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AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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No. 161

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THE AVRO 631 TRAINING AIRPLANE (BRITISH)

A Two-Seat Light Biplane

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Washington  
May, 1932

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THE AVRO 631 TRAINING AIRPLANE (BRITISH)\*

A Two-Seat Light Biplane

The A. V. Roe and Co., Ltd., recognized the existence of a demand for a type of training airplane in which first cost is the main, if not the only, consideration. The result is the production of the Avro 631 two-seat light training biplane, which maintains many of the advantages of a previous type in spite of its smaller size and lower-powered engine.

The Avro 631 is a single-bay biplane with a welded steel tube fuselage and wooden-framed wings and tail unit.

Wings.— The wings, which do not fold, are of equal span and follow standard practice in so far as construction is concerned. The upper wings are attached to a small wooden center section, the construction of which is identical to that of the wings. The center section is carried above the fuselage by two welded-up N struts, which are cross-braced in the front and rear transverse planes by streamlined wires. There is one N-type interplane strut on either side of the fuselage. (Figs. 1, 2, 3, 4.)

The structure of the wings consists of two routed-out solid spruce spars with the usual number of built-up spruce and plywood ribs. The compression struts and the trailing edge are of duralumin tube. The wing tips, unlike those of previous Avro types, are semicircular in plan shape and the suggestion has been made that the improved flow over these tips may account for the extraordinary fine lateral control of the 631.

The ailerons, which are carried on all four wings, have a Frise balance only over the middle portions.

Fuselage.— The fuselage is a welded steel-tube structure. The side panels are rigidly braced by diagonal tubes but the transverse and the top and bottom bays of the rear half of the fuselage are braced with lengths of piano wire, which pass through small loops welded into the angles and are tightened by turnbuckles. (Figs. 5, 6, 7.)

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\*From The Aeroplane, March 23, 1932.

To allow for deep doors to the cockpits the top longerons slope down from the engine bulkhead to the next bay and thence to the bay behind the rear cockpit they are horizontal. From here to the next bay aft they slope up again to their normal height. A side elevation of the main fuselage frame, showing this feature, is included in Figure 7.

The domed decking over the cockpits is a plywood-covered structure, but the remainder of the fuselage aft of the engine bulkhead is covered with fabric. The wooden superstructure over the cockpits overhangs the longerons some five or six inches to give increased elbow and shoulder room, thus introducing into this comparatively small airplane cockpits of generous size.

Two doors, extending down to the main longerons, are fitted on the starboard side only. These doors are merely two pieces of fabric-covered plywood with stiffening strips top and bottom for the hinges and catches, and when shut they bend naturally to the contour of the decking. The spring in the plywood ensures a snug fit and an absence of rattle.

The semicircular contour of the deck over the cockpits is continued to the bottom longerons and aft to the rudder post by wooden formers and longitudinal stringers. The fabric covering in the region of the cockpits and at the tail may be opened up by lightning, or zip, fasteners.

Tail unit.- The tail unit is of the normal monoplane type and is an all-wood structure with fabric covering. The cantilever stabilizer may be adjusted in the air by a chain and sprocket movement (figs. 7 and 8) which raises or lowers the rear tail spar and further adjustment may be obtained on the ground by the Vernier hinge points on the leading edge.

Landing gear.- The landing gear is of the divided type and consists of two oleo-spring compression legs, the top ends of which are attached to the top longerons of the fuselage, with the bottom ends hinged to the center line of the underside of the fuselage by two steel tube Vees. (Figs. 9 and 10.) Dunlop low-pressure wheels and Bendix brakes are standard. To overcome the brake torque, the front legs of the Vees are of heavier gauge tube than the rear legs. The wheel axle, to which the brake drum is bolted, forms part of a Y forging into the branches of which are secured the outer ends of the Vee struts. Lugs on the Y forging pick up the fitting on the bottom of the compression leg. This detail is shown in Figure 10.

The leaf-spring tail skid, with a hardened steel shoe, is of the tracking type. (Fig. 11.)

Power plant.— The 135 hp Armstrong Siddeley Genet-Major 7-cylinder radial engine is carried on a ring mounting which is supported from the fireproof bulkhead by eight short steel-tube struts. (Fig. 12.)

The main fuel tank, which has a capacity of 28 gallons is mounted above the top fuselage longerons behind the fireproof bulkhead and feeds to the engine by a vertical pipe to the filter and thence by about 6 inches of Petroflex tubing to the carburetor. The oil tank, with capacity of 2.8 gallons, is mounted in front of the fireproof bulkhead immediately behind the engine. Both tanks are of welded aluminum and are carried in straps to which all brackets are attached. This ensures that the tanks are free from trouble that may be caused by welding fittings to the tanks themselves.

For aerobatics, both tanks are fitted with nonreturn ball valves and vent pipes which run down within the fairing of the front landing gear struts and have their exits below the level of the wheel axles.

