AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 116

THE JUNKERS "G 38" COMMERCIAL AIRPLANE (GERMAN)

A Giant High-Wing Monoplane

Washington
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THE JUNKERS "G 38" COMMERCIAL AIRPLANE (GERMAN).*

A Giant High-Wing Monoplane.

The economical and dependable transportation of large loads over long distances, and hence with the minimum fuel consumption and the maximum reliability of functioning, is the problem for the aviation of the future and was the problem kept in mind in the designing and construction of the Junkers "G 38." The means for solving this problem, which was in large part indicated in the first Junkers patent (German patent No. 253,788 - See V.D.I. 1924, p.1041) in 1910 and which has been largely realized in the "G 38," is the subject of the present sketch.

Principles of Construction

1. Improvement of the aerodynamic characteristics.
   a) By improving the lift through the selection of suitable wing profiles and the elimination, in so far as possible, of all disturbing parts.

   b) By reducing the structural drag to the minimum, making all the surfaces as smooth as possible, and keeping down the induced drag by a sufficiently long span.

*"Das Junkers-Grosslandflugzeug 'G 38'." From Zeitschrift des Vereines deutscher Ingenieure, January 4, 1930, pp. 2-6.

c) By increasing the efficiency of the power plant by means of a reduction gear, and by mounting the propeller far forward of the leading edge of the wing in the unimpeded air flow.

2. Keeping down the structural weight by the distribution of the heavy masses along the wing span, the reduction of the chord toward the wing tips, and the most advantageous utilization of the material.

3. Increasing the reliability of functioning by increasing the number of engines to four, and especially by the accessibility of the engines and accessories during flight.

Although the "G 38" does not represent the ideal "flying wing," Figures 1, 4, and 20 show a considerable approximation to it. The fuselage, which is still necessary as a support for the tail surfaces, is overshadowed by the wing, which has a thickness of 2 m (6.56 ft.), a chord of 10.4 m (34.12 ft.), and a span of almost 44 m (144.4 ft.).

The wing has a great sweepback and a tapering shape (with a great reduction in thickness toward the tips), and a decided dihedral.

The sweepback was chosen in consideration of the far aft position of the center of gravity, due to the location of the engines and driving gear aft of the leading edge of the wing and to the lack of any large masses forward of the leading edge.

The negative warp of the outer portions of the wing is an effectual preventive of autorotation and spinning. This made it possible to get along with a relatively small tail and a correspondingly short and light fuselage, with the consequent advantages of reduction in weight and in the magnitude of the control forces. The angle of sweepback of the leading edge of the wing with respect to the lateral axis of the airplane is about 20°, while the trailing edge is nearly parallel to said axis.

The greatly tapered shape is used for wings of relatively large span chiefly to reduce their weight, since any reduction in the weight reduces the bending moments and enables the increasing of the height of the girders in the central part of the wing for the better absorption of the flexural and torsional moments. In the case of the "G 38," still another reason was of decisive importance. The need of providing sufficient height for standing in the central part of the wing requires the maximum profile thickness there. Since aerodynamic considerations, however, limit the camber ratio, the minimum central wing chord was thus determined. On the other hand, the size of the airplane was limited by the given engine power and the allowable weight. Consequently, the economically permissible size of the wing was also limited. Moreover, since aerodynamic considerations made a certain minimum span seem desirable, the size of the wing determined its outside chord, which is about 2.8 m (9.2 ft.) at the outermost aileron bearing as against a maximum chord of 10.4 m (34.12 ft.) in the middle, which corresponds to an aspect ratio of 3.7. The wing has a mean dihedral of 8° on the under side, which gives it good lateral and banking stability.

Construction and Equipment

For reasons of production and transportation, the wing is divided into the central section, two intermediate sections and two outer sections.

The 2.02 m (6.63 ft.) high middle section contains, in the nose, the pilot room with the navigation room in front of it and the relatively low baggage room underneath. The inside height of the central wing section is about 1.9 m (6.23 ft.). Instead of the oblique girders used in previous Junkers airplanes, vertical girders are used in order to leave space for large unobstructed rectangular rooms. The three main girders absorb about 90% of the flexural moments of the wing, while the light auxiliary girders absorb most of the local inertia and air forces. The torsional moments of the wing are chiefly absorbed by the wing covering. By a suitable construction of the side walls of the fuselage, a free passageway was provided from the middle section to the side rooms in the intermediate sections of the wing.

The intermediate sections (Fig. 2) which are connected with the outer sections by ball-and-socket joints, contain the outer adjoining wing cabins, which are separated from the inner baggage room by a double fire wall. The forward part of the intermediate wing sections contain the inner engines with the forward propeller-shaft supports.

The forward portion of each outer section of the wing contains one of the outer engines, together with the propeller bearings and the cooling system. The after portion contains the passageway for the mechanics (Figs. 8-9). Behind the main corridor, protected by a double fireproof wall, there is the main fuel compartment with two rows of fuel tanks with a passageway between them (Fig. 21). The wing is accessible for inspection almost to the very tip.

The flanges of the wing spars are made from duralumin tubes, as in other junkers airplanes. The flanges are connected by trellis work or sheet-metal webs. The main and auxiliary spars are connected by numerous tie members in the direction of flight. The corrugated wing covering absorbs the local air forces and serves as the chief protection against torsion.

The fuselage contains two other roomy cabins immediately behind the middle of the wing. The end section of the fuselage is attached by ball-and-socket joints and serves only as a support for the tail surfaces and tail skid. This space is also accessible during flight.

The horizontal empennage is of the unstaggered biplane type with upper and lower parts of nearly equal area (Fig. 16). The vertical empennage consists of a central rudder hinged to a relatively small fin and two balanced rudders at the ends of the horizontal stabilizers. All the control surfaces are balanced, including the ailerons. Due to this fact, the control forces are very small, so that the simple and reliable hand controls, designed from advance calculations, proved entirely satisfactory. The control forces are of the order of magnitude of the Junkers "F 13" and "G 31" (N.A.C.A. Aircraft Circular No. 54: "Junkers Commercial Airplane 'G 31'"). The elevators and ailerons are dynamically balanced for protection against vibration.

The angle of attack of the horizontal stabilizer can be adjusted by the pilot during flight by means of a handwheel, so as to obtain any desired trim. In case of the stalling of one of the engines, the rudders can be set so as to offset, by means of a nearly constant, long, auxiliary spring, the turning moment about the vertical axis. This leaves, moreover, the possibility of further lateral deflection. The control rod runs through ball bearings in a fully enclosed but easily accessible channel, the same as on the "G 31."

