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AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 167

ARMSTRONG-WHITWORTH A.W. XV "ATALANTA" AIRPLANE (BRITISH)

A Commercial Multiplace Cantilever Monoplane

Washington
August, 1932

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A Commercial Multiplace Cantilever Monoplane

Extremely careful streamlining is the main feature that impresses one when first confronted by the "Atalanta." The designers started by selecting the cantilever monoplane type of wing arrangement. (Figs. 1, 2, 3, and 4.) They then decided to place the four engines in the leading edge of the wing, and to fair them into the wing surface with as gradual a change of section as possible. The fairings extend, in fact, very much farther aft on the wing surfaces than we recollect ever having seen before, and the result is a very gradual merging of the engine nacelles into the wing covering. (Fig. 5.) The engines themselves have been fitted with drag-reducing rings, so that everything possible has been done to get rid of all avoidable drag. As an instance of the degree to which drag has been reduced, it may be mentioned that "interference drag," which is the term used to express the extra drag which often arises where two components of an aircraft join each other, is nil. In other words, the drag of the whole airplane is the sum of the drags of its components, and not, as is very often the case, that sum plus something extra which represents interference. Much work has been done in the Armstrong-Whitworth wind tunnel on models of the "Atalanta," and the low drag achieved is largely to be attributed to the wind-tunnel work.

Having disposed of their four engines in the leading edge of the wing, and having faired them as carefully as might be, the designers set to work on the landing gear. (Fig. 6.) In the average airplane the landing gear accounts for anything from one-sixth to one-quarter of the total drag of the airplane, and yet it is in use for a few minutes only at the beginning and end of each flight. If it could be suppressed altogether it would vastly increase the flying economy of the aircraft. Unfortunately, that cannot be done at present. The alternative is to make it disappear into some other part of the aircraft when once in the air. That, however, is accompanied not only by a

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good deal of weight, but also by considerable extra complication. In the A.W. XV the designers have adopted a most ingenious method in that the whole of the telescopic leg, and two-thirds of the wheel axle, is housed inside the fuselage fairing. To make this possible and still retain a reasonably wide wheel track, the wheel is carried overhung on the axle, the outer portion of which is working as a cantilever beam of some 2 feet in length. Such an arrangement demands an axle of rather unusual construction, and in the A.W. XV the axles are very substantial members, in the form of double cones.

On the fuselage corner is a fairing root, inside which the axle moves. On the axle is a corresponding fairing, secured to and moving with the axle. When the airplane is standing on the ground, and the weight is on the wheels, the fuselage fairing root and the axle fairing are displaced relative to one another, so that there is a break in the fairing. As soon as the airplane is in the air, however, and the load is off the wheels, the wheels and their axle fairings sink to the level of the root on the fuselage, and the whole thing is perfectly streamlined. The wheels themselves are partly enclosed in large streamline "spats," so that the total drag of the landing gear should be very small, indeed.

The wheels are Dunlops, fitted with Palmer brakes, and are carried on axles hinged on the center line at the bottom of the fuselage and sprung by telescopic struts running to the top corners of the fuselage. The axles are forgings which taper in form and thickness, and which are, moreover, bent at the outer ends to bring the wheels vertical. The manufacture of the axles must have presented some rather pretty problems.

The radius rods are sheet steel members, each being built up of two channels, back-to-back. They act at the same time as torque rods for the axles. The tail wheel is a low-pressure Dunlop, and its mounting is shown in Figure 7, in which may also be seen some of the details of the tail-trimming gear.

The fuselage itself, although flat-sided, is of very good form and should have a low drag. The wing, which is in three sections, rests on top of the fuselage, and here, again, care has been taken to merge its top surface into the roof of the fuselage.

Control surfaces of orthodox design are employed, Bristol-Frise balances being used on the ailerons, horn balances on elevator and rudder. In addition to its horn balance, the rudder is provided with a servo rudder (fig. 8), which forms the trailing edge of the main rudder instead of being carried on outriggers away from the rudder. The arrangement of the servo rudder is unusual and interesting. When the "Atalanta" was first flown, it was discovered that for small angles of rudder movement the servo rudder gave too much control. The effect of this was that when the airplane was flown "feet off" it had a tendency to yaw slightly, first to one side and then to the other. The manner in which this difficulty was overcome is rather ingenious.

In large airplanes the "weight" on the rudder can become quite considerable, and for long flights would soon tire the pilot, even were he able to put the rudder over to its full extent for short periods. The servo rudder is an auxiliary surface, placed either on outriggers behind the main rudder, or hinged, as in this case, to the trailing edge of the rudder itself. The servo rudder moves in opposite sense to the main rudder, i.e., when it is desired to set the main rudder over to the left for a left-hand turn, the servo rudder is moved to the right. The small force on the servo rudder acts on a long "lever arm," and owing to its distance from the main hinge, has the power to overcome the main rudder which, although its area is much greater, acts on a much shorter "lever arm."

In the "Atalanta" the device adopted so successfully for overcoming the "over ruddering" at small angles is as follows: The control wires from the rudder cranks (which are hinged to the rudder and not rigidly attached to it as in direct-operated rudders) to the servo rudder cranks are left just a little slack. Springs are inserted in the wires from the rudder cranks to the main rudder. For small angles of rudder movement, while the load on the main rudder is small, the springs are not extended, and the rudder is, in fact, operated direct. When the rudder angle increases to such an extent that the load on the rudder is sufficient to stretch the springs, the slack in the servo rudder wires is taken up and the servo rudder comes into operation. From then until the maximum rudder angle is reached, the operation is via the servo rudder.

Further to smooth the rudder action and also to enable the airplane to be flown without undue fatigue when one engine stops, a friction device is incorporated in the pilot's foot bar. The friction of this is adjustable, and can be set to be just sufficient to hold the rudder over against any engine combination.

The internal accommodation of the "Atalanta" has been designed with a view to dividing the pay load approximately evenly between passengers and mails. For the African service there will be seating accommodations for nine passengers only, but the mail compartment, which is under and behind the pilot's cockpit, is large enough to accommodate something like a ton of mail. (Fig. 9.)

