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MILITARY EXPLOSIVES OF TO-DAY.

Cantor Lectures by J. Young, Esq., O.B.E., delivered before the Royal Society of Arts on April 8, 15, and 22, 1918. These Lectures are published by permission of the Royal Society of Arts in anticipation of their appearance in the Society's Journal.

LECTURE II.

Chlorate Explosive Mixtures.

In the first lecture I dealt with the various nitrate mixtures. Next in importance to these are the chlorate mixtures.

Potassium chlorate, $KClO_3$, is a non-deliquescent salt, which, on heating, gives off 39.1 per cent. of its weight of oxygen. It also gives out heat during the decomposition, 1 gram yielding 8.74 calories, and is, therefore, an explosive in itself. It is much used in the preparation of oxygen in laboratories, and if heated too rapidly may explode with great force, as many have found.

When mixed with combustibles it forms explosives much more powerful than nitrates mixtures, but also much more sensitive and dangerous to handle. The discoverer Berthollet, in 1788, tried to use it to replace saltpetre in gunpowder, but at the first attempt the mill promptly blew up and killed some of a company specially invited to see the process.

The sensitiveness may be illustrated by mixing a little powdered chlorate with sulphur; it detonates sharply when struck on an anvil. Similarly with black antimony sulphide, and also with many other combustibles. Chlorate mixtures of this kind are now mostly used for purposes where sensitiveness is a necessity, as in percussion caps, friction igniters, etc.

The mixing of chlorate with combustibles of any kind in the dry state is always dangerous. When done, the substances should be ground separately in clean mortars, and mixed by sifting so as to avoid undue friction.

Potassium perchlorate, $KClO_4$, contains a greater percentage of oxygen, 46.2 per cent., but is a much more stable substance. Heat is absorbed in its decomposition, and mixtures containing it are less sensitive than plain chlorate mixtures.

Ammonium perchlorate, NH_4ClO_4, is still less sensitive, and is now much used in explosive mixtures. With plain combustibles it gives off hydrochloric acid gas when exploded, and as this is very objectionable with mining mixtures a proportion of sodium nitrate is added to convert the HCl into sodium chloride, NaCl, which is harmless.

Potassium Chlorate and Sugar.—Many of the attempts which have been made to reduce the sensitiveness of chlorate mixtures have taken the form of using some imperfect combustible to mix with the chlorate, and sugar has often been proposed. A mixture of two parts of $KClO_3$ with one of sugar is as good as most. It is much less sensitive than a mixture of chlorate with carbon and sulphur, and has about twice the power of gunpowder. But it is still too sensitive and violent in its action. It can be exploded by contact with flame, by moderate percussion on an anvil, and also by contact with strong sulphuric acid. Use has been made of these properties in automatic igniters for other charges. It makes a good flare, but is not a military explosive.

Friction Composition.—Many variations are used, but the following gives the proportions of a typical mixture :—

Potassium chlorate	12
Antimony sulphide (black)	12
Sulphur	1

The substances are ground separately, mixed into a paste with spirit containing a little shellac, and formed into pellets, which are dried. Sometimes one part of ground glass is added to make it more sensitive. Sometimes gunpowder is added.

To show its properties apply a flame to a little ; it ignites instantly, and the flash is very efficient for igniting other explosives.

Put a little on an anvil and strike sharply. It detonates with moderate percussion.

Put a little on the anvil and rub hard with a hammer face ; it explodes sharply.

For many years this has been used in friction tubes for firing heavy guns, and is still used. The friction tube is a copper tube filled with gunpowder which is inserted into the breech of the gun. At the outer end is a cross tube, and in this is a kind of copper rasp or twisted wire. Pellets of the friction composition are pressed closely in contact with the "friction bar," so that when it is pulled out sharply by the gunner the composition explodes and ignites the gunpowder, which sends the flash that ignites the cartridge.

Igniters for safety fuze are made on the same principle. The fuze is tipped with a friction composition which, when rubbed with a prepared surface, flashes off and ignites the fuze.

Equal weights of amorphous phosphorus and chlorate make a most sensitive and powerful explosive formerly used in an Armstrong shell fuze. They are dangerous to mix dry, but can be mixed safely if moistened with methylated spirit, and then separated into very small portions. The mixture explodes with very gentle percussion or friction. It is used in toy caps.

The use of friction compositions is well illustrated by a box of safety matches. The match head is tipped with friction composition diluted with glue, and can be ignited by strong friction or by percussion. The box is coated with a little amorphous phosphorus and ground glass. A little friction between the two suffices to bring about ignition.

Flash Compositions.—A mixture of two parts of potassium chlorate and one part of magnesium or aluminium powder, gives a powerful flash when ignited. The light is very actinic, and suitable for taking photographs. Either mixture can be exploded by percussion, that with aluminium being specially sensitive and powerful, as shown by striking a little on an anvil, and is dangerous to handle in quantity.

Mixtures with potassium perchlorate are much safer, and quite effective. One such mixture contains three parts perchlorate with two parts of magnesium powder. It gives a high temperature, and is used for igniting thermite and other materials in bombs. It also requires careful handling.

Chlorate Mining Explosives.

All of the above-mentioned chlorate explosives are much too sensitive for use in large quantities in military operations. But a discovery made by Street in 1897, that if the chlorate mixture contained oils or fats its sensitiveness was greatly decreased, initiated an entirely new set of blasting explosives. The first, and amongst the best, are the cheddites, made at Chedde in France. They are mixtures of potassium or sodium chlorate with a nitro compound, and castor oil. A typical cheddite has the composition :—

Potassium chlorate	79
Di-nitro-toluene	15
Nitro-naphthalene	1
Castor oil	5

Cheddites are much used as blasting explosives. Potassium perchlorate is used in a number of similar mixtures of which permonite is an example. Some also contain nitroglycerine.

Blastine.—This is the most important military chlorate explosive, and vast quantities have been used in the present War. There are several varieties, but a typical military blastine has the following composition :—

Ammonium perchlorate	60
Sodium nitrate	22
Tri-nitro-toluene	11
Paraffin wax	7

It is made in the form of a soft yellowish, granular substance, which can easily be compressed. It is not very sensitive, but can be detonated by a moderate blow on an anvil. In practical tests rifle bullets have been fired through cartridges without exploding them, but it can hardly be considered safe under such a test, especially if the cartridge had a hard backing. It ignites easily and burns fiercely with a hot flame. In practice it is detonated by a fulminate detonator, and is a powerful high explosive, about equal to ammonal. Velocity of detonation over 4,000 metres per second.

Blastine is extensively used for military mines, and for charging bombs and grenades. The products of detonation do not contain any hydrochloric acid gas, and are not poisonous.

Permite.—This is a mixture intermediate between ammonal and blastine, and may be looked on as ammonal in which the expensive aluminium is replaced by zinc powder, the consequent diminution in power being compensated for by using ammonium perchlorate instead of the nitrate. It is made in several varieties. One has the following composition :—

Ammonium perchlorate	82
Zinc dust	10
Vaseline	5
Asphaltum Varnish	3

Some varieties have sulphur, and methyl alcohol and benzene as solvents.

It is used for the same purposes as blastine, and has about the same power. It is more sensitive to percussion. In form it is a greyish-brown powder.

All of the chlorate explosives require fulminate detonators, and for this reason, besides being too sensitive, are unsuitable for use as a H.E. shell filling. Rate of detonation 4,000 to 5,000 metres per second.

Mixtures of ammonium perchlorate and paraffin wax with combustibles such as aluminium powder or wood meal are also used, and are powerful high explosives.

Ammonium perchlorate explosives, like the corresponding ammonium nitrate mixtures, detonate best when in a porous form. Like these, too, they tend to set into a dense mass in store, especially when exposed to high atmospheric temperatures, and in that condition are very insensitive and may fail to detonate. They should not be exposed to direct sun's rays.

SOME MISCELLANEOUS MIXTURES.

Thermit, now an important munition of war, is in a class by itself. It is a mixture of about six parts of iron oxide with one part of aluminium powder, highly compressed. It has a very high ignition point, and requires a priming of a mixture of magnesium powder with barium peroxide or potassium perchlorate. When once ignited a fierce reaction takes place. The Al abstracts the oxygen from the iron oxide, liberating metallic iron and so much heat that the temperature is in the neighbourhood of 5,000°C., one of the hottest things on earth. It is used for charging incendiary bombs, and sometimes in a kind of shrapnel. A small explosive charge scatters the contents, which rain down bits of blazing iron, which will instantly set fire to anything capable of burning.

Coloured Lights and Flares.—These are mixtures of metallic chlorates and nitrates with combustible matter, and sometimes inert metallic salts. Shellac is one of the best combustibles, and sometimes sugar is used. Chlorates make the most energetic mixtures, but 50 per cent. or so of nitrate is usually added to make the mixture slower in action and safer to handle. The colour of the flame depends on the metal used. Thus :—

Barium compounds give		green.
Strontium	,,	red.
Copper	,,	blue.
Sodium	,,	yellow, etc.

Many formulæ are in use ; the following are examples :—

Green Light.

Barium chlorate and nitrate	80 parts.
Shellac (or milk sugar)	20 ,,

Red Light.

Strontium nitrate and potassium chlorate ...	84 parts.
Shellac	16 ,,

Magnesium Lights.—Mixtures used for illuminating purposes in rockets or star shells consist of magnesium powder mixed with chlorates and nitrates, a little oil or wax being incorporated to slow the action and make it burn a longer time. Sixty-three parts of a mixture of potassium chlorate and barium nitrate, 35 of magnesium powder, and two of boiled linseed oil gives a good lasting light.

The Nitro Celluloses.

As early as 1832 Bracannot discovered that the action of nitric acid on starch and woody fibres converted them into highly inflammable substances. In 1838 Pelouze extended the experiments to paper, linen, and cotton. In 1846 Schönbein, the discoverer of ozone, used concentrated nitric acid and cotton wool, and called the resulting substance guncotton. A little later sulphuric acid was added to the nitric, and this mixture has been used ever since.

Schönbein gave demonstrations of the new explosive in England in 1846. The value of an explosive which was several times more powerful than gunpowder, and quite smokeless, was immediately recognized. Its manufacture was started the same year in England at Faversham, and also in France. A little later in Austria.

Next ensued a series of disastrous explosions which could not be accounted for. The manufacture was stopped everywhere as being too dangerous.

About 1863 the late Sir Frederick Abel conducted a series of experiments at the Waltham Abbey factory which explained the cause of the explosions, and also how the substance could be made and kept safely. The researches were published in 1866—1867. Briefly they amounted to this :—

Cotton in its microscopic structure is made up of minute capillary tubes. During the process of nitration the tubes become filled with acid, and as they are practically waterproof the elimination of the acid by washing is a difficult matter, the amount of washing usually given being quite insufficient. Later it was shown that some sulphuric acid remains chemically combined with the cellulose.

In stored guncotton both free and combined acids set up a decomposition, with evolution of heat. The rise of temperature accelerates the rate, and when large masses are stored the temperature may at last reach the explosion point, which it did in many cases.

Abel showed that to eliminate the acid a prolonged series of boilings was necessary, these acting, partly mechanically by dissolving the acid, and partly chemically by decomposing the sulphate. Pulping the guncotton, by dividing it into infinitesimal fragments, facilitates the process, besides making it more easily manipulated into suitable forms for use.

The cotton used must be nearly pure cellulose. The natural impurities associated with it, which are of a fatty or resinous nature, form unstable nitro-compounds which hasten the decomposition of the whole.

Finally, as the guncotton still contains traces of free or combined acid, a preservative capable of combining with the products of decomposition must be incorporated with it. The guncotton will then be fairly stable, but still it has a limited life, the length of which depends on the temperature at which it is stored.

Acting on these principles Abel established a process for the manufacture of guncotton which, with some modifications, is carried out to this day. There are other forms of nitrocellulose which, with guncotton, form the most important military explosives of to-day, and are the basis of all smokeless powders.

Cellulose has the empirical formula $C_6H_{10}O_5$, and belongs to the class of bodies called carbohydrates, which includes starch, sugar, and gums. Any one of these will produce an explosive compound when treated with nitric acid. Cotton is the purest natural form of cellulose, and when treated with dilute boiling caustic soda, and chlorine, and afterwards well washed, is almost pure cellulose. Wood and other vegetable fibres contain large percentages of modified celluloses, such as lignose, oxycellulose, pectoses, and so on. As these are more chemically reactive than pure cellulose they can be removed by reagents, and most of them are removed in the process of preparing wood pulp for paper making. It has been shown that by a drastic treatment 40 per cent. of good cellulose can be obtained from a suitable wood, and from this a stable nitrocellulose can be obtained, although not quite so powerful as that from cotton. It is extremely probable that most of the German cellulose is now obtained from this source.

Action of Nitric Acid on Cellulose.—When cellulose is acted on by a mixture of nitric and sulphuric acids containing water either a mono, di, or tri nitrate may be formed, depending on the proportions of the acids and water present. Thus:—

(1). $C_6H_{10}O_5 + 3HNO_3 + nH_2SO_4 = C_6H_7O_2(NO_3)_3 + nH_2SO_4.3H_2O$.
Cellulose. Nitric acid. Sulphuric. Tri-nitrate.

(2). $C_6H_{10}O_5 + 2HNO_3 + nH_2SO_4 = C_6H_8O_3(NO_3)_2 + nH_2SO_4.2H_2O$.
Di-nitrate.

Similarly for the mono-nitrate. The H_2SO_4 combines with the water liberated in the reaction and serves to keep the concentration constant (within limits), but it also probably plays a much more important part.

The actual reactions which take place are certainly much more complicated than as represented, and although much research has been devoted to the problem it is still obscure.

Theoretically—

Tri-nitro-cellulose	should contain	14.14	per cent. of N.	
Di-	,,	,,	11.12	,,
Mono	,,	,,	6.77	,,

No one of these has been prepared pure. 13.92 per cent. of N has been obtained, but the substance was not stable. 13.5 per cent. appears to be the limit for a stable compound, and a good guncotton contains about 13 per cent. of nitrogen. Attempts have been made to account for the varying percentages of nitrogen by multiplying the formula of cellulose and assuming a large number of nitrates, but the results are not satisfactory.

