungs by blowing out round the mouthpiece.

Practice "*G.*"—Drill to teach method of testing whether trench or dugout is free from gas.

On the command "Test for gas," with right hand open the face piece away from the right cheek, then loosen the nose clip on the nose and smell gently (do not take a breath). If gas is

smelt, the nose clip and mask are replaced. Then as in Drill "F."

LECTURE NO. 2 (Second Day).

WARNING.

The gas mask if properly and promptly adjusted is a sure prevention of gas casualties. Ample warning therefore is essential in order that men may have time to adjust their masks. Every means must be employed to detect an impending gas attack and spread the alarm at the first sign of its approach.

The gas-cloud attack requires a good deal of preparation on the enemy's part, in the matter of bringing up the containers and digging them in under the trenches, and advance information of an attack can be frequently obtained by aeroplane reconnaissance and constant observation of the enemy's trenches by outpost sentries. These two sources of information should be continuously employed. The only certain signs of an actual attack, however, are:

(*a*) The whistling sound of the gas as it escapes from the containers.

(*b*) The smell of the gas.

(*c*) The appearance of a cloud of any color over the enemy's trenches.

With all gases at night and with certain forms of gas in the daytime the cloud is not visible at a distance.

Recently an English officer told me that one of the earliest signs of a gas attack was a loss of taste in a cigarette or pipe; that he had frequently seen soldiers look suddenly at the cigarette they were smoking and then with a startled face say "gas," and begin to put on their masks.

WIND OBSERVATION.

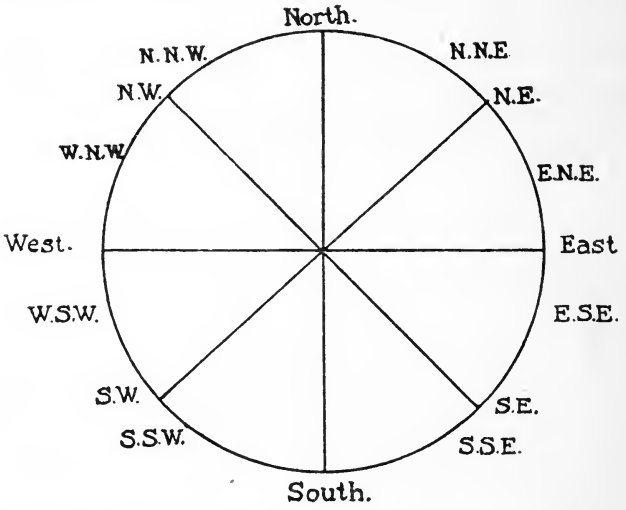
The wind playing so important a part in gas-cloud attacks, a meteorological service is established on all fronts. This organization reports to headquarters of corps or divisions whenever the wind is in a dangerous quarter, showing the direction and strength of the wind. As a result of these reports "Wind dangerous" is announced from these headquarters.

These general reports, however, refer to large areas, and on isolated stretches of front conditions of terrain or the align-

ment of trenches may permit of local air currents which are favorable to the enemy. For this reason company commanders are responsible that wind observations are made in their company front every three hours or oftener if the wind is in or approaching a dangerous quarter, and the reports are forwarded through the regimental commander to brigade headquarters.

In order to make these reports in each company a simple wind vane, bearing a Beaufort flag, is set up. The vane must have as little friction as possible, so that a wind of under 2 miles per hour will turn it.

It must be set up sufficiently high to get a true observation (e. g., 18 inches above the top of the dugout), and it must also



be correctly oriented. An easy way to do this is to have two sticks below the gauge crossed at right angles, one marked on the end with "N" for north. The arms can then be so set that "N" points to the north, as determined either by the sun at midday, the polestar at night, or the compass (remembering that the magnetic north is 13° west of the true north).

Direction of wind must be stated by points of the compass.

Before reading the direction of the wind from the vane the observer should gauge the approximate direction by smoke, etc.

The Beaufort flag is a strip of linen 5 inches long by three-fourths of an inch wide attached either to the wind vane itself

or on the top of the post that supports it. With the aid of the flag the strength of the wind may be determined by Beaufort's scale.

Beaufort scale.

Beaufort's No.	Speed (miles per hour).	Observation of natural objects.	Behavior of flag.
.....	.....	Smoke straight up.....	No movement.
1	2	Smoke slants.....	Do.
2	5	Felt in face.....	Slight.
3	10	Paper, etc., moved.....	Three-fourths up.
4	15	Bushes sway.....	Up and falling down.
5	20	Tree tops sway; wavelets on water.	Up; falling less often.
6	30	Trees sway and whistle.....	Up and flapping.

To determine the number of seconds which it will take for a gas cloud to move from the enemy's lines to our own, double trench distance (in yards) and divide by speed of wind (in miles per hour). Example:

$$\frac{100\times 2}{10}=20 \text{ seconds.}$$

THE WIND-DANGEROUS PERIOD.

"Wind dangerous" is ordered when the wind is in a dangerous quarter, no matter what the strength of the wind may be. At the same time it is advisable that the noncommissioned officers be able to estimate the strength of the wind, as that has some bearing on the likelihood of an attack. The Germans seem to prefer a wind of from 4 to 12 miles.

The order is usually given from corps or division headquarters, but brigade or regimental commanders are empowered to order a "Wind dangerous" as a result of observations forwarded by company commanders. Such action will be reported immediately to the next higher commander. When the order is given "Wind dangerous," notices are posted at the entrance to each main communication trench and at other proper points within the divisional area.

PRECAUTIONS DURING WIND-DANGEROUS PERIOD.

(*a*) All masks should be carefully inspected and the inspection repeated daily. Steps must be taken to ascertain that all gas-alarm appliances are in their position and in good order.

