AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 119

THE "AVRO TRAINER" AIRPLANE (BRITISH)

A Training Biplane

Washington
June, 1930

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A Training Biplane.

Although the "Trainer" has scarcely a single dimension in common with the "504," the "family likeness" is quite striking. The two most marked changes are: the different shape of the rudder and the different landing gear.

This airplane is primarily intended for training purposes and the requirements of training have quite obviously been kept prominently in view throughout the design. Large, comfortable cockpits, good view, effective windshields, wide track are some of the features (Figs. 1, 3, 4) of the "Trainer."

Constructional Features

One of the innovations introduced in the "Avro Trainer" is that it is of all-metal construction (with exception of the fabric covering and the wooden fairings of the fuselage) in order to conform to the requirements of the Air Ministry.

In the "Trainer" fuselage the modern form of Avro welded tube construction is employed (Figs. 5,6).

Uniform stress is not easy of attainment in any aircraft structure, and the welded tube fuselage is no exception. In the "Trainer," however, an approach towards it has been made by

*From Flight, May 2, 1930.

having the longerons of three different diameters, largest in front, medium from cockpits to about halfway towards the tail, and smallest in the tail end. The smaller tube is inserted a short distance into the larger, and the joint is then welded. In the rear portion the typical Fokker type of structure is found only in the top and bottom bays, where small tubular quadrants are welded into the corners and the bays braced by a single wire looped over the quadrants and tensioned by a single turnbuckle. The side panels are strut-braced by welded-in struts running from the lower front corner of the panel to the upper rear corner. In the forward portion the strutting varies slightly, its arrangement being influenced by the fact that various weights, such as seats, controls, etc., have to be carried. For example, if it is found that the diagonal strut of a particular bay would not provide a support in the exact position in which it is required, the strut, instead of being plain straight, is given a "nick" in one side at the point where the support is desired to fall. The strut is then bent over to the required (usually fairly small) angle, and a second, shorter, strut is welded to it at the bend, the other being welded to one of the other corners so as to brace the bent strut. The explanation is a good deal more complicated than the actual job!

In one bay at least, the front one, the diagonal struts are duplicated, not by placing two side by side but by crossing them at their center, the free ends running to the four corners of the panel. The center of the X thus formed serves as a support for the telescopic strut of the landing gear. The welded joint at this point is reinforced with fingerplates, as shown in Figure 5.

On the front cross strut of the fuselage (i.e., the strut at the bottom of the fireproof bulkhead) occurs a joint which would be practically impossible with any form of jointing other than welding. No less than three Vees meet at this point on the center of the strut; a horizontal Vee of the bottom panel, a diagonal Vee, and a vertical Vee of the front vertical panel of the fuselage. Illustrations cannot convey the quality of welding demanded for such a joint to be possible, but Figure 4 shows the formation of the joint. Six struts meet the center of the horizontal member at various angles.

As is usual with metal fuselages, fairings are fitted over the main structure to carry the fabric covering in such a manner as to prevent it from touching the upright struts and thus form unsightly ridges. On the "Trainer" the fairings are somewhat unusual in that they are not light secondary structures permanently attached to the main structure, but units which can be easily removed to expose the main framework. These fairings are of wood, and the clips employed for attaching them to the longerons are particularly neat, as shown in Figure 6. The fairings of the rear portion of the fuselage are not intended to be frequently detached, and thus are secured by the clips referred to. They are, however, built as units, on jigs, and not assembled on the airplane. In the forward part the fairings are secured to the fuselage by quickly detachable fittings in the form of pegs and "safety pins." These units can be removed in a few seconds, and the fuselage structure, etc., is then open to close inspection.

At the forward end the fuselage terminates in a fireproof bulkhead which carries on its forward side the mounting for the engine (Fig. 2). At the rear the fuselage sternpost is formed by two vertical tubes side by side but slightly spaced laterally (Fig. 6). These two tubes are welded to the longerons top and bottom, and carry on brackets the spindles for the worm of the stabilizer trimming gear. The rear ends of the longerons themselves carry two split collars, one at the top and one at the bottom, which clamp tightly and secure the vertical tube of the fin. To this tube is hinged the main tube of the rudder.

