prevent them designing for high horse-power and duration, then fitting a small horse-power engine to come within the restrictions imposed by the Peace Treaty.

The recent air raids appear to be now almost forgotten, and it does not seem to be realised that they could be repeated almost without warning and with more disastrous results.

We should at the present time be converting coastguard stations into air-guard stations, linking up the whole of the coast line; also designing and constructing special types for use in the East; existing types are obsolete, and should be replaced by machines suitable for the work.

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At the conclusion of the reading the Chairman said:—

This is a paper that will stand out in my memory for a long time as being a particularly comprehensive one, and I feel I could go off and design a good aeroplane straight away. There are one or two points I should like to touch upon, but before doing so I will ask others to say a few words.

DISCUSSION.

DR. THURSTON: I came here this evening expecting a very great treat, and I have certainly not been mistaken. It seems to me this paper is of the greatest possible use, and sums up the massed experience of the war. I hope you will be able to publish this paper in its entirety, and the illustrations and charts are all so good that I hope they will be published as well.

The point that strikes me this evening is this—here we have put in a simple and clear way the concentrated essence of the science of aircraft design, without any complicated mathematical formulæ or theories, and it shows how simple things are to the ordered mind. It brings one to Milton's way of putting things:—

"It is not to know at large of things remote from use, obscure and subtle, but to know that which before us lies in daily life; is the prime wisdom."

That strikes me as being the essential point of this paper—the remarkably simple way in which Mr. Folland has chosen to bring forward the essential things in aircraft design.

Relative to the chart of the percentage weights of various machines, at the beginning of the war I had to consider various designs for acceptance, and the most alarmingly optimistic statements as to performance were made by certain designers, so that it was necessary to thoroughly analyse their designs. One way of doing this was to analyse the proportional weights of every machine made, and to plot the results against the total weight of the machine. Hence, if the various parts had the same proportional weight for all sizes, a series of parallel lines would be obtained.

A series of lines representing the weights of fuselage, engine, etc., for every conceivable type were obtained, and the limitations of various designs were indicated.

I agree with Mr. Folland's remarks relative to the necessity for care in landing. During the war many machines were subjected to most severe bumping when landing. One man achieved the distinction of being the champion "bumper" or "bouncer." He was never known to land without crashing the undercarriage. One day he came in, and, to everyone's astonishment, made a perfectly good landing. However, when the other fellows ran out to congratulate him, it was found that the Huns had shot away his controls. (Laughter.) The same gentleman was also rather great on night-landing stunts. His record bump was when he bumped so high that he bumped out the light of the flare. (Renewed laughter.)

The point relative to visibility is a very important one, particularly from a commercial point of view. Everyone who had to fly during the war knew that large numbers of machines had most alarming escapes. I have had pupils glide suddenly straight underneath and overhead, flying at a greater pace, without seeing my machine. If the pilot was placed right in front of the machine I do not think it would be possible to make those mistakes. In the ordinary method of placing the pilot with a wing in front of him, it is always possible to get in some position with a blind spot when you can't see him.

Mr. Folland has mentioned the subject of all-metal construction. That undoubtedly has a very great future, and if the war had only gone on a month or two longer our machines would have advanced more in that month or two than they will in the next twenty years. I agree with him regarding all metal tubular structures; but it is not essential to have metal construction of *tubes*, but of *sections* of tubes. All that is necessary is to have the metal longitudinally corrugated, so that the ratio of the radius of the corrugation to the thickness of the metal does not exceed a certain amount (say 30). In highly stressed parts the ratio should be something less than 30. We did produce during the war a number of spars having greater strength than the best spruce spars, and weighing certainly not more than 80 to 85 per cent. of the corresponding wooden structure. In the development of metal construction it is desirable that we should take only certain simple parts, such as the spars, and convert them into metal, leaving all the other parts in wood.

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Relative to load factors :—During the war there was a tendency to design machines with these factors too small, but it appears to me that some of the figures now given are rather on the high side. It is desirable to make the factors accommodate themselves to the various parts, as certain parts do not require so high a factor. I have in mind a very fast scout machine, which had a load factor of 7 or 8. Nevertheless, there was one wire of that machine which was a factor of safety of over 9, and which was continually breaking. It broke time after time, until the strength of the wire was colossal. Then rubber plugs were placed under the engine bearers, and the wire was reduced below a load factor of 7 without it breaking again. It is only massed experience that enables a design to be improved. With regard to larger machines, undoubtedly they do not require so high a load factor as smaller machines, and the load factors given in the table appear to be somewhat high. Early in the war I plotted the load factors against the weights of machines, and it was clear that as the size of the machine increases the load factor is considerably reduced. I took the strength of every part, and the records of every accident I knew of, and plotted the results on charts. By that means curves were given showing the minmum safe load factor for each individual part.

One further point strikes me as being important, namely, that every part of the vital structure of an aeroplane should be duplicated, if possible, through another member. That is to say, you should, if possible, have two spars side by side, as shown on one of the slides, so that if one breaks you have a second one available. Incidence wires should be made sufficiently strong, so that if the main wires are shot away or get broken, then the incidence wire will take the load, and bring you safely home Another important point with regard to the structure is to see that it is a perfect or complete structure. Many designs during the war were found either to have redundant parts or the structure incomplete. Thus, means should be provided to take the tension of the lift wires across the body, as the other lift wires.

In other cases one had to provide for up-and-down loads on the tail, and the rear part of the body of a machine should be suitably based to take either load. The front portion of the wings should have ample provision to take down loads.

