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No. 130

THE FIAT "T.R.1" TRAINING AND TOURING AIRPLANE (ITALIAN)

A Two-Place High-Wing Monoplane

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THE FIAT "T.R.1" TRAINING AND TOURING AIRPLANE (ITALIAN)*

A Two-Place High-Wing Monoplane

The Fiat "T.R.1" is an airplane for training and long-distance touring. It is a cabin monoplane with two seats and one engine (Figs. 1, 2, 3, 4, 5, 6, 7). The engine may be either the Fiat A 50 (100 hp at 1900 r.p.m.) or the Fiat A 53 (110 hp at 1900 r.p.m.).

The steel fuel tanks are located in the roof of the cabin and have a capacity of 125 liters (33 gallons). Two supplementary tanks, with a capacity of 45 liters (about 12 gallons) each, can be installed in the cabin. The oil tank with a fin radiator is installed under the forward rudder bar and has a capacity of 10 liters (2.6 gallons).

Despite the advantage resulting from the position of the fuel tanks, there is installed a self-regulating engine-driven pump, which maintains the fuel delivery during prolonged stunt flights.

The framework of the fuselage, wing and tail surfaces is entirely of duralumin tubing with steel fittings. The fuselage is covered, as far as the back of the pilot's seat, with metal sheathing, while the rear part is covered with fireproofed fabric (Figs. 8-10). Both pilot and passenger are completely en-

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*From a pamphlet issued by the Fiat Company, Turin, Italy.

closed, the former occupying the rear seat. Good visibility is provided by large side and front windows and also, for the pilot, through the transparent roof of the cabin. The side windows have special windshields which enable both pilot and passenger to stick out their heads without being too greatly disturbed by the wind. A special device is also provided for ventilating the cabin. The large doors give the occupants a sense of freedom. The side walls of the fuselage are so constructed as to leave ample unobstructed spaces of pentagonal form. The doors are therefore quite large. Due to the difficulty of opening the doors during flight, a special device was installed to enable the pilot to open them in case of peril.

The desirability of limiting the empty weight might have made it seem advisable to have doors on only one side of the fuselage. After mature deliberation, however, it was decided that any saving thus effected in the weight would be more than offset by the increased safety in flight and in landing afforded by a larger number of doors. Four doors were therefore installed, two on each side.

The special form adopted for the framework of the sides and especially of the transverse frames made it possible to provide ample space for the occupants without giving the fuselage excessive external dimensions.

Two complete sets of controls are provided, the forward set being disconnectable at the will of the pilot. The rudder has two control cables, while the elevator has a rigid control (Fig. 11). The stabilizer, which is readily adjustable on the ground, can easily be adapted for control during flight.

Behind the pilot's seat there is a large baggage compartment, the slight eccentricity of which can be easily offset by adjusting the stabilizer.

The wing structure consists principally of two spars supported by struts from the bottom of the fuselage. The ribs are made of square duralumin tubing with triangular bracing, forming a wing profile of medium thickness. The triangular spars are drawn from a duralumin tube 105 × 2 mm (4.13 × 0.08 in.) suitably lightened along the walls and reinforced where necessary to correspond with the wing covering. The lightening along the walls of the spar produces a girder whose lateral plates are braced by diaphragms of varying strength according to the shearing stresses to be withstood. Attachments to the spars are made by means of steel fittings suitably riveted and soldered. The spars are mutually braced by steel wires and duralumin compression members. The spars of each half-wing are attached to the central body of the fuselage by means of simple hinges and are not rigidly imbedded. A box rib suitably joined to a corresponding rib integral with the fuselage establishes a perfect junction between the wing and fuselage. Proper precautions have been taken for stiffening the wing structure against the stresses transmitted by the covering (Fig. 12).

The struts connecting the wing spars with the fuselage are made from faired duralumin tubing suitably reinforced in order to avoid all secondary stresses.

The oleopneumatic shock absorbers are mounted on the front landing-gear struts (Figs. 13,14). In this manner, aside from giving the landing gear a slender and elegant shape, a considerable reduction was made in the length of the forward strut which, on monoplanes, is principally stressed in the axial direction. A wide-track gauge gives the airplane lateral stability on the ground.

The axles are made from high-tensile steel and are so shaped as to insure maximum rigidity with minimum weight. They are at the ends of struts hinged to the fuselage in the plane of symmetry so as to reduce the lateral motion of the wheels to a minimum. Each axle has a special device for reducing to a minimum the braking stresses on the whole assembly. The oleopneumatic shock absorbers have a long stroke with damped recoil. The wheels are provided with brakes controlled either by hand or by the rudder bars, in order to facilitate maneuvers on the ground.

The tail surfaces are large and have a structure similar to that of the wing (Figs. 15-18). Figure 15 shows the strong duralumin framework of the stabilizer with the rectangular notch in the leading edge for the adjusting mechanism. Figure 16 shows the details of the elevator framework with the two balancing projections at the ends of the leading edge. The hinge axle at the leading edge has a sheet-duralumin casing which matches a corresponding casing on the rear spar of the stabilizer, both being so shaped as to reduce the structural drag. The elevator is rigidly controlled by a single lever in the center of its axle (Fig. 11). A similar structure is possessed by the fin (Fig. 17), which is completely covered with duralumin, and by the rudder, above which the tail light is mounted (Fig. 18). The structure of the ailerons (Fig. 19) is similar to that of the stabilizer.

The tail skid consists of three steel rods forming a pyramid whose vertex is at the point of contact with the ground (Fig. 20). Two of the rods form a V opening toward the front and are attached to the fuselage by means of coaxial hinges normal to the vertical plane of symmetry of the fuselage. The third rod is vertical and carries the shock absorber composed of rubber disks which are all inside the fuselage. The lower end of the rod is hinged to the top of the skid shoe. The latter is spoon-shaped and has a guiding rib. This type of skid is an excellent substitute for the ordinary type and does not, like the latter, tend to cut into the ground to the detriment of the landing field.