The Wings

As already mentioned, the wings of the "Avro Trainer" are of all-metal construction with exception of the fabric covering. The wing section is one of the "generated" type, with an almost stationary center of pressure, i.e., with its center line having a slight reflex curvature (Fig. 2). The main wing spars are of high-tensile steel strip, and consist of a single web and two bulbous booms, riveted to the web by "pop rivets."

The spar section and construction are illustrated in Figure 7.

The present Avro procedure in building steel spars is to purchase the strip already heat-treated, and to form the bulbous booms, corrugated web, etc., by rolling. Owing to the greater "springback" of the hardened strip, the rolling process is perhaps slightly more difficult than is the rolling of the softer strip, but the necessary plant for heat treatment is saved. The Avro type of spar appears to be a very simple affair to manufacture, consisting of but three separate strips, and the number of rivets required is relatively small.

The attachment of interplane struts, wing-bracing wires, etc., to a metal spar is always something of a problem. In the "Avro Trainer" the strut attachment is simple, consisting of a plate on each side of the spars, and a saddle piece on top of the spar as shown in Figure 7. Liners are inserted in the booms at these points to receive the necessary bolts, etc. The ribs are one-piece pressings, and the shape of one of the lightening holes, that immediately behind the rear spar, is so chosen that the tail end of the standard rib can be used as the Frise aileron rib. The method of mounting the Frise ailerons is rather neat. A bracket on the rear spar carries a short length of oval section tube, which projects horizontally rearwards. The ball bearing hinge on the aileron carries a similar forwardly projecting arm of oval section. This is, however, slightly smaller than the tube attached to the rear spar, so that it enters the latter in the form of a telescopic joint. On assembly the exact distance between leading edge of Frise aileron and rear spar can thus be chosen and the telescopic tubes bolted together, with the assurance that the clearance between wing and aileron is exactly that desired.

The attachment of the lower wings to the fuselage is by means of drop forgings of the shape illustrated in Figure 5. The cross tube of the fuselage at this point is reinforced, and tensile stresses are transmitted from the wing lug to the cross tube without stressing the welded joint. The fittings carry lugs for the attachment of the seaplane landing gear struts.

The landing gear of the "Avro Trainer" is of wide track with a long travel and good shock-absorbing qualities. The telescopic legs, with compression rubbers and oil damping, are stiff enough to let a pupil know when he has made a bad landing, although probably no damage will be done to the airplane. The tail skid is nonswivelling, and consists of a leaf spring carrying a cast-iron shoe (Fig. 8).

Like the fuselage, the tail surfaces are made of welded steel tube. The stabilizer is provided with a worm and wheel trimming gear, but extra range of adjustment is obtained by providing the stabilizer leading edge with two short vertical stubs which rest in sockets on the top longerons. By means of holes drilled through stubs and sockets, the stabilizer angle can be adjusted when the airplane is on the ground, within wide limits, the trimming of the rear spar not being affected.

The Armstrong-Siddeley "Mongoose" is the standard power plant, but if the airplane is required for work from an airport situated at a considerable altitude, an Armstrong-Siddeley "Lynx" can be fitted instead (Fig. 9). The engine is supported on a tubular structure from the four front corners of the fuselage, from which it is isolated by a fireproof bulkhead. The engine ring itself is of channel section (Fig. 10). The gasoline tank (of 30 gallons capacity) is mounted in the deck fairing, which position is high enough to give direct gravity feed (Fig. 2).

Layout of Cockpits

Very great care has been taken in planning the layout of the cockpits. Both are not only identical in size, but the controls, instrument arrangement, etc., are the same in both, so that a pupil changing from one cockpit to another will at once feel at home, and will not be in danger of having to fumble about, in an emergency, for any control or switch. Owing to the heavy stagger of the wings, both cockpits are well clear, and both occupants have a good chance of using their parachutes.

