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SHORT NOTES ON SOME EXPLOSIVES.

By Major W. A. J. O'Meara, c.m.g., *p.s.c.* (Barrister-at-Law of the Inner Temple).

A brief review of an article on "The Technics of Explosives," published in the April number of the *Revue Militaire Suisse* last year, appeared in the *R.E. Journal* for September last. The subject is very fully dealt with in a few standard works devoted to the study of explosives, and much valuable information on the subject also appears in some text-books on chemical processes and also in articles published in various encyclopædia. Further matter has been extracted from the *Revue* article on explosives already referred to earlier and now appears in a form which it is hoped will be found convenient. The headings adopted in these short notes follow generally those forming the framework of the original article.

Introduction.

The term "explosives" is applied in a general way to certain mechanical mixtures and chemical compounds which, on the application of a suitable stimulus, "explode," that is to say, decompose or change from one state into another—generally from a solid or viscous into a gaseous state—in such a violent manner as to give rise to a rapid disengagement of a great quantity of gas, at a high temperature, in accomplishing this transformation from one to the other state. According to the manner and degree of violence of their decomposition explosives are classified either as "propellants" (Fr. *chassants*) or as "detonators" or "high explosives" (Fr. *detonants* or *brisants*). The difference between these two classes is entirely one of rapidity in the rate of explosion, thus:—

(*a*). In the case of "propellants" the decomposition takes place at a relatively *moderate* rapidity and partakes, therefore, of the nature of a combustion or deflagration. Substances which behave in this manner are, very often, spoken of as powders and are, in popular parlance, known as "low explosives."

(*b*). In the case of "detonators" or "high explosives" the decomposition takes place with *extreme* rapidity; the transformation from the solid (or viscous) to the gaseous state occurs instantaneously and the conversion of the whole mass is produced, not by simple combustion, but by the propagation of a kind of shock due to a phenomenon known as the *explosive wave*. In common parlance, the term *explosives* is applied exclusively to substances in this category in contradistinction to the term *powders* employed to distinguish substances possessing ballistic properties.

Some substances are to be found which are capable of both kinds of decomposition, that is by deflagration as well as by detonation, depending on the conditions under which the transformation is effected.

In order to meet practical requirements it is necessary for all explosives to fulfil certain conditions, thus :—

(1). Their constituents must be capable of being concentrated in a small space and must consist of substances which act upon each other with enormous rapidity and independently of a supply of air from exterior sources.

(2). In the process of transformation from the solid (or viscous) to the gaseous state the largest possible volumes of gas must be formed with the development of sufficient heat to create an explosive effect.

It is the almost instantaneous escape of the gaseous products of decomposition from the confined space in which this takes place which gives rise to the explosive effect. The rapidity of the decomposition is in a considerable measure due to the energetic oxygen providers present in all explosives. These oxygen providers consist of the nitrates of metals, ammonium nitrate and a few chlorates, perchlorates, permanganates and chromates. Of the chlorates those of barium, potassium, and sodium are best known and have been experimented with as practical explosives ; the two latter are the most stable and either of them mixed with finely ground cellulose, charcoal, coal, phosphorous, sugar starch, sulphur or sulphides, in certain proportions, yield an explosive mixture. These explosive mixtures are dangerous to manufacture and their storage also presents difficulties ; on account of their tendency to detonate they are quite out of question as "propellants."

Explosives of the "propellant" class, on decomposition, produce a disturbance of such a nature as to project detached substances in their immediate neighbourhood to some distance, whilst those of the "detonator" or "high-explosive" class produce extremely violent disturbances which are very local in character but do not display the property of projecting detached substances to any considerable distance; it is for this reason that the former class of explosives is found suitable for employment in guns and in firearms for the propulsion of projectiles, whilst the latter class, on the other hand, cannot be so used.

All chemical compounds are either "endothermic" (*i.e.*, characterized by or formed with evolution of heat) or "exothermic" (*i.e.*, formed by or pertaining to a reaction which occurs with the absorption of heat). In the former case energy, in some form, is stored up in the process of formation of the compound which is thus raised to a higher potential, as is the case when two elements can only be made to combine under compulsion by the application of very high temperatures, by utilizing an electric current or spark, or under circumstances where a secondary product is formed whilst some other reactions are in progress. The decomposition of chemical compounds belonging to the "endothermic" class is attended with the evolution of large volumes of gas, and this class of chemical compounds on this account provides very valuable materials for the manufacture of explosives. All carbon compounds, except carbon dioxide, and many, if not all compounds of nitrogen, are endothermic. As regards the practical employment of explosives, the manner in which a substance is endothermic is a matter of importance. Mere physical structure may be, at times, responsible for a relative endothermic state. Examples of this are to be found in the cases of chilled steel, glass, etc.: under certain conditions of formation they acquire an internal structure of molecules under a peculiar state of strain, the best known instance of the kind being the glass globules known as "Rupert's drops."

"Exothermic" compounds possess in a certain sense properties which are the reverse of "endothermic"; they are comparatively inert and react either not at all or slowly, and then only if energy is expended upon them from some external source.

Certain explosives when employed for blasting purposes in mines are considered safer than others, and to these the term "safety explosives" is often applied. Such explosives belong, as a rule, to one or other of the two following classes:—

(1). Substances containing nitroglycerin and nitrocellulose; this class consists of weak dynamites, and

(2). Substances containing ammonium nitrate and nitrobenzine or nitronapthalene.

The safety properties of these explosives are largely due to the fact that neither the temperature of the flame produced on decomposition, nor that of the products of explosion reaches the point necessary to ignite fire damp or the coal dust so often present in suspension in a mine gallery after the firing of a shot. Explosives of this class are usually sold under special trade names.

The Explosion.

An explosion consists in a spontaneous disengagement of gas or vapour; oxygen radicals are, as already explained, present in all explosives and by promoting combustion assist the action which results in an explosion. Neither high temperatures nor great quantities of heat energy necessarily give rise to an explosion; for example, a reduction of the oxide of iron by thermit (a method employed daily in connection with the autogenous welding of tram rails) is accompanied by a very considerable thermal effect and presents all the characteristics of an explosion; free air is set alight without, however, disengaging the smallest particle of gas; here all the products of the reaction are solids or liquids and in the absence of gaseous products no real explosive action takes place. A simple transfer of oxygen from the oxide of iron to the aluminium takes place, as shown by the following formula :—

$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe + 380 \text{ calories.}$$

In no case will a similar reaction cause an explosion. On the other hand, the ordinary combustion of a substance can, in some cases, be so accelerated by increasing the area of contact between the combustible and an oxygen radical as to result in an explosion. This acceleration in combustion may take place by design, as when benzine vapour is intimately mixed with air and exploded by means of an electric spark in order to develop pressure on a piston for the purpose of actuating a motor; unfortunately, it may also come about accidentally, as when illuminating gas, petrol vapours, vapour of methylated spirits, etc., become mixed with air within a building and are ignited unintentionally with disastrous consequences. In mines similarly fire damp, as is well known, is the bane of miners and engineers.

Explosive decomposition always requires the intervention of a more or less energetic exciting agent to start it off. This exciting agent may be merely a warm body put into contact with the explosive; it may also have its origin directly in an ignition by flame or electric spark, in a rapid raising of temperature by frictional action or otherwise or in a shock caused by a blow (as of a hammer, etc.); it may even be produced *indirectly by an explosive wave* generated by a percussion cap. In certain cases light, that is to say the ultra-violet rays, may give rise to violent explosions by bringing about an energetic chemical combination of two gases or substances, as for instance that of a mixture of chlorine and hydrogen. In darkness, the two gases last named combine very slowly, but when excited under the influence of ultra-violet light rays a brusque combination is effected with the disengagement of heat resulting in the formation of hydrochloric acid.

The mere fact that a breakage of a receptacle containing some substance has occurred is not necessarily evidence that an explosion has produced this disintegration; for example, when a closed cast-iron bomb with thick walls is filled with water and plunged suddenly into a mixture of ice and salt (at $-18°$ C.), the walls of the bomb break up into fragments resembling those produced by an explosion; in this case it is the expansion of the water in the act of freezing which brings about the breakage of the walls of the containing vessel, and this occurs although no disengagement whatever of gas has taken place. There are, of course, many instances where the contrary is the case, as when the boiler of a locomotive bursts or a tube containing liquid carbonic acid explodes; in the instances last mentioned, a spontaneous disengagement of vapour or of gas is brought about, although no chemical action has taken place. In what follows in these notes, only explosions produced by some chemical reaction will be dealt with; since explosions of this nature alone affect the study of modern explosives, therefore those arising from other causes may here be entirely ignored.

The Propagation of an Explosion.

In the case of the explosion of powders—which in some instances must be suitably confined in an enclosed space in order to produce an explosive effect—the propagation takes place by contact; the application of a flame or light at one point starts a combustion, disengaging enough heat to raise the neighbouring particles to the temperature at which reaction commences. The character of the combustion of powders is eminently favourable to the gradual development of pressure in the breeches of guns and rifles and, in consequence, the use of these substances as "propellants" permits projectiles to be ejected from guns and rifles with high initial velocities, without causing excessive stresses in the breech of a weapon in which the powders are exploded. In practice, each grain of powder burns during the whole period of travel of the projectile in the barrel of the weapon—in the case of heavy pieces of artillery this period may amount to $\frac{1}{10}$ of a second and more. In the arrangements made for firing the powder the aim in view is to set it alight over the whole of the surface of the charge simultaneously.

The propagation of the detonation of a "high explosive" takes place differently and much more rapidly than the explosion of a powder. The reaction is here started at one point and produces the *explosive wave* to which reference has been made earlier in these notes. This wave spreads out with very great rapidity to each particle of the explosive substance lying in its path. Even where interstices exist in the physical structure of the substance, so long as these are not large, the detonation is communicated by *influence* across the gaps formed by the interstices in question. The velocity of explosive waves has been measured by utilizing long tubes filled with the explosive substances under examination in such a manner as to bring about the rupture of two electric circuits; the velocities so ascertained have been found to vary from 1,000 to 8,000 metres per second and exceed those produced by the explosive waves of powders. An explosion can be effected by *influence* at a distance of some metres. A case is on record relating to an explosion by *influence* which occurred on the Rhine in 1895; in that instance a boat laden with 18,680 kg. (about 183 tons) of dynamite blew up off Schurpole and caused a spontaneous explosion of 150 kg. (about 3 cwt.) of dynamite on board a vessel moored in the stream at a distance of 22 metres from the scene of the main explosion; another vessel, carrying explosives, was lying some 20 metres beyond the one on which the subsidiary explosion occurred, but in spite of its proximity to the two explosions referred to its contents escaped unharmed. Apart from the colloidal powders all explosives are more or less sensitive to shock. It is these qualities which render "detonators" or "high explosives" unsuitable for use in guns and rifles for the propulsion of projectiles, and consequently their use is confined to that of bursting charges in high-explosive shells, bombs, torpedoes, and mines, and for the purpose of carrying out demolitions.

Composition and Manufacture of Some of the Better-Known Explosives.

The explosives actually employed at the present day are nitrogen compounds and consist of mechanical mixtures, such as gunpowder and some chlorate compounds, the ingredients of which separately are, in some cases, non-explosive; chemical compounds employed singly, the chief of which are fulminate of mercury, guncotton, nitrocresols, nitroglycerin (in the form of dynamite, trinitrotoluene, and picric acid (in the form of lyddite or mélinite); combinations of explosive compounds, as for example, cordite and the other "smokeless" propellants now so extensively used for military purposes; finally, the blasting and detonating or igniting compounds used for mining and a variety of other purposes. The present-day propellants consist essentially of nitrates of some organic compounds, and may theoretically be considered as being nitric acid the hydrogen of which is replaced by a carbon complex. Nitroglycerin and guncotton belong to this group. Another large group of explosives is formed by a more direct attachment of nitrogen to the carbon complex: many explosives of the detonating type belong to this group, nitrobenzene ($C_6H_5NO_2$) being one of the longest known of the group. The composition and manufacture of some of the better-known explosives are given in outline below:—

Black Gunpowder.—Gunpowder is undoubtedly the oldest explosive mixture known. It consists of an intimate mechanical mixture of potassium nitrate, sulphur, and charcoal; the exothermic reactions involved in the oxidation of the carbon and sulphur by potassium nitrate are responsible for the energy developed on the explosion of gunpowder. The proportions in which the constituents are mixed have varied slightly both in the United Kingdom and on the Continent of Europe ; in some parts of the Continent the proportions used are, 78 per cent. of potassium nitrate (KNO_3), 10 per cent. of sulphur and 12 per cent. charcoal. At the present day, the proportions of the several constituents in black rifle powder is 75 per cent. of potassium nitrate, 10 per cent. of sulphur and 15 per cent. of charcoal. When the size of artillery weapons commenced to grow, it was found that the gunpowder, then employed exclusively as a propellant, burnt too rapidly and the size of grain was, by degrees, increased in order to decrease the rate of combustion until it grew to the large pebble powder, consisting of $1\frac{3}{4}$-in. cubes. This change, however, did not produce the effects desired, so that later developments led eventually to the introduction of *hexagonal* prismatic powder, provided with a longitudinal perforation in the centre of each hexagonal prism ; the combustion is started with this powder in the central cores and thus uniformity of burning of the whole charge is secured. Still later, when the 80 and 100-ton guns were introduced further modifications became necessary and were secured by increasing the percentage of potassium nitrate and charcoal and decreasing the percentage of sulphur ; for instance, in "Cocoa" powder the ingredients are 79 per cent. of potassium nitrate, 2 per cent. of sulphur, 18 per cent. of charcoal and 1 per cent. of moisture. On the other hand, in the case of blasting powders the generation of large volumes of gas within a relatively short space of time is required and this is obtained by increasing the proportion of sulphur and this incidentally augments the inflammability of the gunpowder. Blasting powder usually contains 67 per cent. of potassium nitrate, 19 per cent. of charcoal and 14 per cent. of sulphur. The chemical changes which take place on the explosion are very complex and vary according to the ingredients composing the same. The nature of the chief changes may be gathered from the following equation :—

$$16\ KNO_3+21C+7S=13CO_2+3CO+16N+5K_2CO_3+K_2SO_4+2K_2S_3$$

The manufacture of gunpowder involves the preparation of pure potassium nitrate, distilled sulphur and charcoal, and the mixing of these ingredients intimately so as to form a homogeneous mass. The ingredients of the desired quality having been obtained, the charcoal and sulphur are ground separately and screened and mixed with moist potassium nitrate in a mixing machine, consisting of a gunmetal drum and stirrer. A "green charge" is thus obtained ; it is sifted and then passed into an incorporating mill—consisting of iron or stone runners revolved at a short distance above the plate of a large iron or stone pan-like receptacle. The mixture is kept moist whilst in the incorporating mill ; on completion of the incorporation process the "mill cake" is broken up by being passed between gunmetal rollers and then pressed into cakes in gunmetal boxes lined with wood. The "press cake" is now passed between toothed rollers (this process is known as "granulation"), and the granulated cake is next graded by sieves. The grains are then glazed, that is to say given a polished surface, being for this purpose rotated in drums with powdered graphite. To remove dust and complete the process, the powder is finally dried and finished by being further rotated in a cylindrical frame covered with canvas. In the case of "prismatic" powders, the "press cake" is cut either by hand or by rollers provided with knife-like ridges into the desired shape.