All these are essential points, and during the war, by the massed experience of our designers, this country obtained a foremost position in aircraft design. We seem at the present moment to be losing our position, but I know, Sir, you will, in your honoured position, do what you can to keep this very important national science in full prominence.

Mr. S. T. G. Andrews: I should like to add my congratulations to Mr. Folland on his excellent paper. It is impossible for me to criticise same in detail, as I have not seen it until this evening's reading. I am particularly pleased to note that he has laid stress on the fact that aircraft design should be made more of an engineering proposition. We must get away from the popular tradition that an aeroplane is a collection of bits of wood, string, paper, and hoop iron. I quite agree with the lecturer with regard to metal construction, and think that when aeroplanes are largely constructed of easily replaced metal components we shall have gone a long way towards solving the problem of a satisfactory aeroplane.

MR. A. F. HOULBERG: There are one or two points which I should like to see more stress laid upon. With regard to wing spars, it is essential that the front spar should not be too far from the leading edge.

I endorse his remarks with reference to stresses. The lack of common-sense shown by some workmen is appalling. I have seen machines stressed to such an extent in the shops that they were very dangerous before they were completed.

I should like to make a few remarks on Slide 7, which gives percentages of weights and also areas, particularly those giving areas of rudder. Some of those figures will require modification, especially from the point of view of commercial machine design, where comparatively large fuselages are used.

In conclusion, I wish to offer many thanks for the excellent lecture we have had.

CAPT. SAYERS: This paper is, indeed, a most valuable one ,whether to those who have actual designing experience, or who hope to do so. It is a very difficult paper to criticise. There is such a large amount of material that the one and a-half hours I have had to spare has not allowed me to apply any check to the figures, or to say on what points I agree or disagree. I think there is no point which I wish to criticise adversely. It is very satisfactory to discover that all successful aeroplane designers work on very straightforward and commonsense lines. I know one designer who designed to wonderful formulæ, but none of his machines ever flew.

One interesting point Mr. Folland suggests is the arrangement of different standard wings to suit machines for operations in countries where the atmospheric conditions are different from those here. I am not quite certain whether there exists (can he tell us?) a complete range of wing sections which will suit all conditions. They might be of more than military service.

I agree with him on the subject of metal and wood construction, and have no doubt that steel tubular struts can be used almost anywhere with very much less cost and with no extra weight. For interplane struts and all kinds of struts it is possible to make use of a very small number of gauges and diameters of steel tubes, and to reduce the number of different parts in a machine to a very great extent. If the steel tube were even a little heavier than the wooden structure it would pay to use it.

There is only one other point. On page 24 Mr. Folland says, with regard to racing machines, that one has to consider :—

(1) Clean and shapely lines, etc.

(2) Parts merging into or out of fuselage should be arranged to do so gradually, etc.

(3) All external fittings should be faired off.

(4) The undercarriage should be carefully considered, with a view to avoiding all air pockets and congestion of parts. . . ."

I do not agree that one should confine this to racing machines; it is worth while doing it in any case.

Mr. F. R. Simms : I have not much to say, and prefer that others here who are more able to do so will speak. I have listened with great attention and interest to this paper, and feel sure that students who are present will read it over and over again, and take advantage of the points which have been so ably put before us.

Mr. W. O. Manning : Regarding ailerons, I prefer to use a wing area of about 16 per cent.

A combination structure of steel and duralumin would be unsatisfactory anywhere near the coast, owing to corrosion difficulties.

The safest machine for military types is not necessarily that which is safest to land, but the reverse is true of commercial aircraft, and I suggest that the factor of safety of the chassis for commercial aircraft should be higher than that equivalent in military types. I suggest 5 as a good figure.

Can Mr. Folland give us any details as to three-ply fuselage? Also weight details?

With regard to aeroplane fittings, I prefer the bent lug type, as it is easy with this fitting to make the plane watertight. I agree with Mr. Folland's remarks on this type, but would point out that these difficulties can be overcome in the manner stated by him.

With regard to brazing, I have always found dip-brazing the best, and would point out that if this type is used annealing is unnecessary.

I should like to say that this is one of the most interesting papers I have ever listened to.

Letter received from Mr. F. T. Hill, who was unfortunately prevented from being present :—

I should first of all like to be allowed to congratulate the author upon having placed before us a collection of material—a good deal of which is published for the first time—the value of which to designers is inestimable. It is obviously the condensed result of his many years' experience as an aeroplane designer, and deserves to rank as one of the classics upon this subject.

METAL-CUM-WOOD CONSTRUCTION.—While I agree with the author's remarks upon many advantages of this method of construction, I am not so sure that the complaints against the old wooden construction, from the point of view of non-interchangeability of hinges, have not been greatly exaggerated, and where they did exist were due to designers endeavouring to work to unnecessarily fine limits upon the parts which had to fit rather than constructional faults. Take the case, for instance, of the aileron hinges, in which there are usually three eyebolts fitting in between faces of jaws on the opposite component. As long as all of the faces were designed with small limits of the order of a few hundredths of an inch I agree that the aileron never did fit on to its corresponding hinges on the plane spar after it had been in store for any considerable period. This difficulty was, however, almost entirely eliminated by using the centre hinge as a positioning hinge, allowing the usual small limits on its face to prevent side play, and then allowing considerable limits on the two outside hinges.