The cockpit floors (Fig. 6) are of duralumin, and the controls, with the exception of the actual control sticks and foot bars, are covered in by a tunnel-shaped raising of the floor, along the center line. Behind the aft cockpit there is a slight drop from cockpit floor to the bottom fairing, so that any dirt which has collected can be swept along and dropped through a small trapdoor.

The inside of the fuselage structure is lined with leatherette and only a few controls, etc., project through this into the cockpits, so that the latter are entirely without that conglomeration of struts and other structure members which has been the rule in cockpits of airplanes hitherto. At the same time the detachable fuselage fairings enable the structure to be examined quite readily whenever it is desired to do so.

The controls are of normal type, but a very neat adjustment is provided for the foot bars to suit pilots of different heights (Fig. 2). This adjustment, made by means of a small wheel operating a worm, can be made during flight quite easily. Of controls which are not quite standard yet, reference may be made to the locking arrangement of the Handley Page slots. A sliding bolt arrangement on the starboard side enables the instructor to lock the slots and to unlock them again during flight.

An exhaust heated cockpit is a boon for work in winter, or for flying at considerable altitudes, and in the "Avro Trainer" this takes the form of a duct along the side of the control tunnel on the floor, the hot air entering through openings near the feet of the occupants.

C h a r a c t e r i s t i c s

"Mongoose" Engine

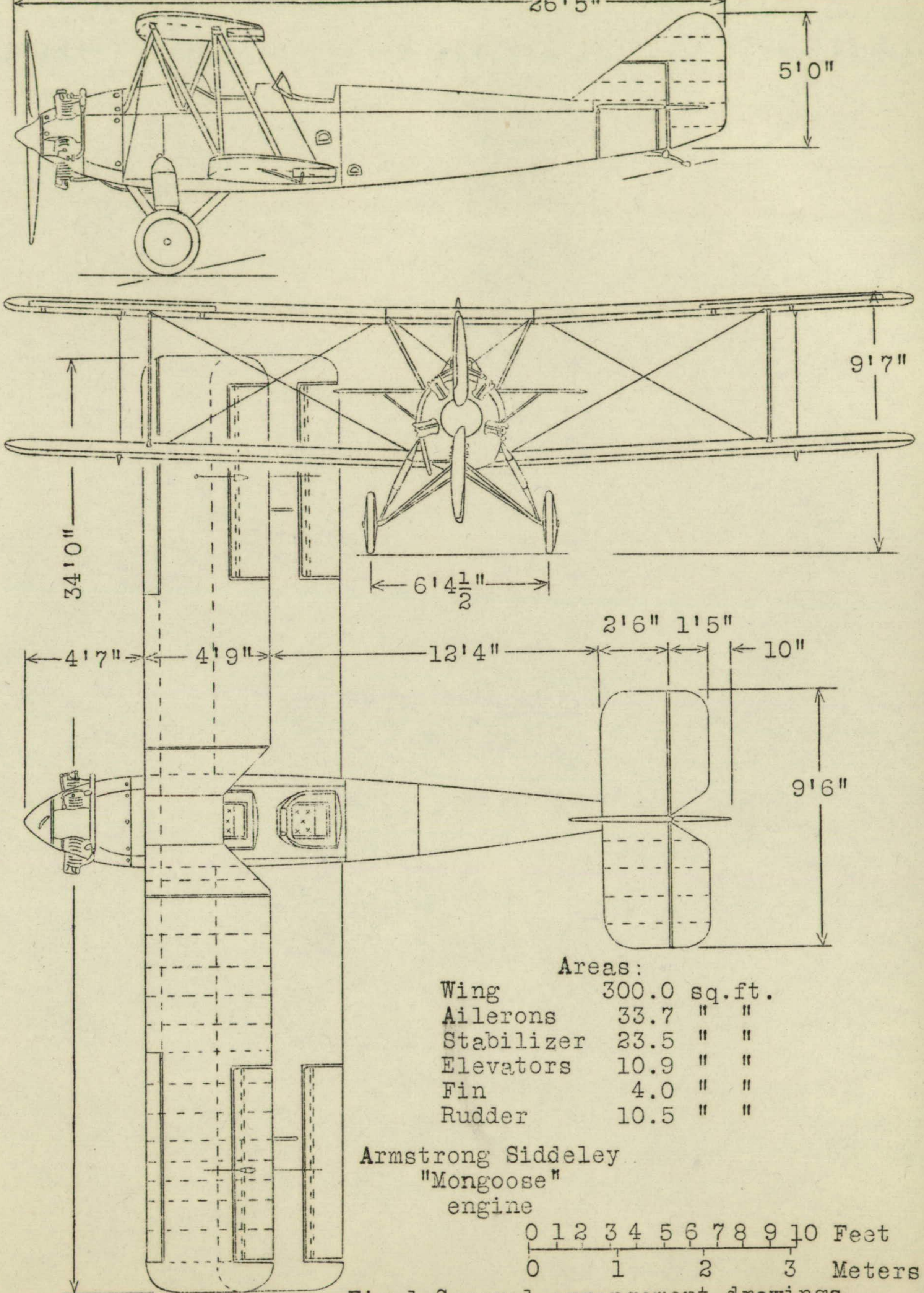
Length, over-all	8.1 m	26 ft. 7½ in.
Wing span, top & bottom	10.36 "	34 " 0 "
Wing chord, " " "	1.45 "	4 " 9 "
Total wing area, including ailerons	27.9 m²	300 sq.ft.
Tare weight	685 kg	1508 lb.
Gasoline (30 gal.)	104 "	228 "
Oil (3 gal.)	13.6 "	30 "
Pilot, pupil & equipment	205 "	452 "
Total load carried	322 "	710 "
Total loaded weight	1008 "	2218 "
Wing loading	35.8 kg/m²	7.4 lb./sq.ft.
Power " (on max.)	6.1 kg/hp	13.43 lb./hp
" " (on normal)	6.7 "	14.8 "

