# LIGHT HELICOPTER PROJECT „*IS-2*"

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Abstract

In the paper the light helicopter project „*IS-2*" is described. Design requirements, basic configuration, some construction features and provisional performance are given. Research carried out for the project, and state of the art of building of prototypes, are presented.

## Introduction

In 1994 the Institute of Aviation in Warsaw and the helicopter factory WSK-PZL in Świdnik commenced work on a joint project to design and develop a 2-seat piston engine helicopter. The research part of the project is subsidised be the State Committee for Scientific Research. The designation „*IS-2*" arises from the initials of Institute of Aviation and Swidnik, with „**2**" representing the number of seats. The basic layout is a side-by-side arrangement with provision for dual controls when used in the primary training role.

„*IS-2*" will be the smallest helicopter commercially manufactured in PZL-Świdnik factory. It is designated to a wide range of operational activities:

- fire and disaster surveillance and control,
- first aid,
- law enforcement and traffic surveillance,
- mustering support or aerial tender for ships or yachts,
- scientific, agricultural, environmental, and other civil and military observation,
- private transportation and leisure,
- rotary-wing primary and advanced training,
- transport of small internal/external cargo,
- other, specialised, civil and military missions.

It is expected that arrival of „*IS-2*" on the market will be attractive and affordable for both domestic and foreign customers and will fulfil the demand in Central and Eastern Europe on such a type of helicopter.

## Design requirements

The technical, operational and economic requirements were set up by marketing and by design departments and were aimed at a relatively low price helicopter of satisfactory performance and complying with FAR/JAR-27 requirements. Structure should assure maximum protection for passengers and should be easily configured into the versions according to customer requests.

An attention is paid to make the helicopter affordable and safe, simple in manufacturing, assembly and maintenance. Composites are to be used in the construction wherever appropriate. Although the selling price will depend on the equipment installed, the average price of „*IS-2*" is estimated at about US $120,000 and the operating cost at about US $100 per flight hour.

„*IS-2*" has been designed for normal operation up to an altitude of 2,500m with external temperature between -30 and +40 Celsius. The maximum payload, including fuel, is 230kg and a hook has been provided for external loads.

The helicopter will have a VFR day and night capability. It should be easily controllable and ensuring high level of comfort as for a light helicopter of its class.

Overall drawing of „*IS-2*" is shown in Fig. 1 and its provisional data are given in Table 1.

