NOTES ON EXPLOSIVES, AND THEIR APPLICATION IN TORPEDO WARFARE

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EXPLOSIVES,

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TORPEDO WARFARE.

BY

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PREFACE.

The following pages are mainly taken from the notes of a course of lectures on explosives, delivered at the Torpedo Station during 1874. The subject is too large and too detailed to receive anything like an extended treatment in the limited space that can now be devoted to it. Therefore, only some of the more prominent topics will be briefly touched upon in some of their practical bearings, and particularly those related to torpedo warfare. In this connection the detonating explosives (nitro-glycerine and gun-cotton) are of the greatest importance, as they have come into extensive use, and will probably be largely applied to torpedo purposes, while they are yet unfamiliar to many persons. Especial attention will, consequently, be paid to them, after a short discussion of the general principles governing all explosions.

In conclusion, some points connected with the application of explosives to torpedoes will be taken up.

Considerable space will be given to details of some operations in use and experiments performed at the Torpedo Station. They have not been described before, and may possess some points of interest. Of course, it has not been possible to undertake at the Station extensive experiment with all explosives, but some of the results of experiment may be of value as far as they go.

Those who wish to study the subject of explosive agents minutely can consult works on chemical technology and a few special books, but, to a large extent, the literature of the subject is to be found in scientific and technical periodicals, and in occasional publications of various kinds.

Professor Hill - left the employ of the U. S. & engaged with the Ramapo (?) Powder Co., in the laboratory of which he was soon killed with several other men - in a terrible explosion due to carelessness of an assistant -

NOTES ON EXPLOSIVES AND THEIR APPLICATIONS IN TORPEDO WARFARE.

EXPLOSIVE REACTIONS.

All chemical changes, whether of combination or decomposition, are called reactions.

Reactions take place in or between molecules. The same atoms are found after a reaction* as were present before, but differently arranged or united, forming molecules different from those which entered into the reaction. The reaction, then, is a change in the manner in which the attractions or affinities of the atoms are exerted. The operations of these attractions are governed by the circumstances under which they are exercised. Then, in order to produce any desired result, certain necessary conditions must be fulfilled.

These conditions vary between extreme limits. Thus, in one compound, the attractions which bind together its parts may be so feebly exercised that the slightest change in its surrounding circumstances will bring about its decomposition, while to reverse those of another compound may require that the most powerful agencies should be exerted for a long time. Again, compounds which are stable at the ordinary temperature, may be broken up when moderately heated, or reactions which occur at the ordinary pressure, may be entirely altered if the same materials are brought together at a different pressure.

Reactions may go on rapidly or slowly, and be accompanied by evolution of gas, of heat, light, electricity, &c. When these accompaniments are of a certain kind explosive effect results, and we have *explosive* reactions, but such chemical changes are governed by the same laws as all reactions.

DEFINITION OF EXPLOSION.

The term explosion is rather loosely used. Considering it as synonymous with explosive reaction, it may be defined as a chemical action, causing the sudden or extremely rapid formation of a very great volume of highly expanded gas.

EXPLOSIVE EFFECT.

Explosive effect is caused by the blow or impulse given by this rapid production of gas in a confined space.

The explosive character of the change, then, depends—

1st. Upon the great change of state produced, that is, the formation of gas very much greater in volume than the substance from which it is derived, and which is still more expanded by the heat evolved.

2d. Upon the shortness of the time required for the change to take place.

Both these causes operate to a greater or less extent in all explosive reactions. When both are fully exerted the most energetic chemical reaction, or, in other words, the most violent explosion takes place. Also, the differences in explosions and explosive bodies depend upon the differing manner and proportions in which they are exerted. Thus, nitro-glycerine is much more powerful and violent than gunpowder, because it generates a larger volume of gas in a shorter time. Again, fulminating mercury is not more powerful than gunpowder, although the decomposition goes on more quickly, since the quantity of gas given off, and the temperature of the reaction are less.

The kinds and quantity of gas given off in an explosive reaction depend upon the chemical composition of the explosive body and the character of the decomposition.

The heat evolved during the reaction adds to the effect by increasing the tension (expanding the volume) of the gas formed. The heat given off in a reaction is an absolute quantity, the same whether the reaction goes on slowly or rapidly. But the *explosive* effect will evidently greatly depend upon the *rapidity* of the formation and expansion of the gas. Thus, if an explosive undergoes the same change under all circumstances of firing, then the total amount of force developed will always be the same, but the *explosive effect* will be increased as the time of action is lessened.

CIRCUMSTANCES OF EXPLOSION.

Explosions are greatly affected by the circumstances attending them. Different substances, of course, give different results, from their different compositions and reactions. But we also find that the same substance will exercise a different explosive effect when fired under certain conditions than under others. These may affect either the rapidity or the results of the chemical change. By shortening the time of the reaction the explosion is rendered sharper and more violent. With some explosives, the decomposition is different under different circumstances. Thus, gunpowder, when fired under great pressure, as in a mortar, gives different products than when fired unconfined.

Circumstances of explosion may be generally considered under—

1st. Physical or mechanical condition of the explosive body itself.

2d. External conditions.