The landing gear has, instead of the hitherto customary single or double wheel on each side, two tandem wheels mounted in a hanging frame which allows them to oscillate about a horizonatl axis (Fig. 17). The oscillating support is kept in the horizontal position by strong springs. This arrangement reduces the shocks, in taxying on rough ground, to less than half those of ordinary single-wheel landing gears, as likewise the track resistance and the danger of sinking into soft ground. This arrangement also enables an aerodynamically favorable cowling of the landing gear. Each pair of wheels, with pneumatic tires 150 x 35 cm (59.1 X 13.78 in.) is mounted in a strong frame of cast elektron. All four wheels are provided with Knorr compressed-air brakes, each wheel being braked by a single brake cylinder. The maximum operating brake pressure is about 6 atm. The braking effect can be varied at will, however, by a special valve. The uniform simultaneous action of all the brakes is produced by a single main brake lever in the pilot room, which actuates the brake valve when pulled back over the idling position of the throttle levers. By pushing the rudder pedals beyond the normal distance, the two brake valves are differentially actuated, so that a one-sided braking effect is produced for steering on the ground. The brakes are so strong that they even suffice for braking the engines on the test stand without using brake clogs (Bremsklötze).

The hitherto customary tail skid has been replaced in the "G 38" by an orientable cast-elektron wheel mounted in a cast-elektron fork (Figs. 1 and 16). It is held by springs, both horizontally and vertically. This wheel greatly reduces the ground friction in taking off and does not tear up the landing field like a tail skid.

The power plant consists of two Junkers engines L 88, each of 800 hp as the inner engines, and two Junkers engines L 8, of

400 hp each as the outer engines. All the engines are entirely inside the wing so that they are removed from the free air flow. They can be attended during flight, and troubles remedied. In order to advance each propeller far enough from the leading edge, an intermediate shaft is interpolated between the engine and propeller. In order to protect the relatively light shaft from excessive stresses, there is inserted between the shaft and the engine a Junkers liquid coupling to absorb the torque. Moreover, between the liquid coupling and the propeller shaft, there is the reduction gear with a step-down ratio of 2 : 1. The new driving gear is the first step in the development of distance engine control for enabling any desired arrangement of the engines and propellers.

Between the engines, there are the radiators, which are accessible during flight and can be drawn in, to regulate the temperature of the cooling water and to reduce the air resistance in horizontal flight (Figs. 3 and 24). The engines and cooling plant, gravity fuel tanks and water tanks on each side of the airplane are installed in a special engine room with double fire walls on the sides and rear. The main passageway between the engines and radiators can be shut off by fireproof doors from the outer wing section, from the central corridor connecting the two engine rooms, and from the chief mechanic's room.

In the left main engine room, there is also a Junkers heavy-oil free-piston compressor, which supplies compressed air for starting the engines, operating the air brakes and actuating the fire and shut-off cocks. The compressor delivers air at about 50 atm., which is stored in several high-pressure cylinders. The air is used at a pressure of 6 atm. after passing through a pressure-reduction valve. The engines are started by means of compressed air which is first led through an auxiliary carburetor and mixed with fuel.

The fuel tanks are suspended in the after part of the wing behind the double fire wall on both sides of a passageway (Fig. 21). The 240- and 140-liter (63- and 37-gallon) welded aluminum cylindrical fuel tanks are all connected by a system of pipes with a receiving tank at the lowest point in each half-wing, into which the fuel flows by gravity. From this tank the fuel is drawn by Jumo pumps and delivered to the carburetor. In case of failure of the engine pumps, the fireproof gravity tanks suspended in the engine room can be switched on. In case of need, fuel can be pumped by hand from the fuel tanks on one side of the airplane to those on the other. The contents of the large inner tanks can be quickly dumped by a single motion of the hand, in order to lighten the airplane in case of failure of the engines. The oil tanks are located aft of the engines directly behind the fire wall in the tank room.

Electric current for the lights is furnished by a current generator driven by an outer engine by means of a friction belt.

The same generator also furnishes the current for the radio plant and the storage battery.

Two fire-extinguishing systems provide for the prompt fighting of fires. One system is operated either automatically by the melting of a fuse near the engine or electrically from the chief mechanic's room. The other system is operated by hand by opening a valve in the mechanics' room. Hand extinguishers are also distributed in the other rooms.

In the front end of the middle section, forward of the leading edge of the wing, there is a navigation room, from which there is an unobstructed view, with an adjoining room for the radio outfit. A connecting passage leads to the navigation room from the pilots' passageway and from the main corridor. The leading edge of the wing contains the pilot room with two seats and two control columns and pedals for the directional control (Fig. 7).

There is a clear division between the duties of the pilot and of the mechanics. Aside from the steering controls, the pilot has before him only the navigation instruments necessary for piloting the airplane. In the middle between the two pilots' seats, there are placed on a narrow shelf the throttle levers (together with the previously mentioned brake lever), the main switch for the magnetos and a switch which, in case of danger (e.g., before a forced landing) can shut off the ignition from all the engines, break all the electric circuits and turn on the electric fire extinguishers. All the fuel cocks can be closed by the operation of a single switch.

Immediately behind the rear wall of the pilot room, in the middle of the transverse passageway, there is the chief mechanic's post, from which the whole power and fuel plant can be controlled (Figs. 22 and 25). The pilot is thus relieved of all care of the power plant. The pilot and chief mechanic can communicate with each other directly or by electric telegraph. The mechanics in the mechanics' rooms receive signals through a mechanical telegraph or a whistle.

The principal characteristics of the "G 38" are:

Span	44.0	m	144.35	ft.
Length	23.0	"	75.46	"
Height	6.5	"	21.33	"
Wing area	290	m²	3121.53	sq.ft.
Weight, empty	13000	kg	28660	lb.
Normal flying weight	20000	"	44090	"
Maximum " "	24000	"	52900	"
Total engine power	2400	hp		

Its cruising speed is about 170 km/h (106 mi./hr.). It can fly 3500 km (2175 mi.) with a take-off weight of 24000 kg (52900 lb.), and a useful load of 3000 kg (6614 lb.). Its first flight was entirely satisfactory. The new-style power plant worked perfectly.

Legends

Fig. 5.-Coverings of Junkers F 13, G 24, and G 38, respectively. Uniform thickness of 0.3 mm (0.12 in.). Width of corrugation increased.

Fig. 6.-Two of the passenger cabins (Photo. 1. See Fig. 2). Instrument board for engine control. Note that the passageways between the various compartments had to conform to the structure of the airplane. The central cabins, being in the wing are lighted through the ceiling. In our opinion they are more suitable for freight, leaving the fuselage cabins for the passengers.

Fig. 7.-Pilots' equipment (Photo. 3. See Fig. 2). Before the board where the dial instruments are mounted, we see the throttle levers; at the lower left the lever which shuts off the gas and electric circuits and turns on the fire extinguishers. All the starting, cooling and fuel devices are attended to by the two mechanics without requiring the attention of the pilots.