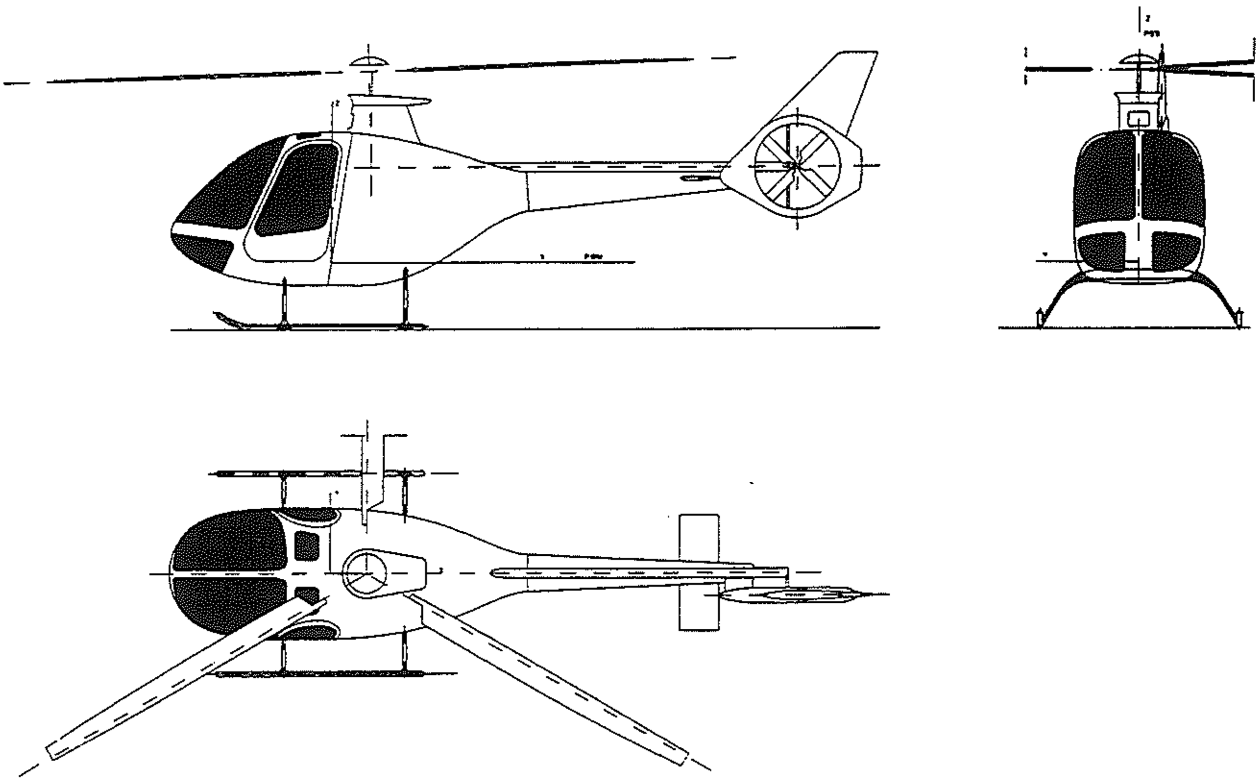

Fig. 1

Table 1

| | |
|---|---|
| **WEIGHTS** | |
| Gross weight | 785 kg |
| Empty weight | 550 kg |
| Fuel | 80 kg |
| Pilot, passenger & baggage | 155 kg |
| **PERFORMANCE** | |
| Max. Airspeed ($V_{ne}$) | 195 km/h |
| Cruise airspeed | 170 km/h |
| Max. rate of climb airspeed | 95 km/h |
| Max. rate of climb GW | 6.5 m/s |
| Hover ceiling IGE | 1,250 m |
| Hover ceiling OGE | 1,000 m |
| Max. hover OGE | 3,500 m |
| Ave. Fuel consumption | 35 l/h |
| Fuel tank capacity | 110 l |
| Max. range (20 min. reserve) | 390 km |
| Max. endurance (20 min. res.) | 3 h |
| Height-velocity IAS 15m | 48 km/h |
| Autorotation IAS/min. ROD | 95 km/h |
| **DESCRIPTIVE DATA** | |
| Main rotor diameter | 7,5 m |
| Disc loading GW | 17.8 $kg/m^2$ |
| Main rotor rpm 100% | 484 rpm |
| Tail rotor diameter | 0.864 m |
| Tail rotor rpm 100% | 4,000 rpm |
| Cabin width | 1,35 m |
| Height of cabin roof | 2 m |
| Height of main rotor | 2.65 m |
| **POWERPLANT DATA** | |
| Engine model | Lycoming O-360* |
| Engine type | 4 cyl./4 stroke |
| Cooling system | Forced air |
| Max. continuous rating | 130 kW |
| Fuel | 100/100 LL |

* later Franklin 6A-350-C1, 6cyl./4 stroke, 150 kW.

## Construction features

### Main rotor

The helicopter is configured with one 3-bladed main rotor.

To speed up the design, construction, manufacturing and testing of the rotor head, initially the articulated rotor head with a hydraulic damper at lagging hinge will be installed. Such an arrangement is, so far, commonly applied for all the helicopters produced in Poland and years of experience will pay back in the design of a light rotor head which is presently under construction. A programme for development of a new generation main rotor head for the „*IS-2*" has already started. At the beginning it is intended to replace the flapping hinge of roll type by an elastic element, and the hydraulic damper at lagging hinge by an elastomeric damper. Then in place of both flapping and lagging hinges a flexbeam will be installed, and finally also the feathering hinge will be eliminated. The programme is scheduled for few years and each completed step of the development of the rotor head will be tested on „*IS-2*".

Conventional swash plate is used for collective and cyclic control. No power or mechanical assist is provided.

Design, construction and manufacturing of the rotor blade have been performed by DWLKK (Experimental Workshop of Aeronautical Composite Constructions) in Warsaw, an organisation owned by Institute of Aviation in Warsaw, helicopter factory WSK-PZL in Swidnik, and Warsaw University of Technology.