Soluble and Insoluble Nitrocelluloses.—Some forms of nitrocellulose, especially the greater part of the highly nitrated guncotton, are insoluble in a mixture of alcohol and ether, while other forms are soluble. The lower nitrates are most soluble. It was therefore assumed that the tri-nitrate was the insoluble form, and that the lower nitrates were soluble. As 10—12 per cent. of guncotton was soluble it was assumed to be a mixture of insoluble tri-nitro with 10—12 per cent. of di-nitro. As the power of explosion of guncotton depends on the extent of nitration, for this reason, as well as the belief that the soluble variety was unstable, every effort was made to keep down the percentage of solubility.

But we now know that the solubility in alcohol-ether is largely a matter of temperature of nitration. The higher the temperature, up to about 40°C., the greater the solubility. The amount of water present is also a factor. Nitrocellulose containing 12.5 per cent. of nitrogen, and soluble in alcohol-ether, or at least completely gelatinized by it, is now made on an enormous scale, and constitutes 99.5 per cent. of N.C. smokeless powders, as well as being used in the new cordite.

All kinds of nitrated cotton retain their original structure and appearance, except that they are a little harsher to the touch. They can be spun into yarn or even made into cloth. When dry, N.C. is very inflammable, and burns rapidly when uncompressed. It can be detonated by percussion, and easily by fulminate.

Manufacture of Guncotton.—Practically the only improvement on the original Abel process is the use of the "displacement apparatus" for nitration, instead of the original earthenware pots where the cotton was allowed to soak in the acid mixture. This was invented by Nathan and Thompson of Waltham Abbey and is now generally used.

The figure shows a section of one pan, of which four form a set.

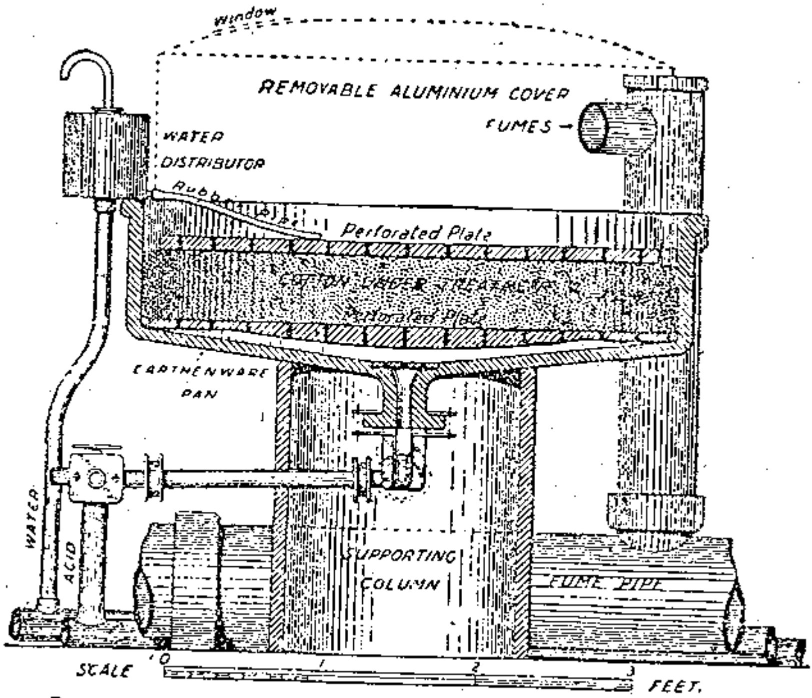


FIG. 1.—*Section showing the New Apparatus of Nathan and Thompson.*

The pan is 3 ft. 6 in. in diameter by 10 in. deep, and is made of earthenware or acid-resisting iron. By means of valves the outlet can be made to communicate either with an acid supply, a waste acid receptacle, or a drain.

The acid mixture found to be best consists of three parts by weight or ordinary pure conc. sulphuric acid with one part of nitric. The mixture contains 8 per cent. of water. The details of the process of manufacture are given in any treatise on explosives. The following is an outline of the Waltham Abbey procedure.

About 650 lbs. of the cooled acid mixture is admitted to the pan, and 20 lbs. of the purified and prepared dry cotton immersed. A perforated aluminium plate is then put on top, and water run on to it to act as a seal and prevent the escape of fumes.

After 2½ hours the acid is run off at the bottom slowly, and water run in on top at the same rate, so that the water displaces the acid, thus giving the name to the process. In 3½ hours the nitrated cotton is free from surface acid, and ready for purification. The advantages over the old process are that it gives a better yield, of a more uniform and stable guncotton, besides saving time and labour, and involving less exposure of the workers to acid fumes.

The guncotton is next boiled in great vats which hold nearly a ton of it. There are 10 boilings lasting 50 hours, starting with long boilings of 12 hours, and ending with short ones of 2 hours. It is next pulped in a paper maker's beater, which cuts it into infinitesimal fragments. The pulp is washed in several changes of water.

When required for the manufacture of cordite the pure pulp is measured into moulds and subjected to gentle pressure, about 34 lbs. per sq. in., which removes much of the water and leaves the guncotton in primers firm enough to be handled. These are taken away to be dried.

When required for use as a demolition agent a mixture of caustic soda, lime water, and whiting is added to the pulp, sufficient to leave 1 to 2 per cent. in the finished article to act as preservative. The pulp is then moulded and pressed as before, but receives a final pressure of 5—6 tons per sq. in. which converts it into slabs. For land service 15-oz. slabs are the standard, and they are moulded with a central conical hole to take a 1-oz. primer. They are dipped in a solution of carbolic acid and caustic soda to prevent mould, and packed in metal cases which are hermetically sealed. They contain about 17 per cent. of water.

The primers are moulded and pressed in the same way as the slabs, with a central hole to take the detonator. Next they are dried down to 1—2 per cent. of moisture, then dipped in acetone to dissolve the surface and give it a waterproof glaze. They are packed very carefully in special tin tubes, each of which contains 1 doz. 1-oz.

primers are the standard for land service. For the Naval Service slabs and primers of different weights are used.

Slabs of wet guncotton constitute the safest and one of the most effective demolition agents, and remain the standard of the R.E. With more than 13 per cent. of water guncotton is quite incombustible, and very difficult to detonate except by large charges of fulminate, or an ordinary detonator and a dry primer. For example, during the present War an 8-in. shell detonated in a wagon load of wet guncotton failed to explode it. The primers and detonators are carried separately. When detonated in good contact with the object to be demolished it produces intense cutting effect, even untamped, although there is little advantage in increasing the depth of charge above two or three slabs. With large charges tamping is an advantage. A guncotton slab will cut through its own thickness of iron, a necklace of primers tied round a good-sized tree will cut it down. The velocity of detonation is about 5,600 metres per second.

As guncotton contains insufficient oxygen for its complete combustion the gases contain 30 to 45 per cent. of carbon monoxide, and 15 to 20 per cent. of hydrogen. They are both inflammable and poisonous, and for this reason alone it is unsuitable for mining.

In practice the slabs are placed or secured in intimate contact with the object to be demolished, and with one another. A primer is inserted in one slab, and a detonator in the primer. A No. 8 detonator is used when firing is to be done by fuze, safety or instantaneous; a No. 13 electric detonator when the firing is done electrically, which is the best method but takes more time.

The firing of a charge I illustrate by firing a detonator in a safety iron box. Military mines are fired in the same way.

Guncotton was formerly used exclusively for torpedo warheads, marine mines, etc., but has now been largely replaced by T.N.T., and ammonium nitrate and chlorate mixtures.

Guncotton in Store.—Like all varieties of nitrocellulose guncotton decomposes on keeping, and the rate increases with the temperature. Hence it should be kept as cool as possible, and never exposed to the direct rays of the sun. In temperate climates it should be good for 20 years at least, but has a much shorter life in the tropics.

When guncotton shows signs of acidity, or brown fumes are seen, it shows that decomposition has proceeded far, and it is unsafe. When it dries it can be re-wetted without any deterioration. It can absorb 30 per cent. of water, but is then too insensitive. In the best condition it should just ooze moisture when pressed by the finger—15 to 17 per cent.

High Nitrated Soluble Nitrocellulose.—The manufacture of this substance is carried out in much the same way as that of guncotton, the only difference being in the composition of the acid mixture and the temperature of nitration. In one method the acids consist of a mixture of equal volumes of conc. sulphuric and nitric acid, and the nitration is carried out at 40°C. for half an hour. The product is washed and stabilized as with guncotton, and contains 12.4 per cent. of nitrogen. It is completely gelatinized by an alcohol-ether mixture.

In the manufacture of American nitrocellulose the acids have the following composition:—

Sulphuric acid	63
Nitric acid	22
Water	15

The nitration is carried out at 30—32°C. in an apparatus similar to that used in the Waltham Abbey plant, and the product is stabilized in much the same way. It contains 12.5—12.7 per cent. of nitrogen, and is completely gelatinized by alcohol-ether.

Contrary to former beliefs this soluble nitrocellulose appears to be as stable as guncotton, but not quite so powerful.

Collodion Cotton (also called pyroxylin).—This variety is made by using a still weaker acid mixture, and nitrating at a still higher temperature. In one formula used the acid contains 35.5 per cent. of nitric acid, 44.5 per cent. of sulphuric, and 20 per cent. of water by weight. The nitration takes place at a temperature of 55°C., and lasts half an hour. The product is well washed, but not boiled or pulped.

It contains about 11 per cent. of nitrogen, and dissolves readily in an alcohol-ether mixture (about 1 part in 30 of the mixture by weight) forming a clear solution called collodion. This leaves a perfectly transparent film when poured on a surface and allowed to evaporate. It is much used in photography, and in surgery for covering wounds. Collodion cotton dissolved in camphor forms celluloid. Dissolved in nitroglycerine it forms blasting gelatine, a valuable explosive. Mixed with camphor and castor oil collodion is used for coating incandescent mantles to preserve them during transport.

(*Note*.—A mixture of 1 vol. of alcohol with 2 vols. of ether is the best solvent for N.C.).

NITROGLYCERINE EXPLOSIVES.

Nitroglycerine was discovered by Sobrero in 1847, and still remains the most powerful explosive in practical use. It is of great military importance, and is a constituent of our standard smokeless powder.

Glycerine, $C_3H_5(OH)_3$, is a constituent of all animal and vegetable fats and oils, which are the only source of supply on the large scale. The various tropical products, palm oil, cocoanut oil, etc., are sources of glycerine.

When these fats or oils are boiled with caustic soda or potash (lye), they form a mixture of glycerine and soap, and this is probably one of the oldest chemical processes.

$$(C_{18}H_{35}O_2)_3C_3H_5 + 3NaOH = C_3H_5(OH)_3 + 3C_{18}H_{35}O_2Na.$$

Mutton fat. Soda. Glycerine. Soap.

Pure glycerine suitable for the manufacture of explosives is difficult to separate from the soap, so other processes in which the fats are acted on by high-pressure steam, or lime, are used, the products being the free fatty acid or a lime soap, and glycerine. Hence, when fats are scarce, and glycerine is required, soap is also likely to be scarce. About 10 lbs. of fat are required to produce 1 lb. of glycerine.

When glycerine is required for conversion into nitroglycerine it must have a high degree of purity, and sp.g. not less than 1.26. The acid mixture found best for the nitration contains 1 part of HNO_3, sp.g. 1.5, and 1.7 parts of H_2SO_4 containing 96 per cent. of pure acid, by weight. When 1 part of glycerine is poured into 8 parts of the acid mixture, previously cooled to a temperature of 15°C., and stirred up with it, the nitrating action takes place immediately. On standing a few minutes the N.G. separates and floats on the acids as a clear liquid. The equation representing the action is :—

$$C_3H_5(OH)_3 + 3HNO_3 = C_3H_5(NO_3)_3 + 3H_2O.$$

Glycerine. Nitric acid. Nitroglycerine. Water.

The sulphuric acid combines with the water liberated by the reaction, and maintains the concentration of the HNO_3. It has no further action.

The N.G. may be separated by pouring the whole mixture into a large volume of water, when the acids dissolve and the N.G., being insoluble, sinks to the bottom. This is the old method and most suitable on the small scale. On the large scale the N.G. is run off from the top through a suitable opening. The operation is perfectly safe if care be taken not to allow the temperature to rise above about 30°C., which necessitates water-bath cooling. Otherwise a decomposition sets in, indicated by the appearance of brown fumes, and may end in a dangerous explosion.

The N.G. only requires to be washed quite free from every trace of acid, and is ready for use. While in contact with acid it is dangerously sensitive and unstable.

MANUFACTURE ON THE LARGE SCALE.

The figure represents diagrammatically the arrangement of the apparatus used at Waltham Abbey.