(*b*) All ranks within 1 mile of the front line must carry their haversacks in the "alert" position. During "Wind dangerous" the chin strap of the helmet must on no account be worn under the chin, as it will impede the rapid adjustment of the mask.

(*c*) A sentry should be posted at each Strombos horn or other alarm device and instructed in its use, and all working parties should have a sentry posted to give instant warning of a gas attack.

A sentry should be posted to every large shelter or group of small shelters, and also to each headquarters, signal office, and each independent body of men.

Arrangements must be made by the officer in charge of the trench for warning the artillery observation post, if there is one in the trench.

Commanders of u nits in billets within 8 miles of the front-line trenches must organize a system of giving the alarm and rousing all men in cellars or houses.

At night sentries should have at least two men within reach of them, so that the alarm can be spread rapidly.

(*d*) When a gas attack is probable, men in front-line trenches should sleep on the fire step instead of in dugouts. Men sleeping in rearward lines, or in works where they are allowed to take off their equipment, must sleep with their haversacks on the person.

(*e*) Company gas noncommissioned officers will report to company headquarters in readiness to assist the company commander should a gas attack occur.

GAS ALARM.

For the purpose of giving the gas alarm the British use, very largely, the Strombos horn, which can be heard very long distances. This instrument is a large horn worked by compressed air and comes in a box with two cylinders of compressed air and a rubber connecting tube. They are placed at intervals of not greater than 400 yards along the front line and at such points behind the front as is required to insure transmission of warning.

In addition to the Strombos horns, bells and gongs made from shell cases, suspended rails, etc., are used, and the buzzer wire is frequently employed to send warning to the rear. No reliance can be placed on bugles, whistles, or such devices as require the use of the lungs.

ACTION TO BE TAKEN IN THE TRENCHES ON GAS ALARM.

(*a*) *Masks* to be put on immediately by all ranks.

(*b*) *Rouse* all men in trenches, dugouts, and mine shafts, warn officers and artillery observation posts and all employed men.

(*c*) *Artillery support* to be called for by company commanders by means of prearranged signals.

(*d*) *Warn regimental headquarters* and troops in rear .

(*e*) *All ranks stand to arms* in the front trenches and elsewhere where the tactical situation demands.

(*f*) *Blanket curtains* at entrances to protected shelters to be let down and carefully fixed.

(*g*) *Movement* to cease except where necessary.

ACTION TO BE TAKEN IN BILLETS AND BACK AREAS.

(*a*) All men in cellars or houses to be roused.

(*b*) The blanket curtains of protected cellars, etc., to be let down and fixed in position.

(*c*) Masks to be put on immediately the gas is apparent.

WARNING OF GAS-SHELL ATTACKS.

Gas-shell attacks are local in their effects, and the gas does not spread to so great a distance as does the gas cloud. Therefore the character of the "gas alarm" for gas shells is different from that for "gas cloud." In the case of gas shells every man must be his own sentry and constantly on the lookout for that form of attack, and give the alarm as soon as he detects gas. For this reason a local gas-shell alarm must be arranged for each individual unit. It must be distinct from the gas-cloud alarm, and every man in the unit must know what it means. It is of the utmost importance that every man within 300 yards of the first gas shell or trench mortar gas bomb should get his mask on at once.

Frequently gas shells do not burst at the commencement of a bombardment but are used intermittently. For that reason when anyone realizes that gas shells are being fired he must give the alarm instantly. This can be done in two ways.

(*a*) By men who are not in the gas at the moment, or may have their masks completely adjusted, shouting "Gas shells" as loudly as possible.

(*b*) By the prearranged signal for the unit being given by the sentry or whoever has first realized that gas shells are being fired. On this alarm may depend the safety of those men who are in dugouts or in different parts of the position who would not otherwise get warning.

Gas shells may be recognized by the following signs:

(*a*) Many gas shells make a peculiar wabbling noise as they come through the air. This is due to their being filled with a liquid instead of a solid.

(*b*) The noise of the burst is very small and might be mistaken for a "blind." There is a difference, however, and after hearing a few gas shells burst one can recognize them.

(*c*) Most gas shells on bursting form a dense white cloud, which hangs together in a peculiar way and is carried along by the wind. This is the easiest sign by which the gas shell can be recognized. The density of the cloud varies with the weather conditions. It is greatest when the air is damp; least when it is dry.

ACTION DURING A GAS ATTACK.

Protective measures.—There should be as little moving about and talking as possible in the trenches. Men must be made to realize that with the gas now used by the enemy, observance of this may be essential for their safety.

When an attack is in progress, all bodies of troops or transport on the move should halt and all working parties cease work until the gas cloud has passed.

If a relief is going on, units should stand fast as far as possible until the gas cloud has passed.

Supports and parties bringing up bombs should only be moved up if the tactical situation demands it.

If troops in support or reserve lines of trenches remain in or go into dugouts, they must continue to wear their anti-gas appliances.

Officers and noncommissioned officers must on no account open up their masks to give orders. The mouthpiece may be removed when it is necessary to speak, but it must be immediately replaced.

Men must always be on the lookout to help each other in case a mask is damaged. When a man is wounded he must be watched to see that he does not remove his mask. If necessary his hands should be tied.

Men must be warned that if they are slightly "gassed" before adjusting their masks they must not remove them. The effect will wear off. After the cloud has passed and the trenches been cleared of gas by the apparatus provided for the purpose, the noncommissioned officer in charge of each trench section will assure himself that the trench is free from gas by raising his mask slightly and will then issue the order to take off masks. *Men will on no account take off their masks until the order to do so has been given.* Dugouts and bombproofs must be entered with caution even after the trenches are clear, as gas frequently remains in them some hours.