The engine mount is made of thick sheet duralumin, to which the steel fittings of the supporting struts are bolted. The fittings and struts are given large dimensions, in order to enable them to withstand the inevitable vibrations of the engine (Figs. 9,10,21). The engine cowling follows the lines of the fuselage in such a way as to give a slender and elegant appearance to the whole airplane, together with excellent penetration, without reducing the efficiency of the engine cooling.

Characteristics of the "T.R.1"

Maximum span	9.000 m	29.53 ft.
Minimum height	2.580 "	8.46 "
Wing chord	1.525 "	5.00 "
Area of wing (including ailerons)	13.500 m²	145.31 sq.ft.
Area of one aileron	0.622 "	6.70 "
" " stabilizer	1.032 "	11.11 "
" " elevator	1.086 "	11.69 "
" " fin	0.133 "	1.43 "
" " rudder	0.520 "	5.60 "
Dihedral of wing	1° 30'	
Engine (Fiat A 50)	100 hp at 1900 r.p.m.	
Weight, empty	440 kg	970.03 lb.
Fuel	90 "	198.42 "
Oil	10 "	22.05 "
Pilot and passenger with parachute	164 "	361.56 "
Accessories and special instruments	21 "	46.30 "
Weight, loaded	725 "	1598.36 "

Performances

Maximum speed near ground with A 50 engine	195 km/h	121.17 mi./hr.
Climbing time to 4000 m (13120 ft.)	36 min.	
Normal range, 4 hours =	750 km	466.03 mi.
Range with supplementary tanks	1150 "	714.58 "

Static Calculation of the "T.R.1"

Fuselage in flight.- The fuselage structure was calculated for the following eight conditions of load:

1. Fuselage in normal flight with the center of pressure at 0.33 to 0.4 of the wing chord with a load factor of 10.

2. Fuselage in a limited dive based on an aerodynamic moment of the wing equal to 1.8 Pl.

3. Fuselage in inverted flight with load factor 4, angle of attack -12°, center of pressure 0.07 of chord.

To these principal load conditions, there were added all the stresses due to the engine torque, the propeller thrust, the action of the tail surfaces and ailerons (transverse load) and the action of skidding (slipping on the wing).

These secondary stresses, carried to the breaking point with the known considerations, were added to the preceding stresses with the rule $\frac{1}{2} T_{min} + T_{max}$, that is, for every individual member there was added the major force and half the minor force. The latter condition is important, because, for not a few structures, it has been found that the stresses arbitrarily called "secondary," are often greater than the "principal" stresses. The above-mentioned force combinations often produce stresses far greater than those produced in the three principal flight cases.

Fuselage in landing.- After the determination of the maximum forces in flight, as above indicated, the stresses of the fuselage in landing were determined under the following hypotheses:

4. Fuselage in landing with tail down, load factor 7.5.

5. " " " " nose " almost to the capsizing point, load factor 7.

6. Landing in the above two cases with allowance for the braking effect of the wheels.

7. Study of the fuselage in the act of skidding with a transverse load factor of 2.5.

8. Study of fuselage in landing on one wheel.

In all the above cases equilibrium was maintained where necessary, by the systematic distribution of suitable inertia moments. Here also the secondary stresses produced by the engine, by the rudder and by the twisting action of the tail skid were added to the principal stresses. After thus determining the maximum forces on the ground, the final determination of the stresses was undertaken by comparing, for each member, the maximum forces in flight with the maximum stresses on the ground and thus obtaining the absolute maximum forces on which to base the dimensions.

Calculation of the wing.- In the study of the maximum stresses on the wing spars, instead of the conditions relative to a few positions of the center of pressure (as has been the usual practice), a systematic study was made with respect to every angle of attack between -12° and $+20^\circ$. In fact, for every angle of attack within the above limits, the curves in Figure 22 give the maximum stresses on the front and rear spars, the tangential force in the wing and the load factor.

These curves were plotted on the basis of the wing polar (see table), which must be previously obtained from wind-tunnel tests and from the course of the curve of the probable speed limits of the airplane in various attitudes. Figure 22 includes the curve of the V^2 limits, which goes from a maximum of 11000 at about -7.5° (zero lift) to 7000 at $+9^\circ$.

The examination of the course of the curves for the front spar in normal flight shows a total stress of 3700 kg (8157 lb.) corresponding to an angle of attack of 8° and a load factor of 10.5. For the stresses in inverted flight the maximum stress, corresponding to $i = -10^\circ$, is 2800 kg (6173 lb.) or about 75% of the stress in normal flight. For monoplanes this stress is excessive and dangerous since the structures are often designed for a load in inverted flight of less than half the load in normal flight. The stress in inverted flight is all the more dangerous, in that it is accompanied by a load factor of about

-2, which is hardly perceptible to the pilot. The course of the stresses in the rear spar is more regular and is integrated with the action of the ailerons.

Figure 21 does not include the negative stress on the rear spar. In any case the dimensions of the rear spar are, for structural reasons, thé same as those of the front spar and are therefore larger than necessary. The internal bracing of the wing is always proportional to the tangential forces plotted in Figure 22.

The above analysis of the wing structure follows the method adopted by the engineer Rosatelli in calculating recent Fiat airplanes.

Aerodynamic Characteristics of the Wing of the "T.R.1"

i	C_p	C_r	$\mu = \frac{C_p}{C_r}$	λ%
-15°	-0.20	0.077	---	+ 19
-10°	-0.105	0.023	---	− 16
-5°	$+0.081$	0.008	10.25	100
0°	$+0.27$	0.0137	19.7	45
$+5^\circ$	$+0.45$	0.026	17.3	36
$+10^\circ$	$+0.578$	0.046	12.35	31.7
$+15^\circ$	$+0.62$	0.079	7.86	31
$+20^\circ$	$+0.565$	0.152	3.71	30

Landing gear.- The landing gear was calculated for landing on the wheels and tail skid, in an almost capsizing position, in line of flight, in both inside and outside skidding, and in braking, according to the standards adopted for the fuselage with a load factor of 6.5.