Owing to its dangerously sensitive nature, especially when in contact with acid, the greatest possible precautions are taken in the manufacture of nitroglycerine, and accidents are rare. It is made to flow from point to point by gravity during the operations. The

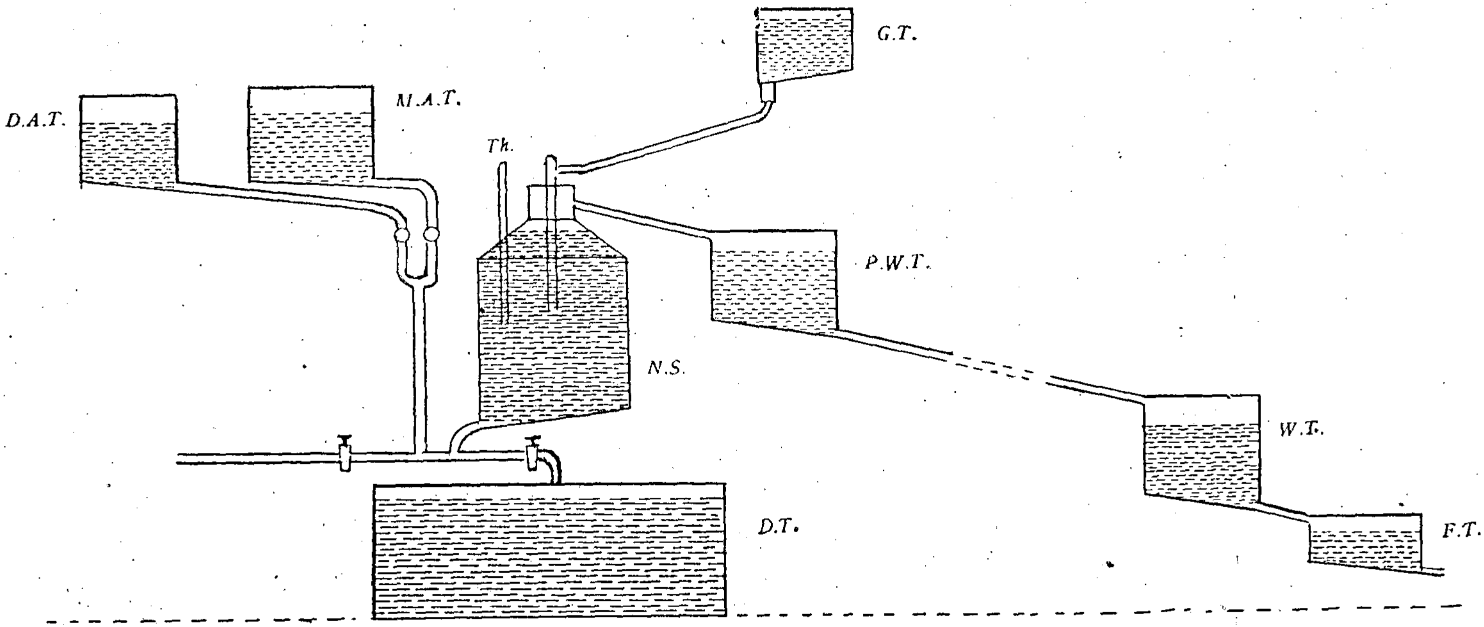


FIG. 2.—*Waltham Abbey Nitro-glycerine Plant. Displacement Process.*

D.A.T.—Displacing acid tank.
M.A.T.—Mixed acid tank.
G.T.—Glycerine tank.
N.S.—Nitrating separator.
P.W.T.—Pre-wash tank.
W.T.—Washing tank.
D.T.—Drowning tank.
Th.—Thermometer.
F.T.—Filtering tank.

temperature is kept low, and watched carefully by means of thermometers immersed in the liquid. All stirring is done by compressed air issuing from perforated pipes laid round the bottom of the vessels, and during nitration the liquid is kept cool by coils of pipes through which cold water is circulated.

A full description of the process of manufacture can be found in the various text books; briefly it is as follows:—

The charge of 4,000 lbs. of nitrating acid is admitted to the nitrating vessel, and cooled to 16°C. The charge of 500 lbs. of glycerine is then injected in fine spray by means of compressed air, and the acids are kept thoroughly agitated by air bubbling through. The temperature is watched, and not allowed to rise above 22°C. If decomposition sets in, as shown by red fumes and a rise of temperature, the whole charge is shot into a drowning tank filled with water underneath the nitrator. This applies to subsequent operations as well.

When the charge has been nitrated, which takes about 40 minutes, it is allowed to stand, and the N.G. separates and floats on the acids. Waste acid from another tank is then admitted to the nitrator to raise the level of the liquid, and the N.G. flows off through a side pipe into the pre-wash tank, which is half filled with water. Here it is washed three times with water, and once with water containing some washing soda. It is then run through a gutter into the washing house proper, where it is washed three times with warm soda water, and finally with plain water, which leaves it acid-free, and practically pure except for a little water.

The water is skimmed off after each washing, and all stirring is done by compressed air.

Finally, it is filtered through flannel bags filled with dry common salt, which removes all scum and absorbs moisture. The N.G. is then pure and ready for use.

Properties of Nitroglycerine.—Nitroglycerine is a slightly yellowish transparent liquid, sp.g. 1.6. It is insoluble in water, but dissolves in alcohol, ether, acetone, and many other organic liquids. It is very poisonous, and gives violent headaches even when placed on the skin. It has a powerful action on the heart, and is used as a drug. Many cases of N.G. poisoning occurred in the S.A. War through soldiers chewing cordite.

The liquid is difficult to ignite, and a taper may be extinguished by dipping it into nitroglycerine. But if a filter paper or some cotton wool be soaked in the liquid it burns quietly, but rapidly, with a greenish-edged flame.

To show its explosive properties; put a drop on a filter paper and strike it with a hammer on an anvil. It detonates with a loud report and blows the paper to shreds. Put a drop on a smooth metal plate, and heat it fairly rapidly. It gives off vapour at 100°C., boils at about 180°C., but begins to decompose. Red fumes appear, and when the temperature reaches about 180°C. it detonates completely with tremendous effect. When the experiment is successful a hole is blown in the plate and the pieces turned right back so as to touch the reverse side.

Fulminate of mercury detonates it completely (about 2 grams will detonate an unlimited amount) with tremendous disruptive effects. A small charge of fulminate sets up an inferior kind of detonation with a velocity of 1,500—2,000 metres per second, but with complete detonation the velocity is 7,500—8,000 metres per second.

N.G. is the only explosive compound in use which contains sufficient oxygen for its complete combustion, which explains its great power. The products of detonation contain free oxygen, and are in accordance with the equation :—

$$2C_3H_5(NO_3)_3 = 6CO_2 + 5H_2O + 3N_2 + O + \text{Heat.}$$

It freezes at about 4°C., and forms crystals. In this form it is very sensitive, and merely squeezing crystals between the fingers may explode them, but it does not carry the detonating wave well, and with large charges a great portion may be blown away and escape detonation altogether. This applies to all the N.G. explosives. All require to be thawed before use, which makes them inconvenient for use in cold climates.

Nitroglycerine is the most powerful explosive in use, but in the liquid form is inconvenient and too sensitive to be handled safely. It is now always absorbed in some substance which enables it to be used in a suitable plastic form.

There are two main classes of N.G. explosives in present use.

(1). *The Dynamite Class.*—The N.G. is absorbed in some porous solid, so that it can be moulded into cartridges. The solid may be an inert substance, or it may be an explosive itself, usually a mixture resembling a primitive gunpowder.

(2). *The Blasting Gelatine Class.*—These have as their basis blasting gelatine, and range from the pure substance to mixtures of mild explosives with varying percentages of it.

Dynamite No. 1, the original dynamite invented by Nobel in 1866, consists of three parts of N.G. absorbed in one part by weight of kieselguhr, a diatomaceous earth. The guhr is calcined and sifted, and is a fine powder free from grit. Up to 2 per cent. of magnesium, sodium, or calcium carbonates are added as preservatives, also ochre to colour it, and sometimes barium sulphate and similar inert substances. It forms a plastic mass, brown or reddish coloured, and is made into cartridges which are wrapped in parchment paper. It is much less sensitive to percussion than free N.G., and safer to handle. When ignited in small quantities it burns fiercely but does not explode. It is readily detonated by a fulminate detonator, and as might be expected its shattering power is about three-quarters that of pure N.G.

Dynamite No. 2 is a mixture of 18 parts N.G., 71 of potassium nitrate, 10 charcoal, and 1 of paraffin wax.

Lithofracteur contains 50 parts of N.G., and 50 of a mixture of kieselguhr, wood meal, barium nitrate, and a little sulphur.

Carbonite contains 25 parts N.G., and 75 of a mixture of wood meal, potassium and barium nitrates, and a little sodium carbonate.

There are many similar mixtures in use, especially in America. Generally speaking the smaller the percentage of N.G. the slower they are in action, and hence the greater the rending and lifting, and the less the shattering effect.

All the dynamites are disintegrated by water. They exude their N.G. which may become dangerous. All freeze at low temperatures, in which state they behave erratically, and are dangerous to handle. They require to be thawed before use, which should be done carefully in the proper apparatus, and not in the rough method of some miners (exposing cartridges to the heat of a fire) which has led to many fatal accidents.

Blasting Gelatine is another valuable explosive invented by Nobel. It consists of five to seven parts of collodion cotton dissolved with the aid of heat in nitroglycerine, with the addition of a little sodium carbonate as preservative. It forms a stiff jelly which does not exude N.G. in contact with water, and is stored under water. It is made into cartridges like dynamite. It is much less sensitive than pure N.G., and comparatively safe to handle. Requires a strong detonator, as jellies do not transmit the detonating wave well, and is as powerful as pure N.G., the excess of oxygen in this substance supplying the deficiency in the collodion cotton. It is the most powerful explosive in use. Rate of detonation 7,700 metres per second.

There are many mixtures in use containing blasting gelatine as their base, all milder in action but very powerful.

Gelatine dynamite contains 80 per cent. of blasting gelatine, and 20 per cent. of a mixture of wood meal, potassium nitrate, and guncotton.

Gelignite contains 60 per cent. of blasting gelatine, and the remainder as with gelatine dynamite. It is a very powerful H.E. with great rending and lifting effect, and much used as a blasting explosive in Britain.

There are numerous other explosives with fancy names, very similar to the above.

Military Uses of N.G. Explosives.—Nitroglycerine blasting explosives are not Service explosives, but all military engineers are expected to be familiar with their properties and uses. Large quantities are kept in mining districts, and in war time they are freely used in back areas. They are not suitable for use near the front line, as they are liable to be detonated by a moderate shock, such as the stroke of a bullet.

Cartridges of these explosives make excellent primers for the detonation of large charges of the safety explosive mixtures.

Military Smokeless Powders.

A gunpowder, to be smokeless, must contain no mineral matter which would produce solid products of combustion. This excludes all mineral nitrates, except ammonium nitrate, and attempts to use this as a substitute for saltpetre were defeated owing to its hygroscopic nature.

Before 1860 von Lenk in Austria had provided several field batteries with guncotton cartridges. In order to slow its rate of combustion it was twisted into threads, and compressed, but although it then burns slowly under atmospheric pressure the high pressures in a gun finds out the pores. The flame gases penetrate, the explosive is then so violent that the gun is liable to be destroyed, as was soon found.

In 1875 Shultze powder appeared. It consists of nitrated grains of purified wood, impregnated with nitrates. It was still porous, but the density was so great that the rate of burning was slow enough to make it suitable for shot guns.

It was some time before it was realized that if the rate of combustion was to be under control the porosity of the substance must be completely destroyed; that no amount of mechanical pressure will do this, and the only way is to completely dissolve it, or at least completely gelatinize it by means of a solvent. When the solvent is evaporated the substance will then be impervious to flame gases at the highest chamber pressures, and burn regularly from the surface only.

The first to realize and make practical use of this fact was Mr. Walter H. Reid, who with D. Johnston took out a patent in 1882 for E.C. powder. This consisted of grains of guncotton impregnated with nitrates, and treated with alcohol-ether. As the guncotton contains a fair amount of soluble N.C. this was gelatinized and formed an impervious coating and binding for the other portions. The result was a good, almost smokeless powder, which is in use to this day.

With the truly gelatinized explosive the time of combustion of a charge can be regulated by the diameter of the cord or stick, and so adjusted to the various sizes of guns, or rather to the length of the gun, so that the whole charge may be consumed just before the shell emerges from the muzzle. It is also necessary that the rate of production of gas should increase as the shell moves forward in the bore and the space enlarges, so as to maintain the pressure. This is partly brought about by the rate of burning of cordite increasing with the pressure. Taking Mansel and Petavel's equation $V=a_0+ap$. Where a_0 is the rate of burning at no pressure, a=Const. a_0=.5 cm. for cordite and a=0.018 cms. Therefore in a field gun where the maximum pressure=15 tons per sq. in.=2,240 atmospheres, roughly, the cordite commences burning at the rate of .5 cm. per second, and at 40 cms. per second at highest pressure.

But the rate of gas production depends also on the surface exposed over which combustion is taken place. With a cylindrical rod the surface diminishes as combustion proceeds. With a flat strip it is practically constant, and the surface is large. With a tube or perforated cylinder it increases as the interior burns away. Hence the various forms, cords, strips, tubes and flakes, of which specimens are shown.

There are two varieties of smokeless military powders in use at present. (1) *Nitrocellulose Powders*, which consist of 99.5 per cent. of gelatinized nitrocellulose, and .5 per cent. of a preservative, and (2) *Nitroglycerine Powders* which are gelatinized mixtures of nitro-glycerine and nitrocellulose, with a few per cents of a stabilizer.

American Nitrocellulose Powder, N.C.T., is typical of the first class. It is made from soluble nitrocellulose containing about 12.5 per cent. of nitrogen. The purified nitrocellulose pulp is freed from water by pumping alcohol through it. Ether is then added to gelatinize it, and $\frac{1}{2}$ per cent. of di-phenylamine to act as stabilizer, and the whole incorporated for about three quarters of an hour, then pressed until it is a block of stiff colloid. This is pressed by hydraulic pressure through a die arranged to leave one or more perforations, and is cut into short lengths as it issues. For field guns the rods have one perforation; for larger sizes they have seven perforations. For a gun such as the 60-pr. the rod is 14 mm. in length and 5 mm. diameter, and has seven perforations. Hence the name N.C.T. It is also made in square flakes.

The greater part of the solvent is afterwards dried out, but from 3 to 6 per cent. remains as a constituent, as without it the powder is too brittle, and the rods are liable to break up and give unduly high pressures.

N.C.T. is a good powder and fairly stable. It is the weakest of the smokeless powders. Charges must be about 16 per cent. heavier than with cordite to give the same muzzle velocity, but as this is due to the lower temperature of the gases there is less erosion, and the guns have a longer life. It gives more smoke than cordite, but a less muzzle flash, and there is less danger of a back flash. It is hygroscopic to some extent, and must be protected from atmospheric moisture, as absorption of moisture alters the shooting.

N.C.T. is now much used in our Service for guns and howitzers, the charges being adjusted to give the same m.v. as cordite M.D.

German N.C. powders are very similar. The rifle powder is made in small flakes which are graphited.

French N.C. powders are different. Poudre B is made from a mixture of guncotton and soluble nitrocellulose. The alcohol-ether used as solvent dissolves the soluble N.C., and this coats and encloses the insoluble part. It has not so good a history as N.C.T. and cordite. The loss of the *Liberté* in 1911, and the *Jéna* in 1907, was undoubtedly due to spontaneous combustion of Poudre B, but this was probably due to other causes than inherent instability.

Russian powders were very similar to American N.C.T., but are of no interest now, since Russians have forgotten their use.

CORDITE.