A Townend low-drag cowling ring surrounds the engine. This ring is halved along the center line of the crankshaft and the halves are joined together by quickly detachable locking clips. (Figs. 13, 14, 15.) On each cylinder head is bolted a special platform which is covered with a felt pad. On the inside of the Townend ring there are a corresponding number of reception plates which bed onto the platforms on the cylinders and are located by the turned-up ends of the ring plates and also by pegs on the cylinder platforms which correspond to holes in the ring plates. By undoing the clips on each side of the ring the top and bottom halves may be instantly removed.

Figure 15 shows the locking clips on one side of the ring and a ring plate with its corresponding cylinder platform detached from the cylinder head.

An Avro one-exit streamline exhaust ring is mounted within the diameter of, but just behind, the Townend cowling ring, and the fuselage cowling from the circular fireproof bulkhead forward to the engine mounting ring is shaped to give the best flow of air past the engine. The Avro Company has conducted a number of experiments on this question of cowling, and the equipment of the 631 represents their latest findings. There is interest in noting that the over-

all diameter of the Townend ring is the same as that of the circular front portion of the fuselage.

Accommodation.- The pilot and pupil, or passenger, are accommodated in tandem cockpits which have complete dual control and duplicated instruments and fittings.

The airplane controls are very simple and straightforward. The two control columns are mounted on a longitudinal rocking shaft which carries at its after extremity a vertical lever which is in a direct line with the rear spars, in front of which run the aileron control wires. (Fig. 16.) The bottom ends of the columns are interconnected by a tube and the elevator control wires are taken from the rear column, at points one above and one below the hinge point, and run straight aft over pulleys to the elevator control lever. The two rudder bars are interconnected by lengths of swaged rod close in to their pivot points and the rudder control wires run from the extremities of the rear rudder bar direct to the rudder control lever.

The wheel brakes are operated by levers on the starboard side of the cockpits. The front lever only has a ratchet quadrant but the rear lever is connected to this quadrant by a Bowden control. The brake control wires run forward from the front rudder bar, over two pulleys carried by brackets on a cross tube just behind the fireproof bulkhead, then back to the rear legs of the landing gear Vees and down within the fairing to the brake levers. The cross tube has a vertical lever which is connected by a tube to the front brake lever, which in turn is interconnected with the rear lever. By partial operation of the brake lever the brake wires are tightened so that either one or the other brake may be applied by the rudder bars for steering on the ground but by complete operation of the brake lever both brakes are applied simultaneously for straightforward braking.

The tail adjustment is duplicated in both cockpits and this operates by continuous cable with chain and sprocket movements at each end. An indicator to show the position of the stabilizer is fitted in each cockpit. This consists of a cable attached to the vertical moving column below the rear spar of the stabilizer at the one end and of a small pointer which slides in a slot at the other, or cockpit, end. (Fig. 8.) The pointer is retained in its correct relative position by a spring.

The instrument equipment consists of a completely duplicated set of the usual instruments, but naturally this can be varied to suit the requirements of the purchaser. In each cockpit there is a Ki-gass engine primer and starter magneto, and if auto slots are fitted a slot-locking device is provided.

The seats are of the parachute type, and although in the airplanes so far built these have not been of the adjustable type, such a seat has been designed and can be fitted. Each seat is provided with brackets which pick up lugs on two of the fuselage cross struts thus eliminating seat bearers. (Fig. 17.) Amply large windshields, large sorbo-rubber pads on the front edges of the cockpits, the deep doors on the left side, the additional shoulder room provided by the overhang of the decking and the very complete equipment all go to make the cockpit of the 631 one of the most comfortable and the most practical for an airplane of this size.