Fig. 8.-Main corridor (Photo. 4. See Fig. 2). Located at the middle of the span and about a quarter of the chord of the wing, this corridor serves as the post for the chief mechanic who operates the main board for the control and surveillance of the engines. This board (on the wall at the right) is situated behind the pilots' seats. In the background and to the right is shown the entrance to the cabin in the leading edge of the left wing. The partition in the background is adjacent to the compartment containing the first engine to the left of the fuselage. By turning left at the end of this corridor and then right (Fig. 2), one enters the corridor leading to the engines.

Fig. 9.-Engine corridor (Photo. 5. See Fig. 2). Located at about a third of the wing chord, this corridor is continually traversed by two mechanics engaged in the direct supervision of the engines and radiators. In the left foreground is seen the Junkers heavy-oil auxiliary engine which furnishes the compressed air for the starter. In the background the tight door, affording access to the outer end of the wing, is open and shows one of the mechanics at work.

Fig. 10.-Tank compartment (Photo. 6. See Fig. 2). In the right lower foreground, one of the fuel tanks for receiving fuel pumped from the other tanks whence it is delivered to the engines by "Jumo" pumps. At the upper right, an auxiliary tank for use in case of pump failure. A fireproof bulkhead separates the engines of this compartment from the tanks. A tight door affords access to the side corridor at the height of one of the V engines (Junkers L 55).

Fig. 11.-Control of radiators from main corridor (Photo. 7. See Fig. 2). Handles, attached to long horizontal rods (Fig. 18), control the vertical displacement of the radiators. This photo. shows, on the one hand, the dimensions of the accessible wing and, on the other hand, the obstacles remaining despite the very careful designing of the structure. The designer succeeded, in fact, in making it possible to control the radiators through the lattice webs of the wing spars.

Elements and Assembling of the "G 38"

Fig. 12.-The front part of the fuselage. The wing section shows the characteristic Junkers structure with multiple spars distributed, this time, in pairs in the same vertical plane. At the bottom, the shock compartment for receiving the freight. The wing profile is much like that of the preceding Junkers airplanes. At the bottom and in front of the pilot room, there is a room for the commander and navigator.

Fig. 13.- The elements of the wing. The central section, which is integral with the fuselage, contains two 650 hp L 55 V engines (one for each half-span). Each lateral section of the wing contains a 400 hp L 8, six-cylinder vertical engine. The wing sections are connected by Junkers ball-and-socket joints of the customary type, simply enlarged to suitable dimensions.

Fig. 14.-The engines in the wing. Installing one of the inner engines (650 hp L 55). The conical projection keeps the propeller far from the wing. It supports the transmission shaft and the planetary reduction gear (See L'Aeronautique No. 124, p.308, for the description of this shaft, which appears to solve the chief problem of providing sufficient space between the propeller and the wing by a flexible transmission at a very low critical speed).

Fig. 15.-The same engine as in Figure 14 seen from above. In order to install the engine, a section of the tubular flange is removed, which section is seen lying on the wing at the right.

Fig. 16.-The tail. Biplane horizontal empennage. This type was adopted in order to give the elevators a large aspect ratio (thus reducing the force required to operate them), while avoiding excessive weight of the tail structure and the torsional stresses on the fuselage which would result from a monoplane tail, especially in the case of a single fuselage. The tail surfaces of the "G 38" were thus reduced to the dimensions of those of the G 31, which made it possible to use transmissions and controls already tested. The controls of the elevators and of the central rudder have axes of articulation far enough aft of the fixed planes to produce a balancing effect. The lateral rudders which are not preceded by fins, are balanced by the after position of their axes of rotation. The tail skid is replaced by a large orientable wheel of elektron.

Fig. 17.-One of the landing gears. The two wheels, with pneumatic tires 150 x 35 cm (59.1 x 13.78 in.), are mounted in a strong elektron chassis. This chassis oscillates about a horizontal axis at the lower end of a vertical elastic strut. On the left wheel is seen the control of one of the Knorr compressed-air brakes enabling either a conjugated or differential action. The tandem arrangement of the wheels lessens the drag and facilitates the use of cowlings. In December, 1929, cowlings were made at Dessau for enclosing the whole landing gear back to the hubs. This type of landing gear equalizes the loads on the two wheels, even if one of the wheels is deflated or on uneven ground, and appreciably reduces the landing and taxying shocks, so dangerous to large airplanes. The tests seem to have demonstrated the value of these provisions.

Fig. 18.-Interior of outer wing (Photo. 8. See Fig. 2). Shows sockets of ball-and-socket joints for attaching to middle section; also, between the radiator and the front spar, one of the vertical guides for regulating the cooling.

Fig. 19.-An outer wing of the "G 38", after removing the scaffolding.

Fig. 20.-Top of wing. Man in foreground is near an opening for filling a fuel tank.

Fig. 21.-Tank room and passageway in outer wing section.

Fig. 22.-Chief mechanic's switch and instrument board.

Fig. 23.-General view of the "G 38."