Personally, I think that a great source of danger in metal construction of the type mentioned in this part of the paper still exists in the possibility of the metal crystallising under the effect of vibration, which the author himself admits later on in the paper does exist, and is of a certainly serious order.

UNDERCARRIAGE.—It appears to me that the practical side of undercarriage design is largely one of ease of replacement of damaged parts, as everyone appears to agree that it is desirable to design an undercarriage in such a manner that it shall collapse under unduly heavy load rather than transmit the shock to the fuselage. In this connection, it is surprising that nobody appears to be now making use of the idea, which was adopted on one of the small war-time scouts—I believe it was a Sopwith machine—of making axles of a fairly heavy gauge, aluminium tube. It was my experience in dealing with these machines that even with an undercarriage, the top of whose vees were rigidly connected to the longerons, these axles could be bent considerably under bad landing without damaging any other part of the structure. If an axle of this type was used in conjunction with the universal joints on the top of the undercarriage already advocated by the author, and the rubber shock absorber was attached to spools, through which the axle could slide instead of being attached to the axle itself, the result would appear to be a particularly simple type of undercarriage, which would only bend its axle in the event of a bad landing, the replacement of which would merely necessitate removing the wheels and sliding the bent axle through the spools. Under these conditions it is almost possible to visualise a machine carrying a spare axle, and being repaired by the pilot on the spot in the event of a forced landing.

PETROL SYSTEMS.—I thoroughly agree with the author's remark that gravity systems should be adopted if possible, but I am not so sure whether there is

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much hope of this becoming universal, bearing in mind the modern trend of aeroplane design. The one drawback is that the main tank must necessarily be above the level of the engine, and therefore the danger from fire precludes it from being fixed anywhere in the vicinity of the centre section of the upper plane in the case of a single-engine machine. If it is placed further back in the fuselage it is quite possible that the gravity head will be lost when climbing, which is obviously a condition under which it is most urgently required. If the tanks are placed further out at the top wing, they introduce a moment about the c.g., which is undesirable, and which would alter the trim of the machine unless both tanks are used simultaneously, and also if the tanks are placed very far out on the plane the friction in the necessarily long length of piping reduces in effect the gravity head, and also introduce an extra chance of damage during handling, as these pipes will necessarily run down one of the struts or some similar part. Personally, I am of the opinion that if a reliable type of flexible joint could be developed, and placed where relative movement of the two parts is known to occur, as, for instance, where the wings are joined to the fuselage, there is no reason why we should not use rigid steel piping for the rest of the system with properly made joints, when I am convinced that the original pressure petrol system would be the lightest and most reliable.

Racing Machines.—I am exceedingly pleased to see that the author emphasises the fact that it is not the maximum speed, but the difference between the maximum and minimum speeds, which is the real criterion of good design on this type of machine. This point is, I am sure, not fully appreciated by the general public, and even by some aeronautical people who ought to know better, in comparing the performance of some of the recent Continental freak machines and the English racing machines of to-day. I can call to mind a conversation which I had with a well-known designer of one of these machines, in which he stated that he devoutly hoped that he would never receive an order for one of them, as in the hands of anybody but his own experienced pilot it would inevitably prove a death-trap, and ruin his reputation as a designer.

Incidentally, designing for a big range of difference between maximum and minimum speeds, means that every encouragement should be given to the development of variable camber wings, which, I hope the author will agree with me, now appears to be most certainly within measurable distance of being a practical proposition.

The Chairman: I do not criticise the lecturer from the point of view of commission. If there is any criticism it is from the standpoint of omission, because it would have been extremely interesting to have heard from him some remarks on such difficult questions as all-metal construction. Dr. Thurston touched on one particularly interesting case of the amounts for a factor of 7 being diminished very much by placing rubber under the engine bearings.

I should like to know from Mr. Folland (he being a past-master in the design of high-speed machines) his views on what is a very interesting subject; that is, the maximum size that an aeroplane can be built to-day, not only a land machine, but also a seaplane. If the air is to replace the Navy and a large part of its work, one of the most essential things that is wanted is a seaplane or flying boat, that is seagoing and seaworthy, so that it could weather a storm on the sea, floating. Until we can get that type it seems to me we cannot do some things which many people are too prone to claim for our service.

Mr. Folland has said that one of the things you should concentrate on is the comfort of the pilot and passenger, and, so far as commercial machines are concerned, I very much agree with him. In the early days of the Paris-London route I took a passage like the ordinary man in the street, especially interested to know just how I should be treated. The first thing that struck me (looking always at the point of view of the man in the street) was the tremendous noise. You sat within ten feet of a 500 horse-power engine with open exhaust, and most of the people arrived in a sad condition after the two hours' journey. Another thing was, that, being a particularly bad sailor, within ten minutes I was very ill, and no provision whatever was made for me. (Laughter.) The position was a most embarrassing one, being in the company of those quite unknown to me, and I arrived in an almost imbecile condition. I do hope that when designers come to deal with some of these questions they will keep in mind the ordinary man-in-the-street point of view. He must be in a good state when he reaches his destination.

Sir Charles Bright, F.R.S.E., M.Inst.C.E., Vice-President of the Institution, said: As I listened to Mr. Folland's very carefully prepared paper I could not help being struck with its solid value. I am not, however, going to talk about the paper, because I do not think I could say anything particularly illuminating upon it. But I do want to say something with regard to our President's address before the Institution in February last, in which he spoke of the functions of the Royal Aeronautical Society and of this Institution and the relations between the two.