Performances

Maximum speed, ground level	177 k.p.h.	110 m.p.h.
Maximum speed at 5000 ft.	175 "	109 "
" " " 10000 "	158 "	98 "
Cruising speed	153 "	95 "
Landing "	74 "	46 "
Rate of climb (initial)	3.43 m/s	675 ft./min.

Time of climb to 305 m (1000 ft.)		1.54 min.	
" " " " 1525 " (5000 ")		9 "	
" " " " 3000 "(10000 ")		25.1 "	
Service ceiling	3780 m	12400 ft.	
Absolute "	4420 "	14500 "	

Everling "High-Speed Figure" $\frac{\eta}{2k_D} = 16.5$



Areas:

Wing	300.0	sq.ft.
Ailerons	33.7	" "
Stabilizer	23.5	" "
Elevators	10.9	" "
Fin	4.0	" "
Rudder	10.5	" "

Armstrong Siddeley "Mongoose" engine

Fig.1 General arrangement drawings of the "Avro Trainer" airplane.

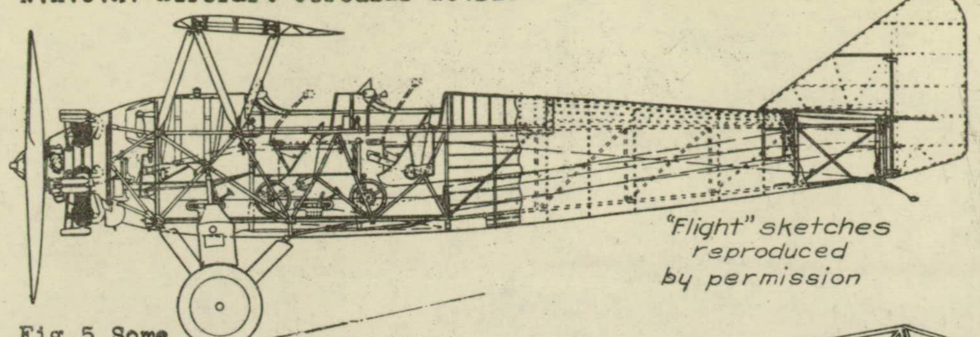


Fig.2 This part-sectional elevation of the "Avro trainer" airplane, shows the general characteristics of the structure and the placing of seats, etc.