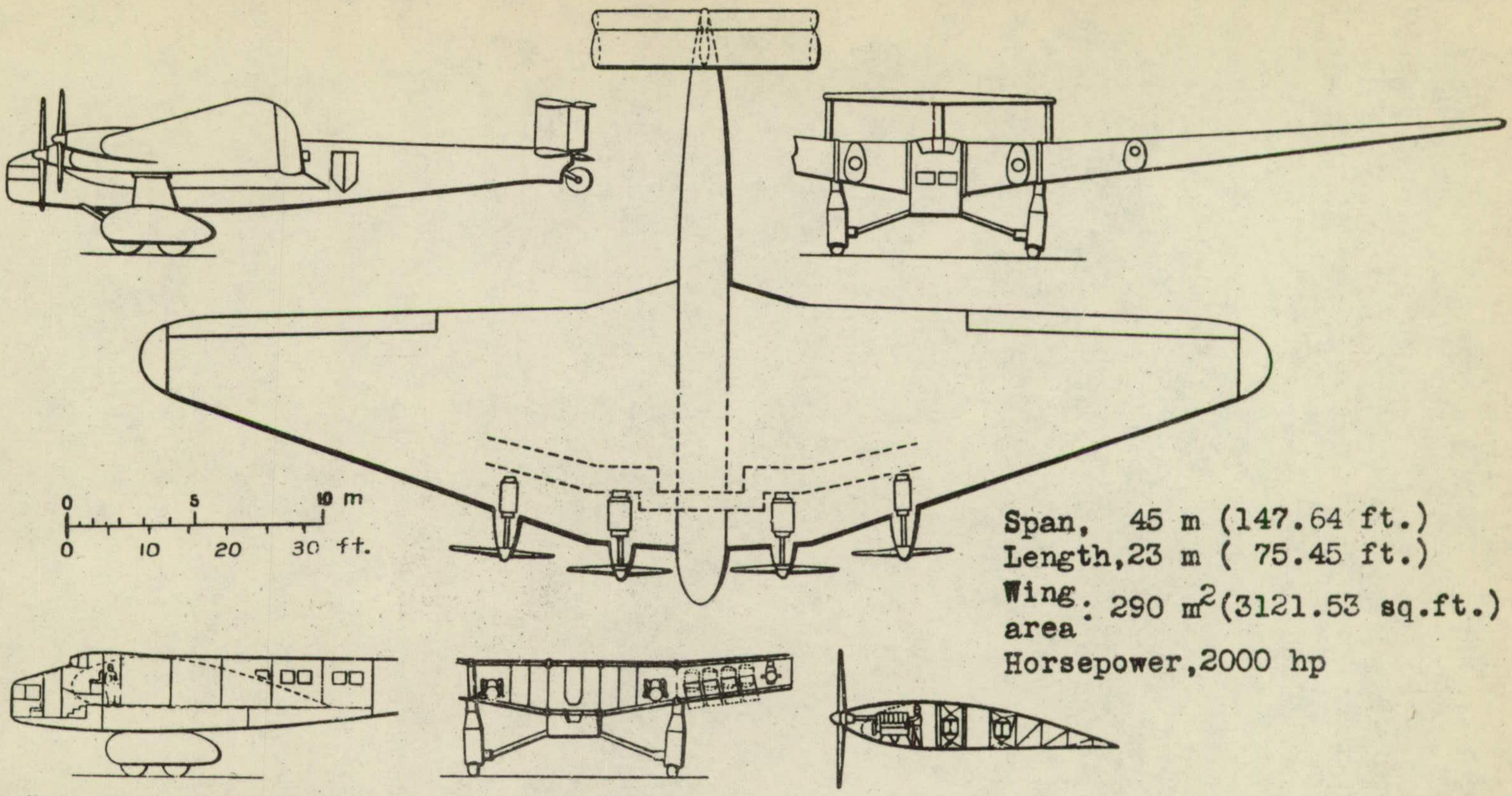
Fig. 24.-Streamlined housing of landing gear.

Note.-Figures 1 to 18 inclusive, taken from L'Aeronautique, March, 1930, pp.83-87.
Figures 19 to 24 inclusive, taken from Junkers-Nachrichten No. 1, 1930.

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

Fig.1

General arrangement drawings of the Junkers G-38 airplane showing postion of aviators' seats, engines, radiators transmission gear and tanks.



"Itinerary" through the G-38. The photos on this and the following pages were selected and arranged so as to correspond to an actual "itinerary" through the airplane. They are numbered according to this diagram(Fig.2)at the point where the photo was taken in the direction indicated by the arrow (the photo 2 being reserved for a picture of the pilot room.).