Tail surfaces.- These were calculated on the basis of a load of 300 kg/m² (61.45 lb./sq.ft.).

Controls.- The controls were calculated on the basis of the loads prescribed by the Royal Aeronautic Engineering Division.

Equipment and instruments.- The airplane has all the regular equipment and instruments and can be furnished, on request, with the Marelli electric lighting system.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.

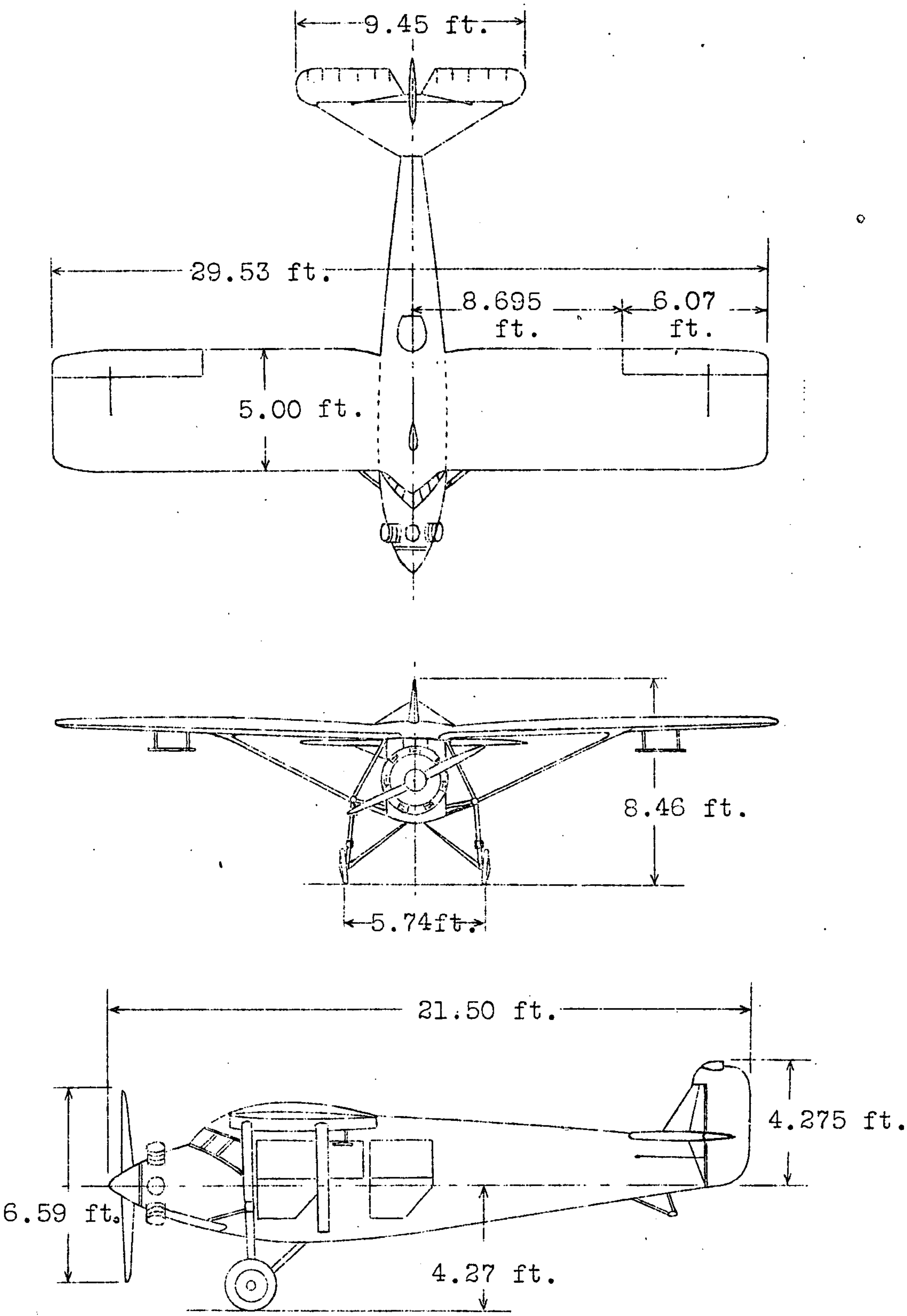


Fig.1 General arrangement drawing of the Fiat T.R.1 airplane.

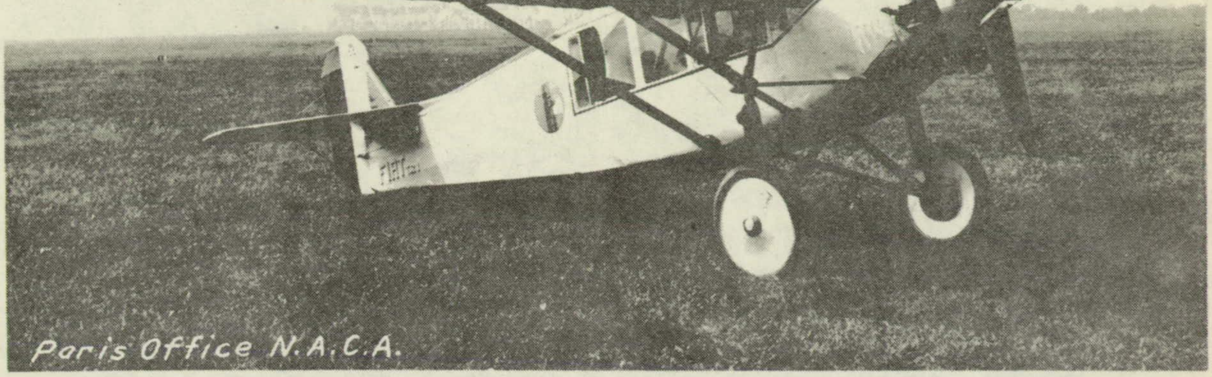


Fig.2 Three-quarter front view of the Fiat T.R.1 airplane.