Cordite Mk. I. was for long the sole British propellant. It was the result of a series of experiments carried out under the direction of the late Sir Frederick Abel, and Sir James Dewar, and its manufacture was commenced in 1889. It was based on Nobel's discovery that when nitrocellulose and nitroglycerine were thoroughly incorporated and gelatinized the sensitiveness of both were diminished, and the resulting substance formed a safe and powerful smokeless powder. Nobel's powder was ballistite, which contained 50 parts of collodion cotton dissolved in 50 parts of nitroglycerine, with a small percentage of camphor added as stabilizer. The collodion cotton was objected to as being unstable, and the camphor as volatile. The composition decided on was N.G. 57 parts, guncotton 38, and mineral jelly 5. Acetone was used as the solvent. The mineral jelly (vaseline) was added to modify the violence of the explosion and act as a lubricant for the bore. But later it was found that it was completely burnt up, and also that instead of being a pure paraffin, as supposed, it contained unsaturated hydrocarbons, and was an efficient stabilizer.

Cordite Mk. I. is a very powerful propellant, but owing to the high temperatures produced it is very erosive, and as the result of the S.A. War a modified cordite, "Cordite M.D." was introduced. It has the composition, guncotton 65, N.G. 30, mineral jelly 5. Its power is about 10 per cent. less than that of Mk. I., but the guns last three times as long. Cordite M.D. is the standard British propellant, although others are used at present.

The following is a brief outline of the manufacture :—

The guncotton, lightly pressed into cylindrical primers containing 50 per cent. of water, is dried in air at 40°C., until the water is reduced to ½ per cent. It is then weighed into rubber-lined bags and the charge of nitroglycerine poured on. The two are worked by hand into a paste which is quite insensitive compared with either of its constituents. The cordite paste is put into a kneading machine, acetone is added, and incorporated for about three hours. Then the vaseline is added and more acetone, and it undergoes a further incorporation, forming "cordite dough." The dough is pressed hydraulically through dies, and issues as cords, strips or tubes. The diameter of the rods and thickness of the tube walls varies from half an inch to one-hundredth of an inch. The acetone is driven off by exposure to warm air, which requires from 3 to 30 days.

Cordite varies in colour from light yellow to dark brown, depending on the vaseline. It is one of the best and most stable of smokeless powders, but like the others is decomposing from the day it is made, and requires care in store and frequent inspection. Different sizes are distinguished by numbers which give the diameter in hundredths of an inch in the case of sticks, and the outer and inner diameters in the case of tubes. Thus: Cordite M.D. $3\frac{3}{4}$. Cordite, M.D.T. 20—10. For strips the numbers give the width and thickness.

In store cordite should be kept cool and not exposed to the direct rays of the sun. In ships the magazines are artificially cooled. When cooled below about 6°C. the N.G. freezes, and appears as an exudation on thawing. The cordite is said to "sweat." The N.G. is reabsorbed on standing. Sweating cordite should be handled carefully, but may be fired in this condition. Water does not injure it, but it should be dried before use.

There are other modifications of cordite. One is similar to Cordite, M.D., except that a mineral jelly containing a larger percentage of unsaturated hydrocarbon, is used to increase the stability. In a new modified cordite soluble nitrocellulose is used instead of guncotton, and alcohol-ether is used for the gelatinization instead of acetone. It contains a larger percentage of nitroglycerine than Cordite, M.D., but is very similar, although not quite so powerful.

Ballistite is also used as a military powder. The original ballistite contained 50 parts N.G., and 50 of collodion cotton gelatinized by heat, with addition of $\frac{1}{2}$ per cent. of di-phenylamine as stabilizer. It is rolled into sheets and cut into small square flakes. It is the most powerful of all the smokeless powders, but the most erosive, and only suitable for howitzers where the chamber pressures are low. A modified ballistite has been introduced in which the more stable highly nitrated cellulose is used, and the percentage of nitroglycerine diminished. It has the same characteristics as the other, but not quite so erosive. The flakes are sometimes graphited. Specimens are shown.

WEIGHTS AND MEASURES.

A Field Company Commander writes :—

In the May number of the *R.E. Journal*, some queries were raised as to the list of weights of vehicles of a Field Company on the march, sent in by my predecessor in this unit.

Certainly, the circumstances were peculiar at the time, as it was immediately after our arrival in this country, when there was no extra transport available in the way of lorries. Consequently all the extra stores, that have to be carried nowadays by units in the field, had to be taken along on our equipment transport. Shortly afterwards the hiring of local vehicles—bullock wagons, etc.—was authorized, and the loads were proportionately reduced. Fortunately, the country was extremely flat.

These extra stores—for which no allowance is made as regards transport—were, when these weights were taken :—

Two blankets per man,
Horse rugs,
Two days' forage and rations,
Leather jerkins and fur coat,
Bridging vehicle fittings for engine draught,

to mention the chief ones.

In addition, it should be remembered that box respirators and steel helmets have been added to the equipment carried " on the man."

Some of the Infantry units tried to ease their transport by making the men carry blankets, jerkins, etc.; but the results were fatal, enormous numbers of men falling out from exhaustion. The Division was marching an average of about 15 miles a day.

I can vouch for the facts, as I was Adjutant of the Divisional Engineers then.

SUN-SCREENS IN SKY-LIT BUILDINGS.

By A C.R.E.

SKY-LIT buildings not provided with blinds and used as temporary offices—many of which no doubt have been taken for this purpose in the U.K.—are apt to be uncomfortably hot in the summer owing to direct sunlight and irrespective of possibly defective ventilation.

Obscuring the glass by painting or otherwise is open to the objection that it cuts off too much light on a dull day. Blinds are expensive and are liable to get out of order, which in a high-roofed building may be awkward.

It was decided in two cases to fix sun-screens. Screens should cause minimum interference with diffused light and ventilation, should give maximum protection against direct sunlight, should be good reflection of light, and should be cheap.

These conditions are fulfilled by a material known as "Bolton Sheeting" fixed as described later to the roof trusses; this material is white, reasonably opaque, and the price in 1917 worked out to about 1s. per square yard.

CASE A.

The building is favourably oriented, its axis being only 5° from true east and west (*Fig.* 3). The skylight is glazed at the sides (which open) as well as on top.

Screens (see *Fig.* 1) were designed to be fixed as follows:—

Longitudinal, AG and BD; cross,—at every truss except the one at west end—FEDB. Instead of screen BD one fixed to the strut DC would have given equal protection but the former was chosen both on account of ease in fixing and as being less attractive of dust.

When the sun is on the meridian the longitudinal screens give complete protection from direct sunlight (*Fig.* 1); and this is the case till 3 p.m.* At 4 p.m. (*Figs.* 3 and 4) the cross screens come into

* *Note.*—Unless otherwise stated time is the Summer Time of the locality and the sun's position is that at its maximum north declination.

SUN-SCREENS IN SKY-LIT BUILDINGS.

FIG.1. SECTION LOOKING WESTWARDS (CASE A)

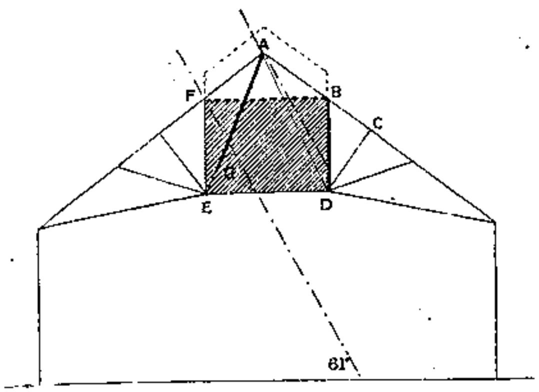


FIG.2. SECTION LOOKING WESTWARDS (CASE B)

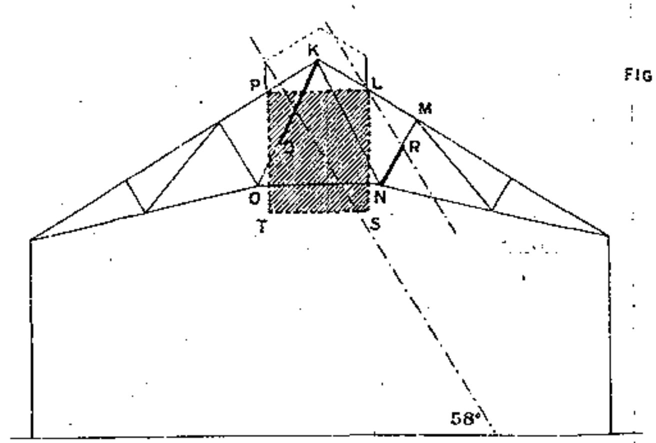


FIG.5. LONGITUDINAL SECTION (CASE A) at 5^H 35^M P.M.

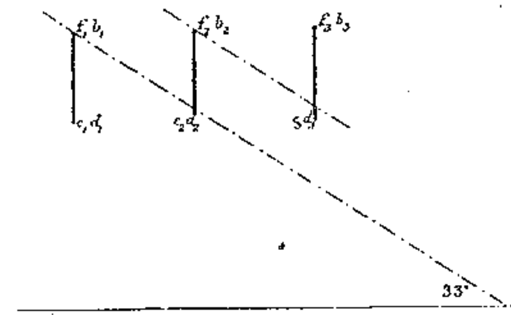


FIG.6. LONGITUDINAL SECTION (CASE B) at 3^H 45^M P.M.

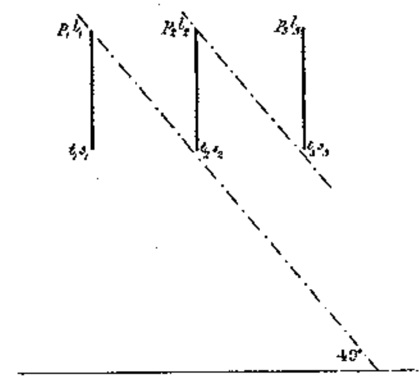
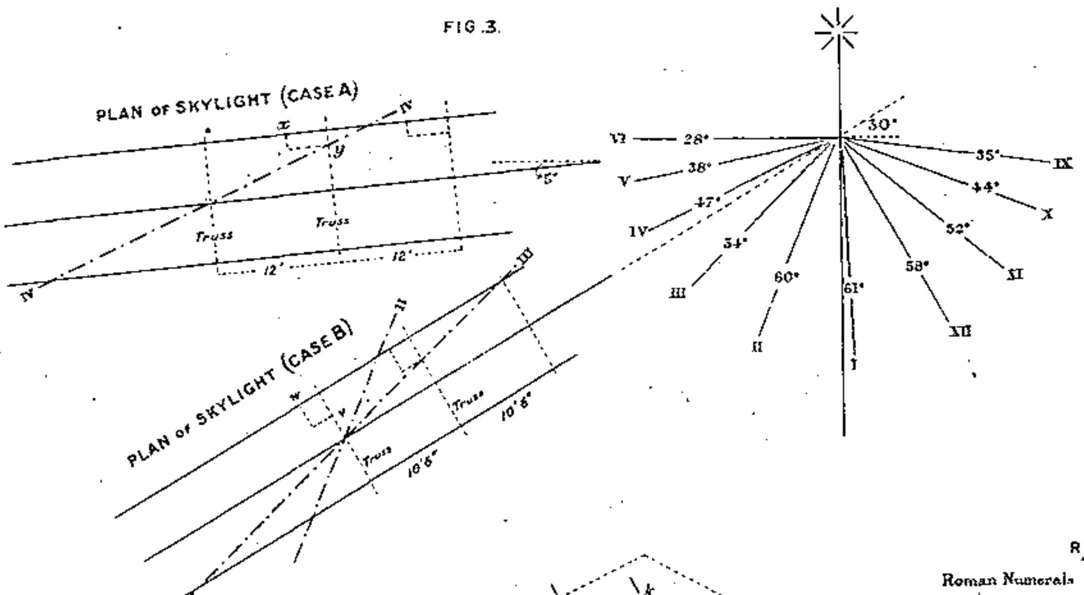


FIG.3.



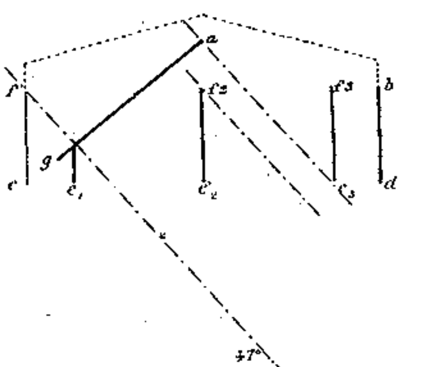


FIG.4. SECTION AT (IV) (CASE A)

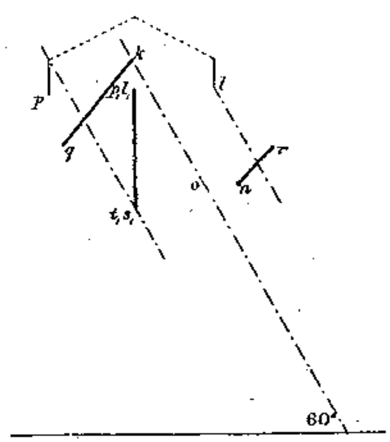


FIG.7. SECTION AT (II) (CASE B)

REFERENCES.

Roman Numerals — Summer Times at Locality & corresponding azimuths } At sun's maximum

Arabic " " — Suns altitudes } Summer declination

— Sun's rays

— Sun-screen in section

" " in elevation

Scale 10' = 1"

10' 5' 0 10' 20' 30'

action and at that time there will be an unprotected area indicated by the rectangle *xy* in *Fig.* 3; this will disappear when the sun's north declination is 15, *i.e.* towards the middle of August. At 5.35 when the sun is in the direction of the axis of the building the cross screens give complete protection (*Fig.* 5).

The screens in this case cost about 6s. per foot-run of skylight. They have been up nearly a year and have required no attention.

Case B.

Here the orientation is not so favourable, the axis of the building running N. 60 E. and S. 60 W., but the trusses are at closer intervals, 10 ft. 6 in. instead of 12 ft. The skylight is glazed on the top only, the sides are of wood, louvered for ventilation.

Screens proposed are: longitudinal—KQ and NR; cross—PTSL, the bottom of this screen to be fixed to a wire fastened to the junctions of small struts and tie rods.