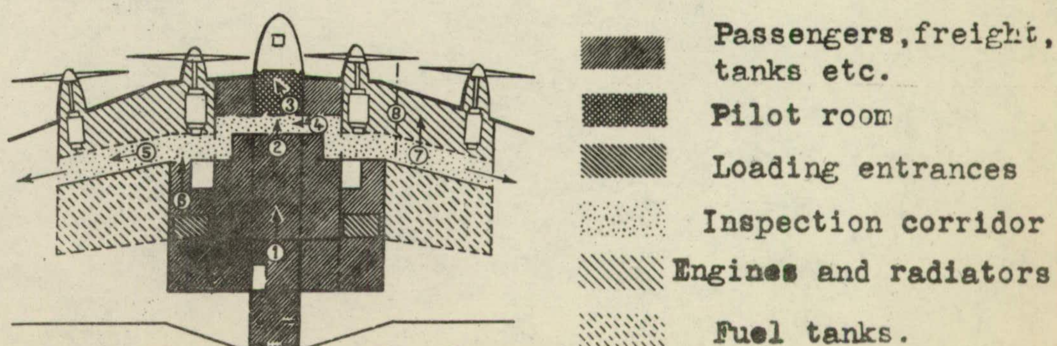


Fig.2

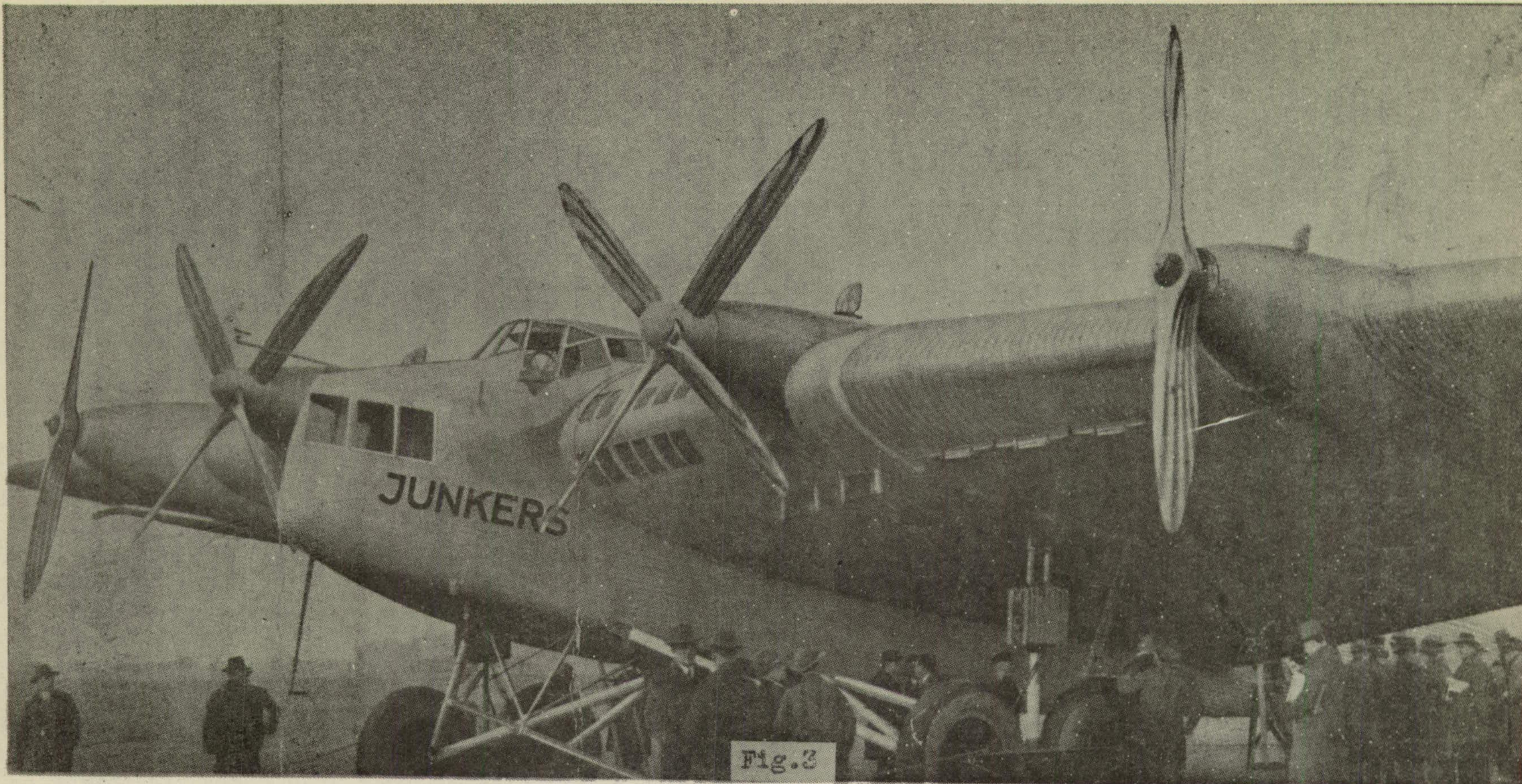


Fig.3

Close-up view of the Junkers G-38 airplane.

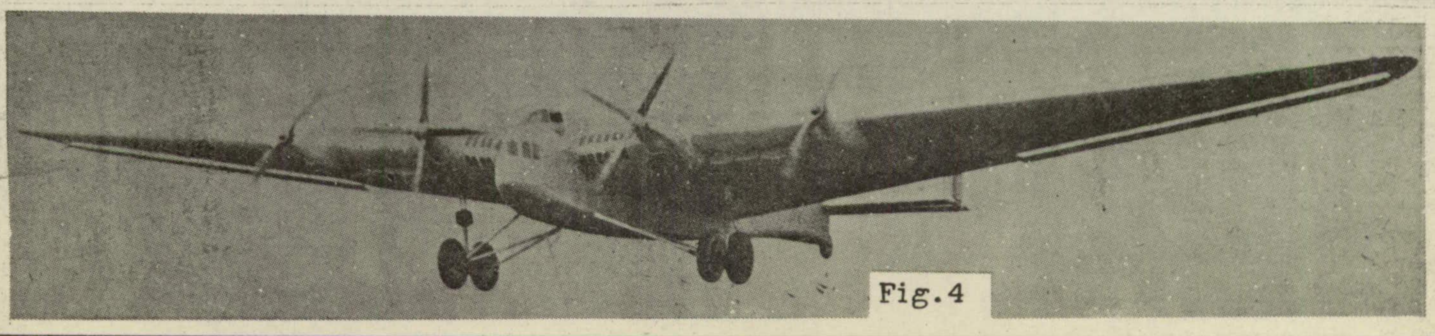


Fig.4

View of the Junkers G-38 in flight.