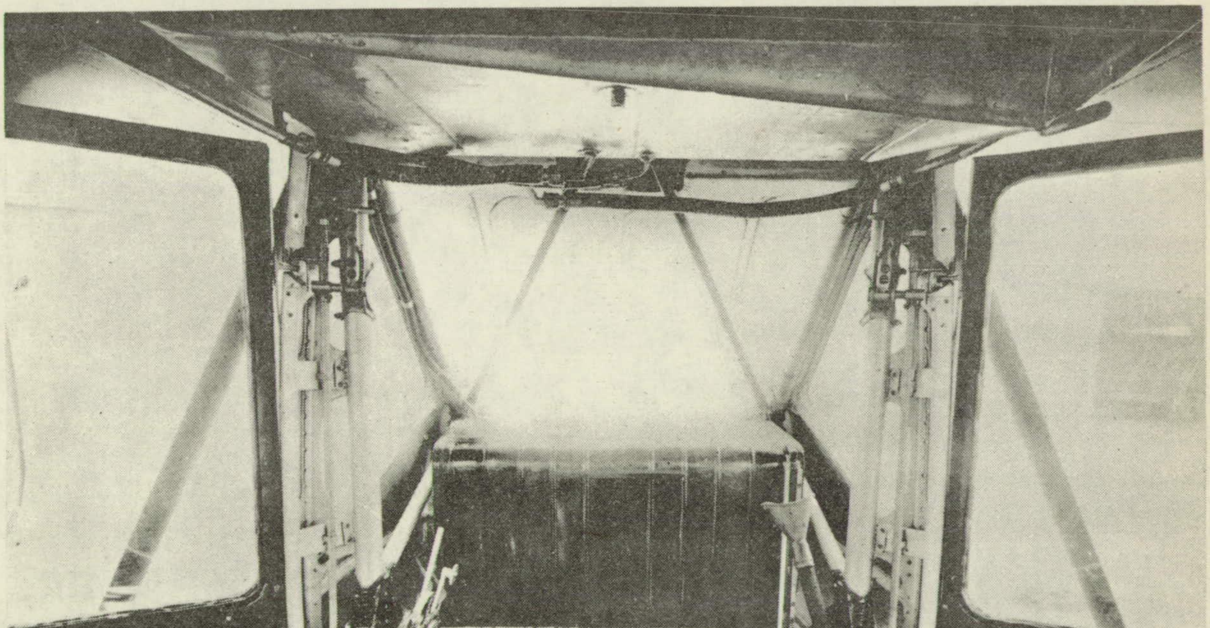


Fig.4 View of front cockpit of the Fiat T.R.1.

Fig.3 Three-quarter rear view of the Fiat T.R.1 airplane.

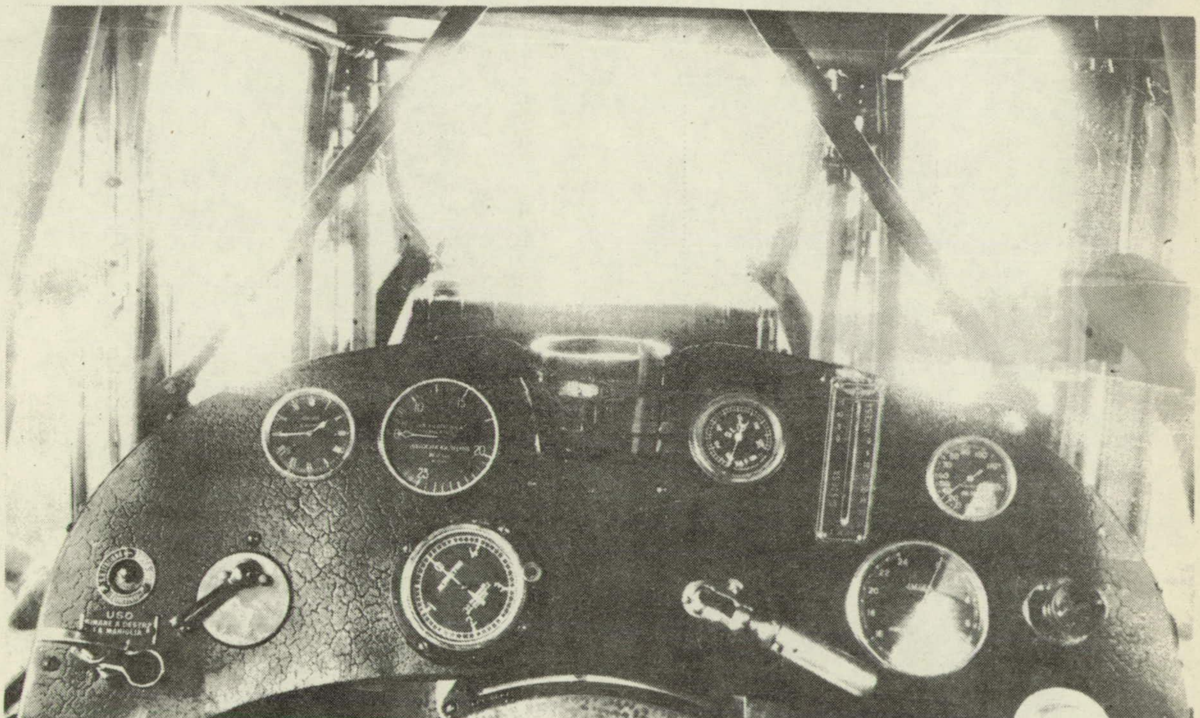


Fig.5 View of instrument board in rear (pilots) cockpit of the Fiat T.R.1.