3d. Mode of firing.

1st. *Physical or mechanical condition of the explosive body.*

Many instances may be given indicating the influence of its state upon the explosion of a substance. Thus, nitro-glycerine at temperatures above 40° Fah. is a liquid, and in the liquid condition may be violently exploded by a fuse containing 15 grains of fulminating mercury.

Below 40° it freezes and cannot be so fired.

The advantage of dynamite over nitro-glycerine lies altogether in the fact that the latter is presented in another mechanical condition, more convenient and safer to use than the liquid form. The nitro-glycerine itself is the same chemically in either case. The same mixture of charcoal, sulphur, and saltpetre gives a very different effect if made up into large grains than if made up into small ones. Gun-cotton presents the most marked example of the effect of mechanical state, since it can be prepared in so many ways.

If flame is applied to loose uncompressed gun-cotton it will flash off; if it is spun into threads or woven into webs, its rate of combustion may be so much reduced that it can be used in gunnery or for a quick fuze; powerfully compressed and damp, it burns slowly; dry gun-cotton may be exploded by a fulminate fuse; wet, it requires an initial explosion of a small amount of dry, &c.

2d.—External conditions.

Confinement is necessary to obtain the full effect of all explosives. The most rapid explosion requires a certain time for its accomplishment. As the time required is less, the amount of confinement necessary is less. Then with the sudden or violent explosives, the confinement required may be so small that its consideration may be practically neglected. For instance, large stones or blocks of iron may be broken by the explosion of nitro-glycerine upon their surfaces in the open air. Here the atmosphere itself acts as a confining agent. The explosion of the nitro-glycerine is so sudden that the air is not at once moved.

Again, chloride of nitrogen is one of the most sudden and violent of all explosives. In its preparation it is precipitated from a watery liquid, and therefore is, when used, wet or covered with a very thin film of water. This thin film of water, not more than 1-1000th of an inch in thickness, is a necessary and sufficient confinement, and if it is removed the explosive effect is much diminished.*

Gunpowder, on the other hand, requires strong confinement, since its explosion is comparatively slow. Thus, in firing a large charge of gunpowder under water, unless the case is strong enough to retain the gases until the action has become general, it will be broken, and a large amount of the powder thrown out unburned. This is often the case in firing large-grained powder in heavy guns. The ball leaves the gun before all the powder has burned, and grains or lumps of it are thrown out uninjured.

The confinement needed by the slower explosives may be diminished by igniting the charge at many points, so that less time is required for its complete explosion.†

3d.—Mode of Firing.

In any explosive reaction the mode of bringing about the change exercises an important influence. The application of heat, directly or indirectly, is the principal means of causing an explosion. Thus in gunnery, the flame from the percussion cap or primer directly

* Abel, Trans. Roy. Soc., 1869, 489.

† Thus, in the spar torpedo issued from this station, only one fuse is used, but this is placed in the hollow spindle which traverses the centre of the torpedo, and which is pierced with many holes, through which the flame from the fuse passes from the main charge.

ignites the charge; so also a fine platinum wire heated by an electric current will ignite explosive material, which is in contact with it. Friction, percussion, concussion, produce the same effect indirectly, by the conversion of mechanical energy into heat, which is communicated to the body to be exploded.

When one explosive body is used as a means of firing another, it may be considered that the blow delivered by the gas suddenly formed from the firing charge acts percussively upon the mass to be exploded. The particles of this gas are thrown out with great velocity, but meeting with the resistance of the mass around them, they are checked, and their energy is converted into heat. It is found, however, that the action of explosives on one another cannot be perfectly explained in this way. If the action were simply the conversion of energy into heat, then the most powerful explosive would be the best agent for causing explosion. But this is not the case. Nitro-glycerine is much more powerful than fulminating mercury, but 15 grains of the latter will explode gun-cotton, while 70 times as much nitro-glycerine will not do it.

Chloride of nitrogen is much more violent than fulminating mercury, but larger quantities of the former than of the latter must be used to cause other explosions.

Again, nitro-glycerine is fired with certainty by a small amount of fulminating mercury, while with a much larger amount of gunpowder the explosion is less certain and feebler.

In these cases, it is evident that the fulminating mercury must have some special advantage, since it produces the desired effect more easily than the others. It may be considered that the fulminating mercury sets up a form of motion or vibration, to which the other bodies are sensitive. Just as a vibrating body will induce corresponding vibrations in others, so the peculiar rate of motion or wave of impulse, sent out by fulminating mercury, exerts a greater disturbing influence upon the molecules of certain bodies than that derived from the other substances.*

* Champion and Pellet have experimented (Comptes Rendus, LXXV., 110, 712) on the "Vibratory Motions Produced by Detonants," and have found that the vibrations excited by different explosions are very different. Thus with a series of sensitive flames corresponding to the scale of g major, 0.03 grm. of iodide of nitrogen at 5 metres distance had no effect, while the same amount of fulminating mercury, affected the flames a, c, e, f, g. At a less distance the iodide of nitrogen influenced the higher notes only, while the fulminate acted on all of them. Nitro-glycerine gave only negative results, due perhaps to the small range of the apparatus.