Figs.3 & 4

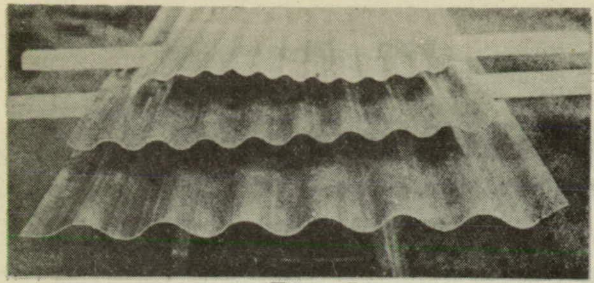


Fig.5

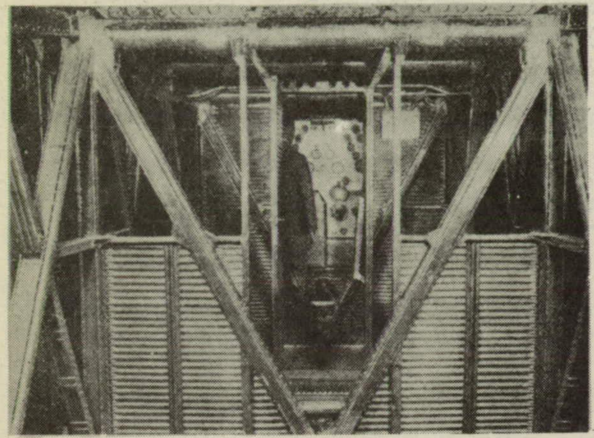


Fig.6

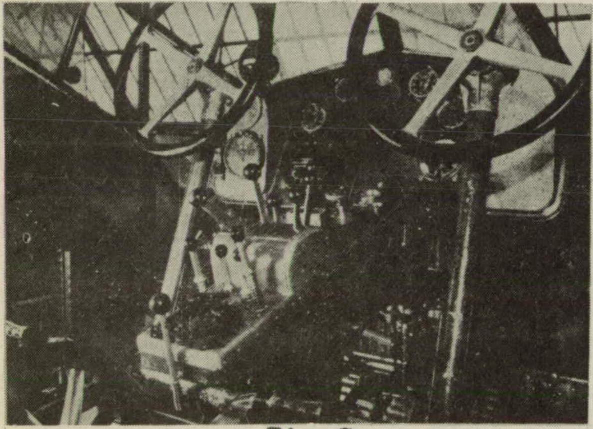


Fig.7

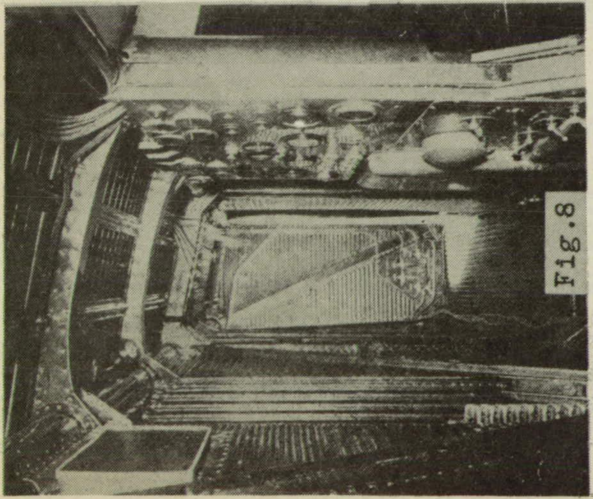


Fig.8

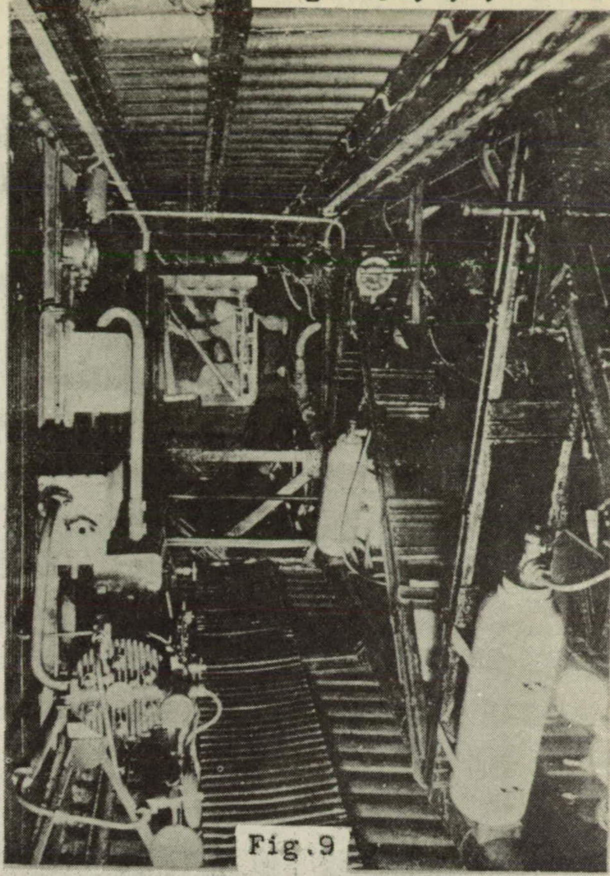


Fig.9

Views of structure of the Junkers G-38 airplane

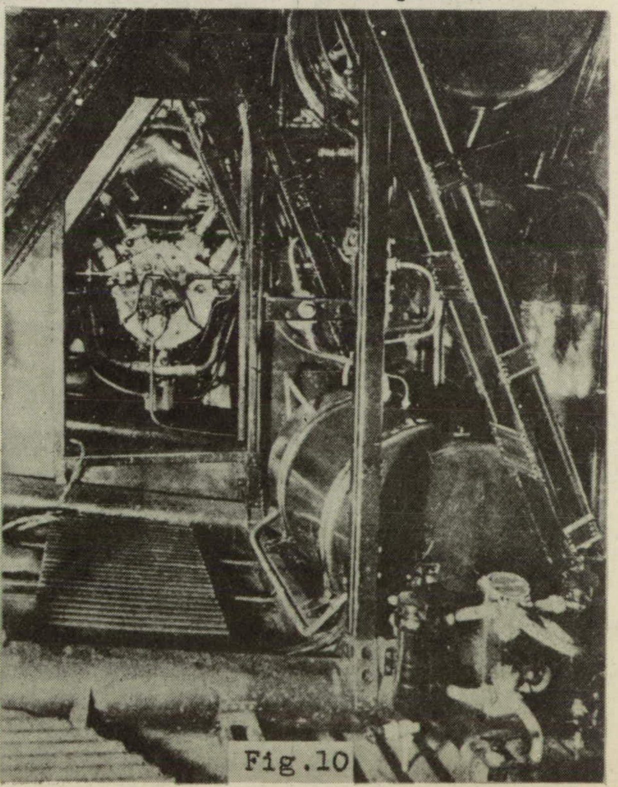


Fig.10

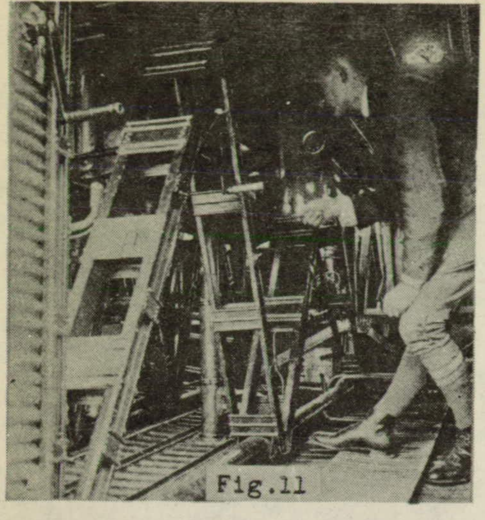


Fig.11

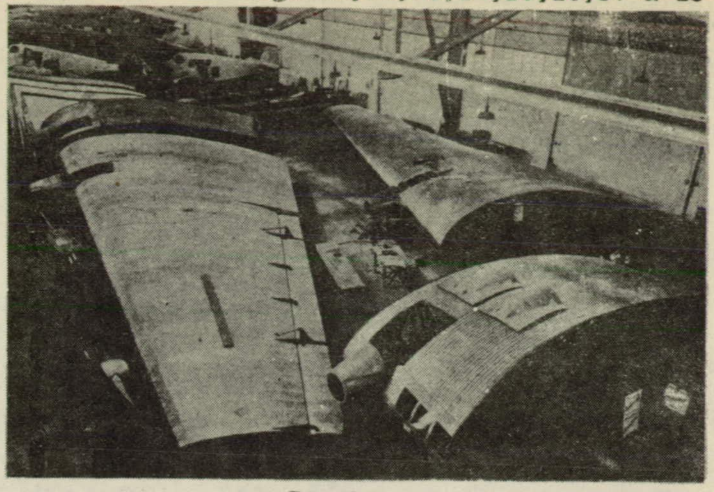


Fig.13

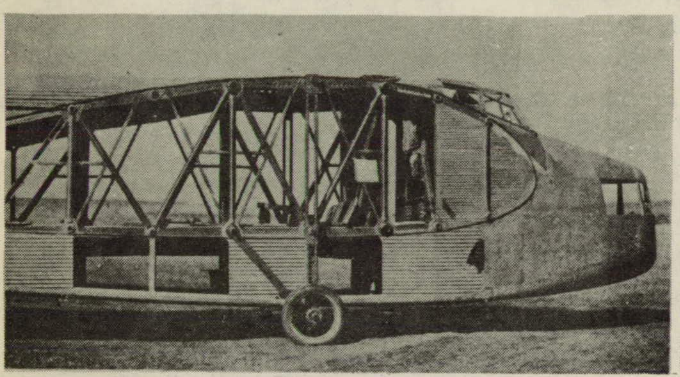


Fig.12

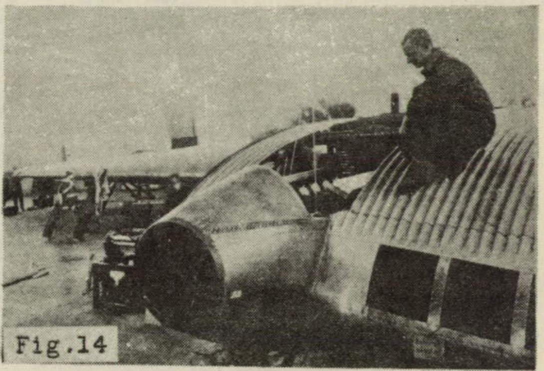


Fig.14

