

saving machines, does tend to encourage the use of all kinds of improved equipment, including tractors. Less consideration should be given to 10-acre farms and more to 1,000-acre farms; the latter can use tractors to advantage; the former cannot. The problem will solve itself if things are allowed to take their own course, or the solution can be hastened by proper action. At present, farmers receive advice on practically every subject connected with farming except on the use of labor-saving machines. All kinds of experiments and investigations are being carried on in the breeding of live stock and better crops; likewise, experiments in the building up and maintenance of soil fertility are being carried on in great number. Such detailed information can be obtained by any farmer who wishes it, but regarding information as to the best crop rotation and acreage to make use of a tractor efficiently, little is available.

It is unreasonable to expect each individual farmer to be capable of working out an organization and crop rotation for his farm which should make it possible and practicable for

him to use a tractor. He is not much more likely to do this than he is to breed a better variety of wheat by hybridizing. Some individuals will solve their own problems of this kind. The large percentage of tractor owners who enlarge their farms and increase their returns by a better farm organization on an extensive scale are ample proof of this. What is needed is to ascertain just exactly how these successful users have reorganized and to pass this information on to other farmers. Organizations are now teaching farmers how to treat their hogs for cholera, how to fumigate seed and inoculate soil and are giving other information which adds to general prosperity. The farmer should be told how to change over from a small and inefficient plant where human labor is being wasted, to a larger and efficient food-production organization, on which he can practise the same principles of quantity production as are practised by large manufacturers today. Farming needs to be put on a quantity production basis fully as much as does any other industry for the good of the individual farmer and of the country as a whole.

More About High Flying*

Aerial Leviathan with Enclosed Cabin Especially Adapted for Flight at High Altitudes

By Dr. Guglielminetti

President of the Section of Physiology of the International Aeronautic Exposition

[Note.—In the January number of this magazine we published, under the title *Aerial Travel at High Altitudes*, an article giving some account of the work done by Dr. Guglielminetti, with respect to the physiological aspect of balloon or aeroplane travel at great heights. The latter part of this article dealt with the devices known as "aerial diving suits" and "submarines," but without going into details. We are now fortunate enough to be able to give our readers further data upon this interesting subject in an article from the pen of Dr. Guglielminetti himself. We omit the first part of the present article since it deals with the physiological studies described in our January number.—THE EDITOR.]

HAVING thus considered the physiological basis of our problem we shall now undertake to describe the apparatus by means of which oxygen can be furnished to pilots or passengers at high altitudes. These include individual inhalation apparatus and closed cabins with the contained atmosphere at a constant pressure.

RESPIRATORY APPARATUS FOR INHALING OXYGEN.

Great improvements have been made in respiratory apparatus since the time of Paul Bert. Rubber balloons have been replaced by steel tubes containing oxygen at a pressure of 150 atm. It was when upon Mont Blanc that I conceived the idea of providing these tubes with decompressors for the purpose of regulating the flow of oxygen per liter and per minute. Thanks to apparatus of this kind, Messrs. Jacques Balsan and Louis Godard were able in 1900 in a free balloon to reach the altitude of 8,600 m. (28,200 ft.), the same altitude at which Crocé-Spinelli and Sivel, 25 years earlier, had perished from suffocation in spite of their supply of oxygen. Balsan commenced the oxygen inhalations at a height of 4,000 m. (13,100 ft.); nevertheless he told me that it became hard for him to work by the time he had reached 6,000 m. (19,680 ft.); he was suffering pain and was no longer able to place the mouth of the pipe connected with the oxygen tube in his mouth; Godard quickly handed him the pipe and in a couple of minutes he felt better; then Godard, in his turn, began to find it impossible to act.

