Use of Gas at the Front

How the British Have Overcome the Use of Gas by the Germans, and Gave the Enemy One Better

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When, in April 1915, the Germans made use of poisonous gas in the second battle of Ypres the remainder of the world remarked in a shocked horror "what devilish ingenuity these German chemists have!" But as regards mere devilish ingenuity they lag far behind the imaginative writers who concoct the lurid ideas that appear so often in the Sunday editions of some of the metropolitan newspapers. Who has not picked up one of these papers and read of some very plausible sounding scheme whereby the enemy are to be killed off in thousands while our army goes marching on without hurt or hindrance? The average reader devours such articles and revels in the slaughter as he sits by the fire on Sunday morning. The main difference between these inventions and that of our friend Fritz is that Fritz has added knowledge to his imagination and has had sufficient contempt of the world's opinion to put the thing into practice.

The use of poisonous gases is no new idea. Perhaps the earliest actual use of such a thing is, like that of many other inventions, due to the Chinese who many centuries ago used a stink bomb for the confusion of their enemies. So far as we know, however, this was not particularly deadly in its effect but was calculated to be sufficiently annoying to distract the attention while more potent weapons were being brought into play. In this respect it is somewhat related to the German tear shells of which more will be said later on. To come down to more recent times there is the story going the rounds of the army regarding a mysterious invention of Lord Dundonald which has been locked up in the tower of London for nearly a hundred years and which would, if only the British Government would consent to use it, completely exterminate the King's enemies. The basis of this story is the fact that away back about seventy years ago it was proposed to use chlorine gas as a weapon of warfare in almost exactly the way that it is now being used. Asphyxiating gases were considered sufficiently possible for the Hague convention to rule against their use some years before this present war. So that German ingenuity is not so extraordinary after all, and all that can be attributed to them is their lack of honor which led them to make use of the weapon. As they have since found out to their cost it is a game that more than one can play and the British have added a few improvements to the scheme as well as developing sufficiently adequate means of defence.

"Gas" is used at the front in two distinct ways. The most important and deadly but not the most frequent is what is known as cloud gas, when it is simply set free in the front trenches and allowed to drift on the wind over the enemy lines. The second way is what is known as shell gas and as the name implies, it is sent over in the form of shells. It may or may not be poisonous; usually it is not, being simply of an irritant nature causing an irresistible flow of tears from the eyes and rendering men temporarily blind. The irritant effect on the mucous membranes of the throat may be sufficient to cause vomiting but the effects wear away rather quickly when the victim reaches fresh air.

At first sight it might seem quite a simple matter to make a gas attack but it is not quite so simple as one is apt to imagine as first thought. First, what gases can be used? The gas must be one which is sufficiently heavy so that it will travel low and not lose itself by diffusion into the higher layers of air —say it must be at least twice as heavy as air. Then it must be one which is capable of being compressed to a liquid at ordinary temperatures, otherwise it would be impossible to bring sufficient of it up to the front line. When it is compressed it must not be under such a pressure as to make it necessary to use exceptionally heavy cylinders or be overly dangerous to handle; neither must the pressure be too low at ordinary temperatures or the gas will not discharge itself from the cylinders with sufficient rapidity. Last, but not least, it must be sufficiently poisonous so that greatly diluted with air, as it will be, it will still be powerful enough to put men out of action quickly, say in five minutes. In comparing the poisonous qualities of gases the term Miminum Effective Concentration (written M.E.C.) has been adopted for the least concentration which will knock a man out in five minutes. The term Maximum Bearable Concentration (written M.B.C.) is the greatest concentration which a man can stand for one hour.

Let us now consider some of the gases commonly known as very poisonous and see which of them can be used. Take first Arsine, AsH_3, it requires 0.10% for twelve hours to cause death so that Arsine is pretty weak. Nickel Carbonyl Ni $(CO)_4$ is rather poisonous but it has a boiling point of 40 deg. C. so that it would not discharge itself from a cylinder. It cannot be used in a shell because it decomposes on detonation. Sulphur Dioxide is a little more than twice as heavy as air and has a convenient boiling point—10 deg. C. It has a M.E.C. of 0.05% and M.B.C. of .005% and should therefore be considered at least a possibility. Nitric Oxide NO_2 has a boiling point of 26 deg. C. and would on that account be difficult to use although it has a M.E.C. of 0.05%. Hydrogen Sulphite, H_2S is not quite heavy enough. Its M.E.C. is 0.1% and its M.B.C. is 0.01%, about half as poisonous as Sulphur Dioxide. Carbon Monoxide is generally supposed to be very poisonous but is not so deadly as might be supposed. It has a M.E.C. of 0.5% and a M.B.C. of 0.1% being only one-fifth as poisonous as hydrogen sulphide. Chlorine is by all odds the most effective of the common gases. It has a boiling point of 36 deg. C. so that when liquified at ordinary temperatures it has a pressure of about six atmospheres which is quite convenient for the purpose. It is about two and a half times as heavy as air, so will hug the ground pretty closely. It is highly poisonous M.E.C. being only 0.01% and M.B.C. being 0.005%. It is also cheap and available in large quantities so that it is most frequently used by the Germans. Phosgene or carbonyl chloride, $COCl_2$ is another German favorite. It is about three and a half times as heavy as air and is more poisonous than chlorine but considerably slower in its action. M.E.C. 0.02%, M.B.C. 0.005%. Even small concentrations such as 0.0002% are liable to cause serious effects on the heart two or three hours after exposure. It has the disadvantage of having a boiling point of 8 deg. C. which is too high to permit of its use alone. By mixing it with chlorine, however, it is possible to use mixtures with about 20% Phosgene in winter and up to 60% in summer and get it all off. These mixtures and straight chlorine are to date the gases which Fritz has been in the habit of serving up in his cloud gas attacks.