PRACTICAL INSTRUCTION (Second Day).

1. Repeat the exercises of the previous day several times and note the improvement in the men. Those men not showing sufficient improvement should be drilled individually or in small squads and their faults corrected.

2. Ordinary infantry drill, including manual of arms, setting-up exercises, and marching will be carried out for two periods of 15 minutes each. Marching should occasionally include double-time for at least 200 yards.

3. Practice in bombing, rapid loading and aiming, judging distance, and range practicing, 15-minute periods.

4. Fitting of masks.—Each man is scrutinized to see that his mask is not obviously too large or too small for him. Then the command "Gas" is given and the class is marched into the gas chamber. The lachrymator benzyl chloride is vaporized in the chamber in the proportion of about 1 teaspoonful to 200 cubic feet of air space either by heating in a tin over a candle flame or by spraying. Each man remains five minutes in the room, moving and talking. If a man's eyes are affected, he goes out of the room and is examined to see if his adjustment is perfect or if he needs a smaller mask. If the latter, he is given a smaller mask, and then reenters the chamber. After five minutes all men are marched out and stand in the open air for some minutes to free their clothes from the vapor. Then the order "Take off masks" is given and the eyes of all men are examined. If the eyes of any are affected, they are given smaller masks. Any man whose face is marked on forehead or cheeks by too much pressure from the face piece is given a larger mask.

After the fitting, the words "Fitted box respirator size X" and the date are to be written on the man's descriptive list.

In order to demonstrate the protection which has been afforded by the mask, the class will now be put in the chamber without masks.

LECTURE NO. 3 (Third Day).

ACTION TO BE TAKEN AFTER A GAS ATTACK.

Cloud-gas attacks are generally made in successive waves (usually three), so that after a gas-cloud attack a sharp lookout must be maintained as long as the wind continues in a dangerous quarter. During an attack the gas sinks into the trenches, and especially into those dugouts and cellars which are not protected by blanket doors. When gas shells are used, the gas sinks into the crater made by the shell and remains in all of these places a long time. Dugouts, cellars, etc., must not be entered, therefore, except by men wearing masks, until they have been thoroughly cleared out.

CLEARING OF SHELTERS.

The only way in which dugouts and cellars can be cleared of gas is through artificial ventilation by means of fires and antigas fans. Formerly a Vermorel sprayer, very much like an ordinary tree sprayer, was used with an alkaline solution which neutralized the chlorine. With the advent of phosgene, however, the Vermorel sprayer lost its efficiency and now is only useful in wetting the blankets at dugout entrances.

Unless a shelter has been thoroughly ventilated by artificial means it must not be slept in or occupied without wearing respirators until at least 12 hours have elapsed. It must not be entered at all without respirators on for at least three hours. The above refers to gas-cloud attacks. In the case of a gas-shell bombardment, time limits can not be stated, as they depend on the nature of the gas used and the severity of the bombardment.

With lachrymatory gases, the times after which shelters can be used without discomfort may be considerably longer than three hours.

Ventilation by fire.—All kinds of shelters can be efficiently and rapidly cleared of gas by the use of fires. Shelters with two openings are the easiest to ventilate, and where possible dugouts with only one entrance should have a second opening made, even a very small one, to assist in ventilation.

In dugouts provided with a single exit at the end of a short passage, the best results are obtained if the fire is placed in the center of the floor of the dugout and at a height of about 6 inches. In dugouts provided with a single exit at the end of a long and nearly horizontal passage, the best results are obtained if the fire is placed about one-third the distance from the inner end of the passage.

In dugouts provided with two or more exits, the fire should be placed at the inner end of one of the exit passages.

In general, 1 pound of dry wood per 200 cubic feet of air space is sufficient for clearance of any gas. The best fuel is split wood, but any fuel which does not smoulder or give off thick smoke can be used. The materials for the fire, e. g., split wood, newspaper, and a small bottle of paraffin for lighting purposes, should be kept in a sandbag inclosed in a tin can provided with a lid. An improvised brazier should be kept ready for use.

The fire should be kept burning for at least 10 minutes and the atmosphere in the shelter should be tested from time to time.

Ventilation by fanning.—Dugouts can be ventilated by producing air currents in them by means of special anti-gas fans. If no anti-gas fans are available, ventilation can be assisted by flapping with improvised fans, such as sand bags, sheets, etc.

Anti-gas fans.—The anti-gas fan consists of a sheet of canvas supported by braces of cane and reinforced in the middle. It is made with two transverse hinges and is fitted with a hickory handle. The flapping portion is, roughly, 15 inches square and the handle is 2 feet long.

METHOD OF USE.

(*a*) *Clearing trenches.*—The fan blade is placed on the ground with the brace side downward, the man using it being in a slightly crouching position with the left foot advanced, the right hand grasping the handle at the neck and the left hand near the butt end. The fan is brought up quickly over the right shoulder, and then smartly flicked to the ground with quick slapping strokes. This drives a current of air along the earth and, on the top strokes, throws the gas out of the trench as if it were by a shovel.

It is essential that the part of the fan blade nearest the handle should touch the ground first, and this can be accomplished in all cases by ending the stroke with the whole length of the handle as close to the ground as possible.

(*b*) In working round a traverse, etc., the fan should be flapped round the corner with the hinge on the corner and the lower edge of the fan as near the bottom of the trench as can be managed. The brace side of the fan is to be outward and at the end of the stroke the whole length of the handle should be close up to the side of the trench.

If several fans are available, men should work in single file and with "out-of-step" strokes, i. e., one fan should be up while the next is down.