Personally, I have always felt that those relations should be nothing but friendly, and I cannot see why they should be otherwise. It seems to me that our President put the matter extremely well. I naturally have strong views on the subject, for, whilst proud to be associated with this Institution, I am also a Fellow of the Royal Aeronautical Society, of which my father was one of the founders in 1866. It will, therefore, be a matter of considerable regret to me if the relations between these two organisations are at all strained.

I sincerely hope that all members of this Institution will do their best to see that there is no bad feeling from this quarter, at any rate. The relations should really be much the same as those subsisting between the Institution of

Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers, all of which carry on their spheres in perfectly friendly accord—or rivalry—if you care to call it that. As a matter of fact, conferences occur periodically between delegates of each, and I see no good reason why the same sort of thing should not hold good between all organisations concerned with the air.

In conclusion, I should like to congratulate the Institution on having secured so distinguished a man in aeronautics and other walks of life as Colonel Moore-Brabazon for its President.

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MR. FOLLAND'S REPLY TO DISCUSSION.

The Chairman has mentioned some very important points in connection with Aircraft Design. I found, when compiling my paper, that if I had dealt with the subject in full detail it would have run into many pages, and would never have been finished.

As mentioned, the subject is such a large one that to deal with each individual subject it would be necessary to separate it into many sections.

The Chairman asks, "What is the maximum size that an aeroplane can be built to-day, not only for a land machine, but also for sea craft?" The limitation of the size of a land machine may possibly be limited to 30 or 40 tons, but I cannot see any particular limit to the size of a flying boat. The question at the present time is one of h.p. available; as we increase the h.p. of our engines, so shall we be able to increase the size and loading capacity of the machine.

The Chairman mentions his discomforts on the cross-channel machines. From my own experience I can agree with him, with the exception that I did not prove so bad a sailor.

The designers of commercial machines now coming forward are studying the question of comfort and ventilation, etc., and a great deal depends on the stability of the machines to damp out the phugoid oscillations. A great deal must be done in this direction to attract the air traveller and to ensure that after his first flight he will come again.

I am glad to hear that Dr. Thurston agrees with the necessity of care in designing for landing conditions, also with regard to visibility.

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With regard to all-metal construction, this will no doubt come in the near future both in the form of tubes and sections. I personally think that the tubular structure of sections rolled from tubes will form the most serviceable and a fool-proof structure. The thickness of the metal should be limited until such time as a proper rust-proof steel can be obtained in reasonable quantities and at a reasonable price.

I agree with Dr. Thurston that during the war spars, struts, etc., were designed and gave excellent results, but in many cases were not good enough for commercial production.

With regard to the remarks in reference to the lift-wire, which was continually breaking, this may have been due to excessive vibration of a badly running engine—certain engines were well known for having bad periods.

The question of load factors is one of utmost importance, and can be varied according to the requirements and the specific work which the component has to do, and is one of international importance. It should be arranged in a similar way to Board of Trade Regulations used in many other branches of engineering.

The question of duplication is one which should be probably more carefully studied in a commercial machine than in a fighting scout. In many cases duplication with regard to spars would mean a big increase in structural weight. This would in turn reduce its co-efficient of utility. One way to ensure this would be as suggested in my paper—to increase the load factor of certain parts which are known to give continual trouble. In a fighting machine duplication is more necessary to guard against fractures due to bullets or shell-fire. In a commercial machine, greater strength rather than duplication is necessary to guard against excessive vibration of a badly running engine, or continual shocks due to a series of bad landings. Machines to-day are invariably duplicated with regard to lift-wires.

I am pleased to note that Mr. Andrews agrees with the principles of my paper, and that we are gradually getting away from the crude aeroplane structure to an engineering proposition.

Mr. Houlberg raises a question with regard to wing-spars and their position in relation to the leading edge.

This, to my mind, is purely a question of designing, and I maintain that a wing can be made strong enough with the spars in any position. The question of having the front spar close to the leading edge was the result of experience during the war—on a number of machines which were not designed for nose-diving conditions. It is therefore possible, with the experience gained, to make due allowance for such conditions.

I note that he agrees with my remarks with reference to stresses and the

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necessity of taking into account initial loads which are likely to occur due to bad workmanship and other causes. With regard to percentage of weights, these are given more for the preliminary design stage rather than the final estimate. These will be useful in the initial stages, and as a starting-point in the design of new types.

Capt. Sayers has asked me to explain more fully my suggestion for the arrangement of different standard wings to suit machines operating in countries where aerodromes would probably be anything from five to eight thousand feet above sea level. The wing sections I had in mind were those of the airscrew-section type, which could be arranged to have the same areas, points of attachment and interchangeability, but would vary in camber and a percentage necessary to give chiefly good climb at ground level and low-landing speeds.

I am glad to note that he agrees with my paper on the subject of all-metal and wood construction, but I do not agree that it is wise to reduce, at the present time, the number of diameters or gauges of the tubes. We are still getting over our teething troubles with regard to steel construction, and for the time being we must endeavour to save every ounce of material we can. With regard to my remarks on page 17, regarding racing machines I agree with Capt. Sayers that these points are of the utmost importance to all aeroplanes, but in many cases to obtain these results it invariably means that the cost of the machine invariably becomes high, and in many cases, when repairs are made, these little additional fairings are invariably left off, and also that they sometimes affect accessibility.

