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TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 570

"GLOSTER" METAL CONSTRUCTION

From Flight, April 18, 1930

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 570.

"GLOSTER" METAL CONSTRUCTION.*

We have not the space here to refer in detail to the history of the evolution of the forms of metal construction used by The Gloster Aircraft Company, Ltd.

From the first, Mr. Mooney and his colleagues showed a preference for steel as their structural material, and this preference is maintained by the Gloster Company, steel being the material used for all highly stressed parts, although the firm is not prejudiced to the extent of excluding light metals where these are considered to offer a better solution.

Crinkled strip was the beginning of efficient metal construction, and crinkled strip still remains the characteristically British way of giving stiffness to thin-walled sections under compressive loads. Modern technique has enabled the aircraft constructor to produce his various sections from the flat strip supplied by the steel manufacturer either in the heat-treated or untreated state. The practice at Gloster's is to obtain the steel strip from the manufacturer already treated. The Gloster plant at Brockworth includes both rolling plant and draw benches, the use of one or the other method being governed by the character of the particular member to be manufactured.

Some typical structural members are illustrated in the riveting along the curled edges. The rivets are easy to get at,

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and the riveted joint is some distance away from the region of maximum stress.

The designer of metal aircraft is faced not only with the problem of producing main spars which are simple to manufacture in themselves, but also with so designing them that other members may be attached to them in a simple manner without complicated fittings. A light type of rib, used in conjunction with the box spars is illustrated in Figures 4 and 5, and the manner of attaching such ribs to the spars by saddle plates is shown in Figure 2. The rib flange is of channel section, while the continuous girder is of V-section, with the edges turned over. The figures show how the rib bracing is attached to the flanges by riveting. Sometimes the stresses are such that certain lengths of the continuous girder web are in compression. Where that occurs, the web is locally stiffened by means of a sliding interlocking piece (Fig. 6). It will be noticed that the rib flange passes around the tubular leading edge without being broken. This is done by flattening out the channel section of the flange and introducing a small strap which secures the rib flange to the leading edge, as shown in Figures 8, 8a, and 9. The method of securing the tubular trailing edge to the ribs is shown in Figure 10.

Where a wing spar is subjected to heavy end loads, a diaphragm is introduced, as illustrated in Figure 3. The diaphragm is held in position by clips, the securing rivets being added when the spar is riveted up. Various ways of reinforcing a main spar section are illustrated in Figures 7, 7a, and 7b. The tubular distance piece takes the compression resulting from tightening up the bolt.

The attachment of the interplane struts and lift and anti-lift wires to the main spars is always something of a problem. The manner in which the Gloster Company solves the problem is shown in Figure 11a. A built-up tubular distance piece runs through the spar webs on the neutral axis of the spar section, the two halves of the distance piece being forced together by a bolt (see Fig. 11a). This bolt only holds together the male and female portions of the distance piece, and does not take the lift loads direct. On each face of the spar is a bent arm, machined to an L-section, the ends of which receive the bolt to which the lift and anti-lift wire is attached via a stirrup plate.

Where ribs are attached to a bent portion of the leading edge, such as at the rounded corners near the wing tip, a slightly modified form of leading edge clip is used, as shown in Figure 12.

Built-up interplane struts are employed by the Gloster Company, one form being illustrated in Figure 13. This consists of a front portion of steel, with a fairing of aluminum. The method of building up the strut will be clear from the figure. The ends of interplane struts are reinforced, as shown in Figure 14, a large-diameter bolt passing laterally through the reinforcing plates, to rest in the notch in the vertical spar bolt (Fig. 11).

The normal type of rib has already been described. Stronger ribs are used where local loads of considerable magnitude have to be carried. For example, a built-up box girder type of rib, designed to carry an aileron control pulley inside the wing, is illustrated in Figure 15, while a simple box rib composed of two normal ribs joined by cover plates at top and bottom is illustrated in Figure 17.

The normal main spar section is not continued right out to the wing tip, as to do so would mean deep and ugly wing tips. The spar is tapered off, as shown in Figure 16, and the wing tip tube attached to it by a clip.

The type of main wing spar illustrated in Figure 1 is employed in airplanes where the distance between supports is not great, such as in two-bay biplanes. Where a greater spar depth is available, owing to a deeper wing section, and where the distance between supports is considerable, the Gloster Company makes use of a lattice girder type of spar such as that illustrated in Figure 19. This type of spar has been found very economical in weight and relatively simple to manufacture, the number of rivets being small. Spars of this type are used, for example, in the Gloster survey airplane. It will be noticed that there are no diaphragms in the ordinary sense of the term. Instead of these, short struts of trough section are riveted to the outside of the spar. These struts also serve as supports for the wing ribs, which with this form of construction are built in three sections. The rib flanges do not run across the spar flanges, but short saddles are attached to the spars, the rib flanges being attached to these. The arrangement will be understood from a reference to Figure 20.