Black gunpowder on being fired from a gun gives off finely divided solids equal to nearly half the weight of the charge; these solids form large clouds of smoke. For this reason when rapid-firing guns and magazine rifles were introduced it became necessary to introduce some form of "smokeless" powder.

Smokeless Powder.—A discovery was made that the rate of combustion of nitro-cotton could be slowed down by destroying the structure that existed in nitro-cotton by gelatinizing it with alcohol and ether, and led to the invention of smokeless powder. Smokeless powders vary very little from one another in their composition, their usual ingredients being 98 per cent. of guncotton, 1 per cent. of acetone and 1 per cent. of mineral salts and moisture.

The nitro-cellulose in a finely divided state is dried out at a high temperature then treated with alcohol. It is next triturated with a solvent in a kind of kneading machine. The paste thus obtained is cut up into bands or ribbons, and after the elimination of the solvents these bands or ribbons are next cut up in a special machine either into short rods or into tablets; in this state they are somewhat unstable and otherwise dangerous by reason of the fact that when the pieces are shaken together, electrostatic phenomena are readily produced by the mere friction caused by the motion of the surfaces against one another. These disadvantages can, to some extent, be got over by polishing the rods and tablets and coating them with graphite by rotation in special drums. The powder is then ready for use.

Cordite.—The discovery was made, in 1875, by Nobel that when a low form of guncotton is macerated in nitroglycerin, the guncotton is gelatinized, all structure disappears, and both explosives are so tamed as to become a suitable basis for a smokeless propellant. Later, an improvement on this was thought out by Abel and Dewar who ascertained that the highest form of guncotton, which is unacted upon by nitroglycerin, could be converted into a gelatinized mass if a common solvent, such as acetone is used to reduce the mixture to pulp, and afterwards evaporated out. This blend consists approximately of 65 per cent. nitrocellulose, 30 per cent. of nitroglycerin and 5 per cent. vaseline; the last-named ingredient being added to increase the stability of the explosive and also to lubricate the gun. The "Mark I." cordite contained 68 per cent. of nitroglycerin; the heat of combustion in guns using this quality of cordite was so great as to give rise to a troublesome form of erosion, which very considerably shortened the lives of field guns.

The Germans and Austrians employ a smokeless powder of a very similar kind to the cordite used in the British service, but the French are using a smokeless powder made by gelatinizing nitrocotton without any nitroglycerin.

Mercuric Fulminate ($HgC_2N_2O_2$).—This explosive is a salt obtained by the action of alcohol on a solution of nitrate of mercury in nitric acid and is prepared by causing 10 parts by weight of nitric acid (Sp. Gr. 1·4) in the cold to act on 1 part by weight of mercury: this solution is heated to 55° C. and poured into 8·3 parts by weight of methylated spirit. An extremely violent action ensues, the fulminate separates into crystals and these are filtered off and washed. The resulting product is a white crystalline powder and, although liable to detonate readily by friction or on the slightest shock, it is one of the most useful high explosives known. Mercuric fulminate can be tamed by adding to it at least 10 per cent. of water; its detonation temperature varies between 150° to 200° C. The decomposition of mercuric fulminate into its elements is expressed by the equation:—

$$HgC_2N_2O_2 = Hg + C_2 + N_2 + O_2 + 62{\cdot}9 \text{ calories.}$$

However, since the carbon and oxygen combine to form CO, with liberation of heat, the actual energy developed on its explosion is greater; the nature of the changes is perhaps more accurately represented in the following equation:—

$$HgC_2N_2O_2 = Hg + 2CO + N_2 + 114{\cdot}5 \text{ calories.}$$

In both the above equations the products on detonation are gaseous; owing to the large volumes of these gases as compared with those of the substances from which they are generated, exceedingly high pressures can be obtained if these gaseous products are confined in a space previously completely occupied by the substances from which they are evolved.

Mercuric fulminate forms the chief ingredient in cap compositions, detonators and fuses; in the case of caps for military cartridges mercuric fulminate is usually mixed with a small quantity of potassium chlorate or nitrate.

Nitrocellulose or Guncotton ($C_{12}H_{14}O_4(NO_3)_6$).—Guncotton of ideal purity is cellulose hexanitrate, but various lower nitrates are found in the guncotton manufactured for commercial purposes. The process of manufacture is as follows :—Waste from cotton spinning mills is thoroughly freed from grease and dried at a temperature of 100° C. The cotton is next plunged in charges of from 1 lb. to 2 lbs., for a few minutes, into a cast-iron vessel containing a mixture of 1 part by weight of nitric acid (Sp. Gr. 1·5) with 3 parts by weight of sulphuric acid ; it is then withdrawn, placed on a grating and compressed to get rid of surplus acid. The charge is now placed in a covered stoneware jar, which is placed in a stream of cold water for 24 hours ; at the end of this time the nitration is complete. The cotton is placed in a centrifugal machine for the purpose of removing the bulk of the acid, the greater part of the remainder being washed away by a stream of water in a paddle machine to which the cotton is transferred, prior to its further treatment in a centrifugal drier ; this part of the process is completed by subjecting the treated cotton to two boilings by steam. The guncotton is then thoroughly pulped, the pulp being afterwards washed in a paddle machine ; in this state it should not give off nitrous fumes on the application of heat, and a small sample is accordingly placed in a test tube, with a piece of paper, moistened with potassium iodine and starch, and heated to 65° C. in order to ascertain that no fumes are given off capable of separating the iodine. If imperfectly washed, the trace of acid left renders the gunpowder liable to spontaneous decomposition and explosion.

For industrial purposes guncotton is generally sold in a loose state, but for military purposes it is compressed into discs and slabs. As dry powder it can be detonated by means of a percussion cap, or by shock (iron on iron) ; in a wet state, containing about 25 per cent. of its own bulk of water, it constitutes a safety explosive which can only be detonated in contact with a suitable proportion of dry guncotton, and it is therefore usually stored with a moisture context of about 30 per cent. Dry discs and slabs of guncotton being very friable they are, as a rule, coated with paraffin wax. Ordinary undried guncotton is, at times, dipped in a solution of sodium carbonate and carbolic acid to prevent the growth of fungi on it.

Guncotton ignites spontaneously at about 150° C. ; it burns fiercely when kindled in an unconfined space. Its decomposition on explosion is represented by the following equation :—

$$C_{12}H_{14}O_4\ (NO_3)_6 = 7CO_2 + 5CO + 8H + 3H_2O + 6N.$$

On explosion guncotton gives more heat and more gas than an equal volume of any kind of gunpowder.

Colloidal guncotton is a mixture of the di-, tri-, tetra-, and penta-nitrates of cellulose. Weaker acids are used in its manufacture, but in other respects the processes are similar to those employed in the manufacture of ordinary guncotton.

Nitroglycerin ($_3H_5$ $(NO_3)_3$).—Nitroglycerin is glyceryl trinitrate and is prepared by the action of a mixture of the strongest nitric and sulphuric acids (in proportion of 1 : 2) on anhydrous glycerin (Sp. Gr. 1·26). The mixture of acids is cooled and run into a leaden vat provided with a coil or worm of lead piping through which cold water is continuously circulated. Glycerin is slowly sprayed into the mixture of acids by compressed air; the temperature of the mixture meanwhile being carefully regulated so as not to exceed 30° C. in order to provide against the risk of sudden decomposition, or even an explosion. The nitration takes place very rapidly, and when the temperature has fallen, the contents of the vat are run into a settling tank. The viscous explosive collects in a layer above the acids; it is separated off from the latter by decantation and carefully washed, first with water and finally with dilute alkali so as to remove residual traces of acid, as these are liable to cause spontaneous combustion. The manufacture of nitroglycerin is dangerous and ought to be carried out only with apparatus of suitable design; furthermore, the acids and other materials should also severally be of the purest quality. Nitroglycerin is a colourless oily liquid (commercial samples, however, often possess a yellowish tint), with a sweetish taste and toxic properties: it is insoluble in water, volatilizes at 100° C. and solidifies at 8° C.

In handling this explosive care must be taken not to subject it to shocks, since very slight ones are capable of producing formidable explosions. It is for this reason that nitroglycerin cannot be utilized singly, but only in combination with other bodies. It is one of the most powerful explosives known at the present day; on explosion it yields the following products:—

$$2(C_3H_5(NO_3)_3)=6CO_2+5H_2O+6N+O.$$

Nitroglycerin is a more rapid explosive than guncotton, and although it gives off more heat than does the latter, on the other hand it gives off less gas. The fumes produced on the explosion of nitroglycerin and its compounds are often poisonous, probably owing to incomplete detonation.

Dynamite.—This explosive consists of nitroglycerin absorbed by some inert substance. The absorbent most usually employed is kieselguhr, a siliceous earth; chalk, charcoal, cork, kaolin, magnesia and mica have also been used, but do not give such satisfactory results. The proportion of ingredients is 75 per cent. of nitroglycerin and 25 per cent. of kieselguhr (or other absorbent); these ingredients are thoroughly mixed by hand and form a plastic mass which is passed through a sieve and finally pressed into a continuous rod of dynamite. The continuous rod is cut up to form charges of suitable dimensions, these are wrapped in waterproof paper and then form the so-called dynamite cartridges. In water, the porous siliceous earth becomes dissociated from the nitroglycerin and absorbs the water instead. Dynamite when kindled in small quantities can be burnt without an explosion, but if a large quantity is set alight the critical temperature of explosion is reached and it will then detonate; it is a powerful explosive and a dangerous one. The common dynamites freeze at a temperature of from 6° to 8° C. and are then comparatively safe for transport. At very low temperatures dynamite again becomes somewhat sensitive to shock. In a frozen state dynamite cannot be effectively exploded with the ordinary detonators, and it must therefore be thawed before being brought into use, an operation requiring considerable care owing to the liability of an explosion in the event of this explosive being heated by improper methods.

Nitrogels, or Explosive Gelatines.—These explosives are mixtures of nitroglycerin and guncotton; they are capable of resisting ordinary shocks without exploding, but not the impact of bullets or other projectiles. These compounds are non-hygroscopic, and burn in ordinary air without exploding. Blasting gelatine consists of 93 per cent. of nitroglycerin, absorbed by 7 per cent. of nitrated cotton, and is made by heating nitroglycerin in a copper vessel, to a temperature not exceeding 35° C., whilst at the same time small quantities of finely divided nitrated cotton are added, from time to time, the mixture being stirred the whole time. At the expiration of 60 minutes or so, the mixture becomes converted into a semi-transparent viscous mass. It is sensitive to shock when in a frozen state, but in its normal state it is more difficult to detonate than dynamite; it possesses another advantage over the latter in that it can be used under water. One kilogramme of blasting gelatine liberates 1,530 calories on explosion. Gelatine dynamite, another variety of this type of explosive, contains 65 per cent. of a thin blasting gelatine, 26·25 per cent. of potassium nitrate, 8·4 per cent. of wood meal and 0·35 per cent. of soda; many other varieties also exist.