It is absolutely necessary that upon reaching a given altitude the inhalations of oxygen should continue without interruption, consequently, these pipettes at the end of tubes

connected with the oxygen supply are scarcely practical since they must be held in one hand which is a difficult thing to do during the maneuvering of the balloon. For this reason they were replaced by masks covering the mouth and nose of the aeronaut in such a manner as to enable him to breathe the oxygen automatically, starting at a height of about 3,000 m. (9,840 ft.) so as to prevent an attack of illness. Provided with these masks Messrs. Bienaime, Jacques Schneider and Senouque reached a height of 10,108 m. (33,163 ft.), this being the French record, while two Germans, Messrs. Berson and Suhring achieved the world altitude of 10,800 m. (35,433 ft.) in 1911.

During the war the French Technical Aeronautical Service perfected the decompressor of these apparatus, whose flow is now regulated by the height of the atmosphere: The percentage of oxygen automatically increases as the aviator ascends and diminishes in the same proportion as he descends. The flow is controlled by a barometric chamber and regulated in function of a decrease of temperature proportionate to the altitude in accordance with the law formulated by Raoult.

In 1919 Casale, provided with such an automatic apparatus, reached a height of 9,500 m. (31,170 ft.) in full possession of all his mental and physical powers. This is the world record in a homologated aeroplane; the American aviator, Major Schroeder is stated to have reached a height of 11,000 m. (36,020 ft.) with a barometer, which was verified but not officially homologated.

Dr. Schroetter of Vienna informs us that his handwriting became almost illegible at a height of 6,000 m. (19,680 ft.), but became normal after a few respirations of oxygen, and a sphygmographic record, taken in a balloon, at 7,500 m. (24,600 ft.) height was absolutely normal, thanks to the oxygen which had been breathed beginning at a height of 5,000 m. (16,400 ft.), whereas, a record of the pulse beat taken at a given altitude (without oxygen) always exhibits marked peculiarities.

Thus we see that hitherto not more than five or six men can boast of having exceeded an altitude of 10,000 m. (32,800 ft.) i.e., of having penetrated the stratosphere: three Frenchmen, one American and two Germans. The last mentioned reached a height of 10,800 m. (35,433 ft.), but in an actually paralyzed condition, incapable of sufficient energy to make the slightest motion. It took all their energy to conquer an almost invincible sleepiness in spite of the oxygen they breathed. As soon as they ceased taking oxygen for a few

*Translated for the *Scientific American Monthly* from *Le Génie Civil* (Paris), March 20, 1920.

minutes the palpitation of the heart increased and they commenced to stagger.

It would seem, therefore, that 11,000 m. (36,000 ft.) is the final limit at which life is still possible, even by means of artificial inhalations of oxygen. This agrees with the results obtained in the pneumatic bell jars of laboratories which show that at a decrease of pressure corresponding to 12,000 m. (39,370 ft.) of altitude, the tension of the oxygen in the lungs falls so low that the tissues are unable to make use of it. The pressure is so low in fact that it seems that the blood is no longer able to absorb sufficient oxygen and asphyxiation ensues. Why was it that inhalations of oxygen failed to save the life of Dr. Jacottet upon Mont Blanc? The oxygen apparatus was not as perfect at that time as today, but it is possible too, that an insufficient supply of oxygen gradually produces, because of incomplete oxidation, toxins which are difficult to eliminate and which, therefore, produce a sort of intoxication.

But is it possible to ascend still higher, in other words, to render respiration possible at a height greater than 11,000 meters? The Italian School of Physiology believes that it is. According to Professor Mosso of Turin, the well-known author of the work *L'homme sur les Alpes* (Man in the Alps), carbon dioxide escapes from the blood in such abundance at high altitudes as to result in impoverishing the bodily supply of this gas, thus occasioning an interference with the proper functioning of the nerve centers which regulate the heart and

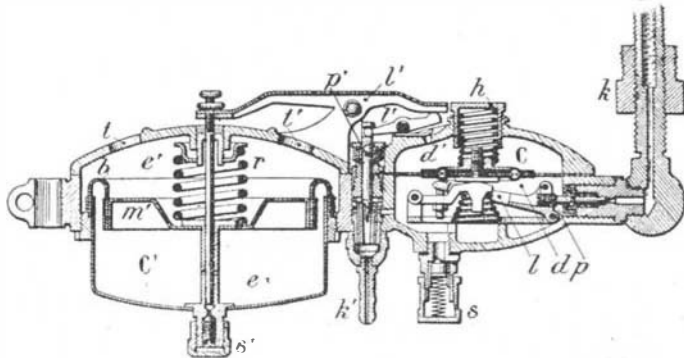


FIG. 1. SECTION THROUGH OXYGEN DECOMPRESSOR AND THE BAROMETRIC GOVERNOR

respiratory organs. This phenomenon has been termed by Mosso *acapnia*; this theory differs from that of Paul Bert, according to whom it is *anoxihemia*, the lack of oxygen which causes the said disturbances.