The cockpit is one of the roomiest ever seen in heavier-than-air aircraft, and the view, due to the position of the cockpit in the extreme nose of the fuselage, and the absence of a central engine is remarkably good. Right across the front of the cabin, in front of the pilots, is a large instrument board with a wonderful array of instruments. Those which require constant observation are placed at the port end of the instrument board, under the eyes of the chief pilot, while those which need less frequent reading are placed on the right, in front of the second pilot.

The ailerons are operated by "kidney-shaped" wheels to give an unhindered view over the wheels, and the brake lever which operates the wheel brakes is placed centrally, within reach from both seats. Sidewise movement of the brake lever applies the wheel brakes differentially.

The four main throttle levers are placed centrally, also within reach of both pilots, while on the left side of the left seat are the four cocks which turn on and off the gasoline at the carburetors. The cocks for turning the gasoline on and off at the tanks are on the rear wall of the gangway over the mail compartment.

The wireless operator occupies the space in the cockpit just behind the pilots.

Two air-speed indicators are fitted, the Pitot tubes being mounted side by side under the belly of the front portion of the fuselage. One would imagine that this position might be somewhat exposed, when the airplane is being taxied on rough ground, or in long grass.

Another mild criticism is the low clearance between the belly of the fuselage and the ground.

STRUCTURAL DESIGN

Interesting as is the A.W. XV from an aerodynamic point of view, it is no less so when examining the internal structure. In other words, there is something very "finished" about the A.W. XV structure in an engineering sense.

THE FUSELAGE

Generally speaking, use is made in the A.W. XV airplanes of steel strip formed into open-channel sections. The actual sections differ slightly according to where in the structure they are used, but the general principle remains the same, i.e., open-channel sections placed back-to-back. In Figure 10 is a sketch of the general layout of the primary structure, with the various types of sections used, the letters referring to Figures 11 to 15, showing how very simple the joints are, the primary structure having been designed not only to give a form of construction which makes all rivets, etc., very accessible, but also to provide simple joints where two or more members meet. Over the cabin portion the longerons and diagonal struts are formed by two channels back-to-back, and the flanges are steadied by distance plates spaced at intervals of a few inches. The struts are attached to the longerons by simple flat plates, the resulting joints being very simple and light.

The rear portion of the fuselage has longerons and vertical struts, the latter being of the section shown in sketch D. (Fig. 15.) Bracing is by R.A.F. wire, and is made very strong by being duplicated, so that it has been possible to dispense with wire bracing in the transverse panels. The extreme tail end of the fuselage is a separate unit, making three in all for the fuselage.

The secondary structure of the fuselage is mainly of wood, the covering over the cabin portion being three-ply carried on light stringers secured to the steel structure by wood screws. Over the rear portion of the fuselage the covering is fabric. This is carried on the four corners only, which are well rounded and formed by aluminum sheet. There are no stringers, but the fabric is taped on at intervals.

THE WING

A Göttingen 387 airfoil is used. An unusual combination of materials has been chosen for the wing structure. (Figs. 16, 17, 18, 19, and 20.) The two main spars are steel girders, and the wing ribs are of wood, except over the central portion, where concentrated loads are caused by the mounting of engines, gasoline tanks, etc., on the front spar. The wing covering is plywood. For ease of transport the wing is built in three portions, and use has been made of taper cones at the joints to prevent any possibility of play and rattle developing.

The main wing spars are, as already mentioned, steel girders. They are built up from steel strip formed into channel sections, and some of the details are indicated in the figures. The rear spar has its top and bottom booms joined by a series of plain X formation struts, while the front spar, which has to carry the loads of engines and tanks, has its bracing members arranged with vertical struts alternating with X's thus: XIXIXI . . . .

The tailplane is a pure cantilever structure, and the front spar is carried on two adjustable points, one on each longeron. This form of mounting has resulted in a very rigid structure, a necessity when it is remembered that the tailplane spars are cantilever beams.

A feature not illustrated but worth mentioning, is that the floor of the cabin has been built as a complete unit. The floor itself is of fairly thin plywood, carried on a wooden grid having cells of some 6 inches square. The whole is braced by a system of duralumin girders underneath, the girders being "buried" in the bottom fairing of the fuselage.

A great deal of trouble has been taken to reduce noise in the cabin, the space between the outer plywood covering and the inner walls being liberally lagged with kapok.

THE ENGINE INSTALLATION

The power units of the A.W. XV are "Double Mongoose" engines of a normal power of 340 hp. This engine is of the two-row radial air-cooled type, with five cylinders in each row. It is of the moderately supercharged type, and develops a maximum of 375 hp at 2,200 r.p.m. and at an altitude of 4,500 feet. The normal power is developed at 2,000 r.p.m. and at 4,000 feet. (Fig. 21.)

The engines are mounted on the front spar of the wing in the manner shown in Figure 16. It will be noted that the mounting is very "open," so that access to the back of the engines is facilitated. The spacing is fairly wide apart, so that, should it at any time be decided to fit geared engines requiring larger propellers, the space to do so is available.

The arrangement for starting the engines is interesting. Each inboard engine is fitted with a Herzmark compressor, driven at engine speed and pumping at a pressure of 275 pounds per square inch. From the two air bottles there is a connection to a Viet auxiliary hand pump, from which the supply reaches the distributors. The air in the two bottles is also used for operating the wheel brakes, the pressure required here being 100 pounds per square inch.

Ignition is by 10-cylinder B.T.H. magnetos, and the fuel mixture is supplied by a Claudel Hobson carburetor, type A.V. 80 A.

The gasoline is carried in tanks in the leading edge of the wing, but in spite of this, simple gravity feed suffices. There are two tanks, one on each side, placed between the two engines on that side and normally supplying them. It is, however, possible to supply all four engines from either tank by opening the equalizing cock in the gasoline system. When this is done, and if one engine stops, the other three are supplied from both tanks. It has been found that a sufficient supply is provided when the fuselage is horizontal, and as the airplane is not likely to climb steeply for long periods under these conditions, the arrangement is considered satisfactory. The tanks are fitted with electric gauges to indicate contents.