### CHARACTERISTICS

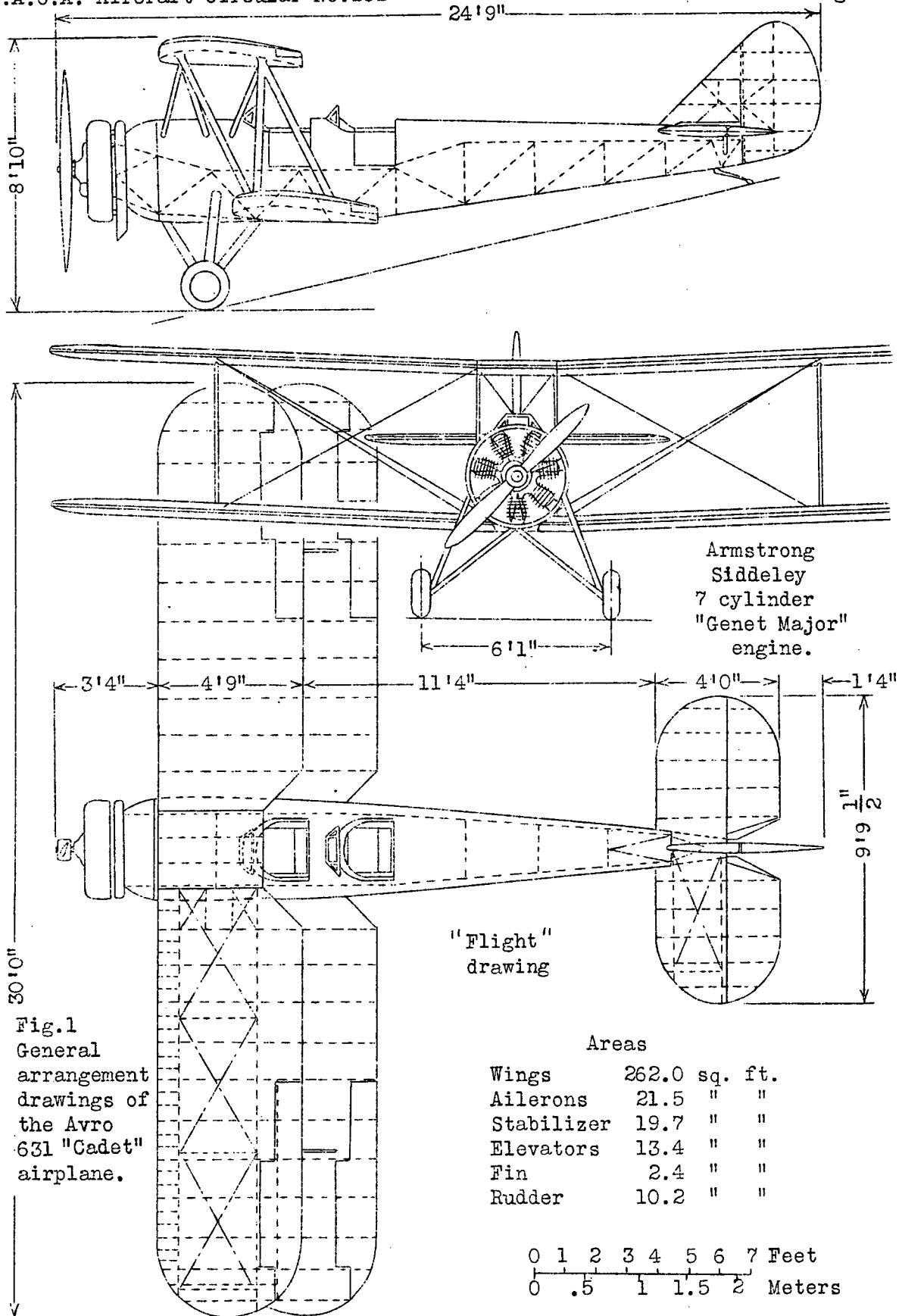
Span	9.15 m	30 ft.
Length	7.54 "	24 " 9 in.
Height	2.7 "	8 " 10 "
Wing chord	1.45 "	4 " 9 "
Gap	1.52 "	5 "
Wings (with ailerons)	24.34 m <sup>2</sup>	262 sq.ft.
Ailerons (four)	2 "	21.5 "
Stabilizer	1.83 "	19.7 "
Stabilizer span	2.97 m	9 ft. 9 in.
Propeller diameter	1.98 "	6 " 6 "
Elevators	1.24 m <sup>2</sup>	13.4 sq.ft.
Rudder	0.95 "	10.2 "
Fin	0.22 "	2.4 "
Weight empty	529 kg	1166 lb.

## CHARACTERISTICS (Cont.)

Pilot and parachute	86.2 kg	190 lb.
Pupil and parachute	86.2 "	190 "
Gasoline (28 gallons)	99.3 "	219 "
Oil (2.8 gallons)	12.7 "	28 "
Total load	284.4 "	627 "
Weight loaded	813.3 "	1793 "
Wing loading	33.44 kg/m <sup>2</sup>	6.85 lb./sq.ft.
Power loading	6.1 kg/hp	13.25 lb./hp