(*c*) *Clearing shelters.*—In the case of a dugout with a single entrance not exceeding 12 feet in length the gas is first cleared from the neighborhood of the shelter as in (*a*) and then the corners worked round as in (*b*). The worker now advanced to the inner end of the entrance, beating rather slowly on the ground to allow the gas time to get out of the tunnel and bringing the fan as near the roof as possible on the return stroke.

It may be desirable to have a second fan working just outside the dugout to throw the gas out of the trench as it comes out.

(*d*) In the case of dugouts with two entrances or with one entrance and another opening, such as a chimney, it is only necessary to use the fan round the corner of one entrance in the manner described in (*b*). When the entrance is cleared, it is advisable to enter the shelter with a respirator on in order to beat up the gas from the floor boards, etc. This greatly facilitates the removal of the last traces of gas.

VERMOREL SPRAYERS.

Vermorel sprayers are withdrawn from general use for clearing out gas after an attack, but a certain number are retained for moistening the blankets of protected shelters and for use in medical dugouts, etc. They should be kept for this purpose only and on no account relied on for clearing trenches or shelters of gas.

Company Vermorel sprayers.—Sprayers on the basis of two per company are retained for moistening-blanket protection. They should be kept by company gas noncommissioned officers with other anti-gas trench stores and should be kept one-third full of water. The solution must be kept in corked demijohns or other closed receptacles close to each sprayer; it must not be kept in the sprayers owing to its corrosive nature. It is made up as follows: Water, 3 gallons (one large bucket); sodium thiosulphate (hypo.), 1½ pounds (three-fourths mess tin); sodium carbonate (washing soda), 3 pounds (1½ mess tins).

Three demijohns are required to hold the above quantity, and the necessity for keeping them corked must be impressed on the personnel responsible for it.

When no solution is obtainable water may be used for spraying the blankets.

TREATMENT OF SHELL HOLES.

Shell holes which are so situated as to be obnoxious should be filled up with fresh earth, care being taken to cover up all places around the hole where the chemical liquid from the shell has dropped. Shell holes so treated should not be disturbed, as the chemical is not destroyed by burying, and only slowly disappears.

CLEANING OF ARMS AND AMMUNITION.

Rifles and machine guns must be cleaned after a gas attack and then reoiled. Oil cleaning will prevent corrosion for 12 hours or more, but the first available opportunity must be taken to dismantle machine guns and clean all parts in boiling water containing a little soda. If this is not done, corrosion continues slowly, even after oil cleaning, and may ultimately put the gun out of action.

After a gas attack small-arms ammunition should be carefully examined. All rounds affected by gas must be replaced by new cartridges immediately and the old ones cleaned and expended as soon as possible.

All hand and rifle grenades exposed to the gas should have their safety pins and working parts cleaned and reoiled.

All bright parts of light trench mortars, together with all accessories and spare parts exposed to the gas, must be cleaned and wiped dry as soon as possible after the attack and in any case within 24 hours, after which they should be thoroughly coated afresh with oil. The same applies to ammunition which may have been exposed to the gas.

Ammunition which for any reason had not been oiled must be cleaned and oiled and expended as soon as possible.

The following precautions apply to medium and heavy trench mortars, as well as to guns and howitzers:

PROTECTION.

Batteries which are in constant danger of gas attacks, whether from gas clouds or gas shells, should keep all bright

parts of the gun or mortar, carriage, mounting, and accessories well coated with oil.

Sights and all instruments should also be smeared with oil and protected with covers when not in actual use, care being taken that the oil does not come in contact with any glass or find its way into the interior of the instrument.

Cartridge cases of the ammunition stored with the battery and all uncapped fuzes, or fuzes which have been removed from their cylinders, should be wiped over with oil as soon as possible and protected with a cover.

CLEANING.

All bright parts of guns and trench mortars, together with all accessories and spart parts exposed to the gas, must be cleaned and wiped dry as soon as possible after the attack, and in any case within 24 hours, after which they should be thoroughly coated afresh with oil.

PROTECTION OF TELEPHONE INSTRUMENTS.

The only method of preventing corrosion of electrical apparatus during a gas attack is to prevent the gas reaching it, and the best way to do this is to have signal shelters thoroughly protected against gas. As the corrosive effect on damp instruments is very much greater than on dry instruments, the shelters should be kept as dry as possible.

During a gas attack telephones must be kept in their leather cases, and, unless the buzzer key is being used, the leather flap must be kept down, leaving only the cords with the receiver and hand sets out of the case. The backs of switchboard and buzzer exchange must be kept closed. All apparatus such as magneto telephones, test boards, space instruments, etc., which it is not essential to have uncovered, should be well covered up with cloths, blankets, or coats, etc.

CLEANING INSTRUMENTS AFTER GAS ATTACK.

After a gas attack, telephone apparatus that has been exposed to gas should be treated as follows: The ends of the wires should be removed from terminals and cleaned by being scraped with a knife, wiped with a damp cloth, and dried. Terminals, exchange plugs, and all exposed metal work should be cleaned by being scraped with a knife, wiped with a damp cloth, and

dried. This process should be repeated after 12 hours have elapsed. The metal work of the leather case of the telephone and of other instrument cases should be cleaned with oil in the same way as rifles, etc. The internal portions of the instruments should not be interfered with. If an instrument has been kept closed or covered up, it is very unlikely that internal portions will have suffered, but if these portions show signs of corrosion the instruments should be sent back to division or corps headquarters, to be dealt with by an instrument repairer.

PRACTICAL INSTRUCTION (Third Day).

1. Repeat mask drill.

2. Practice in cleaning trenches and dugouts with anti-gas fans (show the method of holding the fan and making the stroke as described in the morning lecture). Explain the effects on the gas as each stroke is made.