The amount of gas necessary may be somewhat surprising to anyone who has not made any estimates regarding it. Supposing a wind of ten miles an hour and a cloud eight feet high at the enemy trenches there will be about 22,000 cubic feet of air per minute passing over each yard of trench which will have to be filled with gas. Aiming at a concentration of one-tenth of one per cent. this will call for about twenty-two cubic feet of pure gas per minute per yard of trench—equivalent in the case of chlorine, to about 4½ pounds per minute per yard. The gas is supplied in cylinders holding about 65 pounds of the liquid so that to keep up an attack of this intensity under the conditions given would require one cylinder per yard of trench for every 15 minutes duration of the attack or about 50 tons of gas to the mile front. The cylinders themselves weigh about as much again so that the requirements of material alone amount to about a ton for each 17 or 18 yards of front. Besides the labor of carrying these heavy and clumsy cylinders up through a mile or two of crooked communication trench on a dark night there is the additional work of preparing emplacements for them since they must not be exposed to shell fire. When all this is done and all the cooperation with the artillery and the flanking divisions arranged for, the whole scheme may fall through owing to the perversity of the wind which will probably blow the wrong way until too late for the attack to achieve the object desired.

The use of gas in shells presents a different condition. Here it is not necessary or even advisable to have a substance of too low a boiling point since the bursting charge of the shell will break up a liquid into such fine particles that even fairly high boiling materials are sufficiently vaporized. On the other hand some of the otherwise suitable substances cannot be used since they are decomposed by the detonation when the shell explodes. Prussic acid with a boiling point of 26 deg. C. is one of these. It is about three times as poisonous as chlorine. Moreover it is very difficult to obtain sufficient concentration of a poisonous gas and maintain that concentration long enough for it to be effective. The gas shells used by the Germans are the 150 millimeter howitzer size and have a capacity of 2,350 cubic centimeters. This amount of the liquid is spread by the explosion through the surrounding air to a distance of about ten yards in every direction from the shell or into about 50,000 cubic feet. The greater part of this is immediately shifted by the wind and unless exceedingly heavy bombardment is maintained on the one area the concentration of poisonous material is too small to be dangerous. In consequence shells are not much depended upon for actual toxic effects. By loading them with some substance like Xylyl Bromide, $C_6H_4CH_3CH_2Br$ which has a high boiling point—about 193 deg. C.—a large part of it is driven into the ground when the shell bursts and it takes several days for it to evaporate. This Xylyl Bromide is extremely irritating to the eyes, one part of it in two hundred thousand parts of air being unbearable without protection. It is, however, not permanently injurious. These "tear shells' then though not deadly, are capable of causing a great deal of annoyance at critical times especially when used against artillery who have to maintain their position. In at least one case a battery has been compelled to shift simply on account of these tear shells although no one had been hit. The shell holes generally have sufficient of the Xylyl Bromide in them to be uncomfortable for about three or four days. In the case of the battery just mentioned, about two hundred and seventy shells were planted in the vicinity in about half an hour or so. Another substance used by the Germans in shells is chlormethyl chloroformate. This has the tear producing effect of the Xylyl Bromide though in a less degree and it also has the poisonous effect of phosgene from which it is made. This shell is not particularly effective as neither its poisonous nor its irritating properties are sufficiently great. In one case a small wood in which there were many Canadians was fairly heavily bombarded by these shortly after they came into use, but aside the peculiar smell no one noticed any particular effects.

The first gas attack of the war was made in April 1915, at the second battle of Ypres. It was directed mostly toward the French troops who were on the left of the Canadians, but there was enough on the Canadian front to cause heavy casualties. On the French front it was terribly successful, making a clean sweep over a front of over two miles. No one had any protection and the only survivors were those who buried their faces in the earth or were able to get up high enough to be above the cloud Evidently the immense effect had not been anticipated by the German General Staff since they did not take full advantage of the gap they had opened up although some small parties of Germans wandered so far forward that they got lost and were later made prisoners. The main German force did not advance until the third Canadian Brigade, assisted by a battalion of Durhams just newly arrived from England, had extended their line about three thousand yards and although this did not fill the whole gap sufficient resistance was made to hold back the German forces until re-organization of the defence had been effected.

At this first battle the British and French troops had no protection whatever against the gas, but immediately on word of it reaching England work was started on respirators. Over a million were made in three days by the women of the Old Country. The first forms were very crude and inefficient being simply a pad of absorbent cotton, like a small pincushion, furnished with an elastic band to go over the head. The pad was soaked in a solution of sodium carbonate and placed over the nose and mouth but unfortunately it was too tight to allow much air to filter through and it came instead around the edges and so avoided purification by the soda. The next kind were similar but an improvement, consisting of a larger pad of many layers of absorbent gauze, soaked in a solution of Hypo, soda carbonate and glycerin. These were used at the Hill 60 battle and in some case were quite effective while in others they failed entirely owing to being put on improperly. About this time the "Smoke Helmet" came into being. This was simply a flannel bag with a window of cellulose acetate stitched in. The flannel was soaked in the soda-hypo mixture and breathing was done through the cloth both in and out, the chlorine being removed in passage. When this helmet was being worn the bottom was tucked under the tunic so as to make a tight joint and the head was completely enclosed. Foul air from the lungs accumu-