I was very interested to hear Mr. Manning's remarks, especially on his experience from the seaplane and flying-boat design side. In my paper I was dealing with land machines only, as in flying-boat and seaplane design many other conditions arise, and therefore different figures must be used.

I agree with him with regard to ailerons and their percentage of total wing surface.

With regard to a combination structure of steel and duralumin, this structure would undoubtedly suffer from corrosion due to sea water. This was included in my paper as one of the many ways in which metal structures are built. I agree with Mr. Manning that the safest machine need not necessarily be the safest to land (that is, military type).

I agree that the load factor of the landing chassis of commercial machines should be higher than that equivalent in military types, always providing that the factor of safety is not as large as the rest of the structure, for the following reasons :—

A machine with an under-carriage having a load factor equivalent to the rest of the structure may make a bad landing sufficient to demolish the landing chassis. On investigation the rest of the structure may appear to be sound and serviceable, but it is obvious that if the landing chassis has had sufficient shock to demolish it, the adjacent structure must have been badly strained, and probably at a number of points be at its yield-point.

With regard to 3-ply fuselages, the weight does not work out very much in excess of the wire-braced structure, the increase being approximately 2 per cent. One of the chief difficulties with the 3-ply fuselage is that of repair in the case of a crash. I note that Mr. Manning prefers the bent-lug type of fitting. This is, no doubt, very suitable for sea-work, where a watertight wing is necessary, but at the same time, from an engineering point of view, the direct pull-type of fitting is undoubtedly the best, and could, I think, be made watertight.

With regard to brazing, dip-brazing is undoubtedly good, but is not fool-proof, although often assumed to be excellent, as annealing is unnecessary; but at the same time the operator, unless watched, will hold a fitting by a wiring lug with a pair of pliers, then dip the fitting into the brazing bath locally where the parts require brazing. This obviously affects the molecules of the steel and localises the temperature. Providing the fitting is suspended on a wire and completely immersed in the bath, annealing will be unnecessary, and a fool-proof job ensured.

Mr. Hill raises the question in favour of the all-wooden construction with regard to interchangeability. I do not particularly refer to such parts as ailerons: in many cases these had very bad design of hinges. I was considering more the question of wings and their spar attachments to the centre sections, also such points as warping of spars and shrinkage, which often takes place due to badly seasoned timber. Aileron hinges, rudder hinges and elevator hinges can easily be overcome by locating at one hinge and leaving other hinges floating.

With regard to metal construction and the possibility of the metal crystallising under the effect of vibration, I do not think that this will greatly affect the main structure of an aeroplane. The question of vibration mentioned in my paper referred chiefly to the lift-wires and fittings. It is obvious that with a braced structure certain wires will be redundant, and will therefore be in a continual state of vibration.

With regard to Mr. Hill's remarks on under-carriages, in the main I agree with him, especially with regard to the quick interchangeability of axles which often bend and give more trouble than the rest of the under-carriage structure.

With regard to petrol systems, I note that Mr. Hill is also in favour of gravity systems, but he apparently considers that the petrol tank being above the engine is a drawback in a case of fire. This can be overcome by placing the petrol tank above the engine and to one side of the fuselage without materially altering the lateral trim of the machine.

Incidentally the tankage could be split up into two tanks, one each side the centre section. The tank should, wherever possible, be placed near or over the centre of gravity of the machine. With the gravity system the minimum amount of pipe-line and the minimum amount of joints necessary go a long way in its favour.

I am glad to hear that Mr. Hill agrees with me on the question of racing machines. I agree that variable camber wings would be useful. My experience with variable camber wings dates back to early 1914, when I found that although I obtained a reasonable speed range, the advantage gained did not outweigh the disadvantage of the extra weight and the extra operating gear.

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After Mr. Folland's reply to the discussion the Chairman said:—

I am very proud to have heard this paper and Mr. Folland's comprehensive replies to the points raised. Anyone who has ever read a paper will realise the enormous amount of time, work and thought that one of this kind requires, and I think the suggestion that we should publish it is worthy the deep consideration of the Council. We are not, however, particularly well off at the moment, but it is hoped that an abstract of the paper will be circulated to our members.

I want to draw your attention to one of the last paragraphs in the paper, in which he says, " Those who took part in design during the war should keep abreast of the times." I do not know of any better way of doing that than by joining our Institution and coming to hear such lectures as we have heard to-night.

I noticed a slight dig with regard to lack of orders from the Government. I am not responsible for that. I have done all I possibly can, and I only wish that everybody here would write to their own M.Ps. and make their lives unpleasant until they take the subject of aeronautics a little more seriously and help us to encourage it in the House. I must now propose a hearty vote of thanks to Mr. Folland.

In seconding, Mr. Molesworth said the paper, when printed, would become a classic, and be of great service to all designers of aircraft in the future.

A unanimous vote of thanks then brought the meeting to a close.

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Component Weights Chart.