Picric Acid, or Trinitrophenol ($C_6H_2 \cdot OH \cdot (NO_2)_3$).—This substance, consisting of yellow crystals which attack most metals chemically (iron and lead to a high degree, tin and aluminium scarcely at all), is a nitro-substitution compound and is the main constituent of mélinite as well as lyddite. The compounds of picric acid with metals, such as the potassium salt, ($C_6H_2 \cdot OK \cdot (NO_2)_3$, are easily detonated by friction or percussion when dry and always when heated. Picric acid is formed by heating phenol or carbolic acid ($C_6H_5(OH)$) with sulphuric acid in an iron vessel to a little over 100° C.; when cold the resulting phenol-sulphuric acid is dissolved in twice its weight of water, and then added to three times its weight of nitric acid, precautions being taken to prevent an undue increase in temperature; when fuming has ceased nitrification is completed by the application of steam heat. On cooling, the crystals of picric acid are precipitated and are purified by recrystallization when required. Three atoms of the hydrogen in the original phenol are replaced by the radical nitryl, and the acid in combination with metals forms a class of salts known as "picrates" which are extremely sensitive to shock, although picric acid singly is a very safe explosive. Picric acid is readily soluble in alcohol and ether, but sparingly so in cold water. Its melting point is 122·5° C. The interiors of shells and other iron containers for the explosives of which picric acid is a base should be tinned or provided with some other coating to prevent direct contact between the iron walls of the shell or container and the explosive charge. It is an explosive producing violent disruptive effects, but it requires either to be enclosed and heated, or to be started by a powerful detonator in order to obtain its full effect; its *explosive wave* is propagated with a velocity of 7,500 metres per second. Melted picric acid can be poured directly into a shell or cast into any desired shape; when so cast and compressed it is much more stable than in the crystalline state.

Trinitrotoluene or Trotyl ($C_6H_2 \cdot CH \cdot_3(NO_2)_3$).—The disadvantages inherent in the use of picric acid led to investigations which resulted in the discovery of trinitrotoluol, or T.N.T. as it is now termed; it is obtained by the nitration of toluene and consists of crystals which are precipitated at a temperature of from 77° to 79° C. Crude benzol contains 36 per cent. of toluene and this is separated by careful fractionation of the crude benzol, the boiling point of toluene (Sp. Gr. ·869) being 110° C. and intermediate between those of benzene and xylene. The toluene used for the manufacture of trinitrotoluene should be a clear white liquid and free from solid matter in suspension; it is first converted into the mono-nitro compound; next it is treated with nitric acid at a slightly increased temperature to convert it into the dinitrotoluene, and this is finally nitrated in a sulphuric-acid solution with strong nitric acid to trinitrotoluene. Its manufacture on a large commercial scale is effected by a sulphonating process from the orthonitroluene similar to that employed for the manufacture of picric acid. Very pure materials are obtained by recrystallization; in this case beautiful yellow crystals are precipitated at a temperature of 81° C. Trinitrotoluene when pure has no odour; it darkens on keeping. In some ways it resembles picric acid but has the advantage over the latter of being insensible to shock, powerful detonating caps being necessary to detonate it; further, it is perfectly stable and not being of an acid nature it has no strong affinity for metals, and so does not form compounds with them, this being the case even when moisture is present. When heated to 180° C. it burns readily, giving off a thick black smoke. It should be noted that the salts of the nitroaphthols ($C_{10}H_6 \cdot OH \cdot NO_2$) and the products of higher nitration formed in combination with metals behave much like the "picrates."

Ammonal.—This explosive consists of from 12 to 15 per cent. of T.N.T. mixed with an oxidizing compound, ammonium nitrate, a little aluminium powder and a small quantity of charcoal. The rate of detonation of ammonal is not so great as that of trinitrotoluene, but its destructive effect is far greater than that of the latter; its only drawback is the hygroscopic character of the ammonium nitrate, requiring the mixture to be made up into cartridges capable of excluding moisture. Other constituents of tar are converted into explosives by nitration, thus dinitrobenzol is the basis of "Roburite" and "Bellite," whilst trinitrocresol has been also largely used under the name of "Ecrasite"; this latter possesses the disadvantage of having an acid reaction and of forming sensitive compounds with a number of bases.

Acetylene (C_2H_2).—Acytelene is an endothermic compound evolved when calcium carbide (CaC_2) is brought into contact with water, thus:—

$$CaC_2+2H_2O=Ca(OH)_2+C_2H_2.$$

When the gas is compressed under at least two atmospheres, it can be detonated either by means of a fulminate cap or of a platinum wire raised to incandescence by an electric current. The decomposition is then represented by the following equation:—

$$C_2H_2=C_2+H_2+61\cdot4 \text{ calories.}$$

Acetylene in the liquid state constitutes an exceedingly dangerous type of explosive, its decomposition being effected by a dissociation of the constituent gases—it liquefies at a pressure of 80 atmospheres at 18° C. In the gaseous form it burns with a flame of high illuminating value.

Potassium Chlorate Powder.—Potassium chlorate is a salt which is a by-product in the manufacture of alkali by the Leblanc process, free chlorine being essential for its production; it is anhydrous and used in the manufacture of explosives as an oxidant. When the potassium chlorate is mixed with sulphur and carbon, or better still with sugar, a powerful disruptive explosive is obtained. These very dangerous powders have been studied by Turpin, who has sought to diminish the danger of explosion by shock by embedding the chlorate in a tarry mixture.

Cheddite.—This explosive consists of chlorate potassium powder incorporated with a solution consisting of an admixture of nitrotoluene and oleo-resin. It is used, principally, for blasting purposes in mines.

Generally speaking, mixtures of chlorates with aromatic compounds, such as the nitro or dinitro-benzenes ($C_6H_4(NO_2)_2$) or even napthalene, form exceedingly powerful blasting agents; the violence of the action in these cases being primarily due to the rapid evolution of oxygen, and to the fact that it is possible to detonate a chlorate when alone. To the latter fact is attributable the use made of chlorates to form the basis of firing mixtures and friction tubes. The dinitro-benzenes in admixture with ammonium nitrate produce a blasting powder of a "flameless" type which on account of its safety properties, is valuable for use in gassy or dusty mines. Explosives can also be manufactured from the sodium and potassium perchlorates and permanganates but these are not so sensitive as those obtained from the chlorates. Powerful and sensitive explosives can also be produced by combining metals, such as aluminium and magnesium, in the form of fine powder with perchlorates and permanganates; some compounds of chromic acid with diazo compounds and some acetylides also provide highly powerful and sensitive explosives, whereas bichromates only provide feeble explosive mixtures.

HEAT AND ENERGY GENERATED ON EXPLOSION.

An examination into the calorific power of explosives reveals the astonishing fact that the heat generated by them on decomposition is exceedingly small as compared with that furnished by the ordinary combustibles. Thus, the heat given out by 1 kilogramme of petrol when consumed by burning is 12,000 calories, the same quantity of crude oil furnishes 8,000 calories, of dry wood 3,500 to 4,000 calories, whilst a kilogramme of dynamite on decomposition only gives out 1,300 calories. The latent energy of explosives is far from being as great as that attributed to it in the popular mind; as developers of heat, their efficiency factor is miserably low, but what is of value in them is their property of parting with this latent energy in an extraordinarily short space of time. Thus 1 kilogramme of nitroglycerin on decomposition furnishes 1,600 calories, approximately 650,000 kilogrammetres, during $\frac{1}{1000}$ of a second, that is to say it develops 8,660,000 H.P., or in other words power equal to that which the Falls of Niagara are capable of furnishing.

The energy developable by an explosive depends solely on its calorific power; what this power is can be ascertained experimentally in any particular case by the ignition of a small charge of the substance under examination in a calometric bomb. A suitable pattern of calometric bomb for this purpose consists of a cylindrical vessel, with thick strong walls, having one end permanently closed; a stout cover which can be screwed on or off is provided for the other end, and leads passing through it are connected to a spiral of fine platinum wire, this spiral being enclosed in the cylindrical vessel when the cover is screwed on. The substance under examination is placed inside the calometric bomb; its cover having been securely screwed into position, the bomb is placed in a copper vessel containing a known quantity of water and provided with a stirrer for maintaining uniformity of temperature throughout the mass of water surrounding the bomb. The copper vessel is then placed inside a receptacle of felt or other non-conductor of heat, so as to be well enclosed therein. A thermometer having been placed in the water the platinum spiral is raised to incandescence by means of an electric current; thereby the substance under examination is ignited. The heat generated during the decomposition of the substance is communicated to the walls of the bomb and thence to the surrounding water. The increase in the temperature of the known quantity of water having been read off on the thermometer inserted therein the calorific power can be calculated by means of the following formula (knowing that quantity of heat required to raise 1 kilogramme of water 1° C.=1 calorie) :—

$$\text{Calories} \times 425 = x \text{ kilogrammetres.}$$

When the thermal change which takes place on explosion in a suitably-designed apparatus, and the volume of gas generated are known, the total possible pressure can be calculated from experimental data available. The number of heat units (calories) furnished and of the energy generated per kilogramme* of substance by some explosives is given in the following table :—

Substance.	Heat Units. Calories.	Energy. Kilogrammetres.	Gas at 0° C. and 760 mm. Litres (=61·025 cu. in.).
Explosive gelatine ..	1,640	697,000	—
Nitroglycerin	1,580	671,500	715
Dynamite (75 per cent.) ..	1,300	552,500	—
Guncotton	1,100	467,500	860
Cocoa powder	830	352,750	200
Mélinite	810	344,250	—
Large grain rifle powder ..	720	306,000	275
Blasting powder	510	216,750	360
Fulminate of mercury ..	410	174,250	—

The above figures clearly bring out the fact that mélinite and fulminate of mercury owe their value as explosives entirely to their detonating properties, that is to the extraordinary rapidity with which their decomposition is effected.

Numerous tests and experiments have to be carried out in order to investigate the properties of an explosive. One method of comparing the relative values of different explosives consists in exploding a small quantity of the substance when placed in a cavity, provided

* 1 kilogramme=2·205 lbs.; 1 kilogrammetre=7·235 ft.-lbs.

for the purpose, in the longitudinal axis of a cylindrical block of lead (known as Trautz's block). On decomposition of the substance the lead yields and the cavity is consequently enlarged; a comparison of the volumes of the cavities before and after the detonation gives a measure of the explosive power of the substance under test. In some cases, explosives give rise on decomposition to exceedingly great pressures, and even to pressures which are too high to be measured; in such cases the substance under investigation must be entirely enclosed.

From the point of view of safety, it is further necessary to study the effect of heat on explosive substances; this is done by raising the temperature of the substance by definite successive steps, in order to determine the temperature at which it will ignite or commence to disintegrate. The temperature of spontaneous ignition, obtained by this method, has been ascertained in the case of certain explosives to be as follows:—

Fulminate of mercury	160°—165° C.
Guncotton	183°—186° C.
Dynamite	180°—200° C.
Nitroglycerin	160°—220° C.

It is often merely a question of temperature which determines whether a particular substance will simply burn away or decompose by detonation. An experiment to illustrate this fact consists in allowing nitroglycerin to fall, drop by drop, on to an aluminium plate heated over a Bunsen jet; as each drop of nitroglycerin comes into contact with the heated plate it bursts into flames, but when the temperature of the plate is lowered to a certain critical value, the explosive detonates with extreme violence.

To complete the investigations into the properties of an explosive substance delicate tests have to be carried out to ascertain its sensitiveness to shock, friction, humidity, cold, etc., and the data thus obtained allow a record to be prepared of its characteristics. Such a record affords a means whereby any particular explosive substance can be identified and the uses to which this substance can be put to be ascertained; this record, therefore, constitutes an indispensable complement to the data obtained by chemical analysis.

Conclusion.

It is by no means possible to state definitely which is the best of the high explosives; probably the most powerful explosive is one made by converting benzene into anilin, and by nitration transforming this into tetranitro-anilin. Recent experiments have also proved that explosive alloys can be formed with rhodium, iridium and ruthenium; these alloys evolve heat when dissolved in zinc, and a solution of the rhodium zinc alloy when treated with hydrochloric acid leaves a residue which undergoes a change with explosive violence if heated in vacuo to 400° C. It would be extremely difficult to produce a substance having greater explosive force than those already discovered and in use at the present day; however, it is a matter for speculation whether more powerful explosives could not be obtained by combining acetylene with liquid ozone although, taking practical considerations into account, it appears almost impossible suitably to effect this combination. Whether any advantages would be gained by the discovery of explosives which are more powerful than those already in use is another matter. So far as "propellants" are concerned the corrosive action on the lining of a gun or rifle largely limits the use of explosives which are otherwise suitable from the point of view of their ballistic properties, whilst in the case of "detonators" or "high explosives" once it is possible to plant them on to the exact spot at which it is desired to effect destruction, such destruction can be effected with as great completeness by the employment of one of the present-day "high explosives" as with any new one which may be discovered. On the other hand, any increase in the "safety" properties of "high explosives," and improvements in other directions tending towards facilitating their transport would be a gain from a military point of view.

SEWAGE PRECIPITATION.

At a meeting of the Society of Engineers (Incorporated), held on March 6th, Mr. Reginald Brown, M.INST.C.E., M.I.MECH.E., F.S.I., F.R.SAN.I., read a paper entitled, "Sewage and its Precipitation: Facts and Fallacies from Laboratory and Practical Tests." Taking three of the best-known chemicals in general use, viz., ferric sulphate, sulphate of alumina, and lime, the author pointed out that engineers needed to be fully acquainted with the value of precipitants, and warned them not to expect that a precipitant which was suitable and economical for one sewage must be equally effective and economical with another, or under different working conditions. The composition of sewage varied at different works, and even at the same works at different times, but the practical outcome of treatment in tanks was to reduce to the lowest possible limit the organic impurities present in the sewage and so to relieve the natural or artificial filters provided for the oxidation of the tank effluent.