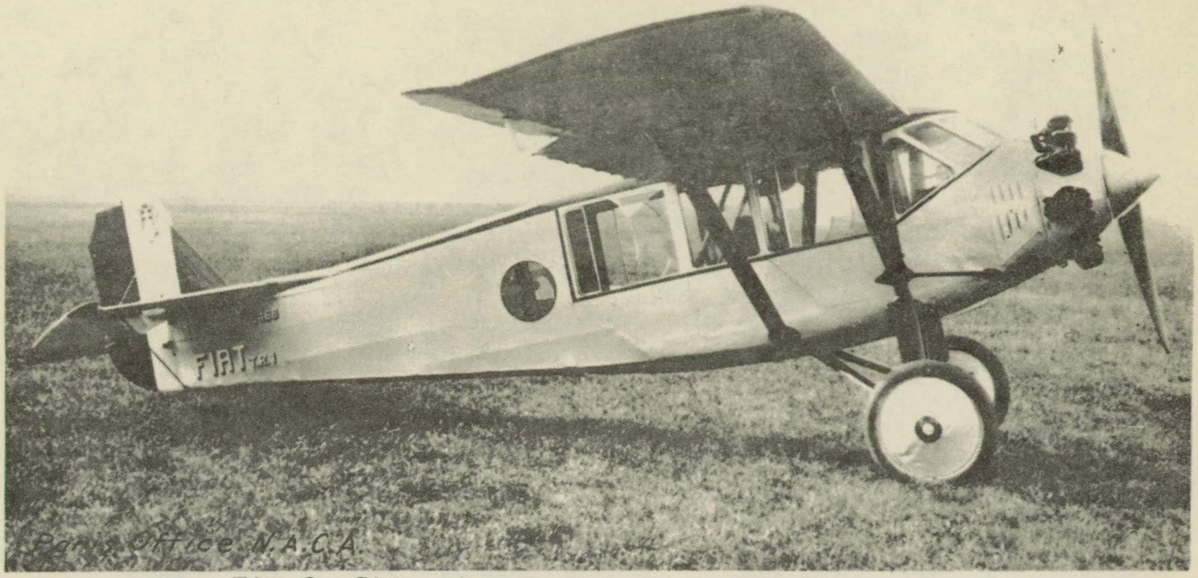


Fig.6 Side view of the Fiat T.R.1 airplane.

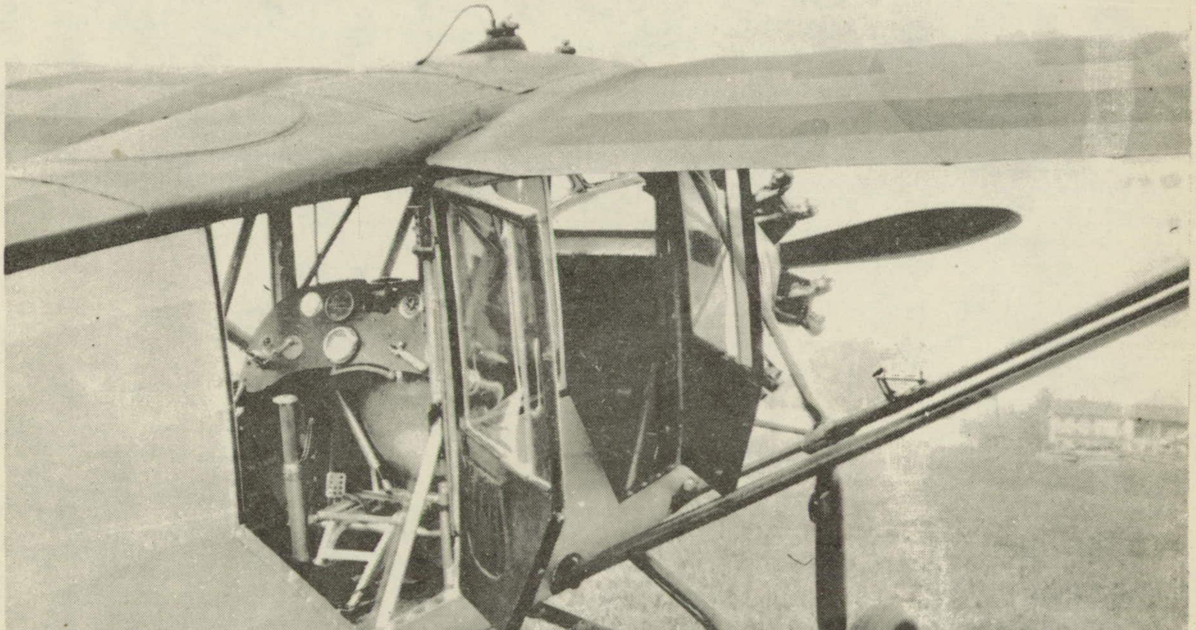


Fig.7 Close-up view of doors and pilots cockpit of the Fiat T.R.1.