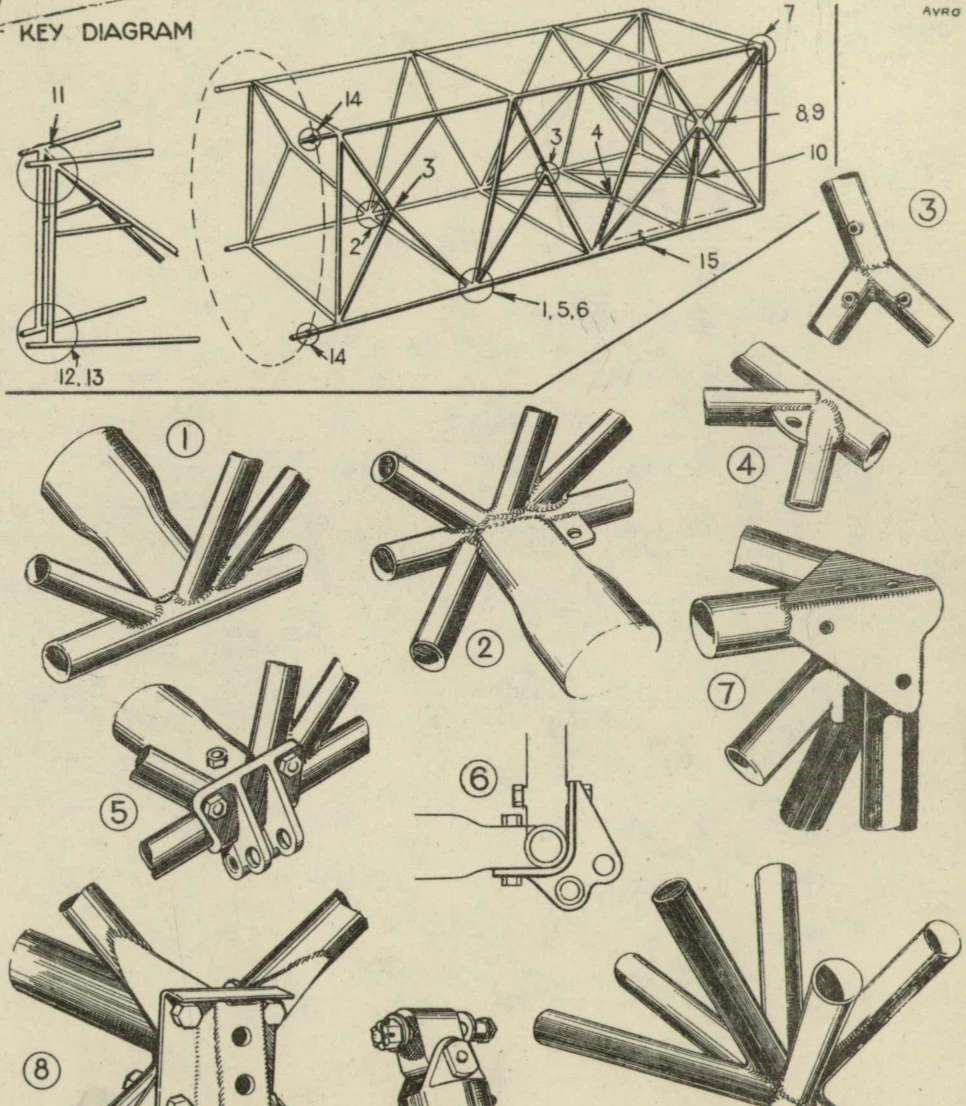


Fig.5 Some constructional details of the fuselage. The locations of the different joints, etc are shown in the key diagram. 1 & 2 are inside and outside views of the cross-tube joint on lower longeron at point where wing spar is attached. The cross-tube is reinforced internally. 3 shows a "Y" joint, formed by giving the main tube a "nick", bending and welding it, and welding to the joint a second tube to steady the first at the bend. Another welded joint is shown in 4. 5, & 6 show the lug (forging) by means of which the lower wing spars are attached to the lower longeron. This lug is attached to joints shown in 1 & 2.