The author laid down as an axiom that to compare the value of precipitants the purification figure for suspended solids should be calculated on *settled* sewage, and not on *crude* sewage as was generally done, because some of these solids would deposit of themselves by reason of their specific gravity, and did not absolutely require chemicals for precipitation where tanks of sufficient extent are provided to take advantage of this factor. Referring to the experiments carried out at Dorking by the Royal Commission on Sewage Disposal, it was shown that the work of chemicals, if calculated on the crude sewage figure, would be represented by 69 per cent. purification, whilst on partially settled sewage (from continuous flow tanks) the percentage was only 29. The value of chemicals was also felt in aiding the precipitation of colloidal matters which clogged the filters. A point the author desired to emphasize was the want of a standard form in which chemists should return their analyses, and he gave examples of varying expressions of analyses of the same material by different analytical chemists. Working tests on ferric sulphate, ferric sulphate and lime, and sulphate of alumina and lime were then described; and also the manner in which the chemicals were applied to the sewage, the class of sewage dealt with, and the works for which the tests were carried out. The following figures were quoted to show the comparative percentage purification obtained by the various chemicals:—

	4 Hours' Oxygen Absorption.	Albuminoid Ammonia.	Suspended Solids.	Colloids.
Ferric Sulphate	41·86	25·61	80·6	16·0
Do. and Lime	43·2	37·7	80·0	19·3
Sulphate of Alumina and Lime	57·2	48·4	91·2	40·1

Figures were also given to compare the results obtained by ferric sulphate alone, and sulphate of alumina and lime, by first settling the sewage and comparing with the averages obtained from the tanks in the practical tests. The sulphate of alumina and lime showed a greater improvement than the ferric sulphate alone.

The author then set out to show from figures that tests in the laboratory on a single large sample of one day's crude sewage treated with the two chemicals did not agree with the actual working results. By means of a chart the analytical results were compared, the costs remaining constant, from which it is seen that although ferric sulphate is a fair precipitant, sulphate of alumina and lime is the best for the particular sewage experimented upon and for the particular method of treatment adopted.

The summary of results showed that laboratory tests must be checked by tests on a practical scale before any definite line could be followed or any definite statement made as to the value of a precipitant, and that a laboratory test is only sufficient in so far as it gives results under ideal conditions which are by no means met with in actual practice of sewage disposal.

COLONEL R H VETCH CB RE

MEMOIR.

COLONEL R. H. VETCH, C.B., ROYAL ENGINEERS.

ROBERT HAMILTON VETCH was born at Birmingham on 6th January, 1841, his father being at that time Resident Engineer of the Birmingham and Gloucester Railway Company. Both his parents were Scots; his father being the third son of Robert Vetch, of Caponflat, Haddington, and his mother the daughter of Robert Auld, of Edinburgh.

Among the many memoirs of Corps worthies which Vetch contributed to the *Dictionary of National Biography* was one of his father, who was a remarkable man and had a varied career. James Vetch was commissioned as second lieutenant in the Corps of Royal Engineers on 1st July, 1807, and took part in the Peninsular War. He joined Graham's force at Cadiz in 1810, and was present at Barrosa. In 1812 he had a share in the storming of Badajoz, and his letters describing the assault are quoted in Porter's *History of the Corps*. These and other letters written by him during his service in Spain were printed in the *R.E. Journal* in 1880 and 1881. After the end of the war he was employed for some years on the Ordnance Survey; but promotion was slow, and in 1825 he went on half-pay, and turned to civil engineering. He paid special attention to marine work, and put forward a plan for a ship canal across the Isthmus of Suez. From 1846 to 1863 he was Consulting Engineer to the Admiralty on questions affecting harbours. He died in 1869 having had ten children, of whom two—Robert and his younger brother William Francis, rose to high rank in the Army, though neither of them saw war service.

Robert Vetch was educated at the Grammar School, Henley-on-Thames, and at Hopkirk's School at Eltham, and after passing through the R.M. Academy he was commissioned as lieutenant, R.E., on 23rd December, 1857. He was under 17 years of age, yet he was second in a batch of 14, Charles Warren being next to him. The two became warm friends in later years. Sir Charles writes:—"At Chatham I did not see much of Vetch in 1857–8 as our difference of age told, but I always had a great respect for him as a consistent Christian. . . . He was the most consistently Christian man I have ever met—always the same for sixty years, from his boyhood at the Shop—without ever degenerating into sentimentalism. . . . Some persons are so infernally opinionated that they cannot discuss a subject; Vetch and I, even when we differed very much, could go on discussing subjects all the day long because each stimulated the other to think at his best."

After being two years at Chatham, on the Establishment and on the District, Vetch went to Shorncliffe, and in November, 1861, he was ordered to the West Indies. He spent nine months at

Bermuda and then went to Barbados. There he became engaged to Marian, daughter of the Deputy Commissary General, George Darley Lardner, a son of Dr. Dionysius Lardner. They were married in the summer of 1863 at St. George's Church, Dominica, having gone there as guests of the Governor. From Barbados they went to Trinidad.

They returned to England in October, 1864, and Vetch was sent to the Western District. He was put in charge of the new defence works for the Bristol Channel—on Steep Holm, Flat Holm, and Brean Down—and lived at Weston-super-Mare. It was a responsible duty for a subaltern; and Colonel J. W. Savage, R.E., who was with him there, speaks of the ability, tact, and sterling common sense with which he carried it out, adding that his even temper and charming manner made it a pleasure to work under him. After about three years at Weston, Vetch was moved to Plymouth, and was employed on the defences of Plymouth Harbour.

In the summer of 1869 he was chosen to report on the laying of the French Atlantic cable from Brest to St. Pierre, and thence to Duxbury Cove, Massachusetts. He went out in the *Great Eastern*, which was the principal cableship. He wrote a very detailed report of what occurred day by day, and afterwards brought together the more important particulars in the *R.E. Professional Papers* for 1870 (Vol. XVIII., New Series, pp. 137—162). It is a good example of the thoroughness with which he did his work. He remained in the Western District seven years and a-half, becoming second captain on 30th July, 1869. In April, 1872, he was sent to Malta where he remained till the end of 1876. That was his last foreign service. It added to the experience in practical fortification which he had already gained at Bermuda, the Bristol Channel and Plymouth.

In January, 1877, Vetch became Secretary of the R.E. Institute. It was then in its first youth and needed good guidance. As editor of the *Professional Papers*, it fell to him to start a new series—*Occasional Papers*, to be brought together into volumes; and in the first volume he reviewed the history of the Corps publications from their inception forty years before. As Secretary of the R.E. Corps Libraries he brought out a new and improved catalogue in a handier form, and he made the books at Headquarters more accessible. He was also Editor of the *R.E. Journal* which soon showed a marked improvement in quality and get-up as well as an increase in size. He was very successful in getting good articles, and he had a high standard and sound judgment. He held his appointment at the Institute for seven years, much to the advantage of the Corps. He was promoted major on 16th February, 1878, and lieut.-colonel on 14th September, 1884.

Vetch remained at Chatham till the end of that year, and for a time he commanded the Submarine Mining Battalion. In December he went to the War Office as Assistant Director of Works for Fortifications, a title changed some years afterwards into Assistant

Inspector-General of Fortifications. On 1st July, 1889, when his term of staff service was drawing to an end, he became Deputy I.G.F., owing to Colonel Durnford's resignation, and he held that appointment till 5th November, 1894. Consequently he had ten years of continuous service in the Fortification Branch, during the latter half of which he was Secretary of the Defence Committee, and of the joint Naval and Military Committee on Defence. It was a busy time in that branch. Works for the defence of the principal coaling stations abroad were in progress, and others were under consideration for our commercial harbours at home. Defence by submarine mines was being developed. The forts and batteries built in the sixties to guard the chief military ports were no longer a match for the guns carried by ships, and needed remodelling as well as rearming. As one who had the good fortune to serve with him for five years, the writer can testify to the value of Vetch's personality at this time—his powers of work and prompt decision, his clear-headedness and fearlessness, his sound judgment and equable temper. In recognition of his services he was made C.B. in 1894. He had become brevet colonel on 14th September, 1888, and substantive colonel on his appointment as D.I.G.F.

On leaving the War Office he went to Dublin as Colonel on the Staff and Chief Engineer in Ireland. Lord Wolseley was then Commander-in-Chief there, but was soon succeeded by Lord Roberts. The most important matter to be dealt with was the improvement of the Irish barracks. The Royal, Portobello, and Wellington Barracks at Dublin were reconstructed, and new cavalry barracks were built at the Curragh under the Barrack Loan; and the Military Works Loan which followed included many Irish items. To meet civil exigencies, Vetch was sworn as a J.P., like other senior officers. He did not hold his staff appointment for the full term, for he reached the age of 57 on 6th January, 1898, and was placed on the Retired List. He was given a Reward for distinguished or meritorious service.

After his retirement he lived in or near London, and found employment for his pen. Even during his busiest years he had written a good deal. About 1888 Dr. William Hunt, the historian, introduced him to Leslie Stephen, the Editor of the *Dictionary of National Biography*, and from that time onward Vetch was a highly valued contributor to that work. He concerned himself especially with R.E. officers, and took care that the Corps should have its due place in this assemblage of our foremost men. He wrote 183 articles (about 360 pages) in the *Dictionary*, and others in the supplementary volumes. His writing, says a very competent judge, was facile, direct, and invariably intelligible at first reading. He was a contributor also to the *Encyclopædia Britannica*. For the 10th edition he wrote 30 articles on distinguished soldiers, British and foreign; for the 11th edition he wrote an account of military affairs in Egypt and the Sudan from 1885 to 1900.

He did some biographical work on a larger scale. In 1901 he published the *Life, Letters, and Diaries of Sir Gerald Graham*, and in 1905 the *Life of Sir Andrew Clarke*, under whom he had served at the War Office. He was the author of *Sir Charles Warren and Spion Kop: a Vindication by "Defender"* (1902), in the writing of which he had to restrict himself to documents already published, so that he could not state his case with full effect.

In 1900 he published a reprint of Gordon's own narrative of his campaign in China, which originally appeared in Vol. XIX. of the *R.E. Professional Papers* (N.S.) under the title "Notes on the Operations round Shanghai in 1862-4." As an introduction to it, he gave a brief but lucid account of the origin and history of the Tai-ping rebellion.

Vetch was always ready to undertake work for the benefit of the Corps, and he was the sort of man to whom people turn when there is such work to be done. He was elected one of the trustees of the Widows' Society on 15th June, 1901, but he had been a member of the Decennial Committees of 1879, 1889 and 1900, to investigate the position of the Society; and he was also a member of the Committee of 1909 which, after very thorough examination, recommended an increase of the bonus by £5. He continued to the end to take a keen interest in the management of the Fund.

In the summer of 1909 he left London and took a house near Kew Gardens, from which he moved six years afterwards to Ilchester, Kew Road, Richmond. He was suffering much from arthritis at the time, and after a very painful illness of more than six months he died there on 28th January, 1916. He was buried in Highgate Cemetery, where his father had been buried. His wife survived him, and the writer is indebted to her for assistance freely given in spite of illness. They had eight sons and six daughters, of whom six sons and five daughters are living. Three of them are married and there are eight grandchildren.

Dr. William Hunt, whose friendship with Vetch began at Weston 50 years ago, says of him:—"Vetch was an extremely pleasant companion and I much enjoyed the days spent with him at the works. He was invariably cheerful, full of humour and energy. He stuck at his work and did not care to go to parties as he said they would interrupt him. He lived frugally. . . . Vetch always struck me as happily combining in his character firmness and resolute will with gentleness. He was a man of high principle yet ready to make allowance for others. If he was perhaps naturally quick in temper, he was never unkind or contemptuous of others, and always placable. . . . His taste in artistic matters was good, and he took an intelligent interest in many things. One more trait, he was exceedingly generous in money matters, almost more than he could afford. Lastly, he was a consistent disciple of Christ, humble-minded and pure in heart, and he was a sincere member of the English Church."

E. M. Lloyd.

REVIEWS.

AIRCRAFT IN WARFARE.

THE DAWN OF THE FOURTH ARM.

By F. W. LANCHESTER, M.INST.C.E., M.INST.A.E. (With an Introductory Preface by Major-General Sir David Henderson, K.C.B., Director-General of Military Aeronautics.—Constable & Co., Ltd. 12s. 6d.).

THE greater part of this work was written during the closing months of 1914; and such has been the progress made in military aviation during the past year that the work, in so far as it relates to aircraft in warfare, seems a trifle out of date.

Mr. Lanchester commences by considering the air service as a fourth arm, and expresses the opinion that (at the time of writing) the machines were numerically so weak that, as an arm of the Service, the aeronautical services were a negligible factor. It being an admitted fact that the machines were too few, though perhaps to say that the flying arm was negligible was rather overstating the case, it is a pity that Mr. Lanchester should have chosen to institute a numerical comparison with the cavalry; for by so doing he puts forward a very false argument, tending to defeat his own end.

He suggests that a suitable basis of comparison will be to compare the aeroplane with a single trooper; admitting that the capital cost of the one is far greater than the other he is still of the opinion that making due allowances for this the value of the comparison is unaltered. He gives figures to prove his argument. At the outbreak of hostilities, he says, the Germans are reputed to have possessed some 500 aeroplanes. Would the German cavalry have proved of any real utility, he asks, had they been limited to this number? Answer is unnecessary. Now if his basis of comparison is correct it follows of necessity that 500 aeroplanes would prove useless. But he draws attention to the effective reconnaissance of the German aeroplanes, proving himself that this number of aeroplanes proved of very real utility.