It will be seen that at 2 p.m. (*Fig.* 7) the longitudinal screens do not give complete protection there being a gap, *n o*, which will not disappear until the middle of August; if found necessary the longitudinal screen NR can be extended 2 ft. 6 in. to S (*ns*, *Fig.* 7) which would effectually seal this gap. At 3 p.m. there is an unprotected area indicated by the rectangle *wv* (*Fig.* 3); at 3.45 p.m. the sun being in the direction of the axis of the building the cross screens are too short by 6 in. to give complete protection.

The cost of these screens is about 12s. per foot-run of skylight.

Calculations.

To determine the amount of protection given by screens it is necessary to know the latitude and longitude of the locality and to find the sun's altitude and azimuth. This can be done graphically or by calculation.

Formulæ are:—

$$\tan A = \frac{\tan t \cos N}{\sin(\phi - N)}, \quad \tan z = \frac{\tan(\phi - N)}{\cos A}$$

$$\tan N = \tan \delta \sec t$$

where A=azimuth, t=hour angle, ϕ=latitude, $z=90° - h$ (the altitude), δ=declination.

The following table is sufficiently correct for this purpose. Due allowance must be made for longitude and Summer Time—*e.g.* in W. Long. 8° an hour angle of 3^{H} would correspond to 10.32 a.m. and 4.32 p.m. (neglecting the equation of time which in summer is small).

TABLE OF ALTITUDES AND AZIMUTHS AT SUN'S MAXIMUM NORTH DECLINATION.

Hour Angle.	N. Lat. 58°		N. Lat. 54°		N. Lat. 50°	
	Alt. Deg.	Az. Deg.	Alt. Deg.	Az. Deg.	Alt. Deg.	Az. Deg.
0	55½	0	59½	0	63½	0
1	53½	23	57½	27	61	29
2	49	45	52½	48	55	52½
3	43	62	45	66	47	70
4	35	77	36	80	37	83
5	27½	90	27½	92	27	94
6	18½	103	18	104	17½	105

CLIMAX OF TWO GREAT WARS.

By J. Holland Rose, Litt.D.

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At no time during the present War have the prospects of the British people been so gloomy as they were after the collapse of Austria in the Wagram Campaign of the year 1809 and the disgraceful Walcheren expedition of that autumn. It may be well to outline the situation in the years 1810–11 and to suggest comparisons at some points with that of the far greater war against the Central Empires and their Allies. In this article I attempt to form estimates on military and naval affairs at the two periods, and in a subsequent article to treat questions of food supply, commerce, and financial stability.

The defection of Russia has brought about a state of affairs not unlike that which Napoleon's triumph over Austria produced in 1809. Thenceforth, up to the end of 1811, he threw his whole strength into the West. In 1810 a veteran army under Masséna swept through Spain and Portugal, and pinned Wellington's forces to the Lines of Torres Vedras. The tenacious British resistance (far from appreciated at the time) saved from utter ruin the cause of the Portuguese and Spanish "Patriots," inaugurated a time of balance in the Peninsular War, and encouraged the Tsar, Alexander I., to the independent fiscal policy which brought about the French invasion of Russia in 1812. Thus the years 1810–12 form the crisis of the Napoleonic War. Without Torres Vedras, there would have been a timorous peace, an unchallenged French ascendancy, broken by no retreat from Moscow, no Leipzig, no Waterloo.

The obedient journalists of Berlin have asserted that the great German push which began on March 21st, 1918, can be more than once repeated; that they do not rely chiefly on the submarine campaign, but will force a military decision. In a general way, therefore, the present push may be compared with the effort of Masséna; but Germany confronts Allies who equal her in determination and excel her in man-power, money, and material. She controls a central mass of territory and possesses an admirable military organization—advantages possessed in a unique degree by Napoleon over his feeble opponents of 1810–11. But her mass, like his, is gripped by sea power; and she, any more than he, cannot escape from its economic pressure by subjecting Russia as he did at Tilsit in 1807. Indeed, the more the Teutonic yoke galls the Russians, the more likely are they to cast it off at the first opportunity. The more intelligent Germans blame their Government for imposing humiliating terms on Russia, just as Talleyrand censured Napoleon for alienating public opinion in 1811–12. But the Germans persist, even as he persisted. Early in 1812 his nervousness as to the East prevented him sending into Spain the forces needed for ending the war. Even so, the Germans persist in their penetration of Russia. Sooner or later, then, sympathy must reawaken among the Russians with their former Allies, just as in the winter of 1811–12 Alexander I. based his resistance to the Napoleonic decrees on his confidence in Wellington's indomitable resistance, while the duke fought his uphill fight with the more spirit because he foresaw the Russo-French rupture. *Adsit omen!*

As the Berlin Press assures the world that the time is at hand when the war-will of the Western peoples must collapse, it may be well to recall the odds against which our forefathers fought. The census of 1811 gave the population of Great Britain as 12,596,803 souls. That of Ireland in 1821 was 6,801,827; and in 1811 it may be reckoned at about 6,250,000. The numbers of the white population in our chief colonies are not known until the following dates:—Canada, 1,172,820 in 1844; New South Wales (inclusive of what is now Victoria), 36,598 in 1828; Van Diemen's Land, 12,303 in 1824; Western Australia, 2,070 in 1834; South Australia, 17,366 in 1844; New Zealand, about 3,000 or 4,000 in 1847; Cape Colony, 68,180 in 1839. In 1811 these figures would be about one-half of those just presented. Consequently, we then had no military succour from the British race beyond the seas; and, owing to the disputes with the United States and the Dutch, Canada and Cape Colony (not to speak of India) needed considerable garrisons from the motherland. It is well, then, to realize that the British race within the Empire (including the Irish, but excluding the French-Canadians and the Dutch of Cape Colony) numbered less than twenty millions in the year 1811. Capt. C. W. Pasley, R.E., in his *Essay on the Military Policy of the British Empire* (1811), reckons only Great Britain as counting in the War, and, estimating the population of the Napoleonic Empire and vassal States at 77,000,000 souls, concludes that the odds against us were more than five to one. Probably he exaggerates the hostile numbers and underestimates our own; but, after Napoleon's annexations of the Papal States, Illyria, Holland, and N.W. Germany (as far as Lübeck), the French Empire must have included nearly 60,000,000 souls. This, however, is not all. In June, 1812, Napoleon marshalled for the Russian campaign 147,000 Germans from the Confederation of the Rhine, and some 80,000 Italians, 60,000 Poles, and 10,000 Swiss, besides exacting contingents of 50,000 from the quasi-dependent States, Austria and Prussia. If we include all the lands which furnished the Emperor with man-power, Pasley's estimate of the odds is within the mark—at least, for 1811.

It is needless to point out the sharp contrast afforded by the present struggle. Probably the white population of the British Empire now approaches—or even equals—that of Germany, about 68,000,000. The deficiencies of the Allies are in their scattered positions and their military unpreparedness. But in 1811 the British and the Spanish and Portuguese patriots were still more deficient by comparison with Napoleon. He had the great advantage of inheriting a system of national conscription founded by the French Jacobins in August, 1793, and developed more systematically in 1798. He applied this system to his vast Empire, and expected vassal princes to supply almost as large a quota. True, by the year 1810, warlike enthusiasm had declined, and bands of refractory conscripts had to be hunted down. The levies which he exacted from his vassals were half-hearted, only the Poles and the North Italians fighting with enthusiasm. Still, love of glory, hope of plunder, or the longing to secure a lasting peace impelled the mass forward. As Count Ségur says: "There was not a hope which Napoleon could not flatter, excite, and satiate. . . . A war was often only a battle or a short and brilliant excursion." Such, too, is the Prussian tradition, based on the triumphant wars of 1864, 1866, 1870.

To break down the moral which in 1810–11 still inspired the best of Napoleon's troops was a stupendous task; but Wellington impaired that moral at Busaco, wore it down at Torres Vedras, displayed the full fighting strength of the British soldier at Badajoz, and his superiority in the mighty clash of Salamanca (July, 1812). Even so, in the present War, the Allies, owing, first, to lack of numbers, and then of thoroughly trained troops, have been confined mainly to a defensive strategy. The Germans, also, like Napoleon, having the advantage of inner lines of operation, could adopt his methods which so often won a decisive triumph in a single campaign. Considering their superiority in numbers, equipment, and position in 1914, they cannot be pronounced brilliant pupils of the great commander.

It is well to realize how slowly and awkwardly the British military machine worked in Wellington's day. Nor must the fault be ascribed solely to the Government; it must accrue to the nation as a whole. Take the following jottings of Lord Uxbridge's agent at Plasnewydd in August, 1807, when England stood entirely alone:—

"Our regular army is now to be increased by enlistments from the militia, but there is great unwillingness to save the country unless in a constitutional way. . . . Our country gentlemen make no distinction in the means of defence they would adopt between an insignificant rebellion in Scotland and the mighty invasion with which we are now threatened. . . . We have nothing very great to expect till the enemy is actually amongst us. He will then give us a practical lesson."*

Nothing awakened John Bull. He jogged along in the old ruts. Successive Cabinets sought to co-ordinate the regular army, militia, and volunteers. Pitt, Dundas, and Windham; Addington and Hobart; Pitt, Camden, and Castlereagh; Grenville and Windham successively produced their reforms until chaos reigned supreme. The Perceval Ministry (1809–12) totally failed to solve these difficulties, which, of course, could be overcome only by the adoption of conscription; but that nervous Cabinet feared to take so drastic a step. After the disastrous failure at Walcheren it hesitated to send Wellington the needful supplies either in men or money; and (as will appear later) so unpopular was the Peninsular War that the Whigs, who opposed it outright, might well have ejected Perceval if he had greatly increased the taxes. Home politics, therefore, prevented a vigorous prosecution of the war, until, in the summer of 1812, the action of Russia breathed new energy into the calculating trimmers of Westminster. Harsh things have been said by soldiers of politicians during this war, but nothing comparable to the insults hurled by Napier at the memory of Perceval: "The politician, believing in no difficulties because he feels none, neglects the supplies, charges disaster on the general, and covers his misdeeds with words."†

But the damning charge against the Portland and Perceval Cabinets is their ineffective use of the existing forces. In 1808–9 the effectives were 26,500 cavalry, 178,000 infantry, artillery and engineers, 24,000; and the embodied militia, 77,000. Pasley in 1811 reckoned that, by calling up the reserve militia and training the volunteers, 120,000 men might be spared for active service. He arraigned British statesmen of timidity and blindness in keeping so many regulars at home, and in frittering others away in spasmodic and generally belated efforts. Our troops (he wrote) cost half as much again as those of any other nation; our politicians rarely looked ahead, never framed a consistent military policy, or provided adequate equipment. If they continued to act thus we should "have nothing before us but the gloomy prospect of eternal war." We must act on land as vigorously as by sea, or else we might be conquered on both elements. Trust in Coalitions was futile; indeed, in course of time—"*Germany might become so powerful as to act the part which France now does.*" Let us vigorously support Wellington and the Spaniards, for there only could we hope to overthrow Napoleon's power.

* *The Paget Papers*, II., p. 316.

† Professor Oman (*Peninsular War*, IV., p. 67) rebuts the diatribes of Napier against Perceval (Napier, bk. xi., ch. 10, xiv., ch. 2); but, surely, after Torres Verdas, Perceval should have properly supported Wellington or resigned if Parliament refused.

Such is the gist of Pasley's essay, which I recommend as a tonic to the croakers of to-day.*

Wellington, also, in the spring of 1812, asserted that Napoleon's ascendancy was rotten at the base, being "sustained by fraud, bad faith, and immeasurable extortion"; and that an honest understanding among the European Powers would end it.† If in those dark times our military thinkers foresaw the issue of 1814–15, have we any cause for pessimism now, when all the Powers of the world are united for the overthrow of a supremacy which is less intelligent and inspiring, far more odious and extortionate? May we not also derive confidence from a survey of our recent military efforts which dwarf everything that Pasley deemed possible? In efficiency the British Army probably excels our Peninsular Army which in December, 1812, Wellington pronounced inferior to a French army presumably of equal size.‡ The levies of 1914–16 are certainly equal to the highly trained German Army—a feat of organization which dwarfs every other effort in our annals.

Relatively to Germany, it seems probable that we occupy a position more favourable in naval affairs than our forefathers did to Napoleon in 1810–12. At that time and down to the spring of 1812 he excluded us from intercourse with the Continent, except Turkey and parts of the Spanish Peninsula. His empire comprised nearly all the coastline from Hamburg to Venice and Ragusa; he had the active support of the Danes, and in June, 1812, when Russia failed him, the United States declared war against Great Britain. Potentially, therefore, his resources in shipbuilding were far greater than ours, and he hoped to overwhelm us at sea. Thus, on March 8th and August 9th, 1811, he bade Decrès, Minister of Marine, prepare for great naval enterprises in 1812; eight sail of the line must be ready at the Texel, twenty at Antwerp or Flushing, and large squadrons in French and Italian ports, for expeditions to Ireland, Sicily, Egypt, Martinique, Surinam, "*et tout le Continent hollandais*" (Australia). Pinnaces were to be built suited to the navigation of the Nile and the Surinam. The Boulogne flotilla must be prepared to carry 30,000 infantry, 6,000 cavalry, and 2,000 artillerymen. In the spring of 1812 fears of invasion revived in England. On January 23rd, 1813 (that is, even after his disaster in Russia), he ordered naval construction which would raise the numbers of his battleships to 104. At that time we had only 102 in commission, with 22 in reserve; and in view of the hostilities with the United States, the horizon was not reassuring. True, we had reduced the last of the enemy colonies, Java, and we controlled the tropics; but the immense extent of the Napoleonic coastline required that at least five

* Pasley, *op. cit.*, pp. 19, 40, 98, 105, 119, 146, 498—501.
† *Life of Sir W. Gomm*, p. 240.
‡ Croker's *Diaries*, I., p. 41.

British squadrons should blockade or observe his chief ports, and he hoped thus to wear us out until his new fleets could challenge us to decisive combat.