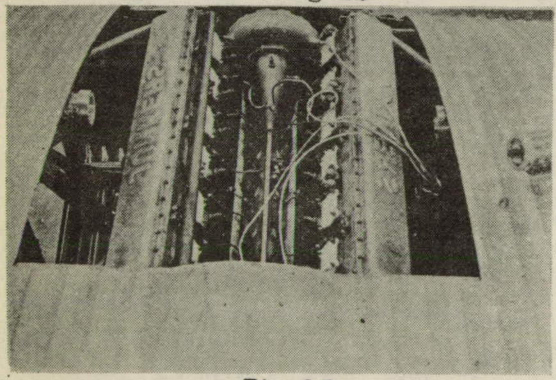


Fig.15

Views of structure of the Junkers G-38 airplane

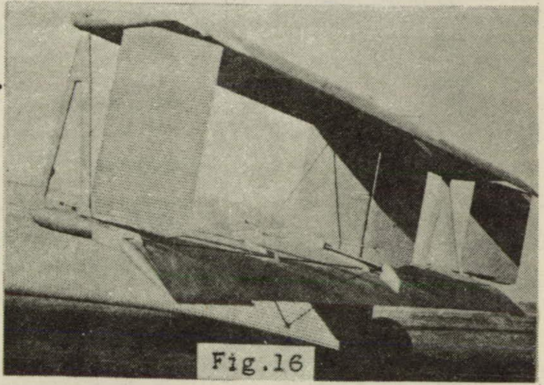


Fig.16

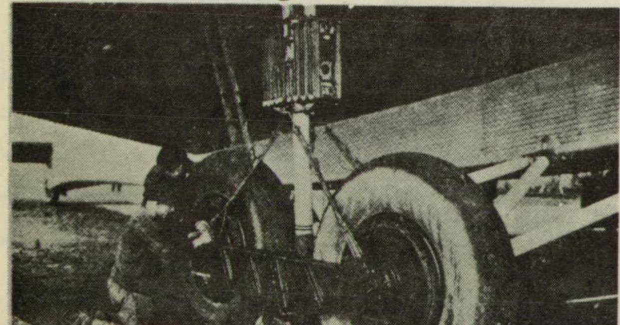


Fig.17

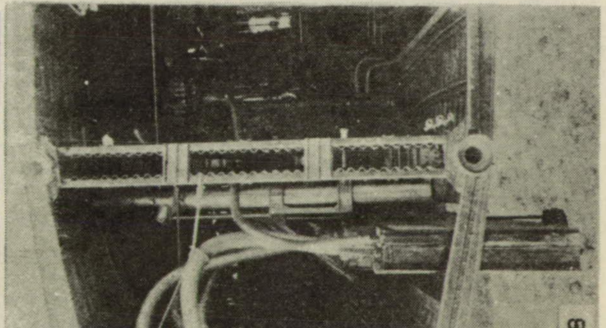


Fig.18

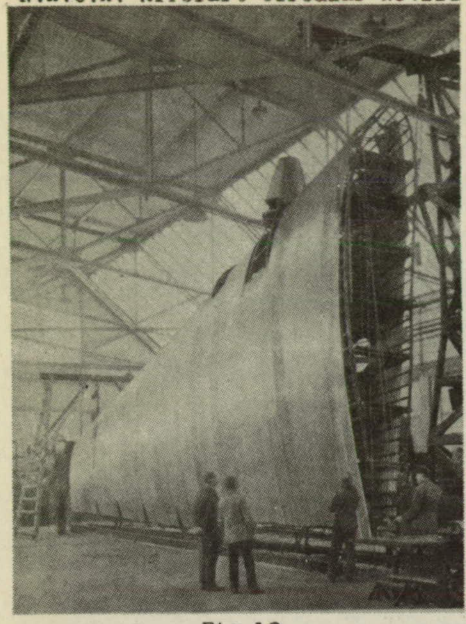


Fig.19

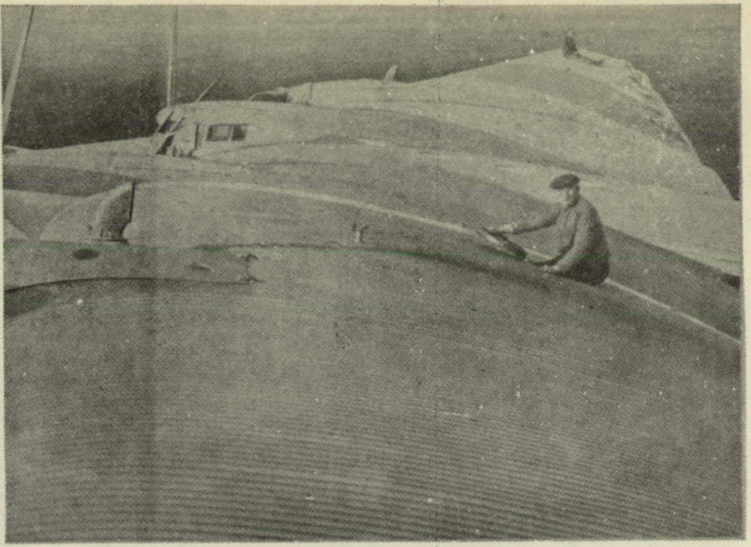


Fig.20

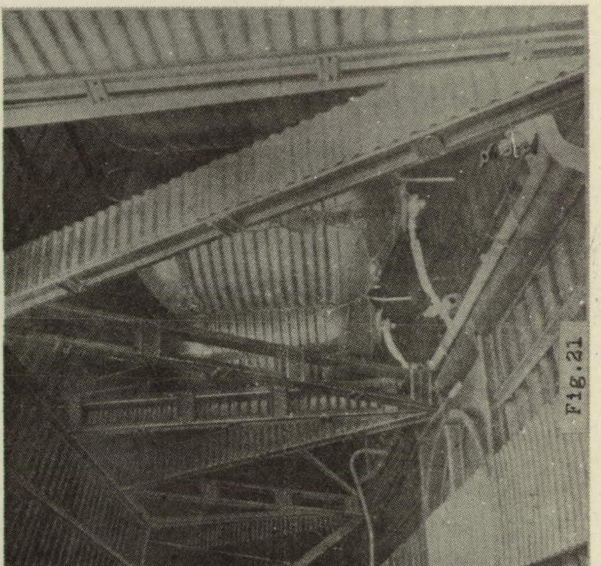


Fig.21

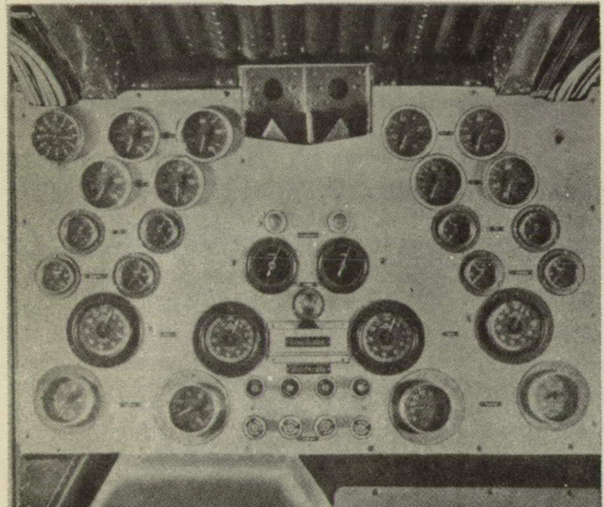


Fig.22

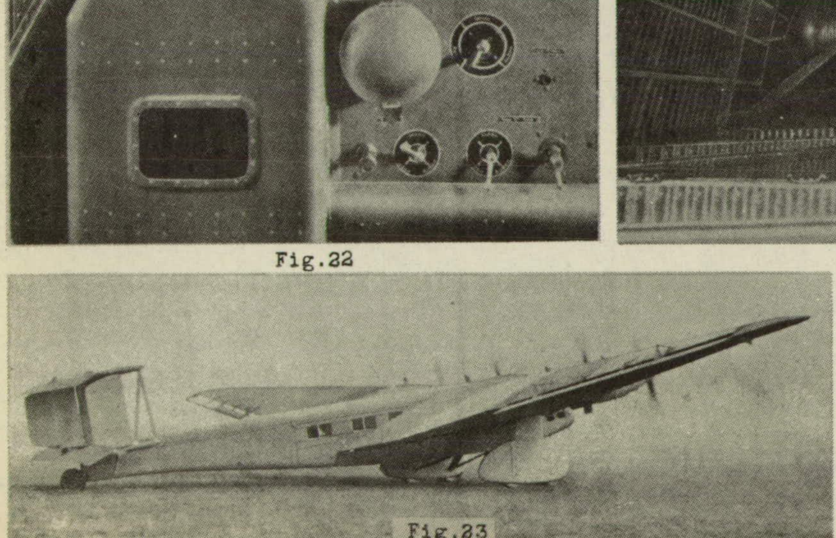


Fig.23

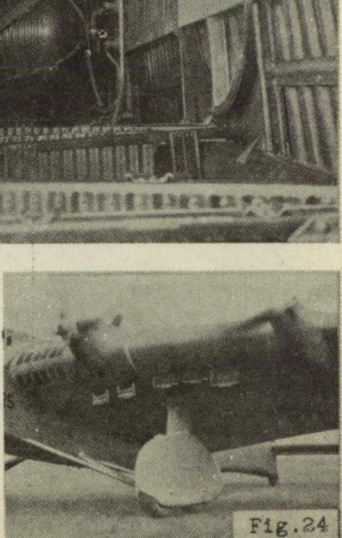
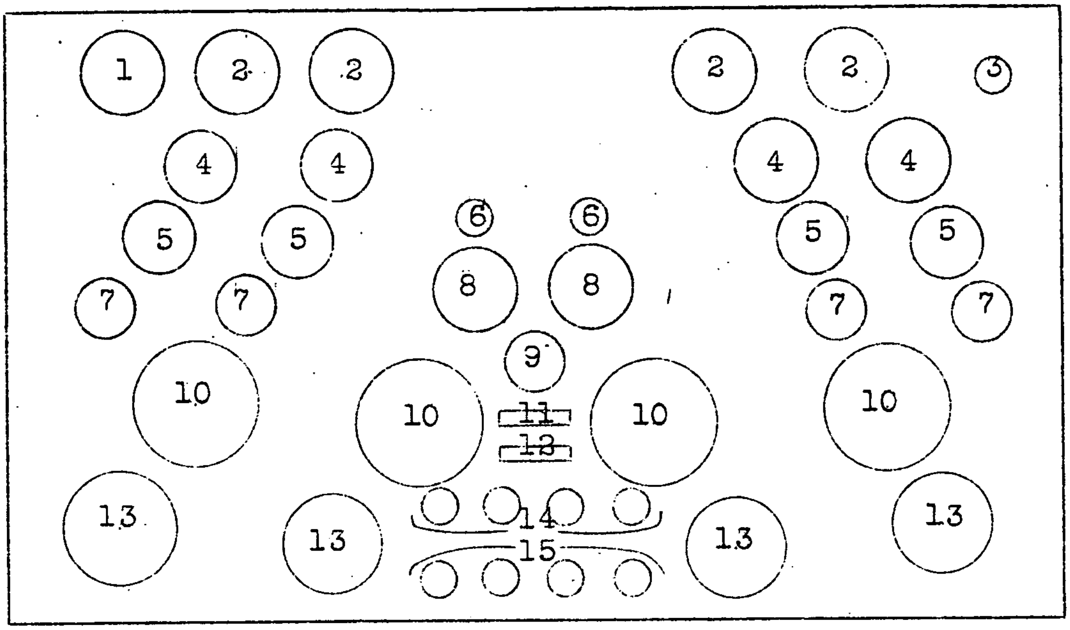