It would seem impossible to institute a comparison on a numerical basis between cavalry and aircraft; experience alone can show the requisite strength of the fourth arm compared with other arms. It is doubtful whether the reconnaissance duties of aircraft and cavalry can be fairly compared. Each has its advantages and its limitations. Troops deployed, or taking advantage of natural cover may and have escaped unseen by an aerial observer, while they would be found by cavalry scouts. On the other hand the radius of action of cavalry is small compared with that of an aeroplane; further, an observer in an aeroplane will be able to see movements of large bodies of troops behind the cavalry screen through which, for a time at any rate, the opposing cavalry would be unable to penetrate.

Mr. Lanchester considers that the obvious disadvantage of the aeroplane for reconnaissance is that it informs the enemy of the presence or advance of a hostile force. This does not seem to be a great disadvantage, as the presence of hostile cavalry gives the same information to the enemy, and further, owing to the smaller radius of action of cavalry, allows him to make a more accurate guess at the probable distance of that hostile force, even have his scouts, aerial and otherwise, failed to discover its presence. These remarks apply of course to field warfare; this portion of the book was written before trench warfare had commenced. Needless to say, under the present conditions reconnaissance duties—except engineer reconnaissance—devolve entirely upon the fourth arm.

The question of aeroplane *versus* dirigible is next discussed. Mr. Lanchester suggests that 100 yards of barbed wire trailed below an aeroplane would prove an efficient weapon against a non-rigid dirigible or balloon; while ordinary rifle or machine-gun fire is comparatively ineffective. The writer does not know whether the experiment of flying an aeroplane with 100 yards of barbed wire trailing from it has been tried; at first sight it seems that unless the aeroplane had been specially designed always to fly in that condition, the head resistance of the wire might so lower the centre of drift as to seriously affect longitudinal stability. This may not be so; Mr. Lanchester knows all that can be known on the subject of lift and drift. Granted that flight is possible; the effect on the aeroplane of catching a gas bag with barbed wire hard enough to rip it open would very likely be such that ramming tactics might as well have been adopted in the first instance, as more certainly productive of the desired result, and no more dangerous to the pilot. In the event of an aeroplane getting within 300 ft. of a dirigible, and above it, *i.e.* near enough to draw the barbed wire across it, the third method of attack suggested by the author seems the safest and most certain, namely the dropping of heavy objects or bombs—preferably bombs—on to the envelope.

Mr. Lanchester draws the conclusion that the weaknesses of the dirigible on the defensive are so great and of such a character as to render it quite unfit to remain an active participant in aerial warfare. Sixteen months later, however, there is only one authenticated case of an airship being brought down by an aeroplane; the occasion being that on which the late Flight Sub-Lieut. Warneford, flying a Morane monoplane, bombed and destroyed a Zeppelin, thereby winning the Victoria Cross.

The question of the most suitable armament for an aeroplane is discussed at some length. The author is of the opinion that in field warfare considerable damage could be done to the enemy's *personnel* by machine guns; while with sufficient aeroplanes an area extending from 50 to 100 miles behind the enemy's front line might be devasted by bombs, breaking down his lines of communication and supply, and forcing him to retire. This seems an excellent suggestion; but when one considers that in front of our portion of the line alone an area of from 1,500 to 3,000 square miles would have to be devasted, the number of machines and bombs required begins to appear somewhat greater than is quite feasible.

Mr. Lanchester expresses the opinion that the aeroplane bomb used as a weapon of offence against *personnel* will not be very useful unless troops can be caught massed; but that the best method of employing it will be to attack depôts, arsenals, etc., with flights of aeroplanes, each dropping several bombs. Since the book was written this has been done several times; it is to be hoped that more military damage has been done in these attacks than the Zeppelins have done in their various visits to this country.

Further questions which are gone into are armour, aerial tactics, attack by and defence from gun fire, naval aircraft, flying grounds, international questions relating to aircraft, air raids, and many other points too numerous to mention here.

As may be seen in the foregoing *résumé* there are, as Major-General Sir David Henderson, K.C.B., says in his preface, many points in the book which are highly controversial. This does not at all detract from but rather enhances the value of the work, as controversy opens new fields of thought and gives rise to new lines of action. At the present time, unfortunately, all matters connected with military aviation cannot be openly discussed, as this would involve the publication of information much of which must not, for obvious reasons, be published; and much of which is still shrouded in the fog of war.

From a military point of view, perhaps the most valuable portion of the work is contained in two chapters which, while applicable to aerial warfare are by no means confined to it, and are referred to by the author as a digression. These chapters contain a theory which Mr. Lanchester terms the N-square law, a mathematical expression of the fundamental principles of concentration; which Major-General Sir David Henderson calls a most valuable contribution to the art of war. The law is perhaps of sufficient interest to warrant its inclusion here.

One of the great questions at the root of all strategy is that of concentration; this is especially the case in modern warfare, in which killing is done at a distance, as this enables the destructive effect of a larger force to be concentrated on the smaller object of a lesser force to a far greater extent than was possible in the days when battles were fought hand to hand with sword and axe. In those days, supposing that battles were fought until the whole of the vanquished force were put out of action, it is reasonable to suppose that if a force of 1,000 men met a force of 500 men, of equal individual fighting value, at the end of the battle 500 men would be left of the greater force, while the smaller force would be wiped out; provided the line of battle remained unbroken. Now, however, the whole 1,000 men would be able to concentrate their fire on the 500, with the result that the rate of losses in the smaller force would be much greater than that in the larger force.

All things being equal except numerical strengths, each man in a given time will score, on an average, the same number of effective hits; that is to say, the losses on one side will be directly proportional to the numerical strength of the opposing force; if the individual fighting values (depending on arms, etc.) are unequal, the losses will be modified according to the respective fighting values of the opposing forces.

To put this in mathematical language:—

Let b be the strength of a "Blue" force.

Let r be strength of a "Red" force.

t represents time.

Then
$$\frac{db}{dt} = -r \times c.$$
$$\frac{dr}{dt} = -b \times k.$$

c and k are constants. ($c=k$ if the fighting values of the individual units of the forces are equal).

For the condition of equality—

Let M be the individual value of a unit of the "Blue" force.

" N " " " " " "Red" "

Rate of reduction of "Blue" force—
$$\frac{db}{dt} = -\text{N}r \times \text{constant}.$$
and "Red"
$$\frac{dr}{dt} = -\text{M}b \times \text{constant}.$$

For the condition of equality—
$$\frac{db}{b \times dt} = \frac{dr}{r \times dt}$$
or
$$-\frac{\text{N}r}{b} = -\frac{\text{M}b}{r}$$
or
$$\text{N}r^2 = \text{M}b^2$$

In other words, the fighting strengths of the two forces are equal when the square of the numerical strength multiplied by the fighting value of the individual units are equal.

This is the N-square law. It appears at first sight theoretical; but the author goes on to deduce from it sound conclusions as to the relative value of rifles and machine guns, and shows with considerable exactness the danger of a divided force. He finishes up by applying the law to a concrete example, namely the Battle of Trafalgar, when Nelson, with a numerically inferior force, defeated the combined French and Spanish Fleets. Whether Nelson had actual knowledge of the N-square law or not, it is impossible to say; probably not; but the fact remains that his plan of attack consisted firstly in cutting the enemy's line into two parts whose proportions exactly corresponded, according to the law, to the reduction of his total effective strength to a minimum; and secondly, in dividing his own fleet in the proportion required, according to the N-square law, to give a fighting strength equal to tackling the two halves of the enemy on level terms.

As Mr. Lanchester remarks: "although we may take it to be a case in which the dictates of experience resulted in a disposition now confirmed by theory, the agreement is remarkable."

J.D.B.

WHAT TO OBSERVE AND HOW TO REPORT IT.

This little book was written many years ago by the late Colonel Sir Lonsdale Hale, R.E., for the use of junior officers and N.C.O.'s of the British Cavalry. The present edition, the eighth, has been revised and brought up to date.

Section 1 explains what reconnaissance is and deals with reports, and general remarks on how to make them.

Section 2 deals with the objects on which reports may be required, and the information to be given with respect to each.

Section 3 is a short section dealing with the manner in which information obtained should be put down on paper.

Section 4 gives simple instructions as to how to make a sketch of the ground reported on, either by enlarging or reducing a map, or without the aid of a map. A simple explanation of contours is also included in this section.

Section 5 contains a few remarks on map reading.

Section 6 gives a list, with reference to reconnaissance, of things which every Cavalry N.C.O. should be able to do fairly, and also the outline of a small scheme explanatory of the kind of road reconnaissance which might have to be carried out on service. At the end of the book are tables of weights and measures, some hints on sketching, and an example of headings for a report: also four plates, two illustrating contours, a road sketch, and a plate of conventional signs.

The book is written throughout in very simple language, and should be useful to junior officers, or N.C.O.'s, desirous of studying the elements of reconnaissance.

NOTICE OF MAGAZINE.

REVUE MILITAIRE SUISSE.

No. 11.—November, 1915.

NOTES AND NEWS.

Portugal.—The Portuguese Government has recently decreed the breaking up of the Portuguese Artillery into two separate branches, namely, into field and garrison artillery. It had been recognized for some time past that, owing to the great complexity in the problems dealt with by the two branches and the great difference in the technical questions affecting them, a change would have to be made. The interests of the old class of officers have, it is said, been suitably protected by the law giving effect to the above reorganization.

A successful mobilization of the Portuguese Army, in the entrenched camp of Lisbon, has been carried out recently. The manœuvres carried out by mixed columns and the range practice of the field and garrison artillery appear to have given complete satisfaction.

INFORMATION.

Obituary notices relating to Colonel Aymon Galiffe and Lieut.-Colonel W. de Rham are published in this number of the *Revue.*

The Army Order published by General Wille recalling Morgarten is reproduced. It was in this field that, six centuries ago (on the 15th November, 1315), the mountaineers of Schwytz, of Uri, and of Unterwald won the right of independence and liberty for the young Confederation to which the Switzerland of to-day owes its origin.

This number concludes with a Bibliography of works of military interest.

No. 12.—December, 1915.

THE OPERATIONS OF THE BELGIAN ARMY IN 1914.

It is stated in an Editorial note that the following works have been consulted in connection with the compilation of the article under review, viz. :—

L'Action de l'armée belge pour la défense du pays et le respect de sa neutralité. Rapport du commandement de l'Armée. Paris, Chapelot, 1915.

La Campagne de l'armée belge (31 Juillet, 1914—1er Janvier, 1915). D'après les documents officiels. Paris, Bloud et Gay, 1915.

Les pages de gloire de l'armée belge, par le Commandant Willy Breton. Paris, Berger-Levrault, 1915.

A review of the first mentioned of these works appeared in the number of the *R.E. Journal* for November, 1915. The second of the above-mentioned works contains a more *detailed* account of the operations than that given in the first mentioned; whilst the last-mentioned work deals to a great extent with the episodes connected with the fighting on the Gette and on the Yser.

The writer of the *Revue* article states that, at a time when the word neutrality still had some signification, it was found to be an interesting study to compare the neutrality of Switzerland with that of Belgium and to distinguish, from the point of view of International Law, the points of difference between this state of national existence in these two countries. However, at the present time, when Might is Right, more is to be gained by making a comparison of the armed forces of neutral states rather than their constitutions.

Belgium, as was the case with Switzerland, felt compelled in recent times to adopt measures for augmenting her army, but as events have turned out this step was taken too late, in the case of the former country, to produce the results aimed at. For, whilst the Swiss Army Laws of 1907 and 1911 have already fulfilled their purpose, on the other hand the Belgian Army Law of 1913 had scarcely come into operation when the present war broke out. The Law last mentioned was intended to provide Belgium with an army of 350,000 men, at War Establishment, in 1918.

The organization of the Belgian Army is given in the article under review and a reference is also made to its armament. As these matters are fully dealt with in the review of the Belgian operations which appeared in the number of the *R.E. Journal* for November, 1915, it is not necessary to repeat the information here.

It is pointed out that it was due to lack of heavy artillery which prevented the Belgian Army from deriving full advantage from the partial successes obtained by it on several occasions during the early stages of the War. The operations of the Belgian Army, prior to the period of the present trench warfare, can be divided into five distinct phases, viz.:—

- (i.). From 4th to 20th August, 1914: defence of Liège, Namur, and the region between the Meuse and the entrenched camp of Antwerp.
- (ii.). From 21st August to 27th September, 1914: offensive strokes by troops based on Antwerp.
- (iii.). From 28th September to 6th October, 1914: defence of entrenched camp of Antwerp.
- (iv.). From 7th October to 15th October, 1914: evacuation of Antwerp and retreat to the Yser.
- (v.). From 16th to 31st October, 1914: Battle of the Yser.

During the first four phases the Belgian Army took care not to enter into a battle likely to involve serious consequences in the event of its defeat. It was able, owing to local successes, to maintain its position on the Gette, but as soon as it was seriously threatened it disengaged itself and retired into Antwerp, with the intention of awaiting developments under the shelter of the works of the great fortress.

