THE USE OF COTTON FOR THE PRODUCTION OF EXPLOSIVES.

THE history of the laboratory production of various forms of nitro-cellulose has been well stated by many chemists, and everything essential can be found either in their own researches or in the ordinary text-books. The practical outcome of such work has been the establishment of modes of manufacture for many purposes, but in the present instance it is proposed to deal entirely with the use of cellulose in one shape or another for explosives of any practicable kind. It is almost unnecessary to state here that every kind of propulsive explosive now used has cellulose as its basis, but it may not be superfluous to say that all military propulsive explosives have cotton for their basis as distinct from cellulose.

The word cellulose must not be understood in the strict chemical sense, but rather as including all those materials which are chiefly cellulose, and this definition will include materials like wood-pulp. Now one may clear the ground on this subject at once by saying that, for military purposes, wood-pulp and other impure forms of cellulose are useless. Very good sporting powder can be made from nitrated wood-pulp, but the artillerist would be in great difficulty if he were provided with such a propellant, because in order to obtain any sort of regularity the nitration of the wood-pulp has to be kept at a low point, and the ballistics on which the artillerist depends would be quite thrown out. The modern gun is really a machine of precision; the artillerist knows that and expects it to throw one shot after another to reach the same point within a fraction of its possible range as computed from its elevation of sighting, and his whole attention has been based on this. If he were supplied with a material, however good, which on explosion developed a lower pressure, he would be relatively helpless and his rivals, using their own standard material, would have him at a sore disadvantage.

In modern practice, the raw material used is cotton waste, which is, as its name implies, merely the rejected stuff in the manufacture of cotton goods; and although linters, which is the technical term for the short fibre material adhering to the cotton seed, may be used, yet its employment presents serious difficulties in that the seed with which it is associated has to be removed by chemical treatment. There have been many experiments made to use such substances as jute, ramie, kapok fibre, and in short everything from sulphite pulp to spun cotton, but as workable substances these have been rejected in favour of the staple material—cotton waste.

The method of producing a satisfactory form of nitro-cellulose from cotton waste is as follows:—The waste is hand-picked so as to remove the grosser impurities. The product is teased, picked once more, and then dried. After that, the nitration process is carried out, and this has been much modified in the light of experience, but in essence still consists in the immersion of the purified waste in a mixture of nitric and sulphuric acids of the following composition: H_2SO_4, 71 per cent.; HNO_3, 21 per cent.; H_2O, 8 per cent. The amount of water in this mixture is important, and the acids as they are written are as their formulæ represent and do not refer to the commercial products. The strict relationship of the water to the two active materials should be preserved. It is of course easy now to obtain sulphuric anhydride (SO_3) and make an anhydrous mixture, but this gives a nitro-cellulose with too high a nitrogen content. After the mixed acids have acted for the required time, they are removed and the gun-cotton is washed to remove as much of the acid as possible, and purified by several boilings with water. The boiling with water is of great importance, as in this part of the process the unstable bodies produced during nitration are dissolved or decomposed, leaving the nitro-cellulose in a stable condition. The only thing now remaining is to pulp the cotton, which is again washed and then partly dried and moulded into the required shape by pressure.

The old idea that something as nearly as possible to the so-called hexa-nitrate of cellulose should be aimed at has been fairly well exploded, and the manufacturer seeks to regularise his output so that he may obtain a nitro-cellulose with approximately 11 molecules of NO_3 to the quadruple molecule, as shown in the formula $C_{24}H_{29}O_9(NO_3)_{11}$. This formula must not, however, be taken as any more than a convenient way of expressing the degree of nitration, which is really better stated in terms of content of nitrogen which ranges between 12·93 and 13·05. This is merely a parenthesis, but is necessary as showing how delicate and complicated a matter it is to obtain a uniform and trustworthy material for propulsive explosives, and as it has been found in practice that even what is apparently such a simple matter as the preparation of a mixture of acids of known composition is really one requiring some care and skill. It will be readily understood that the difficulty is trifling compared with that of providing an equally regular form of cellulose. So well is this recognised that different consignments of cotton waste, all of approved quality, all picked, teased and re-picked, are mixed so that the cellulosic raw material may be as nearly the same grade as possible.

With this fact in front of us, let us consider what the condition of a factory would be which had to use any kind of raw material, clean or dirty, lignified or not, and had to try to make that into a trustworthy propulsive explosive of standard quality. This question has only to be asked for the answer to provide itself. In the present case a great deal too much has been assumed as to the capability of our enemies for making trustworthy nitro-cellulose without cotton waste. Because any competent chemist in his laboratory could make some form of nitro-cellulose from his own shirt cuffs if he pleases, people have jumped to the conclusion that that will be of some use to the artillerist. The fact that the manufacturing process of an explosive like this is of the most delicate kind and has to be conducted with military precision, has been constantly overlooked; and at the present moment it is not too much to say that there is only one material available for modern gunnery, and that is cotton.