Blade is made from a carbon/glass/epoxy composite and consists of two halves bonded together. Due to conductivity of electric charge, blade is protected against lightning strike. Construction of the blade is shown in Fig 2, and the blade cross section is shown in Fig. 3. The blade is empty inside to facilitate possible development of various

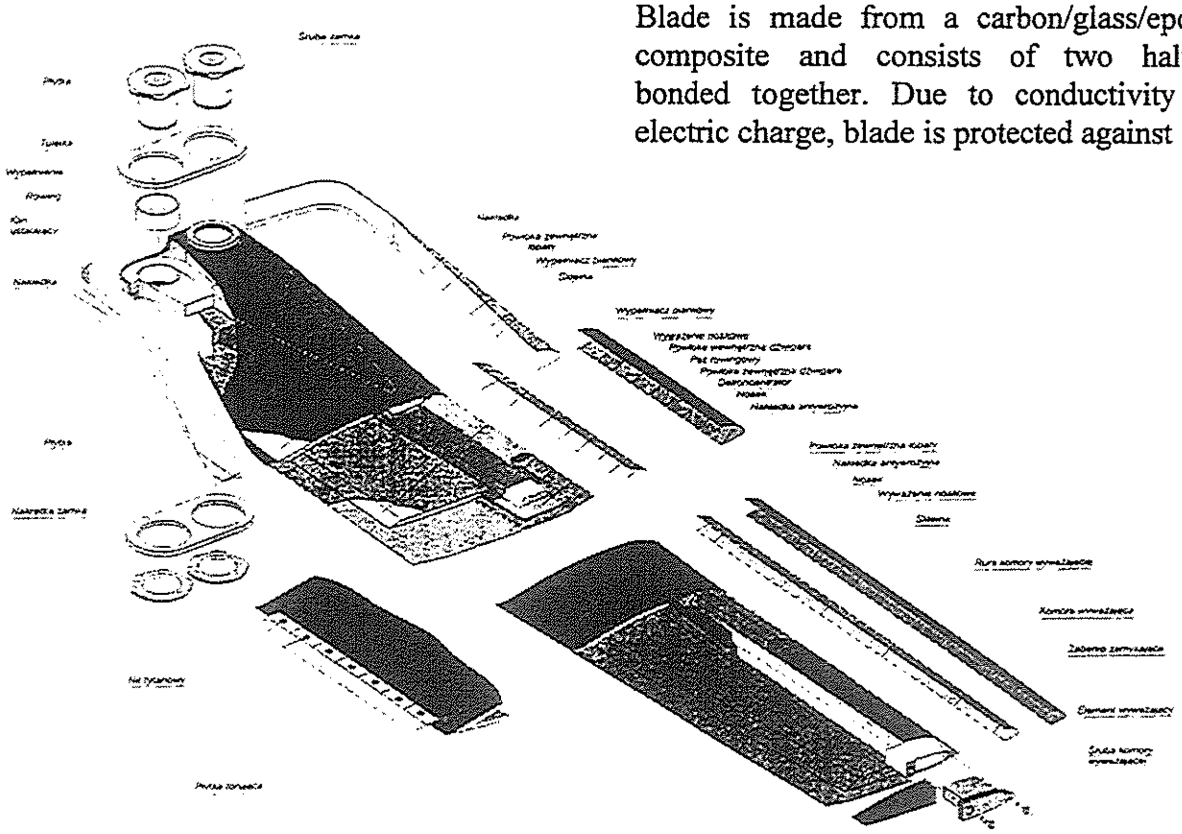

Fig. 2

blade pitch control systems (for instance, by deflection of a tab located in the outer part of the blade).

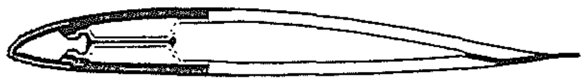

Fig. 3

Rotor blade is rectangular till 80 % of its length and then is tapered to 75% of the root chord. Blade thickness at the root is 12% and constant on rectangular part then linearly decreases to 9% at the tip. The blade is linearly twisted by -10deg as counted between the main rotor shaft and the blade tip. Blade airfoil ILHX4A1-12M1 has low drag coefficient and nearly zero moment coefficient at wide range of angles of attack and Mach numbers. It has been calculated and tested in wind tunnel at the Institute of Aviation in Warsaw. To improve the autorotation properties of the rotor, additional weights are provided at the blade tips. To decrease the rotor noise, the nominal blade tip speed in hover is 195 m/s. The „*IS-2*" main rotor will rotate anti-clockwise as looking from the top. Such a rotation will be applied for the first time at helicopter manufactured in Central and Eastern Europe.