In guerilla tactics at sea he had many advantages. It was impossible to prevent hostile cruisers from slipping out and doing mischief. In 1811 the French and their naval Allies captured seven, and in 1812 eight, British cruisers, while we took or destroyed seven and four respectively. Our losses by wreckage were always far heavier (*e.g.*, three sail of the line and 15 cruisers, as against one French cruiser in 1811). In that year not one hostile squadron evaded our blockading forces, though the Toulon fleet attempted a futile sortie. But Napoleon continued to press on naval construction, and Pasley deemed the scattered British possessions so vulnerable as to make the issue doubtful against the dominating mass of the Napoleonic System. Strategically, it possessed enormous advantages over the present German Empire, which in open waters can act only from "the wet triangle" (the Ems, Heligoland, the Elbe) and from the Flemish coast. The further his System extended, the heavier were the losses to our merchant shipping, viz., 387 in 1804 to 619 in 1810. Thus, Trafalgar procured no immunity for our mercantile marine, which in 1810–12 was at the mercy of cruisers and privateers from nearly all the ports between Copenhagen and Venice.

On one topic the Napoleonic and the German strategy lays equally insistent stress, viz., the supreme importance of possessing the Flemish coast. "He who holds Antwerp," said Napoleon, "holds a loaded pistol at the head of England." During the futile negotiations at Châtillon in March, 1814 (*i.e.*, when he had virtually lost Holland), he said: "I am ready to renounce all the French colonies if I can thereby keep the mouth of the Scheldt for France." That dominating point, then, was worth the former colonial Empire of France, obviously because from Antwerp to Ostend he could coerce England at his will. Such, too, is the creed of Berlin; and by their submarine and aerial warfare, waged largely from Belgian bases, the Germans have, with their usual fatuity, supplied novel and irresistibly cogent arguments for ejecting them thence.

The crowning contrast between 1811–12 and 1917–8 has already been hinted at. Perceval's unwise maritime procedure led to the American declaration of war in June, 1812, and to a serious diversion of British naval and military strength. The signal tact and moderation of the British Foreign Office and Admiralty in 1914–7 paved the way for friendly relations with our kinsmen; and under the pressure of German frightfulness these developed into an alliance which may prove to be one of the decisive issues of the War.

TRANSCRIPT.

IS IT NOT TREASON TO CRY DOWN THE HORSE?

From the "Rider and Driver," U.S.A.

If it be treasonable to do anything by word or deed that impairs our military efficiency with regard to, say, shipbuilding, motor manufacturing, railroad transportation, and other vital activities, why is it not equally infamous to howl down the horse? It is an incontrovertible fact that even in this latest and most scientific of wars, the horse is more necessary than ever before, and that the supply, rapidly diminishing, has been largely reduced as much by the effects of a malignant propaganda as by the economic exigencies that lessen demand. In late years the cries of "down with the horse," "horseless age," "passing of the horse," and similar objurgation, have been heard throughout the land while, at the same time, the contending nations have been scouring the earth for horses, their requirements being estimated to be one horse to every three men in the service of arms. Competition in business affecting the horses' sphere is commendable and the "life of trade"; but, when such selfish considerations materialize into a form of persecution that is detrimental to the best interests of the national weal, it is time to call a halt. Instead of such drastic methods as have been used to displace the horse a spirit of "live and let live" should prevail, at least so far as the commercial phase of the situation is concerned; but when that kind of business promulgation reaches the point of endangering the lives of our heroes at the battle front the nobler impulse of patriotism must be rallied to inspire reactionary sentiment. We are not merely expressing sentimental wishes, but stating facts as to the critical importance of the horse. It is irrefutable, for example, that three months before Germany participated war, that country had purchased 350,000 horses from France alone, thus proving that the most militant power of the world, foreseeing, appreciated the inestimable advantage of the animal. This number was only a drop in the bucket, so to speak, compared to the thousands upon thousands of horses bred in Germany and Austria-Hungary, and bred for many years, with an especial view to their value for campaign purposes. From England, too, Germany had purchased the best stallions for breeding available, without regard to price, paying as high as $125,000 for a single horse, the famous Ard Patrick, which so far as we know, is still in the enemy stud. The losses of horses by the Central Allies have nevertheless, been stupendous and it is believed that they have not been replaced by at least 50 per cent. In the final shocks of the fray this will tell against the enemy tremendously although, we believe, their cavalry have been maintained in the background at the fullest strength, awaiting mobile action when the trenches have been abandoned. In view of these circumstances and especially in response to the call from General Pershing for more horses and more horses, as they say of ships, and for more cavalry, and more cavalry, the Secretary for War has instituted a tardy but strenuous drive to fulfil the obligations imposed and which in better prepared countries were never overlooked nor undervalued. Whole volumes have been printed on the deeds of the horse, but it is not necessary to revert to them as they are known to every intelligent reader of history. As much, if not more could also be written of the horse's incalculable services in the present struggle. It should suffice now for everybody who loves his fellow man, and who is sacrificing affection and fortune for the cause, to realize the stupendous significance of the horse in this titanic struggle for the freedom of the universe. It sounds hackneyed and inadequate to quote Richard III.'s desperate appeal, "A horse! A horse! My kingdom for a horse!" but never was there a time when the immortal phrase applied with such sonorous open diapason as at this moment, when kingdoms tremble, to fall at the approach of whichever may be the mightier hosts' thunderous vibration of horses' hoofs. "Long live the horse; man's best friend in war as in times of peace!"

REVIEWS.

PAGES D'HISTOIRE, 1914—1917.

(Published by the Librairie Militaire Berger-Levrault, 5—7, Rue des Beaux Arts, Paris).

(*Continued from R.E. Journal for May*, 1918).

The 146th and 147th numbers of the above series contain the Official Communiqués issued by the Central Government to the Provincial Authorities of France; they are the XXXIII. and XXXIV. volumes respectively which deal with this subject.

The 146th number relates to the events of August 1917 and contains appendices giving (*a*) the text (in French) of the telegram sent, on 3rd August, 1917, the date of the third Anniversary of the declaration of War, by H.M. the King to the President of the French Republic; (*b*) the text of the telegram from the latter to King George acknowledging H.M.'s message; (*c*) the text of the telegram sent by President Poincaré to the King of Italy after the former's visit to the Italian front in August, 1917; (*d*) the text of the telegram from King Victor Emmanuel to the French President acknowledging the latter's message; (*e*) the text of the telegram sent by the French President to the King of Italy congratulating him on the then recent successes of the Italian troops; (*f*) the text of the telegram from King Victor Emmanuel to President Poincaré acknowledging his message; and (*g*) the text of the speech made by the French President on the occasion of his visit to Verdun, on the 29th August, 1917, at the ceremonial in connection with the investiture of General Pétain with the Grand Croix of the Légion d'honneur.

The ceremonial in question took place in the public square of the historic town; the investiture having been carried out with the customary formalities, President Poincaré addressed the gallant defender of France's much renowned fortress in the following terms:—

"The Premier and the Minister for War have, in the letters sent you conveying the congratulations of the Government of the Republic, expressed to you in heartfelt terms the latter's deep confidence in the army and the sense of gratitude of the whole country. In investing you to-day, in the presence of a part of your valiant troops, with the Grand Croix which has been awarded you, it gives me much pleasure to inform you personally, how proud France is of your success and what reliance she places in you, in the Generals, officers and incomparable men serving under your command.

Since the day on which the task was assigned to you to secure our military position at Verdun for us, the eyes of the whole world have been turned towards this glorious city and the zone of Lorraine territory adjacent thereto and surrounding its ancient walls which are now rent by many an enemy shell. The entire human race has appreciated the fact that in the gigantic and tragic struggle taking place here, on the two banks of the Meuse, was being settled the question of the liberty of peoples and the future of civilization.

This ravaged countryside, through which I have often journeyed in your company—this despoiled territory which has acquired a symbolic significance and no longer remains the outlying feature alone of a celebrated stronghold, but is to-day the glacis itself of an ideal citadel wherein Right itself is entrenched; this soil made illustrious by so many a combat, sanctified by so much blood that has flowed—has the French Army defended step by step and reconquered stretch by stretch; and here to-day, under your supreme command and under the direction of tried chiefs, it has retaken by assault, after a skilful artillery preparation, the heights, so often disputed, whence the enemy was commanding our positions, watching our movements, and controlling the fire of his own batteries. A striking victory now answers, as a resounding echo, to the successes obtained day by day by our troops on the Chemin des Dames; to the brilliant advantages secured by our troops on the plains of Belgium; to the heroic fights, put up in Flanders by British troops; to the important progress made by the Italians on the rugged slopes of the Monte Santo and on the rocky plateaus of the Carso.

In these combined operations on an extensive scale the French Army has put forth, as has ever been the case, its full share of effort. Never in its history has it shown a higher courage, a loftier spirit. Three years of violent fighting have neither worn out its strength, nor cooled its ardour. In this long trial it has been invigorated by knowledge of the fact that the safety of its native land was at stake and by the will to fight on until a triumphant peace could be assured.

In vain our enemies have been trying to spoil history and to disseminate fairy tales in neutral countries. In vain do they make desperate efforts in order to throw off the responsibilities that are weighing them down. In vain are the factories for the manufacture of lying information, located in the cities of the Central Empires, giving off clouds of black smoke without ceasing, clouds which a propitious wind is ever blowing across their frontiers, clouds that continue to evaporate into thin air as soon as they reach the boundaries of the zone of truth.

Convinced, at last, that she can no longer hope for a military victory on our front, Germany has taken refuge in a final illusion; she thinks that she has got the better of us owing to the internal crises of our country and, for weeks past, she has been noisily airing her views on the subject. Neither these puerile manœuvres, nor the infamous propaganda that accompany them—a propaganda which the judiciary will repress with a strong hand—whenever they have attempted to gain a footing in our midst, have succeeded in disturbing the public spirit of our people which continues to remain worthy of our cause and the splendid soldiers who are defending it.

Entire France is at war; no part of it will allow itself to be stampeded.

Confident in the magnificent army which you are commanding in so masterly a manner, wherefrom it has received a new stimulus for hope; confident in the loyalty, in the energy, in the growing strength of its allies, France conveys to you to-day, to your officers and to your men, its congratulations and makes known its vows; it repeats its former assurances: 'Depend upon me as I depend upon you and your men. Together, we will fight on until final victory is ours. Together, we will work to establish, on the firmest of firm foundations, the reign of a propitious Peace and the Sovereignty of Right.'"

Subsequent to the foregoing ceremony the French President, accompanied by the War Minister, and Generals Petain and Guillaumat, visited the Headquarters of the 2nd (French) Army to congratulate the staff on their brilliant success. Some of the Divisions which had taken part in the recent operations were next reviewed.

In the afternoon of the same day, President Poincaré went over a part of the ground reconquered on the two banks of the Meuse, he inspected the troops in the locality and warmly congratulated General Guillaumat, his officers and men.

The 147th number contains in its appendices: (*a*) the text of a telegram from King Ferdinand to the French President on the occasion of the second Anniversary of Roumania's entrance into the War; (*b*) the text of President Poincaré's reply to H.M.; (*c*) the text of the telegram from the Belgian King to the French President after H.M.'s visit to the French Front; (*d*) the text of President Poincaré's reply to King Albert's message; and (*e*) the text (in French) of President Wilson's reply to the Pope's manifesto of the 1st August, 1917, to the belligerent nations.

In his reply to His Holiness Benedict XV., President Wilson stated that no one who was not blind, or whose heart had not been turned to adamant by this War, could have failed to have been touched by the moving appeal of the present occupant of St. Peter's chair, to have felt the dignity and the force of the humane and generous motives that impelled the Sovereign Pontiff to make an attempt to direct the belligerents on to the paths of peace. But, at the same time, the President of the Great American Republic pointed out that it would indeed be fatuous and foolish for any belligerent Power to follow the indications on the guide-post, which His Holiness had put up, if the way indicated, in reality, did not lead to the destination all were seeking.

Clearly, it was not a mere armistice that the Pope was desirous of bringing about, but a permanent and stable peace.

Reviewing the Pontiff's proposals, President Wilson pointed out that what, in substance, the belligerents were required to do was to return to the *statu quo ante bellum*, on the understanding that no reparation should be demanded in respect of injuries suffered, but that a general disarmament should ensue on the basis of the creation of a Concert of Nations, which should rely on the principal of arbitration for the settlement of future disputes and differences; that the liberty of the seas should be secured by a similar international concert; that the territorial claims of France and Italy; the complicated problems of the Balkans and the restoration of Poland should be settled by mutual agreement on bases which would remove all causes of future discord.

In the opinion of the American President no part of the foregoing programme could secure results worth having if the return to the *statu quo* could not be secured on a firm and satisfactory foundation. The main object of the present Conflict was to deliver free peoples of the Universe from the thraldom of a vast military organization, subject only to the dictates of an irresponsible government, which, having secretly laid its plans for the domination of the habitable globe, had put into execution its projects without paying the least respect to Germany's sacred treaty obligations or to the long established customs and recognized principles governing international relations and the code of ethics of civilized peoples; a government, which had chosen its own appropriate hour to force on a war; one which had struck its first blow not only suddenly, but with an excess of brutality; one which had not considered any law or any feeling of pity a hindrance to the most dastardly of acts; one which had submerged a whole continent under a tide of blood, not that of soldiers only, but also that of women and innocent babes and of poor defenceless mortals; and one which was standing in arrogant defiance that day, brought to halt no doubt, but not yet subdued; a government that was the enemy of four-fifths of the population of this world.

It was not, said President Wilson, from the German people that this power sprang, but from their pitiless masters. It was not for the belligerents to seek the why and the wherefore of the subjection of a formerly great people to the domination of a military clique; but it was their affair to see to it that the History of the remainder of the world should not be written by German hands.

His Holiness was next informed that the only effect likely to follow from the acceptance of his proposals would be to allow Germany to recuperate her strength and to permit her to continue the policy which had brought so much disaster to the world. To combat such a situation, it would become necessary to form a permanent coalition of nations hostile to the German people; Russia would have to be abandoned to be a prey to new intrigues.