## PERFORMANCE

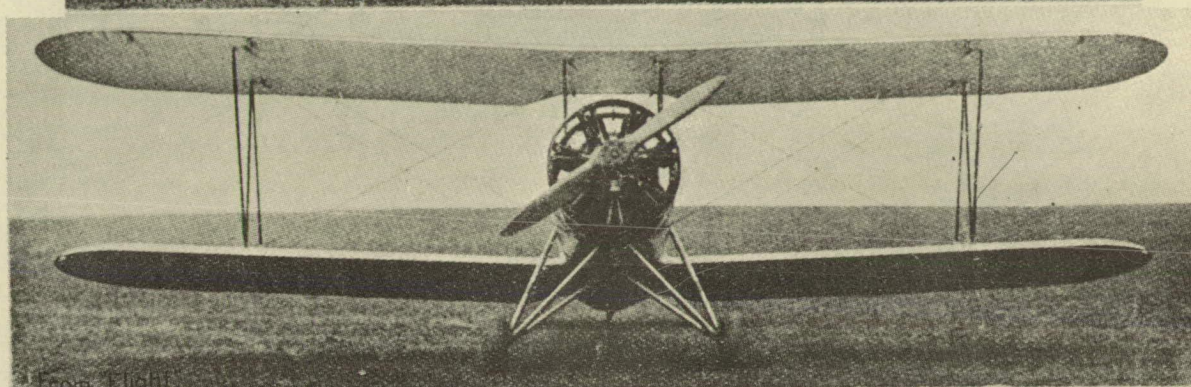
Speed at ground level	189.9 km/h	118 mi./hr.
Speed at 5000 feet (1525 m)	180 "	112 "
Speed at 10,000 feet (3050 m)	169 "	105 "
Minimum speed	72.4 "	45 "
Cruising speed at 1000 feet (305 m)	160.1 "	100 "
Initial rate of climb	228.6 m/min	750 ft./min.
Climb to 1000 feet (305 m)	1.37 min	
Climb to 5000 feet (1525 m)	8.2 "	
Climb to 10,000 feet (3050 m)	21.8 "	
Climb to 12,500 feet (3810 m)	35.9 "	
Service ceiling	3965 m	13,000 ft.
Absolute ceiling	4575 "	15,000 "
Range at cruising speed	564 km	350 mi.







Flight Photo



From Flight

Figs. 2,3 View of the Avro 631 "Cadet"

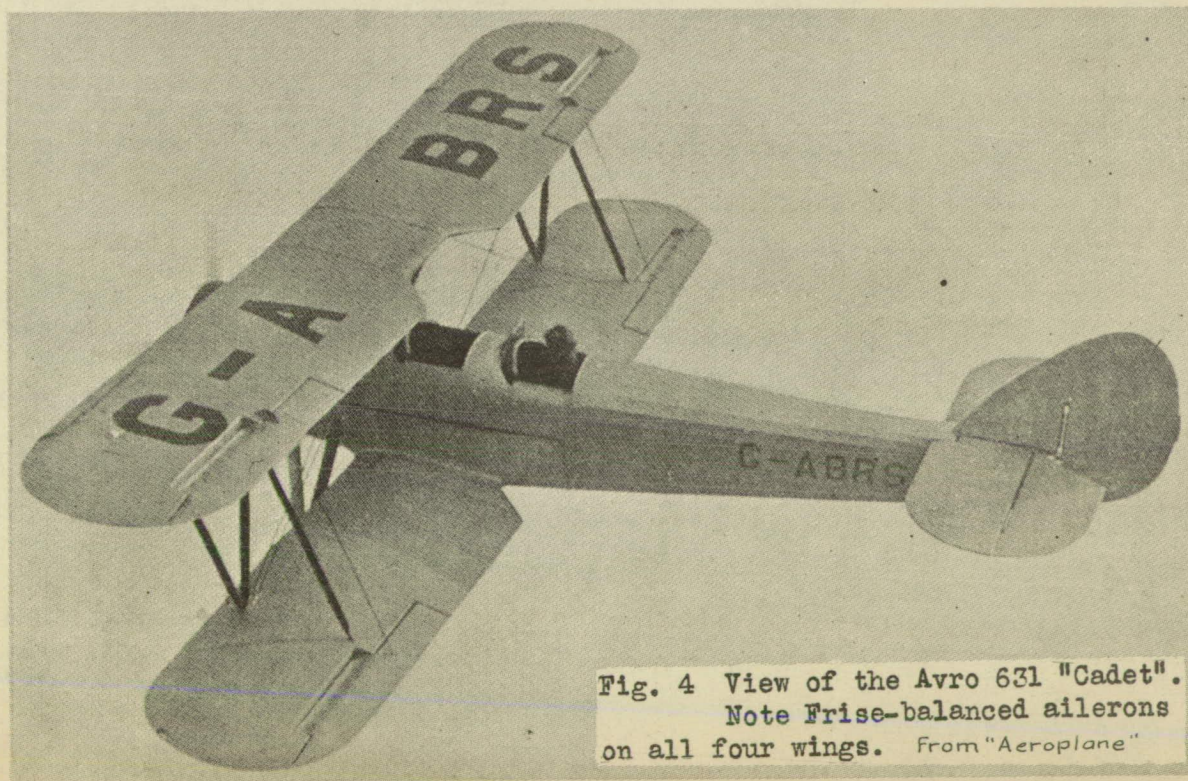


Fig. 4 View of the Avro 631 "Cadet".  
Note Frise-balanced ailerons  
on all four wings. From "Aeroplane"