The joint at the top front corner of the fuselage is illustrated in 7. The fireproof bulkhead and engine mounting is attached here. The telescopic leg of the landing gear is attached to the point of intersection of two cross tubes, by the form of lug shown in 8, the top of the landing gear leg itself being shown in 9. On the bottom cross-tube in the front of the fuselage the assembly of no less than three vees meet in a welded joint as shown in 10.

Fig.3 Three-quarter front view of the "Avro Trainer" airplane.The fabric fairings are made as detachable units to facilitate inspection of the fuselage structure. *"Flight" photographs reproduced by permission*

Fig.4 In this three-quarter rear view,possibility of jumping by parachute from either cockpit is well brought out.

Fig.6 More fuselage details. 11,12 & 13 are dissected views of the sternpost, which is formed by two vertical tubes. The upper fitting for the tail trimming gear worm and wheel is shown in 11,and the lower,welded-on bracket at 12.To the ends of the longerons are welded split collars which carry the fin post,as shown in 13. The rudder is hinged to the fin post and carried on ball bearings. The casings over these bearings contain felt pads soaked in lubricant.The wooden fairings are attached to the longerons by neat clips,as shown in 14. The duralumin floor of the cockpit is supported as in 15. Lighter controls such as throttles,tail trimming gear,etc.,are mounted on the fuselage tubes by a neat clip like that illustrated in 16.

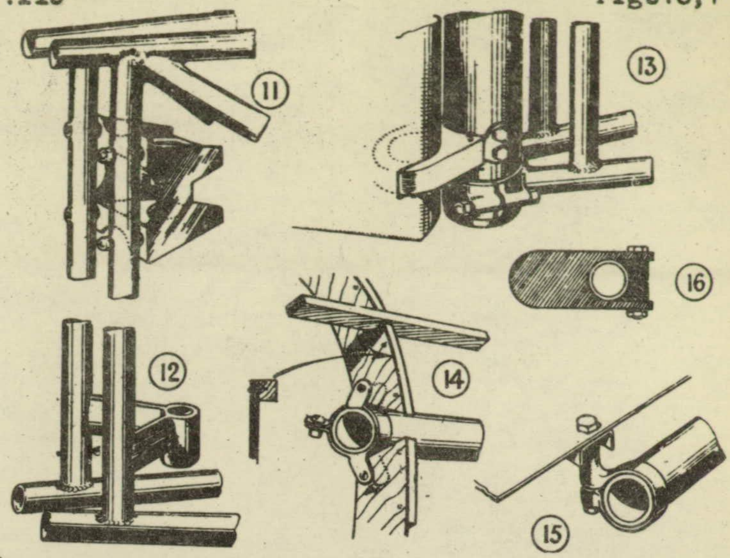
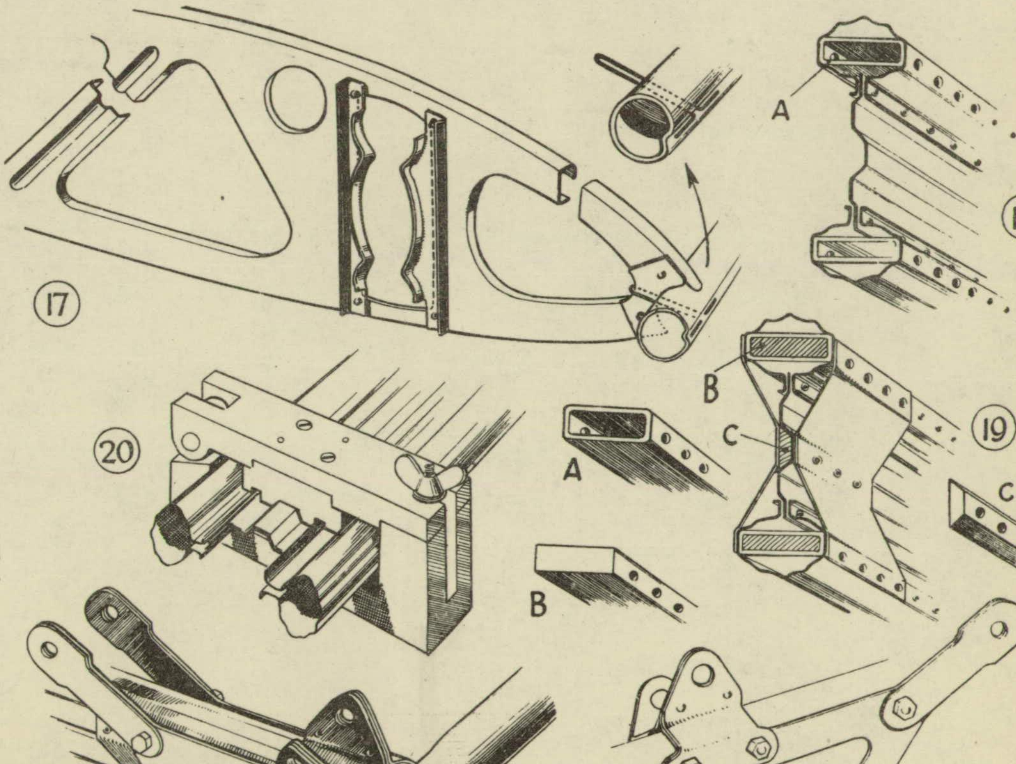