3. *Inspection of masks.*—Box respirators must normally be inspected once a week and daily during "Gas alert." Attention will be paid to the following points:

(*a*) Boxes, face piece, mouthpiece, nose clip, eyepieces, and elastic must be in good order. If the box is rusted through, the respirator must be condemned.

(*b*) Face piece must be firmly attached to the mouthpiece and to the elbow tube.

(*c*) The metal tube inside the mouthpiece must be about one-eighth inch back from the opening of the latter.

(*d*) The rubber tube must be intact and firmly attached to the box and elbow tube.

(*e*) The expiratory valve should be tested by removing the box from the satchel and either closing the cap at the bottom with the hand or pinching the rubber tube so as to prevent inlet of air, at the same time attempting to draw in air through the mouthpiece. It should not be possible to draw in any air. This also proves the absence of leaks in the tube or box. It must be possible to breathe out easily through the valve. If the latter has stuck because of saliva drying in it, this must be remedied by rubbing the valve between the fingers.

(*f*) See that the inlet valve is opening properly and that air can be drawn freely through the box.

(*g*) See that the whipcord is present and not knotted.

(*h*) Any small perforations in the face piece should be temporarily repaired by applying pieces of adhesive plaster from the repair outfit to the perforation, both inside and outside the mask. The adhesive plaster should be large enough to overlap the hole all around.

Respirators so repaired must be exchanged as soon as possible.

(*l*) Replace the box in the satchel so that the face piece comes to the face without twist on the tube. Fold face piece carefully and replace in the satchel so that the expiratory valve is not likely to crumple.

4. *Exposure to chlorine gas in gas house.*—Chlorine should be generated in strength of 1:+10,000 and men required to go to the open door of the gas house and take several breaths of it.

They should then put on their masks and enter the gas house, where they remain 10 minutes. During this time they should exercise, give orders, etc.

LECTURE NO. 4 (Fourth Day).

THE ACTION AND TREATMENT OF POISONOUS GASES.

While the very detailed study of the action of the poisonous gases used in warfare and the technical description of the exact manner in which they damage the human being are matters which are of interest chiefly to medical officers, a clear understanding by line officers of the importance of the means of defense provided can hardly be obtained without at least a general view of the ways in which these substances act upon the human body.

KINDS OF GASES.

Gases which are used in modern warfare are:

1. Gases which act as irritants to the lungs and to the breathing apparatus generally.
2. Gases which act as eye irritants.
3. Gases which act by preventing the blood from taking oxygen.
4. Gases which act as direct poisons to the central nervous system

THE EFFECT OF GASES.

In the beginning of the modern use of gas in warfare, chlorine gas was used almost exclusively, and this gas is the type of the first class—the lung irritants. The curious fact may be here

noted that this gas is at once the soldier's best friend and one of his worst enemies, for it is upon the action of this gas that we depend for the modern method of disinfection of water. It is also the active principle in the new Carrel-Dakin method of wound treatment. Just as chlorine is almost immediately fatal to germ life in drinking water and in the depths of infected wounds, even when used in very dilute solutions, so it is quite promptly fatal to the human being when used in sufficient doses.

When one is exposed to chlorine gas his symptoms will depend upon the strength of concentration of the gas in the air which he breathes. He will at once feel greatly distressed about his breathing and will cough, gasp, and choke.

If the concentration of the chlorine is no more than 1 part to 100,000 parts of air he will not be able to breathe for some time, though there may be severe after effects. If the strength is 1 part of chlorine to 10,000 of air he will not be able to take more than two or three breaths. His eyes and nose will be irritated, he will be choked by spasmodic contractions of his throat, and he will quickly be incapacitated for any exertion.

There is, however, not only the temporary inconvenience to be considered but the permanent damage which is done to the tissues of the bronchial tubes and lungs.

We have in the breathing apparatus a very sensitive set of tissues. The air cells or alveoli of the lungs are guarded from contact with irritating substances by an elaborate system by which the air which finally reaches this region does so only after the most careful filtering through the nose and through the upper air passages. When we realize further that when we are dealing with chlorine we are dealing with one of the most powerful caustic agents in the whole list of chemical elements, a substance capable of causing severe burns when it comes in contact with the much more resistant skin, and even of combining with and corroding steel and other metals, it will not be hard to understand that the damage done to the tender tissues of the breathing apparatus must be of the most severe type.

Experience proves that this is true, and that one or two breaths of a concentration of chlorine gas, one part to a thousand, has been sufficient to damage the lining of the bronchial tubes and of the air cells of the lungs beyond hope of repair.

We are all familiar with the effects of injuries upon those tissues of our bodies which we can see and where we can inspect the results of the damage. We know that within a short time

there will be swelling, the extent of which will depend upon the looseness of the tissues injured. About the eye or lip, for example, such swelling from a blow will be very prompt and often very extensive, the swelling being due to the pouring out of fluid about the seat of the injury, as a first step in the process of repair. A bee sting is an excellent example of the way in which tissues react to damage.

The swelling thus produced is called œdema, and it is exactly this sort of thing which takes place in the lungs when chlorine gas, even in great dilution, is inhaled.

In response to the instant and what might be called an automatic effort on the part of the tissues to wash away the offending material, great volumes of fluid are at once poured out into the air cells, which become so filled with fluid that the air does not have any opportunity to enter the cells.

Even momentary contact of chlorine gas with the delicate membrane lining the fine air vesicles has so far injured them that their capacity for handling the air in their normal way is lost.

Life depends upon a sufficient aerating of the blood. The very delicate machinery by which this is accomplished usually works very efficiently, even in a dusty atmosphere. The nicely strained, warmed, and moistened air is brought into gentle contact with the delicate wall of the air cell, on the other side of which is the network of thin-walled blood vessels, and an equitable exchange takes place according to certain well-defined laws of the diffusion of gases, between the coloring matter of the blood, which has an affinity for the oxygen of the air, and the supply which has been brought to it.