Believing the theory of Mosso to be correct, Professor Agazotti was able to subject himself, thanks to a mixture consisting of 13 per cent of carbon dioxide and 67 per cent of oxygen, to a pressure of 122 m. in a pneumatic bell jar—a pressure corresponding to an altitude of 14,850 m. (48,720 ft.). Monkeys placed in the same conditions were able to support a decompression as low as 100 mm. (3.937 in.), corresponding to a height of 16,000 m. (52,490 ft.).

Carbon dioxide, like nitrogen, is of no value for respiration; it does nothing but dilute the oxygen which is the only gas required to support life; but it has been found that carbon dioxide has the property, as yet unexplained, of considerably increasing the pressure of oxygen in the blood. Since the expansive power of carbon dioxide is $2\frac{1}{2}$ times as great as that of oxygen, it is possible that the pressure of the oxygen in the lungs may be increased by the presence of the carbon dioxide. This appears to agree with observations made in the laboratory, which prove that when the air is very greatly rarefied the blood retains a portion of the carbon dioxide produced by the respiration in order to facilitate the absorption of rarefied oxygen. It is possible, therefore, as has just been pointed out by Dr. Garsaux that both the French theory and the Italian theory are quite correct, one being valid at a height of about 8,000 m. (26,250 ft.) and the other at a greater altitude.

In my opinion the results obtained by these laboratory ex-

periments are absolutely conclusive with respect to flights at high altitudes, and I believe that it is not impossible that still greater altitudes can be attained than those hitherto recorded by means of mixtures of these two gases. Without going so far as that our military aviators were able to operate during the war, as a matter of current practice, at altitudes of from 5,000 to 7,000 m. (16,400 to 22,960 ft.) and it was necessary to provide them regularly with respiratory apparatus consisting of an oxygen flask with a decompressor controlled by a "barometric capsule." The details of such an apparatus are shown in Fig. 1.

The oxygen reservoir contains a little more than 2 liters of water or 350 liters of gas at a pressure of 175 kg.; when necessary several of these are installed parallel to the decompressor. The latter is mounted upon the neck of the reservoir and comprises two chambers: The chamber C forming the decompressor properly so-called, and the chamber C', known as the barometric controller.

The decompressor is made of aluminum and is divided into two chambers; the lower one *d* is the expansion chamber and contains a system of levers *l* which by means of a needle valve *p* open and close the inlet orifice of the gases at high pressure. A safety valve *s* is connected with it. The higher one *d'* contains a spring regulating the pressure and controlled by the band of the cap *h*. The membrane *m* is composed of rubber cloth, armed with a central washer of copper and guided by a rod. The gas arrives by way of the coupling *k* and the valve *p*, the latter being controlled by the levers *l*, and then traverses the compartment *d* and passes into the respiratory masks of the pilot, observer, etc., by means of the coupling *k'*, which may have several branches.

The barometric chamber is likewise divided into two compartments *e* and *e'*: the top one communicating with the outside by means of the holes *t* is subject to the depression due to the altitude, while the lower one *e*, which is entirely closed, takes and maintains the pressure at the level of the ground, thanks to an equilibrium flap-valve *s'*. The copper disk *m'* is subject, therefore, to the difference of pressure, and thanks to the annular rubber band *b* is displaced by the action of the spring *r* in proportion as the pressure of the atmosphere diminishes; this movement, amplified by the system of levers *l'* bears upon the valve *p'* which regulates the flow. Hence the latter increases automatically with the altitude.