The oil tanks are shaped to the form of the wing leading edge, and act at the same time as oil coolers. Hot oil crosses the tanks in pipes in which are drilled small holes, so that the hot oil is squirted in fine jets against the inside walls of the tanks and there cooled before being allowed to drain down into the bottom of the tanks.

The table of characteristics shows that the certificate of airworthiness covers a gross weight up to 20,000 pounds. As the tare weight, i.e., weight of the airplane completely equipped, with cabin furnishings, etc., but without load, crew, fuel or oil, is 13,940 pounds, we obtain a ratio of gross weight to tare weight of 1.435. Put in a different way, the airplane carries as disposable load, 43.5 per cent of its own weight.

Comparisons of airplanes on this basis are always apt to be a little doubtful, since the definition of tare weight is somewhat vague. In this case, however, the tare weight includes everything; in other words, the weight of the airplane in full flying trim, but without any of its disposable load. The ratio of 1.435 may appear slightly low, but it should be remembered that, for one thing, the airplane is a cantilever monoplane, and also that it is designed to have a rather large power reserve, which is merely another way of saying that it carries a considerable surplus of engine weight as well as engine power. Taking these considerations into account, and remembering also that the airplane is quite a large one, the ratio of gross to tare weight is by no means bad, the more so as clean aerodynamic design rather than very low structure weight has been the aim of the designers.

When gasoline, for a range of 400 miles, is carried, the pay load is 4,350 pounds, which corresponds to 3.2 pounds per horsepower, based on normal power. Again, one should remember that a large power reserve has been a fundamental design feature, so that the pay load per horsepower actually used at cruising speed is probably very much greater.

At full gross weight, the wing loading is 15.5 pounds per square foot, and the power loading 14.7 pounds per horsepower. We gather that in the form in which the A.W. XV is to be used in Africa, it will not be loaded up to the full gross weight permitted by the C. of A., but will generally weigh some 18,000 pounds laden. This will bring the wing loading down to 14 pounds per square foot, and the power loading (normal) to 13.25 pounds per horsepower. The minimum speed will probably be in the neighborhood of 60 m.p.h.

Actual performance figures are not yet available, but it is thought that the cruising speed will be 120 m.p.h. or a little more. A rough estimate which we have made indicates that the maximum speed (which is not, of course, a criterion of an airplane's usefulness as a commercial proposition) should, for such a clean design be rather more than 140 m.p.h. The actual figure will be available when the first airplane has passed tests at Martlesham.

CHARACTERISTICS

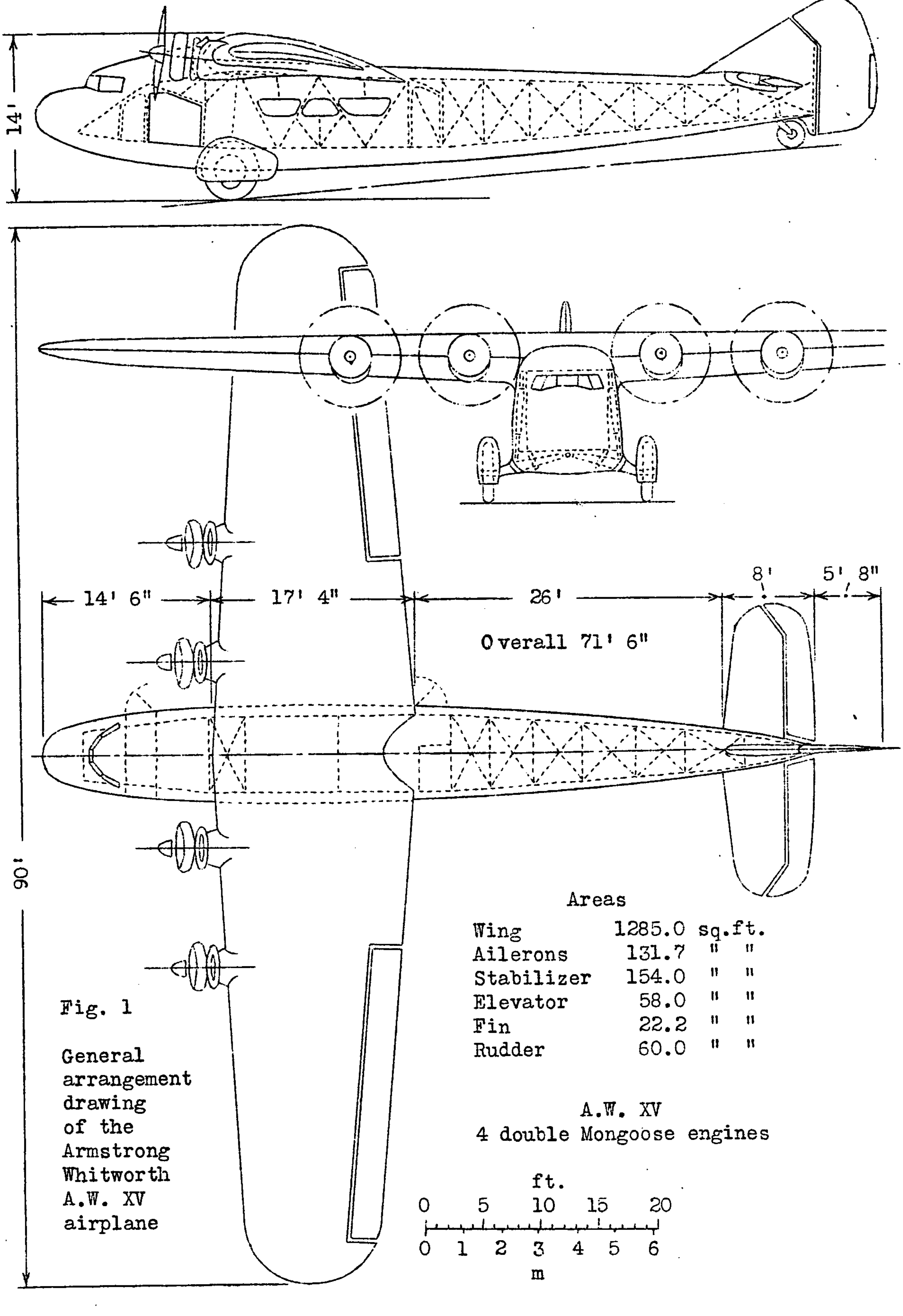
4 "Double Mongoose" engines

Dimensions:		
Length, over-all	71 ft. 6 in.	21.80 m
Wing span	90 " 0 "	27.45 "
Height, over-all	14 " 0 "	4.26 "
Areas:		
Wings (total)	1,285 sq.ft.	119.5 m^2
Ailerons	131.7 "	12.2 "
Stabilizer	154 "	14.3 "
Elevator	58 "	5.4 "
Fin	22.2 "	2.1 "
Rudder	60.0 "	5.6 "