Fig.7 Some wing details of the "Avro Trainer". The rib construction is illustrated in 17.A main spar section is shown in 18.Note the flattened tube and aluminium block reinforcement of the spar booms for attachment of interplane strut fittings. Further details of this are also shown in 21 & 22. 20 shows one of the jigs used while riveting up the spars.



"Flight" sketches

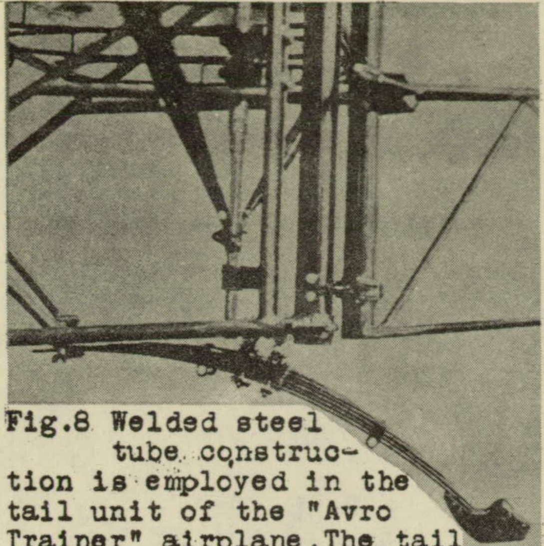


Fig.8 Welded steel tube construction is employed in the tail unit of the "Avro Trainer" airplane. The tail skid is a leaf spring, carrying a chilled cast iron shoe.

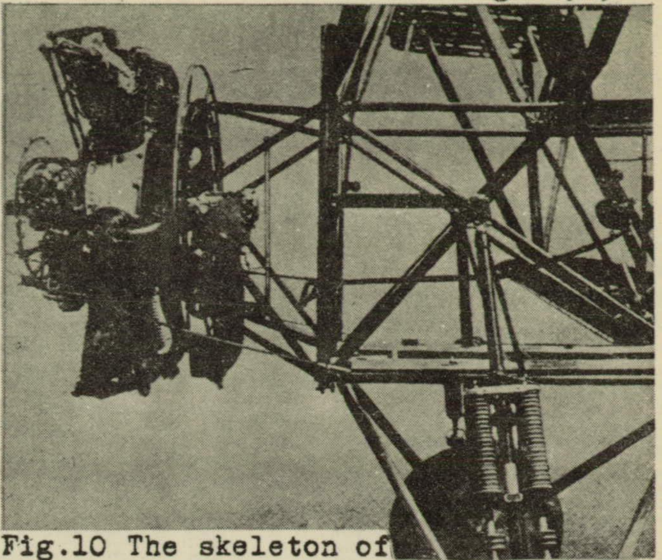


Fig.10 The skeleton of the "Avro Trainer" nose, showing engine mounting, etc. *"Flight photographs"*

