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GAS WARFARE

PART I

GERMAN METHODS OF OFFENSE

ARMY WAR COLLEGE
February, 1918
WAR DEPARTMENT,
WASHINGTON, February 15, 1918.

The following pamphlet, entitled "Gas Warfare," is published for the information and guidance of all concerned.
(062.1 A. G. O.)

BY ORDER OF THE SECRETARY OF WAR:

JOHN BIDDLE,
Major General, Acting Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.
TABLE OF CONTENTS

<p>| Introduction                                      | 11 |
| Gas Clouds                                        | 11 |
| Cylinders                                         | 12 |
| Installation of Cylinders                        | 13 |
| Organization                                      | 14 |
| Materials Used                                    | 15 |
| Conditions for Cloud Attack                      | 16 |
| Terrain                                           | 16 |
| Meteorological Conditions                        | 16 |
| Appearance and Behavior of the Cloud             | 17 |
| Gas Cloud Tactics                                 | 18 |
| Concentration of Gas                              | 18 |
| Surprse                                           | 19 |
| Effects Produced                                  | 19 |
| Details of German Gas Cloud Attacks               | 22 |
| Summary of Cloud Attacks Against the British Army | 22 |
| Details of Individual Cloud Attacks               | 22 |
| On British, May 24, 1915                          | 22 |
| On Russians, 1915                                | 22 |
| On British, December 19, 1915                    | 24 |
| On British, April 27, 29, 30, 1916               | 26 |
| On British, June 17, 1916                        | 30 |
| On British, August 8–9, 1916                     | 31 |
| On French, January 31, 1917                      | 33 |
| On French, April 23, 1917                        | 35 |
| Artillery and Trench Mortar Gas Shell             | 36 |
| Materials Used                                    | 36 |
| Lethal Shell Gases                                | 37 |
| Lachrymatorals                                    | 37 |
| Sternotiators                                     | 38 |
| Eye, Lung and Skin Irritants                     | 35 |
| Summary of German Artillery and Trench Mortar Gas Shell | 37 |
| Details of Artillery Gas Shell                    | 39 |
| Content of Liquid                                 | 39 |
| Bursting Charge                                   | 42 |
| Fuses                                             | 42 |
| 7.7 cm. (Field Gun) Gas Shell                    | 49 |
| 7.7 cm. Short (1915 Pattern) Gas Shell            | 49 |
| 7.7 cm. Green Cross                               | 49 |
| 7.7 cm. Long Gas Shell                            | 51 |
| 7.7 cm. Green Cross                               | 51 |
| 7.7 cm. Green Cross 1                             | 51 |
| 7.7 cm. &quot;B-Stoff&quot;                                 | 51 |
| 7.7 cm. Yellow Cross                              | 51 |
| 7.7 cm. Blue Cross                                | 53 |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>10 cm. Gun Gas Shell.</td>
</tr>
<tr>
<td>53</td>
<td>10.5 cm. Howitzer Gas Shell (Long).</td>
</tr>
<tr>
<td>53</td>
<td>10.5 cm. &quot;T-Stoff,&quot; &quot;B-Stoff,&quot; and &quot;K-Stoff&quot;.</td>
</tr>
<tr>
<td>53</td>
<td>10.5 cm. Green Cross.</td>
</tr>
<tr>
<td>56</td>
<td>10.5 cm. Green Cross 1.</td>
</tr>
<tr>
<td>56</td>
<td>10.5 cm. Yellow Cross.</td>
</tr>
<tr>
<td>56</td>
<td>10.5 cm. Blue Cross.</td>
</tr>
<tr>
<td>58</td>
<td>15 cm. Heavy Field Howitzer Gas Shell.</td>
</tr>
<tr>
<td>58</td>
<td>15 cm. 1912 Pattern Shell.</td>
</tr>
<tr>
<td>58</td>
<td>15 cm. T-Shell.</td>
</tr>
<tr>
<td>60</td>
<td>15 cm. &quot;Green&quot; T-Shell.</td>
</tr>
<tr>
<td>60</td>
<td>15 cm. B-Shell (K-Shell).</td>
</tr>
<tr>
<td>60</td>
<td>15 cm. K-Shell (K-Shell).</td>
</tr>
<tr>
<td>60</td>
<td>Variations of 15 cm. 1912 Shell.</td>
</tr>
<tr>
<td>60</td>
<td>15 cm. Green Cross and Green Cross 1.</td>
</tr>
<tr>
<td>62</td>
<td>15 cm. Phenylcarbelynamine Chloride (Lachrymator) Shell.</td>
</tr>
<tr>
<td>62</td>
<td>15 cm. New Pattern 1912 Shell—Gr. 12 n/A.</td>
</tr>
<tr>
<td>62</td>
<td>15 cm. Green Cross 2.</td>
</tr>
<tr>
<td>64</td>
<td>21 cm. Heavy Howitzer (Mörser) Gas Shell.</td>
</tr>
<tr>
<td>64</td>
<td>21 cm. Green Cross 2.</td>
</tr>
<tr>
<td>65</td>
<td>21 cm. Yellow Cross.</td>
</tr>
<tr>
<td>65</td>
<td>Details of Trench Mortar Gas Shell.</td>
</tr>
<tr>
<td>65</td>
<td>Fuses.</td>
</tr>
<tr>
<td>65</td>
<td>L. W. M. Zdr. 2 (Leichter Wurf-Mine-Zünder).</td>
</tr>
<tr>
<td>65</td>
<td>Z. s. u. m. W. M. (Zünder schwerer und mittlerer Wurf-Mine).</td>
</tr>
<tr>
<td>68</td>
<td>Auxiliary Trench Mortar Bombs.</td>
</tr>
<tr>
<td>68</td>
<td>9 cm. Bomb Filled with Bromine.</td>
</tr>
<tr>
<td>68</td>
<td>9 cm. Bomb Filled with &quot;B-Stoff,&quot; etc.</td>
</tr>
<tr>
<td>70</td>
<td>7.5 cm. Light Trench Mortar Gas Shell (Leichte Wurf-Mine).</td>
</tr>
<tr>
<td>70</td>
<td>C-Shell.</td>
</tr>
<tr>
<td>73</td>
<td>B-Shell.</td>
</tr>
<tr>
<td>73</td>
<td>D-Shell.</td>
</tr>
<tr>
<td>74</td>
<td>Type 1.</td>
</tr>
<tr>
<td>75</td>
<td>Type 2 (Ogival Head).</td>
</tr>
<tr>
<td>76</td>
<td>Type 3 (Short Ogival Head).</td>
</tr>
<tr>
<td>77</td>
<td>17 cm. Medium Trench Mortar Gas Shell (Mittlere Wurf-Mine).</td>
</tr>
<tr>
<td>77</td>
<td>B-Shell (Marked B M).</td>
</tr>
<tr>
<td>79</td>
<td>C-Shell.</td>
</tr>
<tr>
<td>79</td>
<td>D-Shell.</td>
</tr>
<tr>
<td>80</td>
<td>25 cm. Half-Sized Heavy Trench Mortar Shell (Kurze Schwere Wurf-Mine).</td>
</tr>
<tr>
<td>80</td>
<td>18 cm. Smooth-Bore Trench Mortar Shell (Glatte Wurf-Mine).</td>
</tr>
<tr>
<td>80</td>
<td>Methods and Tactics Employed in the Use of Gas Shell.</td>
</tr>
<tr>
<td>80</td>
<td>Early Methods (1915–1916).</td>
</tr>
<tr>
<td>82</td>
<td>Special Points.</td>
</tr>
<tr>
<td>82</td>
<td>Firing Against Infantry Positions.</td>
</tr>
<tr>
<td>83</td>
<td>Firing Against Artillery Positions.</td>
</tr>
<tr>
<td>83</td>
<td>Firing on a Definite Area with Gas Shell.</td>
</tr>
</tbody>
</table>
Example of the Formation of a Gas Barrage ........................................... 84
Use of Green Cross Shell (1916–1917) .................................................. 85
Present Methods of Using Artillery Gas Shell ....................................... 88
Precautions in Storing and Handling Gas Shell ..................................... 103
Present Methods of Using Trench Mortar (Minenwerfer) Gas Shell ........ 106
Details of Some Recent German Gas Shell Bombardments ..................... 108
Pont à Mousson, Feb. 19–20, 1917 ....................................................... 109
Arras, December 27–28, 1916 ............................................................ 110
Ypres, July 12–13, 1917 ................................................................. 113
British Front, July 28–29, 1917 ......................................................... 114
Cambrai Sector, December 10–11, 1917 ............................................. 116
Gas Hand Grenades ........................................................................... 116
Glass Grenades .................................................................................. 116
Bromine (Use Discontinued) .............................................................. 116
Chlorosulphonic Acid ........................................................................ 116
Bromoacetone (Use Discontinued) ...................................................... 118
Metal Grenades .................................................................................. 118
"B-Stoff" ........................................................................................... 119
"C-Stoff" ............................................................................................ 120
Incendiary Shell .................................................................................. 122
15 cm. Howitzer Incendiary Shell ....................................................... 122
13 cm. Gun Incendiary Shell .............................................................. 122
17 cm. Medium "Minenwerfer" Incendiary Shell ................................... 124
Smoke Production .............................................................................. 124
Smoke Shell ......................................................................................... 124
Auxiliary "Smoke-Producers" .............................................................. 124
15 cm. Smoke Shell ............................................................................ 126
Smoke Generators ............................................................................. 126
"Nebel-Trommel (N. T.)" ................................................................. 128
"Nebel-Topf (N. L.)" ......................................................................... 130
"Nebel-Kasten (N. K.)" ...................................................................... 130
Method of Use .................................................................................... 132
Smoke Grenades ................................................................................ 133
Flame Projectors ................................................................................ 133
Small "Flammenwerfer" ....................................................................... 134
Organization of Flame Attacks ............................................................ 134
Tactics ................................................................................................. 134
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Illustration Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>German Gas Cylinder</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>German Trench with Gas Cylinder in Position</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>German Trench with Gas Cylinder Ready for Discharge</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Map showing German Gas Attacks on Russian Front</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>Section of Fuse H. Z. 14</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>Section of Fuse Gr. Z. 04</td>
<td>45</td>
</tr>
<tr>
<td>7</td>
<td>Section of Fuse Gr. Z. 01</td>
<td>46</td>
</tr>
<tr>
<td>8</td>
<td>Section of Fuse E. K. Z. 17</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>1915 Pattern of 7.7 cm. Short Gas Shell</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>7.7 cm. Blue Cross (Sternutator) Shell</td>
<td>52</td>
</tr>
<tr>
<td>11</td>
<td>10 cm. Gun Gas Shell</td>
<td>54</td>
</tr>
<tr>
<td>12</td>
<td>10.5 cm. Howitzer Gas Shell</td>
<td>55</td>
</tr>
<tr>
<td>13</td>
<td>10.5 cm. Light Field Howitzer Gas Shell</td>
<td>57</td>
</tr>
<tr>
<td>14</td>
<td>15 cm. Heavy Field Howitzer T-Shell</td>
<td>59</td>
</tr>
<tr>
<td>15</td>
<td>15 cm. Howitzer GasShell: Green Cross and Green Cross 1</td>
<td>61</td>
</tr>
<tr>
<td>16</td>
<td>15 cm. Gas Shell: Green Cross 2 and Yellow Cross</td>
<td>63</td>
</tr>
<tr>
<td>17</td>
<td>Section of Fuse L. W. M. Z</td>
<td>66</td>
</tr>
<tr>
<td>18</td>
<td>9 cm. Bomb—Used for Bromine (Early Type)</td>
<td>67</td>
</tr>
<tr>
<td>19</td>
<td>9 cm. Trench Mortar Gas Bomb</td>
<td>69</td>
</tr>
<tr>
<td>20</td>
<td>7.5 cm. Light Trench Mortar Gas Shell (C-Shell—Early Type)</td>
<td>71</td>
</tr>
<tr>
<td>21</td>
<td>7.5 cm, Light Trench Mortar Gas Shell (D-Shell—Early Type)</td>
<td>72</td>
</tr>
<tr>
<td>22</td>
<td>Types of 7.5 cm. Trench Mortar Shell</td>
<td>73</td>
</tr>
<tr>
<td>23</td>
<td>Head of 7.5 cm. “Minenwerfer” Gas Shell (D-Shell—Long Pattern)</td>
<td>75</td>
</tr>
<tr>
<td>24</td>
<td>Head of 7.5 cm. Light “Minenwerfer” Gas Shell—Short Pattern, with Filling Hole in Shoulder</td>
<td>76</td>
</tr>
<tr>
<td>25</td>
<td>17 cm. “Minenwerfer” Gas Shell</td>
<td>78</td>
</tr>
<tr>
<td>26</td>
<td>18 cm. Smooth-Bore Trench Mortar Shell</td>
<td>81</td>
</tr>
<tr>
<td>27</td>
<td>Example of the Formation of a Gas Barrage (Old Method)</td>
<td>84</td>
</tr>
<tr>
<td>28</td>
<td>Bombardment of a Target with Gas Shell, with Different Wind Directions</td>
<td>94</td>
</tr>
<tr>
<td>29</td>
<td>Method of Dividing Areas into Sectors for Gas Shell Bombardment (A)</td>
<td>95</td>
</tr>
<tr>
<td>30</td>
<td>Method of Dividing Areas into Sectors for Gas Shell Bombardment (B)</td>
<td>97</td>
</tr>
<tr>
<td>31</td>
<td>Glass Hand Grenade Used for Gas</td>
<td>117</td>
</tr>
<tr>
<td>32</td>
<td>Section of Metal Gas Grenade</td>
<td>118</td>
</tr>
<tr>
<td>33</td>
<td>Metal Gas Grenade with Carrier</td>
<td>120</td>
</tr>
<tr>
<td>34</td>
<td>15 cm. Howitzer Incendiary Shell</td>
<td>121</td>
</tr>
<tr>
<td>35</td>
<td>17 cm. Medium “Minenwerfer” Incendiary Shell</td>
<td>123</td>
</tr>
<tr>
<td>36</td>
<td>15 cm. Smoke Shell</td>
<td>125</td>
</tr>
<tr>
<td>37</td>
<td>Smoke Generator—“Nebel-Trommel” (Smoke Drum) Type</td>
<td>127</td>
</tr>
<tr>
<td>38</td>
<td>Section of German “Nebel-Topf” (Smoke Pot)</td>
<td>128</td>
</tr>
<tr>
<td>39</td>
<td>Smoke Generator—“Nebel-Topf” Type</td>
<td>129</td>
</tr>
<tr>
<td>40</td>
<td>Smoke Generator—“Nebel-Kasten” (Smoke Box) Type</td>
<td>131</td>
</tr>
</tbody>
</table>
GAS WARFARE

PART I.

GERMAN METHODS OF OFFENSE
GERMAN METHODS OF OFFENSE

INTRODUCTION

1. The use of poison gas for offensive purposes has been developed continuously by the enemy since his first gas attack of April, 1915, with the result that gas of one kind or another is now used in enormous quantities in the form of gas clouds, gas shell, trench mortar bombs, and hand grenades. On the Western Front hostile gas cloud attacks are not as frequent as formerly, but, on the other hand, the use of gas shell and trench mortar bombs has increased to such an extent that probably one-fifth of all shell fired by the Germans carry gas. When it is remembered that gas shell cannot be used for ordinary barrage purposes, for wire cutting, or for demolition of fortified works, it is evident that of the total number of shell used against living targets a very large proportion must be gas shell.

2. It must not be imagined, however, that hostile gas cloud attacks are things of the past. It is true that the last cloud attack against the British was made in August, 1916, but since that time the French, Russians, and Italians have all been gassed on a number of occasions, and for various reasons it seems that a recurrence of cloud attacks on the Allies on the Western Front is not unlikely.

3. The total quantity of poison gas used by the Germans on the Western Front is very large and probably amounts to several thousand tons every month. On one stretch of front alone it was estimated that a million gas shell of various kinds were used within 30 days.

GAS CLOUDS

4. The present methods for making gas cloud attacks differ only in slight details from those employed in the first attacks. Nearly all the developments have been in alteration of tactics and in the use of other gases.

11
5. The gas is compressed into steel cylinders of the construction and dimensions shown in Fig. 1. These cylinders when full weigh approximately 88 lbs., and contain 44 lbs. of liquified gas. The siphon tube reaches nearly to the bottom of the cylinder, so that when the valve is opened actual liquid is forced into the atmosphere and vaporises there. Without this arrangement the evaporation of the liquid inside the cylinder would cause such intense cooling that the evolution of the gas would become very slow and almost cease. With the siphon, when the valve is fully opened, the German cylinders take only two to three minutes to empty. When the cylinder is not required for immediate use a protective dome is screwed over the valve and exit tube, a white paint mark on the cylinder showing the position of the latter.
INSTALLATION OF CYLINDERS

6. The cylinders when taken into the trenches are dug in under the parapet as shown in Fig. 2, and covered over with sacking or with a “Salzdecke.” The latter is a kind of quilt stuffed with peat moss and soaked in potassium carbonate solution, which absorbs any gas which may leak out. Over the “Salzdecke” are placed sand-bags which protect the cylinder from shell splinters, and, at the same time, form the firing step of the trench.

7. When the gas attack is to be made the coverings are
removed, the domes of the cylinders taken off, and a lead pipe screwed to each exit tube and bent over the parapet as shown in Fig. 3. The end of this pipe, which is slightly turned up so as to prevent the liquid from impinging upon the ground, is weighted with a sand-bag to prevent "kicking" and consequent displacement of the pipe when the gas is turned on.

8. In the earlier attacks the cylinders are stated to have been used in the ratio of one per meter on the front on which gas was installed. In the more recent attacks three per two meters, or even two per meter, have been used. In the latter case this is generally done, where the width of the trench permits it, by double-banking, i.e., placing one cylinder immediately behind the other in the hole dug under the parapet.

**ORGANIZATION**

9. Gas operations are conducted by the 35th and 36th Pioneer Regiments and also by the Guard Reserve Pioneer Regiment. The latter, however, is chiefly used for flame projector work. Each regiment consists of two battalions of three companies.
and a park company each, and has 78 officers, including chemists, meteorologists, and other specialists.

Each regiment has 24 trench mortars (light rifled “Minenwerfer”) for gas shell operations.

Two pioneers are allotted to each “battery,” which is composed of 20 cylinders. (A recently captured document states that each battery requires the attention of three pioneers, but this may be intended to include a non-commissioned officer.)

**MATERIALS USED**

10. A suitable gas for use in cylinders must satisfy certain easily defined conditions:
(a) It must be highly toxic.
(b) It must be readily compressible to a liquid and yet be easily volatile.
(c) It must be easily manufactured in large quantities.
(d) It should have a considerably higher density than that of air, and should be stable against moisture and other chemicals.

11. The number of gases which even approximately meet these requirements is very limited. Chlorine, which was the gas originally used by the Germans, is the most natural to employ and fulfills all the conditions stated except that of stability towards other chemicals. This deficiency, however, makes protection against chlorine very easy.

12. The first attacks were all made with pure chlorine, but since the end of 1915 German cloud gas has been composed of a mixture of chlorine and phosgene (carbonyl chloride). Phosgene is not much more poisonous than chlorine; but it is far more deadly, owing to its insidious nature, the delayed effects it produces and the greater difficulty in protecting against it. On the other hand, its boiling point (8° C.) makes it impossible to use phosgene alone at ordinary temperatures, owing to lack of pressure. It is consequently mixed with chlorine to force it out of the cylinders.

13. In the attacks on the British in December, 1915, the percentage of phosgene, according to information received, was probably 20. Numerous cylinders have been captured (1917) containing a mixture of 75 per cent chlorine and 25 per cent phosgene, but it is probable that the gas used in the most recent attacks had a higher proportion of phosgene. According to one prisoner’s statement the percentage was as high as 60, but
this is somewhat unlikely owing to the time it would take to empty the cylinder of such a mixture.

14. Quite recently on the French Front cylinders have been captured which hold pure phosgene, but how these were intended to be used is uncertain, as except in very hot weather some arrangement would be needed to force the gas out of the cylinders.

The 75 per cent chlorine–25 per cent phosgene mixture boils at —30° C.

Besides chlorine and phosgene no other gas has been used by the Germans for the purpose of making cloud attacks (for description of these gases see Appendix I).

**CONDITIONS FOR CLOUD ATTACK**

15. **Terrain.**—Extracts from a captured enemy document follow:

Hilly country, intersected by valleys and gulleys, is unfavorable for cloud attacks. [Assumed security, based on this statement, permitted the French to surprise the Germans with a gas attack in the Vosges in 1916. A captured document admitted that this attack was a complete surprise and that the German troops were quite unprepared. Casualties must consequently have been high.]

A district with a downward slope is most advantageous, but slight upward slopes are no obstacle with a favorable wind. Water courses and ponds offer no difficulties to the use of a gas cloud so long as they are colder than the surrounding air. The gas being somewhat heavier than air remains stationary or flows along (like water) into trenches, mine-craters, dugouts, and hollows in the ground. Slight eminences may form so-called "islands" which may remain free from gas. These should be noted beforehand and arrangements made to bombard them with gas from guns or trench mortars.

In woods the cloud moves forward with decreased velocity, but persists correspondingly longer. If woods or corn fields are wet with rain or dew, the gas is quickly absorbed therein and "burns" the plants.

16. As is pointed out more fully in Part II, the choice of a position for making a cloud attack must be governed by the distance apart and alignment of the trenches. The latter should be close together, so as to get the highest concentration of gas possible, and the alignment such that there is no danger of gassing adjacent trenches of the offensive line.

17. **Meteorological Conditions.**—The most important meteor-
ological condition is that of direction and strength of the wind. The general direction must obviously be towards the enemy, but must not come within a certain limiting angle with the line of the trench from which the discharge is being made, or with lines of adjacent trenches. This angle of safety is fully discussed in Part II. on "Defensive Measures Against Gas Attacks." A captured German document indicates diagramatically that the enemy probably adopts an angle of safety of 40 degrees, but it does not follow that in special cases he will not take greater risks or evacuate portions of his own line in order to make an attack on chosen positions.

18. The Germans have made gas attacks in winds varying in strength from 2 to 20 miles per hour, i.e., from 1 to 10 yards per second, but the most suitable wind is one between 4 and 8 miles per hour. An 8-mile wind will carry the gas cloud twice as fast as a man walks rapidly. If the wind is too high, the gas is dispersed too quickly, and if the wind is too low it is likely to be variable in direction. In the German gas attack on the British at Hulluch, April 29, 1916, the velocity of the wind was almost nil on the northern part of the line and the gas cloud blew back over the German trenches, causing there about 1,500 casualties.

19. The following extracts are from a captured German document:

The effect of the gas is decreased by upward air currents. These occur when the barometer is low or when the earth's surface is warmed by the sun, and are particularly noticeable in the middle of the day and in the afternoon when the sun is shining.

Descending air currents, which occur during the night and towards morning, and also when the barometer is high, are, in general, favorable for gas attacks.

Fogs hardly affect the gas cloud, and foggy weather can be used in order to mask a gas attack. Gentle rain is also without appreciable effect, but strong rain washes down the gas.

**APPEARANCE AND BEHAVIOR OF THE CLOUD**

20. Extracts from a captured German document follow:

When the valves of the cylinders are opened the gas is forced out under its own pressure and produces thereby a hissing sound, which on a still night can frequently be heard at a considerable distance. This should be masked, if possible, by artillery and machine-gun fire. [A noiseless valve is stated
to be in preparation. The gas mixes with the air and is carried forward towards the opposing trenches, spreading out as it goes forward in the form of an opaque, clinging cloud bank.1

Under the influence of dilution and warmth, the cloud gradually rises, without thereby becoming ineffective. In very dry air, i.e., during great heat or intense cold, there may be no formation of an actual cloud. Chlorine is then recognizable, even from a long distance, by its greenish-yellow color.

**GAS CLOUD TACTICS**

21. The first attacks on the Western Front, and apparently most of those on the Eastern Front, were made with the purposes of causing casualties and demoralization and of preparing for infantry advances. These aims were successfully accomplished against troops unprovided with respirators or troops badly trained and poorly equipped; but in later attacks it was apparently realized that, against an army provided with good anti-gas appliances and well trained in their use, the number of casualties and the effect on the morale were insufficient to warrant following up the gas cloud with infantry. Since the attack on the British on December 19, 1915, the Germans have made no serious attempt to follow up a cloud gas attack. Even patrols sent out to discover the effect of the gas have generally been unable to approach the British trenches.

Later attacks have all been for the purpose of causing casualties, and so reducing morale and fighting strength. For this purpose everything possible has been done—

(a) To increase the deadliness of the gas.

(b) To effect surprise.

22. **Concentration of Gas.**—The cloud has been made more deadly by the introduction of phosgene (see above) and by increasing the concentration of the gas. The latter effect has been obtained chiefly by discharging a larger number of cylinders during a short time and generally on a restricted front. Thus, whereas the first attacks were of several hours' duration, that of December, 1915, lasted one-half hour, and the most recent attacks have lasted only 10 to 15 minutes for each individual wave. By these means it has been possible for the Germans to increase enormously the strength of the gas cloud. Documents indicate that they aim at producing a concentration of 0.5 per cent by volume in the opposing trenches, but it is extremely doubtful if more than 0.1 per cent has ever been obtained.
23. Surprise.—By making gas attacks at night it is easier to take the opposing troops by surprise since this reduces the chances of detecting the cloud in advance. Moreover, meteorological conditions are usually more favorable at night.

Gas is mixed with and alternated with smoke, which, though generally harmless in itself, enables the enemy to conserve his gas by masking the limits of the true gas cloud. The purpose of these tactics is to force the British troops to wear respirators unnecessarily, the enemy hoping thereby to cause deterioration of the protective chemicals.

24. The gas is frequently sent over in successive waves at intervals varying from a few minutes to several hours. These waves are generally put over on the same front with the object of making the troops relax their vigilance after the first one or two, under the impression that the attack is finished. These tactics were successful the first time they were used. This occurred in the attacks made on the 1st British Army in April, 1916. The first wave was composed mostly of smoke. The second wave was almost entirely gas and caused nearly all the casualties.

**EFFECTS PRODUCED**

25. The effects of German gas cloud attacks have been determined by the equipment, training and discipline of the troops gassed. In the cloud attacks on the British Front the casualties have become less with each successive attack, although the proportion of fatal casualties has tended to increase, showing the greater deadliness of the later clouds.

26. According to a captured document the Gas Regiments had carried out 24 large operations up to August, 1916, and had discharged approximately 3,600 tons of gas. They claim to have killed in that period 35,000 men. Examples of casualties claimed follow:

<table>
<thead>
<tr>
<th>Location</th>
<th>Killed</th>
<th>Prisoners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ypres, April 22, 1915</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Osovicz (Bzura), May, 1915</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Bzura (55th and 56th Siberian Regts. ?), June, 1915</td>
<td>9,000</td>
<td>1,500</td>
</tr>
</tbody>
</table>

Since April, 1915, the Germans have made about 20 large gas cloud attacks on the Western Front, the majority being against the British.
<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Length of front (Yards)</th>
<th>Nature of gas</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 24</td>
<td>Ypres Salient</td>
<td></td>
<td>Chlorine</td>
<td>Duration about 1½ hours.</td>
</tr>
<tr>
<td>May 1</td>
<td>Ypres Salient</td>
<td></td>
<td>Chlorine</td>
<td></td>
</tr>
<tr>
<td>May 6</td>
<td>Hill 60</td>
<td></td>
<td>Chlorine</td>
<td></td>
</tr>
<tr>
<td>May 24</td>
<td>Ypres Salient</td>
<td></td>
<td>Chlorine</td>
<td>Duration several hours (intermittent).</td>
</tr>
<tr>
<td>June 19–20</td>
<td>Ypres Salient</td>
<td>1,200</td>
<td>Chlorine and phosgene</td>
<td>Duration 30 minutes. Probably 20 per cent phosgene.</td>
</tr>
<tr>
<td>Dec. 19</td>
<td>Ypres Salient</td>
<td>5,250 to 7,000</td>
<td>Chlorine and phosgene</td>
<td></td>
</tr>
<tr>
<td>1916</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 27</td>
<td>Hulluch</td>
<td>3,000</td>
<td>Chlorine and phosgene</td>
<td>Two waves of 10–15 minutes each. Much smoke used. Probably 25 per cent phosgene.</td>
</tr>
<tr>
<td>April 29</td>
<td>Hulluch</td>
<td>3,000</td>
<td>Chlorine and phosgene</td>
<td>Two waves of 10–15 minutes each. Much smoke used. Probably 25 per cent phosgene.</td>
</tr>
<tr>
<td>Date</td>
<td>Location</td>
<td>Chlorine and Phosgene</td>
<td>Chlorine and Phosgene</td>
<td>Chlorine and Phosgene</td>
</tr>
<tr>
<td>------------</td>
<td>------------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>April 30</td>
<td>Wulverghem-Messines</td>
<td>3,500</td>
<td>3,000</td>
<td>1,500</td>
</tr>
<tr>
<td>June 17</td>
<td>North of Messines</td>
<td>Three waves of 10 minutes each</td>
<td>Probably about 50 per cent phosgene</td>
<td>Slight increase in casualties due to large percentage of raw recruits</td>
</tr>
<tr>
<td>August 8</td>
<td>Ypres Salient</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DETAILS OF GERMAN GAS CLOUD ATTACKS

Summary of Cloud Attacks Against the British Army

27. A summary of the more important gas cloud attacks against the British Army is given in Table I.

Details of Individual Cloud Attacks.

GERMAN GAS ATTACK UPON THE BRITISH FRONT, MAY 24, 1915.

28. Time and Place.—The attack was made at 2:45 A. M. near the Menin Road and West of Sanctuary Wood in the Ypres Salient.

29. Duration.—The attack was intermittent, lasting certainly 45 minutes. Some reports indicate that it lasted several hours.

30. Nature of the Gas.—The first evidence of the presence of gas was its effect on the respiratory system. At almost the same time dense brown fumes were seen about 70 yards away. It was noticed that the gases were green in one part of the line and brown in another.

31. Protection.—The pad respirators and "Hypo" helmets were put on in most cases without loss of time. As the respirators became choked with gas, the men redipped them in the solution which was distributed along the trenches. As the gassing continued the men became excited and could not be prevented from putting their respirators to their mouths after each dip without squeezing them dry. The result was that the men could not breathe through the saturated respirators, and, thinking they were being suffocated by the gas, dipped them at shorter intervals, breathing between the dips instead of holding their breath.

32. Enemy Artillery Action.—The trenches were heavily shelled. Consequently, there were numerous casualties among the officers, who were moving about to make the men use their respirators properly.

GERMAN GAS ATTACKS UPON THE RUSSIAN FRONT, 1915.

33. Three gas attacks were made in the early part of 1915 on a section of the Russian line about 60 kilometers west of Warsaw (see Fig. 4).

As this was, at that time, a new method of warfare the losses were heavy. Consequently, descriptive details of the attack are not available. The following data show the extent of the Russian casualties:
First Attack.—May 31, 1915.
Length of Front: 12 kilometers.
Duration of attack: 20 minutes.
Distance between trenches: 100 to 200 meters.
Evacuated: Officers, 53; men, 7,735.
Dead on field: Officers, 12; men, 1,089.

Second Attack.—June 12, 1915.
Evacuated: Officers, 28; men, 2,034.
Dead on field: Unknown, as trenches were lost.

Third Attack.—July 6, 1915.
Total evacuated and killed on field: Officers, 87; men, 9,903.
Losses in 21st (?) Siberian Regiment:

<table>
<thead>
<tr>
<th></th>
<th>Officers</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength of regiment</td>
<td>39</td>
<td>4,310</td>
</tr>
<tr>
<td>Left after the action</td>
<td>4</td>
<td>400</td>
</tr>
</tbody>
</table>

GERMAN GAS ATTACK UPON THE BRITISH FRONT, DECEMBER 19, 1915

34. Time and Place.—The attack started at about 5 A. M. or a little after, and was delivered over a 3 to 4 mile front north of the Ypres Salient.

35. Duration.—On the right the gas persisted one or two hours, and the attack was certainly over by eight o'clock. On the left it seems to have lasted a shorter time, probably half an hour. It is uncertain whether there was a continuous emission of gas or whether it came intermittently or mixed with smoke.

36. Warning.—A parachute light of a kind not generally used by the Germans was sent up at 5 A. M., presumably for testing the wind. At 5:15 A. M., red rockets of an unusual kind were sent up all along the front of the attack. Very soon after this, gas was heard issuing from the cylinders with a loud hissing noise.

The wind was favorable, the gas traveled rapidly, and the men in the front line trenches had very little warning before the gas cloud was upon them.

The alarm was given at once, and it is reported that the garrisons of the front line trenches manned the parapets with their helmets on within a minute.

37. Enemy Action.—On one divisional front the gas was preceded by heavy rifle fire; on another, rifle fire commenced only after the gas had reached the trenches. The German artillery
opened up with shrapnel and with lachrymatory and high explosive shell. This artillery bombardment continued throughout the day and most of the night.

No serious infantry attacks took place. Small patrols left their trenches, but were immediately shot down.

38. Action by British Troops.—Warning was at once given, and rapid fire was opened and kept up until the gas cleared. Artillery put down a heavy barrage on enemy lines.

39. Nature of the Gas.—The cloud was generally described as yellow, greenish-yellow or bluish-gray, and was said to be about 6 feet high. There is no doubt that the gas contained phosgene. The evidence on this point is based chiefly on the number of cases of delayed action which occurred, i.e., cases in which men who were apparently suffering little, suddenly collapsed several hours after the attack, and in some instances died. Less weighty evidence was the taste of tobacco smoke, the taste and smell of the gas, and the fact that in one or two cases the Vermorel sprayers were inefficient in clearing the gas out of dugouts.

40. Protection.—The tube helmet (P. Helmet) afforded a perfect protection against the gas, when it was properly and quickly adjusted. A large number of troops were exposed to the gas, but only a small number of casualties occurred. These were due to the following causes:

(a) Officers and men sleeping in dugouts without having their helmets attached to them, or being caught away from their dugouts without their helmets.

(b) Men in fire trenches not putting on their helmets quickly enough.

(c) Men in support trench dugouts (chiefly small ones, outside which no sentry was posted) not getting the warning in time.

(d) A small proportion of defective helmets.

(e) Helmets being worn under overcoats, with consequent difficulty in getting them out and putting them on quickly.

(f) Men being gassed when changing from a defective helmet to a sound one.

(g) Men thinking that the smell of the helmets was due to entrance of gas and taking them off.

For three miles behind the front line helmets had to be put on everywhere. For five miles behind the line helmets were worn in many cases, and some men who did not put them on were gassed.
41. Gas Shell.—The bombardment by gas shell began about an hour before the gas cloud was started, i.e., between 4 and 4:30 A.M. The front line and supports do not appear to have been bombarded with gas shell to any considerable extent while the main gas attack was in progress. The bombardment lasted three to four hours, the effect of the gas being to produce lachrymation, coughing, and vomiting. Xylyl bromide was certainly used as a shell filling. In addition, there seems to have been a gas used which affected the eyes less and the lungs more than the usual lachrymatory shell gas (probably "Palite" in K-shell).

The tube helmet protected the men's lungs, but in some cases the eyes were so much affected by the gas which came through that men were temporarily put out of action.

42. Remarks.—Scores of rats were said to have been killed by the gas, and bread was turned yellow by it, but was not thereby poisoned.

German Gas Attacks Upon British Front, April 27, 29, 30, 1916

43. Three gas attacks were made by the Germans during the last week of April, 1916—two against the 1st Army, on the 27th and 29th, respectively, and one against the 2nd Army, on the 30th.

44. Place.—Both attacks on the 1st Army were over that part of the line near Hulluch, extending south for about 3,000 yards from Cité St. Elie. It seems probable that gas was installed on the whole of this front and then liberated from different portions for the different attacks.

The attack on the 2nd Army was made between Spanbroek-Molen and the Wulverghem-Messines Road, over a front of about 3,500 yards.

45. Wind.—1st Army: N. E. wind, 3 to 5 miles per hour.

2nd Army: N. E. wind, 12 to 15 miles per hour.

46. Hours of Attack.—The hours of attack were as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Cloud</th>
<th>Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 27</td>
<td>First</td>
<td>5 A.M.</td>
</tr>
<tr>
<td>April 27</td>
<td>Second</td>
<td>7 A.M.</td>
</tr>
<tr>
<td>April 29</td>
<td>First</td>
<td>3:50 A.M.</td>
</tr>
<tr>
<td>April 29</td>
<td>Second</td>
<td>4:05 A.M.</td>
</tr>
<tr>
<td>April 30</td>
<td>First</td>
<td>12:35 A.M.</td>
</tr>
</tbody>
</table>
47. Warning.—(a) 1st Army: At 10 P. M., on the 26th, two green and two red rockets were sent up by the enemy. At 5 A. M., on the 27th a heavy bombardment of the British lines began, including two barrages of lachrymatory shell—one on the supports and one about 5,000 yards back.

At 5:20 A. M., April 27th, a dense white cloud was seen advancing from the enemy's lines. The alarm was given at once, and there appears to have been plenty of time for all ranks to put on their helmets. The enemy trenches were 80 to 100 yards distant.

(b) 2nd Army: There were several indications during the ten days prior to the attack that an attempt would be made by the enemy to attack the ——— Corps under cover of gas. The British artillery had broken up gas cylinders on several occasions. Two deserters on the 26th of April stated that gas cylinders had recently been placed in position, and were to be used when the wind was favorable. At 9:25 P. M., April 29th, two more deserters entered the trenches and stated that the Germans intended attacking with gas that night or early the next morning.

The hissing of the cylinders was heard in some parts of the line, but in general this was effectively drowned by the noise of the musketry and machine-gun fire, which also, in some places, prevented gongs and horns from being heard. Opposite one brigade the enemy trenches were so close (about 40 yards distant) that the gas reached the British line almost without warning.

48. Duration of Attack.—It is difficult to obtain exact figures, but the duration of emission of gas seems to have been from 10 to 15 minutes in each of the three attacks. The gas was present in effective concentrations in and about the British trenches for periods varying from 20 minutes to half an hour in the case of each separate cloud, and seems to have lasted much longer at some points.

49. Character of the Attacks.—The gas cloud attack on April 27th was preceded by a heavy bombardment, including two barrages of lachrymatory shell—one on the supports and one about 5,000 yards back. That on April 29th was followed within ten minutes by an intense bombardment on the Hulluch front—shrapnel only. The attack on April 30th was preceded by intense machine-gun fire, probably intended to drown the hissing sound.
of the gas as it escaped from the cylinders. The cloud gas was supplemented by the use of “K-Stoff” against the front line, either in shell or in trench mortar bombs. A small number of lachrymatory shell were used, at the same time, against support lines. On April 27th the first cloud appears to have consisted, at least partially, of smoke, which was so dense as to obscure near objects, even at Brigade Headquarters, 5,000 yards behind the front line. The cloud was followed by an infantry attack, which was repulsed.

The second cloud apparently consisted entirely of gas, and was much more intense than the first.

The attack on the 2nd Army was followed within five minutes by infantry raids, which met with no success, and was accompanied by an artillery barrage on the communications.

All three attacks were characterized by the emission of very large volumes of gas over a restricted front in a short time, thus leading to such a high concentration of gas that any man who was caught without his helmet, or who was slow or unskilled in putting it on, suffered severely.

50. Hostile Infantry Action.—The enemy’s object appears to have been to raid rather than to capture trenches. In the case of the 2nd Army it is known that the objective was the destruction of certain mine shafts.

Attacks were made almost exclusively by bombers. In the attack against the 2nd Army front no attempt was made to cut wire by bombardment. The wire was cut on the flanks of the front over which the gas cloud passed by small parties sent out either before or during the emission of gas. No difficulty was found in dispersing wire-cutting parties who left their trenches before the gas discharge. Attacking infantry was supported by rifle fire from snipers extended in long grass or crops.

51. Nature of the Gas.—The cloud gas appears to have been on each occasion a mixture of chlorine and phosgene, though no chemical evidence pointing to the presence of phosgene is available.

The lachrymatory shell were, in the case of the 1st Army, “T-Stoff” or xylyl (and benzyl) bromide, and, in the attack on the 2nd Army, “K-Stoff” or “Palite,” as well as “T-Stoff.”

52. Protection.—When put on correctly and in time, the helmets gave complete protection.

The total gas casualties were few but severe, resulting chiefly
from failure to wear helmets or from slowness or imperfection in their adjustment. These conditions show that the gas was relatively highly concentrated and could not be breathed without the gravest consequences. On the other hand, where the helmets were properly worn, protection was complete, and the line was successfully maintained throughout the attacks.

Due to the strong smell of chemicals, which invariably develops inside the cloth helmets during exposure to chlorine, many soldiers believed that the gas was penetrating. It appears that this error led a few men to remove their helmets, with unfortunate results.

The protection afforded by the box respirator\(^1\) was complete, except in a few isolated cases where the noseclip was badly adjusted or the facepiece put on incorrectly.

53. Effects on Machine Guns, Rifles, and Ammunition.—Considerable corrosion was occasioned in some cases by the highly concentrated gas, but only in one or two instances were guns put out of action.

The corrosion of ammunition appears to be of more importance than the direct effects upon machine guns and rifles.

54. Remarks.—(a) In these three gas attacks a new type of offensive tactics was introduced. Instead of maintaining a fairly high concentration of gas for a considerable period over a wide front, as in previous attacks, the enemy seems to have aimed at developing a maximum concentration for a short period over a narrow front.

The effects produced by the new method are as follows:

(i) Men who fail to get on their helmets in time are so affected by the gas that they are either killed at once or severely asphyxiated. Subsequent adjustment of the helmet is either impossible or too late to be of much value.

(ii) Any defect in adjustment of the helmet is sufficient to lead to severe "gassing," as even a small volume of the highly concentrated gas is sufficient to produce grave effects.

(iii) The action on rifles, machine guns, and ammunition is marked.

(b) The great concentration of the gas is evidenced by the fact that in 8 minutes all vegetation for 1,200 yards back of the front line was bleached.

(c) The execution of two attacks on the same front at an

\(^1\)The large box respirator, now obsolete.
interval of 48 hours is a new feature in gas operations, and may have been tried in the hope of catching the troops before the used helmets had been replaced.

(d) In the attack of April 29th the light and variable winds caused the gas to blow back over the German trenches, with the result that many German troops were gassed.

GERMAN GAS ATTACK UPON THE BRITISH FRONT, JUNE 17, 1916

55. **Time and Place.**—The attack took place at approximately 1:30 A. M., just north of the Wulverghem-Messines Road. It covered a frontage of about 3,000 yards, the vegetation along this section showing that there were no wide gaps where the gas was not emitted.

56. **Wind.**—The wind was variable between N. E. by E. and N. N. E. Velocity, 4 to 5 miles per hour.

57. **Warning.**—Good warning was obtained everywhere along the line, either from the hissing of the cylinders, which was not, however, very audible, or from actually seeing the cloud as it came over.

58. **Number and Duration of Waves.**—Over most of the front three distinct waves were observed. At one point five waves were reported. It is very difficult to get an idea as to the time which the waves took to pass. One company commander stated that the three waves had taken 15, 10, and 10 minutes, respectively, with 5-minute intervals. These intervals led to a considerable percentage of the casualties.

The concentration of the gas was very high. The cloud was so thick that it was difficult to see from one end of a bay to the other, or to see the wire in front of the British trenches. All metal objects were very strongly corroded, and at some points rifles jammed very quickly.

As a result of the high concentration, helmets had to be worn for over half an hour at a distance of 15,000 yards from the point of discharge.

59. **Nature of the Gas.**—Chlorine was certainly present, possibly mixed with a considerable percentage of phosgene. The cloud is reported as having had at first a marked yellow tint and as being extremely dense, later becoming less dense and whitening. It is extremely probable that smoke was used, although its presence was not confirmed.

60. **Protection.**—The helmets were universally praised.
The gas struck the British trenches in a slanting direction, thus materially increasing the distance it had to travel between the opposing trenches. In practically every case helmets had been adjusted before the arrival of the first cloud.

Of a number of men who were gassed and were able to give an account of the circumstances, a large percentage of the casualties could be traced to more or less preventable causes, such as defective helmets, taking off the helmet too soon, entering dugouts before they were clear of gas, removing helmet between the waves of gas, etc. Others were caused by shell fire damaging the helmets or preventing the men from putting them on. With the box respirator also, several cases of the latter type occurred.

A number of the casualties were cases of men who were only slightly, or not at all, affected at the time, but who succumbed six to eight hours later.

A number of this last type were officers and non-commissioned officers who had, while in the gas, exerted themselves and shouted orders; also men who carried up ammunition or did other work during the prevalence of the gas.

61. Action by the British Troops.—Retaliation by the artillery was most prompt.

62. Remarks.—(a) The chief lesson to be derived from the attack would seem to be that no exertion which can be avoided should be allowed during the passage of the gas, or for some time after.

(b) Over a wide area all metal work was thickly tarnished. Garden crops, such as onions, beans and lettuce, were badly "burned," while cereals and hedges seem to have escaped. Animals along the central line coughed and sneezed badly, but no casualties were reported.

(c) No machine gun jamming is reported to have been occasioned by the gas.

German Gas Attack Upon the British Front, August 8–9, 1916.

63. Time and Place.—At 10:30 P. M., August 8, 1916, in the Ypres Salient, two separate gas attacks were made simultaneously on fronts of 700 and 1,000 yards, respectively. The more severe attack was directed against the shorter front, where the distance between the opposing trenches was only 40 to 160 yards.

64. Wind.—The wind was variable, both in force and direction;
generally light, N. E. It was variously reported as from 3 to 10 miles per hour.

65. Warning.—No enemy signals were observed. The hissing of the discharging gas was plainly heard for some distance back of the front-line trenches. The alarm was given promptly and spread with great rapidity (Strombos horns and gongs). The arrangements were excellent.

66. The Gas Cloud.—Exact information as to the number and duration of the waves is lacking. On the shorter front two main clouds were liberated simultaneously, with an area of less concentration between them. Emission continued for about 20 minutes. Two successive clouds were launched against the longer front. The period between them was short, but not accurately recorded. The complete attack lasted about a half hour. The cloud is reported to have appeared as a dense, whitish fog. It is variously reported as moving from 1.6 to 5.5 yards per second. It appears to have gone forward unevenly, large rifts occurring between areas of highly concentrated gas. The gas penetrated sufficiently to necessitate wearing helmets at Divisional Headquarters, 13,000 yards to the rear. The localization of the clouds in the rear is exemplified by the fact that troops about 100 yards to each flank of Divisional Headquarters were not discommoded. An unusual case is reported in which hens roosting in high trees were gassed, while the occupants of a house below were not discommoded. The gas persisted for a "considerable time." Helmets were removed with safety at 12:30 A. M. At 1 A. M. working parties resumed operations in front of the trenches. In pockets and dugouts the gas persisted much longer and occasioned a number of casualties because of lack of proper precautions. At 7 A. M. men were fatally gassed on entering dugouts which had not been cleared.

The gas was a mixture of chlorine and phosgene, the latter probably predominating, as was witnessed by the lack of serious injury to vegetation and by the symptoms of casualties. The concentration was very high, and the atmospheric conditions were such that dilution of the gas with air was very slow.

67. Protection.—Helmets ("P. H.") gave good protection where they were properly used. Box respirators used by machine gunners were highly praised. Casualties were due chiefly to the following reasons:

(a) Inadequate training and discipline in the use of masks.
These troops had not previously experienced a gas attack, and many officers and men were new. The helmets were not quickly and accurately adjusted.