CHARACTERISTICS (Cont'd)

Weights:		
Tare	13,940 lb.	6,340 kg
Gasoline and oil	1,600 "	729 "
Pay load	4,350 "	1,978 "
Maximum permissible gross weight	20,000 "	9,100 "
Range:	400 mi.	640 km

If pay load is reduced to 3,500 lb. (1,590 kg), the range can be increased to 600 mi. (965 km).



Areas

Wing	1285.0	sq.ft.
Ailerons	131.7	" "
Stabilizer	154.0	" "
Elevator	58.0	" "
Fin	22.2	" "
Rudder	60.0	" "

A.W. XV
4 double Mongoose engines

Fig. 1

General arrangement drawing of the Armstrong Whitworth A.W. XV airplane

Fig.2

Fig.3

Figs.2,3 Views of the A.W.XV "Atalanta" commercial airplane. *"Flight*

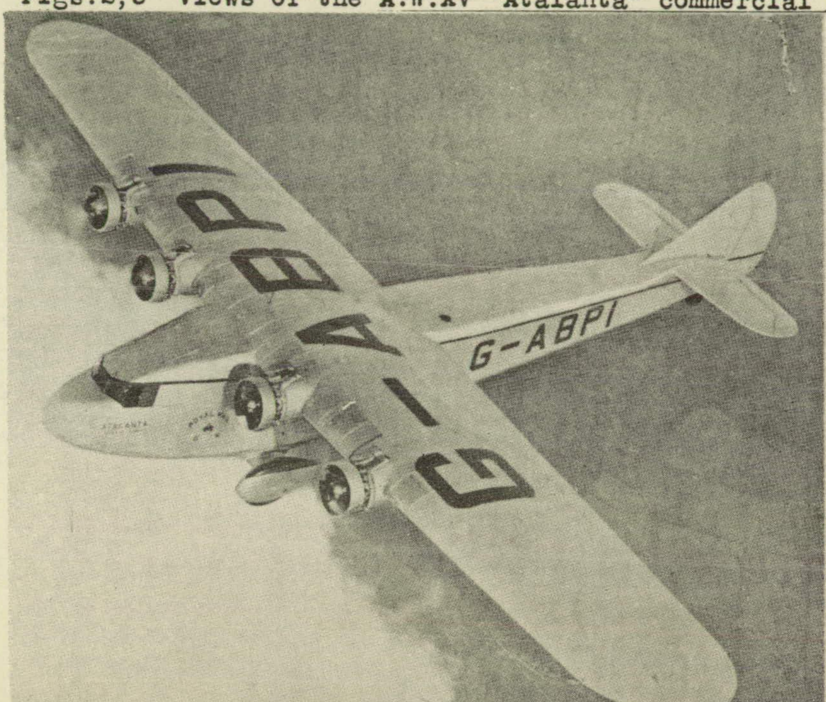
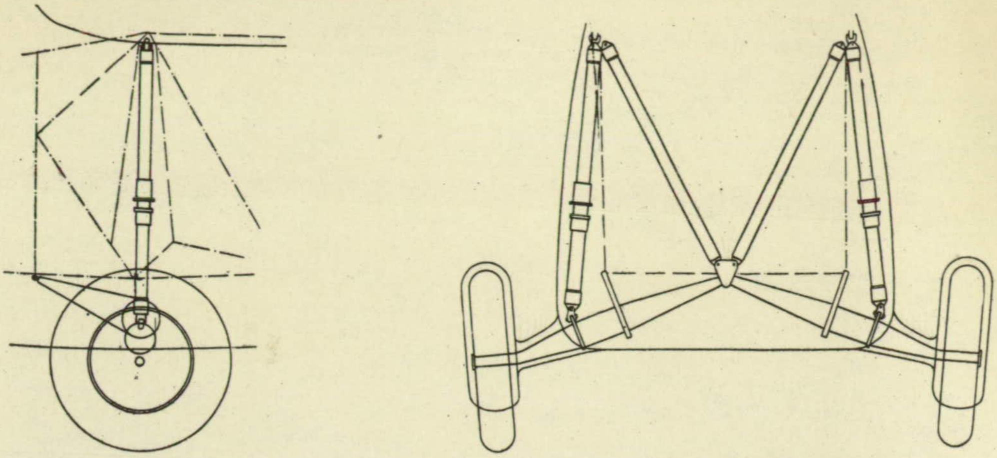
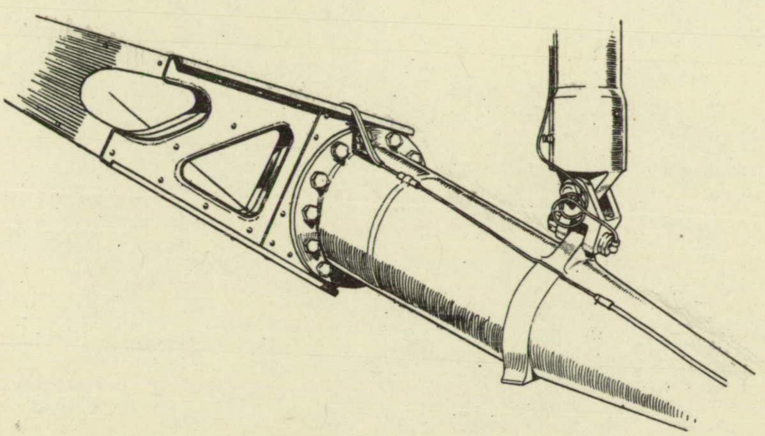