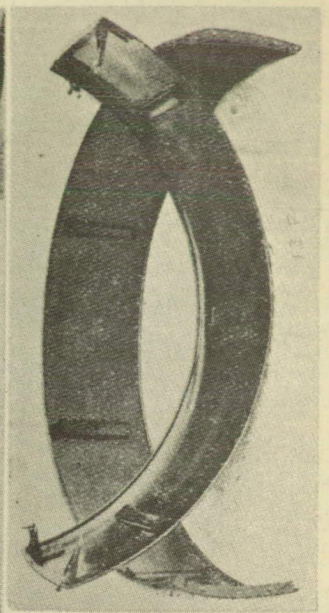
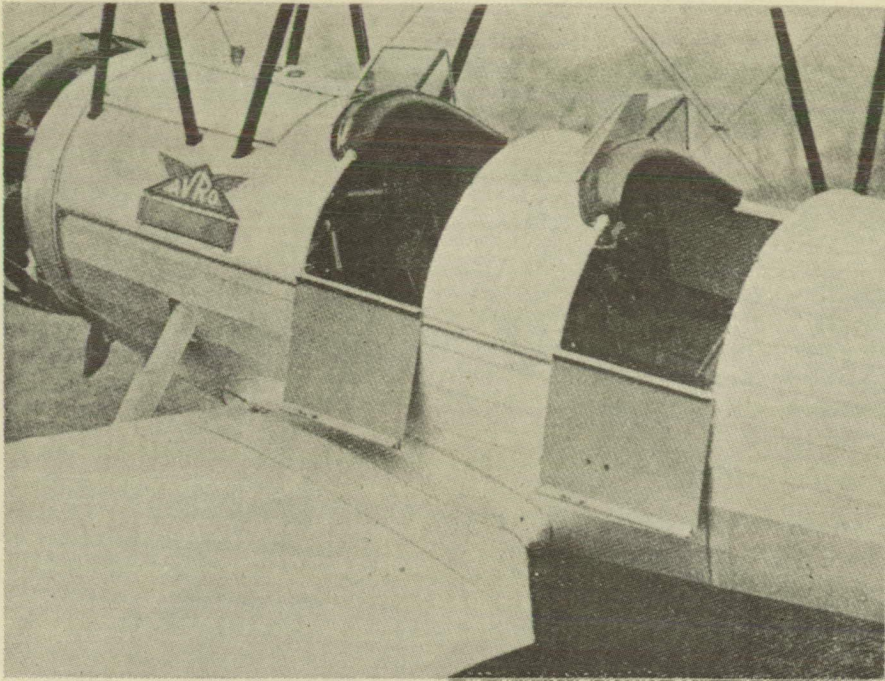


Fig. 5 Easy entry and exit. Both passengers can readily escape by parachute in case of emergency. "Flight" Photo

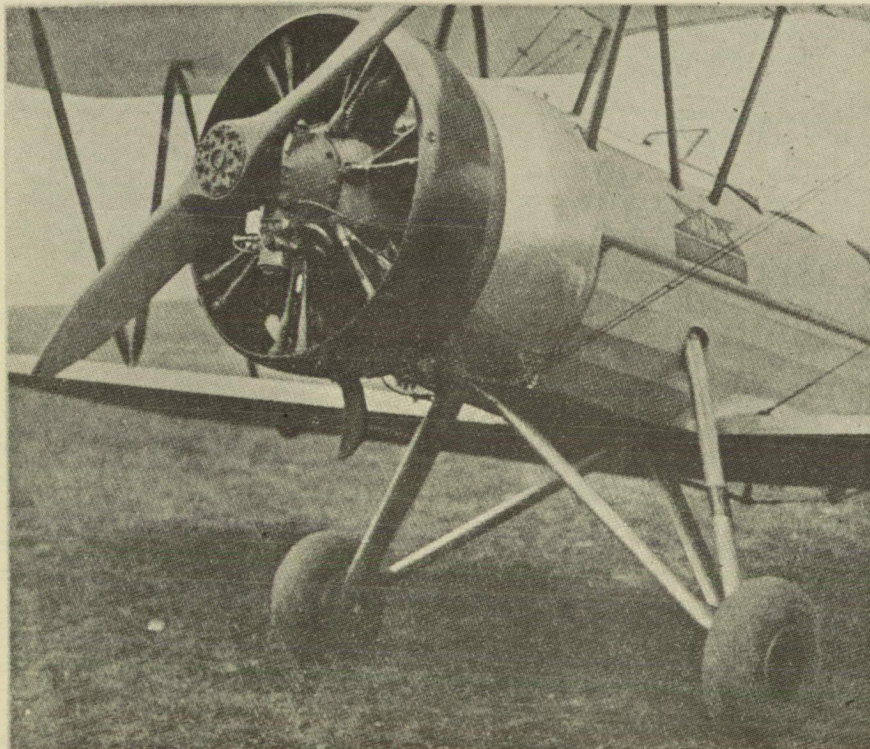


Fig. 9 Behind the Townsend ring is the exhaust collector ring, which in turn is separated by a large air space from the hemispherically-shaped nose of the fuselage. Note also the tripod landing gear. "Flight" Photo

Fig. 13  
The two halves of the Townsend ring.  
(Taken from "Flight")