In the period covered by the second phase, the confidence of the

Belgian Army in its ability to hold out under the shelter of the works of Antwerp increased in spite of the fact that no decisive results had been obtained from the strokes delivered from Antwerp, owing partly to the absence of heavy artillery and partly to the relatively small numbers of the Belgian troops. However, as soon as the third phase was entered, the effects produced by the first shells fired into Antwerp by the Germans, on the 28th September, 1914, rapidly dispelled any illusions, as to what was in store, which may have been cherished at the Belgian General Headquarters. The damage done to the first line forts, during the first two days of the German bombardment, left no doubt in the minds of the Belgian General Staff that Antwerp was doomed and that an early capitulation of this fortress could not be avoided. During the fourth phase the early anticipations regarding the value of the defences of Antwerp were completely dissipated. When the fifth phase opened the Belgian Army had already lost one third of the infantry force with which it began the War, although its artillery was still intact. However, although attacked in its positions on the Yser by a German force of far superior numbers, the Belgian Army gallantly barred the German advance on Dunkirk and Calais and maintained a foothold on its native soil. Briefly, in spite of defects in organization and of its want of readiness to undertake active operations, the Belgian Army, without the aid of other troops, succeeded for a period of two months in holding its own in positions which had been reconnoitred in peace time.

The question is asked—Could Switzerland have done as much as Belgium did (from the political point of view) had she received an ultimatum on the 2nd August, 1914, followed by an attack in force on the night of the 3rd—4th August following? Possibly she might have done so, but it is thought that she would have fared no better than did Belgium.

In seeking for lessons to be learnt from the present campaign, the first matter which attracts attention is the rapidity of the Belgian mobilization and concentration; in less than six days the Belgian Army was ready to move with all its transport, although it was taken by surprise whilst undergoing the process of a reorganization. Under the circumstances the results obtained speak volumes for the capacity and training of the Belgian General Staff.

A further question is asked as to whether similar results could have been obtained by the Swiss General Staff? The reply given is as above; it is possible, but in any case the results would scarcely have been better.

Rapid as was the Belgian concentration, nevertheless it was not rapid enough to save Liège. On the contrary, it was Liège which saved the Belgian Army. As Switzerland has no fortress similarly situated to the last named, the concentration of her army would, under identical circumstances, have run the risk, it is thought, of being seriously interfered with by the enemy.

The fall of Namur was a military event possessing characteristics different from that connected with the German capture of Liège; surprise played no part at Namur. The German success at the more southern of the two fortresses is attributed to the superiority in the attack over the defence, owing to the manifest superiority of the heavy artillery of the attackers over that possessed by the defenders. Switzerland, it is said, should congratulate herself that she has not been spending her money on fortifications which a possible enemy could destroy in five days. This must not be taken to mean that the Belgian fortresses were altogether useless, although they did not effectually fulfil the purpose for which they were constructed.

When, 50 years or so ago, Brialmont took up the question of fortifying Antwerp, a considerable discussion arose in Switzerland as to the advisability of providing a central réduit or stronghold as a base for the Helvetic Army. At that time, and even at a later date, heated controversies have raged between the partisans of the "système central" and those of the "système périphérique"; the advocates of the "système radial," proposed by Colonel Rothpletz and having for object the establishment of a fortified barrier across Switzerland from Basle to Zurich, also contributed their views on the subject about the same time.

Whether a central stronghold, as a base of manœuvre for the Swiss Army, would be of any real value is a question difficult to decide with the information available at the present time. If the six weeks which elapsed between the 20th August to the 27th September, 1914, represents the time required by the Germans in which to complete their arrangements for the investment of Antwerp, there is certainly some evidence in support of the view that an entrenched camp of this nature may still be made to answer a useful purpose; on the other hand, if the delay referred to was attributable to causes other than those connected with the German preparations for an investment, then the value of such an entrenched camp becomes problematic. Consequently, in the one case it would be a matter of regret to the Swiss military authorities that no central stronghold existed in their country; in the other, the Swiss people may well be satisfied that their money has not been spent on a useless venture.

The best proof of the value of the services rendered to the cause of the Entente Powers by the stand of the Belgian Army on the Yser lies in the fact that the French Headquarters were able to detach but one division, in addition to the Marine Brigade, for the purposes of reinforcing the Belgian Army during the fifteen days of the desperate fighting on the front, from Dixmude to the sea. If the Belgian Army had not held out on the Yser, the Anglo-French left wing would have been enveloped and forced back across the Lys, and probably even across the Somme.

Extracts from the *Pages de Gloire* reproduced in the *Revue* deal with the part played by the Belgian Artillery and field fortifications at the Battle of the Yser. The lesson to be learnt from these extracts is that light field guns can, when properly dug in along a defensive position, hold their own for some time against even heavier guns; but to attain this result a high state of discipline is required on the part of the gunners and involves an enormous expenditure of ammunition.

When the Battle of the Yser was ended 200 out of the 350 guns which had taken part therein were temporarily out of action; and on the 4th November, 1914, when the 2nd Belgian Division made the offensive stroke against Lombaertzyde, only 15 out of its 48 guns were still fit for use. On the other hand, the losses in *personnel* in the fight on the Yser do not appear to have been heavy; the thickness of the parapets seem to have played a less important *rôle* in the matter than the courage of the defenders.

A pious hope is expressed that if some day Switzerland is unfortunately drawn into a war fate will deal more kindly with her than it has, up to the present, dealt with Belgium; and further that, in the event of Switzerland being overtaken by such a disaster, her army chiefs will exhibit an energy and aptitude for war equal to that shown by the Belgian chiefs, and that, at the same time, her soldiers will apply the same devotion to their country's cause and the same contempt for death as that shown by the glorious defenders of the battle line on the Yser.

Machine Guns and Infantry.

It is felt to be premature to attempt to draw any general deductions from the events of the present war. Although in some few cases certain facts have been established with some degree of certainty, no definite conclusions can yet be drawn therefrom. Such is the case even in the matter of the *rôle* played by machine guns in the present war, although it exceeds the expectations of those who have been most enthusiastic in pushing this arm to the front.

The belligerents early in the War recognized the importance of machine guns and immediately set to work to increase the numbers of this weapon with their various formations; details relating to these increases are, however, not available. It is known that in France machine-gun companies have been formed—apparently attached to the infantry brigades. The great increase in the number of machine guns in the German Army is made evident by the great numbers known to be in position in the German trenches; they exceed in number the six per regiment existing prior to the War.

Before the present war the machine-gun organization of the Continental Powers was briefly as follows:—

Switzerland: A group of three companies (of four machine guns apiece) per infantry division and a company (of eight machine guns) per cavalry brigade; in addition at least one machine gun per battalion and one such gun per squadron.

Germany: Eleven "Abteilungen" of six machine guns each, attached for training purposes to Jäger battalions, but intended to be employed in connection with operations with the cavalry divisions; one company of six machine guns per infantry regiment and Jäger battalion; also an average of two machine guns per battalion, and one such gun per two cavalry regiments.

France: A section of two machine guns per battalion of infantry and of chasseurs; and two sections of two such guns apiece per cavalry regiment.

Italy: A section of two machine guns per infantry regiment and per battalion of Bergsagleiri; and a section of two machine guns per cavalry regiment.

Austria: A section of two machine guns per "field" infantry regiment and per battalion of Jägers; and a detachment of two sections per "mountain" infantry regiment and per cavalry regiment.

It is further probable that all the belligerents have modified their machine-gun organization since the commencement of the present war.

The question of increasing the number of machine guns in the Swiss Army has recently been under discussion, but no information on the subject has been made public yet.

The experience of the present war has shown how difficult it is to locate machine guns, when properly screened in defensive positions. For example, during the great offensive of September last in the Champagne, when the German positions were subjected to an intense bombardment for a period of 72 consecutive hours so that it appeared that the German first line trenches were completely destroyed, there still remained a number of German machine guns in well-concealed emplacements. These guns were untouched by the French artillery fire, consequently, when the French infantry advanced to the attack, the leading units came under a severe machine-gun fire and suffered very heavy losses. This apparent invulnerability of machine guns may be explained on the supposition that the long period devoted to the "artillery preparation" in this case gave the Germans an opportunity to concentrate a very large number of machine guns on the front threatened. Being small and easily transportable (on tripod mountings), they can be readily withdrawn from one part of a line and quickly transferred to another. Further, as only two men are required to work such a gun in an emplacement, and one of these is always under cover, the casualties in the machine-gun detachments are relatively small.

Although, at the present time, the fighting has degenerated into trench warfare, yet it must always be borne in mind that ordinary field operations may again be resumed; when this occurs, machine guns mounted on travelling carriages will, it is thought, be found most useful for the purpose of being rapidly pushed forward to localities occupied by an advanced guard in order to be utilized for the purpose of compelling the enemy to deploy at distances of at least 2,500 yards from the points held by these guns; for reinforcing the rifle fire against some decisive point; for holding on to a position to the last moment during a retreat; for harassing a retreating enemy, etc., etc. In the last-mentioned case, machine guns are themselves very liable to be surprised, and, therefore, it is recommended that they should be provided with an escort of cavalry.

The *rôle* assigned to machine guns should be to appear suddenly at the point where a particularly intense fire against an enemy is necessary and to disappear as suddenly before they suffer damage at the hands of hostile artillery or machine guns; they should particularly avoid coming under artillery fire. Normally, machine guns should be held in reserve under the direct orders of the divisional commander, and as soon as the special task assigned them has been completed, they should at once be brought back to the position of the divisional reserve; their ammunition supply should then be immediately replenished so that they may be ready for the next task allotted to them.

It is proposed to attach the new Swiss machine-gun companies to the infantry; it is feared that their means of transport will not enable them to move rapidly. It is intended that they shall accompany their regiments, either as a company or broken up into sections, and that they shall take up positions either on the same line as the infantry, or slightly in rear, with the object of giving them material aid and affording moral support. It is expected that the intensity of their fire will compel the enemy to seek cover, and thus provide an opportunity for the infantry, of their own side, to advance by rushes. They will, it is assumed, also be able to bring an oblique fire to bear on hostile troops advancing to the attack as these become exposed to view owing to the irregularities of the terrain. Machine guns are often likely to be attached to an advanced guard but, it is thought, that they should not, as a rule, be employed with troops detailed for outpost duties. Defensive positions will continue to afford the ideal conditions for the most effective employment of machine guns, particularly where the sinuosities of a front enable them to occupy points from which oblique fire can be brought to bear on the enemy's line of advance.

Whether machine guns are employed as independent groups or regimentally, the tactical principles involved in their use are identical; the principle which dominates all others is that there shall be the most intimate co-operation or "liaison" between the machine guns and the other troops with which they are for the time being associated. For some time past considerable importance has been attached to this type of "liaison" and important results have followed in France by the measures adopted to provide for the "liaison" more particularly between the infantry and the artillery. The term "agent de liaison" is now a commonplace term in the mouths of even the civil population. Much attention has been devoted to this subject in Switzerland in recent times, and although sufficiently satisfactory results have been obtained in the vertical scale of the hierarchical ladder, yet the aspect of the question which affects the "*liaison horizontal*," *i.e.*, between commands of same relative status, has not received the attention it deserves. In order that the fullest advantage may be secured from the fire effect of machine guns in assisting the advance of infantry it is desirable that some simple code of signals should be prearranged, in order to provide for a rapid intercommunication of information and orders between the machine-gun detachments and those with whom they are co-operating.

Two important paragraphs from the *Swiss Training Manual for Machine-Gun Detachments* are reproduced in the *Revue*; it is recommended that these paragraphs should also be inserted in the *Swiss Training Manual for Infantry*. They read as follows:—

"315. All demands for ammunition should be addressed to the nearest infantry troops in the fighting line; the latter must, immediately on receipt of such a demand, hand over complete ammunition carts, with the ammunition they contain, to machine-gun units; only thus can a satisfactory replenishment of ammunition be provided for.

"319. Troops on whom a demand is made for *personnel* for the machine-gun service must immediately meet such a demand."

It is considered to be regrettable that rules of such deep significance should only be known to those who are aware of their supreme importance, but unknown to the majority of those who may be required to give effect to them.

Trenches, Obstacles, and their Defenders.

Some Impressions from the French Front.

The article on the above subject in the *Revue* is illustrated with photographs taken at the Front. It is pointed out therein that it is but two years ago that the General Staffs of the European Armies issued their latest regulations on field fortification; and at no time have regulations—in this case based on the experience of the Russo-Japanese War—had to meet so completely and promptly the test of actual warfare.

Since the flanks of the belligerent armies in the western theatre have been secured, it is the complete exhaustion of one or the other side, so it is suggested, which can alone disturb the equilibrium that has been established by the occupation of opposing trench lines by the two sides. In this war of attrition and of technical appliances the calculations as to the probable date when exhaustion will occur must be based on statistics, *i.e.*, in relation to factors of importance in the field of political economy.

The characteristics of the present struggle are of a nature to demand a resort to new methods of procedure of a kind not dealt with in books of instruction; for this reason considerable originality in handling matters in connection with improvised fortifications is required in order to meet these new methods of procedure.

Behind the Trenches.—The talk of certain pessimists causes the new-comer in France, so it is said, some measure of vexation. But a journey along the French lines of communication soon leads to a modification of the first impressions, since it is patent that the situation is far from as unsatisfactory as represented by the aforesaid pessimists. Many difficulties have been overcome and matters are now being dealt with in a calm and strenuous manner.

At the centres where parks have been established motor vehicles and guns are seen in abundance, no longer formed up in parallel lines or in a single column but so disposed as to harmonize with the surrounding scenery and hidden away under trees, etc.

Supplies are being conveyed to the Front by railway, motor transport and in barges. The use of motor transport has brought about considerable changes in the supply services. In other directions also draught animals have been replaced by mechanical transport. For instance, machine guns, artillery and searchlights are now mounted on motor vehicles, and a new echelon has been formed of guns and searchlights so mounted for the purpose of dealing with hostile aircraft.