Fig.4 View from above giving a good idea of the plan form, and also showing the neat merging of the engine housings into the wing surface. *"Aeroplane"*

Fig.5 A close up of the nose of the Armstrong Whitworth A.W.XV monoplane, (four 340 hp Armstrong Siddeley Double-Mongoose engines.) *"Aeroplane"*





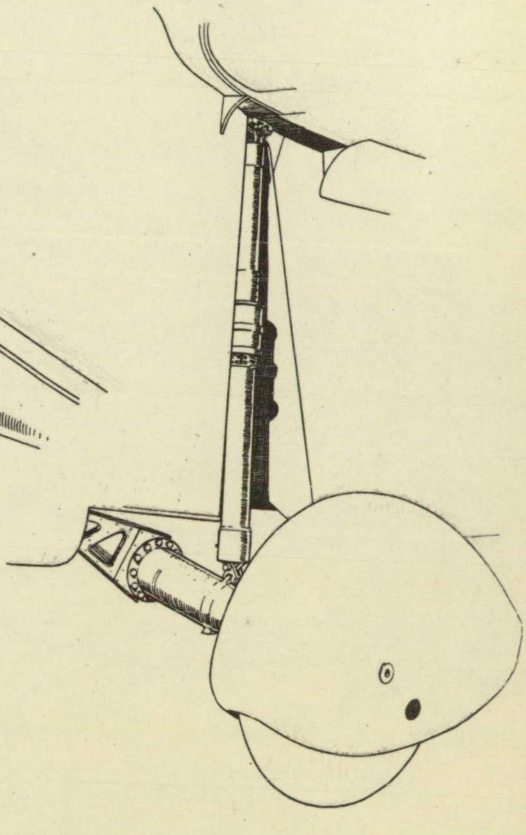


Fig.6 Front and side elevations, axle forging, girder radius rod and oleo leg fitting of the A.W.XV landing gear. "Aeroplane" sketches

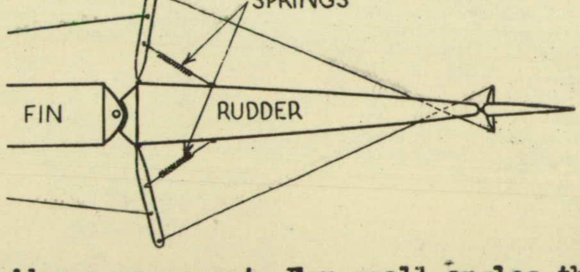


Fig.8 The Servo rudder arrangement. For small angles the rudder is operated direct. For larger angles the Servo rudder comes into action. "Flight" sketch

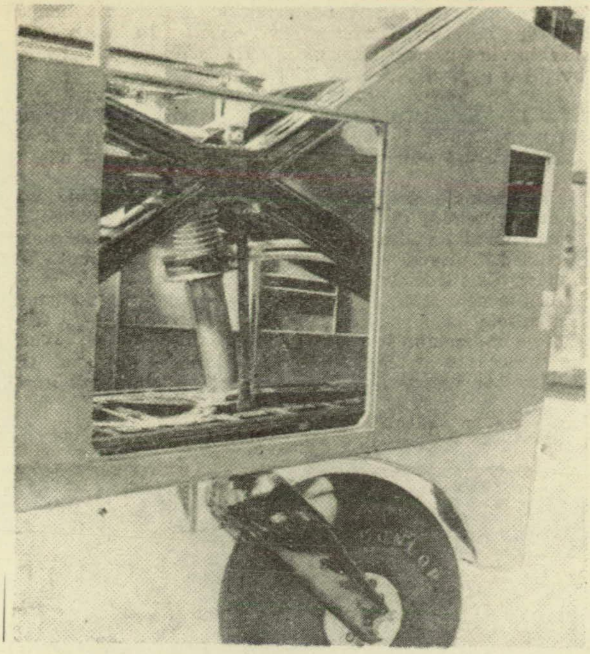


Fig.7 The tail wheel. This is of the castor type, and has a very short travel. Details of the tail-trimming gear can also be seen. "Flight"

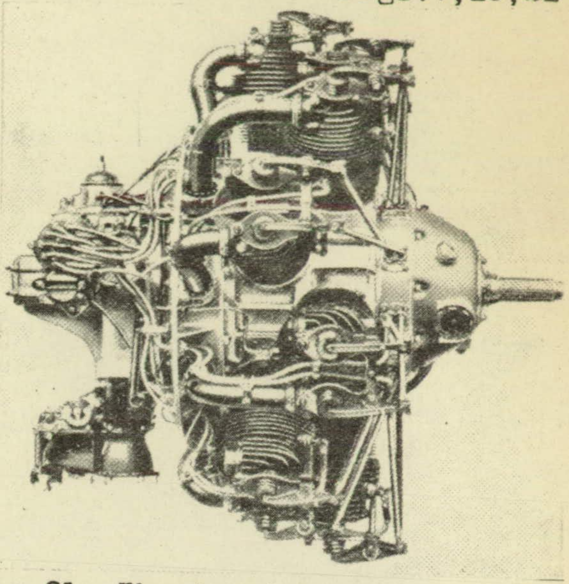


Fig.21 The Armstrong Siddeley "Double Mongoose engine. At a normal speed of 2,000 r.p.m. it develops 340 hp at 4,000 ft. altitude. Maximum power is 375 hp at 2,200 r.p.m.