(b) On one front the troops were not at “Gas Alert.”
(c) A relief was in progress. Consequently, the front-line trenches were unusually crowded. The men were retarded by their packs and equipment in adjusting helmets.
(d) The close proximity of the enemy trenches made surprise possible.
(e) Some men removed helmets too soon.
(f) Unprotected men went into dugouts, trenches, and pockets before the gas was dispersed.

68. Enemy Action.—A bombardment preceded the gas attack. No further notable offensive supported or immediately followed it.

69. Gas Shell.—Some gas shell, both lachrymatory and lethal, were used, with little effect. They were usually aimed at batteries or positions in the rear.

70. Remarks.—(a) The results of this attack strongly emphasize the importance of thorough training and discipline in methods of gas defense.
(b) The delayed action of phosgene was strikingly demonstrated. In many cases men who had previously experienced little inconvenience suddenly collapsed some hours after the attack. Such casualties were particularly numerous in the case of the men who had been most active during the attack.

Hundreds of rats, birds, and other animals were killed in the gassed area. Vegetation was not seriously injured, due to the small percentage of chlorine used.

Whether the attack was purposely made when the relief was in progress is uncertain.

GERMAN GAS ATTACK UPON THE FRENCH FRONT, JANUARY 31, 1917.

71. Time and Place.—The attack, which consisted of two or three waves, each of short duration, began at 4 P. M. It was launched in the Champagne, between Harquises and Auserive, on a frontage of 16 km., upon 10 km. of which gas was actually emitted.

72. Weather.—The wind was northwest, 1.7 to 4.6 miles per hour. The temperature was 14° C.

73. Preparation.—The installation of gas was known to the French some days beforehand.
From the appearance of the cloud, emplacements seem to have been 40 to 50 meters apart. Emplacements were in some cases in the support and reserve lines.

The attack was preceded the previous evening by an artillery bombardment.

From noon to 1 P. M. January 21, a fairly intense trench mortar bombardment took place.

74. The Attack.—The distance between the opposing trenches varied from 50 to 600 meters.

A northwest wind was chosen, presumably, so that the gas would be carried down the valleys, especially those of the Suippes and the Vesse.

The first wave, which was sent over at 4 P. M., was transparent. The second and third were opaque. The waves were clearly visible, and the noise of emission, in spite of machine-gun fire, was easily heard where the trenches were not too far apart. The alarm was at once given.

The gas traveled very slowly, being influenced more by the topography than by the wind.

Deaths occurred at depths of 10 km., and gassing at 22 km. Masks were worn at depths of 28 km.

The gas persisted two to eight hours in front lines and twelve to fourteen hours in back lines.

Lachrymatory and asphyxiating shell were fired on the trenches during the attack, and H. E. on the communications in the rear.

After the attack, three raiding parties, clothed in white and wearing masks, attempted to enter the French trenches. One succeeded, but was at once ejected.

75. Causes of Casualties.—The chief causes of casualties were:

(a) Isolated men (returning from leave, etc.) without masks.

(b) Ignorance of how to adjust the mask properly.

(c) Removal of mask owing to impossibility of seeing through the cellaphone eyepieces. For this reason artillery had to cease fire.

(d) Men not accustomed to changing masks in gas. Change was not necessary, however.

(e) Too early removal of masks.

In general, the mask proved satisfactory, but men had not been properly instructed in its use.

1High explosive.
76. Remarks.—All small animals, including donkeys, were killed. Many horses died. The horse respirator proved unpractical.

Protected dugouts gave satisfaction. It is stated that unprotected dugouts in which fire was burning were only slightly affected by gas.

Arms were not at all affected, owing, perhaps, to the dryness of the atmosphere.

Evidence pointing to the use of phosgene has been obtained.

GERMAN GAS ATTACK UPON THE FRENCH FRONT, APRIL 23, 1917.

77. Time and Place.—The attack was made on the front near Nieuport, beginning at about 4:15 A. M. A second and a third cloud passed to the Nieuport-Dixmude Railroad at 5:25 and 6:20 A. M., respectively.

78. Warning.—Alarm was given by means of sirens and Klaxon horns.

79. Movement of the Gas Cloud.—Table A shows the communes where the effect of the gas was particularly felt, the distance of each from the point of discharge, and the time of arrival of the first gas.

TABLE A.—Data Relative to the Movement of the Gas Cloud.

<table>
<thead>
<tr>
<th>Locality</th>
<th>Distance from the point of discharge</th>
<th>Time of arrival of the first gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramscappelle</td>
<td>3,800</td>
<td>4:30 A.M.</td>
</tr>
<tr>
<td>Steenkerke</td>
<td>11,200</td>
<td>4:40 A.M.</td>
</tr>
<tr>
<td>St. Ricquiers</td>
<td>16,800</td>
<td>About 5:00 A.M.</td>
</tr>
<tr>
<td>Hoogstade</td>
<td>18,300</td>
<td>5:00 A.M.</td>
</tr>
<tr>
<td>Stavele</td>
<td>24,000</td>
<td>5:30 A.M.</td>
</tr>
<tr>
<td>Proven</td>
<td>29,600</td>
<td>About 6:00 A.M.</td>
</tr>
<tr>
<td>Caestre</td>
<td>43,000</td>
<td></td>
</tr>
</tbody>
</table>

These data justify the conclusion that the cloud moved at the average speed of approximately 5 m. per second.

80. Nature of the Gas.—The gas cloud was rendered opaque by smoke from the German lines.

The gas had the odor of bleaching powder, and was undoubt-
edly chlorine and phosgene. Some claim to have detected in addition a pungent odor like that of formaldehyde.

81. Protection.—Adequate protection was furnished by the anti-gas masks.

82. Remarks.—(a) Men in farmhouses were not discomforted. Most of the houses were not generally penetrated by the gas.

(b) A large number of dogs, cats, and hens in the gassed area were killed.

(c) In two trenches food was found to be impregnated with gas and unfit for consumption. Rations protected by containers were not injured. In general, tobacco exposed to gases absorbs them and is no longer smokable.

ARTILLERY AND TRENCH MORTAR GAS SHELL

83. The use of gas shell by the Germans was started almost simultaneously with the use of cloud gas. It has been strongly developed ever since, fresh material, new types of shell, and new tactics having been introduced, until on the Western Front at present the use of gas shell is the chief method of gas warfare employed by the Germans.

MATERIALS USED

84. A very wide range of fillings for gas shell is available, as it is not necessary, as in the case of cloud attacks, for the toxic agent to be a true gas, i.e., present in the shell under pressure. On the contrary, the great majority of “gases” used in shell are liquids of high boiling point, which are transformed into vapor by the bursting of the shell, or which remain for some time in the ground bombarded, slowly giving off the active vapor.

85. The materials employed may be divided into two imperfectly demarked classes:

(a) True lethal substances (generally asphyxiants).

(b) Neutralizing materials.

The neutralizing materials are the less poisonous, but are capable of putting men out of action for shorter or longer periods. To this class belong lachrymators (the so-called “tear shell”), which makes the eyes water; stenubators, which cause sneezing, and eye, lung and skin irritants, which cause more lasting effects on the eyes, produce severe respiratory distress, and blister the skin.

Besides these, there are one or two irritant chemicals used as shell-fillings which are employed primarily for smoke production.
LETHAL SHELL GASES

86. The first true poison gas shell used by the Germans were filled with monochloromethylchloroformate (Palite). These were known as K-shell (K₂-Stoff), and were employed largely during 1915 and 1916, both in shell and in trench mortar bombs. Their physiological effects are similar to those of phosgene, but the gas is less easily dissipated. In low concentrations it causes delayed effects, while in high concentrations it is quickly fatal. It is also strongly lachrymatory. Shell filled with “Palite” had to be lead-lined, as it attacks iron and steel.

87. “Palite” was replaced shortly after the start of the Battle of the Somme by trichloromethylchloroformate (Diphosgene), a liquid of similar action but more toxic and not requiring the use of a lead container, as it has no effect on iron. This material has been used in vast quantities, and is still the principal lethal chemical used in shell by the Germans. It is employed either alone or mixed with chloropicrin, another toxic substance, which is at the same time strongly lachrymatory. “Diphosgene” is sometimes mixed with phosgene and with “sneezing gas.”

LACHRYMATORS

88. These were the first shell gases to be used by the Germans, and were certainly employed during the cloud gas attack of May 24, 1915, and probably earlier. They were largely employed against the French during 1915. Indeed, the use of gas shell seems to have been developed chiefly against the French, in the same way that the gas cloud was developed chiefly against the British. The material used was that known by the Germans as “T-Stoff” (xylyl and benzyl bromide), which is a powerful lachrymator and, in concentrations of 1 volume in one million volumes of air, will immediately make the eyes water. It is not toxic except in high concentrations, when it causes sickness and vomiting. It has a characteristic pineapple-like odor, and is easily recognized.

89. “T-Stoff” will persist, even in the open, for many hours and, in favorable circumstances, even for days. It has been used chiefly for annoying and neutralizing purposes, but it is stated to have had tactical value in a furious bombardment of the French positions in the Argonne in the summer of 1915, and at that time to have been so concentrated that the French troops were in some cases actually rendered unconscious by it.
90. The other chief lachrymator used by the Germans is brominated methylethyl ketone, a liquid known originally as “K-Stoff” (K₁-Stoff ?), but now as “B-Stoff.” This substance is an intense and quick-acting lachrymator, which does not persist so long as “T-Stoff,” and can, consequently, be used against positions which it is hoped to traverse or occupy. It has also considerable toxic value and, if breathed for any considerable length of time, causes acute bronchitis.

Mixtures of xylyl bromide and bromoacetone (so-called “Green T-Stoff”) are also used.

STERNUTATORS

91. As far back as 1915 evidence was obtained of trials being made by the Germans with sternutators for harassing purposes, but not until August, 1917, was the use of the present “sneezing shell” really started. The material employed is diphenylchlordiarsine. It is rarely used alone, however, being generally mixed with lethal chemicals or with a high explosive.

Very low concentrations of diphenylchlordiarsine will cause sneezing, while large amounts are actually poisonous and affect the respiratory organs.

EYE, LUNG, AND SKIN IRRITANTS

92. A material of this kind was introduced by the enemy in July, 1917, and has been used since in vast quantities. The substance is dichlorodiethyl sulphide, and is known generally as “mustard gas,” though it has no relationship to the true mustard oils. Its chief characteristics are:

(a) Its faint smell, resembling garlic or mustard.
(b) The absence of any immediate effects, except in some cases irritation of the nose.
(c) The serious after-effects produced if the respirator is not worn. In the milder cases these may be limited to nausea and vomiting, inflammation of the eyes and slight bronchitis, while the skin in various parts of the body may become reddened or blistered. In the most severe cases the larynx, bronchial tubes and lungs may become seriously inflamed. There is usually a considerable period of delay before these after-effects manifest themselves. In the majority of cases the inflammation of the eyes does not become apparent until an hour or two after exposure to the gas, while it is sometimes postponed as
long as twelve hours or more. No cases of permanent injury to the eyes have been reported. The inflammation of the eyes and of the skin clears up fairly rapidly under treatment.

93. The persistence of dichlorodiethyl sulphide is consider-
able. Several hours after a bombardment has ceased, casual-
ties may be caused by the vapor given off from the ground. The gas persists in dugouts and cellars for a long time. Numerous casualties have been caused, moreover, by gas being carried into dugouts in the clothing.

Men may be blistered from sitting on the ground after a gas shell bombardment has taken place. Experiments have shown that the liquid may remain in the ground for several days in sufficient quantity to cause blistering when samples of earth are kept in contact with the skin.

**SUMMARY OF GERMAN ARTILLERY AND TRENCH MORTAR GAS SHELL**

94. Certain important data regarding the various kinds of German gas shell and trench mortar bombs are summarized in Table II.

95. Besides the fillings listed in Table II, bromine (asphyxi-
ant), bromoacetone and chloroacetone, or a mixture of the two (lachrymatory and asphyxiant), and also probably a mixture of methyl chlorosulphonate and dimethyl sulphate (asphyxi-
ant) have been used. The last-named material is used in hand grenades, and is known as "C-Stoff."

**DETAILS OF ARTILLERY GAS SHELL**

96. The Germans use gas in nearly all calibers of artillery shell, from the field gun up to the 21 cm. howitzer. The 7.7 cm. field gun shell and the 10.5 cm. and 15 cm. howitzer shell are the most frequently used. This type of shell is practically that of shrapnel, with the resin and bullets replaced by liquid. In the case of xylol bromide (T-Stoff), "brom ketone" (B-Stoff) and monochloromethylnitroformate (K-Stoff), all of which attack iron, the liquid is held in a special lead container. In the re-

Content of Liquid

97. Everything possible is being done to increase the amount of liquid which can be enclosed in the shell. This has been
<table>
<thead>
<tr>
<th>Effect of gas</th>
<th>Nature of filling</th>
<th>German name</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For the gas</td>
<td>For the type of shell</td>
</tr>
<tr>
<td>Lachrymatory</td>
<td>Xylyl bromide and benzyl bromide.</td>
<td>T-Stoff</td>
<td>T-shell</td>
</tr>
<tr>
<td>Lachrymatory</td>
<td>Phenylcarbylamine chloride.</td>
<td>B-Stoff</td>
<td>B or B M shell (T.M.)</td>
</tr>
<tr>
<td>ant</td>
<td></td>
<td>Per-Stoff</td>
<td>C-shell (T.M.)</td>
</tr>
<tr>
<td>Asphyxi-</td>
<td>Phosgene</td>
<td>D-shell (T.M.)</td>
<td></td>
</tr>
<tr>
<td>ant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ant and lachryma-</td>
<td></td>
<td>Per-Stoff</td>
<td>Green Cross C-shell (T.M.)</td>
</tr>
<tr>
<td>tory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphyxi-</td>
<td>Trichloromethylchloroformate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphyxiant and lachrymatory</td>
<td>&quot;Per-Stoff,&quot; phosgene and diphenyl chloroarsine</td>
<td>Green Cross 2</td>
<td></td>
</tr>
</tbody>
</table>
| Eye, lung and skin irritant | Dichlorodiethyl sulphide | Yellow Cross | "Mustard gas."
| Sternotomotor | High explosive and diphenylchloroarsine | Blue Cross |
accomplished partly by reducing the space required for the explosive and partly by making the shell longer. Thus with the 7.7 cm. shell the 1915 pattern contained 285 cc. of liquid, whereas the present long shell has a capacity of 670 cc., an increase of over 130 per cent.

**Bursting Charge**

98. The bursting charge must be regulated to the nature of the liquid and by the requirements of the bombardment. In general, it is so adjusted as to burst the shell with not too much explosive force, merely breaking it into a small number of large pieces or blowing off the head and bursting open the shell mushroom fashion. In this way the gas is not too much dissipated. On the other hand, the bursting charge must be large enough to atomize the liquid contents and avoid loss by absorption into the earth.

99. In many of the recent types of shell the only bursting charge is the picric acid contained in the gaine. On the other hand, as much as 627 grams of high explosive is used in the 17 cm. trench mortar (Minenwerfer) shell filled with "brom ketone" (B-Stoff). (See Fig. 25.)

**Fuses**

100. The fuses used with German gas shell are very numerous, chiefly because existing types have been utilized. All are used to burst the shell on impact, and consequently many of the older ones are unnecessarily complicated.

The principal fuses used with gas shell are the following:

1. K. Z. 14 (no safety pin).
4. Gr. Z. 14 n/A (safety pin).
5. Gr. Z. 04 (safety pin).

101. In fuses 1 to 6 the safety device\(^1\) used consists of one or more pellets of black powder, which serve to lock a plunger which holds the percussion pellet so that, until these powder

---

\(^1\) The safety pin locks only the lighting pellet and does not, in any fuse, lock the percussion pellet.
pellets are burnt away, the percussion pellet cannot move forward against the firing pin. These powder pellets are, however, operative only so long as the powder is dry. If the powder becomes damp, the pellets will soften and allow the safety plungers to move and thus release the percussion pellet.

102. In the Gr. Z. 14 n/A an additional centrifugal bolt has been provided, so that in this case, even if the black powder pellet softens, the fuse is comparatively safe.

Water may gain access to the fuse if the safety pin has been withdrawn so as to break the film of paraffin wax with which it is coated, or if one of the discs over the gas escape holes is missing. These are circular or oval discs of thin brass, held in place by stabs and coated with wax. They are intended to allow the gases to escape when the lighting pellet is ignited.

In the case of shell where there is no separate container for the liquid, if the cement which is intended to provide a liquid-tight joint between the gaine and the fuse becomes cracked, the liquid will reach the safety powder pellet if the shell is stood nose downwards or on its side. The fuse then becomes dangerous.

103. It is to be noted that the safety devices used with these fuses are not so elaborate as those employed in the newer fuses used with high-explosive shell, probably because a "premature" in the case of a gas shell is unlikely to do any damage. Gas shell should, therefore, be handled quite as carefully as high-explosive shell. The greatest care should be taken not to give them any jar in a longitudinal direction.

104. Fuses 7 to 9 are modern instantaneous percussion fuses, and burst without producing an appreciable crater, so that as little as possible of the gas is absorbed by the earth, most of it being spread out laterally.

These fuses are actuated by an external needle-holder placed in position just before firing. This is kept safe until a centrifugal bolt is released by the rotation of the shell. Such fuses do not become dangerous when moisture gains access; consequently their use for gas shell of various calibers is increasing.

A description of several typical fuses follows:

105. H. Z. 14 (Haubitzen Zünder, Model 1914), which is shown in Fig. 5, is made of bronze, except the fuse cap, which is steel. The action is percussion without delay. When the shot is fired, plunger 1 is compressed and the detonator carried by spring 2
Fig. 5.—Section of Fuse H. Z. 14.
Fig. 6.—Section of Fuse Gr. Z. 04.
comes against striker 3. The flash is transmitted to powder pellet 5, the burning of which permits spring 7 to force up the piston 6 and free the plunger 8. When the shell strikes the ground this plunger moves forward and carries the detonator against the striker 9. The flash is transmitted to the fulminate primer 10 and to the secondary explosive 11 (picric acid) in the gaine.

106. **K. Z. 14** is a fuse of almost exactly similar action. In more recent varieties of steel fuses, such as K. Z. 14 n/A and H. Z. 14 n/A (n/A = neuer Art), the fuse cap is more pointed and the safety powder pellet is contained in a screwed brass sleeve.

107. **Gr. Z. 04** (Granat Zünder, Model 1904) is a percussion fuse used with the 15 cm. howitzer gas shell. It is shown in cross section in Figs. 6 and 7 and in position in Fig 14. It can be used with or without delay by moving the plate 9, the position of which governs the ignition of different explosives.

When the fuse functions with delay (see Figs. 6 and 7), the fire of the primer of plunger 2 is transmitted through 10 to the powder pellet 11, and thence to channel 13. Pellet 14 is thus ignited, spring 16 is relaxed, and the plunger 17 thus liberated. When the shell strikes the ground this plunger moves forward, and detonator 18, having been fired by pin 19, the flash is transmitted through 20 to the device 21, which, after delayed ignition, actuates the detonator 8, then the bursting charge 6, and lastly the secondary explosive 23.

When the fuse functions without delay, the plate is adjusted so that the original flash is also transmitted through channel 24. Pellet 25 is thus ignited and plunger 28 set free as before. By action of needle 30 on detonator 29 the flash is transmitted directly to the fulminate detonator and bursting charge, thus short-circuiting the delay device.

The double action lessens the chance of nonaction of the fuse and of the shell’s consequently becoming a blind.

108. **E. K. Z. 17** (Einheits Kanonen Zünder, Model 1917) is a percussion fuse without delayed action. (See Fig. 8.) The body of the fuse is made of zinc.

The extension of the aluminum needle-holder 3 is placed in position just before loading, the hole in the top of the fuse having previously been closed by a metal disc attached to a wire. On the shock of discharge, the needle-holder 2 sets back, and, by
Fig. 8.—Section of Fuse E. K. Z. 17.
means of a notch cut on the bolt prevents the centrifugal bolt 9 from flying out. When the positive acceleration ceases, the needle-holder is driven up by the creep spring 5, thus releasing the centrifugal bolt, which flies out owing to the rotation. On impact the needle-holder is driven in, the percussion detonator 7 being fired by the needle 4. The flash fires the relay 11 and the picric acid 12 contained in the steel gaine 8.

A fuse of similar construction (E. H. Z. 17) is used with the light field howitzer long gas shell.

A captured German document says these fuses are safe against shock of discharge, but may give “prematures.”

7.7 cm. (Field Gun) Gas Shell

109. Field gun shell filled with gas were first used in the summer of 1915. Up to that time only 10.5 cm. and 15 cm. howitzer shell had been employed.

7.7 CM. SHORT (1915 PATTERN) GAS SHELL

110. 7.7 cm. Green Cross.—This shell (see Fig. 9) is similar to the short pattern high-explosive shell of the same caliber, the shell case itself being filled with the liquid. The fuse is the K. Z. 14, and the picric acid in the gaine of the fuse is relied upon to open the shell, no additional explosive being employed. The joint between the fuse and the head of the shell is sealed by means of a little cement, the basis of which is magnesium oxychloride.

The following are typical details of the various parts:

<table>
<thead>
<tr>
<th>Part</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Blue, yellow head</td>
</tr>
<tr>
<td>Length</td>
<td>24.3 cm.</td>
</tr>
<tr>
<td>Thickness of base</td>
<td>2 cm.</td>
</tr>
<tr>
<td>Width of driving band</td>
<td>8 mm.</td>
</tr>
<tr>
<td>Weight of shell (empty)</td>
<td>5,675 gm.</td>
</tr>
<tr>
<td>Weight of fuse</td>
<td>945 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>480 gm.</td>
</tr>
<tr>
<td>Volume of liquid</td>
<td>300 cc.</td>
</tr>
</tbody>
</table>

7,100 gm. = 4.2 per cent.

1 This term, which is employed by the French, is determined by dividing the "useful volume" in cc. multiplied by 100 by the total weight in grams.
Fig. 9.—1915 Pattern of 7.7 cm. Short Gas Shell.
The liquid contained is trichloromethylchloroformate (Diphosgene), mixed with some hexachloromethyl carbonate, which is always present as a by-product of manufacture.

7.7 CM. LONG GAS SHELL.

111. 7.7 cm. Green Cross.—This is exactly similar to the long high-explosive shell of the same caliber. It is 72 mm. longer than the short shell, and the thickness of the shell walls is reduced by 5 mm. The coloring is similar to that of the short shell, and the fuse is either K. Z. 14 or K. Z. 14 n/A. There is no constriction of the internal cavity towards the base. Details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>31.5 cm.</td>
</tr>
<tr>
<td>Weight (empty) with fuse</td>
<td>6,279 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>1,015 gm.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7,294 gm.</td>
</tr>
<tr>
<td>Volume of liquid</td>
<td>670 cc.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>$\frac{670 \times 100}{7294} = 9.2$ per cent.</td>
</tr>
</tbody>
</table>

The efficiency is, therefore, over twice as great as that of the short pattern shell.

The liquid contained is “Diphosgene.”

112. 7.7 cm. Green Cross 1.—This is exactly similar in construction to the above, the complete weight being 7,190 grams and the weight of liquid 1,010 grams. The shell is generally marked with a green cross on the base of the cartridge case and sometimes on the side of the shell.

The liquid contained is a mixture of trichloromethylchloroformate and chloropicrin in ratios varying from 65 parts by volume of “Diphosgene” and 35 parts of chloropicrin to 30 parts of “Diphosgene” and 20 parts of chloropicrin. The usual ratio is approximately 70 to 30.

113. 7.7 cm. “B-Stoff.”—This shell is similar in construction to the above, but no complete specimen has been obtained. The fuse employed is the K. Z. 14, and the shell filling consists of brominated methylethyl ketone.

114. 7.7 cm. Yellow Cross.—This shell is of the ordinary long variety, and is painted blue or gray with a yellow head and marked on the base or side with a yellow cross. It is fitted with the E. K. Z. 17 fuse, and bursts with a small explosion like a
Fig. 10.—7.7 cm. Blue Cross (Sternutator) Shell.
pistol shot, forming practically no crater. There is no explosive except the charge in the gaine of the fuse.

The liquid contained consists of impure β β dichlorodiethyl sulphide (colloquially known as "mustard gas"), with a very slight percentage of prussic acid, the latter possibly being added in an attempt to disguise the smell of the "mustard gas."

The weight and capacity are similar to those of the other long field gun gas shell.

115. 7.7 cm. Blue Cross.—When used as Blue Cross shell, the long 7.7 cm. shell is fitted with the E. K. Z. 16 fuse, and is colored blue with a yellow head marked with a blue cross. As shown in Fig. 10, it contains a large explosive charge of trinitrotoluol (occupying about two-thirds of the shell), in which is embedded a thick green glass bottle containing the sternutator. The bottle is corked, with the cork towards the base of the shell.

In one such case the contents of the bottle were crystalline and brownish-yellow. They had the shape of the bottle and had evidently solidified from fusion.

The material is impure diphenylchloroarsine.

10 cm. Gun Gas Shell

116. Gas was used for the first time with this shell in August, 1917. A shell of this kind which was examined appeared to have been painted gray with a yellow head, and was fitted with Gr. Z. 14 n/A fuse. The shell, which was probably the 1912 pattern (see Fig. 11), contained 1,300 cc. of the Green Cross 1 mixture (70 per cent trichloromethylchloroformate and 30 per cent chloropicrin).

10.5 cm. Howitzer Gas Shell (Long)

117. 10.5 cm. "T-Stoff," "B-Stoff," and "E-Stoff."—The 10.5 cm. howitzer shell has been used extensively with these lachrymators. In type the shell is similar to that shown in Fig 12, modified as for the 15 cm. T-Shell, i.e., with lead container for the liquid. The fuse used with this type of shell is the H. Z. 14. Details of dimensions and capacity are lacking.

118. 10.5 cm. Green Cross.—A diagram of this shell is shown in Fig. 13. It is made of cast steel, and is generally painted as shown, but 10.5 cm. shell filled with "Diphosgene" have been painted blue without the yellow head.
Fuses H. Z. 14 and H. Z. 14 n/A have both been used.
The gaine contains about 52 grams of picric acid, with a coating of paraffin wax and paper. No other explosive is used, and the liquid is filled directly into the shell.
The following details are typical of this shell:

Coloring:
Blue, with yellow head... 11.0 cm. wide. (Blue shells without other coloring have also been found.)

Markings (variable) on head........ 726 G
Markings (variable) on body........ 726 G
Markings (variable) on base....... Sp 301 OC
Length................................. 37.8 cm.
Fig. 12. — 10.5 cm. Howitzer Gas Shell.
<table>
<thead>
<tr>
<th>Thickness for all</th>
<th>13.7 mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness near base</td>
<td>17.3 mm.</td>
</tr>
<tr>
<td>Driving band material</td>
<td>copper</td>
</tr>
<tr>
<td>Driving band, distance from base</td>
<td>27 mm.</td>
</tr>
<tr>
<td>Driving band width</td>
<td>14 mm.</td>
</tr>
<tr>
<td>Weight (empty)</td>
<td>13,800 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>2,125 gm.</td>
</tr>
<tr>
<td></td>
<td>15,925 gm.</td>
</tr>
<tr>
<td>Volume of liquid</td>
<td>1,390 cc.</td>
</tr>
<tr>
<td>The efficiency is therefore</td>
<td>8.7 per cent</td>
</tr>
</tbody>
</table>

These shell form craters about 2 feet in diameter and 1 foot deep. The contents are trichloromethylchloroformate.

119. 10.5 cm. Green Cross 1.—These shell are exactly similar to the above. They are sometimes, but not always, marked on the base with a green cross. Their average content is 1,860 cc. of the usual mixture of “Diphasgene” and chloropicrin, those hitherto examined having the approximate proportions: 65 per cent “Diphasgene,” 35 per cent chloropicrin.

The percentage of chloropicrin used in these shell is on the increase.

Shell have recently been found which contain the following fillings:

<table>
<thead>
<tr>
<th>Chloropicrin</th>
<th>“Diphasgene”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>66</td>
</tr>
<tr>
<td>Sample B</td>
<td>54</td>
</tr>
</tbody>
</table>

120. 10.5 cm. Yellow Cross.—The Yellow Cross shell is exactly similar to the Green Cross, except that it is marked on the head with a yellow cross. The fuse is the E. H. Z. 17. The contents are impure dichlorodiethyl sulphide.

121. 10.5 cm. Blue Cross.—A drawing of this shell, showing section and elevation, appears in Fig. 13. As usual with gas shell, the body is painted blue and yellow. Some shell carry two blue crosses. The fuse is H. Z. 05 Gr., time and percussion, with or without delay. The use of this type of fuse for gas shell is unusual. About two-thirds of the shell is filled with cast trinitrotoluol, the remaining space being occupied by a glass bottle containing 300 to 400 grams of the sternutator. (The ordinary high-explosive shell of this size is filled with cast amatol.) In the case shown in the diagram the bottle was not centered: nor was it resting on the bottom of the shell. It was
Fig. 13.—10.5 cm. Light Field Howitzer Gas Shell.
closed by means of a little pitch, then plaster of Paris, and finally a wad of pitch around the neck. Details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of shell complete</td>
<td>15,855</td>
</tr>
<tr>
<td>Weight of T.N.T. (including 30-40 grams of pitch)</td>
<td>1,328</td>
</tr>
<tr>
<td>Weight of bottle (empty)</td>
<td>428</td>
</tr>
<tr>
<td>Weight of sternutator</td>
<td>413</td>
</tr>
<tr>
<td>Weight of fuse</td>
<td>1,315</td>
</tr>
</tbody>
</table>

The contents of the bottle consist of impure diphenylchloroarsine or of a solution of diphenylchloroarsine in coal tar heavy oil.

**15 cm. Heavy Field Howitzer Gas Shell.**

122. This is probably the most frequently used German gas shell. 15 cm. T-shell were employed in May, 1915.

**15 cm. 1912 Pattern Shell.**

123. **15 cm. T-Shell.**—Fig. 14 shows the ordinary 1912 pattern 15 cm. gas shell used for lachrymators. It was used formerly for "K-Stoff." The shell is 19 mm. thick throughout, and has a screw-in case. The liquid is contained in an autogenously welded lead receptable 30 cm. high and 10.5 cm. in diameter, which is lowered into place by means of four plaited paper "strings". Between the receptable and the base of the shell is a felt wad. In the earlier types of shell the space between the lead vessel and the walls was filled with paraffin, but in recent types a white porcelain-like magnesium oxychloride cement has been used to keep the container in position. The upper portion of the shell is filled with cast trinitrotoluol.

This shell is generally used with the Gr. Z. 04 fuse, and is painted gray with a black head and a black T just below the head. Some recent varieties have been marked M T instead of T. Details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of shell empty</td>
<td>34,000</td>
</tr>
<tr>
<td>Weight of explosive (T.N.T.)</td>
<td>1,500</td>
</tr>
<tr>
<td>Weight of lead receptacle</td>
<td>2,580</td>
</tr>
<tr>
<td>Weight of lachrymatory liquid</td>
<td>3,000</td>
</tr>
<tr>
<td>Weight of paraffin or cement</td>
<td>520</td>
</tr>
<tr>
<td>Weight of fuse</td>
<td>1,720</td>
</tr>
</tbody>
</table>

| Total weight                      | 43,320      |

The volume of liquid is 2,350 cc.
The efficiency is, therefore, 5.4 per cent.

58
Fig. 14.—15 cm. Heavy Field Howitzer T-Shell.
The liquid contents of this shell vary. Earlier varieties had a mixture of 60 to 85 per cent xylxyl bromide and 15 to 31 per cent benzyl chloride. More recent shells have been filled with the impure xylxyl bromide only, i.e., mixtures of three different xylxyl bromides with some xylxylene dibromide. The latter is solid and relatively inactive, but, due to bad manufacture, has amounted to as much as 26 per cent of the total, so that the contents of the lead vessel were almost solid with crystals.

124. 15 cm. "Green" T-Shell.—This shell is similar in construction to the above, but came into use only in 1916. It is painted field gray and marked with a green T. It is used with the Gr. Z. 04 fuse. Details follow:

- Weight full: 42,400 gm.
- Weight of liquid: 3,300 gm.
- Weight of explosive (T.N.T.): 1,600 gm.

The liquid is dark brown and resembles "T-Stoff" in smell, but is more irritating and lachrymatory. The density is 1.45, as against 1.37 for "T-Stoff." It consists of 12 per cent of brominated methylethyl ketone and 88 per cent of commercial xylxyl bromide.

125. 15 cm. B-Shell (K₁-Shell).—This shell is similar to the one just described. The liquid contents of the lead vessel consist of mono- and dibromomethylethyl ketone, the proportion of dibromo ketone varying from nil in the earlier varieties to 65 per cent in recent shell.

126. 15 cm. K-shell (K₂-Shell).—This shell is similar to the T-shell. Its use is now discontinued. It carried 3 kilograms of monochloromethylethylchloroformate (Palite) in a container, but had a yellow head instead of black, and below the head was marked K₂ or K in yellow.

VARIATIONS OF 15 CM. 1912 SHELL.

127. 15 cm. Green Cross and Green Cross L.—This variation of the 1912 pattern shell is used for those liquids which do not require a lead container. It is shown in diagram in Fig. 15. The following are the chief differences from the original pattern:

(a) The length is reduced by 8 mm.
(b) The fuse is the Gr. Z. 14 n/A.
(c) There is no lead container, all joints being cemented.
(d) There is no explosive beyond that contained in the gaine
Fig. 15.—15 cm. Howitzer Gas Shell: Green Cross and Green Cross 1.
of the fuse (picric acid). The latter is screwed into the shell with cement, the gaine being screwed on and also cemented to the fuse.

Further details follow:

Coloring: Field gray with blue bands, as shown in diagram. It is marked on the base with a green cross.

Material: Cast steel (density 7.8), turned on the outside only.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, complete</td>
<td>41,360 gm.</td>
</tr>
<tr>
<td>Weight of picric acid in gaine</td>
<td>60 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>6,480 gm.</td>
</tr>
<tr>
<td>Volume of liquid</td>
<td>3,900 cc.</td>
</tr>
</tbody>
</table>

The efficiency is, therefore, 9.4 per cent.

The liquid contained in Green Cross shell is impure trichloromethylchloroformate of the usual composition.¹

The Green Cross I shell has a capacity of 3,900 cc. It contains 65 per cent of "Diphosgene" and 35 per cent of chloropicrin.

128. 15 cm. Phenylcarbylamine Chloride (Lachrymator) Shell.—This shell came into use in July, 1917. It is similar in construction to the ordinary Green Cross shell. The fuse is the Gr. Z. 14 n/A. A shell which was examined had no paint marks and was filled with 5,040 grams of a liquid, the main constituent of which was phenylcarbylamine chloride. This liquid has an irritating, unpleasant smell, and is a moderately strong lachrymator, but it does not appear to be a very effective substance for use in gas warfare.

15 CM. NEW PATTERN 1912 SHELL—GR. 12 N/A.

129. 15 cm. Green Cross 2.—This shell was first used in July or August, 1917. It is shown in section in Fig. 16. The fuse used is the Gr. Z. 92 percussion without delay, with auxiliary exploder Zdlig. 92. The main bursting charge consists of 187 grams of trinitrotoluol, contained in an iron tube which extends the whole length of the shell. The lower end of this tube is closed with cement, which is also used in thick layers at the top and bottom of the shell to render it gas tight. The shell is filled through a hole in the ogive. This is afterwards closed with an iron screw plug.

130. The shell is painted field gray, with two blue bands 15

¹ Specimens have been found, however, which though marked with a green cross, contained brominated ketones.
Fig. 18.—15 cm. Gas Shell: Green Cross 2 and Yellow Cross.
mm. wide, situated, respectively; 179 and 204 mm. above the base. These blue bands are of no significance so far as the contents are concerned, but merely indicate a shell of the new pattern 15 cm. Gr. 12 n/A. A green cross is painted on the base, and another on the vulcanite fuse-hole plug. In some cases these latter are replaced by +2, painted in green. The shell are also marked with one or two red crosses on the side, either above or below the body coat of field gray. These are probably put on to facilitate distinguishing between the types of Green Cross shell. Further details follow:

Weight of shell filled (unfused) .......... 40,300 gm.
Weight of liquid contents ............... 4,650 gm.

The liquid contents consist of a mixture of trichloromethylchloroformate, phosgene and diphenylchloroarsine, of which the percentages vary thus:

<table>
<thead>
<tr>
<th></th>
<th>A per cent</th>
<th>B per cent</th>
<th>C per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosgene</td>
<td>65</td>
<td>58</td>
<td>65</td>
</tr>
<tr>
<td>&quot;Diphosgene&quot;</td>
<td>20</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>Diphenylchloroarsine</td>
<td>15</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

21 cm. Heavy Howitzer (Mörser) Gas Shell

131. Gas shell of this caliber were first used in July, 1917. The shell is of the modified 1916 pattern.

132. 21 cm. Green Cross 2.—This shell is similar in construction to the 15 cm. Gr. 12 n/A. It is fitted with the Gr. Z. 92 fuse, and the bursting charge is contained in an iron tube which extends the whole length of the shell.

The coloring and marking are uncertain, but there appears to be a broad black band about 15 cm. below the shoulder.

Further details follow:

Length ........................................ 84.0 cm.
Thickness of walls .......................... 23 mm.
Weight (unfused) ............................ 11,300 gm.
Weight of bursting charge (T.N.T.) ..... 878 gm.
Volume of liquid ............................ 11,000 cc.

The contents of the shell are the usual Green Cross 2 mixture. In one shell examined the percentages were:

<table>
<thead>
<tr>
<th></th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosgene</td>
<td>69</td>
</tr>
<tr>
<td>&quot;Diphosgene&quot;</td>
<td>18</td>
</tr>
<tr>
<td>Diphenylchloroarsine</td>
<td>13</td>
</tr>
</tbody>
</table>

64
133. **21 cm. Yellow Cross.**—This shell is similar to the above, and is used with the Gr. Z. 92 fuse. Specimens examined were marked with a yellow cross on the side and had a patch of yellow on the base.

The liquid contents consist chiefly of dichlorodiethyl sulphide mixed with chlorobenzene and dichloromethyl ether, together with a small quantity of trioxymethylene. The percentages are:

<table>
<thead>
<tr>
<th></th>
<th><strong>Per cent</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dichlorodiethyl sulphide</td>
<td>75</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>15</td>
</tr>
<tr>
<td>Dichloromethyl ether</td>
<td>5</td>
</tr>
</tbody>
</table>

The chlorobenzene is a harmless substance, probably added as a solvent and to assist in the vaporization of the dichlorodiethyl sulphide. The vapors of the other two constituents are very irritating to the throat and lungs.

**DETAILS OF TRENCH MORTAR GAS SHELL**

134. The principles of construction of the trench mortar shell are similar to those of the artillery shell, except that the former are of lighter construction. Light, medium, and half-sized heavy “Minenwerfer” shell have all been extensively used with gas filling. 9 cm. auxiliary bombs and 17.5 cm. “canister” or “rum-jar” bombs have also been used, the former at the inception of gas warfare, the latter quite recently.

**Fuses**

135. Two fuses, viz., the L. W. M. Zdr. (and its recent modification, L. W. M. Zdr. 2) and the Z. s. u. m. W. M. are used almost exclusively with the “Minenwerfer” gas shell.

136. **L. W. M. Zdr. 2 (Leichter Wurf-Mine Zünder).**—This fuse is shown in section in Fig. 17. It is generally used for percussion, but, as a precaution in case the percussion arrangement should miss fire, it is provided also with a time apparatus set to detonate from 1 to 4 seconds after impact. The percussion arrangement is of simple type, the flash from the detonation of 1 on discharge passing through the channel 2 to the powder pellet 3, and thus liberating plunger 4. On impact the striker 5 is thus free to hit the cap 6 and explode the fulminate detonator 7, and hence the bursting charge which surrounds it is in the form of compressed rings.

137. **Z. s. u. m. W. M. (Zünder schwerer und mittlerer Wurf-**
Fig. 17.—Section of Fuse L. W. M. Z.
Mine).—This fuse is shown in Fig. 26. It is similar to the L. W. M. Zdr. to the extent that, should the percussion arrangement fail to act, detonation is effected by the time arrangement, which is set to act one or more seconds after impact. The fuse acts equally well whether the shell strikes the ground point first or base first.

Blind Z. s. u. m. W. M. fuses are extremely dangerous. If

Fig. 18.—9 cm. Bomb—Used for Bromine (Early Type).
the percussion pellets for any reason do not fire, a short fall or a fairly heavy blow may be enough to compress the creep springs and allow the cap to strike the needle. When unfired these fuses may become dangerous when exposed to moisture, owing to the safety pellet having softened (par. 102).

**Auxiliary Trench Mortar Bombs**

138. The auxiliary trench mortar bombs described below were employed in the earlier stages of the development of gas warfare, but their use has been discontinued.

139. **9 cm. Bomb Filled with Bromine.**—This crude type of bomb was used on the French Front in 1915. It consists of a tube of sheet iron (see Fig. 18), closed at one end by an iron disc and at the other by a wooden block, through which passes a time fuse imbedded in a charge of black powder. The bomb contains about 2,000 grams of bromine carried in two glass bottles, which are kept in position by means of fine sand. The fuse is lit by the flash from the propellant charge. When the bomb bursts the bromine is scattered over the ground.

140. **9 cm. Bomb Filled with “B-Stoff,” etc.**—Bombs of this type (see Fig. 19) were at one time used in considerable numbers. The outer case is a cylinder of sheet iron, welded along the longitudinal joint and closed at both ends by sheet iron discs. The upper disc is welded around a steel tube and the lower one pressed out to take the shape of a lead container. The container is of sheet lead and is closed at the top by a flanged pipe which fits easily over the steel tube which contains the bursting charge. This consists of 20 grams of fine-grain black powder. The lower end of the lead container is closed by a disc carrying a filling hole closed by a screw plug. This and all other joints are burned.

The top of the bomb is finished with a wooden disc covered with a felt disc and an iron disc, the three being held down by a hexagonal nut.

An iron tube which screws into the neck of the exploder tube carries a safety fuse to which it is cemented. The fuse is probably ignited from the flash of the discharge.

The bomb is painted gray and has a capacity of about 1,300 cc.

The contents were generally “B-Stoff” (brominated ketones) or “K-Stoff” (monochloromethylchloroformate).
Fig. 19.—9 cm. Trench Mortar Gas Bomb.
7.5 cm. Light Trench Mortar Gas Shell (Leichte Wurf-Mine)

141. Since the trench mortar from which these shell are fired is a rifled muzzle-loader, the driving bands are studded in order to fit the grooves. The propellant charge is contained in a cavity at the base of the shell, which is closed by a screwed plug (see Fig. 20) and consists of perforated discs of a gelatinized nitrocellulose-nitroglycerine explosive. These are tied in packets numbered 1 to 4, the total weight being 18 grams. Any charge from 7.5 grams to 18 grams can be used.

142. The charge is exploded by a striker set in the base of the trench mortar. This is operated by a lanyard and automatically resets itself. In this way a very rapid rate of fire is obtainable. For short bursts it may reach 20 rounds per minute.

The maximum range obtainable from this "Minenwerfer" is 1,150 yards.

143. The fuse used is the L. W. M. Zdr., with single-branch safety pin, or its modified form L. W. M. Zdr. 2 for percussion and time, with a 2-branch safety pin.

C-SHELL

144. A shell of this type is shown in Fig. 20. It is made of drawn steel 3 mm. thick and is reinforced near the base by a lining made of similar tubing, both tubes being acetylene-welded to a forged base just above the driving band. The head is screwed in and carries a steel tube, closed at the bottom. The fuse is the older L. W. M. Zdr. 16 pattern of cone-shaped section.

The liquid is contained in a lead vessel which almost entirely fills the interior of the shell and is made of sheet lead 1 mm. thick. Its capacity is 460 cc.

The space between the lead receptacle and the inside of the shell is entirely filled with a white cement consisting of carbonate and oxychloride of magnesium. This penetrates into the screw threads and renders the ogive immovable. The fuse is similarly cemented.

The shell is painted gray and has two white bands near the head. With regard to contents and markings there are two types:

(a) Monochloromethylchloroformate.—When used with this filling (K-Stoff) the shell is marked on the body with a white "C." The use of this filling is now discontinued.
Fig. 20.—7.5 cm. Light Trench Mortar Gas Shell.
(C-Shell, Early Type.)
Fig. 21.—7.5 cm. Light Trench Mortar Gas Shell.
(D-Shell—Early Type.)

72
(b) *Trichloromethylchloroformate.*—With this filling the lead container was retained although it is unnecessary (see par. 87). Probably old pattern shell were being utilized. The shell is marked on the body with a red C.

**B-SHELL**

145. B-shell are exactly like C-shell, except that they are filled with either brominated ketones or xylyl bromide (T-Stoff). They are painted field gray with one white band, and a white B is stenciled on the body.

**D-SHELL**

146. The use of D-shell filled with phosgene was started near the end of 1916.

Several types of D-shell exist, the earlier kinds now being obsolete. The main difference from the C-shell is that there is no separate container of any kind.

---

**Fig. 22.—Types of 7.5 cm. Trench Mortar Shell.**
147. **Type 1.**—This shell is shown in Figs. 21 and 22. It is 27.4 cm. long. The head is welded to the body. The exploder tube is flanged towards the end and to the flange is welded a thick steel disc with a central hole obviously for filling (Filling Hole). It would appear that the shell is sealed after filling by pressing a disc of lead surmounted by an iron disc in such a way that the lead disc is forced partly through the filling hole and forms a "blob." At its own periphery and around the edges of the filling hole, the iron disc comes into contact with the steel bottom disc.

Above the iron disc is pressed a second pair of discs, which are followed by a third pair. The iron discs are probably concavo-convex when inserted, and are placed concave side downwards. When pressed from above they tend to flatten out and their edges press against the walls of the exploder tube. They cannot move upwards on account of the exploder tube being flanged.

Above the top disc is a cardboard disc upon which rests the picric acid exploder.

Further details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>274.0 mm</td>
</tr>
<tr>
<td>Thickness of walls near head</td>
<td>5.7 mm</td>
</tr>
<tr>
<td>Thickness of walls near middle of body</td>
<td>3.6 mm</td>
</tr>
<tr>
<td>Thickness of walls near base</td>
<td>5.8 mm</td>
</tr>
<tr>
<td>Thickness of walls of base</td>
<td>12.5 mm</td>
</tr>
<tr>
<td>Driving band material</td>
<td>Brass</td>
</tr>
<tr>
<td>Driving band width</td>
<td>10.0 mm</td>
</tr>
</tbody>
</table>

Markings: Three white bands, about 8 mm wide. The letter D stenciled in black on body. Stamped on the wall above the driving band:

```
H M E 16 GGF 30 k
```

Weight of shell complete with fuse, safety pin exploder, and propelling charge... 4,642 gm.

Weight of shell without safety pin and propelling charge.................... 4,613 gm.

Weight of picric acid in exploder...... 15 gm.

Weight of liquid contents............... 663 gm.

Volume of liquid........................ 466 cc.

\[
\text{Efficiency}^1 = \frac{466 \times 100}{4642} = 10.0 \text{ per cent}
\]

The contents of the shell are almost pure phosgene. The shell is but two-thirds full, however, the reason for this probably being to allow for expansion. The actual capacity is 700 cc.