Views  
of the  
Avro  
631  
"Cadet"  
airplane

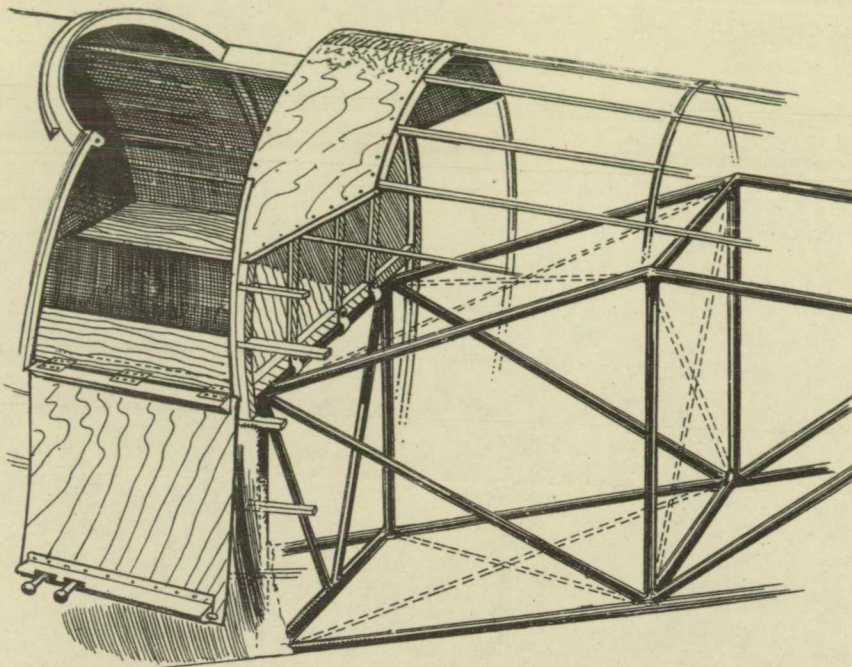
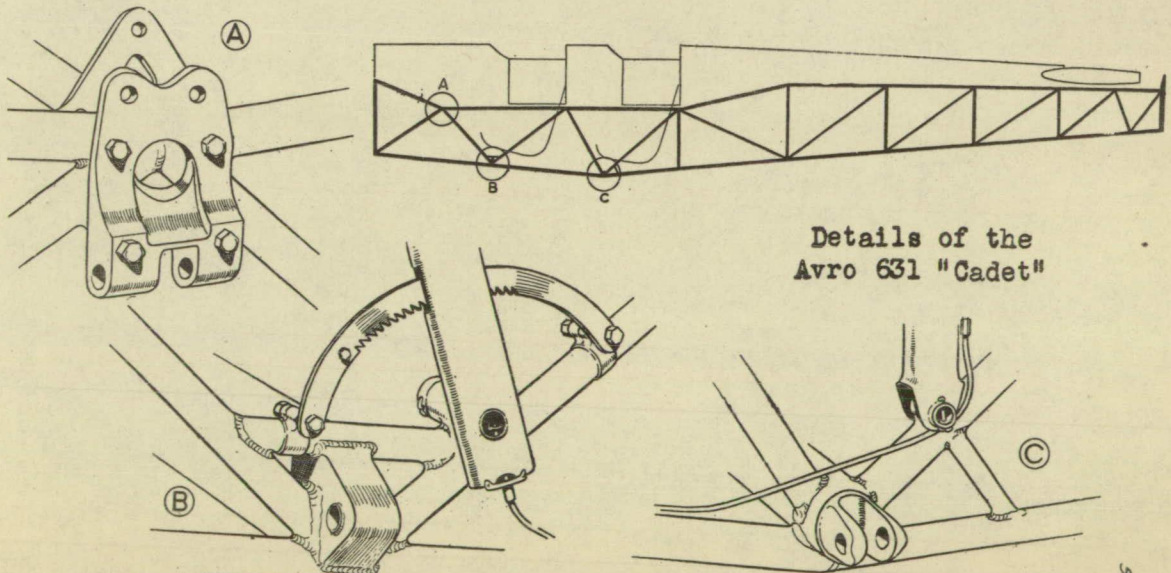
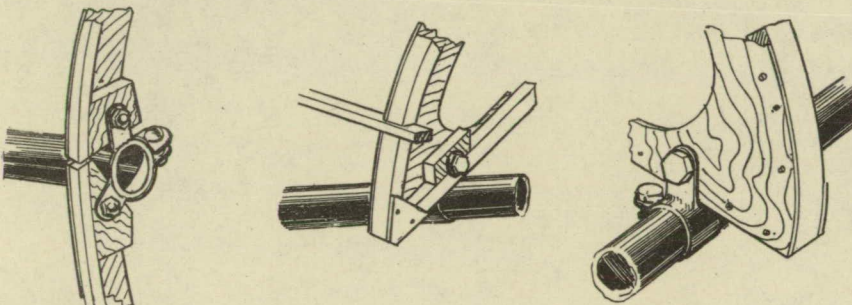