President Wilson pointed out also that well-informed statesmen must now see, if they did not do so prior to the outbreak of the War, that the permanence and durability of peace was not something to be attained by political or economic restrictions imposed with the object of favouring certain nations at the expense of others. The American people had, it was stated in the reply, suffered much at the hands of the Germanic Imperial Government, but it did not intend to pursue a policy of reprisals against the German people. The American people held it as a cardinal article of their political faith that peace must rest on the foundation consisting of the Rights of people and not those of governments, on the former's equal Right of liberty, on the former's Right to determine their own forms of government and to participate, on equitable principles, in full measure in all things connected with the economic activities in the world of industry and commerce. The real criterion of a satisfactory peace was that it should be founded on the reciprocal faith of the peoples interested; it could not be secured by a contract based on the word of an ambitious and intriguing Government of the one part and on the promise of a group of free peoples of the other. The aims of the United States in this War were, said President Wilson, known to the world at large, to all who seek the truth. America was not seeking material advantages of any kind. She demanded that reparation should be made for the disastrous mischief worked by the brutal and infuriated power of the Germanic Imperial Government, but not that this should be secured at the expense or to the detriment of the sovereignty of another people. On the contrary, America claimed the rights of sovereignty on behalf of the weak as well as of the strong; she considered punishments of a penal order, the dismemberment of Empires, the creation of egoistical and economic leagues to be out of place and to represent a most unsuitable coinage in which to measure the damages in the cause. The true foundation of the peace America is seeking must be built up on the principles of justice and equity, on the common rights of humanity.

In conclusion President Wilson made it known that America was not prepared to accept the word of those then responsible for the government of Germany as providing the necessary guarantee on the faith of which the American people could conclude a solemn contract with the German people. Before proceeding further it was necessary, he said, for the Central Powers to provide some new and acceptable proof of their good faith and of the abandonment by them of the principles that have brought so dire a catastrophe into the world as that witnessed in the autumn of 1914.

W. A. J. O'MEARA.

THE YEAR-BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY, 1918.

The sixth Annual number of *The Year-Book of Wireless Telegraphy and Telephony* has duly made its appearance. The volume continues to grow in size; but, needless to say, its quality remains at its previous high standard. *The Wireless Press Ltd.* (Marconi House, W.C.) is indeed to be congratulated on having produced so complete a guide-book on Wireless Telegraphy under the extremely difficult circumstances that prevail to-day. Owing to the general rise in cost of labour and of materials the price of the volume has been raised to 6s. net.

The volume is provided with a large number of photographic reproductions. These illustrations include several pieces of apparatus used by the late Mr. W. Duddell, F.R.S., in his investigations and in connection with his discoveries. Other illustrations relate to the most recent types of wireless instruments, and to views of wireless stations; portraits of some of the leading men in the radiotelegraphic world also appear in the volume.

"The Record of the Development of Wireless Telegraphy and Telephony," provided as an introduction, is brought down to the end of 1917. Among the more important items entered under the year 1917 are a reference to the "Coming of Age" of wireless telegraphy on the

2nd June, 1917; to the considerable developments which have taken place in connection with the utilization of wireless for military and naval purposes, and more particularly in relation to its use in connection with aircraft; to the amended regulations relating to compulsory wireless for sea-going vessels, whereby the former tonnage limit of 3,000 tons has now been brought down to 1,600 tons gross; to the wireless developments in Australasia and the Pacific; to the purging of Africa from enemy wireless influence; and to the suspension of Transatlantic Commercial Wireless Service in August last by direction of the British Government.

There is no change in the matter comprised in the section entitled "National and International Wireless and Regulations." On the other hand, in the section dealing with the various acts, decrees, regulations, etc., in force in the several countries of the world much additional matter has been included; not only do the laws and regulations of some countries appear therein for the first time since the issue of the *Year-Book*, but a useful introduction has been added to the information hitherto furnished in this section: the geographical limits of the several countries, and in some cases a few important historical facts, a reference to the constitution or fundamental law of the country, the organization of the radiotelegraphic service and matters of administrative importance, have also been included.

An increase has taken place in the numbers of both the Land Stations and of the Ship Stations, but owing to the fact that full particulars have not been published, for obvious reasons, in relation to many of these stations it is not possible to say whether the number of long-distance stations have been increased or not. The information given under the heading of Ship Stations bears the impress of war; the compulsory transfer of ownership of many vessels, involving a change of flag, is to be found recorded in the pages of the volume under review. The Land Stations occupy 64 pages (as compared with 62 pages last year), whilst the Ship Stations occupy 153 pages (as compared with 141 pages last year).

The articles on scientific and other subjects, which have formed a special feature of the *Year-Book* since its first publication, are continued. The first of them, by Dr. J. A. Fleming, F.R.S., is entitled "Waves in Water, Air, Earth and Æther." Dealing first with sea waves, Dr. Fleming reminds us that the nature of the movement of a travelling wave as it appears to the unpractised eye is not its real one; floating matter on the surface of sea waves does not actually advance continuously forward, but really describes a wide or closed curve with its plane in the direction in which the waves appear to travel; that is to say, wave motion is in fact a periodic or cyclical motion of some kind wherein the several points of a medium move successfully and not simultaneously.

Wave motion depends upon the power of various kinds of continuous media to store up energy in two forms viz.:—(*a*) the potential form and (*b*) the kinetic form. In the case of the water surface wave, at each point of this surface, the total energy changes its form cyclically and passes by degrees from potential to kinetic and back again.

The number of complete changes per second at any one point is called the *frequency*, and the following rule holds universally for all kinds of wave :—*wave velocity*=*wave frequency*×*wave length*.

In the case of water surface waves (on deep water) the wave velocity varies as the square root of the wave length.

The speed (in miles per hour) of deep sea waves equals the square root of $2\frac{1}{4}$ times the wave length (in feet).

Such waves are called gravitation waves, since the rise and fall of the water is determined by the force causing it to fall towards the centre of the earth.

There is another class of surface water waves which owe their origin to the fact that the surface of the water resists stretching ; they are known as capillary waves or ripples and possess the peculiarity that their velocity is *less* the greater the wave length, being in this respect the opposite of deep sea waves.

Quite another kind of wave motion is capable of propagation in media possessing compressional elasticity: such waves consist of alternate regions of compression and expansion and are termed acoustical waves.

The velocity of acoustic waves in water has been ascertained to be 4,707 ft. per second at ordinary temperatures. Similar acoustic waves can be formed in air and are caused by a to-and-fro motion of air particles in the direction of propagation of the waves, giving rise to alternate regions of condensation and rarefaction. The amplitude of each individual particle is very small—in the case of the least audible sound of a whistle in air not more than one-twentieth part of a millionth of an inch.

The velocity of an acoustic wave is air is 1,090 ft. at 0° C. Only the acoustic type of wave can be produced in a gas, but in solid bodies, such as the earth, owing to the different kinds of elasticity present therein, other types of waves are also possible ; they are known as the compressional and the distortional waves—the earthquakes waves being an example thereof.

In the case of seismic disturbances, some waves, probably the compressional, travel with a velocity of about 10 kilometres per second ; whilst other waves, probably the distortional, travel with a less velocity of 5 kilometres or so per second.

The general law which determines the velocity of a wave is that the velocity is directly proportional to the square root of the elasticity and inversely as the square root of the density.

Reckoning in pounds and feet, and using absolute units of force, Young's Modulus of Elasticity for steel is represented by 134,000 million and since the absolute density of steel is 550 lb. per cubic foot, by the above rule, the velocity of sound in steel is 15,500 ft. per second, *i.e.* approximately 3 miles per sec. Therefore if a steel wire could be stretched from the earth to the moon (240,000 miles distant), a wave impulse started on the wire at the earth at a given moment would not reach the moon till 22 hours later. In the case of such a wire stretched between the earth and the sun a wave impulse started thereon at the earth would take nearly a twelvemonth to reach the sun.

There are as a matter of fact as many types of waves as there are kinds of elasticity. The velocities of the different types of waves along the same materials naturally differ.

For further information on wave velocity the reader is referred to Dr. Fleming's article in the *Proceedings of the Physical Society of London* (Vol. 29, Part III., April 15th, 1917).

The subject of waves in the imponderable and impalpable medium called the æther is next considered. The arguments which lend support to the view that such an ultramaterial substance exists are briefly stated. We are compelled to postulate such a special medium in order to account for phenomena perceptible to our senses, but, from the material point, all we know about the æther amounts to this:—it is not gravitative matter, but something of a superior nature. Investigations made so far have provided no evidence that this universal æther is capable of motion in its parts relative to each other, nor can it be said that it possesses mass in the sense that motion of any part represents kinetic energy associated with the moving portion.

Clerk Maxwell's remarkable contribution to our mathematical knowledge on the subject is touched upon and the experimental confirmations by Lebedew, Nichols, Hull and Poynting of the existence of Maxwell's light-pressure and the correctness of the value thereof predicted by his theory are referred to.

Hertz's work in connection with the creation of Maxwell's electromagnetic waves of long length by means of electric oscillations in open circuits naturally comes in for mention. Further, the work done by Bose, Righi and others whereby electro-magnetic-waves have been shortened—so that they can be obtained of a length not exceeding 0.6 millimetre—is also noticed.

Finally, Dr. Fleming points out that it is possible by certain methods to isolate from sources of heat and light very long heat waves—the Rest-strahlen or residual rays. The wave length of the longest waves so isolated is about 0.006 centimetre. Thus between the longest heat waves emitted by incandescent bodies and the shortest Hertzian waves emitted by oscillators there is a gap or difference of 0.006 to 0.6 cm.—or 1 to 1,000, *i.e.*, nearly 9 octaves.

In spite of the discoveries to date, it must not be assumed that our theories of light or of æther are impregnable; on the contrary, it is necessary to continue our researches in order to formulate some broader and more complete theory of light, so that all the known optical and electrical facts may be embraced thereby.

The second article is entitled "Heroism" and contains a reference to some recent examples of devotion to duty displayed by ship's telegraphists, the portraits of some of whom are included in the volume. The names of the young heroes and a short account of their exploits are duly recorded. The author of the original article points out that Britain's fighting services and her commercial organizations are going forward hand in hand, "marching towards the same goal, animated by the same spirit, and manned by scions of the same indomitable stock." The people of this country have indeed every reason to be proud of every class of its sea-faring population; no signs of decadence have made their appearance in that quarter.

The third article is entitled "On the Energy Transmission in Wireless Telegraphy" and has been contributed by Mr. B. Van-der-Pol (Jun.), Doct.Sc. (Utrecht). The author of the original article points out that the mathematical difficulties in calculating the electric and magnetic forces in the space round a sending antenna are of a very different order from those to be overcome in designing the closed sending and receiving circuits of a wireless station. When the wave-lengths used are great in comparison with the dimensions of the antenna and the other circuits of the station the element of time is the only independent variable entering into the differential equations determining the currents and potential differences, so that the integral solutions of these equations give the currents and P.D. as dependent upon the time only.

On the other hand, in the case of the determination of the electric and magnetic forces set up in the alternating field round a sending antenna terms will occur in the differential equation depending both upon the time as well as upon the co-ordinates of space, thereby adding considerably to the difficulty of solution of the differential equations.

It is for this reason that, during the past ten years, experiments in wireless telegraphy have gone far beyond the theoretical investigations, which cannot yet interpret in a mathematical way the experimental results obtained. And yet, in wireless telegraphy, theory anticipated the experiments performed a quarter of a century later.

All the theories concerning the transmission of energy as used in wireless telegraphy represent so many solutions of one single differential equation, the so-called wave-equation which must be satisfied both by the electric and by the magnetic forces in the space round the sending-antenna.

The wave-equation is given in the original article and Mr. Van-der-Pol reminds us that the first solution thereof of real value for radiotelegraphy was that given by Hertz in 1888; it still forms the principal foundation of most of the transmission theories. Hertz proceeded on the assumption that he had to deal with a doublet vibrating freely in the ether, so that the waves produced by it travelled undisturbed in all directions in space. He found that the electric force in the equatorial plane—*i.e.*, the plane cutting the axis of the doublet perpendicularly—is everywhere at right angles to it. The decay of this force as it travels outwards takes place in an inverse geometrical ratio; at small distances from the doublet the electric force varies as r^{-3}, at greater distances it varies as r^{-2} and ultimately it varies as r^{-1}. It is this law of the inverse first power for a *vibrating* doublet which, together with the effect of oscillations of accumulating energy in a tuned receiver, made wireless telegraphy over great distances possible with comparative low power.

A graph is given in the original article which clearly shows the very rapid decrease in the received current intensity near the oscillator and the much lower rate of falling off at greater distances.

Since in practice the antenna is usually near the earth's surface a modification of the theory for the electric doublet free in space is necessary for the purpose of explaining the circumstances found in actual wireless transmissions, *i.e.*, when the Hertzian dipol is placed on an infinitely extended plane of an ideally low resistance, this plane representing the earth. The condition to be fulfilled by the electric force in such an infinitely conducting plane is that it shall be normal to that surface everywhere. As a matter of fact, the conducting surface of the earth takes the place of the equator-plane in the case of the idealized Hertzian oscillator and, in consequence, the distribution of the electric force is not altered. In the case, therefore of the doublet (representing the sending antenna) placed at a conducting surface (representing the earth assumed plane) the electric force will follow the law stated above.

The simple doublet theory is naturally not applicable to every form of antenna so far as the space very near thereto is concerned, but, at distances exceeding a couple of wave lengths, the theoretical energy distribution found round a vibrating doublet represents sufficiently nearly the electric conditions set up by a wireless telegraph antenna.

The author of the original article refers to the theory, developed by Zenneck, based on the assumption that the earth has a finite conductivity, together with a dielectric constant differing from unity; a theory which is full explained by Dr. Fleming in his work *Principles of Electric Wave Telegraphy*, wherein he shows how great numerically is the influence of the wave-length and the electric nature of the earth's surface for certain transmissions.

In 1909, Sommerfeld propounded a theory which was a combination of the theory of Hertz and that of Zenneck; therein the divergence of the waves from a station in all directions, *together with* the finite conductivity of the earth were both taken into account.

In Sommerfeld's theory the sending aerial is mathematically represented by a dipol oscillator as in the Hertzian theory, but it is assumed to be placed at the boundary surface between the air and the earth's surface. The amplitude of the waves found in this way is given by a definite integral involving a cylinder function of zero order. An artifice, consisting in a certain numerical quantity called the "numerical distance," has to be introduced to render the solution of the function possible.

The author of the original article has computed the approximate values of the "numerical distance," as a function of the distance, for different wave-lengths and conditions of the earth's surface; the results of some of his calculations are included in the text of the original article.

In the case where the "numerical distance" is a large quantity the total electromagnetic field—which is somewhat complicated—can be represented mathematically as being composed of two constituents, (*a*) a space wave and (*b*) a surface wave.