From the coupling *k'* the gas reached the mask worn by the aviator by means of a flexible tube; the mask consists of a small aluminum cap whose contours follow the shape of the nose and mouth. At the bottom there is an orifice which serves to allow normal respiration and for the evacuation of condensed water vapor. The edge of the mask is inserted into a hollow rubber rim, so as to fit closely to the face. The oxygen enters through a perforated tube which diffuses the gas upon each side of the nostril.

The oxygen flasks must be placed as far as possible from the gasoline tanks. The installation is completed by a "flow-controller," a small drum placed in a glass sided box under the eye of the aviator, and inserted in the system of pipes between the expander and the mask: the rotation of pallets, under the effect of the gaseous current, assures the aviator that the apparatus is functioning properly.

STUDY OF A CLOSED CABIN, AT CONSTANT PRESSURE, FOR AERIAL VOYAGES AT HIGH ALTITUDES.

Because a few bold aeronauts, provided with respiratory apparatus have been able to attain high altitudes, and because during the war courageous military aviators were able to ascend into these regions in order to be above their adversary, are we justified in concluding that the same thing could be done by passengers in general? By no means! All these "record men" were men trained to sport or else young pilots

¹This is also the conclusion stated in a communication with Dr. Garsaux, based upon his decompression experiments in the pneumatic caisson of the technical section of Aéronautics at St. Cyr. *Vide* a note in *L'Aérophile* (Paris), June 1 and 15, 1919.

selected after severe tests to which passengers could hardly be subjected. Even aside from the rarefaction of the air there is another danger at high altitudes, namely, sudden variations of pressure, but it might well happen that among the passengers there would be present those suffering from

against the rarefaction of the air, but also against sudden variations in temperature. There would be no special difficulty in heating and ventilating such a cabin.

Such a cabin would be far easier to construct than a submarine, since its walls would not have to support such a

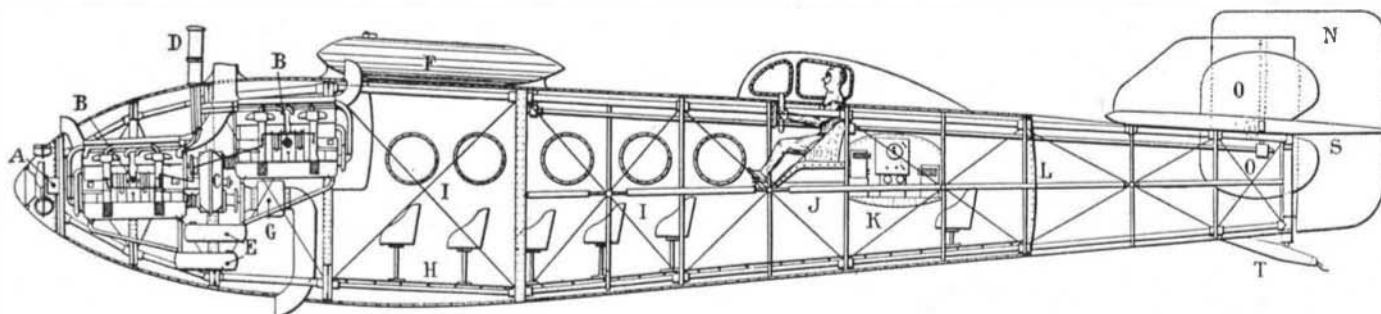


FIG. 2. LONGITUDINAL SECTION OF THE BREGUET LEVIATHAN, TYPE 20, PROVIDED WITH A COMPRESSOR FOR FLIGHT AT HIGH ALTITUDES

A, propeller shaft; B, Bréguet-Bugatti motor; C, clutch; D, radiator; E, oil reservoir; F, gasoline tank; G, turbo-compressor; H, lower wing; I, passenger cabin; J, controls; K, radio station; L, airtight partition; N, rudder; O, fixed lateral planes of rudder; S, elevator; T, skid.

maladies or weakness of the heart and arteries, to whom great variations of pressure might be fatal. Without wishing to discourage passengers who wish to make use of this new mode of transport, it is the duty of the physician not only to second the progress of science but also to draw attention to possible accidents in order that they may be avoided.

