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No. 533

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HANDLEY PAGE METAL CONSTRUCTION

From Flight, May 9, 1929

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 533.

HANDLEY PAGE METAL CONSTRUCTION.\*

All-metal construction, as regards service aircraft at any rate, may now be said to be a "fait accompli" at the works of all British aircraft constructors who build airplanes for the Royal Air Force. For commercial aircraft, and more particularly for the smaller types, all-wood and "mixed" construction is still employed and is likely to continue to be used for some time to come. To those of us who have been privileged to follow in some detail and at fairly close quarters the transition from wood to metal construction as it has matured at the various British works, the last year or two has been a period of quite remarkable interest. When the Air Ministry first announced the change in policy, and issued the ruling that within a certain period no more aircraft not of all-metal construction would be accepted, there was, very naturally, a good deal of speculation concerning the forms of construction which the various firms would evolve. One or two, or possibly three or four, firms had done a considerable amount of experimental work before it became, one might say, compulsory to do so, and were thus regarded by many as being in a more favorable position in the matter of changing over entirely to metal. Other firms had had no experience whatever of all-metal construction, and were faced with

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very serious problems. It speaks well for the British aircraft industry that without a single exception the firms have proved themselves capable of overcoming their difficulties, and there is now not one British aircraft firm which has not produced very creditable forms of structural components in metal.

This is not the place for a discussion of the many problems which had to be solved, but as the uninitiated is liable to fail to recognize the magnitude of the task, it might not be amiss to call attention to some of the difficulties with which the British aircraft industry was faced. To begin with, the Air Ministry had no intention of standardizing any particular type or form of all-metal construction, although it might have done so on the score of economy. Presumably it was held - and probably quite wisely so - that too early standardization would hamper design and prevent full advantage being taken of any structural weight-saving which a thorough exploration of metal construction might bring with it. The saving of weight, it might be pointed out, was not the primary reason for the change to metal construction, but the problem of adequate supplies in time of war. By giving aircraft constructors a free hand in evolving their own particular methods, the Air Ministry caused a vast amount of experimental work to be carried out, and one result of this policy has been that we have now almost as many distinct forms of metal construction as there are aircraft firms. And apart from the advantage of adequate supplies, it has been found that the all-

metal airplane is invariably lighter than its wooden prototype. In some cases, the saving in weight is very material, in others perhaps less pronounced; but at least the change may be said in all cases to have been "on the right side of the ledger."

Apart from the experimental work involved in deciding upon various forms of construction, there was the cost of plant suitable for quantity production of aircraft in metal. In some cases firms have spent large sums of money on the equipment of their rolling and drawing plants. In others some very ingenious schemes have enabled constructors to produce the necessary sections, etc., with a very simple and cheap equipment. The problems were not made any easier by the fact that frequently a metal component had to be produced to take the place of a part which had hitherto been made in wood. This fact was doubtless responsible for determining, in very many cases, the type of metal component produced, which had to fit into certain over-all dimensions not necessarily the most advantageous possible with the newer material.

To add to the constructors' difficulties, workers who had become skilled wood-workers either had to be dismissed, or had, at a moment's notice, so to speak, to change their trade and become metal workers. Neither alternative was very desirable, but there was no choice in the matter. Trade Unions were naturally interested, and in one or two instances objected to wood-workers entering the field of metal workers. But taking it all

around, the British aircraft firms have shown not only great engineering skill in evolving new forms of construction, but also considerable tact and diplomacy in dealing with labor problems arising out of the change-over to metal.

FLIGHT has already published illustrated articles dealing with the forms of construction of several British firms. This week we are able to continue the series with the present article and sketches illustrating the forms of metal construction evolved by the engineers of Handley Page Ltd. So much has been written of the Handley Page automatic slots of late that one is somewhat apt to overlook the progress which the firm has been making in other directions, and it is therefore all the more interesting to find that metal construction is now in full swing at Cricklewood.