---

1. Calculated from actual content and not from total capacity.
Fig. 23.—Head of 7.5 cm. "Minenwerfer" Gas Shell.  
(D-Shell, Long Pattern.)

148. Type 2 (Ogival Head).—This shell differs from the above in the shape of the head and in the method of closing the filling hole. The head A (Fig. 23) and the exploder tube C are in one piece, which is welded to the shell wall at B. The thickness of the base of the exploder tube is augmented by the addition of a plate H, welded around the edge K.

After it is filled, the shell is sealed by screwing E down to a lead washer G (3 mm. thick after compression) surmounted by an iron washer F (0.4 mm. thick). A cardboard disc D is placed above the screw-head, and upon this rests the picric acid exploder.

The range table used with this type of shell is the same as that used with the H. E. type. A label to this effect is attached to the inner side of the lid of the box containing these shell and reads “Zu verschiessen nach Schusstaffel für Sprengminen.”

The color of the round-headed gas shell is a darker gray than that of the cone-headed shell. At the head there are 3 white bands of the same width and spacing as in the cone-headed type. The whole set is, however, about 2 or 3 mm. lower. The letter D is often in black and is frequently omitted.
Further details follow:

Length ........................................... 274 mm.
Thickness of walls near head ...................... 5.8 mm.
Thickness of walls at middle of body (varies) ..... 2.90–3.45 mm.
Thickness of walls near base ....................... 5.8 mm.
Thickness of base ................................ 13 mm.
Driving band material .............................. copper
Driving band width ................................ 10 mm.
Weight of shell complete with fuse, safety pin, and propelling charge No. 3 ..... 4,427 gm.
Weight of shell without safety-pin and propelling charge .................. 4,400 gm.
Weight of liquid contents .......................... 694 gm.
Volume of liquid contents ........................ 485 cc.
Weight of picric acid exploder ..................... 16.0 gm.

Efficiency = \( \frac{485 \times 100}{4427} \) = 10.95 per cent

149. Type 3 (Short Ogival Head).—This shell is 24.8 cm. in length and has a special range table. It has the ogival head and new type fuse and is more completely filled with phosgene than those just described. The tendency with each succeeding type of this shell is for the amount of phosgene to be increased.

The short shell is filled through a hole in the shell wall, near

---

Fig. 24.—Head of 7.5 cm. Light "Minenwerfer" Gas Shell—Short Pattern, with Filling Hole in Shoulder.
the welded joint. This hole is closed by an iron screw plug (see Fig. 24).

In the L. W. M. Zdr. 2 fuse used with this shell, the gaine is of steel and contains picric acid. Previously it was necessary to insert an exploder into the shell before fusing. The driving band is of zinc instead of copper and is high on the side of the shell. The marking continues to be three white bands around the body. Their width, spacing and position on the shell vary. The letter D is generally omitted.

Further details follow:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>248 mm.</td>
</tr>
<tr>
<td>Driving band material</td>
<td>Zinc,</td>
</tr>
<tr>
<td>Driving band width</td>
<td>10 or 15 mm.</td>
</tr>
<tr>
<td>Weight complete</td>
<td>4,177 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>800 gm.</td>
</tr>
<tr>
<td>Volume of liquid</td>
<td>555 cc.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>$\frac{555 \times 100}{4177} = 13.28$ per cent</td>
</tr>
</tbody>
</table>

17 cm. Medium Trench Mortar Gas Shell (Mittlere Wurf-Mine)

160. This is a rifled trench mortar with a range, in the 1916 pattern, of 1,750 yards. The German official text-book, "Die Minenwerfer," dated July, 1917, gives the most favorable range for gas shell as 437 to 1,750 yards. The rate of fire is stated to be 40–45 rounds per hour.

161. B-Shell (Marked BM).—A B-shell of the type used at present is shown in Fig. 25. A central iron tube extends from the nose of the shell and contains the bursting charge, consisting of 500 grams of cast T. N. T. with a pellet of compressed picric acid, through which extends a central core of cast T. N. T. Above the picric acid and around the tinned-iron cup (see Fig. 25) is powdered T. N. T. (37 grams—crystals).

All the explosive is directly contained in a tube of thin tinned sheet iron 0.2 mm. thick, closed at the top of a tinned iron cup to which it is soldered. The lower end of the tube containing the explosive is open. When filled the tube is inserted into the central iron tube (2.5 mm. thick) along with molten paraffin wax.

The liquid contents of the shell are held in a lead container, the walls of which are 2 mm. thick, except where they are thickened near joints. The filling hole is at the bottom and is
Fig. 25—17 cm. "Minenwerfer" Gas Shell.
closed by a lead screw plug which is burnned round after inserting.

The shell is painted gray with a white band 40 to 43 mm. wide at the extreme top.

The markings are shown in the diagram.

Further details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of shell</td>
<td>636 mm.</td>
</tr>
<tr>
<td>Weight full (fused)</td>
<td>44.11 kg.</td>
</tr>
<tr>
<td>Weight of lead container</td>
<td>7.79 kg.</td>
</tr>
<tr>
<td>Length of exploder tube from top of shell to bottom</td>
<td>480 mm.</td>
</tr>
<tr>
<td>External diameter of tube</td>
<td>46 mm.</td>
</tr>
<tr>
<td>Internal diameter</td>
<td>41 mm.</td>
</tr>
<tr>
<td>Weight of liquid contents</td>
<td>12.13 kg.</td>
</tr>
<tr>
<td>Volume of liquid contents</td>
<td>8,500 cc.</td>
</tr>
<tr>
<td>T.N.T. crystals</td>
<td>37 gm.</td>
</tr>
<tr>
<td>Picric acid pellet (compressed) with core of cast T.N.T.</td>
<td>90 gm.</td>
</tr>
<tr>
<td>Cast T.N.T.</td>
<td>500 gm.</td>
</tr>
<tr>
<td>Width of driving band</td>
<td>28 mm.</td>
</tr>
<tr>
<td>Distance of driving band from base</td>
<td>12 mm.</td>
</tr>
</tbody>
</table>

Efficiency = \( \frac{8500 \times 100}{4411} \) = 19.27 per cent

The contents consist of brominated methylethyl ketone, the ratios of the mono- and the dibromo compounds varying. In shell examined at the beginning of 1917 the ratio was 65 per cent mono- and 35 per cent dibromomethylethyl ketone, or a reversal of the ratios latterly used in shell (see Appendix I., p. 136).

152. C-Shell.—The use of this filling is discontinued. The shell differed from that just described by having the bursting charge contained entirely in the head.

This shell was painted gray, with 2 white or yellow bands, and was marked C, or sometimes CM. The filling was 8,500 cc. of monochloromethylethylchloroformate.

Formerly B-shell of this type were also used.

153. D-Shell.—Details of this shell are lacking. It appears to be similar to the C-shell, but it is painted gray with three white bands and a white D on the body.

The liquid contents consist of 8½ litres of pure phosgene. The fuse is the Z. s. u. m. W. M.
25 cm. Half-Sized Heavy Trench Mortar Shell (Kurze schwere Wurf-Mine)

154. These shell are fired from the 25 cm. rifled "Schwerer Minenwerfer," a muzzle-loading trench mortar with maximum range of 930 yards. The half-sized shell is made of steel. It is 59.3 cm. long and the base is screwed on 8.7 cm. from the bottom.

This shell is painted gray, with 3 white bands, and is fitted with the Z. s. u. m. W. M. fuse.

The liquid contents are 16,400 cc. of pure phosgene, filled directly into the shell.

18 cm. Smooth-Bore Trench Mortar Shell (Glatte Wurf-Mine)

155. Shell of this kind have recently been used in considerable numbers as an imitation of the British projectors.

The shell (Fig. 26) is 17.5 cm. in diameter and is without driving bands. It is usually known as the "canister" or "rum-jar" bomb. The ordinary high-explosive shell has been converted so that it can be used with gas and is fitted with the Z. s. u. m. W. M. time and percussion fuse.

The body of the shell is painted gray, with three white bands below the shoulder. Into the head is screwed and cemented an iron tube (A) closed at the bottom. A square wooden block (B) is set in magnesium oxychloride cement at the bottom of this tube. Paraffin wax (E) surrounds the top of the block and also the container (D), which is made of galvanized sheet iron and contains the T. N. T. exploder.

The shell is filled through a hole in the side below the shoulder, the hole being closed by a screw plug and the joint welded.

The weight of the explosive charge is 115 grams. The liquid contents consist of 6 litres of pure phosgene or a mixture of 50 per cent phosgene and 50 per cent chloropicrin.

METHODS AND TACTICS EMPLOYED IN THE USE OF GAS SHELL

Early Methods (1915-1916)

156. In 1915 and 1916, when the principal gas shell used were the T- and K-shell, the Germans relied on their ability to build up effective gas barrages. For local purposes these were occasionally successful. Several trench raids for demoralizing the
Fig. 26.—18 cm. Smooth-Bore Trench Mortar Shell.
front-line troops were carried out with the help of gas shell which were used to build box barrages around suitable areas. A case of this kind occurred at La Boiselle in April, 1916, where gas shell were chiefly used. At Vermelles about the same time an intense barrage of T-Shell was put down in an attempt to prevent the bringing up of reinforcements during an assault on the British positions. This bombardment failed to accomplish its purpose, owing to the impossibility of effectively closing by gas all the routes of approach to a wide front. The quantities of gas shell available and recommended for use for such bombardments were insufficient and, although captured documents showed a good appreciation of the possibilities of gas shell, the effects actually produced were unimportant.

The following extracts from a document captured at the end of 1915 show the methods recommended:

**FIRE PROCEDURE WITH T- AND K-SHELL**

157. Firing with single guns is ineffective. The requisite amount of gas can be obtained only by firing a considerable number of gas shell.

When firing with K-shell, a heavy fire with percussion shell should be maintained for a very short time, in order to force the enemy to abandon his position.

When firing with T-shell, the bombardment may be slightly prolonged. Once the gas barrier is formed, a slow rate of fire is sufficient to maintain it.

The action of the gas barrier, preventing the bringing up of reserves, should be prolonged up to the time when our own infantry have succeeded in penetrating the enemy's position.

In order to make full use of the explosive effect of gas shell, the gas barrier should not be formed on tracts of ground which offer no suitable objective; but, on the contrary, zones must be selected in which points d'appui situated in rear, e. g., camps, depots and exits from villages, can be made to feel the effects of our fire.

Before beginning a heavy bombardment in which gas shell are to be employed, such shell should not be fired singly, since this would give warning to the enemy, who would put into effect precautionary measures.

**SPECIAL POINTS**

158. Firing Against Infantry Positions.—The width of the zone allotted to each battery should be about 150 meters. The ranging of the batteries with ordinary ammunition (with flank observation) should be completed before the attack begins.

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1 The earliest types of gas shell contained much larger amounts of high explosive than those in use at present. The 15 cm. T-shell, for example, contained 3½ pounds of T. N. T.
Fire is generally opened against the more distant portions of the position up to 400 meters behind the front line. The ground is then covered with fire, decreasing the range by 25 meters at a time, until the first line is reached.

At each of these ranges 12 rounds are fired, distributed evenly along a front of 150 meters. When the front line trench has been reached, fire is continued against it for some 20 to 30 minutes, after which the range is increased by 25 meters at a time. At the same time patrols, armed with hand grenades and shields, advance towards the enemy's position to ascertain if it is still held and if the action of the gas has been sufficiently effective to enable our troops to advance and to what extent. If the enemy fires at the patrols, our fire is again directed against the front line trenches. Our infantry must also open fire against the enemy's first line trenches.

If the enemy's fire ceases or becomes very feeble, the infantry attacks as soon as the patrols have gained the enemy's front line trenches. At the same time the artillery directs its fire against the rearward portions of the line by gradually increasing the range.

159. The guns which are not firing gas shell observe the following rules:

The light howitzers distribute their fire along the front of attack and bombard the first line trenches with time shell (H. E.).

The mortar batteries come into action against the strongest points d'appui or, should there be none of these, against the front-line trenches and the shelters in rear of them.

The field gun batteries fire on bodies of the enemy, who may evacuate the position.

The 10 cm. guns and other heavy flat-trajectory guns open fire on the approaches, reserves, etc.

160. **Firing Against Artillery Positions.**—The effect of gas shell is most marked against artillery in covered emplacements, valleys, or small woods. If the artillery is silenced, another target may be engaged, for the effect of the gas lasts for some time. In certain cases, it may also be possible to put the observation stations out of action for a while.

In order to hit gunners who may be leaving the batteries, our artillery should at the same time employ time shell as prescribed for engaging infantry positions.

161. **Firing on a Definite Area with Gas Shell.**—The four guns of a battery are so placed that with parallel lines of fire they will cover a front of 50 meters. A series of four rounds per 50 meters of front will be fired.

The area to be covered is then searched in rectangles 50 meters wide and 25 meters deep, so that no gaps are left.

In order to render it impossible to cross the barrage quickly, the latter should have a minimum depth of 200 meters. The barrage should first of all be established along its whole width and the range should not be increased until this has been effected.
**Fig. 27.—Example of the Formation of a Gas Barrage.**

*(Old Method.)*

162. **Example of the Formation of a Gas Barrage.—**Fig. 27 (A and B) illustrates diagrammatically the formation of a gas barrage. The sequence in which salvos are fired will depend on the direction of the wind, the nature of the hostile positions included in the area to be shelled, and also on the intentions of our own troops. With a west wind, for instance, the salvos will begin from the west. If our infantry intends to advance later towards the area in question, our salvos will begin on the near edge of the area.

Calculations should be indicated on a diagram, the width and depth of which are proportional to those of the target. Thus, Fig 27B represents fire against a ravine situated obliquely to the angle of fire.
In order to retain control of the fire, even during the procedure of searching, the artillery commander has a similar diagram, which enables him to change rapidly the method of searching, in accordance with either his own observations or the reports he receives. He has only to indicate the numbers of the salvos (omit certain salvos or else order a new series at given points).

Use of Green Cross Shell (1916–1917)

163. With the introduction of Green Cross shell instructions were given for bombarding small targets and areas more intensely than before. Either the quantities of shell and methods recommended were inadequate or else the artillery did not obey them. During the Battle of the Somme, for example, the effects produced by the surprise use of this new poison shell were incommensurate with the total expenditure of ammunition. This was probably realized, as may be seen from an order to the German 1st Army Artillery by von Buelow, dated September, 1916:

There have recently been many instances of T-shell and Green Cross shell being fired in small quantities. This is a waste of ammunition, as with all gas shell good effects are to be obtained only by using them in large quantities.

The firing of small quantities of gas shell has also the disadvantage that the enemy is practiced in the use of his anti-gas appliances and attains a higher degree of gas-preparedness. For this reason the effect produced by larger quantities of shell will be reduced.

In accordance with the “Instructions for the Employment of Gas Shell” and “Provisional Instructions for the Employment of Gas Shell for the Field Artillery,” I request that orders be given that gas shell are in the future to be employed in the manner indicated above.

This was followed by special instructions for the use of Green Cross shell. A translation of these instructions, which were to be strictly enforced, follows:

INSTRUCTIONS FOR THE EMPLOYMENT OF GREEN CROSS SHELL

(Berlin, February 18, 1917)

164. General.—The results obtained by firing Green Cross gas shell will be proportional to the stillness of the atmosphere. The best time for firing gas shell is at night. Similar results can be obtained by day only when the sky is quite overcast, or during a fog.

Wooded or decidedly broken country adds largely to the
efficacy of gas shell. There is always less wind in woods than in the open country.

Green Cross shell should never be used for barrage fire.

165. Methods of Fire.—(a) When the principal effect is to be achieved by gas, gas shell may be employed in:

(i) Fire for effect.—A small quantity (up to 10 per cent) of other ammunition may be fired simultaneously. A large expenditure of H. E. shell causes the gas to dissipate rapidly.

(ii) Harassing fire.

(b) When the principal effect is to be achieved by H. E. shell, a proportion of gas shell (up to 10 per cent) may be fired as well, as this will cause the enemy to put on gas masks, and suffer from the disadvantages entailed by the prolonged wear of these masks.

166. The Object of Fire for Effect.—The purpose of fire for effect is to gas a large area so that the enemy cannot escape the effects of the gas. This area must be at least 1 sq. km., and preferably far larger. The greater the extent of the area shelled and the longer it can be kept under gas, the more difficult it will be for the enemy to escape from the effects of the latter. Even the best of the enemy's masks are effective for only a limited period.

The primary object is to neutralize the enemy's artillery prior to an attack by our own or the enemy's troops and to prevent reserves being brought up.

167. Method of Carrying out Fire for Effect.—When fire for effect is to take place on a large scale General Headquarters appoints expert officers to cooperate in reconnaissance, distribution of targets and all preparations for the bombardment. These experts will, in certain circumstances, take entire control of the gas bombardment. An expert meteorologist must be detailed as an adviser.

Repeated bursts of fire for effect, or alternations of fire for effect and harassing fire on successive nights (or very cloudy days), should prove specially effective, as it will generally be difficult for the enemy to exchange the masks already used.

Fire for effect should open without warning and should not cease definitely, but should be changed into bursts of harassing fire, repeated at irregular intervals.

168. On flat ground fire for effect always demands the employment of a large number of batteries and a vast expenditure of ammunition. For a bombardment of 6 to 8 hours' duration, the following are the minimum numbers of batteries and amounts of ammunition required per square kilometer:

<table>
<thead>
<tr>
<th>Gun</th>
<th>Rounds</th>
<th>Batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun</td>
<td>12,000</td>
<td>6</td>
</tr>
<tr>
<td>Light field howitzer</td>
<td>6,000</td>
<td>5</td>
</tr>
<tr>
<td>10 cm. gun</td>
<td>6,000</td>
<td>7-8</td>
</tr>
<tr>
<td>Heavy field howitzer</td>
<td>3,000</td>
<td>5</td>
</tr>
<tr>
<td>15 cm. long gun</td>
<td>3,000</td>
<td>6</td>
</tr>
</tbody>
</table>
169. With this minimum expenditure and with proper distribution, the effect of the gas will begin to be felt in the area bombarded, at the latest, one hour after the commencement of the bombardment.

The area under fire may be approached from one to two hours after the apparent dispersion of the drifts.

On a calm day, pauses of an hour may be made, but in windy weather fire should be continuous and rapid.

170. When an attack is to follow up a bombardment with gas shell, it is essential that the latter be continued until the assault is launched. Consequently, separate batteries should be detailed for the gas shell and H. E. shell bombardments.

171. In flat country, the area to be shelled should be divided into rectangles, with a frontage of 100 to 500 meters and a depth of 200 meters, a certain number of these being allotted to each battery. The rectangles should be shelled in rotation, following the direction of the wind.

A definite sequence may be imposed by tactical requirements. For example, it may be desirable to drive the enemy forward by means of a steadily increasing gas barrage formed in his rear.

172. It should be firmly borne in mind that, in fire for effect, the exact lie of every round is immaterial, for the result does not depend on the effect of the shell at the point of burst, but on an even distribution of gas over the whole country-side.

173. The Object of Harassing Fire.—The purpose of harassing fire is to envelop the target in a small but concentrated gas cloud, fire being opened suddenly and without previous warning. It should be employed in particular against nests of artillery, troops at work or on the march, concentrations of reserves, villages, cross roads, sunken roads, bridges, stations, detraining places, camps and billets, and observation posts. Against living targets, it should be used only when they have been definitely located and justify the expenditure of ammunition.

174. Method of Carrying Out Harassing Fire.—The following number of rounds is laid down for bursts of harassing fire; all these should be fired at the maximum rate within about two minutes, several batteries being detailed, if necessary, for each target:

<table>
<thead>
<tr>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun</td>
</tr>
<tr>
<td>Light field howitzer</td>
</tr>
<tr>
<td>10 cm. gun</td>
</tr>
<tr>
<td>Heavy field howitzer</td>
</tr>
<tr>
<td>15 cm. gun</td>
</tr>
</tbody>
</table>

Fire will not be distributed, and during each burst no change will be made in elevation or direction.

In many cases, it is desirable in harassing fire to employ gas shell alternately with H. E. shell.
When changing over to harassing fire with ordinary shell, it is advisable, in order not to dissipate the gas cloud, to fire shrapnel or time H. E. shell after the gas shell.

175. The limited amount of gas shell and the appreciation of their value for counter battery work is seen in the following extract from a document from General Headquarters, signed by von Ludendorff and dated March 21, 1917:

The general appreciation of the value of gas shell has now risen very much, as is proven by the high demands. Although the proper recognition of the useful nature of gas shell bombardments is very gratifying, the general principle of economy has in this case to be considered to a special degree, as the supplies are limited. It is therefore of special importance to have a sufficient amount of gas shell in the battery positions, in order at the right moment, when the enemy is starting attacks on a larger scale, to neutralize the enemy’s artillery and thus, at the same time, nip his infantry attack in the bud. Small harassing bombardments are to be confined to special cases.

Present Methods of Using Artillery Gas Shell

176. With the advent of the use of Green Cross 1, Green Cross 2, Yellow Cross and Blue Cross shell, the German gas shell tactics have altered and developed. The following points have been noted with regard to the use of these shell:

(a) The Yellow Cross shell are nearly always accompanied by H. E. and shrapnel, and frequently by “Diphosgene” and ordinary lachrymatory shell. Occasionally a regular sequence in the different types of gas shell fired during a bombardment is noted. They are sometimes fired at a low rate for several hours, interspersed at varying intervals with heavy bursts of about 300 shell at a time.

(b) The bombardments fall mainly into two classes, viz., those in which Yellow Cross, H. E., and shrapnel are used, and those in which Blue Cross, Green Cross, H. E., and shrapnel are used.

Blue Cross shell are seldom used alone.

(c) A captured document, dated September 26, 1917, issued by German General Headquarters, states that, as the British box respirator gives protection against Blue Cross and Green Cross 2, Blue Cross shell should be fired at the start of a gas shell bombardment, as they cannot be distinguished from H. E. until they have caused sneezing. Green Cross shell should be fired subsequently, as the sneezing may prevent the adjustment of the respirator.
Enemy gas shell bombardments of this type have been unsuccessful.

(d) In order to obtain a more effective range for gas shell from 7.7 cm. field guns, it is the enemy's practice to bring these guns into advanced positions at night. They are withdrawn as soon as the bombardment is over.

(e) The use of gas shell against infantry on active fronts in the line has been increased. This may have been intended to interfere with the assembling of troops.

(f) Yellow Cross shell have been used by the enemy against roads and tracks during daylight, and in winds of 13 to 15 miles per hour.

177. The following secret official German document issued from German General Headquarters and dated July 1, 1917, is the most recent complete set of enemy instructions for the use of gas shell. It is noteworthy that it makes no mention of lachrymatory shell, although these were undoubtedly still in use in recent bombardments and a new lachrymator (phenylcarblyamine chloride) has recently been introduced. It must be remembered, however, that Yellow Cross is probably more effective as a neutralizer as long as the Germans are on the defensive, but would be dangerous to use in the event of troops having to occupy immediately positions shelled with it. In the latter case a lachrymator would probably be better.

INSTRUCTIONS FOR THE USE OF GAS SHELL

[Translation]

1. GENERAL

178. All instructions hitherto issued for use of gas shell are hereby cancelled.

The object of a gas bombardment is to incapacitate or destroy living targets and generally to neutralize the enemy's fighting efficiency.

Distant targets and hostile artillery are most suitable for a gas bombardment, as our own troops are less likely to be endangered. Very favorable targets may also be found in the neighborhood of infantry positions, and, by exercising sufficient skill in conducting the bombardment, any danger to our own troops may be obviated.

179. As the supply of gas shell is limited, its use is, in general, to be confined to occasions of great importance, such as the preparation for our own attacks and the defense against those of the enemy.
By skilful manipulation of the gas bombardment, considerable losses are inflicted on the enemy, his activity is temporarily paralyzed and he is thrown into disorder. Success, however, depends on the weather conditions, and care must be taken to ensure that full tactical use is made of these.

180. The time to be particularly considered, in the case of the assault, is the period _before and during_ our own infantry thrust, likewise during the movement of batteries, as well as after the successful advance of the infantry, where it is important to neutralize hostile batteries.

_In the defense_, a gas bombardment is most advantageous before, during and immediately after the hostile attack on our positions, at a time when the living target is most concentrated and when our infantry have the greatest need for protection against enemy weapons.

181. _Hostile protective appliances_ against gas present an obstacle. These consist, to a very small extent, of oxygen sets, the maintenance of which involves great difficulties in the field. At best these provide protection for only one hour. The far larger part consists of apparatus which absorbs the gas from the air inhaled (i.e., masks).

If the enemy is taken unawares by a gas bombardment, he will not be able to _utilize his form of protection until it is too late_. Surprise is effected by opening sudden bursts of fire, independent of the type of gas shell used.

The enemy will not make use of his protective apparatus unless he notices the gas shelling. To this end odorless and non-irritant gas (Yellow Cross) may be employed, its use being _concealed_ by firing H. E. at the same time.

182. The protection afforded by the enemy's mask may, moreover, be overcome by employing gas which penetrates the mask. With regard to their capacity for penetrating the enemy's mask, gases behave as follows:

(a) Green Cross and Green Cross 1 penetrate only the French mask and then only after prolonged exposure to a strong concentration.

(b) _Green Cross 2_ penetrates the English mask to the same degree that Green Cross 1 penetrates the French mask. Green Cross 2 is, therefore, much more effective against the French mask than Green Cross 1.

(c) _Blue Cross shell_ (which, in addition to its gas action has only one-third less explosive effect than ordinary H. E.) produces a cloud which, even in small concentrations, passes through every enemy mask at once, and causes the wearer to tear off his mask, owing to the powerful irritation produced on the organs of respiration and vision.

(d) _Yellow Cross_ penetrates the enemy protection to approximately the same degree as Green Cross 2.

183. _Suggestions regarding the mode of employment of these_
gases follow naturally from the properties which have been described:

(a) Green Cross 1 produces its most destructive action when used in combination with Blue Cross which goes through the mask.

It is also especially suitable for use in surprise bombardments (par. 181).

When used alone in very high concentrations it is capable of exhausting enemy protection, but only after prolonged employment.

(b) Green Cross 2 provides a substitute for the combination Green Cross 1 and Blue Cross, but it is not quite as efficient. It is, however, better than Green Cross 1 alone.

It can always replace with advantage Green Cross 1, even in the combination Blue Cross and Green Cross. This use will, in general, be disallowed, owing to the scarcity and value of Green Cross 2.

(c) Blue Cross used alone in sufficient concentrations has also a toxic action.

Blue Cross shell, on technical grounds, contain a large amount of H. E. and only a small quantity of gas. Toxic concentrations can usually be obtained only by heavy expenditure of ammunition, an expenditure which may be substantially reduced by combining Green Cross 1.

The rule is therefore: Whenever a toxic concentration is aimed at, Blue Cross will be fired in combination with Green Cross 1.

Moreover, the temporary interference with the enemy’s fighting efficiency, in the case of small concentrations of Blue Cross, is in itself so extensive that the use of a sufficient proportion of it considerably increases the effect of H. E. shell against live targets, should weather conditions be suitable for a gas bombardment. Blue Cross shell possess the further advantage that they cannot be distinguished from H. E., either by detonation or by the formation of a cloud, and in one-half to one minute after the explosion the action of the gas becomes apparent.

(d) In the employment of Yellow Cross it is essential that its non-smelling and non-irritant properties be utilized (par. 181). It will usually be fired in combination with H. E. Its separate use in a gas bombardment is not advisable, as the enemy at once becomes aware of it. When the condition of the ammunition supply makes it necessary, Yellow Cross may be resorted to in order to supplement Green Cross 1.

(e) The mode of employment of the various types of gas ammunition should be so arranged that, when a target is dealt with by different kinds of gas shell, they do not mutually weaken or neutralize one another.

Exact acquaintance with the properties of the different kinds of gas shell is a preliminary condition for their correct employment. As the supply of gas shell is limited, this is of the utmost importance.
As the protection afforded by the enemy’s defensive measures improves from time to time, it becomes necessary to consider the new points of view that arise; in particular the need for increased duration and for more frequent repetition of bombardments.

All information concerning the enemy’s anti-gas measures will be regularly forwarded to the Gas Staff Officer at Army Headquarters through the Chemical Section of the War Ministry.

II. INFLUENCE OF WEATHER AND TOPOGRAPHY

184. The persistence of the gas and the general effect of the bombardment is very much greater, the smaller the air movement is, both as regards the horizontal and the vertical direction.

Vertical air currents are caused by:

(a) Sunshine.—This causes strong upward currents which rapidly disperse the gas.

(b) Heavy rain.—The gas is beaten to the ground and rendered harmless.

185. The most suitable time for a gas shell bombardment is, therefore, at night. By day, the air is free from vertical currents only in dull weather or when the target is obscured by mist. In such cases results may be obtained similar to those during the night.

Lack of air movement in a horizontal direction, or calm, is by far the most suitable condition. Surface wind of more than 1½ meters per second considerably diminishes the effect of the gas.

This disadvantage cannot always be offset, even by substantially increasing the expenditure of ammunition.

186. Wooded and very undulating ground has the greatest influence on the results of a gas shell bombardment. In woods the air is always calmer than in open country.

Targets such as woods may therefore be shelled with good results when the wind has too high a velocity for targets situated in open ground. When the undulations in the ground are very marked, the fact that the wind is stronger on high ground than on low, must be taken into account. High ground and open places must therefore receive a more intense concentration than those localities which are wooded or enclosed.

187. During gas shell bombardments in open country, particular attention must be paid to the deviation of the local wind from the general wind direction, and to air currents peculiar to the combined action of mountain and valley, which occur on certain days in bright weather. A continuous drift of gas from high ground to low, as in the case of cloud gas, is not to be depended on, a much smaller concentration being produced by a gas shell bombardment than by a cylinder discharge.

The gas produced close to the ground, during a gas shell

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1 Cf. par. 176(f).
bombardment, follows the direction of the wind; in heavy concentrations the cloud evolved is capable of considerable action at a distance of several kilometers from the target area. 188. Blue Cross may, if need arise, be employed in rather unsuitable ground and weather conditions. If the gas diffuses rapidly, there still remains the powerful H. E. effect.

III. VARIOUS TYPES OF GAS BOMBARDMENT

189. All gas shell are fired to burst on impact.

Concentration of gas shell, as regards time and area, namely, the production of the densest cloud on the target sector, is essential to good results.

Single shots are valueless.

190. It is, in general, inexpedient to employ gas shell for barrage fire, as the results obtained are rarely proportional to the increased expenditure of ammunition involved.

191. The following types of gas shell bombardment are to be distinguished:

(a) Ordinary gas shell bombardments.
1. Bombardment of small areas.
2. Bombardment of medium areas.
3. Bombardment of large areas.

(b) Gas and H. E. shell combined.
1. Blue Cross and H.E. shell.
2. Yellow Cross and H.E. shell.

192. During an ordinary gas shell bombardment, it is neither necessary nor advisable to expend H. E. on the target at the same time.

Green Cross and H. E. shell combined is of little value and therefore no longer employed. The interference it causes the enemy, by making him wear his mask, does not repay the expenditure of ammunition, which is necessary for more urgent purposes.

193. All three modes (par. 191) of employing gas shell rely on surprise, the normal method being to fire about 100 rounds. The following amounts of ammunition give essentially equivalent results:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun</td>
<td>100</td>
</tr>
<tr>
<td>Light field howitzer or 10 cm. gun</td>
<td>50</td>
</tr>
<tr>
<td>Heavy field howitzer or 15 cm. gun</td>
<td>25</td>
</tr>
<tr>
<td>Mortar (21 cm. howitzer)</td>
<td>10</td>
</tr>
</tbody>
</table>

In addition, the various calibers may be combined, e.g., as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun</td>
<td>50</td>
</tr>
<tr>
<td>Light field howitzer</td>
<td>25</td>
</tr>
<tr>
<td>Heavy field howitzer</td>
<td>15</td>
</tr>
<tr>
<td>Mortar</td>
<td>4</td>
</tr>
</tbody>
</table>
It is essential that surprise be effected by employing the most rapid rate of fire, thus ensuring that the shots lie together and that a compact cloud envelopes the target. Only during an absolute calm may the rate of fire be diminished.

The direction of the air current should be taken into account, the lie of the shots being to windward.

194. Bombardment of Small Areas (Once or Several Consecutive Times).—This consists in effecting surprise on a limited target (single batteries, observation posts, etc.).

The most efficient type, as regards destructive effect, is that of a small gas bombardment with Blue Cross and Green Cross I combined in equal proportions.

A small gas bombardment, with Blue Cross alone, or with Green Cross 2 alone, is less effective. Green Cross I merely exercises harassing effect on the enemy.

The element of surprise is produced in the shortest time by bringing one or more batteries into action. It is often advantageous to repeat the bombardment at various distances selected according to the wind direction.¹

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**Fig. 28.—Bombardment of a Target with Gas Shell, with Different Wind Directions.**

195. Bombardment of Medium Areas.—This involves the systematic combination of bombardment of small areas, in order to cause damage or destruction to extended target sectors or groups of sectors, as, for instance, groups of several batteries, strongly held parts of hostile positions, or enemy reserves in woods and billets.

In general it is requisite to deal with as limited and as definite an area as possible (several hectares²), in which a strong concentration on the target sector is aimed at. In the preparation for the bombardment, the target area will be divided into

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¹ Fig. 28 (taken from another captured document) shows the method of bracketing and placing the mean point of impact for different directions of wind.
² A hectare = 100x100 m. = 10,000 sq. m. = 11,960 sq. yds.
sectors\(^1\) (of from 1 to, at most, 2 hectares), and each sector will be subjected to a sudden burst of gas shell, as in the case of the bombardment of small areas. The smaller the target area is, considered as a whole, the greater must be the concentration of gas thereon. The sectors therefore are to be taken proportionally small.

196. When the positions of the single targets in the target area are exactly known, the sectors are to be so chosen that the single targets lie in their centers. Sectors containing no target can be excluded during the bombardment, so that a correspondingly greater concentration may be produced on the remainder. Wind conditions are to be observed as in the case of single targets.

197. The sectors of the target area are to be dealt with in the shortest time possible, if practicable within two hours. The greater the number of batteries, therefore, which can be utilized for a medium gas bombardment, the greater will be the success attending the operation.

![Fig. 29.—Method of Dividing Areas into Sectors for Gas Shell Bombardment (A).](image)

In cases where the target area is of considerable extent, those sectors of particular importance may be subjected to more frequent bursts of fire, at intervals of one-half hour to one hour.

198. Repetition of the bombardment after pauses of varying length often proves advantageous.

Either Green Cross 2, or better Green Cross 1, combined with Blue Cross, is to be employed for the bombardment of medium areas.\(^2\)

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\(^1\) See Fig. 29, taken from another captured document.

\(^2\) Another document specifies Blue Cross and Green Cross 1 (50 per cent of each), or Green Cross 2, or Yellow Cross (75 per cent) and H. E. (25 per cent).
199. Bombardment of Large Areas.—In this case a surface of several square kilometers comprises the target area. The same type of shell and the same procedure as for the bombardment of medium areas will be adhered to. Those localities where the targets lie thickly will receive special attention.

A dense gas cloud (Gassumpf) must be produced at once on these localities. For this purpose Green Cross 1 or, if supplies are available, Green Cross 2 will be employed. An admixture of Blue Cross will rarely be used, as it is more urgently required for other purposes. 1

200. The bombardment of large areas involves, as a rule, similar targets to those dealt with in a medium area gas bombardment.

The formation of these dense clouds prevents the enemy from avoiding the action of the gas by withdrawing to places free from gas.

The bursts of fire necessary to produce these dense clouds on the target sectors should be continued for a short time after the bombardment of the main target area has been effected. Towards the completion of the bombardment, fire intended for dense cloud formation should be directed to those sectors from which the gas is driven over the main target area by the action of the prevailing air currents.

201. For the production of dense clouds of Green Cross the following expenditure of ammunition is necessary for each square kilometer:

<table>
<thead>
<tr>
<th>Ammunition</th>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun</td>
<td>6,000</td>
</tr>
<tr>
<td>Light field howitzer or 10 cm. gun</td>
<td>3,000</td>
</tr>
<tr>
<td>Heavy field howitzer or 15 cm. long howitzer</td>
<td>11,500</td>
</tr>
<tr>
<td>Mortar (21 cm. howitzer)</td>
<td>600</td>
</tr>
</tbody>
</table>

The number of batteries to be employed and the duration of the bombardment is the same as in the case of a medium area bombardment.

202. Bombardment with Blue Cross and H. E.—This is always employed in localities in which ordinary H. E. is used against live targets, providing that the safety of our own troops is not endangered thereby. Sudden bursts of fire with Blue Cross shell should be opened up at full rate during the H. E. bombardment. The number of rounds of Blue Cross must not be too small, suitable amounts being approximately half those shown for a surprise bombardment (par. 193).

203. Bombardment with Yellow Cross and H. E.—This in-

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1 Another document states that for important hectares (Fig. 30; hatched areas), Blue Cross and Green Cross 1 (50 per cent of each) or Green Cross 2 should be used.

In less important hectares (within the black line) Green Cross 1, Green Cross 2, or Yellow Cross should be used, but only when necessitated by conditions of ammunition supply.

* Toward the conclusion of the bombardment hectares to windward should be particularly heavily shelled.
volves the use of gas shell (Yellow Cross) and ordinary H. E. against the same target at the same time. From two to four Yellow Cross shell are fired to one H. E.

Owing to its persistence in sheltered positions the combination Yellow Cross with H. E. shell is best employed for the defense.

Fig. 30.—Method of Dividing Areas into Sectors for Gas Shell Bombardment (B).

Those places at which the enemy is accustomed to halt, particularly at night, will be selected as targets.

204. The procedure for small or medium gas bombardments will be employed, according to whether the target is a single one or consists of an area of several hectares, but the number of rounds used in a surprise bombardment against a single target will be larger. Suitable amounts in this latter case, to be mixed with corresponding amounts of H. E., are:

<table>
<thead>
<tr>
<th>Gun</th>
<th>Shell</th>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun.............</td>
<td>Yellow Cross...........</td>
<td>100–200</td>
</tr>
<tr>
<td>Light field howitzer</td>
<td>Yellow Cross..........</td>
<td>50–100</td>
</tr>
</tbody>
</table>

The sectors of a target area should not, preferably, exceed one hectare, so that the concentration effected will be greater.
than in the case of the gas shelling of a single target. Persist-
ence of the gas on the ground will thus be increased, but this
can be depended on only in sheltered spots.
205. As long as the enemy is not familiar with the use of
Yellow Cross shell, it may be effectively employed against the
same targets on consecutive nights, or by day in dull weather.
If, on the contrary, the enemy is acquainted with the action
of Yellow Cross, it may be taken for granted that, after a
single series of surprise bombardments with gas shell, he will
vacate those areas which have been subjected to a sufficient
concentration; for, if he occupies for any length of time
sheltered positions (dugouts, trenches, shell-holes), into which
a considerable amount of gas has penetrated, he will suffer
severely, although there be no indications of the actual pres-
ence of gas.

IV. SPECIAL PRINCIPLES IN THE ARRANGEMENT OF
GAS BOMBARDMENTS

206. On the occasion of gas bombardments over large areas
the Higher Command will place at disposal expert officers,
who will assist in the preparations for the bombardments,
reconnaissance, division of targets, and, if required, will give
every support to the chief artillery officer conducting the
operation.

207. A meteorologist, from Headquarters of Meteorological
Services, will be called in as adviser during a bombardment of
this kind. He should regularly receive, several days before
the operation, all information necessary for preparing the
weather forecast, especially Naval Observatory telegrams. He
must assist in all arrangements, maintaining direct personal
contact with the principal artillery commander.

Gas bombardments over smaller areas will be conducted by
artillery commanders with the cooperation of the local Sections
of the Meteorological and Gas Services.

208. The decision as to the commencement of the bombard-
ment, as far as weather conditions are concerned, will be made
on the weather forecast received from the Meteorological Serv-
ices a few hours before zero.

In order that unforeseen changes in the weather may be
taken into consideration, the order to open fire may, if neces-
sary, be given by a prearranged and widely visible signal
(e.g., from captive balloons). A similar mode of signal may
be arranged in case it should become necessary to interrupt
or conclude the bombardment.

The more restricted the area to be dealt with, the simpler
do these measures become.

209. Each battery employed on a medium or large area gas
bombardment should have a map or tracing (scale 1:25,000)
on which the target to be bombarded is accurately indicated.

In dividing up an area into target sectors, it must be ar-
ranged, as far as possible, so that the range axis of the targets
lies on the line of fire of the battery concerned.
210. When fairly extensive areas are to be subjected to gas shelling, the accurate lie of single shots is of no importance, as success depends on the equal distribution of gas over the area, and not on the effect of shell at the point of impact. On the other hand, in the case of medium and small area gas bombardments, accuracy of fire and rapid concentration on the target increase in importance with the decreasing size of the target.

The dispersion of gas shell is not greater than that of H. E. shell of similar pattern.

211. Registration for a gas bombardment must not be noticeable, and thus is best carried out with H. E. The actual operation must consist of a sudden burst of fire. If the conclusion of the bombardment is concealed, owing to the repetition of bombardments on single target sectors (if need be, with a decrease in the number of rounds), the enemy will experience difficulty in bringing forward fresh effectives at the right moment. He will also be obliged to wear his mask for a longer period.

212. A gas bombardment which is in progress must not be interrupted by other tasks (e.g., shelling of favorable moving targets, preliminary or destructive bombardments). Separate batteries will be detailed to deal with these.

213. The requisite concentration on the target must be produced in the shortest time possible. The ammunition necessary, therefore, should be distributed over as large a number of batteries as possible.

As a general rule for a bombardment of about two hours' duration, the following distribution of ammunition is recommended:

<table>
<thead>
<tr>
<th>Battery</th>
<th>Maximum number of rounds per battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun, '96 and '16</td>
<td>1,000</td>
</tr>
<tr>
<td>Light field howitzer, '98/09, '16 and Kp</td>
<td>700</td>
</tr>
<tr>
<td>10 cm. gun, '04 and '14</td>
<td>300</td>
</tr>
<tr>
<td>Heavy field howitzer, '02 and '13</td>
<td>250</td>
</tr>
<tr>
<td>Long 15 cm. gun</td>
<td>200</td>
</tr>
<tr>
<td>Mortar (21 cm. howitzer)</td>
<td>100</td>
</tr>
</tbody>
</table>

The amount of ammunition for older German guns and Belgian 15 cm. guns corresponds to the above.

214. Even when gas shell are issued to many batteries, it must, in general, be fired off very rapidly. This makes a heavy demand on material. Sufficient reserves must therefore be kept in readiness in the case of more extensive bombardments.

215. The use of the extra charge for the light field howitzer '98/09, of the No. 9 charge for the light field howitzer '16, and of the No. 10 charge for the light field howitzer Kp., is to be allowed only under exceptional circumstances.
216. When a bombardment with gas shell is being carried out at night, it is advisable to issue a sufficient quantity of flash reducer, in order to avoid disclosing our battery positions.

V. PRECAUTIONARY MEASURES

(A) Protection of Gun Crews

217. The German mask affords complete protection against all enemy and all German gas shell, except Green Cross 2 and Blue Cross.

To guard against the danger arising through direct hits on our shell dumps, the safety precautions set forth in Appendix 1, last column, for Green Cross 2 and Blue Cross must be adhered to.

Where rapid detonation occurs the gas is harmlessly dispersed by the explosion.

218. In the event of gas shell receiving direct hits and the contents thereof being set free, the area affected (trenches, etc.) is to be approached only by men wearing masks, even when no smell is noticeable. This is to be observed particularly in the case of Yellow Cross shell dumps. Liquid from the shell is to be well covered with earth, and, if it has been scattered about in fairly large quantities, the Divisional Gas Officer is to be informed. Care is to be taken that no Yellow Cross liquid comes into contact with the hands or other part of the body, as it attacks the skin severely.

219. If any Green or Yellow Cross shell are found to be leaking, they are to be fired off at once or buried.

Leaking Blue Cross shell will not be met with.

(B) Protection of Our Own Troops in the Front Line

220. The following instructions (pars. 221–223) apply to level, open country.

In the case of other types of ground formation, deviation from these instructions is advisable or even necessary. For this the meteorologist may be consulted.

221. During a calm, bombardment of large areas with gas shell will be sanctioned only when the targets are situated at least 2,000 m. from our own front line. The same applies to the gas shell bombardment of smaller areas, in which Green Cross 2 or Blue Cross is employed during a calm.

When Yellow Cross is fired during a calm, a distance of 1000 m. suffices in the case of the bombardment of less extensive areas, while, with Green Cross 1 under similar atmospheric conditions, still smaller distances may be permitted.

222. On all occasions, targets to be subjected to gas shelling

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1 This appendix was lacking in the captured document.

‡ A captured document, dated Sept. 29, 1917, states that after a bombardment with Blue Cross at 2,200 meters from the trenches, the gas blew back and caused casualties among the German troops.
must be so selected that, in the case of a calm, no "shorts" will ever fall nearer than 200 m. to our front line. Should it be necessary to employ gas at shorter ranges, trench mortars are to be used.

223. When there is a fairly strong wind of definite direction, the following procedure will be adopted:

(a) *With Green Cross 2 and Blue Cross*, the distance of the target from our own front line, measured in the direction of the wind (not the shortest distance between the target and our line) must never be less than 2,000 m.

When the wind is blowing directly towards our own front line, the same distance must be observed as in the case of a calm.

When the wind is blowing obliquely to our front line, nearer targets may be dealt with.

With a wind blowing in the direction of the enemy, the distance of the targets may be decreased up to the point where it is perfectly certain that no "shorts" will fall nearer than 200 m. in front of our foremost line. This decrease of distance of the target is conditional on a report from a responsible office of the Meteorological Services, so that the danger of a change of wind during a gas bombardment (in the case of smaller bombardments half an hour after, in the case of larger bombardments two hours after the conclusion of the bombardment) to a direction necessitating increased range is avoided.

(b) When a target is being bombarded with *Yellow Cross*, the wind being steady in any of the above directions, the shortest distances (2,000 m. or 1,000 m., as the case may be) are to be observed, as during a calm.

(c) *With Green Cross 1* the same applies to definite air currents as to perfectly still air.

224. Every Artillery Commander, on the commencement of a gas bombardment, must advise the Divisional Gas Officer in time for the latter to order a gas alert for any of our units who may be affected by the ultimate drift of the cloud.

With *Yellow Cross and H. E.*, particular care must be taken that all troops concerned are warned in time.

225. Anti-gas precautions will come into force on the opening of the bombardment and will be maintained until the bombardment ceases. These precautions will be ordered over a depth corresponding to the expenditure of ammunition. Concerning this the following points are to be kept in view:

(a) *Depth within Which Troops Will Wear Masks.*—The effect of Yellow Cross does not extend further than that of an equal amount of Green Cross. At the point where Green Cross becomes merely troublesome and not dangerous, the danger from Yellow Cross likewise ceases.

(b) *Time during Which the Mask Is to be Worn.*—After the dispersion of the gas cloud from Yellow Cross, those traces of gas which remain on the field of fire have no danger in store for our own troops, owing to the distance of the targets, provided our troops do not move forward. The definite
establishment of the necessary limits to be observed in each individual case is the duty of the Gas Services.

(c) Entry into the Bombarded Area.—If our own troops have to enter the area bombarded, either for the purpose of attack or for patrol work, the standard safety precautions laid down in “General Instructions” may be departed from only in the case of small areas subjected to gas shelling.