The solution which naturally occurs to the mind is to entirely remove, not only the passengers but likewise the pilot and even the motors from the pernicious effects of the atmospheric depression, by enclosing them all in an air-tight cabin, a sort of huge collective diving suit. This idea has already been elaborated in every detail as we shall show a little further on.

It is interesting from a historical point of view to recall that even fifty years ago various projects were proposed for enabling mankind to navigate the air in balloons at very high altitudes. In 1871 Louis Tridon presented before the French Society of Aeronautic Navigation a project for a closed car² composed of solid portions and flexible portions. The solid portions comprised two platforms, a "ceiling" and a "floor" made of willow; the upper platform acting as a maneuvering car. When at a high altitude the aeronaut was supposed to descend by a manhole into the lower car which contained flasks of oxygen and cloths saturated in lime water to absorb the carbon dioxide produced by respiration.

In 1900 M. Andrieux presented before the same society a plan for an *aerial diving suit*³ designed to enable the wearer to reach the loftiest regions of the atmosphere without danger. This so-called diving suit consists of a costume of impermeable cloth. A special system of tubes supplied by an oxygen tank is supposed to maintain around the aeronaut a sufficient pressure to cause the proper circulation of air and ensure good respiration.

Since that time mankind has succeeded by means of such apparatus, of diving bells, diving suits, and submarines, in living within a medium which provides no means of respiration in itself. In an analogous manner the airplane or the dirigible might comprise a closed cabin, in which the atmospheric pressure at the ground level could be kept constant by means of a pump drawing in air from the outside, within which would be contained an indefinite amount of oxygen, which would merely have to be compressed. This same pump would also furnish the necessary supplement of air to the motor, since the motor like the man needs more air at high altitudes. For this purpose M. Reatau advises the use of a turbine driven by the exhaust gases of the motors, which is a very rational idea.

In this manner the passengers would not only be protected

heavy pressure. The difference of pressure between the internal and external air would not exceed one-half atmosphere at the loftiest altitudes, while submarines often have to withstand pressures of three or four atmospheres. Furthermore, a breach in the walls would be by no means so dangerous as such a breach in the hull of a submarine: It would always be possible to remedy it temporarily by means of the compression pump, while descending to a lower altitude.

Figs. 2 to 4 show sections of the plan devised by the well-known airplane builder, Louis Bréguet, for an aerobus for use at high altitudes. The caption of Fig. 2 sufficiently explains the general arrangement. We may add a few remarks concerning certain features of the construction and method of functioning.

This biplane, which has been named the Leviathan, weighs about 2,500 kg. empty, or about 1,500 kg. for the motor part and only 1,000 kg. for the plane itself. It has a spread of 26 meters, a length of 14 meters and a surface of 140 square

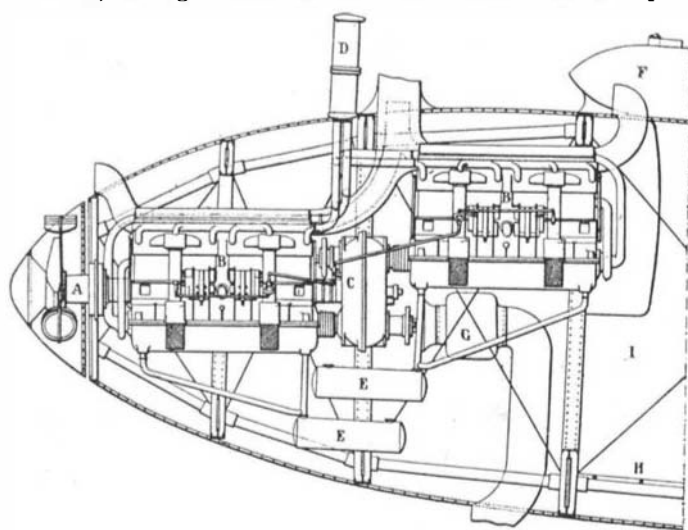


FIG. 3. ENLARGED VIEW OF THE BOW OF THE BREGUET BIPLANE

meters. It is built entirely of metal having a broadly calculated solidity and an exceptional lightness not hitherto attained.