Type	Structure % of Total Weight	Structure Components as % of Structure Weight: Body	Wings	Rear Skid	Rudder	Fins	Tail & Elev.	Undercarriage	Controls	Tanks	Power Plant % of Total Weight	Components as % of Power Plant: Engine Dry	Accessories	Load as % of Total Weight	Components as % of Load: Crew	Oil & Petrol	Useful Load
Single Seater Scout with Air Cooled Engine	33·7%	30%	41%	·9%	·6%	·8%	3·8%	11·6%	4·2%	7·1%	32·8%	91%	9%	33·5%	24%	45%	31%
Single Seater Scout with Water Cooled Engine	32·4%	31·2%	38·5%	·9%	·7%	1·1%	4·3%	11·6%	4·1%	7·6%	38·1%	71%	29%	29·5%	30·5%	43%	26·6%
Two Seater Fighter with Air Cooled Engine	31·7%	25%	41%	1·1%	·63%	·62%	3·15%	14%	5·1%	11·4%	26%	91%	9%	42·3%	11%	40%	49%
Two Seater Fighter with Water Cooled Engine	33·6%	28·6%	39·6%	·9%	·75%	1·1%	5·8%	11·4%	4·05%	7·6%	30·4%	71%	29%	36%	20%	40%	30%
Twin Engine Machine Water Cooled	30·8%	23·7%	44·7%	·52%	·85%	·33%	3·4%	12·76%	6·65%	8·1%	25·7%	75%	25%	43·5%	6%	46%	48%
Single Engine Commercial Machine Water Cooled	31·7%	34·2%	40·6%	·55%	·72%	·75%	4·65%	8·92%	2·76%	6·85%	27·8%	72%	28%	40·5%	10%	46%	44%

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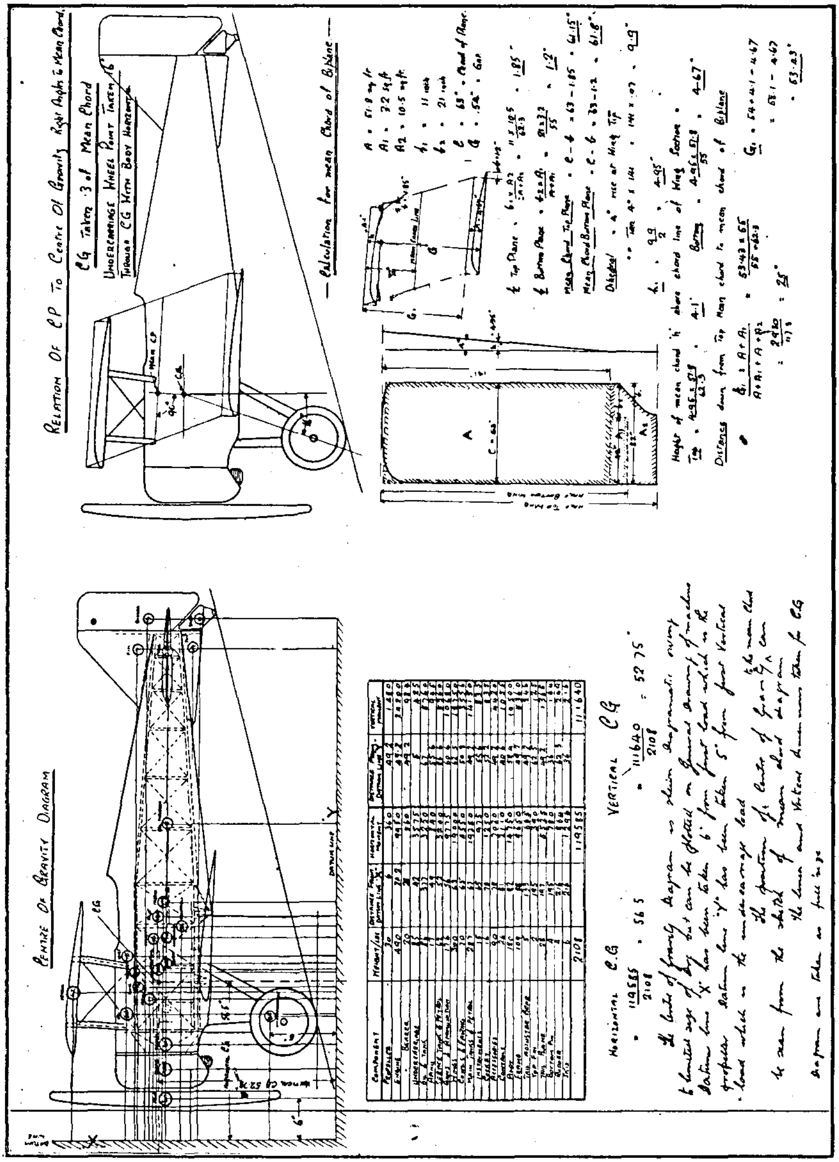

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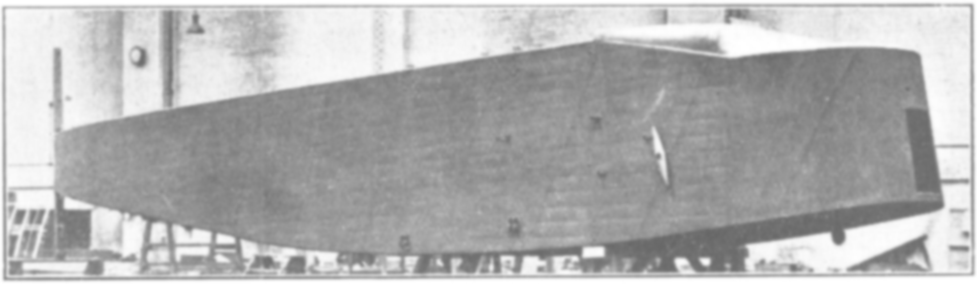