"Flight" photo

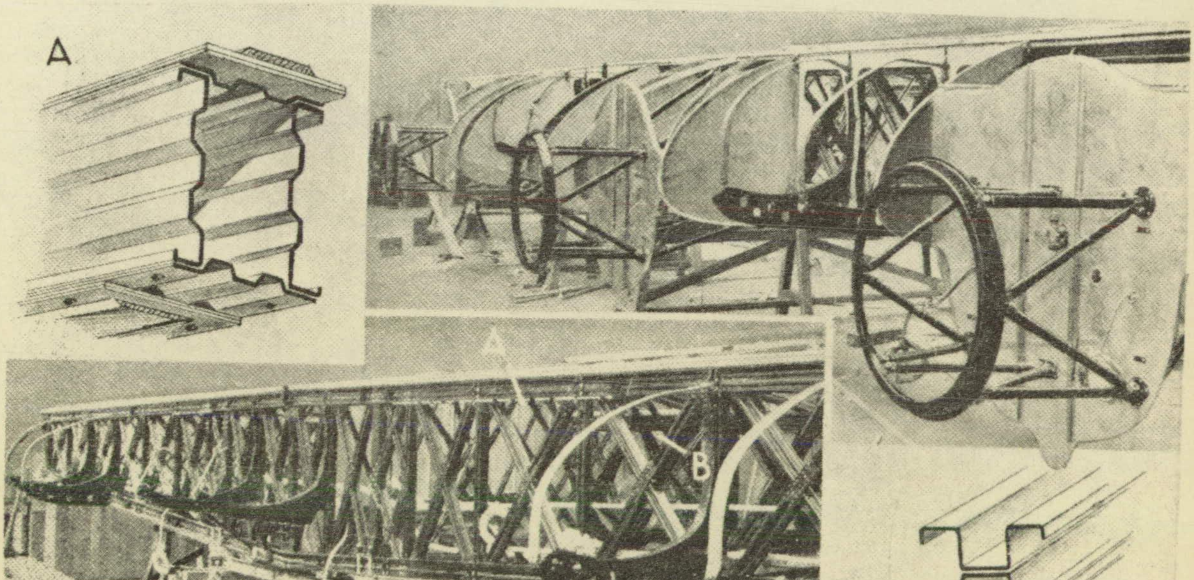
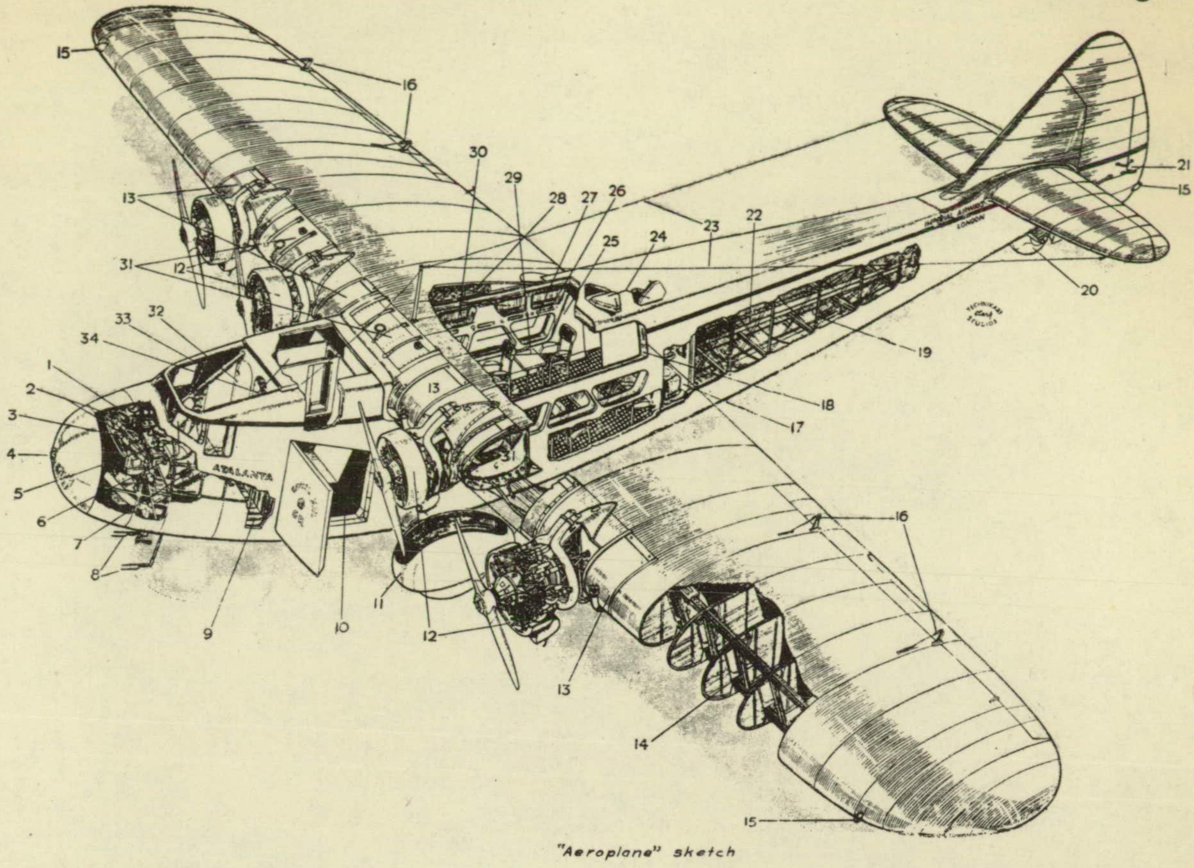
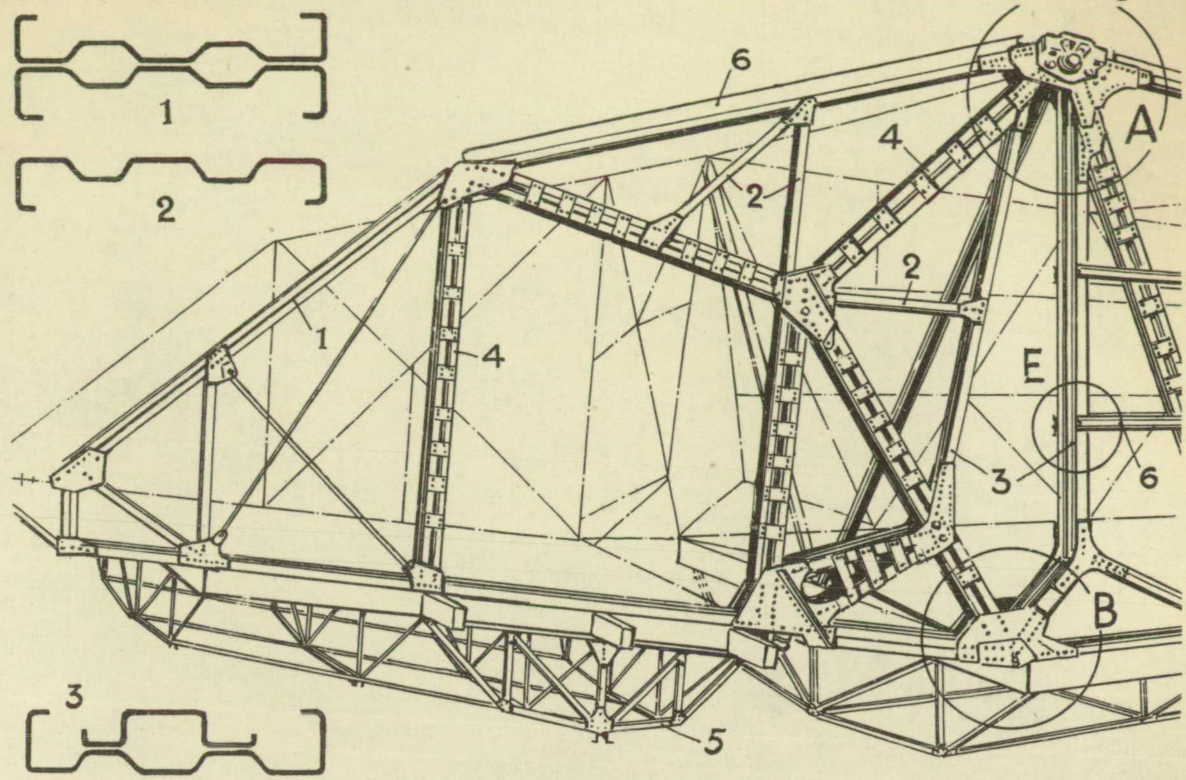