Among other improvements is a considerable acceleration in the railway services provided for military purposes.

The Trenches.—The *rôle* played by the French first and second-line trenches, their profile and the obstacles provided vary according to the tactical situation at the locality concerned and the circumstances under which the trenches, etc., came into existence. The first-line trenches by no means consist of a continuous parapet. Where the opposing sides are at least 500 yards apart *points d'appui* have been constructed at intervals and are connected up by trenches with smaller posts and the positions of the sentries. In localities where less than 300 yards separates the two sides the number of the "centres de résistance" are increased and they are connected up to numerous supporting trenches, echeloned back on their flanks; under these circumstances, this line is, so to speak, the first parallel. Saps are thrown forward from these "centres de résistance," and at a distance of some 25 to 15 yards from the enemy's defences, narrow trenches are constructed laterally and are eventually connected up to form a second parallel. The third phase is that where mining replaces sapping, the grenade the rifle, the dagger the bayonet.

The springing of mines and countermines, which is continually in progress, causes mining galleries to fall in, and thus passages are formed connecting up the two fronts; bayonet contests often take place in the passages. In this way was formed the "*labyrinthe.*"

In the most advanced parallels, 8 to 10 yards from the enemy, grenades and ammunition are stored within reach of the men holding the trenches. The men in the forward trenches are keenly alert; the strictest silence is maintained by them, for the smallest noise draws a grenade attack and is the signal to the enemy's listeners to explode their mines.

The French have adopted the narrow deep type of trench, so much in vogue to-day, along their part of their front; the bottoms of these trenches are, as a rule, 6 ft. 6 in. below the surface of the ground and about 18 in. wide; the walls of the trenches are vertical and revetted with brushwood; drains are provided along the bottoms of the trenches; banquets are kept as narrow as possible, being generally less than 9 in. wide. Loopholes of wood have replaced sandbag types of head-cover. No excavations are made under the front parapets; shelters, to contain from 10 to 15 men, are placed on the rearward side of the trenches.

Machine-gun emplacements are sited so as to provide flanking fire along the front of the position and so as to command the obstacles in front of the French positions. They are provided with head-cover, consisting of wood planks and some 30 in. of earth. The "listening posts" near the lines of obstacles are connected by alarum bells with the observation posts in the trenches.

The trace of the trenches is very sinuous. The ordinary traverses are said to be useless, but very numerous splinterproofs have been provided and practically form bulkheads at every 6 to 9 ft. along the trenches.

Everyone at the Front now recognizes that copses and woods form the best screen; not only do they render the manœuvre preceding the battle invisible, but they also mask retreating troops from view. Artillery positions are, whenever possible, selected close along the edges of woods. The salients of woods are, as a rule, transformed into "*centres de résistance*" to be held by a company of infantry; double approaches are provided thereto; one direct, for use at night, and the other defiladed from the enemy's position, for use by day. The line of trenches is placed inside the edge of a wood and provided with casemates, having about 30 in. of earth as cover. Listening posts and observatories in woods are invariably connected to the commander's post and the nearest batteries of artillery by telephone.

Obstacles.—Obstacles have been very plentifully provided. Three zones have, as a rule, been established; two rows of wire entanglement 12 to 18 yards wide consisting of the ordinary barbed wire type are provided, separated from one another by a line of the more recent type of coiled wire entanglement. Military pits are often combined with the lines of wire entanglement, the whole forming a zone of obstacles which is, at times, at least 100 yards wide. The coiled wire type of entanglement is said to be more easily constructed than the other types; to be less visible; and to be more difficult to surmount unless previously damaged seriously; its destruction is, however, not so easily effected as in the case of the other types of wire entanglement.

During the second phase of the advance, it is no longer possible to construct lines of obstacles on the foregoing scale; it is usual in these cases to put out *chevaux-de-frise* in front of the sapheads. In the third phase countermines are the best means of checking the enemy's offensive.

Under the Trenches.—The enemy's position is in many cases but a few yards from the advanced parallel; owing to the enemy's machine guns the mine is the only means by which further progress forward can be made thence. In order to carry out mine warfare efficiently men are being specially trained for the purpose.

The Defenders of the Trenches.—The men of both the active army and the territorial force created a favourable impression on the writer of the article in the *Revue*. The spirit of loyalty and of altruism, which pervades all ranks of the French Army, exist in an exalted degree. Officers and men, who were spoken to, expressed the most implicit faith in the future, and exhibited the best of humour and good spirits.

Notes and News.

Switzerland.—The extreme left of the Socialist group in Switzerland have delivered a double attack against the military institutions of the Helvetic Republic. Their latest step has been to demand the abolition of Military Courts for the trial of offences against the Military Code; in taking this step they appear to have quite overlooked the fact that as military discipline is something out of the ordinary, therefore, those who are called upon to administer the Code should be drawn from the ranks of those who have made a special study of the subject and have in addition received a suitable training to fit them to undertake the responsibility placed on their shoulders.

The Socialists have further put forward the demand that the pay of officers and men shall be equalized; in this matter also they have missed the mark. If this proposal were carried, the tendency would be to make the career of an officer in the Swiss Army a luxury open only to those belonging to the aristocracy of wealth. This is the last thing that the Socialists—and indeed the whole Swiss people—are anxious to see in their country.

The Swiss General Staff have recently brought out a military history of Switzerland, entitled *Histoire Militaire de la Suisse*. The work consists of twelve parts and is published in German, French and Italian; some of the most distinguished historians in Switzerland have collaborated in its production. The work covers the three great periods in

Swiss history, namely, 1315 to 1515, Morgarten to Marignan; 1515 to 1815, the Perpetual Peace with France to the fall of Napoleon; 1815 to 1915, the Last Hundred Years. This work is likely to prove extremely popular in Switzerland.

The editors of the *Revue* draw attention to the difficulties they have been experiencing in connection with the production of their publication by reason of the prolongation of the European War; they, however, hope to extend the usefulness of their journal as soon as circumstances permit. Among other things, the Editors hope, at an early date, to devote more space in the *Revue* to matters connected with foreign countries.

United States of America.—Reference is made to the project which is being discussed in the United States of converting the National Guard or Militia, now controlled by the several states, into a central reserve under the style and title of the *United States Reserve.* The project has not yet been laid before Congress; it is anticipated that it will be vigorously opposed by certain States as being subversive of the responsibilities assigned them under the Constitution.

The project in question provides for a regular army of 125,000 men recruited by voluntary enlistment for two years Colour Service; at the expiration of which time the men so recruited are to pass into a reserve for a further period of eight years. If the project becomes law, the United States of America will, eight years from the passing of the law, have a second line of 425,000 reservists.

It is proposed that the 3,000 officers required shall be obtained by offering 12,000 scholarships, each tenable for four years, at the principal American universities. Senator Dick, the promoter of the Militia Law bearing his name, desires to see the United States in possession of a regular army of 250,000 men and the strength of the National Guard raised from 125,000 men to one million.

Congress passed a Bill in October, 1914, which was framed with the object of encouraging rifle practice in the United States; but it would appear that, in spite of this, more than 80 per cent. of the civilians, between 18 and 25 years of age, who are members of the National Rifle Association have never handled a rifle. However, there are indications that the general public in the United States are beginning to take a closer interest in questions affecting national defence. Some of the important trading corporations have recently made it known that they will do all in their power to enable their employés, who belong to the Militia, to attend drills and military exercises; they also undertake to pay full salaries and wages to their employés during the period that they may be engaged in military duties. One Boston house has even gone so far as to offer double pay, during the period of military training, to such of their clerks who may be serving in the Militia. The Association of American Bankers has also passed a resolution to afford financial aid to the Federal Governments and the various States for the purposes of national defence. The most significant step which has been taken in the United States is that connected with the *Business Men's Camps* formed recently at various centres. Merchants, bankers, stockbrokers, lawyers, etc., of all ages have congregated at these camps—the most important of which was located at Plattsburg, in New York State—for a period of from 10 to 12 days in order to receive instruction in military subjects from officers of the regular army. The *Business Men's Camps* appear to be looked upon with disfavour by the members of the Militia; probably, it is said, because the public and the Federal Government have shown a decided disposition to support the movement. These camps have also won the support of the *National Security League*, a powerful association, which is already firmly established in some 40 American cities.

The business men of New York, on their return from Plattsburg, decided to retain their regimental organization under the title of the "*Business Men's Training Regiment.*" The Militia, properly so-called, also shows signs of having taken on a new lease of life. In many directions much is being done to improve the training of this force. Recently a Bill was passed in the State of New York for the formation of a reserve to the National Guard, into which officers, N.C.O.'s and men of the Militia could pass on release from the Militia.

This number of the *Revue* concludes with a Bibliography of literature of military interest.

A number of sketch maps relating to the Austro-Italian and Russo-German theatres of operations have also been issued with this number of the *Revue*.

No. 1.—January, 1916.

A TALK ON AERONAUTICS.

It is pointed out in the *Revue* article that the present war has shown how very considerable has been the progress in the science and art of aeronautics during recent years. Those who desire more detailed information on the subject than that contained in the article under review can, it is stated, with advantage consult the following publications:—

L'emploi des dirigeables et des aéroplanes à la guerre et le combat contre ces engins. By Major Gœbel, 1910.

L'aviation. By M. Reymond, 1st Lieut., Engineers, 1911.

L'aviation militaire. By Lieut.-Colonel Borel, 1912.

L'aviation à l'exposition aéronautique de Berlin en 1912. By General Hartmann, 1912.

L'aviation militaire en Suisse. By Lieut.-Colonel Borel, 1913.

Les moteurs d'aviation. By Major C. Le Royer, 1914.

L'aviation militaire. By Lieut.-Colonel Borel, 1914.

The author of the article in the *Revue* confines his attention to those aspects of the subject which deal with matters possessing practical importance from a military point of view, such as observation and detection, means of communication between aircraft and troops, fighting power of aircraft and their capabilities for effecting destruction. The subject is divided into two main heads, namely that relating to captive or stationary aircraft and that relating to free or mobile machines.

Captive and Stationary Machines.—In this category are included captive balloons of the spherical as well as the sausage-shaped types, and kites. Aircraft of these types are naturally used for observation, and for communication or signalling purposes only.

A table is provided giving the theoretical range of vision over flat land or an expanse of water from points at various altitudes above the same. This table, reduced into British lineal measure, is given below:—

Altitude above Land or Sea.	Approximate Range of Vision.
16·5 ft.	5 miles
33·0 ft.	7 miles
164·0 ft.	17 miles
328·0 ft.	22·5 miles
1640·0 ft.	50 miles
3280·0 ft.	70 miles

Owing to the atmospheric conditions which prevail at certain seasons of the year, the range of vision from captive balloons, etc., is in practice naturally often much less than stated above.

Captive balloons were used for the purpose of reconnoitring the enemy's positions by Custine in 1792 at the Siege of Mayence, and by Moreau in 1794 at the Battle of Fleurus. In 1796 Napoleon made use of balloons in Egypt. Difficulties in connection with the manufacture of hydrogen in the field and other causes militated much against the successful use of balloons for military purposes in the early days referred to. Later, the introduction of coal-gas as an illuminant and improvements effected in the manufacture, etc., of balloons removed some of the earlier disadvantages in their use, and balloons were, in consequence, employed with some success during the Italian War, the American Civil War, and in the Crimea, at the Siege of Sebastopol.

Captive balloons of the spherical type have been found to possess certain disadvantages; for example, it is dangerous, if not impossible, to make ascents in them during periods when strong winds prevail.

Two problems connected with the use of captive balloons have in the past claimed attention, namely, those dealing with—

(i.). The adoption of measures to secure the stability of the passenger car.

(ii.). The adoption of measures to ensure a proper distribution over the whole of the fabric of the balloon of the strain produced by the cable by which the balloon is anchored.

Arrangements for suspending the car have been devised which allow it to hang with its sides vertical and which cause it to return rapidly to this position when swayed out of it by the motion of the balloon.

In order to provide for the proper distribution of the tension in the anchoring cable to the cordage of the balloon it is generally necessary to pay out, at least, 3,000 ft. of this cable.

The greater the velocity of the wind the greater is the tendency for a captive balloon of the spherical type to be blown down towards the earth; on the other hand, in the case of a captive kite an increase in the velocity of the wind causes it to rise to a greater height above its anchorage, that is to say, the tendencies produced by high winds in the case of these two types of stationary aircraft are contrary to one another.

Parseval and Siegsfeld, two German engineers, have utilized the property which kites possess of rising with an increase in velocity of the wind in designing the sausage-shaped captive balloons now in use in the German Army. The stability of the last-mentioned type of balloon depends on—

(i.). The rudder which is provided with a valve connected to the gas bag of the balloon.
(ii.). The tail piece, with its funnels.
(iii.). The side wings.

The Chinese are said to have employed kites for military purposes two hundred years before the Christian era; but this field of employment for kites was later completely lost sight of for many centuries. Weight-lifting kites made their first ascent in England in 1804. In 1874, a man-lifting kite, consisting of a series of fan-shaped structures, was experimented with by the British military authorities. Later, much progress was made with this type of machine in England by Cody; it is recorded that a British officer ascended to an altitude of 3,300 ft. in a Cody machine. Some attention has also been devoted to the subject of weight-lifting kites in Russia and in France. Kites have at various times been utilized for elevating antennæ at wireless stations, for carrying photographic apparatus to obtain records of the enemy's positions, and for detecting the presence of submerged submarines.