Fig. 6  
Some fuselage details. Welded steel tube construction is used for the main structure of the fuselage. The top longerons are dropped in the center portion to give deeper cockpit doors. The secondary structure is of wood and attached to the primary structure by simple clips.  
("Flight" Sketches)



Details of the Avro 631 "Cadet"

Fig. 7 A side elevation of the main fuselage frame showing the dropped top longerons. The enlarged sketches show details of certain points as designated by letters. The tail trimming control is shown at B and C. From "Aeroplane"

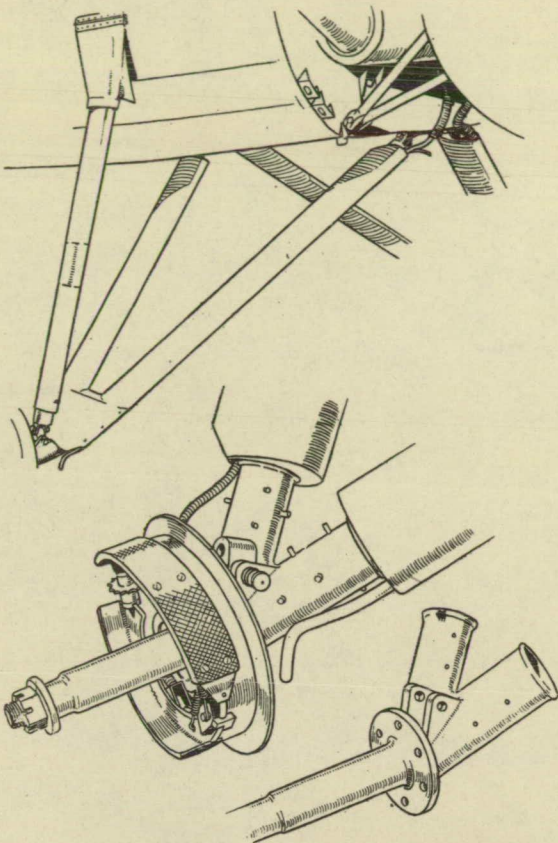


Fig. 10 One side of the landing-gear, showing details of the "Y" axle forging. From "Aeroplane"

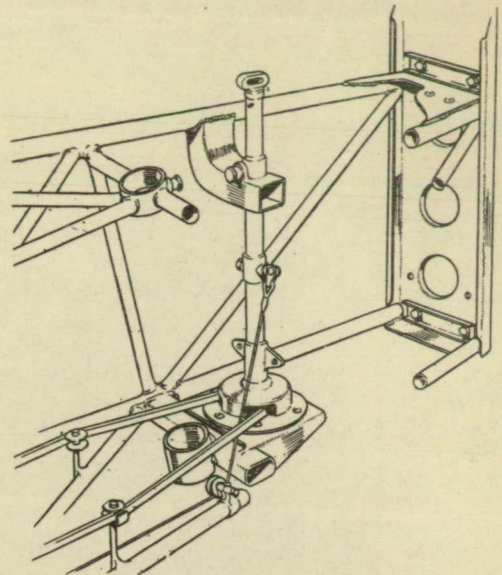
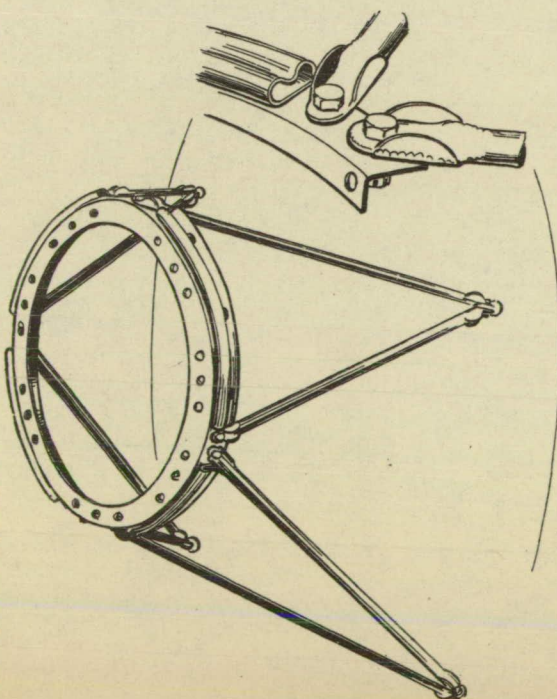


Fig. 8 The stabilizer adjustment with the operating chain drawn conventionally solid. The cable attached to the vertical column operates the stabilizer position-indicators in the cockpits. From "Aeroplane"



Details of the Avro 631 "Cadet"