Unlike some British firms who have definitely chosen steel as their structural material, or others who have decided to concentrate exclusively on duralumin, in the construction of the latest types of Handley Page aircraft one finds both materials used; steel mainly in the fuselage and duralumin exclusively in the wings. In the following notes on Handley Page all-metal construction, reference is not made to any particular aircraft type, the constructional methods being common to several types, although differing slightly in detail. By way of showing that in the case of Handley Page airplanes the change-over to metal has also brought with it a considerable saving in weight, it may

be mentioned that in the case of one airplane - a fairly large one, admittedly - the metal version is 500 pounds lighter than the older wooden type.

To take the fuselage construction first, this makes use of circular section steel tubes for its material, and the joining of one member to another is by welding. In certain parts of the fuselage, where two tubes are joined together, such as, for instance, a longeron joint, the two tubes are butt-jointed and a sleeve is slipped over the joint (see Fig. 1). A series of holes is then drilled through sleeve and tubes, and the holes are welded up. It has been found that in this manner the actual weld forms almost a rivet inside the holes, except that the metals are fused together. Somewhere on the sleeve, in line with the butt, one hole is left unwelded for inspection purposes.

A form of joint which is really the basis for the whole fuselage construction is shown in Figure 2. The strut "socket" is formed from two pieces of sheet steel welded to the longerons at the ends only, and to this socket is welded the end of the strut tube. The assembled joint is as shown in Figure 3, and it will be seen that the longeron is held to the struts by the welds only. As, however, the angle of the bracing wires reduces the tendency for the struts to shift along the longerons, the welded joints on the latter are subject to shear loads only.

A different form of longeron joint is shown in Figure 4, which represents the case where a longeron is stepped down in

diameter. The larger tube passes through the sleeve, and the smaller goes inside it. The strut sockets are spot-welded to the longeron sleeve, and are joined to the struts by spot-welding through short internal sleeves. Yet a different type of joint, occurring towards the tail of a large airplane, is illustrated in Figure 5. Again the peculiar form of spot-welding is made use of.

On certain Handley Page airplanes the forward portion of the fuselage is built up of structural members of duralumin in order to reduce magnetic effects on compasses, etc. In such cases the longerons take the form illustrated in Figures 6 and 7. Two hollow-backed channel sections are placed back to back and riveted, the turned-over free flanges being very convenient for attachment of other members, etc. Incidentally, the same, or a very similar, hollow-backed channel section is used in the construction of wing ribs, of which more later. Figure 7 also shows the manner of attaching the rear end of a duralumin longeron to the forward end of a steel tube longeron.

In the wing construction duralumin is, as already mentioned, used exclusively, this material being used for spars, ribs, compression ribs and interplane struts. A typical Handley Page main wing spar section is shown in Figures 8 and 9, the latter showing the actual spar section. This is built up of two corrugated webs and two semicircular flanges, the joints being by riveting. The flats on the sides of the web corrugations facil-

itate rib attachments, etc. Where compression ribs occur, internal stiffening plates are used, of the form indicated in Figure 8.