The type of rib which goes with the lattice spar is illustrated in Figure 18. This type of rib has flanges of channel section, but the channel has a slightly hollowed back, which at intervals is pressed outward in the opposite direction, as in the inset of Figure 18. The wing fabric is attached to the ribs by threading a long wire through these little "eyelets," a method of attachment which is both neat and strong, and avoids the usual method of vertical stringing. The building of the ribs in three pieces enables repairs to a damaged portion to be made quite readily in the field, as the damaged part can be removed and a fresh part substituted and attached by bolts and not by rivets.

In fuselage construction also the Gloster Company has evolved its own methods. Although the type of construction varies somewhat in different airplanes, bolted joints are always made use of, and not welded joints. As one example, one may take the forward portion of the survey airplane, in which square section tubes are used, the joints being by bolts and large fishplates, as in Figures 21, 22, and 23. A very neat way of introducing internal distance pieces to avoid crushing of the steel tubes when the bolts are tightened up is shown in Figure 24. The distance piece simply consists of a piece of flat metal strip, bent roughly to the form of a letter S. In the rear part of the fuselage circular section steel tube is used both for longerons and struts, and the method of joining them together is as illustrated in Figure 25. A sheet steel pressing is wrapped outside the longeron through approximately 90 degrees, and is formed with a lug for wiring and with a half-socket for the fuselage struts. Another pressing is placed on the inside of the joint, its flanges meeting those of the outside portion. An eyebolt passes diagonally through the longeron, securing the joint in place on the longeron as well as forming the anchorage for the transverse panel bracing wire (Fig. 26). The resulting joint is very simple and neat, and once the necessary dies have been made and a few sizes standardized, the joint must be a very cheap one in quantity production.

Having described and illustrated some of the main components of the Gloster Company's forms of metal construction, a few words concerning the workshop methods of the firm may not be without interest.

Reference has already been made to the fact that the works at Brockworth are equipped with both rolling mills and drawbenches. The latter are used, in addition to the production of small sections, largely for experimental work, the dies for a new section being a good deal cheaper than the corresponding rollers. The rolling mills are of a somewhat unusual type in that the roller spindles project from the sides of the main bed. This arrangement makes the rollers very accessible.

When the spar sections, ribs, etc., leave the rolling mill or the drawbenches, as the case may be, they are assembled into complete wings. Both sides of the wing can be got at simultaneously, and the workmen have the advantage of being able to work in an upright position. The jigs are so designed that all the main points of attachment, etc., can be accurately located, so that complete interchangeability is ensured. In the case of wings of very large chord the vertical jig might show less advantage, as the workers would then have to use some form of platform or scaffolding to reach the upper part, but for the type of wings for which they were designed, i.e., wings of normal proportions, the Gloster wing jigs impress one as being singularly effective.

When the wing assembly is complete, the wing is heated to a moderate temperature for two hours or so in order to remove any oil or grease that may cling to the surface of the steel. The complete wing is then dipped in an enamel bath, hoisted out and allowed to hang for a short time above the bath so as to let superfluous enamel drip off, and is then run into a large gas-heated oven and baked. The fuselages are not dipped as a whole, but each component is stoved in a similar manner in a smaller plant.

In the case of metal plate fittings, hardened master templates are made for each fitting on a machine. Care is taken that any bends in a fitting are of such radii as not to strain the metal, and hammering is avoided wherever possible by the use of special bending jigs and tools. All fittings are heat-treated to remove any internal stresses set up by working the metal, and all heat treatment is accurately controlled by the liberal use of pyrometers. In the case of high-tensile steels, test specimens are heat-treated with each batch of fittings, and tested for strength before the fittings are released for use on an airplane.