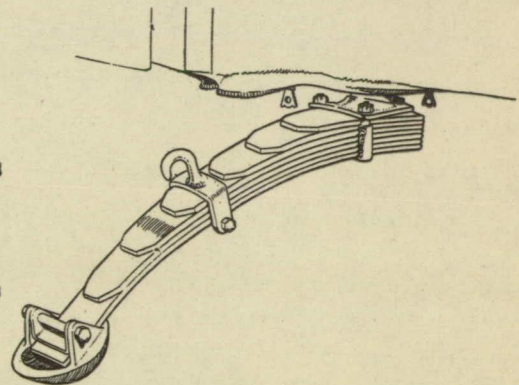


Fig. 11 The tracking leaf-spring tail-skid. From "Aeroplane"

Fig. 12 The engine mounting. The curved tube on the ring, shown in the inset, locates the cowl-securing cable. This type of mounting has been found to resist torque reaction very well, and has the further advantage of making the back of the engine very accessible. "Flight" sketch

Fig. 14

Brackets fixed on cylinder heads locate the ring, which is in two halves. On the ring are corresponding brackets, felt pads being interposed between the two brackets. Quick-release catches on opposite sides of the ring diameter can be undone in a few moments, and the two halves of the ring removed from the engine. From "Flight"

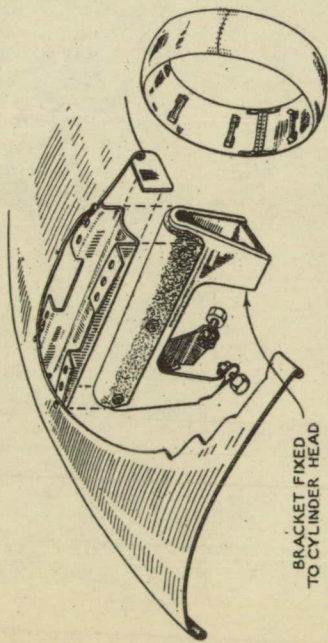


Fig. 15

Details of the Townsend ring showing the locking clips and another view of one of the cylinder-head platforms. From "Aeroplane"

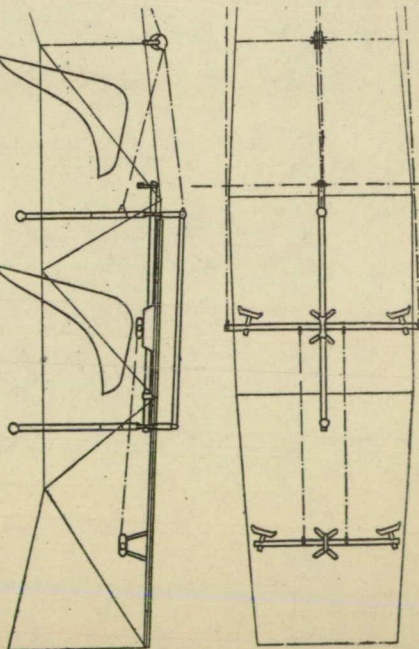
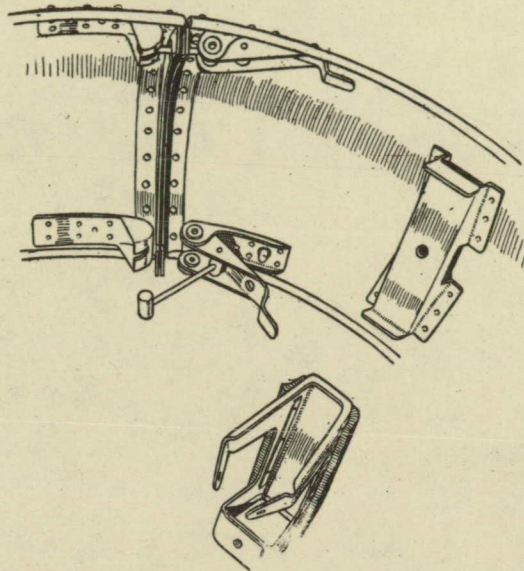
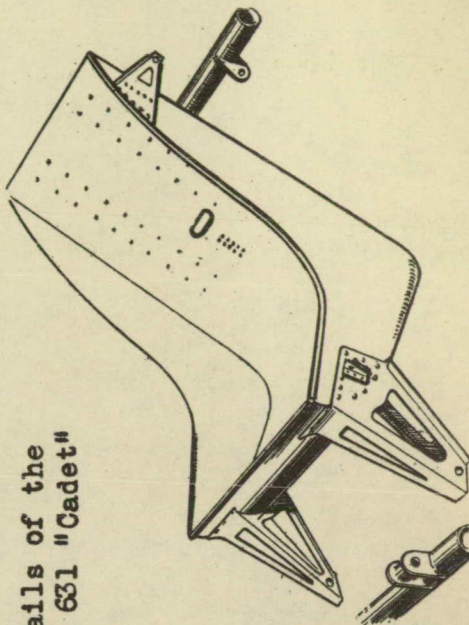


Fig. 16 A diagram of the controls of the Avro 631 "Cadet". "Aeroplane"

Fig. 17

Simple seat supports. No seat bearers are used, the seat being carried on two of the main structure cross tubes in the manner shown. "Flight"



Details of the Avro 631 "Cadet"