Fig.16 The front spar with bearers for engines and petrol tanks. The inserts show sections of spar booms and ties. "Flight".



1, Engine starter.
2, Airplane controls.
3, Engine controls.
4, Air control to cabin.
5, Tail-trimming wheel.
6, Pilot's adjustable seat.
7, Gasoline cocks.
8, Pitot head for air-speed indicators.
9, Wireless cabin.
10, Mails and freight compartment.
11, Wheel and fairing.
12, Towend ring for 340 hp moderately supercharged Armstrong Siddeley Double-Mongoose engine.
13, Oil tank.
14, Front spar.
15, Navigation light.
16, Lateral control.
17, Lavatory.
18, Sound-proof lining.
19, Steel rear frame.
20, Tail-wheel.
21, Servo rudder control.
22, Cat walk.
23, Wireless aerial.
24, Emergency exits.
25, Main cabin seating nine persons.
26, Cabin ventilators.
27, Windows and emergency exits.
28, Steel wing ribs.
29, Adjustable seats and folding tables.
30, Hat racks.
31, Gasoline tank.
32, Door to freight compartment.
33, Sliding roof.
34, Gangway to cabin.

Fig.9 A diagrammatic drawing of the Armstrong Whitworth A.W.XV monoplane.



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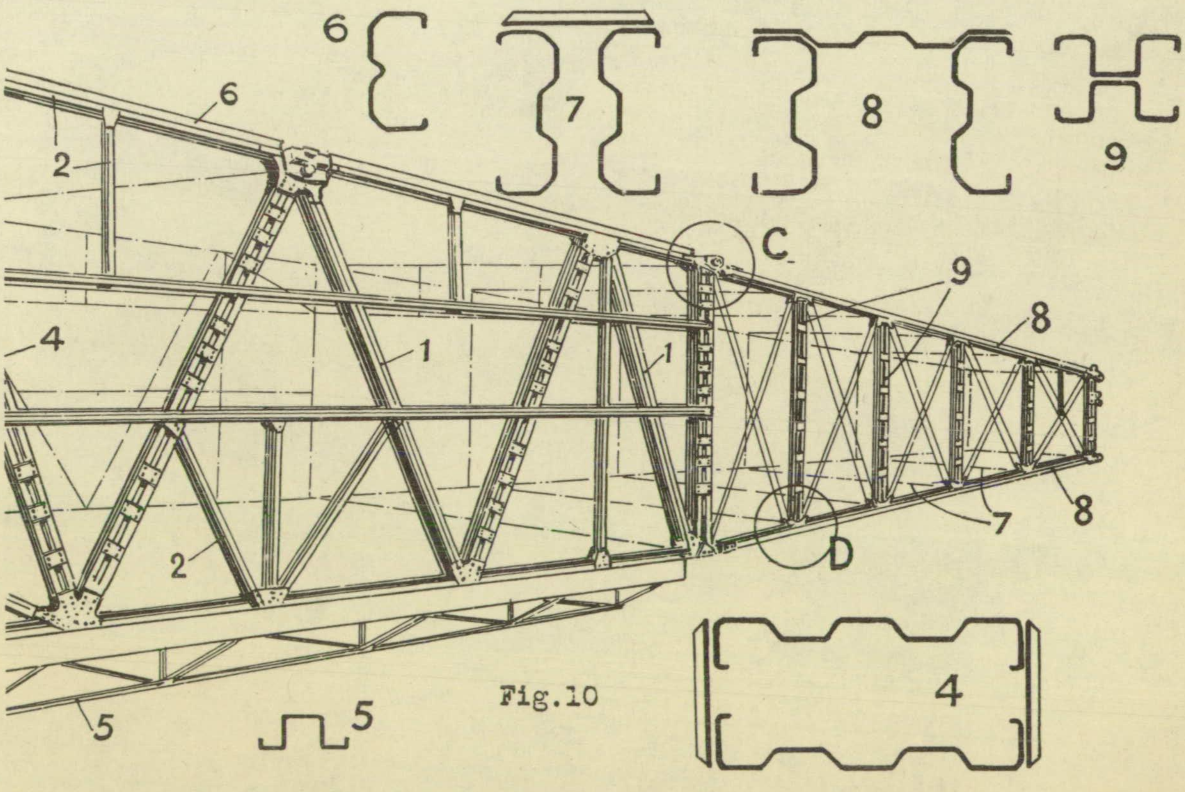