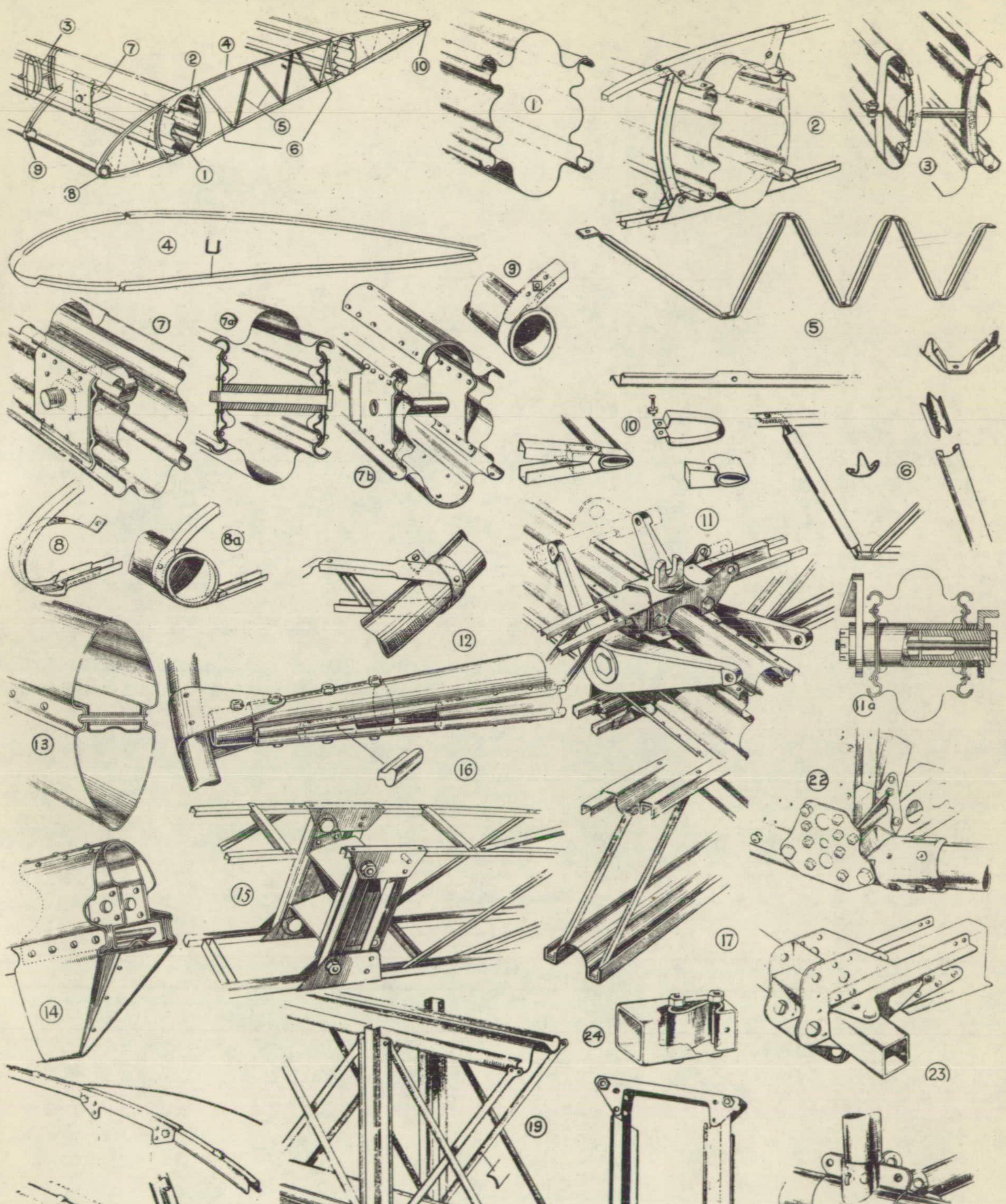
After heat treatment all fittings are shot-blasted. This treatment removes all scale and oxide, and leaves the surface quite clean, so that the subsequent inspection has the best possible chance to discover any flaws or cracks that may have been produced in the metal during working.

After passing this inspection, all fittings are baked in an oven to remove all traces of oil or grease, and to dry off any moisture that might linger between riveted surfaces. After leaving this oven the fittings are dipped in enamel and stoved at a temperature of 250° to 300°F.

So far we have dealt with Gloster steel construction only. Light metals are, as mentioned previously, employed for certain parts, and in their manufacture as great care is taken as in the case of steel components and fittings. In addition to certain parts of the secondary structure of airplanes, duralumin and aluminum are used for seaplane floats, tanks, fairings, etc., while the Gloster Company produces a special form of metal propeller, manufactured from duralumin. This type of propeller is machined from a substantial forging, twisting of the blades not being employed.

Protection against corrosion is sought by the process known as the anodic treatment, in which the article to be treated is placed in special baths, through which an electric current is passed. An oxide covering is thus formed, which being very hard and resistant to heat, weather, and salt water, protects the material underneath from contact with the air. For heat treatment where great accuracy of temperature is necessary, such as in normalizing duralumin, duplicate thermocouples are placed in the salt baths to warn the operator of any errors that may occur in the instruments themselves.

Figs.1 to 26.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