When larger areas are bombarded with gas shell, the period of the persistence of the gas on the area will be reckoned from the disappearance of the more or less visible cloud, and not from the time of the conclusion of the bombardment. The dispersion of the cloud will be slower in the case of the larger areas bombarded with gas shell.

Local conditions (topography, vegetation) exercise considerable influence. After the bombardment of extensive areas, therefore, the meteorologist is to be consulted as to whether these areas may be entered without danger.

No further addition need be made to the rules laid down in “General Instructions” regarding Green Cross.

226. In the employment of Blue Cross and Yellow Cross, the following points are emphasized:

(a) With Blue Cross the action of the gas is entirely limited to the cloud. There is no after-effect when the cloud has once dispersed.

(b) With Yellow Cross a dangerous concentration obtains, in the first place, in the cloud.

Furthermore, the gas still persists in dangerous concentrations for a considerable time in sheltered places (dugouts, deep trenches, shell holes) where the air remains unchanged for a long period.

Hence open ground which has been bombarded becomes passable much sooner after the dispersion of the cloud than sheltered places in the same area.

227. In order to increase the visibility of the cloud, where the bombardment of larger areas is concerned, towards the conclusion of the bombardment groups of smoke shell may be fired on to those portions of the target area where it is important to know when the cloud has dispersed. The gas disperses with the smoke. Only the after-effect then remains on the ground.

228. The following extract from a captured Divisional Field Artillery order gives an actual program for a bombardment and illustrates the enemy’s practice in employing Yellow, Green and Blue Cross shell:

Field Artillery Order No. 46, 22-7-17; Evening

ASSIGNMENT FOR ARTILLERY OF 233D DIVISION

229. No. 1. b. If weather favorable.
Annihilating fire included:
Against the Wieltje Sector (H. E.) from 3:15-3:18 P. M.

1 Cf. par. 304

102
Gas (shell) cloud from 3:15–3:25 P. M.
Against Hummel Sector (H. E.) from 3:40–3:43 P. M.
Gas (shell) cloud from 3:43–3:50 P. M.
Gas (shell) cloud, accompanied by annihilating fire (H. E.)
on the whole Divisional front from 7–7:10 P. M.

If weather unfavorable, only H. E. will be used.
Hostile artillery fire will be kept down by gas after the
above bombardments.

230. *Additions by the Field Artillery Commander.*—Field
gun batteries (except Nos. 2 and 6 of 81 Regt.) will each
fire 30 shell as H. E. surprise fire. In the three gas “surprise
bombardments” the total gas ammunition will be employed
according to the time distribution laid down: Yellow with
H. E. 3:1. Nos. 4 and 5 batteries of 81 Regt. will each fire
100 Green in addition.

231. *Light Field Howitzer Batteries.*—During each H. E.
surprise bombardment, six rounds per gun. During the three
surprise bombardments with gas, batteries will fire with great-
est rapidity Green and Blue mixed 1:1, care being exercised
with regard to material.

If weather is unfavorable, there will be a general “surprise
bombardment” with H. E.

232. It will be noticed that the enemy in one instance starts
with H. E. to cause confusion and distract attention, and that
he uses Yellow Cross and H. E. together in the ratio of 3 to 1,
the object being to prevent detection of the Yellow Cross shell.
This plan was reasonably successful until experience had been
gained, and proper instructions given to all ranks.

233. Blue Cross shell are ordered to be fired with an equal
number of Green Cross, the object apparently being to cause
such violent sneezing that men cannot adjust their respirators.
Although sneezing has often occurred, no cases have been re-
ported in which it has prevented the adjustment of the respirator
and led to casualties.

**Precautions in Storing and Handling Gas Shell**

234. Directions for storing and handling gas shell are given
in a recently captured document, dated September 17, 1917,
issued from the Headquarters of the German 4th Army. A
translation of this document follows:

**STORAGE AND HANDLING OF GAS SHELL, AND
PRECAUTIONS TO BE TAKEN**

235. The following instructions will supersede all previous
instructions regarding the storage and handling of gas shell,
and the precautions to be taken by batteries, columns, etc.:
I. General

236. The German mask affords protection against the effects of all kinds of German gas shell, with the exception of Green Cross 2 and Blue Cross.

II. Storage

237. In the battery positions every kind of gas shell should be stored in small dumps, arranged checkerboard fashion and, if possible, upright. The number of rounds in each dump should not exceed the following:

<table>
<thead>
<tr>
<th>Rounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field gun batteries</td>
</tr>
<tr>
<td>Light field howitzer and 10 cm. gun batteries</td>
</tr>
<tr>
<td>(15 cm.) Heavy field howitzer and long 15 cm. gun batteries</td>
</tr>
<tr>
<td>(21 cm.) Mortar batteries</td>
</tr>
</tbody>
</table>

The dumps will be located to leeward of the battery positions (i.e., as a rule, to the east of the batteries on the 4th Army front).

The dumps will, whenever possible, be placed on boards laid across trenches or shell holes, so that, in case of a direct hit, the shell fall into the trench, etc., and can be easily buried. By the side of each dump a heap of loose earth and a spade will be kept ready for covering any liquid that may escape.

III. General Measures of Precaution Applicable to All Types of Gas Shell

238. If a direct hit occurs on a dump of gas shell, masks will be put on immediately in all circumstances and without waiting for orders, and if possible a move will be made to windward. All the personnel of a battery will be kept constantly informed of the direction of the wind (wind-vanes, flags, etc.).

IV. Special Precautions for Green Cross 2, Blue Cross and Yellow Cross Gas Shell

Green Cross 2

239. The shell, which are closed by a screw plug on which is painted a blue cross, will be stored apart from the fuses and exploders. (Shell will be fused just before firing.)

Blue Cross

240. It is forbidden to store Blue Cross with other types of gas shell. Batteries ordered to fire Blue Cross simultaneously with other gas shell will store the Blue Cross shell separately on one flank, from which they will also be fired.

The shell will be taken out of their baskets before they are stored.

Articles of an inflammable or combustible nature (baskets,
boxes, sand-bags, cleaning rags, etc.) will be cleared out of the way.

Yellow Cross

241. Yellow Cross ammunition demands special precautions. For this reason it is essential that both the Nos. 1 and the gunners should be acquainted with their characteristics and the consequent necessary precautions.

242. Details of Yellow Cross.—Yellow Cross liquid is tasteless, practically odorless and in dry weather scarcely visible. The gas has no immediate irritant action on the human body, and consequently is seldom immediately noticeable.

Yellow Cross, either gas or liquid, hangs about for some time, especially in sheltered spots such as dugouts, trenches, craters, ruined buildings, woods, undergrowth and more particularly in clothing.

In either gaseous or liquid form, Yellow Cross blisters the skin, even though to all appearances it is protected by cloth or leather (gloves, clothes, shoes, etc.).

243. Action of Chloride of Lime (Bleaching Powder) on the Yellow Cross Liquid.—Chloride of lime, more especially when dry, neutralizes the Yellow Cross liquid. It must, therefore, always be kept in boxes with well-fitting lids, as when exposed to the air it rapidly absorbs moisture.

The action of chloride of lime is limited. Soil that has been saturated can still be neutralized one to two days later, but as regards the prevention of blisters caused by splashes of Yellow Cross liquid on the bare skin, it must be applied immediately, for after a delay of even a few minutes it will prove ineffectual.

244. Chloride of lime has no action on the fumes or gas of Yellow Cross. The action of chloride of lime on Yellow Cross liquid has resulted in the following measures of precaution:

(a) The general instructions for the use of the gas mask must be strictly adhered to, even when no smell of the gas is perceptible and no fumes of gas are visible.

(b) Boxes of chloride of lime will be kept by all batteries to which Yellow Cross shell are allotted, and also at all large dumps of these shell. Every ammunition column carrying Yellow Cross shell will also carry a box of chloride of lime.

(c) Spots where Yellow Cross liquid has escaped will be strewn with a thin layer of chloride of lime and covered with earth. In an emergency, loose earth by itself is also of assistance. Cases of contamination, due to leakage on a large scale, will be reported to the Divisional Gas Officer. Rooms contaminated by Yellow Cross gas can be cleared only by artificial ventilation (creation of a draught, fires, etc.).

The division may order battery positions saturated with gas to be evacuated until clear of gas.

(d) Any surface contaminated by Yellow Cross liquid must not be touched with the bare skin. It is dangerous to walk on it even with boots on. Do not lie, sit or kneel on it.

105
(e) Where the skin has been in contact with Yellow Cross liquid, it must be dusted over at once with powdered chloride of lime.

(f) Contaminated clothing will be discarded immediately and should not be touched even with gloves on. It will be aired out of doors, preferably in the sun. A closed room will be contaminated by evaporation from impregnated clothing.

(g) Undamaged shell of a dump struck by a direct hit will not be set apart for future use, but will be buried with the fragments of the damaged shell.

The use of chloride of lime for the protection of our own troops against Yellow Cross liquid must not become known to the enemy. Observation of the strictest secrecy is a matter of duty just as much now as it was previously.

The troops will be thoroughly instructed in these precautionary measures, but nothing will be taught them as regards the nature or composition of the antidote employed.

245. Experience shows that casualties arising from direct hits on dumps of gas shell can usually be traced to the ignorance of the troops of the necessary measures of precaution. Commanders of all ranks are responsible that the troops under their commands are made acquainted with the precautionary measures laid down in "Provisional Instructions for the Employment of Gas Shell," and that these instructions are strictly followed.

ADDENDA BY INFANTRY DIVISION

246. The preventive against Yellow Cross liquid will never be mentioned, either verbally or in writing, other than as "Streupulver." The boxes in which it is issued are not marked. They will be kept in a safe and inconspicuous place, away from the immediate vicinity of dumps of gas shell.

The 16th Divisional Train Echelon has already received some "Streupulver." At the Divisional Gas Stores, 5 iron barrels and one wooden barrel full of "Streupulver" lie at the disposal of all the artillery. The Artillery Commander will arrange with the Train Echelon Commander for its distribution to batteries, ammunition columns and depots.

"Streupulver" will be withdrawn from places where no longer needed and, if not required for use at other points, will be returned to the Divisional Gas Stores.

For protecting the feet from Yellow Cross liquids, it will perhaps be advisable to wear wooden shoes over the boots. All cases of the use of "Streupulver" and of casualties arising from Yellow Cross liquid will be reported immediately to the division.

Present Methods of Using Trench Mortar (Minenwerfer) Gas Shell

247. From their comparatively limited range trench mortar gas shell are, of course, principally employed against infantry in
the front system of trenches. Experience has shown that they are
used both for destructive fire over considerable areas, frequently
in combination with artillery gas shell bombardments of more
distant areas, and for harassing fire. For the latter purpose
the light "Minenwerfer" is generally employed, a few rounds
being directed at varying intervals against particular points likely
to offer favorable living targets. Surprise bombardments of this
kind are increasing in frequency and extent.

248. On one occasion the enemy appears to have attempted to
imitate the British projector attacks by firing five salvos of gas
bombs from about ten medium "Minenwerfer."

More recently (see pars. 282-287) the Germans have made simi-
lar discharges of gas, using the 17.5 cm. "canister" bomb, usually
fired from the 18 cm. smooth trench mortar. The bombs are
fired in groups at intervals of a few seconds and several hundred
are thus fired almost simultaneously.

The following data regarding the use of Gas "Minenwerfer" shell
are taken from the revised edition (July 1, 1917), of the
German official text-book "Die Minenwerfer."

LARGE GAS BOMBARDMENTS (AREA BOMBARDMENTS)

249. Ammunition expenditure per hectare: 331 lbs. gas-
producing liquid = 200 light or 15 medium gas shells.
Total expenditure: At least 2,205 lbs., i.e., sufficient for
an area of 6.7 hectares.
Method of fire: A heavy concentration of fire will be di-
rected against the area, and the series will be repeated at
intervals. The duration of the bombardments will be 1 to 2
hours.

MEDIUM GAS BOMBARDMENTS (AGAINST SMALL TARGETS)

250. Ammunition expenditure for a target 20 x 50 m. = 1,000
sq. m.: 661 lbs. liquid = 30 medium gas shell. The concentra-
tion of gas is 20 times that required for large gas bombard-
ments.
Total expenditure: 220 to 2,205 lbs. of liquid.
Method of fire: Bursts of concentrated fire, masked possibly
by H. E. fire from the artillery or from "Minenwerfer."

SMALL GAS BOMBARDMENTS (HARASSING FIRE)

251. Irregular bursts of harassing fire from 2 to 4 light
"Minenwerfer," or a few rounds fired at irregular intervals
from a medium "Minenwerfer."
Note: In the new edition of "Die Minenwerfer," the
medium and light patterns only are referred to in connection
with gas bombardments. No mention is made of heavy gas
"Mines," so that apparently these are no longer manufactured.
Details of Some Recent German Gas Shell Bombardments

252. Details of some recent German gas shell bombardments appear in the following summaries:

A LACHRYMATORY GAS SHELL BOMBARDMENT IN THE VICINITY OF PONT À MOUSSON, FEBRUARY 19–20, 1917

253. Lieutenant X. of the 8th Army reported that on the night of February 19–20 (1917) the enemy dropped about 600 gas shell upon a battery of 155 mm. guns situated near Montauville in the vicinity of Pont à Mousson.

From 6 to 7 P. M. about 300 shell were fired in salvos of 10 about every 2 minutes. From 7 to 11 P. M. 300 more projectiles were sent over.

This bombardment was executed in a light fog. The temperature was about zero degrees C. and the wind was light. The battery was situated half way up a hill in a forest.

254. According to witnesses, the cloud which formed was opaque, and one could not see farther than a meter. The Commanding Officer of the battery was not able to read the fire tables and aiming by the glass was impossible. The cloud was slow to disperse.

255. Only two men were gassed, but at the end of the bombardment numerous animals, such as rats and mice, were found dead in the zone of fire. (One donkey and one horse died.)

256. The bombardment was executed with 15 cm. shell of the type already described, furnished with fuses Gr. Z. 14 n/A.

Two intact shell were found. The first was painted gray, with two circular bands of blue about 1 cm. wide, situated about 20 and 22 cm., respectively, from the base. Finally, upon the body of the shell, the letter M was painted in black.

The second shell was likewise painted gray, with 2 blue bands, but had no other distinctive markings.

257. Conclusions.—This bombardment was effected, it appears, almost exclusively with 15 cm. shell charged with brominated methylethyl ketone.

One of these shell carried as distinctive markings, besides the customary blue bands, a green square painted upon the head (ogive) and the letter M upon the body of the projectile.

From information at hand, it appears that, when the density of fire is sufficient and conditions are favorable, these shell
make an opaque cloud, although no smoke generator was added to the liquid. In addition, the toxic action of these shell appears to be marked (witness the effects upon rats, mice, etc.).

A GAS SHELL BOMBARDMENT OF ARRAS, DECEMBER 27-28, 1916

258. It is estimated that between 2,000 and 3,000 gas shell were fired between 9:30 P. M. and 3 A. M. The fragments picked up were all 4.2" howitzer shell. The shell contained asphyxiating gas, and were probably Green Cross shell.

There was a slight breeze blowing during the bombardment, at times dropping to a dead calm. The night was misty and cold.

259. Box respirators were worn for periods varying from three to five hours and gave a complete protection. They were found to be very comfortable and some men slept in them. The only complaint was that the fogging of the eyepieces made movement in semi-darkness difficult.

Gas blankets at the entrances to dugouts gave good protection and enabled signallers to work without wearing box respirators.

260. In the open the gas soon cleared and little could be detected after the bombardment had ceased. In billets the gas persisted for a much longer time, particularly where shell had burst in a room. As the night was cold some of the liquid from the shell probably soaked into the floors and evaporated on the following morning when the air grew warmer.

261. The gas was not found to be very unpleasant in small quantities, and one of the dangers of this type of gas shell is that it may not arouse immediate suspicion. Some observers did not notice the gas immediately on encountering it, although those who had been breathing it for some time thought it strong.

262. Casualties.—A few deaths and severe casualties were caused by shell bursting in a room or within a few yards of unprotected men in the open. Most of these cases occurred at the start of the bombardment.

A number of light cases were due mainly to four causes:

(a) 34 per cent of total casualties.—Men who were asleep when the bombardment began were slightly gassed before they were roused.

(b) 18 per cent of total casualties.—Men returned to their billets after the bombardment ended, or during the following
day, and entered rooms without wearing box respirators, although the rooms still contained gas. A few men slept in blankets smelling of gas.

(c) *12 per cent of total casualties.*—Men thought the shell contained "tear gas" and neglected to put on their respirators immediately.

(d) *12 per cent of total casualties.*—Men removed the facepieces of the respirators when moving from billets to cellars, as they found difficulty in seeing in the semi-darkness.

It was generally agreed that the casualties would have been more numerous and serious if the same number of H. E. shells had been fired with the same accuracy.

**263. Lessons.**—The lessons to be drawn from the bombardment are:

(a) Casualties may be caused by men breathing small quantities of shell gas. Therefore, strict discipline with regard to protective measures against gas shell must be maintained to prevent unnecessary losses.

(b) All men in the shelled area must be roused at once so that they can adjust their box respirators.

(c) In spite of the order that box respirators should be put on as soon as gas shell of any kind are detected, the idea is still prevalent that only goggles are needed against "tear shell." The enemy frequently uses a mixture of "tear" and asphyxiating shell in which the latter may not be detected.

(d) Facepieces of box respirators must not be removed so long as any shell gas is present.

(e) In and near buildings shell gases may persist for a number of hours and rooms must be entered with caution. Box respirators must be worn if any trace of gas is detected.

(f) The entrances to cellars and dugouts within the gas shell area should be provided with doors or gas blankets.

**A GAS SHELL BOMBARDMENT OF YPRES, JULY 12-13, 1917**

**264. Weather Conditions.**—Slight wind, E. to S. E., 1 to 2 miles per hour.

The day preceding the bombardment was very warm. The ground was dry, no rain having fallen for several days. The temperature during the night was 50° to 55° F.

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1 Goggles are now withdrawn from use in the British Army.
265. **Area Affected.**—The area affected included practically the whole town of Ypres and the immediate neighborhood.

266. **Nature and Duration of Bombardment.**—Concentrated bursts of gas shell were fired on different points in turn, beginning about 8 P. M. on the 12th and ceasing between 4 A. M. and 5 A. M. on the 13th. A considerable amount of shrapnel and H. E. was fired during the same period.

267. **Caliber and Marking of Shell Used.**—Fragments of shell of both 7.7 cm. and 10.5 cm. caliber, smelling of gas, were found in many places. All the blind shell collected were of 7.7 cm. caliber, long pattern field gun shell. They were painted blue, with a yellow head, and were marked with a green cross on the base and a yellow cross near the shoulder.

The fuse was the new E. K. Z. 17 which has a very quick action and thus prevents much of the liquid from being lost in the ground.

There was no explosive beyond the charge in the gaine of the fuse, and the shell burst with only a slight explosion.

268. **Nature of the Gas.**—The main content of the shell was a liquid boiling at 223° C., and consisting of dichlorodiethyl sulphide. This liquid has not previously been found in enemy projectiles.

The gas liberated on the burst of the shell has a smell resembling garlic or mustard. Owing to its high boiling point, some of it is scattered on the ground and continues to give off gas for some time. It could be smelled in Ypres on the day following the bombardment.

269. **Effects produced.**—In all cases the initial symptoms appear to have been much the same. First, there was a tendency to sneeze, without any lachrymation or irritation of the eyes, but with gradually increasing nose and throat irritation. Later on, in some instances as much as twelve hours after exposure to the gas, there was intense and very painful irritation and inflammation of the eyes, accompanied by free discharge of mucus from the nostrils and occasional fits of vomiting. Many men also complained of pains in the forehead and stomach. The skin between the thighs occasionally became red and sore, and sometimes blistered. Contact with the earth near shell holes or with gas shell fragments is liable to cause painful blistering of the skin, even through clothing.

The pain in the eyes diminishes after about twenty-four hours,
though the eyes may remain acutely inflamed in severe cases for a number of days.

Severe cases are liable to develop bronchitis and inflammation of the lungs after the expiration of 36 to 48 hours.

There is no evidence that the gas causes dulling of the sensory nerves, and thus renders its detection impossible.

270. Total Casualties.—Of the total number of casualties, 45 per cent were slight, and will return to duty within 14 days or less, 12 per cent were serious, and 2 per cent were deaths, but the latter may have been due to other gases.

271. Causes of Casualties.—The majority of the casualties were due to three causes:

(a) Owing to the smell of the gas not being very noticeable and being new to the troops, and to the slight immediate effects produced by the gas, box respirators were not adjusted.

(b) Men who had adjusted their respirators during the bombardment removed them after a time, under the impression that the concentration of gas remaining was not harmful. A number of men went to sleep after taking off their box respirators and woke up to find their eyes seriously affected.

(c) The facepiece of the box respirator was allowed to hang down, while the mouthpiece and the noseclip were left adjusted. The eyes were thus exposed to the gas.

Additional causes were:

(d) Men asleep in billets or dugouts were not warned that a gas shell bombardment was in progress.

(e) Working parties returning to cellars in which gas had collected were not warned that a gas shell bombardment had taken place.

(f) Men left their box respirators in gun emplacements and were separated from them by a gas shell barrage.

(g) Men did not wear box respirators while engaged in work near the shell holes smelling of gas.

272. Efficiency of the Box Respirator.—Box respirators were found to give complete protection against the new gas. This conclusion has been verified by experiments with the contents of a blind shell.

273. Protected Dugouts.—Gas blankets gave most valuable protection. Where they were let down immediately when the bombardment began, no gas got into the dugouts, save under exceptional circumstances, e.g., a shell bursting in the chimney of
a dugout, or the blast of a shell blowing down the blanket. In one
battery there were no ill-effects among the men in two pro-
tected dugouts, while a large proportion of the men not so
sheltered became casualties.

274. Lessons Learned.—(a) The precautions laid down against
gas shell must be strictly observed. If all the instructions had
been followed on the night in question, large numbers of casual-
ties might have been avoided.

(b) The slight smell of the new gas and the possibility of
the employment of other gases by the enemy make it necessary
that precautions against gas shell should be taken when any
shell are observed to give only a slight detonation, even if no
gas can be smelled or recognized.

(c) Box respirators must be adjusted properly during gas
shell bombardments, and the facepieces must not be allowed to
hang down, leaving the eyes exposed.

(d) After a gas shell bombardment, respirators must not be re-
moved without the order of an officer. If this is left to the
judgment of individual men, casualties are bound to occur.

(e) All ranks must be thoroughly trained in wearing the
respirator for long periods. They must be practiced in moving
in the dark, in speaking, and in using the telephone while wear-
ing the respirator.

GAS SHELL BOMBARDMENT ON THE BRITISH FRONT, JULY 28–29, 1917.

275. Time and Place.—The bombardment began at 12 mid-
night, and continued until 3:30 A. M. The area affected included
three or four streets in the vicinity of Rue de Lille, Armentiers.

276. Weather Conditions.—The weather was fair, with a light
northeast wind.

277. Conduct of Bombardment.—The bombardment started
with a rapid burst of gas shell, accompanied by H. E. and
incendiary shell. It is stated that gas shell were fired in four
periods of 15 minutes each. The gas shell are stated to have
come at the rate of 120 per minute, so many thousands must
have fallen in the town.

278. Nature of Shell.—From fragments collected, it is evident
that the shell were chiefly Yellow Cross of 7.7 cm. and 10.5 cm.
calibers, the same as had previously been used in this sector.
7.7 cm. "Diphosgene" shell were also used.

279. Casualties.—Most of these were eye cases. A few were

113
lung cases. There were comparatively few cases of blisters. Of the total casualties, comparatively few were serious.

280. Causes of Casualties.—The casualties seem to have been due to three main causes:

(a) The suddenness of the bombardment, which opened with a rapid fire of gas shell.

(b) A relief was in progress at the time.

(c) After the bombardment was over men entered cellars without wearing box respirators. After the gas shell bombardment the enemy kept up a bombardment with H. E. and shrapnel, probably with the object of making men seek cover in cellars which were full of gas. This bombardment with H. E. and shrapnel lasted most of the day.

A heavy battery is reported to have been in the act of moving guns when the gas shell bombardment started.

281. General Conclusions.—Tests for prolonged periods in strong concentrations of gas have been carried out with the box respirators which have been taken from the worst cases in hospitals, and in every instance they have given absolute protection. From these tests and from careful interrogation of casualties the following conclusions have been reached:

(a) The box respirator has been proved absolutely proof against the gas in strong concentrations for a prolonged period.

(b) Casualties have been carefully questioned, and invariably state that they had been surprised and had got a dose of the gas prior to adjusting their box respirators.

(c) Other units exposed to these rapid bursts of shell fire instantly adjusted their box respirators and came through without a casualty.

(d) The enemy sends over rapid and heavy bursts of these shell, but whenever they have been met, if the eyes were closed and the box respirator was immediately adjusted, absolute protection has been obtained.

(e) Great care should also be taken that masks are not removed until it is certain that the gas has been cleared away.

It must be emphasized that cellars must be cleared of gas by means of fires before being entered without box respirators.

AN ENEMY GAS BOMBARDMENT RESEMBLING A PROJECTOR ATTACK,
DECEMBER 10-11, 1917.

282. The enemy employed gas projectiles in a way similar to
a projector discharge for the first time on the night of December 10-11 on the 1st Army front.

Two discharges took place at 1 A. M.—one in the Cambrai Sector and the other south of Givenchy.

283. Weather.—The wind was N. E., 3 to 5 miles per hour. There was a slight frost.

284. Nature of Bombardment.—In both cases a large number of gas bombs, estimated at several hundred, were fired almost simultaneously into a small area, including our front and support lines.

The bombs appear to have been fired from the German support line, as observers state that they saw a sheet of flame run along this line, accompanied by a loud explosion. In the Cambrai Sector the bombs were fired in several bursts at intervals of a few seconds. The bombs were seen in the air in large numbers, and made a loud, whirring noise. The time of flight was considerable. One report described them as remaining in the air as long as a "Very" light. They burst with a loud detonation, producing a thick white cloud of gas.

The discharge of gas was followed immediately by a bombardment with H. E., shrapnel and gas shell, and a raid was attempted south of Givenchy.

285. Nature of Projectile.—A "blind" and numerous fragments show that the projectile employed was the 17.5 cm. bomb without driving bands, usually fired from the 18 cm. "Glatte Wurf-Mine" ("rum-jar" or "canister" gun). (See par. 155 and Fig. 26.) The bomb had been converted for filling with gas, and was used with the Z. s. u. m. W. M. time and percussion fuse.

The "blind" contained 16½ pounds of pure phosgene,¹ and there is no evidence of any other gas having been used except in artillery shell.

There is some doubt as to the range at which the bombs were fired. If the guns were in the German support line, the mean range would have been from 800 to 1,000 yards.

286. Effects Produced.—The alarm was given by the flash and the explosion, which was sufficiently loud to rouse men asleep at Battalion Headquarters. In many cases respirators were adjusted before the arrival of the bombs, owing to the resemblance of the discharge to one of our projector attacks. Where this was done practically no casualties occurred. At one point

¹ Similar attacks have since been made in which a mixture of phosgene and chloropicrin was used.
five bombs burst in a trench without harming the occupants.
Casualties were caused by delay in adjusting the respirator
and by gas entering the shelters which were not properly pro-
tected. In some cases the symptoms were aggravated by subse-
quent exertions.
Up to a distance of 1,500 yards from the point where the
bombs burst, respirators were worn for periods varying from
20 to 45 minutes in the area traversed by the gas cloud.
287. Lessons Learned.—(a) All ranks must be warned to ex-
pect discharges of this kind, and must be informed of the signs
by which the discharge can be recognized.
(b) If the alarm is given immediately when the flash is seen
or the explosion heard and respirators are promptly adjusted,
casualties should be avoided entirely.
(c) As the gas cloud produced by the simultaneous discharge
of a number of gas bombs may be effective at a considerable
distance from where they burst, the above measures of protec-
tion must be adopted wherever the flash or explosion are
detected.
(d) The value of gas-proof shelters and the importance of the
quick adjustment of gas blankets by sentries were again
demonstrated.

GAS HAND GRENADES.

288. Gas hand grenades are not extensively used by the Ger-
mans, and when employed are chiefly incidental to trench war-
fare. They are used during raids for throwing into dugouts
in order to render the latter untenable.

GLASS GRENADES.

The use of glass grenades is apparently being discontinued.
289. Bromine (Use Discontinued).—Bromine glass grenades
consisted of thin glass bulbs filled with about 450 grams of
commercial bromine, sealed and enclosed in a net.
290. Chlorosulphonic Acid.—These grenades consist of spher-
irical glass bulbs 8.5 cm. in diameter (Fig. 31), holding about 250
cc. of a mixture of chlorosulphonic acid and sulphur trioxide.
This corrosive liquid causes severe burns and produces heavy
suffocating fumes. The grenades are transported in cylindrical
iron boxes packed with "Kieselguhr."
291. Bromoacetone (Use Discontinued).—Bromoacetone gre-
Fig. 31.—Glass Hand Grenade Used for Gas.
nades were similar to those used for chlorosulphonic acid. They contained commercial bromoacetone, and were known as "Hand-A-Stink-Kugel."

**METAL GRENADES.**

292. These are all of the same type (Figs. 32 and 33). They consist of spheres of sheet iron 10 cm. in diameter, made in two parts and crimped together. There is an opening in each half. The lower opening is for filling, and is closed by an iron screw stopper with a lead washer. The other opening is fitted with a closed tube 6.5 cm. long and containing 3 to 4 grams of black powder. Into this tube screws a 5-second fuse fitted with a friction lighter actuated by pulling out a wire before throwing. The carrying device is shown in Fig. 33.

![Diagram of Metal Gas Grenade](image)

**Fig. 32.—Section of Metal Gas Grenade.**

293. "B-Stoff."—These are lachrymatory grenades, and were originally filled with commercial bromoacetone, in some cases mixed with chloroacetone. These grenades weighed about 1 kilogram and contained 640 grams of liquid.
The present B-grenades are filled with brominated methylethyl ketone only. This is more potent than bromoacetone. When the change from bromoacetone was first made the liquid was almost entirely the monobrom derivative. It is now generally 30 per cent mono- and 70 per cent dibrom.

294. “C-Stoff.”—A large number of these grenades were captured in May, 1917. They are of the usual type, painted field gray, with Gas C painted in red. They are filled with liquid and contain some small shot. Details follow:

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight complete</td>
<td>798 gm.</td>
</tr>
<tr>
<td>Weight of liquid</td>
<td>543 gm.</td>
</tr>
<tr>
<td>Weight of shot</td>
<td>35 gm.</td>
</tr>
<tr>
<td>Weight of black powder charge</td>
<td>4 gm.</td>
</tr>
</tbody>
</table>

The liquid consists of methylchlorosulphonate, containing a small quantity of dimethyl sulphate, the latter probably a by-product in the manufacture of the former. The following instructions were inclosed in each case of (20) bombs:

METHOD OF USE OF THE HAND GAS BOMB “C.”

295.—Quick Action.—(a) The hand gas bomb “C” is destined to damage the foe. It can be thrown with the hand, but preferably with the thrower. It can also be used with the infantry rifle by means of the grenade holder. To obtain good results, it is necessary to have a large quantity of hand gas bombs, and to have them well distributed over the enemy position.

(b) The escaping fumes attack the eyes, and are dangerous to the lungs if inhaled during any considerable period of time. The lungs of the foe will be so strongly affected that he will no longer be able to offer any resistance.

Enemy positions are, therefore, to be attacked during a certain period with hand gas bombs.

Their use is especially destined to drive the enemy out of trenches and saps. The gas will remain up to 30 minutes, depending on the strength of the wind.

(c) The direction of the wind, therefore, must be ascertained. With a contrary wind, the gas can have a dangerous effect on our own troops, especially when it is thrown by hand.

(d) Fusing and handling is the same as with the bomb grenade.

The zinc screw nut for the fuse case should be unscrewed with the bayonet. No powder should fall out of the hand gas bomb during the unscrewing. The threads of the screw should be kept free from powder. The screw which is placed opposite must remain firmly shut.

296. Safekeeping of the Drums (Cases).—“C” gas is dan-
gerous. The drums are, therefore, to be kept in a special place. This place should not be used too long. The contents of the drums should be kept in the open on account of the strong vapors which rise from them.

Bombs which are damaged should be taken out and buried and the materials in which they are packed should be burned.

The cases should be kept clean with water.

**INCENDIARY SHELL**

297. For incendiary purposes, the incendiary shell proper (see below) are used. Various shrapnel shell also produce incendiary effects. The latter are moderately effective when fired as percussion shrapnel, the flame from the fuse or the flash from the burst producing the incendiary effect, but they are uncertain in their action and cannot be relied on.

298. 15 cm. Howitzer Incendiary Shell.—This shell (Brand

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Fig. 33.—Metal Gas Grenade with Carrier.
Fig. 34.—15 cm. Howitzer Incendiary Shell.
Granate) is shown in Fig. 34. It is made of cast iron, and produces good incendiary effect.

The fuse employed is the Gr. Z. 82, percussion only.

At the top of the cylindrical portion is a thin metal disc, which is kept in place by the head of the shell being screwed down. Through the center of this disc runs a brass tube 32.5 mm. in diameter, containing black powder, and reaching nearly to the base of the shell.

Around this tube 12 incendiary cylinders are packed in two layers, and kept in place by being imbedded in paraffin wax. These cylinders, which are 95 mm. long and 30 mm. in diameter, consist of a thin outer shell of celluloid, inside which is a solid cylinder of a highly inflammable celluloid-camphor composition. Around each cylinder are wound eight turns of cotton yarn, the space between the cylinders being filled with yellow phosphorus to a height of 40 mm. from the bottom, and thence to the top with paraffin wax.

A space range table is necessary.

A similar filling is sometimes used in the 1914 A pattern 15 cm. H. E. shell, which is 42.5 cm. long and has walls 3.8 cm. thick.

299. 13 cm. Gun Incendiary Shell.—This shell is the 64.8 cm. long H. E. shell of this caliber, filled with incendiary material (thermite and sodium) described fully in paragraph 300.

A variation of the shell, 56.5 cm. in length, has also been used with the same filling (at Ypres).

300. 17 cm. Medium “Minenwerfer” Incendiary Shell.—This shell is shown in section in Fig. 35. B is a wooden cylinder in the gaine of the fuse, and is pierced by a channel leading to the tin receptacle C, which contains the powder charge. The incendiary materials consist of metallic sodium, contained in a tin receptacle which is hermetically sealed, and is kept in place by paraffin wax. The remainder of the shell, including the channel down the center of the sodium receptacle, is filled with thermite, which melts the sodium and ignites it. An analysis of the thermite showed it to be:

<table>
<thead>
<tr>
<th>Component</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic oxide of iron</td>
<td>23.9</td>
</tr>
<tr>
<td>Aluminium</td>
<td>11.2</td>
</tr>
<tr>
<td>Manganese dioxide</td>
<td>34.4</td>
</tr>
<tr>
<td>Lead sulphide</td>
<td>21.0</td>
</tr>
<tr>
<td>Sulphur, silicon, etc.,</td>
<td>9.8</td>
</tr>
</tbody>
</table>

This shell is used with the Z. s. u. m. W. M. fuse.
Fig. 35.—17 cm. Medium "Minenwerfer" Incendiary Shell.
SMOKE PRODUCTION.

301. The Germans do not make extended use of shell for smoke production, i.e., for putting down distant smoke barrages, but, on the other hand, they make considerable use of smoke-producers for employment within their own lines.

SMOKE SHELL.

302. The smoke shell employed are apparently intended chiefly, though not entirely, for ranging purposes and for facilitating observations of the dispersal of the cloud of gas produced from gas shell.

303. Auxiliary "Smoke-Producers."—Numerous shell have been found which contained, in addition to the H. E. bursting charge, a cardboard cylinder containing a mixture of red phosphorus, arsenious oxide and wax. The weights of material used vary as follows:

<table>
<thead>
<tr>
<th>Shell</th>
<th>Weight of case, &quot;smoke mixture&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7 cm. 1915 H.E.</td>
<td>42 gm. 37 gm.</td>
</tr>
<tr>
<td>7.7 cm. Long shell</td>
<td>74.5 gm. 66 gm.</td>
</tr>
<tr>
<td>10.5 cm. L.F.H. 1914 pattern H.E.</td>
<td>42 gm. 36 gm.</td>
</tr>
<tr>
<td>10.5 cm. L.F.H. 1915 pattern H.E.</td>
<td>145 gm. 134 gm.</td>
</tr>
</tbody>
</table>

304. 15 cm. Smoke Shell.—A section of this shell is shown in Fig. 36. The shell is painted gray, and is marked as follows:

N 16 (= Nebel, Dezember, 1916).
XII.

The upper half of the shell is filled with T. N. T., and the lower half is occupied by a lead container filled with sulphur trioxide. The use of the shell is indicated by the following extracts from a captured document, dated February 18, 1917:

The effect of the Green Cross gas shell now used is obtained by drifts, which outlast the upward dispersion of the visible drifts by about two hours in winter and 1 hour in summer. The area under fire may, therefore, be approached in from one to two hours after the apparent dispersion of the drifts.

Smoke shell increase the visibility of gas drifts. They may, therefore, be employed at the conclusion of a bombardment in cases where it is important to ascertain whether or not an area is free from gas.

124
Fig. 36.—15 cm. Smoke Shell.
Indications have been obtained that this shell sometimes contains a mixture of sulphur trioxide and gelatinous silica, instead of sulphur trioxide alone.

**SMOKE GENERATORS.**

305. These generators are made in three sizes, their designations and weights being as follows:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kg.</td>
</tr>
<tr>
<td>1. Nebel-Trommel (N T)</td>
<td>95</td>
</tr>
<tr>
<td>2. Nebel-Topf (N L)</td>
<td>69</td>
</tr>
<tr>
<td>3. Nebel-Kasten (N K)</td>
<td>34</td>
</tr>
</tbody>
</table>

The "N. T." generator has to be transported in one piece, while the "N. L." can be transported in three sections, each weighing about 23 kilograms (50 pounds), and the "N. K." in two sections, each weighing about 17 kilograms (37 pounds).

306. Each generator consists of an iron vessel containing chlorosulphonic acid and another vessel containing lumps of quick lime ranging in size from about 2 inches in diameter downwards. To form the cloud of smoke, the chlorosulphonic acid is allowed to flow on to the lime. As it is important to protect the lime from moisture, it is enclosed in the case of the "N. L." and the "N. K." patterns, in an iron box, which is hermetically sealed. By stripping off a soldered band, the lid can be removed when the apparatus is to be used. In the "N. T." pattern the generator is closed by a strip of waterproof material, which is bound over the hole through which the smoke escapes.

307. "Nebel-Trommel (N. T.)."—This generator is shown in Fig. 37.

It consists of a cylindrical iron vessel (A)—thickness of walls, 2 mm. (.079 inch)—22 inches high and 20 inches in diameter. On the top of this fits a cap (B)—thickness of walls, 2 mm.—7½ inches high, and pierced with 11 holes, each 7½ inches in diameter. The handle (C) for opening the acid receptacle passes through a hole in the center of this cap. Finally, there is a protecting lid (D), 9½ inches high, which has to be removed before the generator is used.

The acid is contained in a drum-shaped iron receptacle, which is supported on trunnions. One of these trunnions passes through the wall of the vessel (A) and has a handle (F), by means of which the receptacle can be rotated.

The lime is placed at the bottom of the vessel (A) and is
covered with a disc of wire gauze. A circular iron plate is attached to the center of this disc, with the object of scattering the acid as it falls over the lime.

The volume of the acid receptacle is 21.3 liters (37.5 pints), and the weight of the lime about 63 pounds.

To use the generator, the lid (D) is removed and the strip of waterproof material which covers the holes in the cap (B) is torn off. The stopper of the receptacle in which the acid is contained is unscrewed by means of the handle (C), and then the receptacle is rotated on its trunnions through 180 degrees by means of the external handle (F).

![Diagram of the generator](image)

**Fig. 38.—Section of German "Nebel-Topf" (Smoke Pot).**

308. "Nebel-Topf (N. L.)."—This generator is shown in Figs. 38 and 39.

It consists of a cylindrical iron vessel (A), 14½ inches in diameter and 2 ft. 7 inches high—thickness of walls, 75 mm. (.03 inch)—closed at the top by a cover (D), 6 inches high,
which is pierced with 8 large holes. Inside this vessel there is a cylindrical iron box (B), which is closed by a soldered lid. This box contains lumps of quick lime, and before use the lid is removed so that the liquid contained in the sphere (C) may reach the lime. A layer of wire gauze is placed over the lime. An iron sphere (C) contains the chlorosulphonic acid, and is closed by a screw plug.

When the generator is to be used the lid of the box (B) is removed, as is likewise the screw plug closing the sphere. The sphere is then turned through 180 degrees by means of a handle (E). In this way the opening of the sphere is brought to the bottom and the liquid falls on the lime, the smoke produced escaping through the holes in the lid.

The walls of the sphere are 2 mm. (.079 inch) thick, and its volume is 12.2 liters (21.5 pints).

The weight of the lime is 39 pounds.

309. "Nebel-Kasten (N. K.)."—This generator is shown in Fig. 40.

It consists of an iron drum (A)—thickness of walls, .75 mm. (.03 inch)—which contains the chlorosulphonic acid, and a rectangular box (B) which contains the lime. This box has a slot at either end, into which fit two iron bars. These bars have notches at their upper ends, and the trunnions of the acid drum rest on these notches. A handle (C) serves to rotate the drum when the acid is to be poured out on the lime.

The walls of the drum are 1 mm. (.039 inch) thick, and its volume is 8.9 liters (15.6 pints).

The box contains about 24 pounds of lime.

310. Method of Use.—The following quotations from the paper of instructions sent out with the "N. L." generator will give an idea of the uses to which these smoke generators are to be put:

One or two "Nebel-Töpfe" set in action simultaneously produce a thick white cloud of smoke, which lasts about 10 minutes. This spreads out quickly, owing to the wind currents, and forms a high opaque wall of smoke, which, provided that there are not strong upward currents in the air, clings fast to the ground. It travels with the wind as a continuous cloud, and, depending on the weather, persists up to half an hour. The smoke cloud is absolutely nontoxic and can be traversed without danger. It causes only slight irritation of the throat and face, but it is absolutely harmless.

The "Nebel-Topf" can be used under the following circumstances:
Fig. 40.—Smoke Generator—"Nebel-Kasten" (Smoke Box) Type.
(a) Use in operations at the front.
   (i) Concealment of the bringing up of reserves.
   (ii) Prevention of concentrated fire.
   (iii) Simulation of movements which are to take place at quite a different spot, i.e., diversion of the attention from the real point of attack.
   (iv) Simulation of gas attacks.
   (v) Execution of change of position of infantry, artillery, etc.
   (vi) Passage of valleys under cover of a smoke cloud while the ridges are occupied.
   (vii) Passage of rivers.
   (viii) Employment in reconnaisances in force (disadvantage—the troops may to some extent lose their way).
   (ix) Attack of small parties under cover of a smoke cloud released by patrols either to the front or to the side of the position.

(b) For the purpose of concealing groups of buildings, etc. If the wind is strong, the object which is to be concealed by the cloud must be about 500 meters distant from the apparatus.

If the wind is slight, 200 meters is a satisfactory distance.

When the wind is very weak and the air dry, the cloud rises high, but it falls again to the ground at a distance of about 100 meters.

If several generators are set up around the object in question, important buildings, workshops, magazines, halls, factories, etc., can readily be concealed as a protection against the attacks of aircraft, since the cloud of smoke extends over several kilometers and so alters the aspect of the country from above that it is very difficult to obtain one's bearings from an aeroplane.

The "Nebel-Topf" generator is said in the pamphlet to be half as effective as the "Nebel-Trommel," and the "Nebel-Kasten" one-third as effective as the "Nebel-Trommel."

SMOKE GRENADES

311. The German smoke bomb (Fig. 33) is similar in appearance to the chemical hand grenade. It consists of a hollow steel sphere with a filling hole (A) and an insertion (B) which contains a bursting charge consisting of 3 grams of black powder and into which the friction time-fuse (C) of the usual pattern is screwed. The thickness of the walls is 1 mm., the diameter of the sphere being 9.5 cm.

The sphere contains 660 to 710 grams of chlorosulphonic acid (the same liquid used in the glass smoke grenades).
Some of these grenades are marked “Nebel,” others “N-Stoff.” On explosion, each grenade gives off a burst of smoke, which persists for some time and drifts away on the wind. The evolution of smoke lasts about 10 seconds.

**FLAME PROJECTORS**

312. The Germans have made considerable use of flame projectors (Flammenwerfer), of which they have two chief types, viz.:

(a) Large “Flammenwerfer.” Range of flame, 33 to 44 yards. Duration of flame, about 1 minute.

(b) Small “Flammenwerfer.” Range, about 20 yards. Duration of flame, about 1 minute.

Both types consist of vessels filled with graded inflammable oils and connected with containers of compressed nitrogen. The latter forces out the oil, which is ignited as it comes out.

313. Small “Flammenwerfer.”—The type originally used consisted of one cylinder of two compartments, one to hold the oil, the other as container for the compressed nitrogen, which is carried into the field in large cylinders. The flame projector is carried on a man’s back, and is fitted with a long flexible tube ending in a detachable nozzle. The latter has an automatic friction lighting device. This is actuated by the release of the pressure when the attack is started, and ignites a combustible core, which continues to burn and insures the oil being kept alight. The core consists of a wick impregnated with wax and surrounding a fiercely burning nitrate mixture.

The oil consists of heavy and light fractions, generally mineral oil, but sometimes wood-tar fractions, mixed with light petroleum. In some cases recently examined the lightest fraction has consisted of ordinary ether.

A modification of the portable pattern has been recently captured. In this pattern the compressed nitrogen is contained in a spherical vessel, which is surrounded by a ring-shaped oil container. The apparatus is carried on the back in the usual manner. The flexible tube carrying the jet is made of canvas and rubber, and captured documents show that only one of these is provided for each three reservoirs. After the discharge of one apparatus, the flexible tube is handed on to the others in succession.
314. Organisation of Flame Attacks.—Flame attacks are generally made by the Guard Reserve Pioneer Regiment, each company of which was originally equipped with 20 large and 18 small "Flammenwerfer." Flame projectors have had very little success on the Western Front since their first use at Hooge in 1915.

315. Tactics.—It is essential for the man with the flame projector to get near enough to his target to make the flame effective. In attempting to clear mined villages, fortified buildings, etc., this can sometimes be done by cautious approach, unprotected. In the open it is necessary to clear a way for the carrier. This is generally done by an oblique covering fire from machine guns.

The following is an account of a flame projector attack made on the British Front, September 30, 1917:

"There was an intense barrage from 4:30 to 5:15 A. M., and smoke was also used by the enemy.

"At 5:15 A. M. jets of flame were sent by the men in the front line, and what appeared to be two squads of 'Flammenwerfer' were seen advancing towards our front line. Each of these apparently consisted of one man carrying the instrument, followed by a bomber, who threw bombs over the head of the carrier. One squad disappeared. The other carrier was shot before he reached our parapet, with the result that the flame shot upwards and did no damage.

"In no case was burning experienced in the front line. The attack was a complete failure, and the 'Flammenwerfer' aided it in no way. Rather it assisted the defense, since it lit up the advancing foe. There was a dense fog at the time, which prevented our troops from seeing exactly how many flame projectors were in use.

"The flame projector was recovered from the body of the carrier.

"The size of the flame could not be definitely seen.