In the case where the "numerical distance" is a small quantity, the Hertzian theory of ordinary space waves may be applied with a fair degree of approximation; it is found that, under these circumstances, the value of the wave amplitude will be very near the value calculated on the assumption of a perfectly conducting earth.

The author of the original article points out that the mathematical abstraction called a surface wave will, in general, dominate the accompanying space wave at distances from the sending station whereat the electrical constants of the earth and the wave length used together determine a "numerical distance" of quite moderate value. A table is given in the original article showing the limits within which the real distance must lie—corresponding to the different wave-lengths and materials—in order that the surface wave contribution to the total electro magnetic disturbance may be regarded as of importance in comparison with the space wave.

It is further stated that " the way in which the sending antenna is earthed can have no direct influence on the production of surface waves. Their development cannot be assisted by the use of a direct earth or a balancing capacity, but is wholly determined by the 'numerical distance.' "

A later mathematical investigation by Sommerfeld indicates that, given a suitable combination of a comparatively high dielectric constant and a fairly low conductivity, even a larger amplitude than would be obtained in the case of an infinitely good conducting earth surface should be secured for certain wave-lengths at short distances ; *e.g.*, for waves of 2,000 metres length travelling over fresh water a greater amplitude can be expected at distances up to 100 km. than a perfectly conducting earth would allow.

The author of the original states that so far as he is aware this very unexpected result has never been explained in a physical way. He suggests that the favourable effect of a material like fresh water with a high dielectric constant but of low conductivity may be due not to a better *transmission* of the waves than in the case of a perfectly conducting earth, but to a better *emission* of electro-magnetic energy.

Mention is made of the fact that the problem of the bending of electric waves round the curved surface of the earth has been attacked by several mathematicians, among whom are numbered Macdonald, Poincaré, Nicholson, March, von Rybczinski and Love.

A brief description of the problem and the methods of attack thereon are given in the original article, which should certainly be consulted by all who are interested in the theory of wireless telegraphy.

Graphs are published with the text of the original article ; these graphs show the results obtained by various workers ; that these results do not agree is not to be wondered at when the complicated nature of the problem dealt with is considered.

In the theories considered by the eminent mathematicians in question the earth has been treated as a sphere consisting of an infinitely good conducting material. But a closer approximation to the circumstances as found in actual practice of wireless telegraphy has been obtained by solving the same problem for a sphere of finite conductivity.

The author of the original article refers to the experiments made by him with a view to the determination of the conductivity of sea-water in relation to high-frequency alternating currents. He has arrived at the conclusion that down to wave-lengths of 600 metres the conductivity of sea-water does not vary with the frequency.

Attention is called to the fact that the measurements of received antenna currents at different wave-lengths and distances by Austin, Hogan and others show discrepancies in relation to the values which should, on the basis of the theories discussed in the original article, be obtained ; it is for this reason that a consideration of the reflective and refractive action of the ionised higher layers of the atmosphere has been introduced into their investigations by some workers in this field.

In conclusion, Mr. Van-der-Pol points out that, in order to eliminate the still apparent discrepancy between the electro-magnetic theory of the bending of the waves round the earth's surface, based on the Maxwellian equations, and the actually measured values of received currents, first, an agreement on the theory of the subject has to be reached so that further investigations may all proceed on the same foundation, and, secondly, very careful measurements, on a more extensive scale than carried out hitherto, are necessary.

The fourth article is entitled "Wireless Telegraphy in the U.S.A." and has been contributed by Mr. David Sarnoff, Secretary, Institute of Radio Engineers, who points out that "while a declaration of war naturally affects, in a material way, the industries of a nation, yet it is questionable whether any enterprise in the United States has undergone so complete a change as wireless in so brief a period with less friction, lost motion, waste, uneconomical production, and many other evils which attend a hasty transformation."

The satisfactory results that have been obtained have been due, it is recognized, in a large measure to the wisdom, fairness, and efficiency of those who administer the affairs of the United States Government. The capabilities of the officers directly charged with responsibilities connected with the provision of wireless equipment and for the maintenance of wireless communication is distinctly high and the manner in which they are carrying out their duties has produced a feeling of confidence in the minds of those who have dealings with them.

The pressing needs of the hour, it is pointed out, were: "To provide facilities for the manufacture of the radio equipment for the large number of vessels built and commandeered by the Unites States Shipping Board and the United States Navy Department; a constant supply of licensed wireless operators for service on the rapidly increasing merchant marine; trained men to instal the radio apparatus on the vessels, and engineers capable of coping with the many problems of wireless communication and production."

The response of the wireless companies and their *personnel* has been "in tune" with the requirements and everything has been done to meet and satisfy the needs of the Army, the Navy and the Shipping Board programmes.

"The effect of the war, on the wireless art in the United States has," Mr. Sarnoff states, "been a rapid development and expansion of a comparatively limited industry to one of considerable magnitude."

The fifth article is entitled "The Magnetic Behaviour of Iron in Alternating Fields of Radio Frequency" and is from the pen of Dr. N. W. McLachlan. In an introductory paragraph, we are reminded that it has long been known that iron is influenced by the oscillatory discharge of a condenser; the discovery of this fact was made in 1842 by Professor Joseph Henry. Much experimental work has been carried out, in recent years, on the magnetic behaviour of iron and other magnetic substances, *e.g.*, nickel. It is now fully recognized that iron responds to high-frequency magnetization produced by damped or undamped oscillations; experiments also prove that it undergoes cyclic changes and retains its magnetic properties even at frequencies of several millions per second.

The subject is dealt with in the article under review under the following heads:—The propagation of magnetization in iron; the behaviour of iron under alternating magnetization; hysteresis and eddy current losses; variation in permeability with temperature; the use of iron in high-frequency apparatus; and the efficiency of using iron at H.F. compared with that at L.F.

The original article contains a great deal of important and interesting information on the subject, the value of which can only be appreciated when studied with the tabulated data and graphs which accompany the original text. It concludes with a very useful bibliography of the works dealing with the subject.

The section of the volume dealing with "International Time and Weather Signals" contains a few introductory remarks, wherein it is pointed out that the war has brought added dangers, *e.g.*, minefields, to those with which the navigator has had to contend under normal circumstances; this makes it incumbent upon him to navigate his ship nowadays with more than usual exactitude. Since the accuracy with which a ship's position can be fixed depends on the correctness of the ship's chronometers, wireless time-signals have acquired a much enhanced value for navigation purposes.

The utilization of wireless telegraphy for the dissemination of weather signals, as adjuncts to scientific farming, is touched upon as one of the possibilities of the immediate future.

The information given in relation to time signalling and meteorological services in the volume under review contains a great deal of matter that is published for the first time in the *Year-Book*; it is a collation of the operations carried out at various wireless stations in different parts of the world.

Under the title "Notes on Valve Patents published in 1917," Mr. I. Shoenberg contributes a considerable volume of valuable information on this important device, the very peculiar and significant feature whereof consists in the manifold applications to which it lends itself so admirably; the variety of these applications comes out very clearly in the specifications analysed by Mr. Shoenberg.

In an article entitled "Wireless Possibilities," Mr. A. R. Burrows deals with speculations upon the future of radiotelegraphy and allied developments and the forthcoming demand in Anglo-Saxon countries for specialists in this rapidly widening field of activity.

Many mysterious happenings have occurred during the period of the great world contest; warships consisting of the finest products of modern engineering have gone sky-high when lying peacefully at anchor; airships have, without any apparent reason, fallen suddenly to earth a heap of ruins. The word "wireless," Mr. Burrows tells us, has been whispered abroad as the mysterious agent of destruction in such cases. Discussion of the subject is under restrictions, so that it would be unprofitable further to pursue the matter here, apart from stating that the credence attached to such suggestions indicates very clearly a certain inherent faith in the possibilities surrounding etheric phenomena.

It is stated in the original article that "one of the most interesting possessions of Marconi's Wireless Telegraph Company is a collection of Press cuttings dating from the time of Mr. Marconi's arrival in England. In view of the present position of radiotelegraphy, many of these cuttings read like extracts from comic journals, and not the serious expressions of weighty organs of public opinion. Nothing could demonstrate more clearly the ease with which dispassionate thought can be disturbed and how powerful are the human frailties which serve to retard evolution."

The obstruction and difficulties with which Mr. Marconi had to contend as soon as he arrived in England are briefly touched upon by Mr. Burrows. Mr. Marconi, however, decided to peg on and eventually reaped the reward of his perseverance. Under the heading "Seventeen Years Ago" a reference is made to the epoch-making events of December 12th and 13th, 1901, connected with the reception at St. Johns, Newfoundland, of the signals sent out from Poldhu. It is now a case of "Looking Ahead"; those who are in a position to express a sound opinion on the subject predict that a vast extension of the application of "wireless" to ordinary commercial purposes must certainly take place in the immediate future. A sign of the times, it is pointed out, is provided in the announcement that a French transocean cable company has definitely decided to erect a wireless station for the conduct of uninterrupted communication between France and the United States. Germany makes no secret of the fact that she expects her high-power station at Nauen to be her sole direct means of communication with the outer world for some period after the War.

Many of the possibilities of long-distance wireless telegraphy are touched upon by Mr. Burrows, among which he includes the peace-time dissemination by wireless of international information.

In a section entitled "The Wireless Telephone," it is pointed out that although the War has to some extent hindered the development of this branch of the wireless art, yet the fact remains that wireless telephony over distances even transoceanic in extent has already been accomplished. Speech so transmitted very nearly approaches the technical quality of direct conversation.

One of the logical but unwelcome developments of wireless telephony may, it is suggested, turn out to be "audible advertisements"; at the present time a field for such a use of this means of communication exists in connection with the financing of the War and it is hinted that wirelessly operated megaphones might even to-day be established at the traffic centres with profit to the State.

Under the title "'Twixt Earth and Heaven," it is pointed out that "in the intensive commercial life which will be thrust upon us to make good the ravages of the present conflict there will certainly arise a need for such speedy long-distance transit as the aeroplane alone can afford. . . . One of the essentials for long-distance aerial traffic will be a complete wireless system enabling the aeroplane to keep in touch with mundane affairs throughout the journey, and to signal in turn to stations below as the journey progresses."

The wireless equipment, under such circumstances, would further render aerial navigation relatively independent of weather conditions affecting visibility over land or water.

The suggestion is thrown out that lighthouses may at some future time be controlled from shore by impulses radiated at sundown and sunrise and at such times as storms break over the neighbourhood. Were this done, there would no longer be any necessity for many groups of watchers being kept in close confinement in isolated homes; in their place there would be needed only an inspecting staff to refil gas containers and make any necessary adjustments from time to time.

Under the title "In the Backwoods" Mr. Burrows deals with the possibilities of utilizing wireless direction-finders for triangulation purposes and points out that by wireless means vast areas of territory can be surveyed at a speed impossible by any other method at present known.

The uses of wireless telegraphy in connection with Polar exploration, for the purpose of notifying storm damage in remote regions, and for assisting police to keep in touch with their headquarters when patrolling by motor-car on land or by boat on water, are touched upon briefly in the original article. The announcement made by the Admiralty last autumn in relation to an attack upon British ships by an electrically-controlled boat also comes in for mention and the imagination of man is stirred by a reference to the fascinating problems connected with the wireless control of torpedoes and similar devices which still await solution on a practical scale.

Mr. Burrows concludes his article by pointing out that "A Wide Field for Young Anglo-Saxons" to busy themselves in exists in connection with "wireless" research and "wireless" engineering.

In an article entitled "S.O.S." Mr. H. J. B. Ward gives an outline sketch of wireless achievements in life-saving at sea. A reference is made to the Orders in Council issued under the Defence of the Realm Act, wherein provision is made that British ships of 1,600 tons and over shall in future be equipped with wireless telegraphy and it is pointed out that in many other countries legislation on similar lines has been instituted in relation to their mercantile fleets.

A schedule of "Timely Rescues" accompanies the article; this schedule is, in the present state of affairs, necessarily incomplete, but the details given provide the reader with almost inexhaustible material for the exercise of what may appropriately be termed the pictorial side of mentality.

An extract is given by Mr. Ward from an account printed in a current magazine, wherefrom we learn of the admirable manner in which wireless has been utilized for "shepherding" a vessel from the start of its voyage to the finish.

The immense German projects for mercantile expansion the moment that the British Fleet "ceases from troubling" and in which radio-telegraphy is to play a conspicuous part are touched upon in the original article.

It is pointed out that many exploits of wireless remain unrecorded in the schedule referred to earlier. The *lacunæ* must be laid mainly at the door of the exigencies of the times; the censorship is, and naturally must be, rigidly exercised in relation to all information of a military character.

Especially does this hold true in the case of transports; some day we may learn something of what wireless has to its credit in this connection.

An introduction to the schedule of British Applications for Patents is provided under the heading "Particulars of Wireless Telegraph Patents in 1917," wherein we learn that the character of the times we live in is depicted by the steady concentration shown by inventors upon the methods of and means for waging a successful war. The total number of applications for patents filed in 1917 exceed by about one thousand those filed in 1916; those having reference, both direct and indirect, to "wireless" total but 160 in 1917 as compared with 190 in 1916. The present year has witnessed steady concentration upon receiving apparatus of the Fleming valve type.

The concluding portion of the volume contains a "Useful Data Section" *i.e.*, Definitions of terms used in Wireless; a dictionary of technical terms in English, French, Italian, Spanish and German; useful formulæ and equations; international units and symbols; relation between sparking distances and impressed voltage; a specific electrical resistance table; specific inductive capacities; wire tables; Gilbert's Table (ordinary catenary); table showing maximum current permissible with various classes of wire; data for B.H. curves; weights and measures; length of a degree in latitude and longitude; specification of the Beaufort Scale; measures of time; standard or zone time; foreign and colonial money; particulars of the leading companies engaged in the commercial development of wireless telegraphy; biographical notices of those prominently associated with wireless telegraphy; a comprehensive bibliography of works on wireless telegraphy and telephony; a directory of Wireless Societies; Code Signals; and finally, Lloyd's list of signal stations.

The utility of the volume under review to every one interested, however remotely, in wireless telegraphy and telephony is unquestionable; the foregoing enumeration of its contents indicates the very wide range of matters connected with the subject that are contained within the covers of the *Year-Book*.

W. A. J. O'Meara.