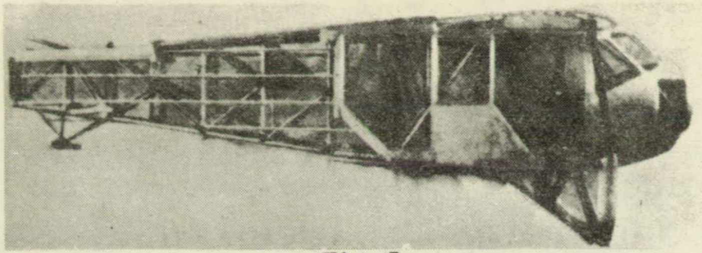


Fig.8

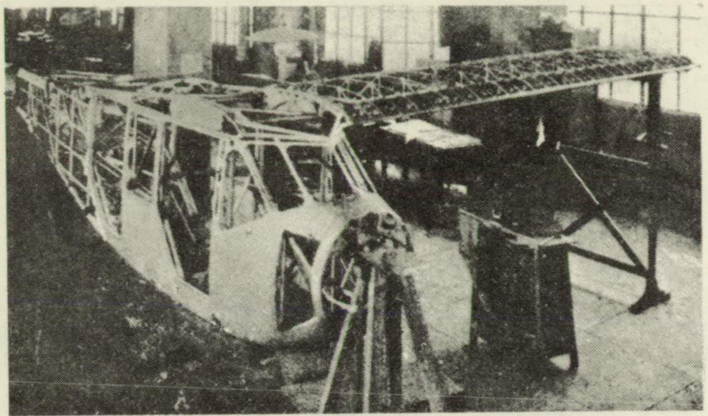


Fig.9

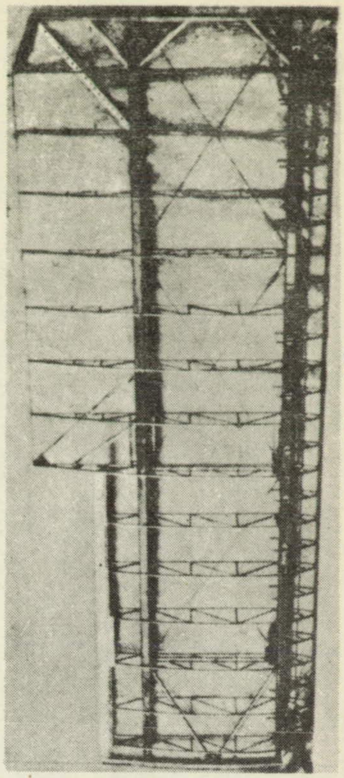


Fig.12