Very obviously, under the conditions which we are supposing, this change can not take place, and the subject not only feels suffocated but actually becomes blue from lack of air.

Owing to the caustic character of this gas, there is great discomfort and pain in the chest, and coughing, gagging, and sometimes vomiting in the effort to clear the lungs.

The cough may be so violent and the injury to the cells so great that the partitions between the air cells are broken and air may leak out into the tissues. In the early cases of gassing this was a very prominent feature of the symptoms.

When the blue stage of suffocation is reached the mind becomes dulled and unconsciousness soon follows. Later, the breathing being so much interfered with, the heart gets a poor supply of

blood, its strength fails, the blue color of the sufferer gives way to the leaden color of collapse, and he succumbs to heart failure. When the dose has been insufficient to cause a fatal inflammation, there results a long-continued bronchitis, and sometimes a stretching of the air cells, from the violent cough, which leads to shortage of breath and permanent disability.

In 1916 the cloud gas used showed somewhat different effects, due to the fact that instead of being pure chlorine alone it was a mixture of chlorine and phosgene, or in some instances phosgene alone.

This gas, which has the formula "$COCl_2$," is a derivative of Cl. It does not so quickly cause œdema of the lungs and is not so immediately irritant to the breathing apparatus.

The cough and strangling are not so marked, and for an hour or so the subject may be abe to go on with his work. A little later he may then suddenly go into a fatal collapse.

The reaction which takes place in the lungs is due to the fact that phosgene, where it comes into contact with a warm, moist surface, as in the air cells of the lungs, forms HCl (hydrochloric acid), and it is upon the formation of this substance in the lungs that the poisonous effects of the gas depend.

As there is not so much of the violent coughing and strangling with this form of gas, there is not so likely to be a tearing of the air cells and a leakage of air and gas into the tissues as with chlorine.

The second group of lung irritants, the nitrous fumes, nitric oxide, and nitrogen peroxide, do not cause so much immediate irritation, but after a few hours of comparative freedom from symptoms after exposure, sudden, fatal collapse may occur. This delayed action is quite characteristic of gases of this group, and it is important to remember, since men suffering from the immediate effects of these fumes may die suddenly after 24 to 48 hours.

LACHRYMATORS.

The second type of gases are those which are used primarily as eye irritants and have practically no permanent effect upon the breathing apparatus. This is the group called lachrymators, or *tear producers*. Benzyl bromide is the type of this gas. Even in very minute concentration these gases cause a very profuse flow of tears, the lining of the eyelids swell, and the subject may be temporarily blinded.

The effect passes off entirely in a day or two, leaving no permanent effects. In very concentrated states these gases may also act as lung irritants to a certain extent. Formalin, the use of which as a fumigating material is familiar to all, may be used in this way. Protection against gases of this type is, as a rule, easily afforded by goggles, but lachrymatory gases are rarely used alone, and therefore the mask must always be worn when their presence is detected.

Carbon monoxide is typical of the third group of gases, which act by combining with the oxygen-carrying substance in the blood (hemoglobin), and is of importance, though it occurs accidentally in warfare and is not used deliberately in cloud gas or gas-shell attacks, its physical properties not lending themselves readily to these purposes.

It is peculiarly liable to occur under circumstances where the presence of gas would not ordinarily be expected; from the imperfect combustions of explosives of the TNT type, from the escape of illuminating gas, which is largely made up of CO, in the fumes from firing of guns in close compartments, in burning buildings, from the warming of sleeping quarters by charcoal braziers, in mine galleries, in the coal bunkers and stokeholes of battleships and transports, etc. Its chief danger lies in the fact that it is odorless, tasteless, colorless, and nonirritant, so that in places where carbon monoxide is liable to be generated every precaution must be taken. Small animals, such as mice and canary birds, are quickly affected by even small quantities of carbon monoxide and are excellent means of warning.

The first symptom is usually a sense of weakness in the limbs. The subject is then unable to handle himself, the coordination is lost, the muscular weakness increases, he staggers, perhaps becomes excited, and shouts, laughs, or sings like a drunken man. Violent headache is one of the early symptoms.

PARALYZING GASES.

The fourth group of gases, of which hydrocyanic or prussic acid is the type, act as direct poisons to the central nervous system and in high concentration are instantaneously fatal.

The effects of a dose which is not immediately fatal are dizziness, confusion, headache, blurring of vision, palpitation, pain in chest and over the heart, labored breathing. Convulsions may occur. In fatal doses there is immediate unconsciousness, dilation of the pupils, gasping respiration, and death with or

without convulsions. HCN has an odor like that of bitter almonds or crushed peach kernels, and this odor is perceptible even in very dilute concentrations insufficient to cause death.

FIRST AID AND TREATMENT IN GAS CASES.

Rest is the most important point of all in the general treatment of gassed cases. Men, and especially officers, should be warned that if even lightly gassed they must refrain from moving about or shouting out orders. Physical strain after being gassed may easily cause the loss of a life that might otherwise have been saved.

Warmth is needed in many of the severe cases, especially at the outset, when they are collapsed and their skin is cold. To attain this, it may even be necessary to transfer them temporarily indoors. Otherwise the fullest supply of fresh air is needed for all cases. When outside, care should be taken to protect against chill, which might lead to a subsequent broch-pneumonia.

Every impediment to the easiest breathing should be removed. Belts, suspenders, the blouse, etc., should be loosened.

If the patient is vomiting much the head should be turned so as to empty the mouth. Frequently gassed men attempt to remove their masks. This should be looked out for by the men who are not gassed, and if a patient shows a disposition to remove his mask his hands should be tied.