Blade prototypes have been already manufactured and preliminary tests have been completed. Static load tests showed good agreement with calculations. Blade bending and torsion natural modes and frequencies have been determined be ground resonance tests. Distribution along the blade length of stiffness, mass and moments of inertia as well as centres of gravity and location of elastic axis have been measured. Calculations of blade motion stability (divergence and flutter) showed good blade behaviour within the whole flight operation envelope.

Fuselage

The mock-up of „*IS-2*", showing its overall view, is presented in Fig. 4. Cabin external skin is manufactured from glass/epoxy composite. Its 135cm width ensures enough room for two persons and large windows make possible good visibility. Internal fuselage structure is shown in Fig. 5. In front part of the fuselage two beams (1) made from duraluminum form the frame supporting the cabin floor (2) (honeycomb plate) and they are attached to the truss (3) made from the steel tubes. In this part of fuselage the engine and transmission is housed. The truss has been chosen purposely to facilitate, after slight modification of shape, a room for various possible power plants. Between the cabin and the truss a duraluminum plate (4) is provided for safety reason (fire wall). Behind the plate a trunk is located. Two composite, crash proved fuel tanks (5) are placed symmetrically in the rear upper part of the fuselage. In the latest concept the fuel tanks have slightly different shape, less straight, thus better adjusted to the real shape of this part of the fuselage interior.