In order to withstand an accident to the motor without fear of forced landing, the motor power of 950 hp. has been divided among four eight-cylinder motors.⁴ These motors, grouped

⁴This group was exhibited at the last *Salon de l'Aéronautique*, where it attracted much attention; it was reproduced in *Le Génie Civil* for January 10, 1920, p. 31.

²See *Scientific American Monthly*, Jan., 1920, p. 50.

³Ibid.

in a space big enough to be called a room, drive the same propeller. When a motor has an accident it is immediately thrown out of gear automatically and the biplane continues to fly by means of the three other motors. Thanks to the large dimensions of the "machine room" the mechanic can move about at ease having ready access to all parts of the motors, and thus is able in most cases to repair the damage, which is usually due to some trifling cause such as sticking of the spark plugs, the breaking of an axle rod or valve spring, the stopping up of a pipe, etc. Thus such a biplane can be repaired while flying, like a dirigible. Even with two motors not working, the flight of the avion would merely be somewhat slightly in a descending direction.

Furthermore, the single central fuselage enables the pilot to enjoy the advantage of excellent aerodynamic properties and ease of manipulation: the central propeller does away with the swerving so dangerous for the pilot, which occur in planes having multiple propellers when a side propeller stops suddenly.

The accompanying diagram (Fig. 5) indicates the possibilities in the Leviathan's progress, the variations in its radius of action and its "ceiling" in function of the loads carried and the amount of fuel taken along. Here we may read for example that if we fix upon a ceiling of 6,000 m. (19,680 ft.) we can transport a total load of 3,200 kg. (7,055 lbs.). If to this load we add 2,000 kg. (4,409 lbs.) of fuel we read upon the upper scale opposite the vertical line at the point *b* the possible distance of transport 3,100 km. (1,926 miles) and upon

the lower scale the value 0.35 of the ratio $\frac{Q}{P}$ of the weight of fuel carried to the total weight at the starting point. The latter 5,700 kg. (12,566 lb.) is read upon the vertical scale at the right at the side of the scale of *total loads*. These run in practice up to five tons: with a single ton the ceiling is 9,000 m. (29,530 ft.); even with five tons it is still 3,500 m. (11,480 ft.).

According to the proportion in which the total load is divided between the fuel and the useful weight, i.e., passengers, cargoes, or bombs, we shall have an avion carrying a limited useful load to a great distance, or a much larger useful load to a much shorter distance. If, for example, the distance to be covered is but 1,000 km. (620 miles) as from Paris to Madrid, with a ceiling of 4,500 m. (14,760 ft.) the plane could

ments, supplies) and there would remain 4,200 kg. (9,260 lb.) for the possible fuel weight; this would allow a voyage of 5,000 km. (3,100 miles) in a calm in 28 hours of flight, at 180 km. (112 miles) per hour, or with a steady head wind of 30 km. (19 miles) per hour we would still be able to travel more

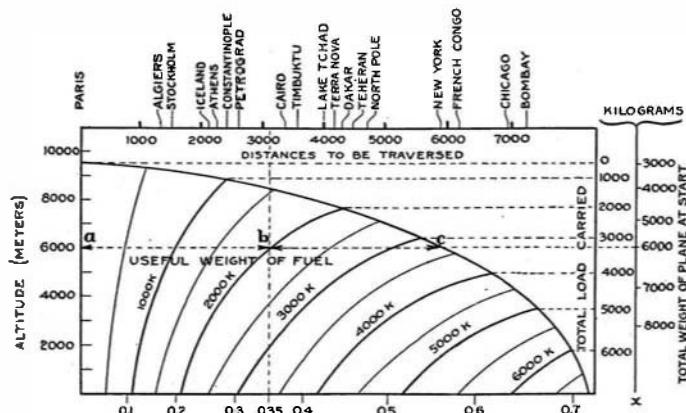


FIG. 5. CHART OF CAPACITY AND RANGE OF THE BREGUET BIPLANE

The scale of the abscissae x represents the ratio Q/P , i.e. the weight of the fuel consumed divided by the total weight at the start.

than 4,000 km. (2,480 miles), in other words the distance which separates Paris from Lake Tchad, from Dakar, or from the American continent (Newfoundland).