PROBLEMS OF AIRSHIP DESIGN AND CONSTPUCTION.

THE problem of the airship falls naturally into three parts, concerned with flotation, propulsion and steering respectively. The best results in any of these three branches are to a great extent antagonistic to similar success in one or both of the other two. For instance, flotation, which is purely a displacement problem at bottom, demands that the displacement body should have the greatest volume for the least superficies, *i.e.*, that it should be spherical. Propulsion, on the other hand, demands that the body be of the shape having least head-resistance, *i.e.*, of long fish-shape. Steering, with which is linked dynamic stability, demands that large fins and control surfaces be affixed to the body, which otherwise would set itself broadside on to the relative current caused by its forward movement. These auxiliary surfaces add to the weight, that is, oppose flotation and add to the head-resistance, thus opposing propulsion. Again, the displacement body must of necessity consist mainly of a gas lighter than air. All the light gases are highly inflammable (or if not have some other disadvantage), and consequently are dangerous in proximity to an internal-combustion motor, such as is universally used for propulsion, as being the only motor with a good ratio of power to weight. Therefore the motor must not be placed too close to the gas-container, and in consequence it is difficult to enclose all the parts of the airship in a single "streamline" body of least resistance, and the head-resistance and weight are thus both increased considerably, opposing propulsion and flotation.

The above list of incompatibilities might be extended considerably, as every airship designer knows to his cost. It is not to be wondered at, therefore, that airship design is in so fluid and embryo a condition that the future of the airship is looked upon as extremely dubious in many cuarters. The fact, however, that so much progress has been made in face of stupendous difficulties is a happy augury for the future of the airship, especially as many of the difficulties met with are due mainly to the fact that airships are at present small, and they will disappear as soon as experience and growing confidence enable large and larger vessels to be built.

To deal with the displacement body, or lifting unit, first. The lift obtainable is, of course, directly proportional to the weight of air displaced and inversely proportional to the weight of the displacement body in itself. Roughly, thirteen cubic feet of air at sea-level and normal temperature weigh one pound, so that a lifting unit displacing that volume would lift one pound minus its own weight. Consequently, if the lifting unit consisted of "nothing shut up in a box" as the schoolboy's definition of a vacuum runs, only the weight of the box would have to be deducted from the gross lift obtainable. As no light vacuum-container could maintain its shape against atmospheric pressure, however, a gas must be used to keep the displacement body distended by its expansive properties. The gas universally used for airships is hydrogen. This weighs about one-fifteenth of unit volume of air, so that only 1/15 gross lift is lost by its use. The possibilities of getting wonderfully enhanced lift by new gases, lighter than hydrogen, are thus seen to be illusory.

Coal gas was long used (and still is) for ordinary spherical balloons, as being cheaper and more available than hydrogen, but being about ten times as heavy as hydrogen, is comparatively useless for airships. Ammonia vapour has been suggested for airships, as being non-inflammable, but is about eight times as heavy as hydrogen and of a destructive character to metal, etc. The provision of a stable non-inflammable light gaseous mixture would solve so many practical difficulties in the construction of airships that many thousands of pounds could profitably be expended in research on this problem. Failing this provision, all precautions must be taken to prevent fire, or to minimise its effects on board airships.

Hydrogen being non-explosive apart from oxygen, can be isolated in containers jacketed with an inert gas and thus rendered harmless. The division of the displacement body of an airship into compartments is desirable from this and other points of view. For example, a large volume of gas in a thin fabric container is prone to surge about and strain the container when in motion. Compartments prevent this and also localise leakage due to rupture of any part of the container.

The type of airship in which this principle is carried farthest is the rigid type (Zeppelin) in which the displacement body consists of seventeen or eighteen separate gas-containers, set in a rigid cylindrical framework, like peas in a pod. The chief advantages of the rigid framework are (i) that the actual gas-containers are relieved of strain and are (ii) protected from the influence of weather. The disadvantages are (i) the loss of gross lift due to the weight of the framework, and (ii) the fact that the airship cannot be folded up for transport or storage, and must consequently be housed in a large and expensive shed.

The gross lift of a large Zeppelin is about twenty-five tons, of which about twenty tons are absorbed by the framework, engines, etc. This gives a net lift of only about one-fifth of the gross lift, a figure that could be much improved upon by making the vessel larger. This net lift has to account for crew, etc., so that not more