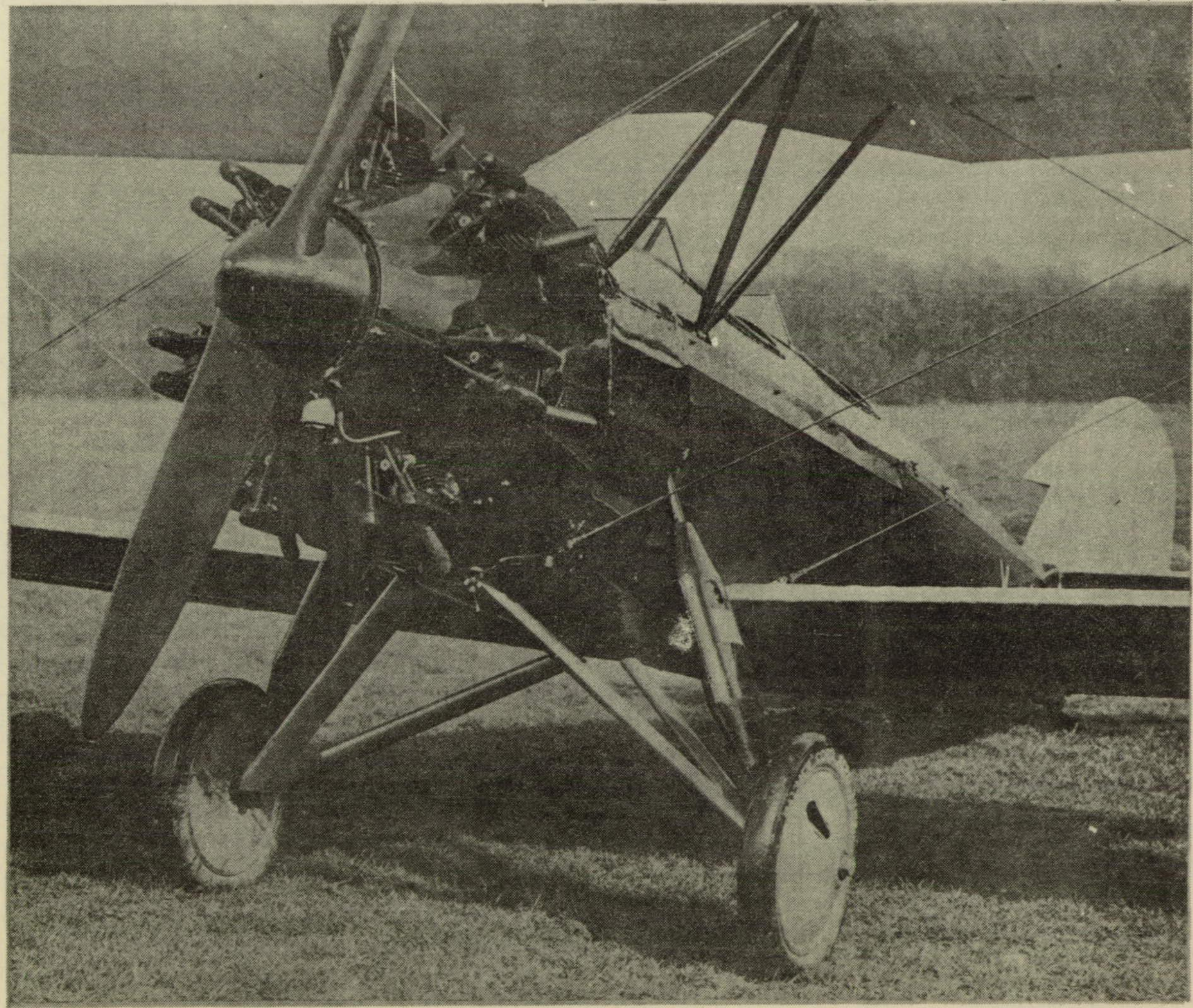


Fig.9 An alternative power plant. The "Avro Trainer" fitted with "Lynx" engine.