In seeking the practical limit of the maximum distance which it is possible to cover, we find that a crew of three men consisting of two pilots and a mechanic plus the necessary provisions (about 500 kg. or 1,100 lb.) would be able to carry 4,700 kg. (10,360 lb.) of gasoline and fly for 38 hours at 170 km. (106 miles) per hour, thus covering a distance in a calm of 6,500 km. (4,039 miles) or more than the distance which divides Paris from New York, from the French Congo, or from Lake Victoria.

It is extremely probable, therefore, that within a few years at most we shall be traveling over the invisible roads of the stratosphere at velocities of more than 300 km. per hour.

A FOG ELIMINATOR FOR MOTION PICTURE STUDIOS.

EVERYONE who has ever seen a typical London fog of the "pea soup" variety knows very well that its murky yellow obscurity not only makes traffic impossible in the streets, but inevitably invades houses in spite of artificial light. It is impossible to take clear studio pictures in such an atmosphere. Formerly there was nothing to do but to stop the work of the cameras until the air cleared up. It is now reported, however, that a well-known motion picture firm, the Famous Players-Lasky British Producers, Ltd., has found a method of obviating this difficulty in its London studios, situated at Islington.

The fog eliminator is described as being composed of a series of high and low pressure coils installed at points of vantage around the big stages. One side of the building carries a series of high pressure coils along the entire length of the stage. On the opposite side a little higher up on the wall, is a series of low pressure coils. The roof contains other high pressure coils and a large exhaust fan.

On entering the studio the fog encounters the high pressure coils and is thrown up to the ceiling, where it is taken in charge by the other high pressure coils and the exhaust fan, and is quickly dissolved, or at any rate eliminated as a factor in interfering with the cameras.

Experiments conducted several weeks ago by the studio staff have demonstrated the complete success of this method of treating even the heaviest of London fogs; even when it is not possible to disperse the fog entirely, its heavy blanket can be lifted to a height of 15 or 16 feet above the floor of the stage, thus enabling the directors to go on working.

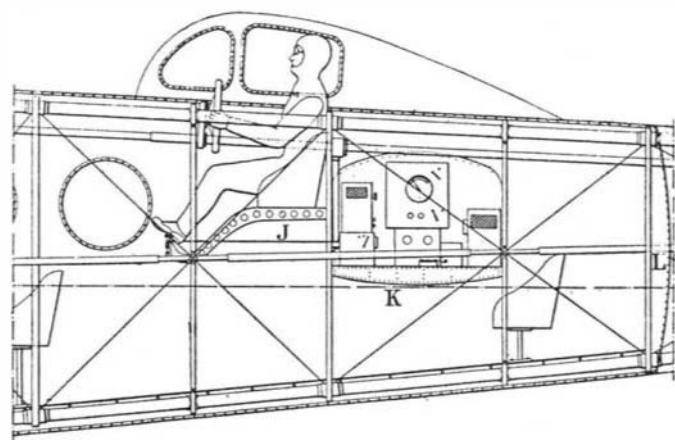


FIG. 4. SECTION SHOWING THE PILOT'S HOOD

carry a total load of 4,200 kg. (9,260 lb.), 800 kg. (1,760 lbs.) of fuel would be a sufficient supply which would leave a useful load of 3,400 kg. (7,500 lb.) (or 27 passengers, each with an allowance of 40 kg. (88 lb.) of baggage); the voyage could be made in five hours and a half.

If, on the contrary, a long cruise was in question, for which the minimum ceiling would be put at 3,000 m. (9,840 ft.), 5.2 metric tons (5.73 short tons) of total load could be carried. Such a load might comprise, for example, the following items: 1 metric ton of useful weight (five men in the crew, instru-