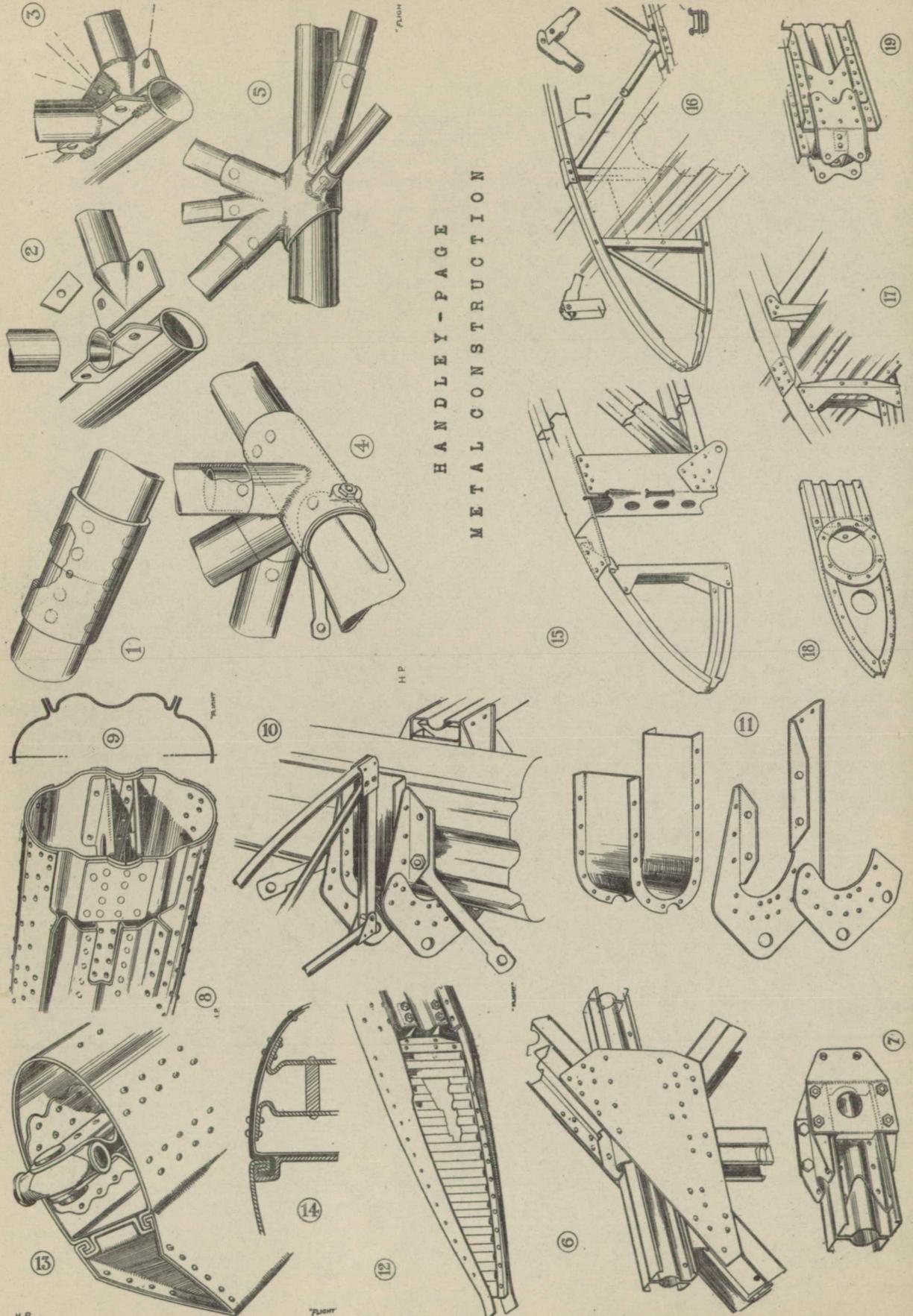
Having evolved a good type of spar, one of the problems that arises is always how one is to attach to it the fittings for interplane struts. The manner in which Handley Page, Ltd., have solved the problem is shown in Figures 10 and 11. It will be seen that simple flanged plates are used. Figure 10 also shows the attachment of wiring plates for lift and antilift wires. At the wing tip the spars are tapered off, the webs of the main spars being cut away and thin corrugated webs being substituted, as shown in Figure 12. The main top and bottom flanges are tapered off and continue right to the tip.

The interplane struts (Figs. 13 and 14) are built up of thick duralumin sheet drawn to section (as are also the wing spars, ribs, etc., no rolling being employed). The strut consists of a strong forward portion, a transverse internal web and a streamline tail fairing, the whole being assembled by a form of closed joint, as shown. Note should be taken of the trunnion in the strut end, which, in connection with the bolt through the fitting on the wing spar, forms a universal joint for the strut attachment, so that the joint can be used for a wide range of dihedral angles and stagger.

In the construction of the plain wing ribs extensive use is made of small channel sections for the flanges and circular sections for the braces (Fig. 16). These circular sections are made

from flat sheet with the edges turned over inside the tube thus formed. Compression ribs, and ribs taking heavier local loads than the normal ribs, have flanges and braces of the same section as used in the forward portion of the fuselage. Such a compression rib is shown in Figure 15, while a similar one (center-section rib) with a slightly different form of attachment, is illustrated in Figure 17.

Solid-drawn tubular duralumin spars are used in the stabilizer, and the tail ribs take the form shown in Figure 18. Plain channel sections are used extensively for minor components, and the manner of assembling them into a stabilizer compression strut is shown in Figure 19.



HANDLEY - PAGE  
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