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 quarters. 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 than two tons of explosives could be carried, and this only at a low altitude. Naturally, other things being equal, the weight of the framework, etc., of a small airship is a larger proportion of the gross lift than the corresponding weight of a large airship.

In that type of airship in which the walls of the gas-container are themselves the "framework" of the displacement body (the "non-rigid" type), much weight is saved, but disadvantages come in that strains on the fabric affect its gas-tightness, which is also much affected by action of sun and other influences.

Again, the attachment of the car (containing the engines, etc.) by wire ropes to the container is worked out on the assumption that the gas-container will retain its shape. This end is attained in single gas-containers by having a bag of air (the "ballonet") inside the container, into which is pumped air under pressure, to maintain the full volume and shape of the envelope. If, however, compartments are to be used in the container, some means of equalising their pressures even if one be ruptured must be devised, otherwise the shape will be distorted. This is no easy task.

The non-rigid type has the great advantage of being quickly deflatable for transport packed up. Examples of this type are the Parseval and Astra-Torres, in which latter ship an ingenious system of suspension greatly strengthens the gas-container.

The "semi-rigid" type has some of the advantages and the disadvantages of both the other types. Examples are the Forlanini (Italian) and Astra XIII. (Russian).

The material of which gas-containers are usually constructed is made of layers of cotton fabric cemented to layers of rubber. In order to intercept the blue (actinic) rays of light that "rot" the rubber very quickly and make it porous to the gas, the fabric is coloured yellow. Goldbeater's skin makes a very gas-tight container, but untreated is affected by rain, which is absorbed, and by its weight decreases the net lift. This disadvantage applies to untreated fabrics, which are therefore usually varnished with an aluminium varnish, thus preventing water absorption and promoting gas-tightness. Fabric impregnated with gelatine, rendered flexible by added glycerine, and insoluble by formaldehyde, has given promising results. Oiled silk is very gas-tight but seams are troublesome. Very much research is still required into the question of fabrics.

Propulsion demands a power plant and means for obtaining a reaction from the air. The ratio of power installed to weight lifted has been steadily rising both in airships and aeroplanes. The first Zeppelin airship (1900) weighed 10,200 kilograms and the motors were two, totalling 32 horse-power. Zeppelin III. (1906) lifted 12,575 kg., and the motors (2) totalled 130 effective h.p. The "L1" (marine) of 1913 lifted about 28,000 kg., and the motors totalled 720 h.p. As an indication of the performances that may be expected from airships in years to come, we may note the proportion of power to weight lifted in the last vessel as one horse-power to every 80 lb. lifted. The speed attained is fifty miles an hour. In the case of an aeroplane doing ninety miles an hour or so, the weight lifted is only about 15 lb. per horse-power.

Screw propellers are universally used for airships, and are often of wood. They are usually placed at the sides of the gas-container in rigid vessels and below it in non-rigid vessels. Much research is needed as to the best position for propellers relatively to the body to which they are attached.

A strong reason for increasing the power of airships is that by so doing a large amount of lift can be obtained by the dynamic action of the large control surfaces, which, by directing the airship's nose up, are able to give it a very fast rate of rise, much quicker than that of aeroplanes.

The maximum height attained by airships is somewhat more than 10,000 feet (Zeppelin and Italian). Aeroplanes have ascended twice as high and ordinary balloons three times as high. To attain 10,000 feet high an airship must sacrifice much ballast and gas, so that it cannot voyage for its longest period at a great height. Zeppelins are claimed to be capable of holding the air for three days, but not at full speed or height. There is no advantage in going very high (except for military reasons), and under 3000 feet would be a usual zone in which to operate were it not for anti-aircraft measures. Some day, when the airship is better developed, it may pay to go to great heights in order to obtain the advantage of lessened resistance to advancement due to the tenuity of the air.

As regards steering and stability, it may be said at once that most airships steer clumsily and require large spaces in which to manœuvre. Our little non-rigid vessels have been specially developed for handiness in our much wooded country, but Zeppelins are craft for vast open spaces. The dynamic stability of an airship is a complicated matter to work out. Besides ordinary pitching and rolling there are added effects due to surging of the gas and distortion of the gas-container. Propellers also complicate the stability question. Large control surfaces are essential, sticking well out from the body, to avoid its "wash."

A REGIONAL SURVEY.[1]

A MODERN element in the fascination that islands undoubtedly exert is their biological interest. What are the island's inhabitants of high and low degree? How came they there and whence? How has the isolation affected them?

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[1] "A Biological Survey of Clare Island in the County of Mayo, Ireland, and of the Adjoining District." Section I. (comprising Parts 1 to 16), Introduction, Archæology, Irish Names, Agriculture, Climatology, Geology, Botany. Section II. (comprising Parts 17 to 47). Zoology (Vertebrata, Mollusca, Arthropoda, Polychæta). Section III. (comprising Parts 48 to 68), Zoology (Oligochæta to Protozoa), Marine Ecology, Summary. (Dublin: Hodges, Figgis, and Co., Ltd.; London: Williams and Norgate, 1911–15.)