"The projectors caused no casualties."
APPENDIX I.—CHEMICALS USED BY THE GERMANS IN GAS WARFARE

(1) Allyl Isothiocyanate

"Allyl Mustard Oil."

This liquid is suspected to have been used in shell, although no "blind" shell have been obtained.

It is a lachrymatory and respiratory irritant, affecting especially the eyes, nose, and throat.

\[ \text{C}_4\text{H}_4\text{N C S} \quad \text{M. W. 99} \quad \text{Sp. Gr. 1.01} \]
\[ \text{B. P. 151°C.} \quad \text{V. P. 12 mm. (44.5°C.)} \]

The vapor is 3.3 times as heavy as air.

(2) Benzyl Bromide

Benzyl bromide, a colorless liquid, is mixed with xylyl bromide to make "T-Stoff." It never constitutes more than 31 percent of the mixture.

Shell containing T-Stoff must be lined with lead, as it is decomposed when in contact with iron or steel.

It is chiefly a lachrymator, but also irritates the respiratory organs.

\[ \text{C}_6\text{H}_5\text{CH}_2\text{Br} \quad \text{M. W. 171} \quad \text{Sp. Gr. 1.438} \]
\[ \text{B. P. 198°C.} \quad \text{V. P. 1 mm. (25°C.)} \]
\[ \quad \quad \quad \text{3 mm. (50°C.)} \]

The vapor is 5.7 times as heavy as air.

(3) Bromoacetone

Monobromoacetone, a liquid with a pungent smell, has been used both in shell and hand grenades, mixed either with chloroacetone, which serves to make it more stable, or with brominated methylethyl ketone.

This mixture is a lachrymatory and respiratory irritant, even in low concentrations.

\[ \text{CH}_3\text{Br C O C H}_3 \quad \text{M. W. 137} \]
\[ \text{Sp. Gr. 1.99} \quad \text{B. P. 137°C. (725 mm.)} \]
\[ \text{V. P. 1 mm. (10°C.)} \quad \text{9 mm. (20°C.)} \]

The vapor is 4.5 times as heavy as air.

135
(4) Brominated Methylethyl Ketone

"Brom Ketone."

Brominated methylethyl ketone is largely used in shell (which must be lead-lined, as "brom ketone" is unstable) and in hand grenades.

There are two forms of monobromomethyl ketone, CH₃Br CO-C₂H₅ (B. P. 145°C., M. W. 151) and CH₃CO CH Br CH₃ (B. P. 133°C., M. W. 151). There is also a dibromomethylethyl ketone, CH₃CO CH Br CH₂ Br, which boils at 53°C. under a pressure of 0.2 mm. (M. W. 230).

The mixture now used in shell is about 35 per cent mono-bromo and 65 per cent dibromo ketone. It causes lachrymation, and is to some extent a respiratory irritant, in that it causes a burning sensation in the throat, but no feeling of constriction in the chest.

V. P. (of mixture) 16 mm. (14° C.).

The mixed vapors are about 6 times as heavy as air.

(5) Bromine

At ordinary temperatures, bromine is a red-brown liquid, which fumes strongly. It was at one time used by the Germans in glass hand grenades and in shell, with glass bottles as containers for the liquid. Its use has now been discontinued.

The effects of bromine are much the same as those of chlorine. Bromine is, in addition, very irritating to the eyes, even in low concentration.

Bromine is soluble in water, and is readily absorbed by alkalis, alkaline sulphites, and thiosulphates.

\[ \text{Br}_2 \quad \text{M. W. 160} \]
\[ \text{B. P. 59°C.} \quad \text{V. P. 212 mm. (25° C.)} \]

Bromine vapor is \(5\frac{1}{2}\) times as heavy as air.

(6) Carbon Monoxide

This colorless and odorless gas has not been used for offense, but occurs in the gases resulting from the decomposition of various explosives, especially in confined places, and in ordinary coal gas. It is not irritating, and therefore offers no evidence

---

The proportions of the mono- and dibromo compounds have been changed as follows: The first shell contained the monobromo compound only—

Then 57 mono- to 43 dibromo:

Then 50 mono- to 50 dibromo:

Then 40 mono- to 60 dibromo:

Then 35 mono- to 65 dibromo:
of its presence. However, it is highly toxic, even in minute quantities.

The chief symptoms of carbon monoxide poisoning are headache, nausea, giddiness on exertion, and, finally, loss of muscular power, followed by complete loss of consciousness.

Carbon monoxide burns with a blue flame.

CO  M. W. 28.
Carbon monoxide is only 0.96 times as heavy as air.

(7) Chloroacetone

Chloroacetone is a colorless liquid, which, mixed with bromoacetone, was at one time used in hand grenades. Its use has been discontinued.

It is a lachrymator and asphyxiant similar to bromoacetone, but not so powerful.

Chloroacetone is insoluble in water, but is miscible with alcohol, ether, and chloroform.

\[ \text{C} \text{H}_2\text{Cl CO CH}_3 \quad \text{M. W. 92.5} \]

Sp. Gr. 1.16  B. P. 119° C.

The vapor is 3 times as heavy as air.

(8) Chlorobenzene

Chlorobenzene is a colorless liquid, which is used in Yellow Cross shell to the extent of 15 per cent, probably merely as a solvent and to assist in vaporization of the dichlorodiethyl sulphide, as it is harmless.

\[ \text{C}_6\text{H}_5\text{Cl} \quad \text{M. W. 112} \quad \text{Sp. Gr. 1.104 (25° C.)} \]

B. P. 132° C. (757 mm.)  V. P. 15.3 mm. (30° C.)

41.5 mm. (50° C.)

The vapor is 3.7 times as heavy as air.

(9) Chlorine

This greenish-yellow gas was used by the Germans in their first cloud attack. In such attacks it is now used mixed with phosgene. It has not been used in gas shell.

Chlorine is chiefly a respiratory irritant, although in high concentrations it affects the eyes also. It causes spasm of the glottis, burning of the nose and throat, and, at a later stage, bronchitis and oedema of the lungs.

A man exposed to a low concentration for a time is likely to develop bronchitis. In a concentration of 1-10,000, the struggle
for breath becomes acute, and it is probable that a man would be incapacitated within five minutes.

At a pressure of 7 atmospheres at 15° C., or under ordinary atmospheric pressure at a temperature below −34° C., it condenses to a yellow liquid, which boils at ≈33.5° C., and has a Sp. Gr. (0° C.) of 1.44. This liquid, if perfectly dry, can be stored in steel cylinders.

Chlorine is somewhat soluble in water, one volume of water at 10° C. dissolving 2.5 volumes of gas. The gas is also absorbed readily by alkalis, alkali carbonates, and thiosulphates.

Cl₂ M. W. 71.
The gas is 2½ times as heavy as air.

(10) Chloromethylchloroformate

“Palite.”

Monochloromethylchloroformate, a yellow, transparent liquid, with an unpleasant, suffocating odor, has been used in lead-lined shell. Its use has been discontinued.

It is chiefly a respiratory irritant, resembling phosgene in its effects. It gives off acid fumes, acts slowly on metals, and decomposes in contact with water.

\[
\text{Cl COOCH₂ Cl} \quad \text{M.W. 129}
\]

\[
\text{B. P. 77° C. V. P. 3.6 mm. (10° C.)}
\]

\[
5.6 \text{ mm. (20° C.)}
\]

The vapor is about 4.3 times as heavy as air.

(11) Chloropicrin

“Nitrochloroform.”

Chloropicrin is a colorless liquid, which, mixed with trichloromethylchloroformate (“Diphosgene”: 30 per cent chloropicrin and 70 per cent “Diphosgene”), or with diphenylchloroarsine, is used in shell.

Chloropicrin is a lacrymator and a respiratory irritant. Repeated exposure causes increased susceptibility. It induces cough, nausea, and vomiting, and in high concentration, may cause unconsciousness. Secondary effects are bronchitis, asthma, shortness of breath, weak irregular heart, and gastritis. It may cause acute nephritis.

Chloropicrin is almost insoluble in water, but soluble in alcohol. Its vapor explodes when superheated, but it can be distilled in
a current of steam. Chloropicrin may be absorbed by alkaline sulphotites.

\[ \text{C Cl}_2 \text{ NO}_3 \]  
M. W. 164.5  
B. P. 112° C.

Sp. Gr. 1.69  
V. P. 10.4 mm. (10° C.)

21.3 mm. (20° C.)

The vapor is 5.7 times as heavy as air.

(12) Chlorosulphonic Acid

This is a colorless liquid, which has been used, mixed with sulphur trioxide, in glass and metal hand grenades and in shell. It is also very largely used for the production of smoke for smoke screens.

The liquid produces dense white fumes in the air, is irritant and corrosive, and produces severe burns when it comes in contact with the skin: It is decomposed by water with explosive violence.

\[ \text{SO}_2 \text{HCl} \]  
M. W. 116  
B. P. 152° C.

Sp. Gr. 1.76

(13) Dichlorodisethyl Sulphide

"Mustard Gas."

This oily liquid is now very largely used in German shell. It has but a faint smell, resembling that of garlic or mustard.

This gas is characterized by the absence of any immediate effects (except in some cases irritation of the nose) and by its serious after-effects. In the milder cases these after-effects may be limited to nausea, vomiting, inflammation of the eyes, and slight bronchitis, while the skin on various parts of the body may become reddened or blistered. In the most severe cases the larynx, bronchial tubes and lungs may be seriously inflamed, and there will be widely spread burns on the skin. A prolonged exposure to a low concentration causes the same general effects as a short exposure to a higher concentration.

There is usually a considerable period of delay before these after-effects manifest themselves. In the majority of cases the inflammation of the eyes does not become apparent until an hour or two after exposure to the gas, and it is sometimes postponed as long as 12 hours or more. No cases of permanent injury to the eyes have been reported. The inflammation of the eyes and of the skin clears up fairly rapidly under treatment.

\[ (\text{CH}_3 \text{ Cl CH}_2) \text{S} \]  
M. W. 159

139
B. P. 217 (with decomposition); solidifies at 0° C.; slightly soluble in water.
The vapor is 5.3 times as heavy as air.

(14) s-Dichloromethyl Ether

This liquid is present to the extent of about 5 per cent in the "mustard gas" used in shell.
The vapor is very irritating to the throat and lungs.

\[(\text{CH}_3\text{Cl})_2\text{O} \quad \text{M. W. 115} \quad \text{Sp. Gr. 1.315 (20° C.)}\]
\[\text{B. P. 105° C.}\]
The vapor is 3.8 times as heavy as air.

(15) Dimethyl Sulphate

Dimethyl sulphate is an oily liquid, which is used in hand grenades with methyl chlorosulphonate.
Spilled on the skin, it has strong corrosive action, producing the appearance of a scald. When diffused in the air it exerts a corrosive action on eyes, air passages, and skin, but the action on the skin is less intense than that of dichlorodiethyl sulphide. A few cubic centimeters spilled on the skin may be inhaled with fatal results if the subject is in a confined space.

Dimethyl sulphate is soluble in water, with decomposition, and is saponified by alkalis.

\[(\text{CH}_3)_2\text{SO}_4 \quad \text{M. W. 125} \quad \text{Sp. Gr. 1.3} \quad \text{B. P. 188° C.} \quad \text{V. P. 3.3 mm. (11.3° C.)}\]
The vapor is 4.2 times as heavy as air.

(16) Diphenylchloroarsine

This is a yellow solid of slight odor, which is used, either alone or mixed with "Diphosgene" and chloropicrin in high explosive shell.

In small amounts diphenylchloroarsine causes intense sneezing. Large amounts cause painful irritation of the respiratory tract.

\[(\text{C}_6\text{H}_5)\text{As Cl} \quad \text{M. W. 264.5} \quad \text{Sp. Gr. 1.42 (15° C.)} \quad \text{M. P. 37° to 40° C.} \quad \text{B. P. 333° C.}\]

(17) Hydrocyanic Acid

"Prussic Acid."

Hydrocyanic acid is a colorless liquid, with an odor of bitter almonds. As it boils at 26° C., its vapor pressure at ordinary
temperature is high. It has been used in small quantities in the "mustard gas" shell.

This substance is a "paralysant." Moderate quantities cause vertigo, headache, palpitation of the heart, nausea, vomiting, and difficult, gasping respiration. The next stage is spasm, then collapse. With inhalation of large quantities, death ensues practically immediately.

Prussic acid burns with a violent flame. It is soluble in most solvents.

\[ \text{Sp. Gr. (of liquid) 0.697 (18° C.)} \]
\[ \text{HCN M. W. 27} \]

The gas is .9 times as heavy as air.

**18) Methyl Chlorosulphonate**

Methyl chlorosulphonate is a colorless liquid of pungent odor, which has been used in hand grenades.

It is a lachrymator and asphyxiant.

\[ \text{CH}_3\text{SO}_2\text{Cl M. W. 130.5} \]
\[ \text{Sp. Gr. 1.51 B. P. 160° C.} \]

The vapor is about 4.3 times as heavy as air.

**19) Phenylcarbylamine Chloride**

This is a heavy liquid of unpleasant odor, which has been used in shell, although not very extensively. It is prepared by chlorination of phenyl mustard oil.

It is a lachrymator and somewhat of an asphyxiant, but is not particularly effective as a substance for offense.

\[ \text{C}_6\text{H}_5\text{NCl}_2 \quad \text{M. W. 179} \]

The vapor is about 6 times as heavy as air.

**20) Phosgene**

"Carbonyl Chloride."

Phosgene is a colorless gas, which is used, mixed with chlorine, for cloud gas attacks. It is used as pure liquid phosgene in trench mortar and other shell. It is mixed with trichloromethylchloroformate and with diphenylchlooroarsine.

Phosgene has a peculiar odor, described as that of "musty hay." It acts chiefly as a respiratory irritant, but is also lachrymatory. The effect differs from that of chlorine, in that, in small concentrations, its influence is limited mainly to the
terminal air cells of the lungs. This effect leads to oedema of
the lungs, accompanied by interference with the passage of
oxygen inwards, and consequent cyanosis—a grave condition—
and often death. It usually takes some hours for the serious
symptoms to develop, and in the interval there may be no sign
of danger. The first symptoms are dizziness and cyanosis on
exertion. Phosgene incapacitates a man more slowly than the
same concentration of chlorine, but is more poisonous in its
after-effects.

Phosgene may be recognized by its odor. Tobacco smoked
subsequently by a man lightly gassed by phosgene has an un-
pleasant and objectionable taste. This is the well-known phos-
gene tobacco reaction.

Phosgene is not absorbed by so large a variety of substances
as chlorine. It is reacted upon by amines, such as aniline,
urotropine, and pyridine, and is fairly rapidly hydrolyzed by
water.

\[ \text{COCl}_2 \quad \text{M. W. 99} \]
Sp. Gr. 1.432 (8.2° C.)
V. P. 1.1 atmospheres (at 10° C.)
B. P. 8.2° C.

(21) Sulphur Trioxide

This is a white solid, which is used, mixed with chlorosul-
phonic acid, in hand grenades, and also in shell containing high
explosive. It evolves dense white fumes.

Sulphur trioxide is irritating to the nose, throat, and lungs,
but its effect on the eyes is negligible.

It is soluble in water, with the evolution of heat.

\[ \text{SO}_3 \quad \text{M. W. 80} \quad \text{M. P. 15° C.} \]

(22) Trichloromethylchloroformate

"Diphosgene."

"Superpalite."

"Diphosgene" is an oily liquid, with a disagreeable, suffocating
odor. It is largely used in shell, replacing "Palite." It is mixed,
as a rule, with chloropicrin or with chloropicrin and phosgene.

The physiological effects of "Diphosgene" are almost identical
with those of phosgene. It is less lachrymatory than "Palite",
but more suffocating and more toxic.

It does not attack metals as does "Palite". It is hydrolyzed
by water, forming phosgene.

142
Cl COOCCl₂  M. W. 198
Sp. Gr. 1.652 (14° C.)  B. P. 127.5° C.
V. P. 40 mm. (20° C.)

The vapor is 6.6 times as heavy as air.

(23) Trioxymethylene

Trioxymethylene is an imperfectly crystalline solid, which has been found to a small extent in specimens of "mustard gas" from shell.
The vapor is very irritating to the throat and lungs.

C₃H₄O₃  M. W. 90
M. P. 152° C. (Sublimes at 100° C.)

Upon volatilizing, trioxymethylene is converted into formaldehyde.
The vapor (formaldehyde) is of the same weight as air.

(24) Xylyl Bromide

A mixture of ortho-, meta-, and para-bromides mixed with benzyl bromide, is generally used in shell. This mixture also usually contains some xyylene dibromide.
The mixture is chiefly lachrymatory.

CH₃C₆H₄CH₂Br  M. W. 185
Sp. Gr. 1.37 (23° C.)  B. P. approximately 215° C.

The vapor is about 6.1 times as heavy as air.
## APPENDIX II.—German Artillery Gas Shell.

<table>
<thead>
<tr>
<th>Shell</th>
<th>Fuse</th>
<th>Liquid employed</th>
<th>Nature</th>
<th>Volume</th>
<th>Coloring of shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7 cm, (1915 pattern shell) and 7.7 cm. (long shell). (Max. range, 9,186\textsuperscript{b} yds.).</td>
<td>K.Z.14</td>
<td>Trichloromethylchloroformate (A and L)</td>
<td>cc. 285</td>
<td>Blue: yellow head.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K.Z.14</td>
<td>Brominated ketone (A and L)</td>
<td>670</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E.K.Z.17</td>
<td>Dichlorodiethyl sulphide (E)</td>
<td>670</td>
<td>Blue: yellow head with yellow cross.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E.K.Z.16</td>
<td>H.E. and Diphenylchloroarsine (A and S)</td>
<td>......</td>
<td>Blue: yellow head with blue cross.</td>
<td></td>
</tr>
<tr>
<td>10 cm. Gun (1912 pattern shell?). (Max. range, 12,085 yds.)</td>
<td>Gr.Z.14n/A</td>
<td>Mixture of trichloromethylchloroformate and chloropicrin (A and L)</td>
<td>1,300</td>
<td>Blue: yellow head.</td>
<td></td>
</tr>
<tr>
<td>Artillery Type</td>
<td>Description</td>
<td>Range</td>
<td>Color Notes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.5 cm. Howitzer</td>
<td>(long shell) (Max. range, 9,624 yds.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H.Z.14</td>
<td></td>
<td>1. Benzyl and xylyl bromide (L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Brominated ketones (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H.Z.14n/A</td>
<td></td>
<td>1. Chloromethylchloroformate (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Trichloromethylchloroformate (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Mixture of trichloromethylchloroformate and chloropicrin (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E.H.Z.17</td>
<td></td>
<td>Dichlorodiethyl sulphide (E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,360</td>
<td>Blue: yellow head and sometimes green cross on base of shell.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H.Z.05 Gr.</td>
<td></td>
<td>H.E. and diphenylchloroarsine (A and S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>300</td>
<td>Blue: yellow head: blue cross on head.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 cm. Howitzer (1912</td>
<td>(1912 pattern shell) (Max. range, 9,296 yds.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr.Z.04</td>
<td></td>
<td>Benzyl and xylyl bromides (L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,350</td>
<td>Gray: black head: T in black.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr.Z.14n/A</td>
<td></td>
<td>Phenylcarbylamine chloride (L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,350</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gr.Z.14</td>
<td></td>
<td>Chloromethylchloroformate (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,350</td>
<td>Gray: yellow head: K in yellow.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>Fuse</td>
<td>Liquid employed</td>
<td>Coloring of shell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------</td>
<td>-----------------------------------------------------</td>
<td>---------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1912 n/A shell</td>
<td>Gr.Z.14n/A</td>
<td>1. Trichloromethylchloroformate (A and L)</td>
<td>Gray: green cross on base.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Mixture of trichloromethylchloroformate and chloropicrin (A and L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Brominated ketones (A and L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New variation of 1912 shell</td>
<td>Gr.Z.92</td>
<td>Diphenylchloroarsine, phosgene and trichloromethylchloroformate (A and S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1912 shell</td>
<td>Gr.Z.04</td>
<td>Xylyl bromide and brominated ketones (A and L)</td>
<td>Gray: Green head: T in green.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1896 type of shell. (Max.</td>
<td></td>
<td>2. Dichlorodiethyl sulphide, chlorobenzene and dichloromethyl ether (L)</td>
<td>Yellow cross on side: yellow patch on base.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>range, 10,300 yds.)</td>
<td></td>
<td>11,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a A = Asphyxiant; L = Lachrymator; S = Sternutator; E = Eye, lung and skin irritant.
*b Probably about 10,000 yards with the 1916 pattern field gun.
*c These shell are said to be used also with 15 cm. long gun, old pattern (maximum range, 10,936 yds) 1912 n/A shell.
## APPENDIX III.—“Minenwerfer” Gas Shell.

<table>
<thead>
<tr>
<th>Shell</th>
<th>Liquid employed</th>
<th>Volume</th>
<th>Coloring of shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 cm. Light “Minenwerfer” shell (274 mm. long; coned head)</td>
<td>Phosgene (A)</td>
<td>466 cc.</td>
<td>Gray: 3 white bands. Very often D stencilled in black or in white.</td>
</tr>
<tr>
<td>(274 mm. long; ogival head)</td>
<td>Phosgene (A)</td>
<td>485 cc.</td>
<td>Gray: 3 white bands. Very often D stencilled in black or in white.</td>
</tr>
<tr>
<td>(248 mm. long; ogival head)</td>
<td>Phosgene (A)</td>
<td>515 cc.</td>
<td>Gray: 3 white bands.</td>
</tr>
<tr>
<td>(Max. range 1,148 yds.) (Fuse L. W.M. Zdr. 2)</td>
<td>Chloromethylchloroformate (A and L)</td>
<td>460 cc.</td>
<td>Gray: 2 white bands: C in white.</td>
</tr>
<tr>
<td></td>
<td>Trichloromethylchloroformate (A and L)</td>
<td>460 cc.</td>
<td>Gray: 2 white bands: C in red.</td>
</tr>
<tr>
<td></td>
<td>1. Brominated ketones (A and L) 2. Xylyl bromide (L)</td>
<td>460 cc.</td>
<td>Gray: 1 white band: B stencilled on body in white.</td>
</tr>
</tbody>
</table>
### APPENDIX III.—“Minenwerfer” Gas Shell—Continued.

<table>
<thead>
<tr>
<th>Shell</th>
<th>Liquid employed</th>
<th>Volume</th>
<th>Coloring of shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 cm. Medium “Minenwerfer” shell (Max. range 1,300 yds.) (Fuse Z.s.u.m.W.M.)</td>
<td>Brominated ketones (A and L)</td>
<td>8,500</td>
<td>Gray: white band; stencilled B. M.</td>
</tr>
<tr>
<td></td>
<td>Chloromethylchloroformate (A and L)</td>
<td>8,500</td>
<td>Gray: 2 white bands and C.</td>
</tr>
<tr>
<td></td>
<td>Phosgene (A)</td>
<td>8,500</td>
<td>Gray: 3 white bands: D in white.</td>
</tr>
<tr>
<td>18 cm. Smooth “Minenwerfer” shell (“canister” bomb) (Fuse Z.s.u.m.W.M.)</td>
<td>1. Phosgene (A)</td>
<td>6,000</td>
<td>Gray: 3 white bands.</td>
</tr>
<tr>
<td></td>
<td>2. Phosgene and chloropicrin (A and L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 cm. Half-sized heavy “Minenwerfer” shell (Max. range 930 yds.) (Fuse Z.s.u.m.W.M.)</td>
<td>Phosgene (A)</td>
<td>16,400</td>
<td>Gray: 3 white bands.</td>
</tr>
</tbody>
</table>

\( a \) A = Asphyxiant; L = Lachrymator.
CONFIDENTIAL

GAS WARFARE

PART II.

METHODS OF DEFENSE AGAINST GAS ATTACKS

COMPILED AT
ARMY WAR COLLEGE
JANUARY, 1918
WAR DEPARTMENT
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WAR DEPARTMENT,
WASHINGTON, January 2, 1918.

The following pamphlet, entitled "Gas Warfare, Part II, Methods of Defense Against Gas Attacks," is published for the information of all concerned.

By order of the Secretary of War:
(A. G. O. No. 062. 1).

TASKER H. BLISS,
General, Chief of Staff.

Official:
H. P. McCAIN,
The Adjutant General.
GAS WARFARE.

Part II. Methods of Defense Against Gas Attacks.

I. General Considerations ........................................... 7
II. Early Methods of Protection:
    (a) Early British Respirators and Helmets .................. 10
    (b) Early German Respirators .................................. 12
    (c) Oxygen Breathing Apparatus ............................... 13
    (d) Other Early Methods ....................................... 14
III. Present Day Masks:
    (a) American Respirator ....................................... 14
    (b) French Masks .............................................. 18
    (c) The Italian Mask .......................................... 19
    (d) The Russian Respirator ................................... 19
    (e) German Respirator ........................................ 19
IV. Anti-Gas Appliances for General Use:
    (a) Alarm Appliances .......................................... 28
        Gas Shell and Local Alarms ................................. 28
        Cloud Gas Alarms ......................................... 29
    (b) Protection of Shelters and Dugouts ..................... 30
    (c) Clearing Gas from Trenches and Dugouts ............... 32
        Natural Ventilation ....................................... 33
        Ventilation by Fire ....................................... 33
        Ventilation by Fanning .................................... 33
    (d) Clearing Trenches ......................................... 34
    (e) Clearing Shelters .......................................... 34
    (d) Protection of Weapons and Equipment .................... 35
    (e) Protection of Animals ..................................... 37
        Horses ..................................................... 37
        Carrier Pigeons ........................................... 40
    (f) Gas Detectors and Sampling Devices ...................... 40
V. Organization of Gas Defense:
    (a) Organization of Anti-Gas Duties ......................... 43
    (b) Organization of Gas Defense Within an Infantry Unit 44
VI. Action Before, During and After a Gas Attack:
    (a) Before an Attack ........................................... 45
    (b) Gas Alarms ................................................. 51
    (c) During an Attack ........................................... 52
    (d) Action After a Gas Attack ................................ 53
    (e) Precautions to Be Taken with Regard to Our Own Use of Gas ........................................... 59
VII. Explosion and Mine Gases .................................... 60
Appendix. Standing Orders for Defense Against Gas Attacks, American Expeditionary Forces 62
METHODS OF DEFENSE AGAINST GAS ATTACKS.

1. GENERAL CONSIDERATIONS.

1. The first and most vital consideration in the protection of troops against hostile gas attacks is the provision of an efficient individual protective appliance to each soldier. Decision as to the type of protective device to be adopted will depend on the following considerations:

(a) The apparatus must be capable of protecting the lungs and eyes for long periods from the gases used, or likely to be used, by the enemy. Protection must, moreover, be furnished against any concentrations of these gases liable to be met with in the field.

(b) It must be of simple design so that—

(i) It will not get out of order from the rough handling it is certain to meet with in the field.

(ii) Even the most uneducated type of soldier can learn to use it quickly and correctly.

(c) The weight must be the minimum possible and the design such that the soldier is not immobilized or seriously discommoded either by carrying the apparatus or wearing it in position.

2. Protection for the respiratory organs and protection for the eyes can obviously be kept separate, and in the earlier designs of apparatus in all the armies this was invariably done. It has been found more convenient, however, to combine the protection of eyes and lungs in one apparatus as being much simpler for the individual soldier and avoiding the danger of goggles alone being used in cases where lung protection was also needed.

3. Protection of the lungs from poisonous gases can be obtained in two ways: Either an entirely fresh atmosphere is provided for breathing, or else the poisonous gas is filtered out either chemically or mechanically.

4. The former method obviously gives absolute protection, and because of this fact many types of oxygen breathing apparatus have been tried at one time or another. These all suffer from two fatal defects: they do not last long
enough, and even the lightest forms are too heavy for the soldier to carry about.

5. The filter type of respirator is the one which has been universally adopted. Within the limits of weight which can be carried by the soldier such respirators do not protect against very high concentrations of gas, but fortunately the concentrations of gas met with in the field are relatively low and probably rarely exceed one part in 500 parts of air. "Filter" respirators to deal with concentrations of this order have been devised by all the armies taking part in the war.

6. In settling the design of a respirator the considerations mentioned in Par. 1 must be weighed to give the soldier the maximum of protection with the minimum of inconvenience. For this reason the standard of protection required must be carefully decided. All the past experience of gas warfare has shown that the concentrations of gas produced in the field are continually increasing, and a respirator which efficiently protected against the earlier cloud attacks would be practically useless today. It is obviously necessary, therefore, that a good respirator should have a very large margin of safety to allow for future developments of gas warfare in the same direction and also to deal with the local very high concentrations met with at present.

7. The chemical filling, also, must be such that it will provide protection not only against gases known to be used or likely to be used, but also against such as are considered unlikely because of difficulty of production, scarcity of raw material, etc. It must also provide the maximum safety against future inventions and developments. These, however, are matters for decision by chemical experts.

8. For the reasons quoted above, the American and British respirators have been given a larger margin of safety than the German respirator, which, though simpler in design, will not protect against as large a number of gases nor against such high concentrations; nor will it last so long.

9. A respirator having been issued to each soldier, he must be taught how to use it to the best advantage and the importance of keeping it in good condition. These are matters of training and inspection and are dealt with fully in the section devoted to training in defense against gas.

10. It must be remembered that in the absence of suitable means of protection the poisonous gases used in war are extremely deadly and the breathing of only very small quanti-
ties of them may cause death or serious injury. This being the case, it is essential that not the slightest time should be lost in putting on the respirator when the alarm is given. Arrangements for giving and spreading the gas alarm must consequently be thoroughly prepared beforehand, both as regards the provision of actual alarm appliances and the promulgation of orders which will ensure every man being given the earliest possible warning. Such alarm arrangements must include not only the troops in the front line, but also those in support and reserve, as the effects of a strong gas cloud may be felt over fifteen miles from the line. Alarm to the rear must therefore be thoroughly arranged and be independent of methods of communication liable to break down during an attack or bombardment.

11. Other defensive methods, such as the protection of shelters and dugouts from gas, the clearing of gas from trenches and dugouts, the protection of arms and ammunition, etc., are also of great importance in reducing casualties. It is essential, however, that all devices adopted should be simple in construction and use and really capable of being employed under field conditions. Similarly, all orders on the subject of gas defense must be consistent with active service conditions, but those which are given must be enforced to the letter.

12. It will thus be seen that the whole basis of protecting troops against gas lies: (a) in keeping all appliances in perfect working order; (b) in learning to adjust them rapidly under all conditions; and (c) in ensuring that every man is given immediate warning. These results can only be attained:

(i) BY FREQUENT AND THOROUGH INSPECTION OF ALL PROTECTIVE APPLIANCES.
(ii) BY THOROUGH INSTRUCTION AND TRAINING IN THEIR USE.
(iii) BY EVERY MAN UNDERSTANDING AND COMPLYING WITH ALL STANDING ORDERS ON THE SUBJECT OF DEFENSE AGAINST GAS.

If these measures are effectually carried out, there is nothing to fear from hostile gas attacks. Officers must impress this on their men, as an important object of all anti-gas instruction should be to inspire complete confidence in the efficacy of the devices and methods which are adopted.
II. EARLY METHODS OF PROTECTION.

13. The first German gas attack made against the British and French in April, 1915, found the Allies entirely unprepared and unprotected against poisonous gas. Steps were immediately taken to improvise protective devices and to supply respirators for all front line troops.

14. Among the improvised respirators used were gags made with rags or handkerchiefs and soaked in water or washing soda solution, handkerchiefs filled with moist earth, etc. One suggestion was to use bottles with the bottom knocked off and filled with moist earth, the user to breathe in through the neck of the bottle and out through his nose.

It was not necessary to use such methods for long, as an appeal to the women of Britain and France to make respirators of cotton wool in a gauze envelope met with such instant response that by the time of the next attack on May 10th, directed against the British at Hill 60, every soldier had a respirator of some kind. These respirators were kept moist with water, soda solution or "hypo" solution and had to be dipped and wrung out before use.

(A) EARLY BRITISH RESPIRATORS AND HELMETS.

15. BLACK VEILING RESPIRATOR.—This was the earliest type of respirator officially issued to the troops, and consisted of cotton waste enclosed in a length of black veiling. (See Fig. 1.) The cotton waste was soaked in a solution of:

- Sodium thiosulphate .................. 10 lbs.
- Washing soda .......................... 2 ½ lbs.
- Glycerine ............................. 2 lbs.
- Water ................................. 2 gals.

The glycerine was put in to keep the respirator moist, thus obviating the need for dipping before use.

The respirator was adjusted over the mouth and nose, the cotton waste being moulded to the shape of the face, and the upper edge of the black veiling pulled up so as to protect the eyes.

These respirators were much used in the attacks of May 10th and 12th, 1915, and were found reasonably efficient against the low concentrations of chlorine then used, but they were difficult to fit exactly to the face and the cotton
Fig. 1.

The Black Veiling Respirator.
DEFENSE AGAINST GAS ATTACKS

waste had to be frequently shredded out to prevent it becoming lumpy.

16. **HYPO** HELMET.—The gas helmet in its original form consisted of a flannel bag soaked in the same solution as was used for the veiling respirator and was fitted with a pane of mica to act as a window. The helmet was tucked down inside the jacket, which was then buttoned up tightly around the neck.

This form of protection had many advantages. It was very simple to use and experience in the attack of May 24th showed it to be very effective against chlorine in the field, though some casualties were caused by the mica pane becoming cracked. In later types the mica window was replaced by celluloid, and later still by glass eyepieces set in metal rims.

17. **P. AND P. H. HELMETS.**—As it became apparent in the summer of 1915 that the gas phosgene was likely to be used by the enemy in future attacks, and as the “hypo” helmets did not protect against this gas a new form of helmet was adopted. This helmet was soaked in an alkaline solution of sodium phenate containing glycerine, and was called the P. Helmet. (See Figs. 2 and 3.) It protected against three parts of phosgene in ten thousand of air. Since the solution used attacks flannel, two layers of flannelette were used instead and the helmet was fitted with an expiratory valve, partly to prevent a man from breathing any of his own breath over and over again, and partly to prevent unnecessary carbonation of the alkali.

Later on the protection against phosgene was further strengthened by the addition of hexamethylene tetramine (Urotropine), the other ingredients remaining the same. Thus modified, the helmet (the P. H.) protects against one part of phosgene in 1,000 of air and is still used in the British Army for the convenience of troops in the “Precautionary Zone,” i. e., between 5 and 12 miles from the front line.

18. **GOGGLES** of various types were formerly used in the different armies for protection against lachrymators. The last British type had glass eyepieces and made a good fit around the eyes by means of rubber sponge. (Fig. 4.) They gave an excellent protection against lachrymators and were intended for use only after a lachrymatory bombardment...
when the concentration was still sufficient to affect the eyes without causing respiratory distress. It was found, however, that they were frequently used during a bombardment and at other times when the respirator should have been worn owing to the presence of real poison gases. They were consequently withdrawn.

An attempt was made to include goggles in the P. H. helmet and a special helmet based on this principle (the P. H. G.) was issued to artillerymen, etc. Its chief objection was the increased time necessary to put it on, and it was discarded previous to the box respirator being adopted.

19. The helmet form of respirator as latterly used by the British suffered from the following disadvantages:
   (a) It deteriorated from exposure to air.
   (b) Practically the limit of protection obtainable by this type of respirator had been reached. It was incapable of further development.
   (c) It had a peculiar smell and when very wet occasionally burned the foreheads of the men.
   (d) It did not give good protection against lachrymators, etc.

(B) EARLY GERMAN RESPIRATORS.

20. The first German respirators were simple pad respirators soaked in a sodium thiosulphate-sodium carbonate solution. Each soldier was provided with a bottle of this solution (Schutzzalzlösung), wherewith to moisten his respirator from time to time.

These pads were replaced by a small compact respirator made of absorbent cloth soaked in “Schutzzalz” solution and shaped like a snout, which fitted over the mouth and nose, the latter being closed by means of a steel spring. Many of these snout-respirators were still in use when the British made their first gas attack at Loos in September, 1915, and the troops using this form of protection were among those most seriously affected by the attack. About this time the Germans started the use of their present type of respirator (see par. 33), which has the advantage of protecting against lachrymators as well as chlorine. Later on it was modified so as to protect against phosgene also.
DEFENSE AGAINST GAS ATTACKS

(C) OXYGEN BREATHING APPARATUS.

21. In the early days of gas warfare, when the individual soldier was provided with protection only against chlorine, etc., all the armies furnished their machine gunners and other specialists with oxygen breathing sets, so that in the event of an unexpected gas being used it would be possible to hold the line by their aid. Forms of this apparatus are still used for rescue work and in mine galleries and dugouts which have been fouled by poisonous explosion gases. (See par. 171.)

22. Two types of oxygen breathing sets have been used in the present war:

(a) Apparatus containing a reserve supply of oxygen under pressure. This is the co-called "oxygen helmet," often used in mine rescue work. The main features of the apparatus consist in:

(i) A rubber bag or bags into which and from which the wearer breathes.

(ii) A steel cylinder or cylinders containing compressed oxygen which feeds into the bag through a reducing valve.

(iii) Several pounds of sodium hydroxide in the form of sticks, granules or plates, carried either in the rubber bag or in a metal box connected with it. This alkali absorbs the carbon dioxide exhaled.

Apparatus of this type, known as the "Selbstretter," is still in use by the Germans for rescue work, but with limited distribution, as follows:

Infantry Company ....................... 3
Pioneer Company ....................... 25
Battery .................................. 3
Medical Company ....................... 20

For each apparatus a reserve oxygen cylinder and a reserve potash cartridge are kept in the dugouts. The apparatus of this type used by the British is called the "Salvus set" and is now reserved entirely for mining operations.

The complicated nature of this type of apparatus, its weight and the necessity of reserve cylinders of oxygen will prohibit its general adoption and limit its use to special conditions.

(b) Apparatus in which oxygen is generated from a chemical
Fig. 2.

The P. H. Helmet.
Fig. 3.

- Method of Wearing the P. H. Helmet.
GAS WARFARE

A mixture of potassium and sodium peroxides is used in this apparatus. The moisture in the breath of the wearer liberates oxygen from the peroxides and the alkalis remaining absorb the carbon dioxide exhaled.

This method is very attractive, but in practice has a number of disadvantages. Among these may be mentioned the great amount of heat produced when oxygen is liberated from sodium peroxide by water vapor, and the foaming of the material and the resulting blocking of the air ducts.

To these may be added most of the disadvantages under (a). An apparatus of this type has been used, however, by the French.

(D) OTHER EARLY METHODS.

23. When gas defense methods were first beginning to be organized, a number of procedures were recommended for combating the gas cloud. Among them were the building of fires on the parapet, and the use of black powder hand grenades or high explosive shells, to be thrown into the cloud. Such projectiles are useless for dissipating the gas cloud or reducing its noxiousness. Infantry fire is, of course, valueless.

For a long time the Germans placed great reliance on the use of fires for raising and dissipating hostile gas attacks. These fires were built in the firing trenches or in special shallow trenches dug in front. Experiment has shown that this method is useless for combating a gas cloud and the Germans have now given it up.

III. PRESENT-DAY MASKS.

(A) THE AMERICAN RESPIRATOR.

24. With the exception of certain minor changes the respirator adopted for use in the American Army is essentially the small box respirator used by the British.

The following are the important features of this respirator:

(a) The wearer inhales and exhales through the mouth, the nose being closed.
Fig. 4.
Rubber Sponge Goggles.
Fig. 5.

The Box Respirator.
Fig. 6.

The Elbow Tube.
(b) The inhaled air is purified by being drawn through a box of chemicals. These chemicals filter out the impurities.
(c) The exhaled air is discharged through a special valve provided for this purpose.
(d) To protect the eyes from lachrymators and to allow the wearer to speak when the face is covered with a mask.

The details of the respirator are shown in Fig. 5.

The Rubber Inlet Valve (A) is open while air is inhaled—closes when air is exhaled from the lungs.

The Canister (B) is a tinned iron box reinforced with ribs. It contains chemicals that absorb the poisonous gases. These chemicals are packed loosely to permit the passage of air through the canister and supported by the curved wire screen (C).

The Flexible Tube (D) is wired at one end to the canister and at the other to the elbow tube. The tube is corrugated to permit easy extension and prevent kinking.

The Elbow Tube (F) (see Fig 6) joins the flexible tube with the mouthpiece (H). It also carries the outlet valve (E). An important feature of this tube is the baffle (G), which acts as a saliva trap. This allows any saliva that may accumulate to escape through the outlet valve and prevents it from flowing into the canister with resulting deterioration of the chemicals.

The Outlet Valve (E) is made of pure gum rubber. During intake of air at A it remains closed. When air is exhaled, the pressure forces open two slits in the end of this valve and the expired air escapes. There also escapes through this valve some saliva, which, however, the wearer should not allow to escape from his mouth, but should learn to swallow.

A metal guard which encloses and protects the outlet valve has recently been added to the American respirator.

The Rubber Mouthpiece (H), through which the wearer breathes, is provided with a flange which is held between the teeth and the lips. The mouthpiece can be removed from the mouth to enable the wearer to speak without disturbing the fit of the mask.

The Noseclip (I) consists of two rubber pads held by a wire spring. It closes the nostrils, thus making it impossible
to breathe any air except that which has passed through the canister into the mouth.

The Eyepieces (J) are made of celluloid or of specially prepared glass. They should be treated with anti-dimming composition to prevent their becoming clouded by the deposition of particles of moisture. If necessary they can be cleaned without removing the respirator by means of folds in the material.

The Facepiece (K) is a rubberized fabric impervious to gases. It fits closely at the sides and is held in position by the elastic bands, which pass over the head to the full extent allowed by a non-elastic retaining tape.

25. The complete respirator is carried in a special satchel which is divided into two compartments—one of which holds the canister and the other the mask. The canister rests on a wire platform which raises it from the bottom of the satchel and allows the free access of air.

Each man is provided with a respirator which has been fitted to his face. He must be made to realize that this appliance is PERSONAL EQUIPMENT, that it is of IMPORTANCE SECOND ONLY TO HIS WEAPONS, AND THAT HIS LIFE MAY DEPEND ON LOOKING AFTER IT AND KEEPING IT IN GOOD ORDER.

The respirator will protect the wearer against all poisonous gases with the exception of mine and explosion gases, and will not become exhausted for hours, even in concentrations of gas normally unobtainable in the field.

In order that the mask may fit the face closely, every man must be clean shaven except that he may wear a moustache.

26: Method of Use.—The satchel containing the box respirator is carried outside all other equipment. When over two miles from the front line it may be worn slung over the right shoulder, but men in the trenches or proceeding thither must carry it slung on the chest, as in the “Alert” position. The flap of the satchel with the snap fasteners must always be toward the body.

It must be remembered that the box respirator can be worn in gas for many hours on end without losing its efficiency or causing any distress. It may be breathed through in drills for a period of one hour per week for an indefinite time without impairing its efficiency. This is in addition to initial drills when the respirator is first issued and fitted.
Fig. 7.

Fastening a New Canister to the Flexible Tube.
Fig. 9.

The French M-2 Mask (Front View).
Fig. 10.

The Tissot Box Respirator.
Fig. 10B.
The Russian Respirator
27. Local Repairs.—A small repair outfit, consisting of pieces of adhesive plaster, is included, with a record card, in each satchel.

Small perforations in the facepieces can be temporarily repaired by applying pieces of the adhesive plaster to the perforation, both inside and outside the mask. They should be large enough to overlap the hole all around. Box respirators so repaired should be exchanged as soon as possible. The repair is only intended to make them safe until a new respirator can be obtained.

No other local repairs are permitted and all defective respirators must be handed in and new ones obtained.

Box respirators which have fallen into water must be exchanged as soon as possible.

28. Record of Use.—The correct keeping of records as to hours of use of the respirator by means of entries on the small card forming part of the repair outfit is a matter of the greatest importance, as these records form the only guide as to whether the canisters should or should not be replaced. Decision as to replacement is made on the advice of the Divisional Gas Officer. The approximate time during which the respirator is worn in shell gas or cloud gas must be correctly recorded. In order to allow for the total time during which a respirator has been breathed through, it should be assumed when estimating its condition that it has been worn for one hour per week for drill purposes.

29. Exchange of Respirator Canisters.—Exhausted or damaged respirator canisters should be replaced as follows:

(i) Remove the canister from the satchel, take off the adhesive tape from the lower end of the rubber tube, and carefully lever off the latter by means of the special tool provided for the purpose. Great care must be taken not to injure the rubber in doing this.

(ii) Remove the plug from the neck of the new canister, wet the neck slightly and insert it in the rubber tube, the end of the tube coming right down to the shoulder of the canister. See that the canister lies in the correct position so that the tube will not be twisted when the facepiece is put on.

(iii) Bind the rubber tube to the neck of the canister by
means of the string provided, in the manner shown in Fig. 7. The end (B) is caught up in a long loop and the string wound tightly round the neck in an upward direction. Pass end A through the loop, then pull B down tightly and tie A and B in an ordinary reef knot.

(B) FRENCH MASKS.

30. THE M-2 MASK.—While certain types of box respirators have been used in the French Army for special purposes, the main protection at present is obtained from the type (M-2) illustrated in Figs. 8 and 9. This consists of a mask made of a number of layers of muslin impregnated with various absorbent chemicals. It fits the face tightly and as a consequence the inhaled air can only be obtained by drawing it in through the pores of the impregnated fabric. There is no outlet valve. The exhaled air must make its escape through the fabric. The eyepieces are made of a special non-dimming celluloid.

The front of the respirator is protected by a flap of waterproof fabric, which protects the mask from rain and consequent deterioration of the absorbent chemicals.

This mask is at present used as a reserve by the American Expeditionary Forces for the convenience of troops in the "Precautionary Zone," i. e., within 5-12 miles of the front line.

31. TISSOT BOX RESPIRATOR (Fig. 10).—The Tissot apparatus, which is issued by the French Army to artillerymen, stretcher bearers and certain other specialists, is a box respirator based on the filter principle. It consists of a canister, a rubber mask and a tube for connecting these two, the canister being carried on the back.

It differs from the American and British respirators in the following particulars:

The wearer can breathe through the mouth or the nose, consequently there is neither mouthpiece nor noseclip. The inhaled air enters the mask from two tubes which open directly under the eyepieces and allow the air to sweep across them. This prevents moisture from condensing on the eyepieces, so that the vision is not clouded. The exhaled air escapes through a simple outlet valve.
DEFENSE AGAINST GAS ATTACKS

32. The Tissot mask has the following advantages:
The facepiece is tight and comfortable.
The eyepieces do not become dimmed.
There is no difficulty in speaking, since there is no mouthpiece.
It suffers from the following disadvantages:
The wearer depends entirely on the fit and strength of the facepiece. If this leaks around the edges or becomes ruptured he becomes a casualty.
The canister is heavy and not easily carried.
The whole apparatus is too complicated and fragile to trust in the hands of the average soldier.

(C) THE ITALIAN MASK.

This mask, which is shown in Fig. 10A, is a modification of the French M-2 type. It is kept in a tin box which can be carried at the slung position by means of a cord.

(D) THE RUSSIAN RESPIRATOR.

32b. This mask, which is shown in Fig. 10B, consists of a box canister to which a rubber face piece is attached direct. The face piece has neither mouthpiece nor nose-clip. It is also not provided with retaining tapes. It is made of a good quality of rubber, with a considerable amount of elasticity so that it fits the face tightly. When worn in position it completely covers the top of the head, the face and the ears. The canister, which is filled with charcoal, is provided with an inlet and an outlet valve, both of which are shown at the bottom. When not in use these valves are covered with rubber caps. The mask is very uncomfortable. In numerous instances soldiers have been so discommoded by it that they have removed it in gas.