All cases should be evacuated as soon as possible to the regimental aid station, and, except in very slightly gassed men, all cases should be carried. In no case should a man who has been gassed attempt to carry his own equipment to the rear.

At the regimental aid station inhalations of ammonia, stimulating hot drinks, etc., may be given, and vomiting may be induced in certain cases by tepid salt water.

Oxygen is of great advantage in certain cases and each dressing station is provided with several cylinders of oxygen. From these the oxygen flows through a hose to a valved face mask, which fits over the face tightly. The pure oxygen is administered every 15 minutes for 4 or 5 minutes each time.

Many drugs have been tried to combat the poison of gases, but very few have been proved of value. A summary of the treatment of gas cases seems to show that rest, warmth, fresh

air when possible, oxygen inhalation, and gentle stimulation is all that can be done. When these measures are employed, however, many cases recover.

PRACTICAL INSTRUCTION (Fourth Day).

1. Repeat mask drill, *marking the time.* Upon the alarm "Gas" have squads of four men put on the mask. When the mask is completely adjusted each man will step forward one pace. Men should be drilled until they can complete the adjustment in six seconds.

2. If the weather is favorable, liberate a gas-cloud attack on the trench. Place three gas cylinders about 300 yards from the trench and to windward of it. Have the men in the trenches with sign "Wind dangerous." Two men posted as sentries with alarm signals conveniently at hand. At a signal from the instructor the gas will be liberated and the alarm sounded by the sentries. Men in the trenches will put on their masks and man the parapets. After the attack has passed trench and dugout will be actually cleared of gas.

3. Demonstrate the protection afforded dugouts by means of wet blankets. Have men enter the dugout in squads of four and remove their masks. Masks should be replaced before they reenter the trenches.

LECTURE NO. 5 (Fifth Day).

THE CHEMISTRY OF GAS WARFARE.

As you already know, gases are used in modern warfare in two different ways, namely, as—

1. The gas wave or cloud.

2. In shells, bombs, or grenades.

In order that a gas may be used in the first way, namely, for the purpose of the cloud offensive, it must possess certain definite physical properties.

(*a*) It must be heavy, so that it will stay close to the ground and not disperse rapidly, but will fill up all depressions, such as trenches and dugouts.

(*b*) It must be easily obtainable.

(*c*) It must be easily liquefiable and capable of being transported in suitable containers.

GAS USED IN CLOUD ATTACKS.

Chlorine and phosgene, either individually or mixed, are the principal gases used in attacks of this type. Bromine has been used, but is so corrosive that it is difficult to handle. Because it is so heavy it is frequently mixed with one or both of the other two gases.

PROPERTIES OF THESE GASES.

Chlorine is a greenish-yellow gas with a very irritating and pungent odor. It is two and one-half times as heavy as air and can be easily liquefied and transported in dry iron containers. It does not attack iron when no moisture is present.

Phosgene is a colorless gas with an odor resembling that of green corn that has begun to sour. It is slightly heavier than chlorine and irritates the throat in such a manner as to produce coughing, even though present in very small amounts. It is a liquid below 45° F., and can also be transported in dry iron containers.

Bromine is a reddish-brown gas, about five and one-half times as heavy as air and is a liquid at about 43° F. It is an intense irritant, producing severe burns of the skin when in contact with it. However, it corrodes metals very rapidly and because of this fact and its expense is used only in connection with one or both of the other two. Because of its weight one can readily see what an advantage it is when it is mixed with others.

Both chlorine and bromine are acid gases, and hence an alkali is used to combat them. This is furnished in our mask by a special chemical mixture of alkali substance.

GASES USED IN SHELLS, ETC.

The gases in shells are in some cases not gases but liquids, which give off varying amounts of vapor when spilled upon the ground. In other cases they are easily liquefiable gases. You can readily see that unless this were the case the amount of gas that could be sent to the enemy trench in a shell would be so little as to make the range of effectiveness very slight.

Practically all the lachrymatory gases belong to the former type—that is, they are liquids. These liquids spill around a shell hole and continue for weeks to give off their irritant or poisonous vapors, for some of them are toxic as well as irritant.

Most of these gases are from liquids derived from bromine and the various liquid distillates obtained as by-products of the coke industry.

Prussic acid and phosgene are representatives of the easily liquefiable type. Prussic acid is a liquid below 79° F. As a gas it is slightly heavier than air and has an odor resembling that of bitter almonds. A gas shell containing 7 liters of liquid prussic acid will liberate about 200 cubic feet of gas on exploding. This is also an acid gas, and is taken care of by our absorber.

New gases are, however, being constantly devised, and all countries have large laboratories ever at work to devise new gases and also to devise new preventives against the enemy's gases.

The detection of new and unusual gases require constant watchfulness by troops at the front, and for this purpose certain men are detailed to collect samples of gas after every gas attack, either cloud or shell. These samples are collected from the air in trenches and dugouts by means of vacuum bulbs (show sample vacuum bulb) or by collecting samples of earth from shell craters after a gas-shell bombardment. Samples so collected are sent to laboratories in the rear, where they are studied in the search for new gases. So far the English and American mask has been found proof against all gases now in use, but surprise is the main feature in gas attacks and the utmost vigilance must be maintained to detect the first sign of new gases.

THE ORGANIZATION OF THE GAS SERVICE IN FOREIGN ARMIES.

The British gas service, upon which our gas service is modeled, consists of a home service and an over-seas service. Both the home service and the over-seas service are divided into an offensive and a defensive. The offensive in England is under the direction of the Royal Engineers, and the defensive is under the direction of the Royal Army Medical Corps. In our Army the offensive, so far as it concerns the production of gas shells, etc., is under the direction of the Ordnance Department, and the defensive, e. g., gas masks, resuscitating apparatus, etc., is under the direction of the Medical Department.