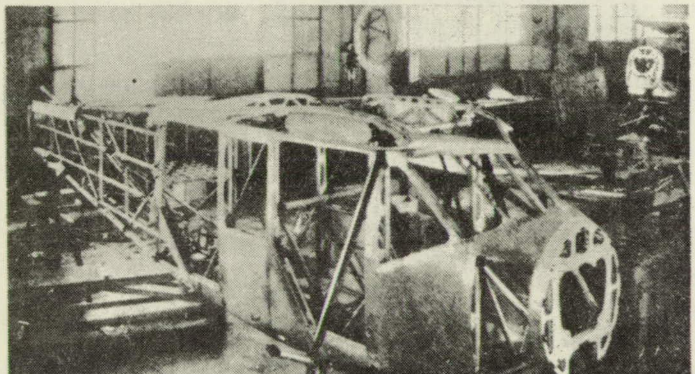


Fig.10

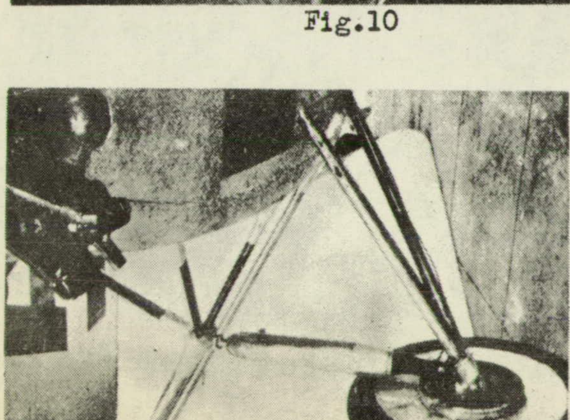


Fig.14

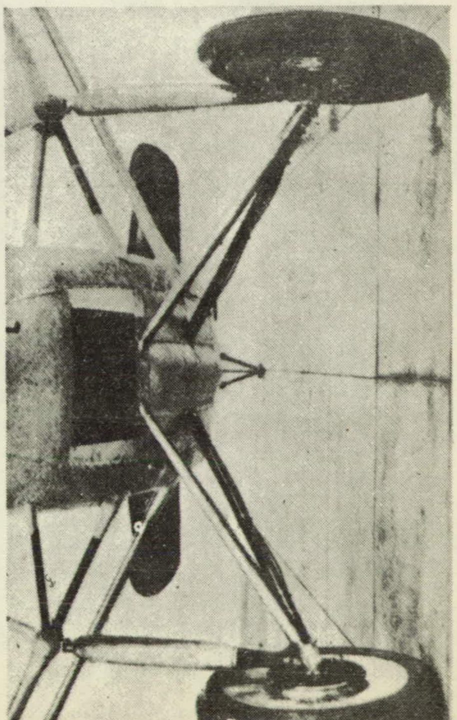
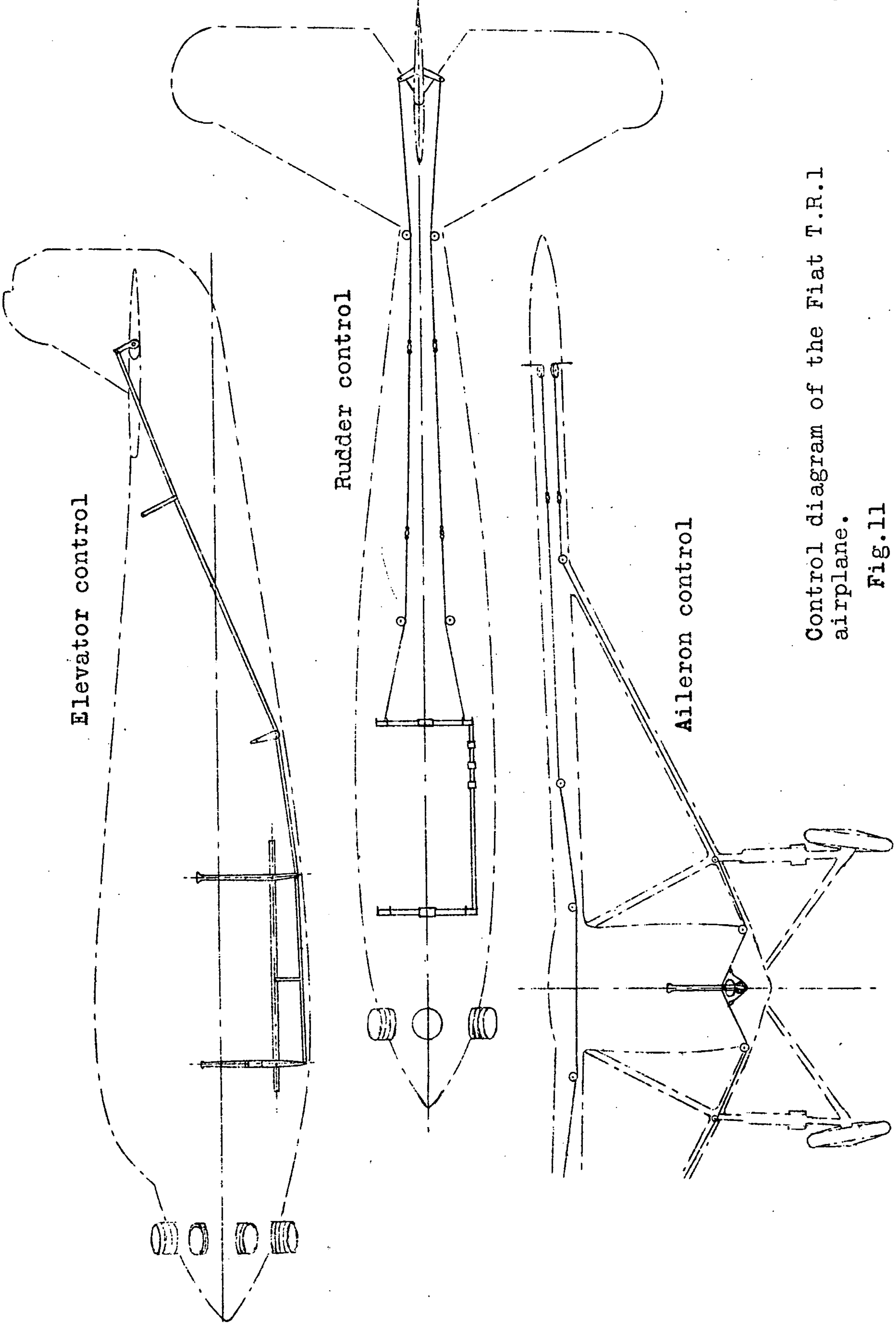