(E) THE GERMAN RESPIRATOR.

33. The German respirator is similar to the American type in that the inhaled air is purified by passage through a canister filled with chemicals. There is a facepiece, but no noseclip, mouthpiece nor valves. The exhaled air passes out through the canister, which is attached directly to the facepiece. Figs. 11 and 12 show the latest type of German mask. The facepiece is made of leather. The elastic bands of the British and American masks are replaced by small spiral steel springs encased in cloth. The eyepieces are of glass
GAS WARFARE

provided with a gelatin disk to prevent dimming. Each soldier is furnished with several spare disks. The eyepieces are further protected by a light metal frame, easily seen in the right eyepiece of Fig. 11.

The canister screws on to the facepiece, thus permitting each soldier to carry an extra one for emergency. The canisters issued with the first masks contained but one layer consisting of granules of baked earth saturated with potassium carbonate and covered with fine charcoal. Later another layer of charcoal was added, and the present canister, of which a cross section is shown in Fig. 13, contains three layers. The Urotropine in layer C absorbs phosgene. A detailed description of this respirator is given in pars. 50-60.

34. In comparison with the American respirator the German mask suffers the following grave disadvantages:

(a) The absence of noseclip and mouthpiece forces the wearer to depend entirely on the fit of the facepiece and on its freedom from tears, holes, etc.

As a consequence a flaw or a hole in the fabric or an opening between the face and the edge of the mask means that the wearer becomes a casualty.

(b) The existence of a considerable "dead" space which forces the wearer continually to breathe a certain amount of his own expired air. This causes an increased rate of breathing (with consequent greater danger of passage of gas) and discomfort, owing to increased pulse and body temperature.

(c) Deterioration of the chemicals in the canister, due to the continual passage of expired air.

(d) Mechanical difficulties caused by the canister being hung from the facepiece. The weight of the canister tends to pull the mask away from the face.

(e) Permeability of leather to certain gases.

(f) Shorter life, owing to smaller canister.

(g) If leather becomes wet it tends to dry hard and the mask will not fit.

35. NEW GERMAN ANTI-GAS APPLIANCE.—A new emergency device for gas defense which has recently been developed by the Germans is shown in Fig. 14. It consists of a mouthpiece, with an adapter which can be screwed to the breathing drum of the German respirator. A wire noseclip is attached by a cord. The mouthpiece is made of
CANISTER OF GERMAN RESPIRATOR

PERFORATED SHEET IRON LID.

SHEET IRON CUR

IRON WIRE DISCS.

COARSE MESH SCREEN.

A-Granules of baked earth soaked in Potassium carbonate solution and covered with powdered charcoal.

B-Charcoal.

C-Pumice stone mixed with Urotropine.

Fig. 13.
Fig. 14.
New German Anti-Gas Device.
enamel metal (probably owing to shortage of rubber), and is similar to that used by the enemy with the Draeger oxygen breathing apparatus (Selbstbretter).

The appliance is intended:
(a) For the use of observers and gun layers, who require full use of their eyes.
(b) As an improved method of using the spare canister when the first becomes exhausted.
(c) For attachment to the spare canister when hung round the neck, so that immediate protection can be obtained in case of a projector attack.

The disadvantages of the appliance are:
(i) It affords no protection against lacrymatory gas without the use of goggles.
(ii) It is unsuitable for men on the move, as there is little support for the canister.

36. GERMAN GAS DEFENSE APPLIANCES.—Translation from Orders of the 3rd Bavarian Infantry Division, 1917.)—All our troops are now supplied with the Army Mask. This is a face mask and covers only the face and not the whole head; consequently the space between the head and the mask—the so-called "dead space"—is very small. The smaller the dead space the easier it is to breathe.

The Army Mask provides complete and lasting protection against both our own and hostile battle gases. The air which is breathed through the mask is filtered from all harmful mixtures.

37. From the nature of the mask—i.e., an air filter—it is limited in its application: the mask must not be put on for use in places in which there is insufficient oxygen for normal breathing, for example, in gassed mine galleries and mine shafts. In these cases the oxygen breathing apparatus provided for such personnel is used.

38. The principal components of the mask are the facepiece with its mouth ring, and the canister (Einsatz); other accessories are the carrying tape for hanging the mask around the neck and the elastic head bands, especially arranged for holding up the canister in front of the mouth.

The facepiece consists of an impervious material which by treatment with rubber solution is rendered absolutely gastight. There are three openings in the facepiece, two of which are fitted with metal rims for the eyepieces, and the
third for the mouth ring. The mouth ring is fitted with a threaded socket containing a washer. The canister can be screwed into this socket.

39. The facepiece becomes useless when it is defective, either in the material, in the sewing, the eyepieces, or the mouth ring. The following are the chief defects:

A. In the Fabric:
   1. Holes.
   2. Tears.
   3. Abrasions.
   4. Faults in weaving.
   5. Poorly rubberized.
   6. Rust, oil or fat spots.

B. In the Sewing:
   1. Folds not sewn in.
   2. Varnish broken off in such a way that the actual stitches are visible.

C. In the Eyepieces:
   1. Cracked or broken windows.
   2. Windows so loose that they shake about.
   3. Made gas tight with shellac instead of pressure.
   4. Rough edges on frame.

D. In the Mouth Ring:
   1. Holes in the metal.
   2. Bad screws.
   3. Rubber washer missing.

All the above named defects influence in a greater or less degree the tightness of the mask. It is frequently found that the presence of one or the other of these faults shows the mask to be useless only after lengthy exposure in a gas attack. Masks with even one of these defects must immediately be discarded for use in the field.

The final decision as to whether or not a mask is suitable for use in the field can be made only as the result of testing in gas chamber.

40. The canister consists of a light pressed metal case which contains the materials for absorbing and fixing the gas. As the canister contains three different materials, in three layers, it is known as the "Three Layer Canister." All canisters of later date than 1-6-16 are termed "Leichtatmer." In such canisters the resistance is 50 per cent. lower than in the previous three-layer canister.
41. One canister will protect against gas attacks of many hours' duration. If it falls into water, or is exposed for a very long time in moist air, it becomes useless, because the resistance to breathing is then too great. The wire gauze in the canister rusts because of the moisture, and this stops up the meshes, thus making it very difficult to breathe. For this reason the canister must be tested every three months with a special apparatus for measuring the resistance to breathing.

All canisters that rattle when shaken, or in which the rim of the perforated cover has become so loose that the cover can be turned or removed, must be discarded.

All canisters which have allowed even the slightest trace of gas to come through, during a smoke or gas attack, or when in the gas chamber, and also canisters which have been used for practice, must no longer be employed during an attack.

42. The life of the canister for use in the trenches must be the maximum. The method of carrying the mask depends on the danger of a gas attack. Outside the danger area, the mask is carried in the canvas container; the mask with one canister tightly screwed in, being placed in the gas alert box, and this together with the spare canister placed in the canister holder. The latter must be so worn and affixed to the equipment that it can be easily opened and the mask quickly taken out. Within the danger zone the mask with the canister in position is carried in the gas alert box, which is suspended over the shoulder.

43. In the "extreme" gas alert period the mask is carried by the carrying tape only. During rainy weather care must be taken to protect the canister from becoming wet. When the mask is carried in this way, smoking must be absolutely prohibited, as the blowing of sparks or hot ashes may burn holes in the material or damage the rubber.

The "extreme" gas alert period is ordered when it is probable that there will be a hostile gas attack and especially in places where the gas cylinders are built in and gas projectiles (shells and bombs) are stored or carried.

44. The putting on or taking off of the mask is to be done with great care. Everyone must be able to put on his mask quickly and correctly in six seconds. Too vigorous adjust-
ment of the mask should be discouraged, as it is apt to damage the mask. It is best that the adjustment be made in separate movements which follow in quick succession. Every movement must be made cool and collected. The correct method of putting on the respirator must be drilled into the men so that it becomes first nature to them.

45. The anti-gas mask must be regarded as part of the permanent equipment of a man. In order to avoid a dangerous change each man must write his name on the mouth ring, on the gas alert box and on the canvas container. It must not be written on the fabric of the mask, as thereby its tightness against gas might be affected.

46. It must be made perfectly clear to each man that his gas mask fits him, and him only; that it is his sole protection against enemy gas, and that only a mask of which the various parts are in perfect condition is sure to give protection. The gas mask is a more delicate instrument than the rifle; it must therefore be looked after even more carefully.

47. A defective mask is more dangerous to its owner than none at all. A man without a gas mask can protect himself to a certain extent, but one with a defective mask believes that he is protected and consequently becomes a casualty. By means of training, each man must be made to realize the importance of his gas defense equipment. He must look after them, inspect them, and immediately report all defects or losses.

48. In the front line the gas mask must be carried everywhere—when on sentry duty, when in working quarters, or engaged in carrying or in marching. In this way it is possible to be absolutely prepared against a "surprise gas attack," and only thereby are the dangerous exchanges of masks avoided.

49. Men wearing spectacles must remove their glasses before putting on a gas mask unless they are provided with specially protective spectacles, fastened with tape, as otherwise gas would be likely to penetrate at the point where the bows pass between the edge of the mask and the head. The glasses can be prevented from dimming by previously breathing on them.

A man with a damaged ear-drum must stop the particular ear with wadding, so that no poisonous gas penetrates
through the walls.

50. LEATHER MASKS.—(Translation of Extracts from a Captured Document dated 6th June, 1917. Issued by the German War Ministry.)—Leather is used for making the mask because it is effective in the field and supplies are available.

It is rendered impermeable to gas by treatment with oils. The stiffness of the leather ensures that the facepiece remains open when mask is withdrawn from the box; its adjustment is thus facilitated.

51. As wiping folds are excluded, owing to the stiffness of the leather, anti-dimming discs are provided, which are attached to the inside of the eyepieces. The mask functions without these discs, as they have no protective importance.

52. The dead space in the leather mask amounts to only half that of the rubber mask, owing to the absence of the wiping folds. A further decrease in the dead space is affected by the process of the “tying up” of the mask, which practice must always be carried out. A length of string, for this purpose, is attached to each mask and runs from the mouth ring, between the eyepieces and to the back of the head, serving to raise the drum.

53. For technical reasons the eyepieces are situated somewhat obliquely to the axis of vision, contrary to the rubber mask, and, further, are fitted with stronger rims set farther apart.

The field of vision directly before the face is consequently somewhat diminished, owing to the outer ring of the eyepieces. This has no importance when both eyes are used when one eye alone is used, as in aiming, etc., the difficulty of vision is obviated by: (a) practice and (b) the process of “tying up,” mentioned above, which reduces the obliquity of the eyepieces.

The Eyepieces in the leather mask differ from those in the rubber mask, owing to the introduction of the anti-dimming discs.

54. The impermeability of the mask is, however, previously insured by the “Cellon” eyepieces, which are protected on the exterior by a metal flange. On the inside there is a screw thread for taking a zinc ring to clamp the anti-dimming disc. This zinc ring is fitted with a wire grid to protect the disc. This grid may be partially or wholly removed.
in exceptional cases, where men wearing spectacles complain of pressure on the nose.

55. The Anti-Dimming Discs consist of detachable, circular discs, with up-turned edges, of approximately similar diameter to the Cellon eyepieces. They absorb moisture by gradual swelling up and softening at the same time, without becoming opaque. Even when the mask is worn uninterruptedly for six hours, these discs ensure perfectly clear vision, and after that lapse of time the dimming only sets in gradually. (The period varies according to the temperature and time of year, likewise on the nature of the work on which the wearer is employed at the time.) On exposure to the drying action of the air, the discs give up the moisture absorbed and can thus be used continually.

56. Moisture on the discs produced by respiration should be poured off inward, in order to facilitate the drying of the mask and to avoid unnecessary use of the discs. Discs which have become opaque will be changed, but not during a gas attack. While being changed they must not be exposed to the action of rain. They are to be held by the edge, and the eyepieces must be kept horizontal, so that the discs (when clamped) lie in the middle.

57. The mask is issued, for use in the field, with anti-dimming discs already fitted; there are, besides, in a special receptacle in the lid of the box, four pairs of anti-dimming discs, each pair contained in a waterproof envelope. The discs must be so inserted that their upturned edges lying toward the interior of the mask, the lettering on them may be read. In screwing up the zinc ring the rough rim is to be gripped, and not the protective grid.

58. Treating and Testing of Leather Mask.—By kneading the leather with the fingers undue pressure on the chin, owing to the stiffness of the leather, may be reduced.

In taking the mask out of the box, light spots are often noticeable, near which the oil has oozed out. The oil should be rubbed in again and the spots will disappear. Parts of the leather, which have become soiled with grease, must not be wiped with cloth or paper. Re-oiling of the leather is forbidden. The leather stands well against any wear caused by frequent usage. Leather through which light shows is faulty, likewise leather which is half frayed through. If the interior of the leather facepiece has become as rough in texture as
the exterior, the mask is to be changed.

59. While slight defects on the outer edge of the mask are of no importance, defects in the lacquer on the seams render the mask faulty. Faults in the seams of the eye and chin-pieces—i.e., gaps in, or fraying of, the lacquer—also interfere with protection. Particular attention is to be paid to those parts of the seams which run under the eyepieces and mouth-ring.

60. The leather mask with drum is carried in a somewhat larger box, fitted with a double catch to lid (the ordinary press catch and a wire clip).

The use of the canvas wallet is discontinued. The spare drum is carried in a small wallet attached to the belt, and is protected against dirt and damp by a metal cap, which screws into the mouth aperture, and by an easily removable cardboard disc inserted at base of drum.

61. RESISTANCE OF RESPIRATORS TO THE PASSAGE OF AIR.—The facility with which air passes through the canister of any of the types of box respirators is obviously of importance from the standpoint of ease of breathing. It is, however, absolutely no indication of the absorbing capacity of the chemicals in the canister. It has been shown that a freshly filled canister may have much the same resistance to the passage of air as one that has been discarded because the chemicals are no longer active.

62. A field apparatus used by the Germans for measuring the resistance of their canisters is shown in Fig. 15.

The apparatus consists of a box with a socket in each end, into which the canister can be screwed. One of these canisters (S) has the standard resistance; the other (X) is the one to be tested. The canisters are connected with a tube (A). This tube is in turn connected with a manometer (B), which is simply a capillary tube containing a liquid. Air can be forced into the system at (A) by means of an ordinary bicycle pump (P). If the resistance in (X) is greater than the standard, the liquid in the manometer will move to the right. If it is less, it will move to the left. Canisters in which the resistance is higher than that of the standard are withdrawn from use.
Fig. 15.
Apparatus for Measuring the Resistance of Canisters.
Fig. 16.

Rattle for Giving Gas Alarm.
IV. ANTI-GAS APPLIANCES FOR GENERAL USE.

(A) ALARM APPLIANCES.

63. GAS SHELL AND LOCAL ALARMS.—A local gas alarm must be fitted up at every sentry's post, occupied sap, battery position, etc., for the purpose of rousing men in the immediate vicinity and conveying warning to the sentries in charge of long-distance cloud-gas alarms.

These local alarms should be used for all forms of gas attacks and are particularly useful for giving notice of the use of gas shells. No reliance can be placed on devices giving the alarm involving the use of the lungs—e.g., bugles or whistles.

No standard pattern has been adopted for these local alarm devices. Klaxon horns, gongs (shell cases), large bells, 2-ft. lengths of steel rail or triangles made of steel rail and policemen's rattles (see Fig. 16) are all in use. Klaxon horns are generally unobtainable in sufficient quantity. Shell cases are usually too weak and triangles too cumbersome. The best alarms undoubtedly are the policeman's rattles, which are especially useful for employment at battery positions, and the lengths of steel rail and bells.

64. It is essential that gongs, steel rails, etc., be suspended in such a way that they swing free and do not rest or hit up against the parapet. Bells should be at least 7 inches in diameter at the base and should be fastened to a cross beam so that they do not sound when brushed against. They should be rung by pulling the clapper, as a ship's bell. The great advantage is that they are complete in themselves and do not require separate strikers.

65. It has been suggested as a suitable alarm that a triangle of light steel be mounted in such a way that it can be beaten by working a treadle. It can thus be sounded by a sentry while he is putting on his respirator. The disadvantage of this and similar devices is their cumbersome nature, difficulty of provision in very large numbers and the possibility of their getting out of action under service conditions.

66. For the purpose of rousing men in dugouts it is a good plan to have a bell installed in the dugouts which can be
Fig. 17.

Strombos Horn.
DEFENSE AGAINST GAS ATTACKS

worked from the outside by the sentry responsible for warning the occupants.

67. CLOUD GAS ALARMS.—Experience in recent gas cloud attacks has shown that compressed air sirens like the Strombos horn are the most effective devices for conveying the alarm to troops in support and reserve lines and in billets behind the trenches. Strombos Horns are audible for very long distances and are intended for use only when it is certain that a cloud gas attack is being made.

68. The Strombos horn (see Fig. 17) is issued in a box containing one horn, two compressed-air cylinders, one length of rubber tubing with butterfly screw connections, one screwdriver and one gimlet. A third cylinder is issued with the horn, to be kept at the Divisional or Brigade Headquarters, to replace used cylinders without delay. An extra reserve of charged cylinders is also kept at the refilling stations.

69. Method of Use.—Strombos horns should be in the front line at intervals ordinarily not greater than 400 yards apart and at such other points behind the front, as required, to ensure transmission of warning. In back areas they should, if possible, be installed at places connected with the telephone, so that telephonic confirmation of the alarm may be obtained before the horn is sounded, thus avoiding the disturbance consequent on a false alarm.

70. The horn should be mounted in a horizontal position by screwing to the outside of the case or to some other suitable support, and must be protected as much as possible from rain or shell splinters. If possible, it should be so located that it has a clear field of sound to the rear and does not blow straight into the parados. Should it be necessary to change its position, the horn should be fixed in the box by means of the butterfly nuts provided. Strombos horns must always be ready for use, the horn being connected to one of the compressed-air cylinders by the rubber tube. The union joints at both ends of the tube must be tight.

71. TO SOUND THE HORN, UNSCREW THE SCREW CAP ON THE AIR CYLINDER TWO COMPLETE TURNS. The horn will sound for about one minute.

Immediately after use, couple up the horn to the second air cylinder and leave it ready for use in case of a second
gas cloud. The used cylinder should be clearly marked
EMPTY and replaced as soon as possible from the reserve.
Should it be necessary to use the second cylinder before the
first one is replaced, the horn should be sounded for only
20 seconds at a time.

72. Replacement and Repair.—The pressure of the cylin-
ders must be tested under arrangements made by the Divi-
sional Gas Officer once every week and defective ones re-
turned for recharging.

On no account is any adjustment of the horn to be at-
tempted except by the Divisional Gas Officer or his trained
Divisional Gas Non-Commissioned Officers. A horn may be
thrown completely out of action by movement of any of its
parts.

Damaged horns must be sent back immediately for re-
pairs.

(B) PROTECTION OF SHELTERS AND DUGOUTS.

73. It is most desirable that dugouts should be rendered
proof against gas if possible. Such protection is effected if
all entrances are closed by well-fitting doors or by wet blank-
ets or similar material. Doors and frames covered with
blankets are generally unsatisfactory because of the wood
warping and not providing a gas-tight joint.

Blankets moistened with water or with a dilute solution of
glycerine allow very little gas to pass through and protec-
tion then depends on getting a good joint at the sides and
bottom of a doorway, so as to stop all draughts. If two
blankets are used with an air space between them, complete
protection can be obtained.

74. The following methods of fitting blankets have been
found to give good protection and to allow the entrance to
be used during a gas attack:

METHOD I.—Two sloping frames made of 4-in. by 1-in.
boards and covered with blanket material are fitted to the
outside and inside of the entrance of a dugout at an angle of
15 degrees or 20 degrees with the vertical, as shown in Figs.
18 and 19. Blankets cut to the proper size are nailed to the
top of the frames with a lath to prevent tearing. The blank-
gets overlap the edge of the framework by two or three
inches and hang with about nine inches resting on the ground.
Fig. 18.

Protection of Dugouts.
Fig. 19.

Protection of Dugouts.
Three small weights are tied to the side of the blanket, and a roller is fixed on the outside about three inches from the ground, so that the blanket hangs closely to the wooden frame. The blankets should be not less than two feet apart to allow a man to stand between them and adjust one before raising the other. The distance should be increased for Aid Posts and Dressing Stations to allow stretcher cases to be brought in.

When not in use the blankets should be rolled up and held so that they can be readily released.

**75. METHOD II.**—In many cases such a projecting framework cannot be fitted conveniently. In these circumstances a flat framework of 4-in. by 1-in. board, covered with blanket material, should be fastened flush with the wall, and the blanket curtain must be cut to reach the wall, and not to overlap the frame. It must be kept extended by three wooden laths. While the blanket is rolled up the bottom of the frame should be protected by a metal step (see Fig. 20). Figure 21 shows a similar arrangement on the stairway of a mine dugout. The blankets should be sprayed with water or with a dilute solution of glycerine (e.g., from a Vermorel sprayer, see Fig. 22). If they dry, they should be re-sprayed.

**76.** Everyone must be taught how to use gas-proof dugouts—e.g., how to enter a protected doorway quickly, replacing the blanket immediately, and carrying in as little outside air as possible.

The protection afforded by these means is just as complete against lachrymatory and mustard gases as it is against cloud gas and poisonous shell gases.

**SHELTERS WHICH SHOULD BE PROTECTED.**

**77.** The following should always be protected:

Medical aid posts and advanced dressing stations; Company, Regiment and Brigade Headquarters; at least one dugout per battery position; Signal Shelters and any other place where work has to be carried out during a gas attack.

In addition to the above, it is desirable to protect all dugouts, cellars and buildings within the shell area, and this should be proceeded with as soon as the essential shelters mentioned above, have been fitted. It should be noted, however, that the protection of dugouts for troops in the front
Fig. 20.

Protection of Dugouts.

Blanket rolled and kept up by a string.

4 in. frame covered with blanket lying flush to tunnel wall.

Metal step protector.
Fig. 21.

Protection of Dugouts.
Fig. 22.
Method of Keeping Blankets Moist.
Fig. 23.

Trench Fans.
line of trenches is usually inadvisable on account of the delay involved in getting men out in time of attack. It is desirable to protect stretcher bearers’ dugouts with a view to putting casualties in them.

78. VENTILATION OF DUGOUTS DURING A GAS ATTACK.—Pumps of various types have been suggested from time to time as a possible means of ventilating dugouts during a gas attack or clearing them subsequently. In the former case the intake of the pump is connected with a filter bed of earth by which chlorine, etc., is removed from the incoming air. The pumps may be operated by hand or by electric motors.

It is obvious that difficulties of transportation, installation and operation seriously limit the value of such devices, and up to the present, artificial ventilation has not been found necessary.

79. No standard method has been adopted by the Germans for the protection of dugouts, though important shelters are fitted with blankets or with a “Schutzsalzdecke”—a kind of quilt stuffed with peat moss and moistened with potassium carbonate solution.

(C) CLEARING GAS FROM TRENCHES AND DUGOUTS.

80. It is essential that no dugout be entered after a gas attack, except with respirators adjusted, until it has been ascertained that it is free from gas. Clearing gas from dugouts, etc., was previously done by spraying with hypo and soda solution.

81. The use of Vermorel sprayers for clearing gas has been given up. The hypo solution originally used against chlorine has very little effect on phosgene, and even with the addition of hexamethylene tetramine it cannot be relied upon to remove this gas from the air when present in appreciable quantity. Sprayers have consequently been withdrawn from general use and are now employed only for moistening the blankets of protected dugouts. The only efficient method of clearing shelters from gas is through ventilation.

82. An appreciable quantity of gas may be retained in the clothing of men exposed to gas attacks and also in bedding, coats, etc., left in shelters. Precautions should, therefore, be
taken to air all clothing.

83. NATURAL VENTILATION.—Unless a shelter has been thoroughly ventilated by artificial means, as described below, it must not be slept in or occupied without wearing respirators, until at least twelve hours have elapsed. It must not be entered at all without respirators on for at least three hours. The above refers to cloud gas attacks. In case of gas shell bombardments the times cannot be definitely stated, as they depend on the nature of the gas used and the severity of the bombardment. With mustard gas and with lachrymatory gases the time after which shelters can be used without discomfort may be considerably longer than those mentioned above.

84. 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 of 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, one pound of dry wood per 100 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., the split wood, newspaper, and a small bottle of paraffin for lighting purposes—should be kept in a sandbag enclosed in a biscuit tin provided with a lid. An improvised brazier should be kept ready for use.

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

85. VENTILATION BY FANNING.—Dugouts can be ventilated by producing air currents in them by means of
special anti-gas fans known as Canvas Trench Fans.

The 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. (See Fig. 23.) The fan folds up into a small space, as shown in B.

METHOD OF USING CANVAS TRENCH FANS.

86. (a) CLEARING TRENCHES.—The fan blade is placed on the ground with the brace side downwards, 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. This drives a current of air along the earth and, on the top strokes, throws the gas out of the trench. 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.

87. In working round a traverse (Fig. 24), 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.

88. If several fans are available, men should work in a single file and with “out-of-step” strokes—i.e., one fan should be up while the next is down. (Fig. 25.) The alternative method shown in Fig. 26 may also be used.

89. (b) CLEARING SHELTERS.—In the case of a dug-out with a single entrance not exceeding 12 feet in length, the gas is first cleared from the neighborhood of the shelter as in par. 86 and then the corners worked round as in par 87. The worker now advances 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.

90. If two men are available they should take up positions outside the entrance facing each other and slightly toward
Working around corner of a traverse
Dispersal of gas in trenches — "out of step" method

Fig. 25.
Dispersal of gas—alternative method

Fig. 38.
Clearing a small unprotected dugout

Fig. 27.
Fig. 27A.

German Deodorizing Cartridge
the entrance. They flap alternately, striking inward and slightly downward, as shown in Fig. 27. These movements force in a current of pure air at the bottom of the entrance, the gas being forced out at the top.

91. 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 par. 87. 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.

92. If no anti-gas fans are available, ventilation can be assisted by flapping with improvised fans such as sandbags, ponchos, etc.

93. GERMAN DEODORIZING CARTRIDGES.—In cases where it is impossible to clear gas quickly from dugouts by ventilation, the Germans make use of "deodorizing cartridges" (Entstänkerungspatronen), which are fired into the dugout from a flare pistol. These cartridges are of two kinds, marked E-I and E-II, and containing respectively 7 grams of dimethyl aniline and a mixture of dimethyl pyridines. For poison gas one of each type of cartridge is fired, but for lachrymators E-II only is used.

This method of clearing dugouts is rather unsatisfactory and the Germans do not place much reliance on it. The atmosphere left after explosion of the cartridges is still irritant and must be cleared by ventilation, but it is claimed by the Germans to be non-poisonous.

Fig. 27A shows a cartridge used for this purpose. These cartridges are also used with a glass bulb filled with lachrymator for the purpose of producing a lachrymatory atmosphere in chambers used to test the fit of respirators.

(D) PROTECTION OF WEAPONS AND EQUIPMENT.

94. Arms and ammunition and the metal parts of special equipment (e.g., telephone instruments) must be carefully protected against gas by greasing them or keeping them completely covered. Otherwise, particularly in damp weather, they may rust or corrode so badly as to refuse to act. A
mineral oil must be used for this purpose. The following in particular should be protected:

95. SMALL ARMS AND SMALL ARMS AMMUNITION.—Machine guns and rifles must be kept carefully cleaned and well oiled. The effects of corrosion of ammunition are of even more importance than the direct effects of gas upon machine guns and rifles.

Ammunition boxes must be kept closed. Vickers belts should be kept in their boxes until actually required for use. These belt boxes should be made gas-tight, if necessary by inserting strips of flannelette in the joint between the lid and the box.

Magazines for light machine guns should similarly be kept in some form of gas-tight box.

A recess should be made, high up in the parapet if possible, for storing ammunition and guns. A blanket curtain, kept moist, as in the case of blankets for dugouts, will greatly assist in keeping the gas out.

96. HAND AND RIFLE GRENADES.—Unboxed grenades should be kept covered as far as possible. All safety pins and working parts, especially those made of brass, should be kept oiled to prevent their setting from corrosion by the gas. The rods also require the same treatment.

97. LIGHT TRENCH MORTARS AND AMMUNITION.—As far as the supply of oil permits, the bore and all bright parts of light trench mortars and their spare parts should be kept permanently oiled. When not in use, mortars should be covered with sacking or similar material.

Unboxed ammunition should be kept covered as far as possible and the bright parts oiled immediately after arrival. Ammunition which has been in store for some time should be used up first.

98. GUNS AND AMMUNITION.—The following precautions apply to medium and heavy trench mortars as well as to guns and howitzers:

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 fuses, or fuses which have been removed from their cylinders, should be wiped over with oil as soon as possible and protected with a cover.

99. SIGNAL EQUIPMENT.—The only effective method of preventing corrosion of electrical apparatus during a gas attack is to prevent the gas reaching it and the best way of doing this is to have Signal Shelters and Offices 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 receiver and hand-set out of the case. The backs of switch-boards and buzzer exchanges must be kept closed. All apparatus, such as magneto telephones, test boards, spare instruments, etc., which it is not essential to have uncovered should be well covered up with cloths, blankets or coats, etc.

(E) PROTECTION OF ANIMALS.

HORSES.

100. Horses can stand a higher concentration of gas than human beings without material damage, and it is not necessary, therefore, to protect them against cloud gas attacks at long distances from the trenches. Nor is it necessary to protect their eyes.

101. HORSE RESPIRATORS.—Horse respirators should primarily be supplied for transport animals and for artillery horses when they are sent to the vicinity of the trenches or to areas liable to heavy gas shell bombardment.

102. The American Horse Respirator, which is similar to the British, consists of a flannelette bag with a canvas mouth-piece which goes into the horse’s mouth and saves the flannelette from being bitten through. The bag is provided with an elastic band which passes round the opening so as to draw the respirator close to the face when in use. The
Fig. 28.

Horse Mask in the “Carry” Position.
Fig. 29.
Horse Mask in the "Alert" Position.
upper side of the mouth of the flannelette bag is furnished with a small unbleached calico patch by which the respirator is attached to the nose band of the head collar when in the "alert" position, and while in use. Inside the bag and attached to the canvas mouthpiece there is a canvas frame which is stitched on the bag in such a way as to prevent the material drawing into the nostrils when the respirator is in use. The whole is folded and carried in a canvas case provided with a flap, secured by three snap fasteners, and having two straps at the back by which the case is attached to the head collar.

103. CARRYING WHEN NOT IMMEDIATELY REQUIRED.—When not required for immediate use the respirator can be conveniently carried on the breast band or on the supporting strap of the breast band, as shown in Fig. 28. However, when carried, the case is steadied by being strapped on either side to the metal ring on the supporting strap, and its flap should be passed under this strap, between it and the wither pad, and buttoned as in the "alert" position.

104. ALERT POSITION.—When horses are being sent up to the trenches, the transport or other officer responsible should have the respirators adjusted in the "alert" position before moving off, as follows:

(a) The flap of the respirator case is unbuttoned and slipped under the nose-band of the head collar from below upward.

(b) The two straps at the back are also passed under the nose band and secured to the cheek pieces of the head collar, above the metal D on each side.

(c) The small unbleached calico patch on the upper side of the mouth of the respirator is buttoned on to the nose-band of the head collar so that the respirator is ready to be slipped on immediately in the event of a gas attack.

(d) The cover of the case is then closed over the nose-band, and the respirator is thus protected from rain, etc., and held in position on the nose-band. Fig. 29 shows a respirator in its case carried in the "alert" position.

In cases where the horse is galled by wearing the respirator in the "alert" position, as above, it may be advisable.
Fig. 30.
In the Gas Area.
Fig. 31.
German Box for Protecting Carrier Pigeons from Gas
to continue carrying it attached to the breast band. It must then be completely adjusted from this position for wearing in gas, as in par. 105.

105. WEARING IN GAS.—The respirator being carried in the “alert” position is adjusted for use as follows:

(a) The flap of the case is unbuttoned and the respirator removed, leaving the case attached to the cheek pieces of the head collar and lying flat on the face.

(b) The mouth of the bag is drawn down over the lip and upper teeth with one hand on each side of the mouthpiece, slipped into the mouth, and drawn well up to the angle of the lips.

(c) The elastic band is seized on either side close to the mouthpiece and pulled outward so as to draw the mouth of the bag tight around the upper jaw, above the nostrils, and is then slipped over the poll.

The respirator is then in position and the animal may be worked in it without difficulty or undue distress. The bit and reins are not interfered with in any way. (This is shown in Fig. 30.)

106. REPLACEMENT IN CASE.—In folding the respirator and placing it in the case ready for use the following points should be observed:

(a) The canvas mouthpiece should be wiped as clean as possible.

(b) The flannelette bag should be held with the canvas mouthpiece underneath and the elastic band placed over the top of the bag in such a way that when the canvas patch is buttoned on to the nose-band the elastic band has simply to be passed straight up over the face and over the poll. The bottom end of the respirator should then be tucked in and rolled up over the elastic band to make a neat roll for insertion in the canvas case.

107. GERMAN HORSE RESPIRATOR.—The form of horse respirator adopted by the Germans is a much cruder form of appliance and consists of a double nose bag stuffed with rags, etc., which is dipped into water before being drawn over the horse’s nose. When respirators are not available it is recommended that an ordinary nose bag filled with wet grass or straw be pulled over the horse’s head.

As far as possible the Germans remove their horses from
the Gas Zone. Those in stables are protected by making the stable doors gastight (with dung, wet cloths, etc.).

**CARRIER PIGEONS.**

108. British Method.—Special gasproof covers made of flannelette are provided for drawing over pigeon baskets. These bags are soaked in chemicals and are fastened by means of pull-tapes.

When the gas alarm is sounded, all baskets containing pigeons are placed in the special anti-gas bags or removed to gasproof shelters. If for any reason the birds cannot be protected from the gas, they are liberated at once. Anti-gas bags should always be kept near baskets containing birds, and should be regularly inspected.

109. Pigeons can be utilized during a gas attack. Experience has proved that they will fly through any gas cloud, but it is imperative that the bird should be exposed to the gas for as short a time as possible. The message and its carrier should, therefore, be prepared and if possible fastened to the pigeon’s leg before the bird is exposed to the gas. Twenty seconds should suffice to attach a carrier and liberate a bird.

110. German Method.—Special boxes are provided for carrier pigeons in which the ventilation is provided by holes at either end into which canisters similar to those used in the German respirator can be screwed. (Fig. 31.) In the event of a gas attack all that is needed is to screw a canister into either end of the box, which is thus rendered gas-proof.

(F) GAS DETECTORS AND SAMPLING DEVICES.

111. Detection of Gas.—Many types of apparatus have been devised and suggested for detecting poison gas in the atmosphere. Such devices are of two types:

(a) Those for detecting in advance a hostile gas cloud, so as to give quicker and automatic warning of its approach.

(b) Those intended for detecting gas in trenches and dugouts in order to determine when respirators must be put on or may be taken off.

112. Apparatus of the former type must be placed in “No Man’s Land” as near the enemy trenches as possible. No such device has been adopted for use, chiefly owing
DEFENSE AGAINST GAS ATTACKS

(a) To the danger of depending on an automatic device which may be destroyed or put out of order or may be tampered with by the enemy.

(b) To the fact that a really sensitive instrument requires frequent expert inspection which it is almost impossible to give under active service conditions.

113. Devices of the second type have also not been adopted chiefly owing to the difficulty of obtaining sufficiently sensitive detection of the most dangerous gases. The degree of sensitiveness of a gas detector must be such that it will show conclusively the presence of concentrations of gas which will be dangerous even only after long exposure. If it does not do this, or if it is liable to deteriorate or get out of order it acts as a trap to men depending on it and may induce them for example to remove their respirators too soon.

Up to the present time the most sensitive and safest method for detecting small quantities of gas is smell. This can be done without danger by any careful man who has attended a gas school.

114. Sampling Apparatus.—For the purpose of obtaining information as to the nature and concentration of the enemy gas used in attacks it is very desirable that samples be obtained.

In the case of gas shells, knowledge of the nature of the gas is generally readily obtainable from examination of blind shells, earth from shell holes, etc., but in the case of gas clouds, actual samples should be obtained. For this purpose two kinds of appliances are kept in the trenches, viz.: Vacuum bulbs and gas-testing tubes. These should be looked after by the Company Gas Non-Commissioned Officers, whose duty it is to take the samples, but officers should take all possible steps to ensure that samples of the gas are actually taken, as the information obtained may be of the greatest importance.

115. Method of Use.—The vacuum bulbs provided for taking samples of hostile cloud gases are strong glass vessels of the general shape shown in Fig. 32b. The capacity is usually about one litre. The air in these bulbs has been removed by means of a pump. One end of the bulb is drawn out to a point, and the glass here is so thin that on scratching it with a file the point is easily broken off. The air will
then rush in and fill the vessel and if it has been opened in a gas cloud attack it is obvious that a sample of the noxious gas will be obtained. The bulb can then be sealed and sent to a chemical laboratory for identification of the contents.

Samples of gas should be taken both in the fire and support trenches. The first sample should be taken about two minutes after the commencement of the attack and other samples at intervals during the attack.

The exact time and place should be noted on the form on the back of the box immediately after the sample is taken.

If, when the gas waves have passed, any bulbs remain unused, samples of air in unprotected dugouts should be taken before the latter are cleared.

Immediately after the vacuum bulbs have been used they should be taken under shelter.

116. Phosgene Detectors.—Various types of apparatus have been in use for detecting and estimating the concentration of phosgene in cloud and shell gas attacks. Most of these depend on the reaction between the phosgene and aniline water, which produce characteristic crystals of diphenyl urea. Others have been reactions showing a color change on specially prepared paper. In any case it is generally necessary first of all to remove any chlorine which may be present.

One such type of apparatus, as formerly used in the British Army, is shown in Fig. 32a.

After pulling out the small glass stopper air is pumped through the apparatus by squeezing the rubber bulb in the hand for ten minutes. If the number of times the bulb is squeezed is counted and recorded, useful information may be obtained by examination of the chemicals in the lower part of the tube. After the sample has been taken, the small glass stopper is replaced and the lid of the box put on at once, care being taken to avoid compressing the rubber bulb. On the label is noted the time and place at which the sample was taken.

V. ORGANIZATION OF GAS DEFENSE.

117. Officers are held responsible that all anti-gas appliances for protecting their men are maintained in perfect con-
DEFENSE AGAINST GAS ATTACKS

dition, and that everyone under their command is thoroughly trained in the use of these appliances and in all other measures which may affect his safety against gas.

118. The protective measures may be summarized as follows:

(a) Provision to each man of individual protective devices.
(b) Inspection of these appliances, training in their use and instruction in all other measures of gas defense.
(c) Provision of gas-proof shelters and dugouts.
(d) Weather observations to determine periods when the conditions are favorable to a hostile gas attack.
(e) Arrangement of signals and messages for immediate warning of a gas attack.
(f) Provision of appliances for clearing gas from trenches and shelters.

(A) ORGANIZATION OF ANTI-GAS DUTIES.

119. Everyone must be fully conversant with the measures to be adopted for defense against gas attacks as laid down in the existing orders of his formation or unit.*

120. Specialist Officers.—In order to provide efficient supervision of gas defense training, inspection of appliances, etc., and to provide readily available technical advice on all matters connected with gas defense, specialist officers are attached to headquarters of Corps, Divisions, etc.

The organization is practically identical in all the belligerent armies and allows for a Staff Officer (or an Officer attached to the Staff) at the Headquarters of Army, Corps and Division and for the appointment in each Regiment of a Regimental Gas Officer to be detailed by the Commanding Officer.

121. In the American and British armies, Gas Defense Schools are formed at Corps Headquarters for the purpose of training Officers and Non-Commissioned Officers in all defensive measures against gas attacks. (For training purposes in America a Gas Defense School is attached to each Division and is in charge of the Divisional Gas Officer.)

* For Standing Orders of American Expeditionary Force see Appendix
Nothing in the above organization, however, absolves officers in any way from the responsibility as laid down in paragraph 117.

(B) ANTI-GAS DUTIES WITHIN AN INFANTRY REGIMENT.

(To be modified for other units to suit their organization and duties.)

122. The Commanding Officer will be directly responsible for all measures against gas attacks, and will be assisted by the Regimental Gas Officer. Battalion and Company Commanders will be responsible to the Commanding Officer for all anti-gas measures within their battalions and companies.

123. In each Company one Non-Commissioned Officer, who has been trained at an Anti-Gas School, and who has been recommended as suitable for duty as “Company Gas Non-Commissioned Officer,” will be specially detailed to assist the Company Commander in anti-gas measures. At least one other similarly trained and recommended Non-Commissioned Officer will be immediately available to take the place of the Gas Non-Commissioned Officer in case of need.

A similarly trained Non-Commissioned Officer will be detailed to Regimental Headquarters for duty with Headquarter details.

124. The special duties of Gas Non-Commissioned Officers will be defined explicitly. No other duties will be performed that interfere with the gas duties laid down.

125. The selected Non-Commissioned Officers who attend the Gas Defense Schools will be reported on as follows: At the end of the course the Commandant of the School will, if the Non-Commissioned Officer is, in his opinion, suitable for duty as “Company Gas Non-Commissioned Officer,” notify the Commanding Officer to this effect. The latter will then cause the words “Passed Gas Defense School” to be entered in his service record. Only Non-Commissioned Officers who have been reported on favorably will be detailed for duty as Company Gas Non-Commissioned Officers.

126. Commanding Officers must facilitate in every way the duties of the Divisional Gas Officer and his Non-Commissioned Officers in visiting their lines and inspecting anti-gas
arrangements, testing Strombos horn cylinders, etc. They should take every opportunity of consulting with the Divisional Gas Officer on all technical questions relating to anti-gas measures within their lines.

VI. ACTION BEFORE, DURING AND AFTER A GAS ATTACK.

(A) BEFORE AN ATTACK.

127. Carriage of Respirators.—(a) Between five and twelve miles from the front line (the "Precautionary Zone") respirators or masks must always be carried. This is necessitated by the far-reaching effect of gas cloud attacks.

(b) Within five miles of the front line the box respirator must always be carried. Between five and two miles from the front line (the "Ready Zone") respirators may be carried in the slung position, but nothing should be worn to interfere with the immediate shifting of the respirator to the alert position. To make sure that the mask fits properly, every man while in this region should be clean shaven (except that a mustache may be worn).

(c) Within two miles of the front line (the "Alert Zone") and in areas exposed to gas shelling, the respirator must be worn in the "alert" position. In order that nothing shall interfere with quick adjustment, it must be worn outside all clothing, and nothing should be slung across the chest. The chin strap of the steel helmet should be worn on the point of the chin.

128. General Precautionary Measures.—The following action should be taken within the two mile limit:

(a) Respirators must be inspected daily.

(b) Daily inspection of all gas alarm appliances and other gas defense stores must be carried out. The entrances to gas-proof dugouts must be kept in good order and the blankets kept moist.

(c) It is a part of the duty of all sentries to act as gas sentries. They should consequently be provided with alarm appliances, to give warning of gas shell or gas cloud attacks. All sentries must be instructed in the method of using the Strombos horn.
(d) Each sentry group should be assigned a definite area to alarm in the event of a gas attack or bombardment by gas shells.

(e) Special sentries must be posted to give warning to men in dugouts.

(f) All working parties of ten or more men must have a sentry posted to give warning in the event of gas attacks.

(g) Precautionary measures must be taken to protect ammunition from the corrosive action of the gas.

(h) Stores of fuel must be kept available for clearing dugouts.

(i) Wind observations must be made by units in the line and sentries warned to be specially on the alert for signs of cloud gas whenever the wind is in a dangerous quarter.

129. In the area between two and twelve miles from the front the following precautions must be observed:

(a) All gas defense appliances must be inspected at least once a week.

(b) All sentries, traffic control men, military police, etc., when on duty must act as gas sentries and when considered necessary should be provided with suitable alarm devices.

(c) Men may be allowed to take off their respirators when sleeping, but they must keep them within reach.

(d) Arrangements must be made by Commanders of units and area Commandants to communicate a gas alarm to everyone in the danger zone.

130. Special Precautionary Measures.—(a) For Artillery.—Aiming points and aiming posts are likely to be obscured by gas clouds or smoke, and arrangements should therefore be made in every Battery to meet this eventuality by providing gun pits with means to check the line of fire if necessary, without depending on the use of aiming posts.

(b) For Tunneling Companies.—Tunneling companies are reminded that the respirator does not afford protection against mine or explosion gases.

Owing to the difficulty in clearing gas, especially lachrymatory gas, from mine-shafts and galleries, the entrances to mine-shafts should be protected from gas by blanket curtains.
in the manner already described for dugouts.

The enemy has occasionally attempted to render galleries untenable by the use of lachrymatory bombs in conjunction with the explosion of a charge. If this is done, the respirator must be worn if work has to be continued.

WIND OBSERVATIONS FOR CLOUD GAS ATTACKS

131. Dangerous Quarter for Winds.—On all stretches of enemy front there are only certain directions of wind which can be used for making cloud gas attacks. If the enemy trenches ran in a straight line from north to south, for example, a wind that blew north by east would be very likely to gas his own trenches, owing to slight changes in the wind and diffusion of gas cloud. There is therefore a factor of safety by which he must be governed. In the case just mentioned it would probably be an angle of 45 degrees with the general line of his own trenches. He would therefore only use winds blowing from NE to SE to make a gas attack.

132. The limits of wind direction are therefore governed by the general direction of the enemy’s line and the “factor of safety” which he is willing to adopt. For isolated stretches of front this is probably 45 degrees to the line of trenches, but it must be remembered that the enemy may be willing to take greater risks than this or to evacuate for the time certain portions of his line which might come within the gassed area. In Fig. 33, which shows a section of trenches (enemy line shown in black), the margin of safety chosen is an angle of 40 degrees with the trench line, but it may be taken even lower than this.

133. If gas were to be liberated from the Section c-d, the margin of safety for this section would be represented by the entire shaded area. This includes winds between NxE and ESE. However, a wind blowing ESE would gas the section c-b. The margin of safety for c-b must therefore be considered. This restricts the available winds to those between NxE and NExE. Therefore the dangerous wind for an attack from the enemy section c-d is one which lies between these limits. It is represented on the map by the dark shaded area. The same section c-d is shown in Fig. 34. With the wind from NxE the enemy would gas his own trenches at and below i. If necessary for tactical reasons to make a
gas attack under such conditions, these trenches could be warned in order that the men might put on masks, or they might also be temporarily evacuated.

134. In the larger map the dangerous winds for each section (assuming an angle of 40 degrees is taken) are shown by shading the interval between the limits on the compass in each case. For example, in section b-c winds between NxE and NExE may be used for a gas attack, but no others. In the sections d-e, e-f and g-h, the margin is even narrower.

135. Wind Charts.—In order to allow for the above mentioned risks and not to have too many different angles of wind for the front occupied by our own troops it is customary to cover all dangerous directions of wind in one wind chart for each Division or Corps.

This allows not only for the variations of wind, as observed over large tracts, but also on isolated lengths of front where conditions of terrain or the alignment of the trenches may permit of local air currents which are favorable to the enemy. Wind charts built up on these lines for particular Corps and Divisional fronts should be prepared and issued to all units, so that sentries can be warned to be specially on the alert for signs of cloud gas attacks whenever the wind is in a dangerous quarter.