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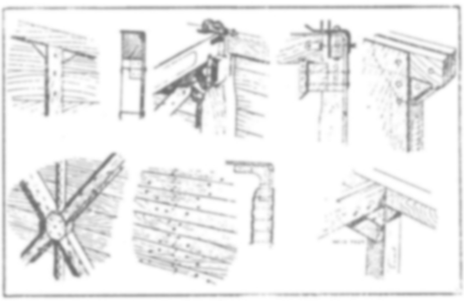

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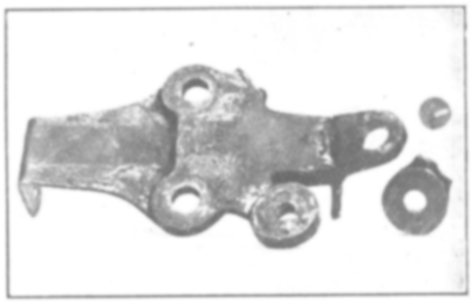

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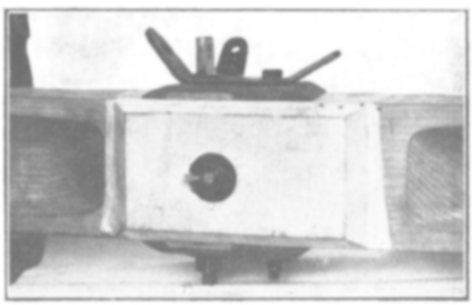

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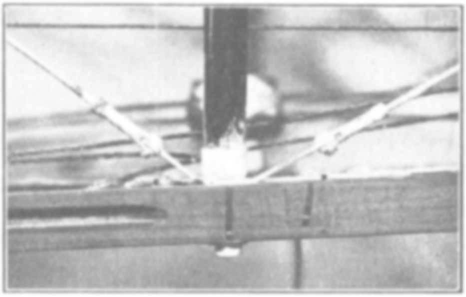

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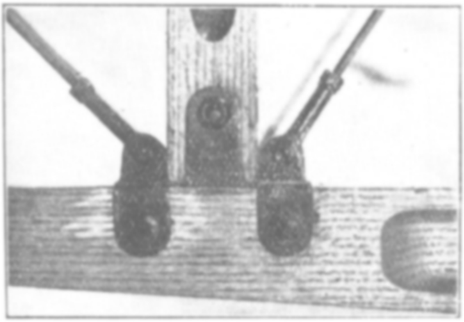

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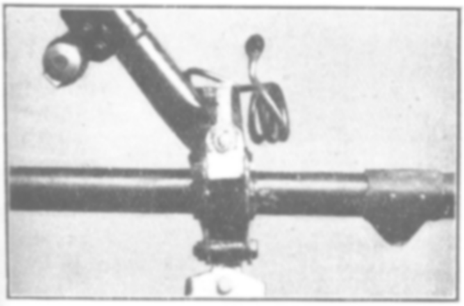

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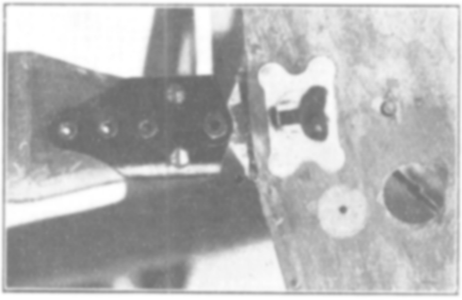

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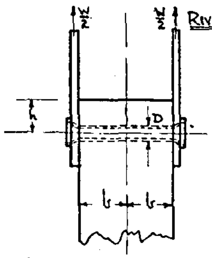
STRENGTH OF TUBULAR RIVETS.

RIVETS IN DOUBLE SHEAR.



$$W = \sqrt{9 \times f_c \times Z \times f_w \times D}$$

$$b = \frac{W}{f_w D}$$

$$h = \frac{W}{4 b \cdot f_{sw}}$$

WHERE f_c = COMPRESSIVE STRESS OF RIVET = 31,400 LBS/□″

f_w = COMPRESSIVE STRESS OF TIMBER = 5,500 LBS/□″

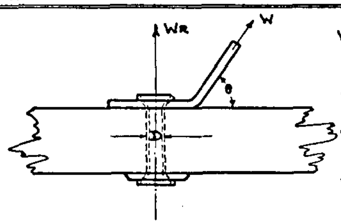
Z = MODULUS OF SECTION OF TUBULAR RIVET.

W = MAXIMUM PERMISSIBLE LOAD.

f_{sw} = SHEAR STRESS OF TIMBER = 400 LBS/□″

SIZE OF RIVET	Z	W.	b maximum	h minimum
3/16″ O.D. × 20 GAUGE	·00055	403 LBS	·39″	·7″
1/4″ " × 18 "	·00133	724 "	·53″	·9″
5/16″ " × 17 "	·00246	1100 "	·64″	1·1″
3/8″ " × 16 "	·0042	1560 "	·76″	1·3″
1/2″ " × 14 "	·00964	2750 "	1″	1·8″
7/16″ " × 16 "	·00616	2050 "	·85″	1·5″

NOTE:
IF PLATES PULL ON RIVETS AT ANY OTHER POINT THAN UNDER HEAD AS SHOWN THE LOADS GIVEN MUST BE REDUCED BY 15%.