The gas work for both departments in the home territory consists of research work and providing of supplies, and this must be all done on a large scale.

The research work for the Ordnance Department concerns itself with the devising of ever-changing and ever more poison-

ous gases for use in cloud attacks, shells, and other projectiles. Research work for the Medical Department concerns itself with the devising of chemical preventatives for nullifying the effect of all gases which the enemy may bring against us. The supply problem for the Ordnance Department is to produce the proper projectiles in which to deliver the offensive gases; that for the Medical Department to produce the paper devices to carry the neutralizing substances.

The research work, both offensive and defensive, is of a chemical and physiological character and requires the service of a large number of scientists in those professions, whose whole time must be devoted to a constant study of the various elements entering into the offensive and defensive side of gas warfare.

In England two laboratories are maintained for this purpose—one under the engineers for the study of offensive material and another under the medical department for the study of preventive material. In our country we have one large laboratory working on both the offensive and defensive material for both the Army and Navy. The work that this laboratory is called upon to do is enormous, as upon the chemical findings of the laboratory the ultimate success or failure of gas warfare must largely depend.

ANTI-GAS DUTIES WITHIN AN INFANTRY REGIMENT.

The gas service in the field forms an intimate part of all tactical organizations. Attached to each army there is an engineer brigade under command of a general officer charged with the duty of making all the gas-cloud attacks with that army, and a chemical adviser charged with all technical matters regarding gas warfare.

A special gas officer is appointed in each division, so that technical advice is readily available on all matters connected with gas defense. This officer is also charged with the instruction of the divisional anti-gas school. Standing orders are to the effect that commanding officers will facilitate in every way the duties of the divisional gas officer in visiting their lines and inspecting anti-gas arrangements, testing alarms, etc. They should take every opportunity of consulting with the divisional gas officer on all technical questions relating to gas defense.

In order that there may be a thorough understanding in each organization of all matters pertaining to gas defense, an anti-gas

school is established in each division, and the following officers and noncommissioned officers are required to attend a course of instruction at this school.

OFFICERS.

(*a*) The commanding officer or the second in command and a medical officer from each regiment.
(*b*) All company commanders.
(*c*) Other officers when possible.

NONCOMMISSIONED OFFICERS.

(*a*) Two per company.
(*b*) Two from headquarters company.
(*c*) Other noncommissioned officers when possible.

ANTI-GAS DUTIES WITHIN AN INFANTRY REGIMENT.

[To be modified for other units to suit their organization and duties.]

The commanding officer is directly responsible for all measures against gas attacks, and company commanders are responsible to the commanding officer for all anti-gas measures within their companies.

In each company one noncommissioned officer who has been trained at an anti-gas school, and who has been recommended by the divisional gas officer as suitable for duty as "Company gas noncommissioned officer," is specially detailed to assist the company commander in anti-gas measures. At least one other similarly trained and recommended noncommissioned officer should be immediately available to take the place of the gas noncommissioned officer in case of need.

A similarly trained noncommissioned officer is detailed to regimental headquarters for duty with headquarters details.

The special duties of company gas noncommissioned officers are as follows. Other duties may, however, be performed, provided they do not interfere with gas duties:

1. They will assist officers at the inspection of box respirators and in making such local repairs as possible. They will assist in training men in the use of anti-gas appliances.

2. Under the company commander they will have charge of all anti-gas trench stores, as follows:

(*a*) *Strombos horns* and other gas-alarm devices. Inspect daily and see that sentries posted to them know how they should be used.

(*b*) *Gas-proof shelters.*—See that the blanket doorways fit and are kept in good order.

(*c*) *Anti-gas fans.*—See that they are in their proper position and in serviceable condition.

(*d*) *Stores of fuel for cleaning shelter.*—Insure sufficient supply for clearing dugouts, to be maintained under company arrangements.

(*e*) *Vermorel sprayers.*—Maintain in working order and see that supply of solution is available.

(*f*) *Gas-sampling apparatus.*—Have charge of the vacuum bulbs and gas-testing tubes. Keep a stock of corked bottles and small tins with well-fitting lids for collecting samples of earth and water after a gas-shell attack.

3. On relief they will assist the company commander in taking over all anti-gas trench stores. The gas company noncommissioned officers should accompany the advance party and take over anti-gas trench stores (by daylight if possible).

4. They will make wind observations every three hours, or more frequently if the wind is in or nearing a dangerous quarter, and will report any change of wind to the company commander.

5. During a gas-cloud attack they will take gas samples by means of the vacuum bulbs and gas-testing tubes.

6. During or after the attack the noncommissioned officer must note down in writing as much information regarding the attack as possible.

7. As soon as possible after the conclusion of a gas-shell bombardment, the gas noncommissioned officer must fill his bottles and tins (two) and take samples of water, mud, or earth from those parts of the line which are smelling most strongly of shell gases. He should note the position of any blind shells.

8. As soon as possible after a gas attack, all samples and notes will be handed in to the company commander for transmission to the divisional gas officer.

PRACTICAL INSTRUCTION (Fifth Day).

1. Repeat gas-mask drill in its various forms.

2. Practical demonstration of lachrymatory gas in shell crater. (Pour some benzyl chloride in hole previously prepared.) Then

demonstrate method of filling shell craters to destroy effects o gas.

3. Familiarity with the smell of phosgene. (Liberate a smal quantity of phosgene under a closed tent.) Have each man pul back the flap and smell the phosgene.

(Sixth Day.)

General review of the subjects taught during the week. A short written qu'z is usually advisable for officer.