THE USE OF HELIUM IN DIRIGIBLES

In view of the recent regrettable loss of the French (ex-German) airship *Dixmude*, which, as far as can be ascertained, was destroyed by fire, we publish below (through the courtesy of our American contemporary *International Aeronautics*) an article on "The Use of Helium in Dirigibles," by Col. G. Arthur Crocco.

One of the biggest problems of the airship is that of fire, therefore the following notes on helium, which, owing to its non-inflammable properties, is probably a solution to this vital question of fire, should be of special interest just now.

About 30,000 cubic metres per day of helium have been extracted in the United States with a total expenditure of $70,000 for the installations needed for this purpose. Of this total amount about 10,000 cubic metres were easily obtained, the other twenty thousand were more laboriously extracted. Taking twenty years as the average life of a helium producing pit, spreading over this period of time the cost of installation and adding to it the production expenses, we obtain a minimum cost of $2 per cubic metre of compressed helium, while the probable annual production is three million cubic metres.

Aside from the use of helium in military dirigibles, when the matter of cost would be relatively unimportant, let us consider whether it would be feasible to use this gas in commercial dirigibles, in spite of the fact that its cost is about 15 times the cost of hydrogen. Let us calculate the annual gas consumption of a dirigible and the total tonnage of airships that can be supplied with the limited American production of helium.

The consumption of gas of an airship is due to: (*a*) diffusion; (*b*) washing of gas needed in order to maintain the necessary percentage of purity; (*c*) navigation losses. Of the three, the last one is the most important at the present time.

Navigation Losses.—Theoretically, an airship must lose during a trip about one cubic metre of gas for every kilogram of fuel burned. Practically, a number of other factors modify this rather simple rule, such as: losses when leaving the ground, differences of temperatures between air and gas, eventual external loads on the envelope, dynamic sustentation, losses when landing, etc. A good pilot who knows how to take advantage of changing meteorologic conditions can make a trip without wasting any large amount of gas; this, however, cannot be depended upon in commercial operation of airships, which must follow a given route at a given altitude, and must leave the ground and land according to schedule.

If we figure the navigation losses on the basis of one cubic metre of gas per every kilogram of fuel burned, in the case of long trips and intensive operation (about 4,000 hours per year), we find that an airship of about 100,000 cubic metres capacity, equipped with 3,600 h.p. power-plants, operating at half-power, and burning 500 kg. of fuel per hour, in one year it will have used up 2,000,000 cubic metres of gas, or twenty times the volume of the airship. On this basis, the total annual production of American helium would be absorbed by the operation of one single airship, and the cost of operation would be entirely too high for commercial purposes.

Under these conditions, even hydrogen would be too expensive to use and furthermore a practical autonomy of dirigibles could never be obtained until a method of compensating the losses of weight due to the fuel burned during the navigation had been devised. In principle this problem has been solved, and the navigation losses of gas can be considered as being entirely avoidable.

Diffusion Losses.—Not much data is available yet on the losses of helium due to diffusion through the various materials out of which gas bags of dirigibles are made. Experiments have proved so far that for the same materials used, the diffusion losses of hydrogen are double those of helium. Experiments made at the Aeronautical Institute of Rome (Rend. I.A., Zallo, February 1, 1921) with Italian rubberised materials used for gas bags with a weight of p of rubber (between 80 and 160 grams per square metre), at ordinary temperatures, gave a loss of helium in litres per day, which can be very closely expressed by the formula $520/p$. The same losses with hydrogen were expressed with the formula $1000/p$.

Experiments made by the National Advisory Committee for Aeronautics in 1915 (see report No. 6) failed to verify the law of proportionality existing between the losses of gas and p that the Italian experiments seem to indicate, but they proved nevertheless that these losses can be greatly reduced, even at high temperatures, if specially treated materials are used.

It does not seem to be very far from the present-day reality to figure on a diffusion loss of three litres of helium per every twenty-four hours in a dirigible of the cubic content given above. The surface of the gas bag of a 100,000 cubic metres dirigible is about 18,000 square metres and the annual diffusion losses of a dirigible of this size would be 19,440 cubic metres, or just about 20 per cent. of the total volume of gas. In the case of larger dirigibles this percentage is still smaller, due to the smaller ratio existing between surface and volume of the gas bag and, also, due to the larger value of p in the formula given above. (See Bulletin No. 10, 1922, I.A., Rome.)

Washing Losses.—At the present time the amount of gas that must be supplied for offsetting the navigation losses is sufficiently large for insuring the desired degree of purity of the gas. When, however, these losses will be entirely eliminated, a daily washing of the gas bag will be absolutely necessary. For every cubic metre of helium which escapes through the envelope about 400 litres of air will pass through the envelope into the gas bag and must be separated from the helium in order to maintain the desired degree of purity of this gas. If we call a the degree of purity which must be maintained in the gas and v the percentage loss of gas due to diffusion in a unit of time, in order to separate from the gas the quantity of air: $0 \cdot 4v$ which has penetrated into the gas bag in the same unit of time, we must substitute to a percentage volume of impure helium expressed by: $\frac{0 \cdot 4v}{1 - a}$, an equal volume of pure helium in the same unit of time.

For instance, if we want to maintain a degree of purity of the helium $a = \cdot 96$ and the diffusion losses are $v = \cdot 20$ per year, the volume of pure helium that in one year must replace an equal volume of impure helium is twice the volume of the gas bag.

Fortunately this last cause of loss of helium can be entirely eliminated through process of purification of the gas mixture extracted from the gas bag, from which the remaining pure helium can be recuperated.

In conclusion, of the three causes of losses that we have here investigated: *Navigation Losses, Diffusion Losses and Losses Due to the Necessary Washing* of the gas, which are in the ratio of 100, 10 and 1 respectively, only diffusion losses, amounting to 20 per cent. per year of the total volume of the gas, is irreparably lost.

Such being the case, we find that the present supply of American helium is sufficiently large to take care of a fleet of 150 airships of 100,000 cubic metres each, and the cost of helium needed for repairing the diffusion losses is only one-fifth of the original cost of the helium needed for filling up the gas bag. Under these conditions the helium of a dirigible can be considered as a part of the equipment which is depreciated after five years of operation, and, therefore, the commercial operation of helium-filled dirigibles in the future becomes a practical possibility.

Two Calendars for 1924

We wish to acknowledge the receipt of two artistic calendars for 1924 from two of our pioneer aviation houses. One of these, from the Blackburne Aircraft Company, of Olympia, Leeds, consists—in addition, of course, to the "tear-off months of the year"—of a two-colour picture depicting a Blackburne torpedo 'plane flying over the sea at sunset (or sunrise?), and in the act of dropping its deadly messenger. Our second calendar is from our old friends Short Bros., of Rochester and Belford, and bears a really delightful reproduction in colours of a water-colour drawing by Donald Maxwell, showing an old-world street with a new-world "Railless" electric car threading its way through the traffic, whilst the Short "Silver Streak" biplane flies overhead. The manufacture of "Railless" electric cars—that is, a steerable electric "tram" with overhead power wires but without the rails in the roadway—forms an important branch of Short Bros.