WR = MAXIMUM PERMISSIBLE LOAD PARALLEL TO AXIS OF RIVET

$$W_R = W \sin\theta$$

$$W_R = \frac{f_T \times \pi \times D \times T}{2}$$

WHERE f_T = TENSILE STRESS OF RIVET = 31,400 LBS/□″

T = THE GAUGE THICKNESS OF RIVET

SIZE OF RIVET.	WR.
3/16″ O.D. × 20 GAUGE	332 LBS
1/4″ " × 18 "	590 "
5/16″ " × 17 "	865 "
3/8″ " × 16 "	1190 "
1/2″ " × 14 "	1980 "
7/16″ " × 16 "	1380 "

NOTE IN NO CASE MAY W × cos θ EXCEED 5 TIMES THE LOADS GIVEN ABOVE FOR RIVETS IN DOUBLE SHEAR.

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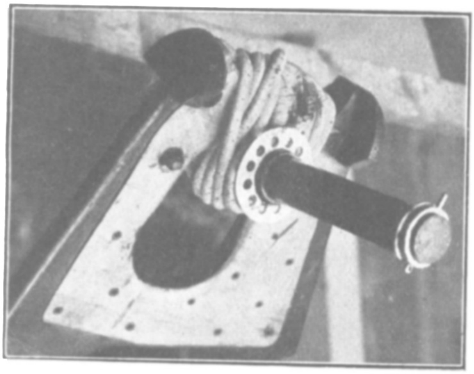

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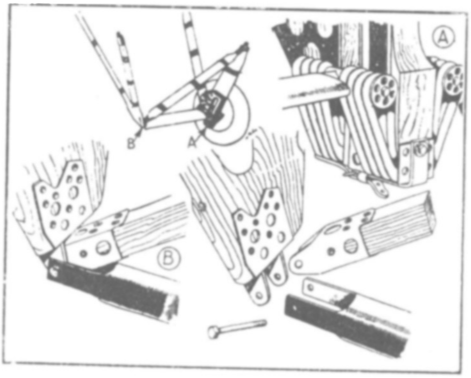

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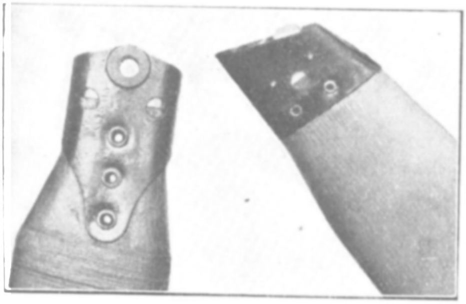

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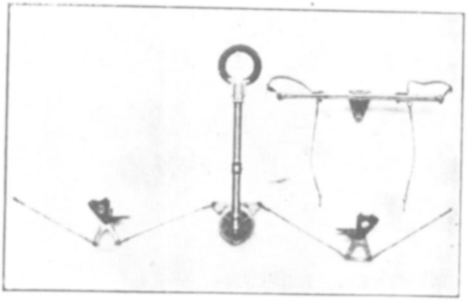

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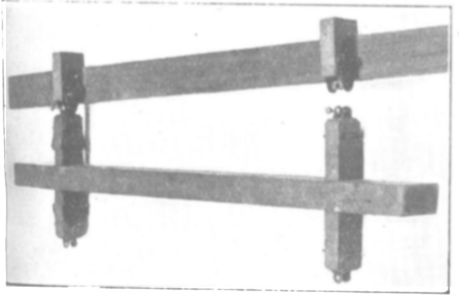

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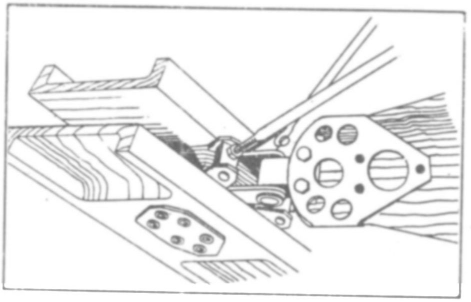

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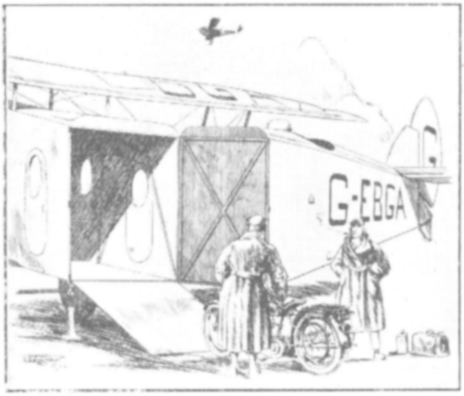

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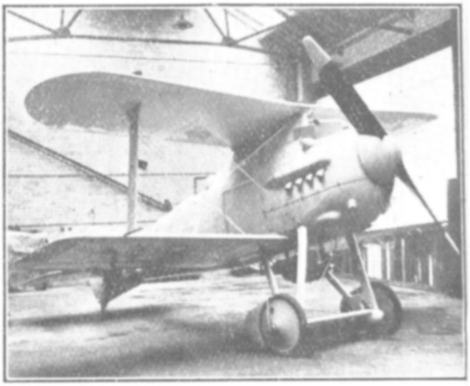

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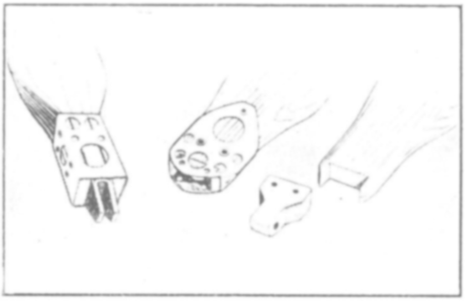

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