A typical wind chart used for this purpose is shown in Fig. 35, which represents the dangerous winds for all sections of trench shown on the wind map in Fig. 34.

136. Meteorological Reports.—The direction and strength of the wind, together with forecasts for the next twenty-four hours, are sent daily by the Meteorological Service to headquarters of formations. These reports are general, however, and refer to large tracts of country. They are to be used in conjunction with local observations, but never replace them.

137. Local Observations.—It is possible that on isolated lengths of front air currents may occur which are favorable to the enemy. It is essential therefore that the troops themselves should be on the lookout for the possibility of a cloud gas attack. For this purpose Company Commanders are responsible that wind observations are made on their company front every three hours, or oftener if the wind is in or approaching a dangerous quarter, and the reports forwarded to the proper authorities.
Fig. 34.

Wind Map.
The following chart shows the winds regarded as "Safe", "Neutral", and "Dangerous" in the area............

Fig. 35.
These reports involve the consideration of the following:

138. The Wind Vane.—A simple wind vane must be set up. The wind vane must have as little friction as possible, so that a wind of under two miles per hour will turn it. It should carry a strip of linen 5" x ¾" (the Beaufort Flag), by the movements of which the strength of the wind can be judged. A wind vane that can be easily made in the field is shown in Fig. 36.

Correct orientation is obtained by getting North by the North Star and South by the sun at midday.

Wind vanes must be set up sufficiently high to get a true observation (e.g., 18 inches above the top of the dugout, etc.). But it must be remembered that an obtrusive wind vane is liable to draw fire and the simplest possible type must be adopted. A very simple form of vane, which is sufficiently sensitive and accurate, is formed by attaching a tuft of cotton to the end of a short length of thread which is tied at the top of a short pole, the points of the compass being laid out on the ground.

139. Direction of the Wind.—Before reading the direction of the wind from the vane the observer should gauge the approximate direction by noting the course taken by smoke, etc. Direction of wind must be stated in points of the compass, as shown in Fig. 35.

140. Strength of Wind.—Anemometers of sufficient sensitivity to measure the strength of the wind with accuracy are too delicate to employ in front line trenches. With a little practice the strength of the wind can be gauged with sufficient accuracy by means of Beaufort's Scale.

<table>
<thead>
<tr>
<th>Beaufort's No.</th>
<th>Speed in m.p.h.</th>
<th>Observations of natural objects</th>
<th>Behavior of flag at top of vane</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Smoke straight up.</td>
<td>No movement.</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Smoke slants.</td>
<td>No movement.</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Felt on face.</td>
<td>Slight.</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>Paper, etc., moved.</td>
<td>¾ up.</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>Bushes sway.</td>
<td>Up and falling often.</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>Wavelets on water; tree tops sway.</td>
<td>Up and falling less often.</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>Trees sway and whistle.</td>
<td>Up and flapping.</td>
</tr>
</tbody>
</table>

141. Warning Available.—The following simple calculation determines 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 m. p. h.).

\[
\text{Example} = \frac{100 \times 2}{10} = 20 \text{ seconds.}
\]

142. German Meteorological Service.—The following extract from a captured German document shows the enemy’s dispositions for obtaining meteorological information:

“In the area occupied by each battalion in the front line there is a forward weather-observation station provided with three men, who hourly observe the wind direction and strength at a height of 0.5–1 metre above the surface of the earth. The results are communicated daily to the Field Meteorological Station at Army Headquarters, which in turn decides from these results and from the weather charts whether the weather conditions are favorable to an enemy gas attack and whether such an attack is possible or not. These decisions are communicated every evening to the headquarters of Army Corps and divisions. Should the Field Meteorological Station consider during the day that the weather conditions have become more favorable for a hostile gas attack, divisions are again warned about 12 noon or 6 P. M.

143. “These gas-attack warnings only refer to the front of one Army Corps. Showers of rain which, in general, prevent a gas attack are not taken into account in the reports, which are concerned only with the direction and strength of the wind. It is, of course, possible that on isolated short lengths of front wind currents may occur which may be favorable to the enemy. The troops themselves must, therefore, be on the lookout for the possibility of a gas attack. For this purpose small weather-cocks are advantageously arranged on each company front to show the wind direction at a height of about one meter above the ground. The sector commander decides, from the lie of the trenches, within what limits of the direction and strength of the wind it is desirable to have hourly reports from the forward observation posts. The observers themselves merely report on the direction and strength of the wind and are not in a position to state whether a gas attack is likely to occur. This decision
is the duty of unit commanders (battalion commanders, etc.) and is to be made as a result of the various reports. According to the probability, possibility or impossibility of a hostile gas attack, arrangements are made for the anti-gas preparedness of the troops."

(B) GAS ALARM.

(a) Cloud Gas Alarms.

144. In the event of a hostile cloud gas attack sentries must at once give the alarm by all means available—by gongs, rattles, etc., telephone, and, if necessary, by orderly. In order to prevent the spreading to the rear of false alarm Strombos horns should be sounded only when the sentry in charge is instructed to do so by an officer or non-commissioned officer or when he himself is aware that a cloud gas attack is being made.

145. Sentries must be prepared to give the alarm on the first appearance of gas, as a few seconds delay may involve very serious consequences. Signals must, therefore, be passed along by all sentries as soon as heard. Everyone in the trenches, dugouts, observation posts and mine-shafts must be immediately warned.

146. The earliest warning of a gas attack is given:

(a) By the noise of the gas escaping from the cylinders.
(b) By the appearance of a cloud of any color over the enemy's trenches. If the attack takes place at night the cloud will not be visible from a distance.
(c) By the smell of the gas in advanced posts.

147. If the gas cloud is unaccompanied by an infantry attack no S. O. S. signal should be sent, but the letters G. A. S. telephoned or telegraphed, followed by the name of the trench opposite to which the gas is being liberated.

This message must not be sent in case of a gas shell bombardment.

148. Arrangements must be made for an immediate report of a hostile cloud gas attack to be sent to all formations within twenty miles, giving the map reference of the point of attack as follows:

Divisions should arrange to warn:
Corps Headquarters.
All other divisions of the same corps.
GAS WARFARE

(If a flank division) neighboring division of adjoining corps.
Corps should arrange to warn
Army Headquarters.
All other corps of the same army.

(If a flank corps) neighboring corps of adjoining army.
Arrangements must be made for the warning to be repeated, where necessary, to an officer in each village or camp within a radius of twenty miles of the point of attack, who will be responsible for warning units billeted there.
Corps must arrange to warn civil authorities, who are responsible for the protection and warning of all civilians within the corps area.

149. Action to Be Taken on the Alarm Being Given.—
Everyone must at once put on a respirator. Men in dugouts must do this before leaving the dugouts.
Troops in the front line and wherever the tactical situation requires it must stand to arms.
With the exception of sentries and of officers and non-commissioned officers on duty, there is no objection to troops in rear lines remaining in dugouts if the tactical situation permits it.
The blanket curtains of protected dugouts and cellars must be properly adjusted and fires in such dugouts put out at once.
All bodies of troops or transport on the move should halt and working parties should cease work until the gas cloud has passed.
If a relief is in progress, units should stand steady as far as possible until the gas cloud has passed. Supports and parties bringing up ammunition and grenades should be moved up only if required for tactical reasons.

(B) GAS SHELL ALARMS

150. Owing to the small explosion which occurs with these shells they are liable to be mistaken for blinds, and even when the gas is smelt men may not realize its possibly dangerous character at once and so may delay putting on respirators or helmets until too late. Men sleeping in dugouts may be seriously affected unless they are roused. Men in the open air are unlikely to be seriously affected by poison gas
DEFENSE AGAINST GAS ATTACKS

shells, provided they put on respirators or helmets on first experiencing the gas. The following points should, therefore, be attended to:

(i) On the alarm being given or at the first signs of a gas shell bombardment of any kind the breath must be held and respirators put on at once.

Particular attention must be paid to all shells which burst with a small detonation.

(ii) The alarm must be spread immediately to everyone in the danger zone:

(a) By gongs, bells, rattles, etc.

(b) By men shouting "Gas shells" after masks have been adjusted.

(c) By any other means available (runners, if necessary), except that Strombos horns must on no account be used to give the alarm.

(iii) Dugouts must be visited, sleeping men roused, gas-proof blankets adjusted and any fires in protected dugouts put out.

(C) PROJECTOR ALARMS.

150a. The simultaneous firing of a large number (several hundred) of Trench Mortar shells, a method recently adopted by the Germans and copied from the British, may necessitate such attacks being viewed as gas cloud attacks. The amount of gas used is very large and may produce a cloud comparable in size with that from a cylinder attack. Such an attack may be felt several miles behind the front line.

150b. The very high concentrations of gas produced locally by such methods render rapidity in obtaining protection imperative. Warning is obtained by the extensive flash and the loud noise of discharge. The alarm must be given as soon as these signs are recognized.

(C) ACTION DURING A GAS ATTACK.

(a) Cloud Gas.

151. Protective Measures.—THERE SHOULD BE AS LITTLE MOVING ABOUT AND TALKING AS POSSIBLE IN THE TRENCHES. MEN MUST BE MADE TO REALIZE THAT OBSERVANCE OF THIS MAY BE ESSENTIAL FOR THEIR SAFETY.

If troops in support or reserve lines of trenches remain in, or go into, unprotected dugouts they must continue to wear
their respirators.

Officers and non-commissioned officers must on no account remove or open the face-pieces of their respirators to give orders. The mouthpiece should be removed from the mouth when it is necessary to speak, but it must be replaced.

Men must always be on the lookout to help each other in case a respirator is damaged by fire or accident. When a man is wounded he must be watched to see that he does not remove his respirator until he is safely inside a protected shelter; if necessary, his hands should be tied.

Men must be warned that if they are slightly gassed before adjusting their respirators they must not remove them. The effect will wear off.

152. Tactical Measures.—From the point of view of protection against a gas cloud, nothing is gained by men remaining in unprotected dugouts or by moving to a flank or to the rear. It is, therefore, desirable that on tactical and disciplinary grounds all men in the front line of trenches should be forbidden to do these things. In support or reserve line, where there are protected dugouts, it is advisable for men to stay in them unless the tactical situation makes it desirable for them to come out.

Nothing is gained by opening rapid fire unless the enemy's infantry attacks. A slow rate of fire from rifles and occasional short bursts of fire from machine guns will lessen the chance of their jamming from the action of the gas and tends to occupy and steady the infantry.

It should be remembered that the enemy's infantry cannot attack while the gas discharge is in progress and is unlikely to do so for an appreciable time—at least ten minutes—aftter it has ceased. It is, in fact, a common practice for the enemy infantry to retire to the second and third line of trench while gas is being discharged. There is, therefore, no object in opening an intense S. O. S. barrage of artillery on "No Man's Land" during the actual gas cloud, and it is advisable that the warning to the artillery of a gas attack should be a signal differing from the ordinary S. O. S. signal, as the latter may have to be sent later if an infantry attack develops.

It must be remembered also that smoke may be used by the enemy at the same time as, or alternately with, the gas and that under cover of a smoke cloud he may send out assaulting or raiding parties. A careful lookout must, therefore, be kept: hostile patrols or raiders may be frustrated by
cross-fire of rifles and machine guns, and should an assault develop the ordinary S. O. S. procedure should be carried out.

153. Artillery Action.—During the gas discharge a heavy artillery fire on the actual trenches whence the gas is issuing is the best way of dealing with the situation. Also, it is essential that the gas discharge should be interfered with as early as possible, as the opening periods of the discharge are the most effective.

To ensure an effective and immediate artillery fire the following points require attention:

(a) Certain batteries should be detailed to open a rapid fire for a short time as a defensive measure.

(b) As already explained, only certain portions of the enemy's front trenches can be used for gas discharge in any given wind, and these can easily be indicated on any accurate trench map. (See Fig. 34.) Each battery charged with the task of hampering an enemy gas attack should be provided with such a map and a table, showing from what portions of the enemy's lines (within the Battery's zone of action) gas can be discharged in any given wind.

Nothing in the foregoing paragraphs in any way affects the responsibility of artillery for dealing with any infantry attack, or for the execution of counter-battery work.

(b) Gas Shell Bombardment.

154. Protective Measures.—All precautions laid down with regard to a cloud gas attack must be observed, with the following in addition.

(i) Respirators should continue to be worn throughout the area bombarded with poisonous gas shells until the order is given by the local unit Commander to remove them.

(ii) Care must be taken that men do not enter protected dugouts if their clothing is contaminated with gas.

(iii) Sentries must be posted at suitable points to warn men to put on their respirators before entering the shelled area. These sentries must not be withdrawn until the area is free from gas.
(D) ACTION AFTER A GAS SHELL BOMBARDMENT OR CLOUD GAS ATTACK.

155. General.—THE MOST IMPORTANT MEASURE TO BE TAKEN AFTER A GAS ATTACK IS TO PREPARE FOR A FURTHER ATTACK.

Since the enemy frequently makes intermittent gas shell or trench mortar bomb bombardments and cloud gas attacks, made at intervals varying from a few minutes up to several hours, it is necessary to be on the alert to combat this procedure. The following measures should be adopted as soon as bombardment has ceased or the gas cloud has passed:

156. Removal of Respirators.—Canvas trench fans should be used to assist in clearing the trenches of gas, so that respirators can be taken off. Respirators must not be removed until permission has been given by an officer, who will, when possible, ascertain from officers and non-commissioned officers who have been trained at a gas school that it is safe to do so.

A sharp lookout must be kept for a repetition of the gas attack.

157. Movement.—Owing to the enemy gas sometimes causing bad after-effects, which are intensified by subsequent exertion, the following points should be attended to:

(a) No man suffering from the effects of gas, however slightly, should be allowed to walk to the dressing station.
(b) The clearing of the trenches and dugouts should not be carried out by men who have been affected by the gas.
(c) After a gas attack, troops in the front trenches should be relieved of all fatigue and carrying work for 24 hours by sending up working parties from companies in rear.
(d) Horses which have been exposed to the gas should not be worked for 24 hours if it can be avoided.

SPECIAL PRECAUTIONS AFTER A GAS SHELL BOMBARDMENT.

158. General.—The gas may remain on the ground in liquid form for several hours after a bombardment. When it is impossible to withdraw men from an infected area, res-
pirators must be worn until it is certain that the ground is clear. Closed spaces such as dugouts and cellars may retain gas for many hours and must be thoroughly ventilated by means of fires. Men must not enter such places without wearing respirators until permission has been given by an officer.

When a man is close to the burst of a gas shell, his clothes may become contaminated with the liquid. When possible they should be removed and exposed to the air. Care must be taken that men sleeping in closed spaces are not gassed by long exposure to small quantities of gas brought in on their clothing or equipment.

Transport must move out of the shelled area when possible.

159. Mustard Gas.—(Dichlorethyl Sulphide.)—Mustard gas, which is very largely used in shells by the enemy, is very persistent and will render an area dangerous for as long as two days. Shelters and dugouts into which this gas has penetrated or has been carried by clothing and equipment should, therefore, if practicable, be temporarily evacuated. Men who remain in the shelled area or dugouts must wear their respirators continuously.

Occupants of entire dugouts have been gassed from two or three men who, having been exposed to mustard gas, had entered the dugout. Medical officers have been gassed while attending gassed cases.

For all these reasons it is imperative that the clothing of gassed cases be removed entirely. The patient must, however, be at once reclothed with warm clothing or covered with unaffected blankets, as chilling of the patient must be avoided by all means. Clothing washed in a four per cent. solution of chloride of lime is free from the gas; the clothes should then be washed in pure water, and later in a dilute solution of hyposulphite of soda to destroy the chlorine.

160. Treatment of Shell Holes.—Various methods have been tried for the treatment of shell holes in order to destroy gas remaining in the ground and thus causing danger and annoyance.

161. German Methods.—For lachrymatory shells the Germans have recommended the use of pyridine to hasten the removal of the noxious substance, but the method is neither very practical nor effective and seems to have fallen into
abeyance. The pyridine is sprayed over the ground impregnated with the tear gas and then brought into as close contact with the latter as can be managed. The effect of the lachrymator begins to disappear after one or two hours. The unpleasant smell of the pyridine is removed by the application of excess of water.

For poisonous gas shells (e.g., phosgene) the enemy recommends spraying the ground with milk or lime, which is applied by means of a switch made of twigs. The treatment is probably unnecessary, as the gas does not remain long in the open.

162. Treatment with Earth.—The best general method for dealing with gas shell holes is to cover them with at least a foot of fresh earth. Shell holes so treated should not be disturbed, as the chemicals are not thereby destroyed, and some of them disappear only very slowly.

163. Mustard Gas Shell Holes.—Chloride of lime (bleaching powder) freely spread on the ground destroys the gas. If not enough is used, the gas near the surface is destroyed, but that which has soaked in is not. Hence, ground so treated should not be again dug up. Men not wearing masks have been gassed from digging around such areas. Fresh earth may also be used for treating mustard gas shell holes, as above, but in all cases men must wear respirators when doing such work.

164. Cleaning Arms and Ammunition.—Rifles and machine guns must be cleaned after a gas attack and then re-oiled. Oil cleaning will prevent corrosion for twelve 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.

Ammunition should be carefully examined after a gas attack. All rounds affected by gas must be immediately replaced by new cartridges 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 re-oiled.

All bright parts of guns and trench mortars, together with all accessories and spare parts exposed to the gas, must be
DEFENSE AGAINST GAS ATTACKS

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.

165. Cleaning Telephone Instruments After a 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 the 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 first with a damp and then with a dry cloth. This process should be repeated after 12 hours have elapsed. The metal work of leather cases of telephones 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 Headquarters to be dealt with by an Instrument Repairer.

(E) PRECAUTIONS TO BE TAKEN WITH REGARD TO OUR OWN USE OF GAS.

166. Protection of troops is necessary during our own gas attacks. Adequate protective measures should always be possible, as arrangements can be made in advance and the element of surprise can be excluded. The following points should be noted:

167. Handling Gas Cylinders and Canisters.—Men engaged in handling gas cylinders, canisters, shells, bombs, etc., should carry their box respirators in the "Alert" position at whatever distance they are from the line.

168. Action When Gas Cylinders or Projectors Are in Position in Trenches.—If a cylinder or canister is burst by shell-fire, men should retire up-wind for a short distance. Dugouts in the neighborhood of the burst must be evacuated at once.
169. Action During Our Gas Attacks.—(a) All Commanders of units in the neighborhood must be warned when a gas attack from cylinders or projectors is contemplated. If a cylinder or canister is burst by shell-fire, men in the neighborhood should retire up-wind for a short distance. Dugouts in the neighborhood of the burst must be evacuated at once.

(b) It is advisable that all troops, except those whose presence is considered absolutely necessary, should be withdrawn from the trenches in which gas is installed before the attack is made. Any officer or man who has special orders to remain must wear his respirator.

(c) All troops in any part of the line within half a mile of the nearest point where gas is being discharged must wear their respirators.

(d) If troops advance after a gas attack has been made, it must be remembered that the gas may hang about for a considerable time in long grass, shell holes and hollows, and for several hours in the enemy's shelters. Dugouts should not be occupied until they have been thoroughly ventilated and the absence of gas established. This is equally necessary with regard to shelters which have been penetrated by gas from shells or bombs.

170. Gas Shells, Bombs and Grenades.—These may, if necessary, be stored with other ammunition. In the event of leakage they should be buried in the ground 3 feet deep. They should not be thrown into water. All rescue work and disposal of leaky shells should be carried out by men wearing respirators.

VII. EXPLOSION AND MINE GASES.

171. When black powder and many "smokeless" powders explode there is formed the poisonous carbon monoxide which is colorless and without smell or taste. When breathed it produces headache, dizziness and loss of consciousness, frequently culminating in death. The effect takes place almost instantaneously when large quantities of the gas are present in the air, as, for instance, in isolated cases after the explosion of a "direct hit" in a dugout. If only a little carbon monoxide is present the poisoning may take place only after several hours. One-half per cent. of carbon
monoxide in the air is harmful after breathing the mixture for a long time. After the explosion of mines, the carbon monoxide percolates gradually through the soil, into the mine-galleries, and may be the cause of poisoning there after several days, without there being the slightest trace of the smell which is peculiar to the fresh explosion gases. Poisoning by the gases produced by explosions is treated by breathing oxygen. The oxygen breathing apparatus is the only certain protection against explosion-gases. Tunneling companies are again reminded that the respirator does not protect against carbon monoxide.
GAS WARFARE

APPENDIX.

STANDING ORDERS FOR DEFENSE AGAINST GAS.

Issued to American Expeditionary Forces in France.

1. Carriage of Respirators.
   (a) Within 12 miles of the front line a box respirator or mask will always be carried.
   (b) Within 5 miles of the front line a box respirator will always be carried, and every man will be clean-shaven excepting that a mustache may be worn.
   (c) Within 2 miles of the front line and within areas specially exposed to gas shelling, the box respirator and mask will always be carried. The respirator will be carried in the "Alert" position. It will be worn outside all clothing, and nothing will be slung across the chest in such a way as to interfere with the quick adjustment of the respirator. The chin strap of the steel helmet will be worn on the point of the chin.
   (d) Military Police will report all cases of infringement of the above orders.
   (e) The above-mentioned lines will be conspicuously marked by each Corps, in such manner as to attract the attention of persons entering the above areas.
   (f) When not carried in the "Alert" position, the box respirator will be carried over the left hip, the sling passing over the right shoulder. Nothing shall be worn so as to interfere with the immediate shifting of the respirator to the "Alert" position. If the mask is also carried, it will be over the right hip, so as not to interfere with shifting the box respirator to the "Alert" position, the sling passing over the left shoulder, but under the sling of the respirator.

2. General Precautionary Measures.

Within the two-mile limit the following will be observed:
   (a) Box respirators will be inspected daily.
   (b) Gas N. C. O.'s will inspect daily all gas alarm appliances and anti-gas stores. They will see that gas-proof dugouts are in good order and the blankets kept moist.
DEFENSE AGAINST GAS ATTACKS

(c) All sentries will act as Gas Sentries and will be provided with alarm appliances to give warning in case of gas shelling or a gas cloud attack.

(d) Each sentry group will have a definite area to alarm in the event of a gas attack or bombardment.

(e) Sentries must be posted to give warning to men in dugouts.

(f) All working parties of 10 or more men will have a sentry posted to give warning in the event of gas being used by the enemy.

(g) Precautions will be taken to protect ammunition from the corrosive action of gas.

(h) Stores of fuel will be kept for clearing dugouts.

(i) Units in the line will make wind observations and sentries will be warned to be on the alert for signs of cloud gas whenever the wind is in a dangerous quarter.

In the area between two and twelve miles from the front line the following will be observed:

(j) Anti-gas appliances will be inspected at least once a week and immediately before men proceed to any point within the two-mile limit.

(k) All sentries, traffic control men, military police, etc., when on duty, will act as gas sentries and will be provided with suitable alarm devices where necessary.

(l) Men may be allowed to take off their respirators when sleeping, but must keep them within reach.

(m) Arrangements will be made by Commanders of units and Area Commanders to communicate a gas alarm rapidly to all ranks.

3. ACTION TO BE TAKEN IN THE EVENT OF AN ENEMY GAS SHELL OR TRENCH MORTAR BOMBARDMENT.

(a) At the first sign of gas shell of any kind or on hearing the alarm, the breath must be held and the respirator adjusted immediately, without waiting until the presence of gas is recognized.

(b) The alarm will be spread immediately to all troops in the neighborhood:

(1) By gongs, rattles or Klaxons.

(2) By shouting “Gas shells”—after the respirator has been adjusted.
GAS WARFARE

(3) By runners where necessary. Strombos horns will not be used. Men in dugouts, observation posts and mine shafts must be warned, and sleeping men roused.

(c) Gas-proof dugouts will be closed immediately, and any fires burning in such dugouts put out. Care must be taken that men do not enter protected dugouts if their clothing is contaminated with gas.

(d) Sentries will be posted at suitable points to warn men to put on their respirators before entering the shelled area. These sentries will not be withdrawn until the area is free from gas.

4. After a gas shell or Trench Mortar Bombardment the following precautions will be observed.

(a) RESPIRATORS WILL BE WORN UNTIL PERMISSION TO REMOVE THEM IS GIVEN BY AN OFFICER.

(b) Gas may remain in liquid form on the ground for several hours after a bombardment. When it is impossible to withdraw men from an infected area, respirators will be worn until the ground is clear. Gas Shell holes will be covered with fresh earth when possible.

(c) Closed spaces such as dugouts and cellars may retain gas for several hours and must be cleared by means of fires. Men will not enter such places without wearing respirators until permission has been given by an officer.

(d) When a man is close to the burst of a gas shell his clothes may become contaminated with liquid. When possible the clothes will be removed and exposed to the air. Care must be taken that men sleeping in closed spaces are not gassed by long exposure to small quantities of gas brought in on their clothing or equipment.

(e) Men affected by gas will be spared exertion as much as possible and casualties will not be allowed to walk to the Dressing Station.

(f) Transport will move from the shelled area when possible.

5. Action to be taken in the event of an enemy cloud gas attack.
The Alarm.

(a) Alarm will at once be given by all means available; by Strombos horns, gongs, rattles, telephone, and, if necessary, by orderly. Sentries will warn all ranks in the trenches, dugouts, observation posts or mine shafts.

(b) Sentries on Strombos horns will sound the horn: (1) when they detect cloud gas, (2) when they hear other Strombos horns sounding. Strombos horns will not take up the alarm from gongs and rattles.

(c) In order to restrict the spread of false alarms, when possible, Strombos horns in back areas will be placed so that they need not be sounded until the alarm is confirmed by telephone.

(d) Should the gas cloud be unaccompanied by an infantry attack, no S. O. S. signal will be sent, but the letters G. A. S. will be telephoned or telegraphed, followed by the name of the trench opposite to which the gas is being liberated. This message will not be sent in case of a gas shell bombardment only.

(e) Arrangements will be made for an immediate report of a hostile gas attack to be sent to all formations within 40 kilometers (25 miles), giving the map reference of the point of attack, as follows:

Divisions will warn:
Corps H. Q.
All other divisions of the same corps.
(If a flank division) neighboring divisions of adjoining corps.

Corps will warn:
Army H. Q.
All other corps of same army.
(If a flank corps) neighboring corps of adjoining army.

(f) Arrangements will be made for the warning to be repeated where necessary, to an officer in each village or camp within a radius of 40 kilometers of the point of attack, who will be responsible for warning units billeted there.
(g) Corps will arrange to warn civil authorities who are responsible for the protection and warning of all civilians within the corps area.

**Action on the Alarm being given.**

(h) **THERE SHOULD BE AS LITTLE MOVEMENT AND TALKING AS POSSIBLE.** All ranks will at once adjust their small box respirators. Men in dugouts will do so before leaving dugouts.

(i) The blanket curtains of protected dugouts and cellars will be properly adjusted, and fires in such dugouts put out.

(j) Troops in the front lines, and wherever the tactical situation demands, will stand to arms.

(k) In rear lines there is no objection, where the tactical situation permits, to troops, with the exception of sentries and of officers and N. C. O.'s on duty, remaining in dugouts.

(l) All bodies of troops or transport on the move will halt, and working parties will cease work until the gas cloud has passed.

(m) If a relief is in progress, units should stand steady as far as possible until the gas cloud has passed.

(n) Supports and parties bringing up ammunition and grenades will only be moved up if the tactical situation demands.

**Action during an Enemy Cloud Gas Attack.**

(o) The troops in the front trenches will open a slow rate of rifle fire at once against the enemy's trenches, and occasional short bursts will be fired from machine guns to ensure that all weapons are in working order.

(p) Corps will arrange a suitable artillery programme to be carried out in the event of a cloud gas attack.

**Action after an Enemy Cloud Gas Attack.**

(q) Trenches will be cleared of gas with anti-gas fans and sandbags.

(r) Respirators will be worn until permission to remove them is given by an officer.

(s) **A sharp lookout will be maintained for a repetition of the attack as long as the wind continues in a dangerous quarter.** Men will sleep on the fire-step within reach of a sentry.
DEFENSE AGAINST GAS ATTACKS

(t) The instructions given in Section 4 (c) above, with regard to entering dugouts, etc., will be observed.
(u) No man suffering from the effects of gas will be allowed to walk to the Dressing Station.
(v) The clearing of trenches and dugouts must not be carried out by men who have been affected by the gas.
(w) After a gas attack, troops in the front trenches are to be relieved of all fatigue and carrying work for 24 hours, by sending up working parties from companies in the rear.
(x) Horses which have been exposed to the gas will not be worked for 24 hours if it can be avoided.
(y) Rifles and machine guns must be cleaned after a gas attack. Oil cleansing will prevent corrosion for 12 hours, but the first opportunity must be taken to clean all parts in boiling water containing a little soda.
(z) Small arms ammunition must be carefully examined. All rounds affected by the gas must be replaced by new cartridges immediately, and will be cleaned. Especial attention must be paid to the brass clips.
(zz) Expended air cylinders of Strombos horns will be replaced by full ones.

6. Anti-Gas Trench Stores.
(a) These comprise:
   Extra supply of respirators and masks (5 per cent. of strength).
   Strombos horns and other alarm devices.
   Wind vanes.
   Gas-proof coverings for dugouts.
   Anti-gas fans.
   Stores of fuel for clearing dugouts.
   Vermorel sprayers.
   Gas sampling apparatus.
(b) Commanders of formations or units relieving one another are responsible that trench stores are duly turned over and receipted for and that they are in good condition and in proper positions for use or replacement.
(c) The actual taking over should be done by company (battery) Gas N. C. O.'s, who will go up with the advanced party (if possible in daylight) for this purpose. They will report any defects to their Company (battery) commander.

(d) As soon after the actual taking over as possible the Battalion Gas Officer will make an inspection of all anti-gas arrangements and stores. He will call the attention of Company Commanders to any defects or deficiencies for correction.
GAS WARFARE

PART III.—METHODS OF TRAINING IN DEFENSIVE MEASURES

COMPILED AT THE
ARMY WAR COLLEGE
DECEMBER, 1917

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The following pamphlet, entitled "Gas Warfare," is published for the information of all concerned.

[A. G. O., No. 062.1.]

JOHN BIDDLE,
Major General, Acting Chief of Staff.

OFFICIAL:
H. P. McCAIN,
The Adjutant General.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>7</td>
</tr>
<tr>
<td>II. Training of instructors</td>
<td>8</td>
</tr>
<tr>
<td>Program in gas defense, twelve-day course</td>
<td>8</td>
</tr>
<tr>
<td>Hints on gas-defense instruction</td>
<td>12</td>
</tr>
<tr>
<td>III. Training officers and selected noncommissioned officers</td>
<td>17</td>
</tr>
<tr>
<td>Four-day course for officers and noncommissioned officers at a gas-defense school</td>
<td>18</td>
</tr>
<tr>
<td>IV. Training of troops</td>
<td>19</td>
</tr>
<tr>
<td>V. Principles of training in defense against gas-shell bombardments</td>
<td>20</td>
</tr>
<tr>
<td>General</td>
<td>20</td>
</tr>
<tr>
<td>How to detect gas and what to do when it is detected</td>
<td>21</td>
</tr>
<tr>
<td>VI. Drill with respirators</td>
<td>22</td>
</tr>
<tr>
<td>Practices A to G</td>
<td>22</td>
</tr>
<tr>
<td>Practices in breath holding</td>
<td>33</td>
</tr>
<tr>
<td>Advanced drill with respirators</td>
<td>34</td>
</tr>
<tr>
<td>Inspection of respirators</td>
<td>35</td>
</tr>
<tr>
<td>Inspection of masks by numbers</td>
<td>36</td>
</tr>
<tr>
<td>Disinfection of respirators</td>
<td>37</td>
</tr>
<tr>
<td>VII. Suggestions for carrying out demonstrations</td>
<td>37</td>
</tr>
<tr>
<td>Cloud-gas demonstrations</td>
<td>38</td>
</tr>
<tr>
<td>Cloud-gas demonstration for machine gunners</td>
<td>40</td>
</tr>
<tr>
<td>Gas-shell demonstrations</td>
<td>40</td>
</tr>
<tr>
<td>Demonstrations for special units</td>
<td>41</td>
</tr>
<tr>
<td>VIII. Equipment of divisional gas schools</td>
<td>43</td>
</tr>
<tr>
<td>IX. Fitting of respirators</td>
<td>43</td>
</tr>
<tr>
<td>X. Instructions for divisional gas officers at the gas chambers</td>
<td>47</td>
</tr>
<tr>
<td>Responsibility</td>
<td>47</td>
</tr>
<tr>
<td>Procedure when passing men through gas in the gas chamber</td>
<td>48</td>
</tr>
<tr>
<td>XI. Duties of gas-defense personnel with troops in the field</td>
<td>48</td>
</tr>
<tr>
<td>Divisional gas officers</td>
<td>48</td>
</tr>
<tr>
<td>Divisional gas noncommissioned officers</td>
<td>50</td>
</tr>
<tr>
<td>Company or battery gas noncommissioned officers</td>
<td>52</td>
</tr>
<tr>
<td>Reports</td>
<td>53</td>
</tr>
</tbody>
</table>
DEFENSIVE MEASURES AGAINST GAS WARFARE.

I. INTRODUCTION.

1. It is a well-known fact that in the present war the employment of gas clouds and projectiles filled with gas is now a common feature of offense, and that the use of noxious gases by both sides is continually increasing in extent and deadliness. It is almost impossible, therefore, to overestimate the importance of the thorough training of troops in defense against gas.

2. On the other hand, the perfection of antigas appliances has kept pace with the developments in the offensive, and modern respirators are capable of dealing with high concentrations of all the gases in use or which are likely to be used. Defensive appliances against poison gases are at present ahead of offensive measures; consequently a soldier can be guaranteed perfect protection from gas if he keeps his respirator in good condition, knows how to use it properly, and is able to get it on in time. This puts defense against gas on an entirely different footing from defense against shells, bullets, etc. In gas warfare by far the greater number of casualties have been proved to be due to inefficient training and slackness of discipline.

3. For destructive effects, gas must depend on surprise, on poor discipline, or on defective appliances. Consequently gas casualties are preventible if the soldier is trained continually to exercise vigilance and is well drilled in the use and care of his respirator.

4. Gas is also used for harassing and for reducing the fighting efficiency of troops by forcing men to wear masks under difficult conditions. Troops must therefore be trained until they are accustomed to wear masks for considerable periods in all
circumstances and to carry out their ordinary work while protected against gas. This applies to all branches of the service, including such specialized work as that of telephone operators, ambulance drivers, bombers, etc.

5. The whole basis of gas defense lies, therefore—
   (a) In frequent and thorough inspection, to insure all protective devices are in good working order.
   (b) In thoroughly training men in their use under all conditions of war.
   (c) In making sure that every man understands and rapidly complies with all orders on the subject of defense against gas.

These are all matters of training and maintenance of discipline. Training in gas defense can be divided into three categories, viz:
   (a) Training instructors and specialists.
   (b) Training regimental (etc.) officers and noncommissioned officers.
   (c) Training the individual soldier.

II. TRAINING OF INSTRUCTORS.

6. Instructors in gas defense should have had a chemical training. This is particularly necessary if they are to act as gas officers at the front where their duties will not be confined to giving instruction. On the other hand, it is of the greatest importance that they be thoroughly trained soldiers and that they view the subject chiefly from the military standpoint. As explained above, the essence of gas defense is discipline, and it is toward this end that all instruction must be directed.

7. A suggested course for divisional gas officers and other special officers is contained in the following outline:

PROGRAMME IN GAS DEFENSE, TWELVE-DAY COURSE.

First day.

First hour: Lecture—Introductory, history of gas warfare.
Second hour: Practical—Enrolling, issue and provisional fitting of respirators.
Third hour: Lecture—Description of respirators.
Fourth hour: Practical—Demonstration of drill, preliminary drill, and inspection of respirators.
Fifth hour: Practical—Accurate fitting of respirator and removal of in lachrymator.
Sixth hour: Conference—Writing up notes and review of day's work.

Second day.

First hour: Lecture—Methods of gas offensive, cloud method in detail.
Second hour: Practical—Respirator drill, practices A, B, and F.
Third hour: Lecture—Methods of gas offensive, projectors, etc.
Fourth hour: Practical—Mutual instruction in practices A, B, and F.
Fifth hour: Lecture—Chemicals employed in attack and defense.
Sixth hour: Conference—Review.

Third day.

First hour: Lecture—Gas shells.
Second hour: Practical—Drill, practices C, D, E, and G.
Third hour: Lecture—Gas shells, trench mortar gas bombs.
Fourth hour: Practical—Drill.
Fifth hour: Practical—Breathing exercises (a) in the open, (b) in the gas chamber.
Sixth hour: Conference—Review, etc.

Fourth day.

First hour: Lecture—Protection against gas, evolution of protective appliances.
Second hour: Practical—Mutual instruction in respirator drill.
Third hour: Lecture—Gas alarms, Strombos horn, etc.
Fourth hour: Practical—Examination of faulty respirators and report upon same.
Fifth hour: Practical—Gas chamber, (a) with respirator adjusted, (b) adjusting from "alert" position to completion.
Sixth hour: Practical—Respirator drill and march by night.

29172—18—2
Fifth day.

First hour: Lecture—Protected dugouts, clearing of trenches and dugouts.  
Second hour: Practical—Use of fans and fires, dispersal of gas.  
Third hour: Practical—Practice in entering protected dugouts.  
Fourth hour: Practical—Mutual instruction in respirator drill.  
Fifth hour: Practical—Wind observation and practical writing of wind reports.  
Sixth hour: Conference—Review, etc.

Sixth day.

First hour: Lecture—Effects of gas on arms, ammunition, and equipment.  
Second hour: Practical—Standard tests of respirator drill.  
Third hour: Lecture—Standing orders, action before, during, and after a gas attack.  
Fourth hour: Practical—Gas-cloud demonstration to bodies of men (e.g., one company).  
Fifth hour: Lecture—Gas-defense organization and duties of divisional gas officer.  
Sixth hour: Conference—Review, etc.

Seventh day.

First hour: Lecture—Recent gas attacks and lessons.  
Second hour: Practical—Detecting faulty canisters of respirators and fitting new ones.  
Third hour: Lecture—Smoke, its production and tactical uses.  
Fourth hour: Practical—Respirator drill, games.  
Fifth hour: Practical—Drill in antigas trench duties.  
Sixth hour: Lecture—Horse respirators, practical demonstration.

Eighth day.

First hour: Lecture—Physiological effects of gases and treatment, first aid.  
Second hour: Practical—Advanced drills, specialists, Artillery, machine guns, signals, etc.  
Third hour: Lecture—Flame projector (Flammenwerfer), demonstration.
GAS WARFARE.

Fourth hour: Practical—Qualifying examination in standard tests.
Fifth hour: Lecture and demonstration, chemical hand grenades and bombs.
Sixth hour: Conference—Review, etc.

Ninth day.

First hour: Lecture—Duties of gas noncommissioned officers.
Second hour: Practical—Gas-shell demonstration to bodies of men (e.g., one company).
Third hour: Lecture—Field operations, explanation of night attack.
Fourth hour: Practical—Gas-cloud attack and antigas precautions in trenches.
Fifth and sixth hours: Practical—Night field operations.

Tenth day.

First hour: Conference—Note books handed in; conference on operations.
Second hour: Practical—Mutual instruction in respirator drill.
Third hour: Lecture—Principles of training and hints to instructors.
Fourth and fifth hours: Practical—Advanced drill in respirator with specialists.
Sixth hour: Lecture—Carbon monoxide poisoning and oxygen inhalator.

Eleventh day.

First hour: Examination—Practical in respirator drill, etc.
Second hour: Examination—Lecturing, officers.
Third hour: Examination—Oral, noncommissioned officers.
Fourth, fifth, and sixth hours: Examination—Written, officers and noncommissioned officers.

Twelfth day.

First hour: Practical—Disinfection and handing in of stores, etc.
Second and third hours: Lecture and conference—Recapitulation.
8. The following paragraphs are intended to state some general principles which should guide instructors in antigas measures:

A. THE FINAL OBJECT OF INSTRUCTION IS THAT TROOPS SHALL BE ABLE IN ALL CIRCUMSTANCES OF WAR TO PROTECT THEMSELVES AS COMPLETELY AS POSSIBLE AND AS QUICKLY AS POSSIBLE AGAINST GAS.

9. To achieve this object two things are necessary within the Army:

1. Full knowledge of the scientific principles underlying the offensive and defensive in gas warfare and of the special tactics relating to it.

2. Discipline and practical proficiency in the use of antigas appliances.

For all concerned proficiency in the use of antigas appliances is the first and literally the vital consideration; whatever else may be sacrificed in training, this must be achieved.

For the rank and file proficiency in the use of appliances is the only thing in which they need be expert.

Drill is therefore the main element in the instruction of the rank and file.

10. Officers should bear in mind that the existence of specialist officers and specialist noncommissioned officers in their unit does not absolve them from the duty of qualifying in the highest degree possible as instructors of all serving under them. For this purpose they should receive special instruction much beyond that required for men.

B. INSPIRING CONFIDENCE IN THE MEANS OF DEFENSE.

11. A fundamental difficulty in antigas instruction arises from the mystery associated with the materials used. The very word "gas" is not understood; even what are called educated men often do not know that air is a mixture of gases. Most people think that all gases will burn. When the word "chemical" is used in addition the mystery is increased. Everyone knows that a solid or liquid projectile, if heavier than air, will fall; few know this about gases. Gases are credited with all sorts of impossible qualities of movement and death dealing. There is,
GAS WARFARE.

In fact, an intensity not only of ignorance but of what is almost superstition attached to the material of gas warfare that is found in connection with no other branch of military training.

The consequence of all this is that there is a question of morale to be reckoned with in antigas training so pronounced as to put this branch of training in a category by itself. The alarm and distrust that exist in the recruit with regard to gas can hardly be known to those who have not been engaged in instructional work.

12. It is therefore of primary importance in antigas training that all ranks shall be given confidence in the means of defense. This can not be done by drill or by assertion. It can only be done effectively through the personal experience of the soldier himself. An indispensable part of training is therefore exposure to gas. Whilst it is essential to create confidence, it is equally so to check recklessness. Exposure to gas must therefore be done in circumstances where negligence incurs real danger to life.

13. It is obvious that to give men the right attitude toward gas the personality of the instructor is very important. He should have both confidence and caution and be watchful to check both timidity and recklessness.

C. Teaching the Common Sense of the Operations.

14. It might be concluded from the foregoing that the needs of antigas training for the rank and file would be met by drill followed by exposure to gas. This is by no means the case.

In antigas training, if not in all training, every man has a need, if not a right, to know something at least of the common sense of the operations in which he is being drilled.

If an order appeals to the intelligence it gains in force, and real knowledge of appliances inspires confidence.

It becomes necessary, therefore, to give a clear idea of the conditions under which a respirator protects or ceases to protect; how gas travels; where gas accumulates; how it is removed, etc.

But here again it is most important to show rather than merely tell. No antigas training can be regarded as satisfactory in which men have not seen gas issuing from a cylinder, gas lying in trenches, and gas being removed by fan and fire. Operations with gas—especially night attacks, with all the usual
dispositions—should be regarded as of equal importance to field training with other instruments of war.

All this means that a fair allowance of time is necessary.

D. Qualifications of Instructors.

15. A full comprehension of the basis of gas defense is only possible to those who have an adequate knowledge of natural science. It is, however, obviously more important that an instructor should have—

(1) The ability to teach and maintain discipline.

(2) A knowledge of the actual conditions imposed by warfare in the field.

If these qualifications can be found combined in one instructor so much the better, but in no case should the more soldierly portion be absent. Innumerable examples have shown how satisfactory an understanding of the basis of gas defense can be acquired by a capable officer or noncommissioned officer with little or no previous formal knowledge of science.

16. Amount to be taught.—A real danger attached to all instruction lies in the tendency to try to teach too much, both of theory and detail. In antigas instruction the danger is especially acute. It should be remembered that theory, which is very simple to the man who knows, may be very difficult and confusing even to an intelligent novice. He must not be expected to absorb on a first hearing what has become established by long familiarity in the mind of the teacher. Theory teaching should, therefore, be in the simplest outlines and simplest terms and should be applied continually to actualities.

17. Simplicity of language is most important, and the use of scientific terms should be reduced to a minimum. This applies to the highest teachings as well as to the lowest, for it must be borne in mind that unusual language arrests attention and is passed on, often in a distorted form, from one level to another, especially by people who are not practiced teachers. The use of expressions like "minimum effective concentration" easily becomes a kind of fetish.

18. It is far more important that a limited number of things should be taught simply and thoroughly than that a large number—relevant and important though they may all be—should be taught superficially. Great attention is therefore necessary to the due suppression of detail. Detail in teaching the com-
ponent parts of a box respirator is important, but in such a case as a gas detector the teaching of detail is entirely mischievous.

19. Method of teaching.—It is also to be borne in mind that mere telling or lecturing is a poor way of teaching. Lecturing may interest, but it instructs very little. The wise teacher will place the subject before his class and lead them as far as possible to think it out with his help. He will encourage questions at every stage and be impatient only of interruptions that are frivolous.

Lecturing is best adapted for narrative purposes and for appealing to the emotions, when fine language, a large audience, and a spacious auditorium may have a useful dramatic influence. As a substitute for the real teaching that is possible with groups of 20 or 30, lecturing to 100 people must be regarded as an evil, even if sometimes a necessary evil. A lecture by some one on his recent experiences in war is wholly admirable, but a set lecture on the internal structure of a Vermorel sprayer is not to be endured.

20. Illustrations.—It is very important that where principles are being described they should be illustrated by actual things.

The handling of things is vastly more instructive than elaborate descriptions or drawings. It is much better that a future instructor under training should draw the parts of his own respirator and attach his own description of it than that he should copy a diagram and take down a lecturer's description.

Drawing is a useful auxiliary to teaching, but a clear distinction should be made between pictures and diagrams. A picture is not usually an explanation, whereas a diagram always should be.

Pictures are useful where the thing pictured is not accessible, and occasionally where it is. A moving-picture film of a gas attack would be valuable, but can easily be overrated, and a film of a whole battle would not compare in value to personal experience of a mimic gas attack in a small trench system.

Diagrams are of great value if made by the person under instruction from an actual object. They are also valuable if used by the teacher, but with him they are best when built up on a blackboard as simply as possible while he is teaching, and preferably with the object in front of him.

21. It should be remembered that in order of interest to a class are (1) things, (ii) pictures, (iii) words.
GAS WARFARE.

If an object is displayed it monopolizes attention till it is fully "taken in;" if a picture is displayed it is usually copied openly or furtively. During this time listening ceases, or becomes subconscious. This makes it all the more desirable not to use elaborate diagrams or to suspend a whole series at once before a class.

22. In conducting a class it would be well, though it is often impracticable, for the numbers to be kept to 20 or 30. It is then possible to keep an eye on individuals, to ply them with questions, and to discover and rectify their misunderstandings as the teaching progresses.

Attention should be given to the physical comfort of those under instruction. Men can not listen long if they are standing or are crowded. They should all be in front of the instructor. He should speak clearly and make sure that he is heard. Any kind of fidgeting on his part will distract attention.

23. Notes.—The value of notes depends on whether they are a mere imperfect version of descriptions easily accessible in textbooks or are the outline of something not so accessible.

The fuller the notes taken the more the listener's attention is diverted from understanding to recording. In the extreme case of dictation the listener has usually no time to think at all. A full understanding is therefore by no means to be inferred from a full notebook; it may be exactly the reverse.