Fig.13



Control diagram of the Fiat T.R.1 airplane.
Fig.11

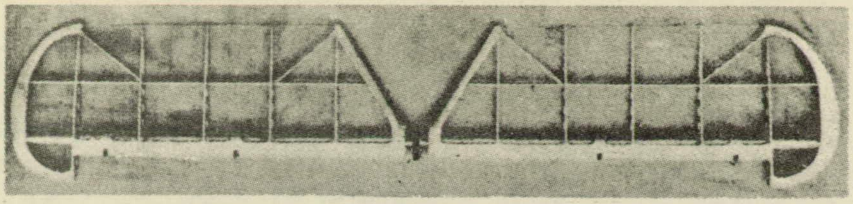


Fig.16

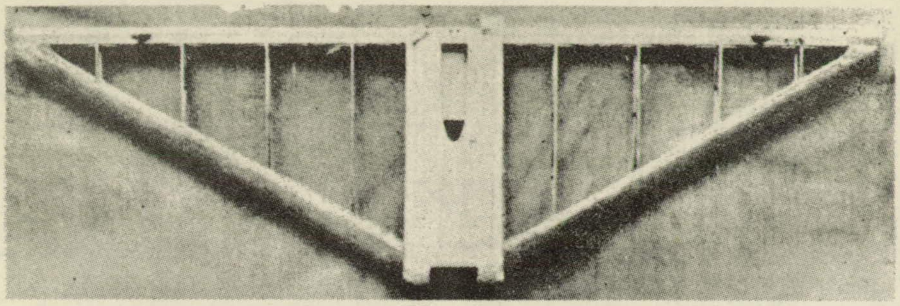


Fig.15

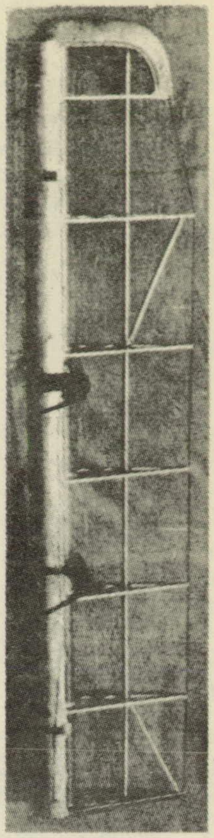


Fig.19

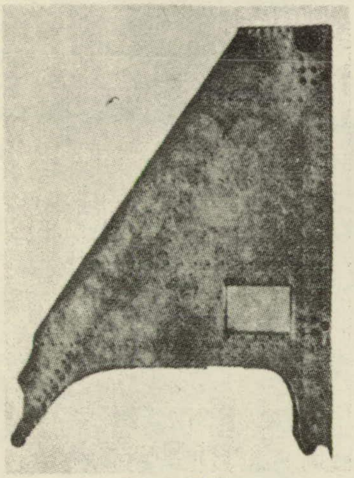


Fig.17

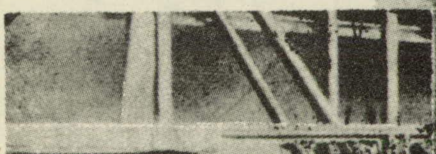


Fig.20

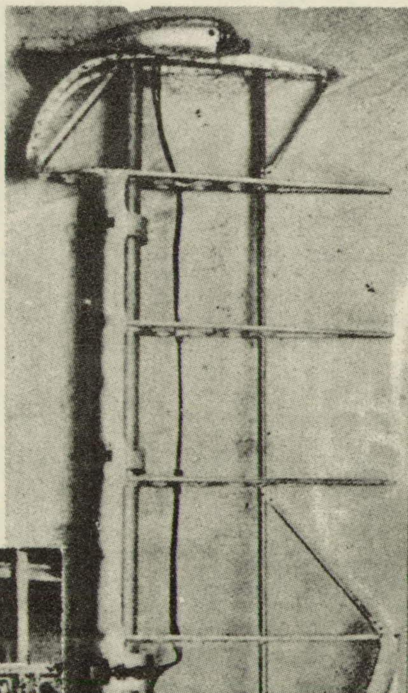


Fig.18

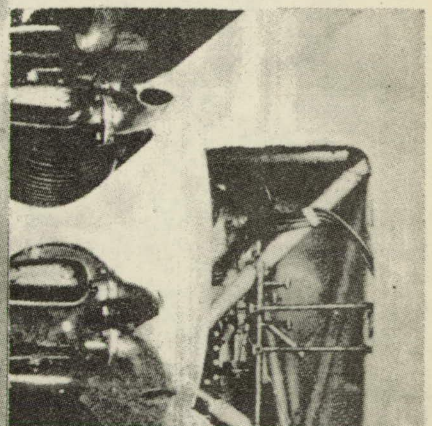


Fig.21

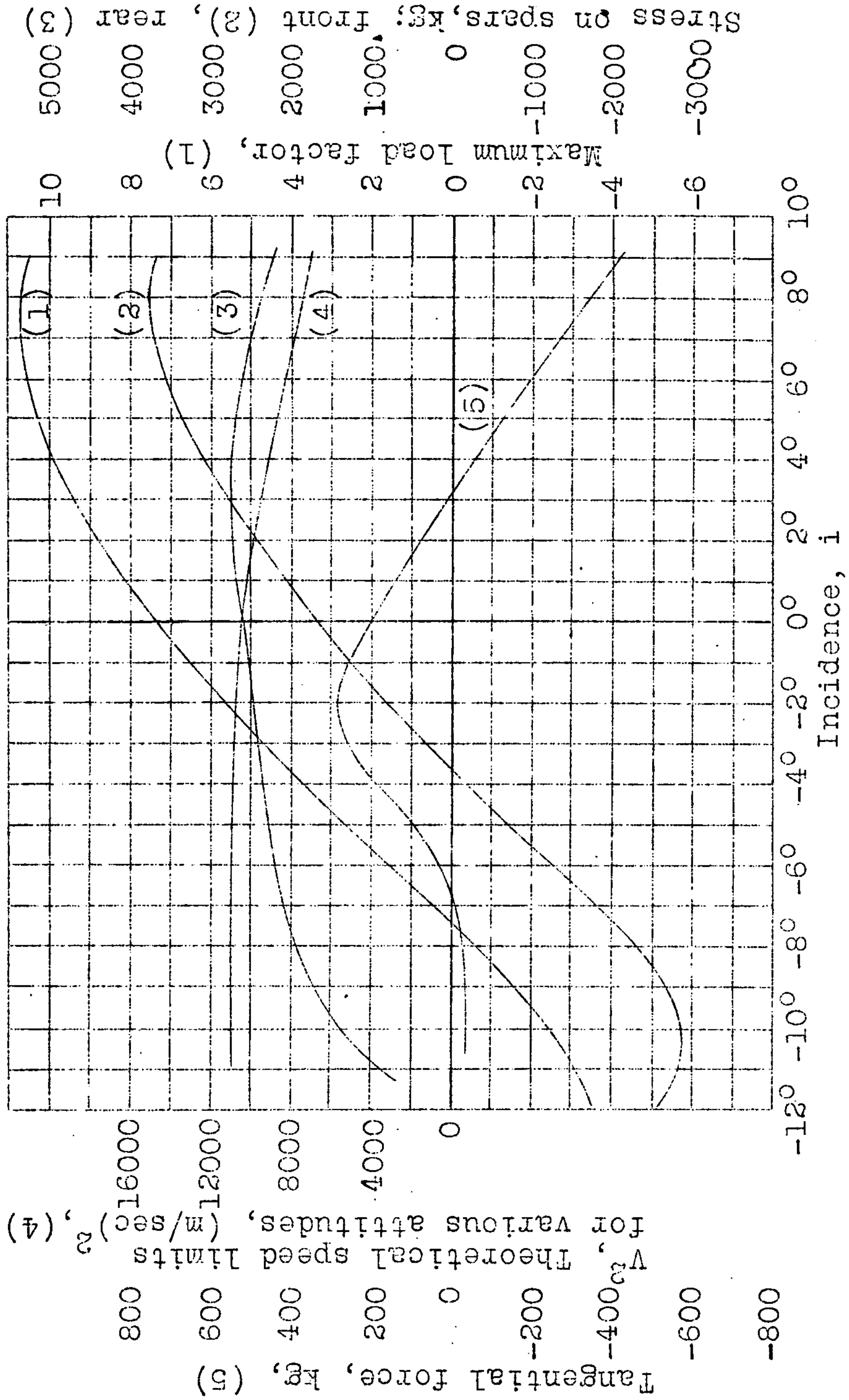


Fig.22 Wing-stress diagram.