Fig.10

(Continued from above)

"Flight" sketches

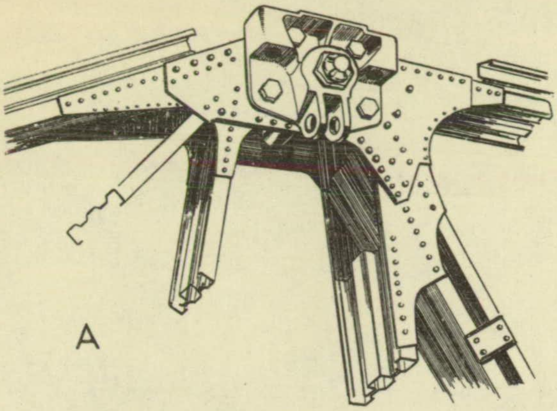


Fig.11

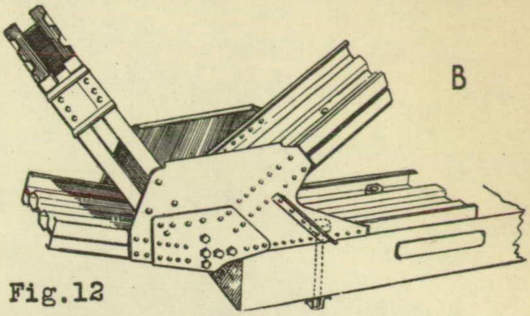


Fig.12

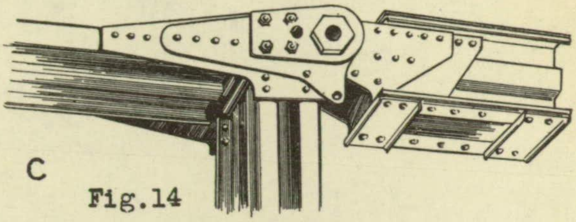


Fig.14

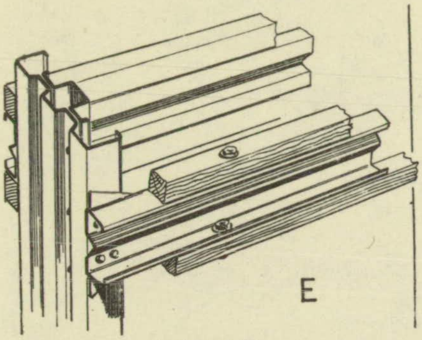


Fig.13

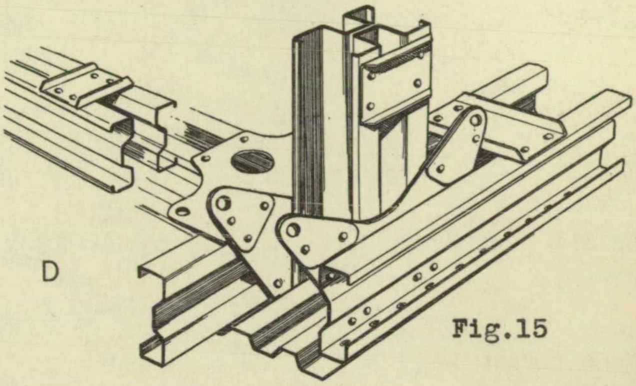


Fig.15

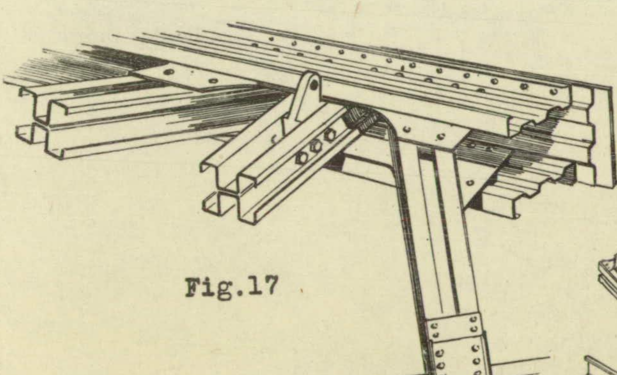


Fig.17

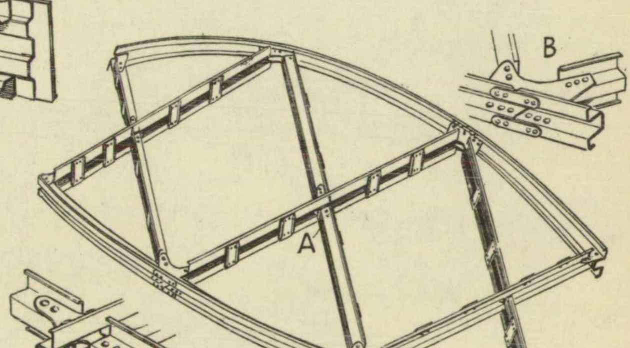
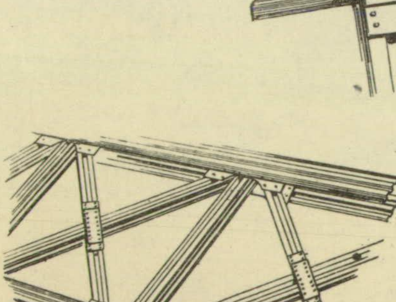


Fig.20



"Flight" sketches

Fig.18

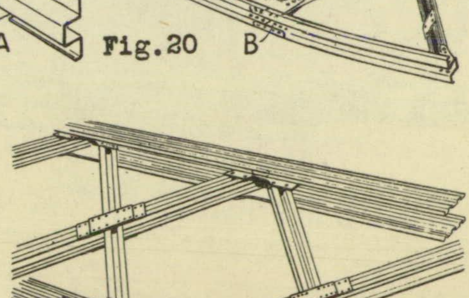


Fig.19