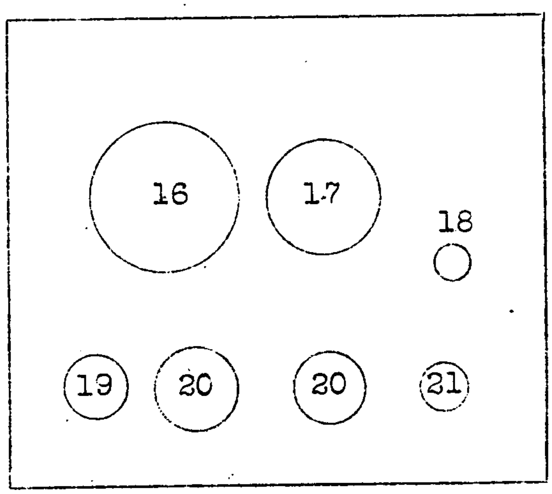


Fig.24





1.Clock; 2.Water thermometer ; 3.Signal button ; 4.Oil thermometer; 5.Oil pressure gauge; 6.Fuel pump; 7.Fuel pressure gauge; 8.Fuel gauge for receiving tank; 9.Compressed air manometer; 10.Revolution counter; 11.Fire-extinguisher switch; 12.Battery switch; 13.Oil-coupling thermometer; 14.Fire valves; 15.Fuel valves ; 16.Ignition and starting switch; 17.High tension switch ; 18.Starting magneto; 19.Injection pump; 20.Distribution cock; 21.Compressed-air starting valve.

Fig.25 Diagram of chief mechanic's switch and instrument board.