In varying degree all captive or stationary aircraft possess a value for communication or signalling purposes; optical devices, ordinary telephones and telegraphs, and even wireless telegraphy have been utilized for establishing communication between captive aircraft and the ground.

Free or Mobile Aircraft.—Under this head are included spherical free balloons, dirigibles and aeroplanes. It is stated that the Swiss aviator Audemars succeeded in reaching an altitude exceeding 21,500 ft. in an aeroplane in 1915.

Free balloons were first employed for destructive purposes in war by the Austrians in 1849, when they laid siege to Venice, but without success. In 1870 and 1871, during the Siege of Paris, as is well known, communication between the French capital and the provinces was maintained by free balloons. It was during this siege that the design for a dirigible of the elongated type was worked out. In 1872, an airship of the type just referred to was actually constructed. Its propellers had to be worked by manual power; the labour required to propel this airship was disproportionate to the speed obtained and the construction of this type of aircraft was therefore abandoned for the time being.

It was not till 1884—1885 that the problem of aerial navigation may be said to have been definitely solved; this result was attained largely by the labours of Ch. Renard who carried out successful experiments with the dirigible "la France"; an airship constructed in accordance with his own designs. But at this time sufficiently efficient petrol engines had not yet been designed to meet the requirements of aircraft constructors. It was first in 1907 that 4 and 8-cylinder motors developing 50 h.p., and weighing just under 20 lbs. per h.p. developed, were put on the market. The advent of these motors gave Count Zeppelin, Santos Dumont, the Brothers Wright engines which were entirely suitable for their purposes.

According to the *Taschenbuch für Luftflotten* the position as regards military dirigibles was as follows on the 1st January, 1914:—

	Total Capacity of Airships in cubic feet.	No. of Airships.
Austria	530,000	3
England	883,000	7
Russia	2,225,000	13
Italy	2,416,300	11
France	4,118,000	14
Germany	8,797,000	17

It is pointed out in the *Revue* article that the information given concerning Germany's air fleet in the above table is incorrect, being much below its real strength which was probably twice as great as that stated here.

A brief description of the construction of a rigid Zeppelin airship is given in the *Revue* article. One model of this type of ship is provided with three 180-h.p. engines of the Maybach design, capable of 1,200 revolutions per minute; each engine weighs approximately $8\frac{3}{4}$ cwt.

It is claimed that at its trial trip the Zeppelin L.Z. 24 rose to an altitude of 10,700 ft., and was in the air for 35 hours continuously, making a round trip of 1,055 miles during this period. However, it carried neither guns nor bombs on this journey.

A very brief description is given of the dirigibles which the British are said to be constructing for the purpose of dealing with the Zeppelin menace.

Aeroplanes.—Considerable progress has been made in the design and construction of aeroplanes since the year 1890—1891, when the matter was first seriously taken up. It was in 1904 that the earliest engine suitable for aeroplanes was first constructed.

Military aeroplanes first put in an appearance at the manœuvres held in France and in Germany in the year 1910, and since then every European power has taken up the subject of military aircraft. The radius of action of a military aeroplane is stated to be about 95 miles; the record flight is 628 miles in 13 hours $17\frac{1}{2}$ minutes.

Monoplanes are said to have entirely superseded biplanes in France; on the other hand, the British, Belgians, Austrians and Germans still show a preference for biplanes.

The Russians have constructed the giant type of Sikorsky biplanes, each capable of carrying 14 passengers. Since the beginning of the present war machines of this type have been armed, and they therefore provide a powerful engine for offensive aerial warfare.

In France, the question of dropping projectiles from aircraft on to definite targets has received considerable attention. It is suggested that, in order to counteract the horizontal velocity communicated to projectiles by the forward motion of the aircraft, such projectiles should be fired from tubes, trained in a direction opposite to that in which the aircraft is travelling and with a velocity equal to the forward motion of the aircraft. The moment for releasing bombs so as to hit a particular target is, at the present time, largely a question of guess-work.

In a short summary it is pointed out that, although mobile aircraft are generally believed to be superior to captive balloons for observation purposes, yet in practice this is not really the case. The speed at which aircraft fly through the air is a positive disadvantage. Dirigibles have an advantage over aeroplanes in the performance of *observation* duties, but so far as the *detection* of these two types is concerned the opposite is naturally the case.

From the point of view of communicating information, dirigibles and aeroplanes are in as good a position as captive balloons ; since all types of aircraft are provided with identical means for providing this service. The power of mobility possessed by the former types, however, makes their use preferable for this service.

Captive balloons cannot naturally be employed for effecting the destruction of enemy works, etc. ; so far as mobile aircraft are concerned those with the lowest speed are most suitable for effecting destruction, and those with the highest speed have the greatest fighting power. —(*To be continued*).

The Suez Canal.

In view of the possibility that military operations may take place in the vicinity of the Canal, some particulars of this important engineering enterprise are given in an article prepared for the *Revue*.

The construction of the Canal was commenced on the 25th April, 1859, and the waterway was opened for traffic on the 17th November, 1869.

Particulars relating to the length, depth, width, etc., of the Canal, and the improvements carried out in 1890 to provide facilities for the increased tonnage passing through the Canal are given in detail in the *Revue* article.

Some of the most important improvements effected since the Canal was first opened have had for their object the reduction of the time taken by ships to pass through this waterway ; for example, whereas an average of 48 hours 5 minutes was required for the Canal journey in 1870, this time had by 1890 been reduced to 24 hours 6 minutes. Now that ships are allowed to travel at night the average duration of the Canal journey has been further reduced to 16 hours 11 minutes. One of the most important improvements carried out gradually has been the deepening of the Canal. In consequence, since the 1st January, 1915, vessels, having a draught up to 30 ft., have been able to use this waterway, whereas in 1870 no vessel drawing more than 24 ft. 6 in. of water was allowed to enter the Canal.

It is the policy of the Canal Company to anticipate, as far as possible, the future requirements of the shipping interests and with this object in view a definite programme of work for the improvement of the waterway has been drawn up and put into execution. The deepening of the Canal, so as to permit ships having a draught up to 33 ft. to pass through it, is already in hand.

The harbours at Suez and Port Said have also received much attention since the Canal was first opened to traffic ; the capacity of the latter has been increased at least fourfold since 1869.

The Canal Company has in recent years made a beginning with the construction of a large workshop on reclaimed land, on the Asiatic side of the Canal, for the repair, etc., of the dredgers and other appliances required in connection with the maintenance of the waterway. This workshop will be equipped with electrical machinery; an electric power station for the generation of the energy required and for lighting Port Said, etc., is also being provided.

A plan of the Canal route is given in the *Revue* article, as also a sketch map, borrowed from *Le Génie Civil* of 18th December, 1915, showing the railways from Asia Minor leading towards the Canal. A main railway line connects Constantinople *viâ* Aleppo and Damas to Maan—about 65 miles N.E. of Akaba on the Red Sea. The length of this railway, which is of normal gauge except for a section of about 30 miles north of Damas, is about 1,500 miles. At the beginning of the War, two short sections of the railway were incomplete; a tunnel 5,226 yards long had still to be pierced west of Adana, and about 24 miles of track had to be laid across the Taurus, north of Adana. The tunnel has since been completed, but the track across the Taurus is still incomplete. During 1915 sections of narrow gauge tracks were laid from Afouleh to Bires-Seba, situated close to the Egyptian frontier; and thence a strategic railway has been built across the Sinai Peninsula *viâ* El Aoudjé. A branch railway is also in construction between Maan and Akaba.

It is stated that the carrying capacity of the main line from Constantinople to Maan does not permit the transport of more than 5,000 men per diem.

A Retrospect.

The Return of a Contingent: Freiburg, 1499.

In this article is described the return to their homes, in the autumn of 1499, of the Freiburg Contingent which had been enlisted under the banner of Maximilian of Austria two years earlier to take part in the expedition against Rome. In the form of a supposititious conversation between a local inhabitant and a British merchant, who, being on a business visit to Freiburg, is assumed thus to have been a spectator of the historical scene described, much information of historical interest is given concerning the nature of the military service existing in that part of the world in the late 15th century and the customs which prevailed in the Swiss Army of those days.—(*To be continued*).

Notes and News.

Switzerland.—The unhappy fate of Belgium and of Serbia and the occupation of Greek territory by belligerent armies are causing some anxiety in Switzerland, particularly in regard to what the future may have in store for the Helvetic Republic. It is felt that the time has not yet arrived for the Swiss people to relapse into a state of somnolence and so to speak disarm themselves in a moral sense. It is pointed out that the danger of an invasion of Swiss territory taking place are by no means past and that Switzerland may yet have to undergo experiences in 1916 similar to those which Belgium went through in 1914 and Serbia in 1915. It is urged that Switzerland should remain ready to meet every eventuality; her preparations should be maintained in a high state of efficiency, as well in regard to the moral as the material requirements of the situation.

This being the train of thought of the contributor to the *Revue*, he naturally expresses satisfaction at the measures adopted by the Swiss General Staff for the development of the *morale* of the soldier-citizens of the Republic, particularly in view of the neglect alleged to have been shown by the Civil Authorities to strengthen the *morale* of the Swiss citizen-soldiers.

Last winter, the Swiss General Staff organized a series of lectures for the troops and made an appeal to the intellectual classes to assist them in this matter. The appeal met with a hearty response and lectures on a variety of subjects were given to the troops. During the present winter lectures are also being given to the troops, but, instead of leaving the matter entirely in the hands of civilians, it has been arranged that commanding officers of the various units shall themselves deliver a number of lectures to their men. In order to assist the military lecturers pamphlets have been prepared, giving an outline of the subjects concerning which information is likely to be of value to the troops.

Last year the lectures were arranged with the object of preventing the troops, which have been mobilized for the period of the War, falling into a state of lassitude and becoming bored. A very large proportion of the men doing military duty in Switzerland at the present time have not a bellicose temperament; being withdrawn from their businesses and from hearth and home, there was a serious risk of their relapsing into a lethargic condition during the long winter days unless some mental stimulus could be applied to keep them fully interested in the abnormal situation. The object in view in the lectures arranged for the present winter course has been to arouse and develop the patriotism of the troops. These lectures therefore deal largely with Swiss history, its political institutions, etc.

In order to ensure that not only the patriotism of the troops shall be stimulated but also their martial spirit roused, matters connected with the present war are also being dealt with in the present course of lectures as well as the subjects already mentioned.

Portugal.—In a contribution by a special correspondent it is stated that, in commemoration of the centenary of the Peninsular War, a popular history of the great upheaval of the preceding century has recently been published by a committee appointed for the purpose. The work has been written with the object of bringing before the Portuguese people some of the most stirring events in the history of their country, in order to teach them what they have gained from the self-denial and patriotism of their ancestors.

In the Notes, a few of the leading features of the period dealt with in the history in question are mentioned. It is pointed out that the second invasion of Portugal clearly teaches that: "It is impossible to conquer a nation which, like Great Britain, possesses the dominion of the seas. For, without doubt, it was the mastery of the seas which made possible Wellington's surprise disembarkation at Lavos, the rapid change of base to Corunna by Moore, the concentration of a new army at Lisbon for an attack on the French in the north of the Peninsula."

The Peninsular War is the greatest national convulsion of all time which has affected Portugal. It is stated that the following lessons can be drawn from the history of this war, namely :—

(1). The great vitality of the Portuguese nation and their attachment to the independence of their country.

(2). The fact that States which neglect their army in peace time are, at critical periods in their history, at the mercy of those who come to their assistance at the hour of need.

(3). The fact that the Portuguese, when well led, make excellent soldiers, capable of acts of the greatest heroism.

A century has gone by since the days of the Peninsular War and Europe is once more a great field of military operations. Portugal herself has entered into alliances and the question is asked whether it can remain outside the present general conflagration? All that can be said in reply is that Portugal will show herself worthy of the noble and heroic traditions handed down by the Portuguese of former generations.

INFORMATION.

The Affair of the Swiss General Staff.—The plenary powers conferred on the military authorities at the beginning of the War, it is said, are casting a dark shadow over Switzerland. Trouble has arisen by reason of the confusion which has been created in the public mind between a state of peace and that of war, between military power and civil power, between sovereignty and neutrality.

The situation created by the arrest of Colonels de Wattenwyl and Egli on a charge of espionage, and the decision to try these officers by court-martial have produced a depressing effect in Switzerland. The present unfortunate situation is attributed to the many errors which the Federal Government is alleged to have committed since the first days of the Swiss mobilization after the outbreak of war.

Among other faults attributed to the Government one of the most serious is said to be that connected with the selection of the officer, appointed Chief of the Staff to the G.O.C. of the Swiss Army in 1914. The previous history of these two officers, it is said, made it morally certain that they were not likely to work with that degree of harmony so necessary in the highest ranks of a military hierarchy. Experience seems unfortunately to have proved the correctness of the views held on this matter by those outside Government circles. There is no intention on the part of the contributor of the article to disparage either of these officers; he states definitely that both officers possess high qualifications, and are entitled to hold the most important posts in the Army. The difficulty in the present situation is due entirely to their incompatibility of temper.

Another matter which is causing anxiety in some quarters of the Republic is the impression that the Swiss General Staff is imbued with the idea that the German Army must eventually be victorious in the present war; and the conviction that the opinion so held is reacting on deliberations of the Federal Council at the present time. The present situation in Switzerland is referred to as one bordering on anarchy and it is urged that steps shall be taken at once to alter this state of things.

W. A. J. O'MEARA.