Notes would be better replaced by correct printed or manifolded accounts of any subject about which explicit information really needs recording and retaining.

24. It need hardly be added that the worst form of teaching is where an instructor, No. 2, merely tries to recite (often doing it inaccurately) the very words of his own instructor, No. 1, on subjects he (No. 2) had failed to understand thoroughly. No competent instructor will affect knowledge which he does not really possess, though, of course, there is no virtue in making a parade of ignorance.

25. Examinations.—The testing of knowledge by examination presents many difficulties. Written examinations alone may be very misleading, even as to knowledge, and useless as to practical proficiency. Oral examinations are valuable if conducted not too peremptorily. Practical examinations occupy much time.

In antigas training a competent instructor will attain the most reliable judgment of individual efficiency by contact with
GAS WARFARE.

Those whom he is instructing. The impression so gained may be tested and confirmed or modified by examinations, written, oral, and practical, but it should be given due weight in assessing marks. Elaborate “systems” of apportioning marks are apt to put the examiner in chains and annul his better judgment.

III. TRAINING OFFICERS AND SELECTED NONCOMMISSIONED OFFICERS.

26. Previous to the training of the mass of troops in gas-defense measures it is necessary to instruct all available officers and noncommissioned officers. Courses for this purpose are in no way similar to the courses intended for training divisional gas officers or other special officers, but should be so organized that they are of a very practical and personal nature, capable of being readily reproduced in units by nonspecialist officers and noncommissioned officers.

27. In order that subsequent training in units may be given the greatest support and be taken up with vigor it is particularly important that the senior officers of a regiment should attend such a course as soon as possible. The following officers and noncommissioned officers should therefore attend in the order named—

(i) The commanding officer or second in command and one officer to act subsequently as regimental gas officer; all battalion and company commanders; all first sergeants.

(ii) Other officers (including medical officers) and noncommissioned officers as soon as can be arranged.

The course for these officers should be so arranged that theory is avoided and great stress laid on drill, practical demonstrations, and suggestions for the training of large bodies of men. Every officer and noncommissioned officer attending the course must be able to pass the same tests as are insisted on in the case of the men.

In general, the training should consist of instruction—

(a) In the various forms of gas attack.

(b) With respirators and other protective appliances.

(c) In tactical measures before, during, and after a gas attack.

29172°—18—3
GAS WARFARE.

28. The following is a typical outline of a course for such officers:

FOUR-DAY COURSE FOR OFFICERS AND NONCOMMISSIONED OFFICERS AT A GAS-DEFENSE SCHOOL.

First day.

First hour: Lecture—Introductory, history of gas warfare.
Second hour: Practical—Issue of respirators, preliminary drill.
Third hour: Lecture—Description, inspection, and demonstration of drill with respirators.
Fourth hour: Practical—Inspection of respirators and drill, practices A, B, and F.
Fifth hour: Lecture—Methods of gas offensive, the cloud method.
Sixth hour: Practical—Accurate fitting of respirators and removal in lachrymator.

Second day.

First hour: Lecture—Gas shells.
Second hour: Practical—Respirator drill, practices C, D, E, and G.
Third hour: Practical—Drill in breath holding.
Fourth hour: Practical—Mutual instruction in respirator drill, all practices.
Fifth hour: Lecture—Gas alarms.
Sixth hour: Practical—Drills in breath holding in gas chamber; recognition of various gases used in war.

Third day.

First hour: Lecture—Dispersal of gas and protection of dugouts.
Second hour: Practical—Use of fires, fans, blanket doorways, etc.
Third hour: Lecture—Procedure before, during, and after a gas attack.
Fourth hour: Practical—Respirator drill, all practices.
Fifth hour: Practical—Testing respirators in various gases; adjustment in gas.
Sixth hour: Practical—Night march in respirators with gas-shell attack.
GAS WARFARE.

Fourth day.

First hour: Hand in notebooks. Lecture and demonstration—Wind observations and use of smoke.
Second and third hours: Practical—Demonstration of cloud and shell attack with trench duties.
Fourth hour: Practical—Standard tests.
Fifth and sixth hours: Examination.

IV. TRAINING OF TROOPS.

29. The training of troops must be as practical as possible. Lectures should not be given except for the purpose of stimulating interest and should be in the form of short talks by the officer or noncommissioned officer in charge of the instruction. These talks should include as much demonstration as possible, and in no case should last longer than half an hour.

30. The most important feature of the training is drill and familiarization with the respirator. Within twelve miles of the firing line the soldier is never parted from his respirator and may have to use it at any time. His training in its use must therefore be regarded as of importance second only to the handling of arms, and instruction in gas defense must be started as early in the recruit's training as possible. The best time to begin this training is immediately after he has been familiarized with the fundamentals of the school of the soldier and the school of the squad. After that, gas-defense training must be continuous and universal, and must be combined with all other forms of training, so that the soldier develops confidence in the respirator, discipline in its use, and the ability to combine gas-defense measures with his other military duties.

31. In the final stages of the antigas training of troops the assistance of the gas-defense school can be of great use. This cooperation will permit the arrangement of simulated gas attacks, using such accessories as gas cylinders, gas hand grenades, smoke materials, alarm arrangements, etc. Special lectures can also be given, respirators fitted, men "passed through gas," and so on. The divisional gas officer can also assist in the inspection of appliances and antigas training in units.

32. The time allotted for antigas training should be the maximum time available and should not be less than two hours per week, one hour of which may be devoted to combined training.
V. PRINCIPLES OF TRAINING IN DEFENSE AGAINST GAS-SHELL BOMBARDMENTS.

GENERAL.

33. *What to expect.*—Every man should know what to expect, and should be told to regard as gas shells all those which burst with a small detonation, and to remember that gas shell is difficult to detect when fired with high-explosive shell, as it usually is.

34. *Gas alarm.*—Every man must be practiced in spreading the alarm by shouting "Gas shell" as soon as he has adjusted his respirator. Warning must be conveyed to troops to the leeward of the area bombarded. Sentries should be posted to warn men to put on their respirators before entering affected areas. Arrangements must be made to warn men who are asleep immediately a gas bombardment begins.

35. *Wearing respirators.*—Respirators must be adjusted properly during gas-shell bombardments, and must not be removed after the bombardment is over except on the order of an officer. If removing respirators is left to the judgment of individual men casualties are bound to occur.

36. *Respirator drill.*—It is important that men should be practiced in adjusting the small-box respirator while wearing steel helmets, by going through the necessary motions, even when not wearing the steel helmet. Practice in prolonged wearing is necessary, as many instances have occurred of men having to wear the respirator for five to eight hours. Men must also be practiced in moving in the dark and in speaking while wearing the respirator.

37. *Realistic training.*—It is important that the actual training should be made realistic and combined with ordinary work, e. g., a party engaged on night operations might suddenly be given the alarm "**GAS SHELL,**" whereupon the correct action should be taken and respirators worn for an hour without interrupting the operations.

Night practices are essential, because gas shelling nearly always occurs at night. Specialists and men of all arms must be able to perform their duties in the dark while wearing their respirators.

38. *Gas-proof dugouts.*—All ranks must be acquainted with the proper method of adjusting the blankets at the entrances
GAS WARFARE.

21

to gas-proof dugouts. The adjustment of the blankets should be practiced in the dark when wearing respirators.

The value of gas-proof dugouts and cellars has been clearly demonstrated. This should be borne in mind in view of the inflammation of the skin produced by mustard gas. Billets and dugouts into which gas has entered must not be occupied until they have been completely cleared of gas by fires or fans.

HOW TO DETECT GAS AND WHAT TO DO WHEN IT IS DETECTED.

39. With the present wide use of gas in artillery shells, trench mortar bombs, cloud gas waves, and even hand grenades, it is a very difficult matter to be sure there is no gas around.

 Everywhere within the reach of artillery, front line, communication trenches, batteries, billets, or, in fact, wherever a body of men are likely to be found, gas-shell bombardment is to be expected and guarded against. Salvos of gas shells are sent over in the hope of catching bodies of men unprepared or unwarned. Such a bombardment is apt to be heavy, especially at first, in order to develop a strong concentration of gas. Not only will gas shells be sent but also frequently a large proportion of high-explosive shells in an attempt to conceal the former or to detract attention.

40. Both in the case of gas artillery shells and gas trench mortar bombs, the sound of the burst is very small and they are therefore sometimes considered as “duds” (high-explosive shells that fail to burst).

When a gas shell explodes most of the liquid gas turns into vapor, sometimes in the form of a white cloud. However, this is not true of all kinds of gas.

41. If a gas shell bursts 20 yards or less to windward of a body of men they have no time to wait for any alarm, and unless each acts for himself he will be killed. Each must hold his breath and get his respirator or mask on as quickly as possible. In doing so follow the methods described in Practice B or Practice C. Whenever putting on a mask do so according to the methods given in the practices, because these have been worked out with great pains to save loss of time.

42. Mustard gas (dichlorehyl sulphide).—The slight smell of mustard gas and the absence of any immediate effect on the eyes and lungs make it necessary that precautions against gas shells should be taken when any shells are observed to burst with only a slight explosion, even if no gas be smelled or recognized.
GAS WARFARE.

43. Cloud gas is usually, if not invariably, chlorine or chlorine mixed with phosgene. Both have a very distinct irritating odor like that given by chloride of lime, well known as a disinfectant. Both are irritating to the throat and cause coughing. There is no difficulty in recognizing them, but one full breath of a phosgene cloud will kill a man, therefore hold your breath while putting on your respirator or mask. The responsibility for recognizing cloud gas rests with the sentries in the front-line trenches. The actual gas cloud is preceded a few seconds by a hissing sound like the escape of steam; this noise, however, can not always be heard on account of artillery or machine-gun fire. In the daytime these gas clouds are visible at quite a distance and readily recognized, but as they are now used only at night and often when there is fog it is seldom that they can be seen more than five seconds away.

SUMMARY.

There are three things to do:

First. Hold your breath and give the alarm.

Second. Keep on holding your breath until your respirator is fully and accurately adjusted.

Third. Give the alarm for all your comrades.

VI. DRILL WITH RESPIRATORS.

44. The following drills are designed to teach officers and men to quickly adjust their respirators and masks. The drills must be so thoroughly mastered that one will protect himself instantly upon hearing the gas alarm.

45. At the beginning of each drill the recruit should first be taught how to wear the respirator correctly, i. e., at the left side with the sling passing over the right shoulder and the snap fasteners of the satchel toward the body. (See fig. 1.)

PRACTICE A.—ADJUSTMENT OF THE RESPIRATOR IN THE "ALERT POSITION."

46. At the command GAS ALERT, pass the left arm back through the sling and bring the satchel to the front of the body. With the right hand grasp the metal hook (or leather tab) at the left of the satchel, with the left hand reach behind the neck for the metal eyelet (or brass stud) on the sling, pull down and fasten the two together. Undo the snap fasteners, but replace the flap to keep the respirator from the wet.
Complete the adjustment by taking the cord from the right-hand compartment, passing it through the ring on the right of the satchel, then round the waist, and secure it to the ring on the left of the satchel. (See fig. 2.)

*Note.—* Explain the reasons for the adjustment and the replacement of the flap. When first detailed this practice may be divided into two parts, the completion of the adjustment being detailed separately.
ADJUSTMENT IN "ALERT POSITION" (ALTERNATIVE METHOD).

47. Pass the left arm back through the sling, bring the satchel to the front of the body and undo the snap fasteners. Support the respirator with the right hand at a convenient height on the chest and with the left hand pull the sling down on the back to form a "V." Hold the sling in this position with the thumb
and the first finger of the left hand and with the right hand remove the cord from the satchel, passing it round the body through the "V" of the sling. Hold the respirator in its position on the chest with the right forearm and fasten the cord to the ring on the left of the satchel. (See fig. 3.)

**Note.**—This method is very comfortable for troops wearing skeleton equipment, as, for example, in the trenches, and will be used at the discretion of the commanding officer.

29172°—18—4
PRACTICE B.—COMPLETE ADJUSTMENT OF RESPIRATOR.

1. BY THE NUMBERS.

At the command GAS, knock off the headdress, place the rifle between the legs, open the satchel flap, seize the mask with the right hand, the elbow tube being in the palm of the
hand, the thumb and first finger grasping the wire frame of the nose clip. (See fig. 4.)

**Note.**—Always go through the movement of knocking off the headdress, even when practicing.

**TWO** Bring the mask smartly out of the satchel and hold it in both hands in front of the face with all fingers outside around the binding and the two thumbs inside, pointing inward and up-
ward under the elastic. At the same time _throw the chin well forward_ ready to enter the mask opposite the nose clip. (See fig. 5.)

**THREE** Bring the mask forward, digging the chin into it, and with the same motion bring the elastic bands over the crown of the head to the full extent of the retaining tape, using the thumbs.
(FOUR) Seize the elbow 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.

(FIVE) Adjust the nose clip to nose, using the thumb and the first three fingers of the right hand. Run the fingers around the mask on either side of the face to make sure that the edges are not folded over. Correct any faults in adjustment. Come smartly to attention. (See fig. 6.)

NOTE.—At the completion of this exercise the instructor inspects each man and corrects any faults of adjustment. 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.

2. RAPID ADJUSTMENT.

49. At the command GAS, the breath will be held until the mask is finally in position. All of the above movements will be gone through in order.

NOTE.—Speed must be developed, but not at the expense of accuracy.

When he has obtained complete adjustment each man must be instructed to take one pace forward and come to attention. This and similar methods cause emulation and increase the speed of the class as a whole.

All men must be drilled until they can make a perfect adjustment in six seconds.

3. REMOVAL OF RESPIRATOR.

50. At 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. (This movement must be done without undue strain on the mask or elastics.) Wipe the face piece and mouth-piece. Fold the face piece in one fold, as in closing a book; gather the elastics around to one side and replace the mask in the left compartment, taking care that the outlet valve is not crumpled. (See figs. 7 and 7A.)

NOTE.—When sufficiently practiced, men must be instructed on every occasion to carry out Practice "G" on permission being given to remove masks.
PRACTICE C.—COMPLETE ADJUSTMENT OF RESPIRATOR FROM THE “SLUNG” POSITION.

51. At the command GAS, open the satchel flap and adjust the mask as in Practice B, allowing the satchel to hang by the rubber tube. Then proceed to complete adjustment in “Alert” position as in Practice A. The breath must be held during this practice, but after the mask is adjusted breathing can be resumed and the satchel fastened in the “Alert” position. Complete protection must be obtained in seven seconds. The final adjustment is then made.

NOTE.—The reason for this practice must be explained to the class.

FIG. 7.

PRACTICE D.—CLEANING EYEPieces.

(See fig. 8.)

52. At the command CLEAN RIGHT (OR LEFT) EYEPiece, grasp the right eyepiece between the thumb and first finger of the left hand. Push the first finger of the right hand gently into the fold of the mask behind the right eyepiece and clean with a gentle rotatory motion.

The left eyepiece will be cleaned in a similar way.

NOTE.—The eyepieces of the respirator should be cleaned once weekly, or after each time the respirator has been worn.
DIRECTIONS FOR USE OF ANTIDimming OUTFIT.

53. Remove moisture and dust from respirators, apply a little of the paste from the tube to the cleaned surface, rub it in with the fingers, then polish gently with the flannelette until the eye-piece is clear.

Do not use the mask material for polishing.

PRACTICE E.—GIVING ORDERS.

Note.—It must be explained that long messages or orders must be broken up into short phrases, so that each part can be shouted out with plenty of breath. The squad is then extended to four paces and messages passed along under supervision.

54. Take a long breath and, without removing the nose clip, remove the mouthpiece sideways from the mouth by turning the elbow tube to one side. Then shout the message and immediately replace the mouthpiece before taking a breath.

PRACTICE F.—CLEARING GAS OUT OF MASK.

Note.—Explain how a little gas may be present in the mask when it is first put on.

55. At the command EMPTY MASKS, press the face piece close to the face with the fingers and palms of both hands, thus forcing out foul air around the sides. At the command FILL
Masks, fill the face piece again from the lungs by blowing around the mouthpiece.

Carry this out three times, thus removing the last trace of noxious gas.

Note.—When sufficiently practiced, men should be instructed to carry out this practice on every occasion after adjusting the face piece.
GAS WARFARE.

PRACTICE G.—TESTING FOR GAS.

56. At the command TEST FOR GAS, empty mask as in Practice F. With the forefinger of the right hand lift the face piece slightly from the right cheek, then loosen the nose clip with the left hand and smell gently. Do not take a breath.

If gas is smelled, replace the nose clip and mask and go through Practice F.

If no gas is smelled, remove the mask gradually, face piece first, leaving nose clip and mouthpiece adjusted; then take off the nose clip and gradually breathe through the nose. Finally, remove the mouthpiece.

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 the clip.

57. As soon as each man has been supplied with his service respirator, he must wipe his mask dry and apply antidimming composition to the eye pieces after each drill before replacing it in the satchel.

58. No record will be made on the entry card for periods of breathing through the respirator in drill. Men must be taught to make the entry automatically after wearing the respirator in the gas chamber, under gas-shell attacks or cloud-gas attacks, but it will be assumed as regards drill that the respirator is used for the maximum time permissible.

PRACTICES IN BREATH HOLDING.

59. It should be explained to the squad that the object of the drills is to train all ranks to refrain from drawing in breath for certain periods of time or while moving certain distances, rather than to hold the lungs filled with air during the exercise.

There is no objection to releasing breath gradually from the lungs, which, in any case, should not be filled to full capacity.

60. In the following exercises, therefore, for the words “Holding the breath,” etc., the sense “Refrain from taking in fresh breath” should be understood.

Practice 1.—The squad will be formed in single rank. On a whistle or other signal, breath will be held until a second signal is given 15, 30, 40, 50, or 60 seconds after the first.

As each man fails to “hold his breath” any longer, he will take one pace forward.
The practice will be carried out with, and then without, warning, preceding the first signal.

Practice 2.—The squad is formed facing the wind. The instructor moves 15, 30, 40, 50, or 60 paces into the wind. He then drops a stone or similar object to represent a gas shell. Immediately the men hold their breaths and march or double time to windward of the object before breathing afresh.

If any man is unable to hold his breath until he has moved the required distance, he will halt immediately.

Practice 3.—Respirators, or other objects to represent them, are laid out on the ground in a line. The squad is formed at varying distances from and facing away from the respirators. On a given signal the men will hold their breaths, about face, double time to their respirators, and pick them up.

Practices 1 and 2 may be carried out competitively in a slightly modified form, as follows:

Practice 4.—On a given signal the squad hold their breaths, taking one pace forward when unable to continue. The instructor calls out the number of seconds as each man comes out of the line.

Practice 5.—On a given signal the squad marches or double times into the wind, halting when unable to proceed farther without breathing afresh.

When all have halted the instructor paces out the distances, calling out the number of paces as he reaches the position of each man.

Practice 6.—Men will be marched in small detachments into the gas chamber containing chlorine at a low concentration, say, 1–50,000, and instructed to hold their breath for 10 seconds and then leave.

Practice 7.—Under similar conditions men will be instructed to hold their breath as long as possible or until compelled to leave the chamber.

The above drills should be continued until every man can hold his breath for at least 30 seconds and while marching at least 50 paces.

NOTE.—Squads should be given a few minutes's rest between practices.

ADVANCED DRILL WITH RESPIRATORS.

61. The respirator is first adjusted. Using the ordinary commands, drills are carried out in handling arms and in move-
ments appropriate to the particular branch of the service under
instruction.

Infantry.—The drill should include physical and rifle exercises, marching over rough ground, and marching at double time
for at least 200 yards.

Training in rifle exercises (including actual firing on the range), bombing, use of the automatic rifle, etc., must also be
practiced while wearing gas masks.

Officers must particularly be instructed in giving orders, both
in writing and word of mouth, using the telephones, etc.

Artillery.—Gun practice and battery control must be carried
out frequently. Gun layers, fuse setters, etc., must be particu-
larly well trained in performing their duties while wearing gas
masks.

Officers will practice using the telephone and megaphone.

Signal service.—Telephone operators must be specially prac-
ticed in using their instruments when wearing respirators.
Talking and "buzzing" should both be practiced.

Linemen must be well practiced in carrying on their work
while wearing respirators.

Mounted branches, motorcyclists, etc.—Mounted branches of
the service and all horse and mechanical transport personnel
must be practiced in riding and driving while wearing gas
masks.

Note.—The above exercises must be carried out by night as
well as by day.

INSPECTION OF RESPIRATORS.

62. The importance of frequent and thorough inspection of
respirators can not be overemphasized.

During gas-defense training respirators should be carefully
inspected before each drill. A soldier must be made to feel an
individual responsibility for his respirator, taught to inspect it
for himself, and to report any faults at once.

63. For instructional purposes or as a drill the inspection will
be carried out as follows:

The unit being in proper formation, the command is given:

PREPARE FOR INSPECTION OF MASKS.

Pass the left arm back through the sling, bring the satchel to
the front of the body, and then unbutton the flap.
GAS WARFARE.

INSPECTION OF MASKS BY NUMBERS.

(ONE) Examine the satchel and sling to see that the metal hook and metal eyelet (or leather tab and brass stud) and the metal rings at each side are securely fastened in their proper positions. Then remove the canister and hold under the left arm, and examine the interior of the satchel to see that the wire platform, record card with repair plaster, and antidimming compound are present, and that the whipcord is in good condition and free from knots.

(TWO) Examine the canister for rust spots and holes and for weak places by pressing lightly with the fingers. See that the inlet valve at the bottom of the canister is in good working order; that the flexible tube is properly fastened to the canister and to the metal tube, and is free from obvious defects.

(THREE) See that the metal elbow tube is properly connected with the mouthpiece and outlet valve. Examine the outlet valve to see that it is in good condition and working properly. The mouthpiece should be flexible and the metal bushing present.

NOTE.—In cold weather the saliva on the outlet valve will freeze. This can be prevented by two drops of glycerine or heavy thick oil. However, as both tend to injure the rubber they should be used only in very cold weather.

(FOUR) Examine the face piece. It should have no holes nor tears and should be securely fastened between the flanges of the metal elbow tube. Make sure that the nose clip and eyepieces, elastics, and tape are in good condition and securely attached to the face piece, and that the outer fold of the face piece is firmly cemented down.

NOTE.—The instructor should explain to the recruit the proper methods for inspecting the several parts of the respirator and the reasons for so doing. The outlet valve may be tested by closing the inlet valve with the hand so as to prevent passage of air, and at the same time attempting to draw air in through the mouthpiece, which should not be possible. This also proves the absence of leaks in the tube or canister.

The inlet valve may be tested by pressing the outlet valve with the fingers and alternatively breathing in and out; the valve should vibrate back and forth and no air should pass out.

64. At the completion of the inspection men with faulty respirators will be instructed to fall out. Respirators which are unfit for use must be repaired or exchanged.
GAS WARFARE.

DISINFECTION OF RESPIRATORS.

65. Whenever respirators are to be exchanged and worn by other men they should be disinfected immediately after use, as follows:

MATERIALS REQUIRED.

Two per cent lysol or cresol (immaterial which is used).
One test-tube brush per respirator.
Two small pieces of cloth.
One small tin to hold disinfectant.

DIRECTIONS.

(1) Hold the mask in the hand, saturate one of the pieces of rag with disinfectant, and sponge the whole of the inside of the mask, including the nose clips.
(2) Dip the test-tube brush in the disinfectant and insert into opening of the mouthpiece. Push as far as possible with rotatory movement, and brush back and forth repeatedly; 15 seconds active brushing suffices.
(3) Dip mouthpiece up to mask in disinfectant. Do not shake off the excess after removal from solution.
(4) Hold the outlet valve between the forefinger and thumb, across the breadth, and press slightly so as to open valve and dip as deeply as possible into disinfectant. Do not shake off excess.
(5) Leave all parts moist with disinfectant for 15 minutes, then wipe inside of mask (but not mouthpiece) with dry rag (not handkerchief) and allow to dry, if possible, in air before returning to satchel.

VII. SUGGESTIONS FOR CARRYING OUT DEMONSTRATIONS.

66. The object of carrying out demonstrations with actual gas is to improve the quality of both individual and collective training. It can do this by—
(a) Demonstrating the efficiency of the mask.
(b) Representing actual conditions.
(c) Stimulation of interest.

In order to carry out an effective demonstration it must be thought out carefully beforehand. The following points must be especially considered:
(a) The most favorable ground must be chosen with regard to terrain, prevailing winds, proximity to buildings and thoroughfares, etc.

(b) The officer in charge of the operation must make arrangements for clearing the ground to leeward, and must decide how much gas he may employ and how long the bursts of gas may last. If there is any doubt about this, advice may easily be obtained from the divisional gas officer.

(c) Instructors should be carefully drilled in order that the operation may be carried out without confusion and misunderstanding.

67. The following suggestions may prove instructive:

CLOUD GAS DEMONSTRATIONS.

(A) FOR BATTALION, COMPANY, OR OTHER SIMILAR COMPLETE UNITS.

(1) The battalion is formed and a lecture is given lasting 15 minutes to 20 minutes, which ends with a description of what is to take place. Men are cautioned that if they feel any gas they are to hold their breath and fall out to the front.

(2) Four cylinders are placed about 15 to 20 yards interval and 30 to 40 yards distant from the front of the battalion. Ground is cleared to the leeward.

(3) All respirators are carefully inspected and then placed in "alert" position, company commanders reporting "All correct." Men with faulty respirators fall out.

(4) Three smoke bombs are burst at such distance to leeward of the battalion that the cloud will just reach its front in six seconds. This is to be the alarm signal, breath is to be held, and all respirators correctly adjusted. Then sufficient smoke cases are thrown to make the cloud thick and evenly dispersed over the battalion.

(5) When the smoke has cleared away a burst of gas lasting 10 seconds is commenced and the officer in charge observes the effect, and collects any men who have fallen out. A second cloud of the same duration is then sent over.

(6) It is of the utmost importance that the men who have fallen out should receive special attention and their respirators must be examined and tested if necessary.

68. Most men fall out owing to sudden panic, and if this is the case the names should be taken and extra training given them either by the unit or at the gas school.
69. The most important points to note are:
Respirators are placed in "alert" position. The party is divided into two. One part acts as a working party to leeward of the trench. The officer or noncommissioned officer in charge is told to organize the working party and post a sentry over it. The other party mans the trench. The officer or noncommissioned officer to act as company commander, appoints the company gas noncommissioned officers, and sees that all sentries are posted. Ordinary trench routine is carried out as far as possible. Only the sentries are permitted to look over the trench. (One of the party may be told off secretly to act as a casualty.)

The instructors with three or four cylinders of gas and about eight smoke cases take up positions from 60 to 100 yards to windward of the trench. If possible, they should be screened from view by trench, breastwork, hedge, or canvas screen.

At a given signal each instructor lights one smoke case. In about 5 to 10 seconds all the gas cylinders are turned on full at once and are turned on and off in short bursts of gas until the smoke cases are burnt out. The party is under observation of the officer in charge, who may be in the trench with the class, or, better, in a position away from the trench where he can observe all that happens in the trench and at the same time shout or signal directions to the instructors.

When the class has cleared the trench and respirators have been removed, a second attack is suddenly commenced, starting with a sudden burst of gas from all cylinders and then reinforced with smoke.

Further attacks may be made if desired.

70. Afterwards the class is formed and faults are criticized.
(Chief faults: Half-hearted alarm, forgetting to lower blankets of gas-proof dugouts, mistakes in treatment of casualties, not changing cylinders of Strombos horn when exhausted, clearing trenches and dugouts not correctly carried out, definite permission to take off masks not being given.)

The company gas noncommissioned officer should be expected to make a written report.

71. Special emphasis should be laid on the following points:

(1) The attack must be thoroughly organized; as many anti-gas fans, combustibles for clearing dugouts, Strombos horns, minor alarms, etc., being in the trench as can be used.
GAS WARFARE.

The responsibility of the company commanders or the company gas noncommissioned officers for testing for gas, clearing trenches, and warning sentries after one cloud has passed must be clearly explained.

(2) It is most important that when trenches have been cleared and masks removed that a weak wave of gas should be sent over simultaneously with smoke in order that the necessity for a good lookout should be thoroughly brought home.

(3) A criticism of the defense should always be made by the officer in charge.

CLOUD-GAS DEMONSTRATION FOR MACHINE GUNNERS.

(Taken from a demonstration at a gas school in France.)

72. Two guns firing and two packed up for transport, the detachments being on the road. Smoke and gas were let off. Alarm was given by shouting "Gas!" A runner was sent (wearing respirator) to bring up spare detachments, who came up at double time in respirators and got their guns into action.

GAS-SHELL DEMONSTRATIONS.

(A) FOR A BATTALION, COMPANY, OR SIMILAR COMPLETE UNIT OF INFANTRY.

73. The unit is formed and a lecture of 15 to 20 minutes on gas-shell bombardments is given. It should conclude with a description of the demonstration about to be held.

(a) The unit is marched, a company at a time, in column of squads along a given line and sufficient smoke bombs are burst to windward to cover the frontage.

Action taken, the company will halt. Every man will hold his breath, adjust his mask, then shout "Gas shells!" The local alarm should also be sounded. Masks are adjusted from the "slung" or the "alert" position. Men must then gather up any of their equipment which they have scattered and the company will move out of the bombarded area.

(b) Action taken in (a) will be repeated, only this time men will be warned that gas will be used as well as smoke, and bursts of gas from cylinders will commence simultaneously with burst of the smoke bombs.

(c) In order to show men that if isolated gas shells burst to windward of them, complete protection may be obtained while
GAS WARFARE.

In the cloud by holding the breath, the following may be carried out:

Mimic gas shells are exploded or a chlorine cylinder is turned on in short bursts at 40 yards to windward of a company.

The only action which men take is to hold their breath while in the cloud.

Instruction in smelling for gas without taking a breath must also be given in this way:

(d) Instruction on the above lines can be varied at will so as to accustom men to protect themselves from gas shells under all conditions. For example, an attack can be organized and the instructors should burst occasional mimic gas shells among the attacking waves, supports, etc. Each man must protect himself properly and then proceed with the work in hand.

Most gas-shell attacks occur at night. It is therefore necessary that these practices be carried out by night as well as by day.

(B) FOR ARTILLERY.

74. Batteries of all calibers must carry out gun drills and practice operations under conditions of gas-shell bombardment.

Gas-shell alarms, gas-proof telephone dugouts, and observation posts should be represented, and smoke, gas, and lachrymatory bombs used.

It is hardly necessary to indicate how this should be organized, but if it is carefully carried out it is a most effective form of demonstration.

DEMONSTRATIONS FOR SPECIAL UNITS, SIGNAL COMPANIES, BOMBERS, ETC.

75. The following demonstrations have been carried out in a gas school in France and indicate the organization of demonstrations for special units.

(1) MACHINE GUNNERS.

(A) DEMONSTRATION ON RANGE.

76. Four guns firing and spare crews standing near. Without warning, mimic gas shells, smoke and lachrymatory bombs were burst to windward. Alarm was given, “Gas shells,” and the men were instructed to hold their breath, put on respirators, and then continue firing.
GAS WARFARE.

(B) DRILL IN GAS CHAMBER AT THE GAS SCHOOL.

77. Lachrymator was first used to test masks, and then a good concentration of chlorine was put in the chamber. Men carried out the usual drills with one gun in the gas.

Note.—In giving such a demonstration the officer in charge must give his orders clearly and men repeat them. The gun will not be much affected, but must be washed in soda after the tests.

(2) BOMBERS (PARTIES FROM BOMBING SCHOOL).

78. All men were first tested in the lachrymatory chamber. They were then taken to a point some distance from the practice trenches and were given detailed instructions by their officers for a properly organized bombing attack on the trenches.

Smoke was put up so as to obscure the trenches and ground in front of them, and lachrymatory bombs were burst in the trenches. The men put on their respirators and advanced to the attack—gas was discharged as they approached. A trip wire was arranged some 25 yards in front of the trench. Only dummy bombs were used.

(3) SIGNALLERS.

79. Besides laying lines through a smoke cloud while wearing respirators and connecting up the instruments in gas in two houses, these parties were made to transmit written messages on the ordinary form, and to find and repair cuts made in the wires. During these tests respirators were worn continuously for 40 minutes.

80. The following points might be mentioned in connection with arranging these practices:

(a) A competent officer should accompany each party to organize and criticize the work of the men.

(b) Everything should be ready so that delays are avoided and the interest of the men is kept up.

(c) Respirators should be tested in lachrymator if the men are to be exposed to much gas.

The above instructions indicate the lines on which demonstrations should be carried out, but they can obviously be varied at will.
VIII. EQUIPMENT OF DIVISIONAL GAS SCHOOLS.¹

81. For a properly organized divisional gas school the following equipment is required:

(a) Buildings:
(1) Lecture room, large enough to contain 60 to 100 men (lantern, exhibits, and diagrams).
(2) One well-equipped office for instructional staff and clerk.
(3) Storeroom for gas cylinder and apparatus, workshop.
(4) Drill shed for use in bad weather.
(5) Gas chamber. (The type used at the cantonments of the United States Army is outlined in figure 9.)
(6) Lachrymator shed for fitting large numbers of men with service respirators.

(b) Special splinter-proof shed or dugout for storing explosives and combustibles.

(c) Demonstration trenches and dugouts.

These should be located according to the prevailing wind in the district. It will be seen that the typical demonstration trenches shown in figure 10 can be used when the wind is in any direction, since in this system the support trenches have been reversed, as shown by the position of the firing steps and traverses.

The dugouts should be protected by blankets according to standard methods.

IX. FITTING OF RESPIRATORS.

82. Procedure to be adopted and instructions to be carried out by qualified instructors at the lachrymatory shed of the divisional gas school under the supervision of the divisional gas officer or his assistants:

(1) Each man will be supplied with a respirator of the size which it is anticipated will fit him.

(2) A few unusual sizes will be kept at the divisional gas school to replace those which are found to be ill fitting.

(3) On arrival at the school the men will be formed and will put on their respirators for a few minutes. The officer in charge will assure himself that the respirators fit, at least approximately. This is done by making the soldier take a deep

¹ Refers to training in America. In the American expeditionary forces the gas-defense schools are attached to corps headquarters.
breath, removing the mouthpiece and breathing out into the mask, the instructor in the meantime closing the outlet valve with thumb and finger. The mask balloons out, and bad fitting is determined by the easy escape of air at certain places around the edge.

(4) The respirator will then be taken off and the further procedure to be adopted explained to the men as follows:

After readjusting their respirators—

(a) Men will file into the lachrymatory chamber, walk about, and talk.
(b) Any men who are lachrymated will file out and fall in as directed.

(c) The remainder, after five minutes, will file out and fall in separately. Each man will remove his respirator only as the inspecting officer approaches him. The men will be examined
for pressure marks on their faces and signs of lachrymation. They will file up to a table and—

(i) Write their names with indelible pencil on the bottom right-hand corner of the fastener side of the satchel.

(ii) Have the size of the respirator, date of issue, and school stamp impressed on record card.
(d) All men who have been lachrymated or ill fitted will, as soon as they recover, be refitted and again passed through the chamber and procedure as in (a) and (c) gone through.

(e) The whole party will then be inspected by the officer in charge.

83. It must be carefully impressed on the men that it is most important for each man to retain the respirator with which he has been fitted. Badly fitting respirators, in which men have been lachrymated, must be exposed to the air until all traces of lachrymator have disappeared.

X. INSTRUCTIONS FOR DIVISIONAL GAS OFFICERS AT THE GAS CHAMBERS.

RESPONSIBILITY.

84. The divisional gas officer or his assistant in charge of the gas chamber will be responsible for discipline and the strict observance of the following instructions:

(1) Cylinders.—No officer or other rank will remove or loosen any part of a cylinder unless qualified to do so by attendance at a course of instruction at a divisional gas school.

Any officer or other rank manipulating a cylinder will invariably wear a respirator.

The valves of the cylinder will be on every occasion turned only by an officer or qualified instructor, and with a key or spanner authorized for that purpose.

(2) Concentration of gas.—The concentration should be about 1 in 5,000. The gas can be measured, approximately, by the means of the flow meter (see fig. 9A) and the concentration estimated by the following method: Aspirate 1 liter of the mixture of chlorine and air through the 10 per cent solution of potassium iodide, disconnect, add starch paste, and titrate with $\frac{N}{\text{1000}}$ sodium thiosulphate solution. It is unnecessary to carry out this estimation every time the chamber is used after experience has been gained.

(3) First-aid remedies.—The following should be kept near at hand:

(a) Ammonia solution in atomizer.
(b) Aromatic spirits of ammonia.
(c) Drinking water and cup.
PROCEDURE WHEN PASSING MEN THROUGH GAS IN THE GAS CHAMBER.

85. The battalion or regimental gas defense officer will march the men to the divisional gas chamber with rifles and packs and with respirators in the slung position.

Upon arrival at the gas chamber the men will be ordered to form in detachments of about 40.

The divisional gas officer or his assistant will then inspect the men in the fitting of their respirators and in the standard tests.

These men showing insufficient training will not be allowed to pass through the gas chamber, and a report upon them will be sent to the regimental commander.

When the inspection is completed the men of each detachment will remove packs, stack arms, and will file into the gas chamber.

One qualified instructor, including the battalion or regimental gas officer or his assistant, shall be present with each detachment of 20 men.

The divisional gas officer or his assistant will be on duty outside close to the chamber, with respirator, ready to render assistance should necessity arise.

The men will be moved about in the gas chamber and instructed to talk.

They will remain in the gas at a concentration of 1–5,000 for five minutes.

Should a man consider his respirator to be noneffectual, he should be instructed to leave the chamber at once, and the matter investigated.

Upon leaving the gas chamber men will form upon their equipment and be given permission to remove respirators. They will be examined in folding and returning the respirators to the satchel and then dismissed.

XI. DUTIES OF GAS-DEFENSE PERSONNEL WITH TROOPS IN THE FIELD.

86. The following duties are reprinted for instructional purposes and may be taken as typifying the practice followed for some time by divisions at the front.

DIVISIONAL GAS OFFICERS.

87. Advisory.—While officers commanding units are directly responsible that the precautions laid down in the various pamphlets and instructions on antigas precautions are taken, the
divisional gas officer must place his special knowledge at the
disposal of commanding officers and advise them on all questions
of defense against gas attacks. To enable him to do this effec-
tually he must be in close and frequent touch with troops in the
line. He will advise the general staff of the division on the
antigas protective measures to be taken, and will bring to
notice any alterations or improvements that he considers neces-
sary.

88. Operations.—(a) To superintend the taking over of anti-
gas trench stores. When divisions are moving into the line the
divisional gas officer will be attached to the advanced head-
quarters of the division.

(b) On relief, outgoing and incoming divisional gas officers
will render a certificate that antigas trench stores and maps
have been handed over to and received by the incoming divi-
sional gas officer.

(c) To arrange with the divisional general staff to be at once
notified of any hostile gas attack or gas-shell bombardment.
To investigate and render reports and samples.

(d) To examine captured appliances dealing with gas, smoke,
flame, etc., and report on same.

(e) To supervise the production of smoke when required.

89. Routine.—(a) To visit the divisional front and divisional
artillery when the division is in the line.

(b) To visit all units from time to time and supervise inspec-
tion of antigas appliances.

(c) To ascertain that all units keep gas defense equipment
up to scale.

(d) To arrange for the inspection of the reserves of gas-
defense equipment as required.

(e) To arrange for the examination of salvaged antigas ap-
pliances as required.

90. Instruction.—(a) To hold courses at the gas schools for
both officers and noncommissioned officers.

(b) To lecture to units on gas, smoke, and gas shells.

(c) To train noncommissioned officers and men from each
unit in the tactics of production of smoke as required.

(d) To arrange for the gas-defense instruction of all new
drafts.

(e) To arrange for fitting and testing the antigas equipment
of other troops (e.g., Army or corps troops) in the divisional
area.
91. Reports, weekly.—(a) Report of instructional stores at the divisional gas school.
   (b) Report of gas-defense stores in the divisional area. This should include all stores actually issued for use in the divisional area. All stores should be accounted for, whether actually in the line or not. Any kept at the gas school should be noted.
   (c) Report of gas alarms. This should include:
      (i) Map locations of Strombos horns with local name of position, number of cylinders and pressure, complement of tools, and protection and condition of horns.
      (ii) Remarks should include number of empty cylinders returned, damage to horns, etc.
      (iii) Statement as to supply and condition of minor alarms.
   (d) Divisional gas officer's general report. This should include:
      (i) An account of instruction given during the week (including number of reinforcements dealt with and the time spent in training them).
      (ii) Visits paid to the front, and reports on the condition of gas-defense precautions and discipline, and efficiency in the use of antigas equipment.
      (iii) Inspection of reserves of gas-defense appliances and salvage dumps of enemy material, etc.
      (iv) Distribution of gas-testing apparatus.
      (v) Trench and area map, whether up to date and correct. It should show—
         (a) Exact locations of Strombos horns and sprayers.
         (b) Number of vacuum bulbs and antigas fans per sector.
92. Reports, monthly.—(a) List of equipment of antigas school.
   (b) Number of shortages in antigas equipment in the division. It should show the number of officers and other ranks not in possession of serviceable respirators.
   (c) Nominal roll of all gas noncommissioned officers on duty with units in the division.

DIVISIONAL GAS NONCOMMISSIONED OFFICERS.

93. The duties of the noncommissioned officers when detached to regimental headquarters will be:
   (1) To carry out the weekly inspection of antigas equipment of personnel attached to regimental headquarters and prepare a list of shortages.
GAS WARFARE.

(2) To keep a record showing number and position of all antigas trench stores in the regimental area or held by batteries, and prepare weekly reports to be forwarded to the divisional gas officer on the following:

(a) Gas-defense equipment and inspections, consolidated weekly reports.

(b) Strombos horns, as for divisional gas officer’s weekly report.

(c) Other antigas trench stores—

(i) Vermorel sprayers, number and map location.

(ii) Chemicals, amount in stock.

(iii) Canvas trench fans, distribution and location.

(iv) Vacuum bulbs, distribution and location.

(v) Gas-proof dugouts, condition and location.

(vi) Number of wind vanes, gongs, and alarms in the regimental area.

(d) Changes in personnel of company, etc., gas noncommissioned officers.

(3) To inspect and test all antigas appliances before they are distributed.

(4) To visit all Strombos horns in the divisional area at least once a week and test the pressure of the compressed air in the cylinders.

(5) To keep a nominal roll of battery or battalion and company gas noncommissioned officers.

(6) To supervise the replacement of useless or damage containers of respirators.

(7) To keep in touch with company, etc., gas noncommissioned officers and assist them when necessary.

(8) To keep a supply of lachrymator for testing the fit of masks.

(9) To assist in training reenforcements.

(10) After a cloud-gas attack or gas-shell bombardment to obtain reports, samples, and specimens from battery or battalion and company gas noncommissioned officers to transmit to the divisional gas officer and to supplement inquiries made by them.

(11) To collect enemy antigas, smoke, or flame apparatus and forward to the divisional gas officer.

(12) To assist in salvage of antigas equipment.

(13) To assist in smoke production when required.

(14) On relief to visit all Strombos horn positions with relieving gas noncommissioned officers and check all antigas trench stores and locations, if possible, one or two days before relief.
GAS WARFARE.

Give or receive an acknowledgment that all is correct or otherwise.

(15) The divisional Artillery gas noncommissioned officers should assist at the inspection of at least two batteries per week and report on the gas-defense discipline and efficiency in use of gas-defense equipment to the battery commander and divisional gas officer.

COMPANY OR BATTERY GAS NONCOMMISSIONED OFFICER.

94. The duties of the company or battery gas noncommissioned officer will be:

(1) To assist officers at the inspection of respirators.
(2) To keep the following records and prepare weekly reports on the following:
   (a) Number of inspections held during the week.
   (b) Number of officers and other ranks in possession of serviceable respirators.
   (c) Number of officers and other ranks not in possession of serviceable respirators.
   (d) Number and location of all antigas trench stores and appliances in the company sector.
(3) To see that record books of respirators are entered up correctly.
(4) Under the company commander, to have charge of, and inspect daily, all antigas trench stores, as follows:
   (a) Strombos horns, gongs, rails, rattles, etc., and see that sentries posted over them know their duties.
   (b) Gas-proof shelters, assist in the erection of gas-proof doors and see that they are kept in a serviceable condition.
   (c) Canvas trench fans, see that they are placed in proper positions and kept in good order.
   (d) Stores of fuel for clearing dugouts, arrange to have a supply on hand.
   (e) Vermorel sprayers, see that they are well protected and kept in working order.
   (f) Gas sampling apparatus, have charge of vacuum bulbs and gas-testing tubes and take samples during a gas-cloud attack. Keep a stock of corked bottles and tins with well-fitting lids for collecting samples of earth and water after a gas-shell bombardment.
(5) To train men in the use of antigas appliances.
(6) To see that the men detailed to handle gas shells are wearing their respirators and know how to use them, and that proper precautions are taken at dumps of gas shells and grenades.
(7) To make wind observations every three hours, or more frequently if the wind is in or nearing a dangerous quarter, and report any change of wind to the company commander. Reliefs of gas noncommissioned officers for this purpose should be arranged when responsible.

(8) To make wind vanes and keep them in order and see that the "Wind dangerous" area is correctly marked on them.

(9) To salvage antigas equipment in area and hand it over to the proper authorities.

(10) To assist in smoke operations if required.

(11) On relief to accompany the advance party and take over antigas trench stores (by daylight if possible), and to obtain or give a receipt for them.

95. The company or battery gas noncommissioned officer is not available for other duties if they interfere with the antigas duties laid down.

The duties of gas noncommissioned officers of other units will be modified to suit their organization.

REPORTS.

96. In writing reports clearness, combined with conciseness must be aimed at and the various details tabulated as far as possible.

The following must be stated: Place (names of places should be in black capitals), date, time, signature, rank, and unit.

After a gas attack reports should be forwarded as soon as possible to the divisional gas officers, together with cloud-gas samples. Shell-gas samples, water, and earth impregnated with the liquid chemical or gas; gas-shell bases, and fragments.

I. WIND REPORT.

Place........

Trench No........

Date...........

<table>
<thead>
<tr>
<th>Time</th>
<th>Direction of wind</th>
<th>Speed (miles per hour)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.m...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p.m...</td>
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</tbody>
</table>

Signature........

Unit............
### GAS WARFARE.

#### II. REPORT ON GAS ATTACK.

<table>
<thead>
<tr>
<th></th>
<th>Gas cloud</th>
<th>Gas shells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time commenced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time finished</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section of line affected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
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<tr>
<td>Color changes</td>
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<td></td>
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<tr>
<td>Sound of escaping gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effects on:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii) Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iii) Vegetation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iv) Arms and ammunition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(v) Artillery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(vi) Telephone dugouts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(vii) Machine-gun emplacement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Position of—

(i) Blind shells.
(ii) Shell fragments.
(iii) Shell bases.

Number of samples taken:

(i) Gas.
(ii) Shell liquids.
(iii) Earth.

General remarks:

(a) Alarms, satisfactory working or otherwise.
(b) Warning, how given, how much did men get?
(c) Removal of respirator, did order come through satisfactorily?
(d) Casualties, how caused; how far back were men gassed; did any die?
(e) Civilians, how were these affected?

Dated__________
Place__________

Signature__________

Unit__________
### REMARKS

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Number</th>
<th>Position</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protected dugouts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strombos horns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinders</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Local alarms</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canvas trench fans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respirators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas-sampling tubes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vermorel sprayers</td>
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<td></td>
</tr>
</tbody>
</table>

Place: 
Date: 
Unit: 
Signature: 

[O]