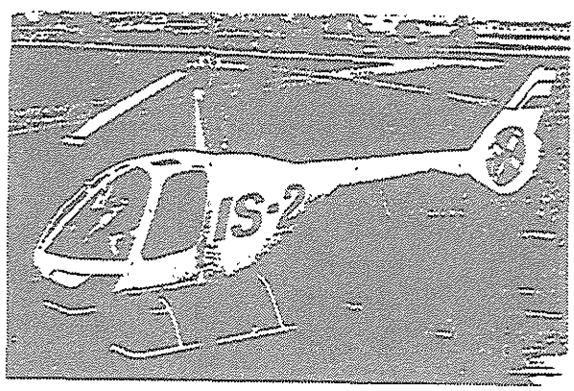


Fig. 4

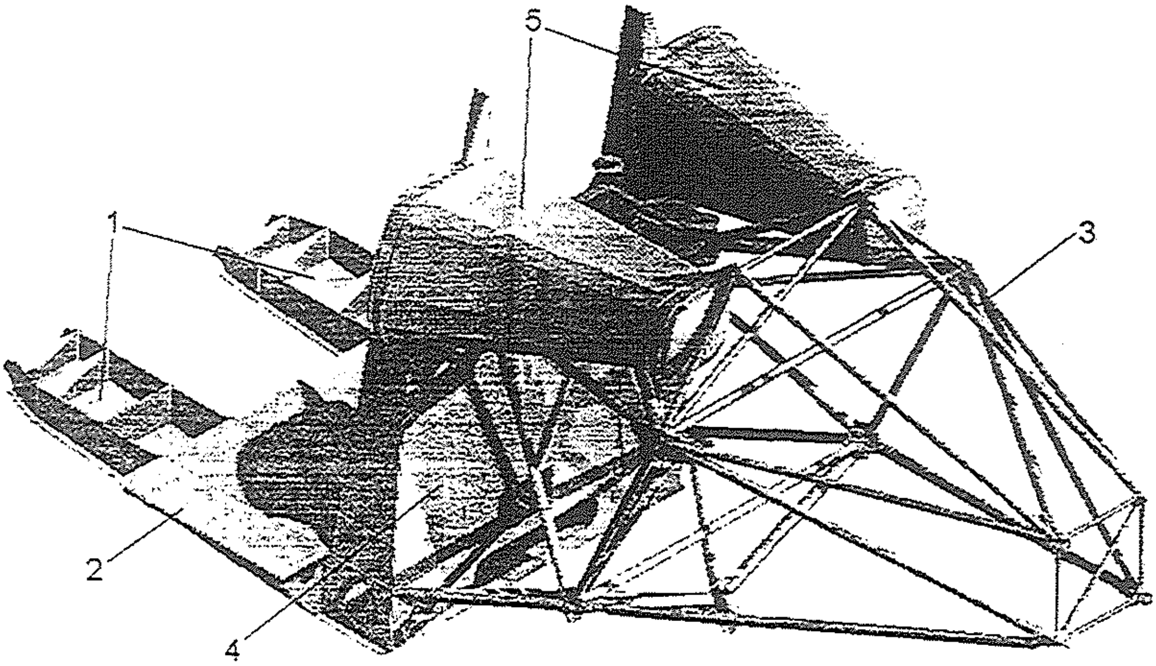


Fig. 5

Tail boom has a tube-like shape and is made from deraluminum. In the upper part of the boom the tail rotor shaft is housed, and in the rear part of the boom the horizontal stabiliser is attached. In the prototypes of „*IS-2*" the possibility of changing the pitch angle of the stabiliser is provided.

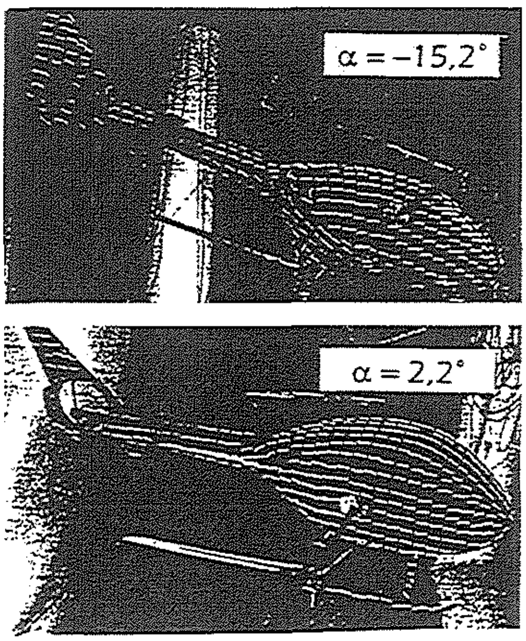


Fig. 6

Aerodynamic characteristics of the fuselage model have been determined in wind tunnel. The loads were measured and the flow around the fuselage was visualised (Fig. 6).

Tail rotor

Several arrangement of the tail rotor were considered. Finally, the shrouded, 4-bladed tail rotor has been selected. Such configuration has been chosen due to ground protection and expected aerodynamic advantages. Extensive tests of this configuration are undertaken. Their purpose is to optimise the geometry of the system. The tests include the open air as well as wind tunnel measurements of the system thrust and power required. An influence of a set of geometric parameters is investigated. Among the parameters are: thickness of the shroud, gap between the blade tip and the shroud, location of the rotor relatively to the shroud etc.

Landing gear

The landing gear is of skid type (Fig. 7). Both forward and aft bows are fabricated from duraluminum and are designed for high energy absorption. Under a load, stress distribution is such that the whole landing gear absorbs energy uniformly. The forward bow is attached to the fuselage at two points (1) through elastic joints. The aft bow is connected at one point to the centre of an intermediate beam (3) which at its ends is attached to the fuselage. Between the aft bow and the fuselage two hydraulic dampers (2) are provided.

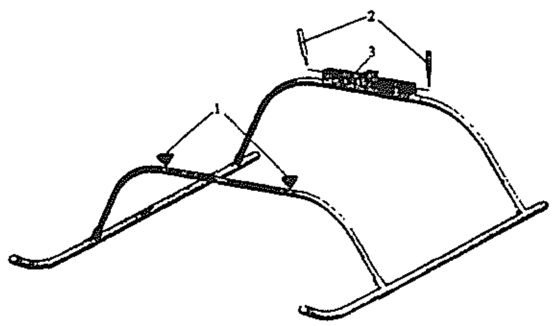


Fig. 7

Powerplant

The powerplant (Fig. 8) is a reciprocating air-cooled engine (1) with cooling fan (2). The primary drive is via a V-belt drive with actuator (5) to the main gear box shaft (6) and then to a conical type main transmission (7). The tail rotor gear box (4) is driven by the tail rotor shaft (3) which is an extension of the shaft (6).

Initially the Lycoming O-360 130kW engine will be installed. Later the more powerful (150kW) 6-cylinder Franklin 6A-350-C1 engine will be applied.

Both gear boxes (main and tail) are designed, constructed, manufactured and tested at the factory of engines (Franklin) and transmissions WSK-PZL in Rzeszow.

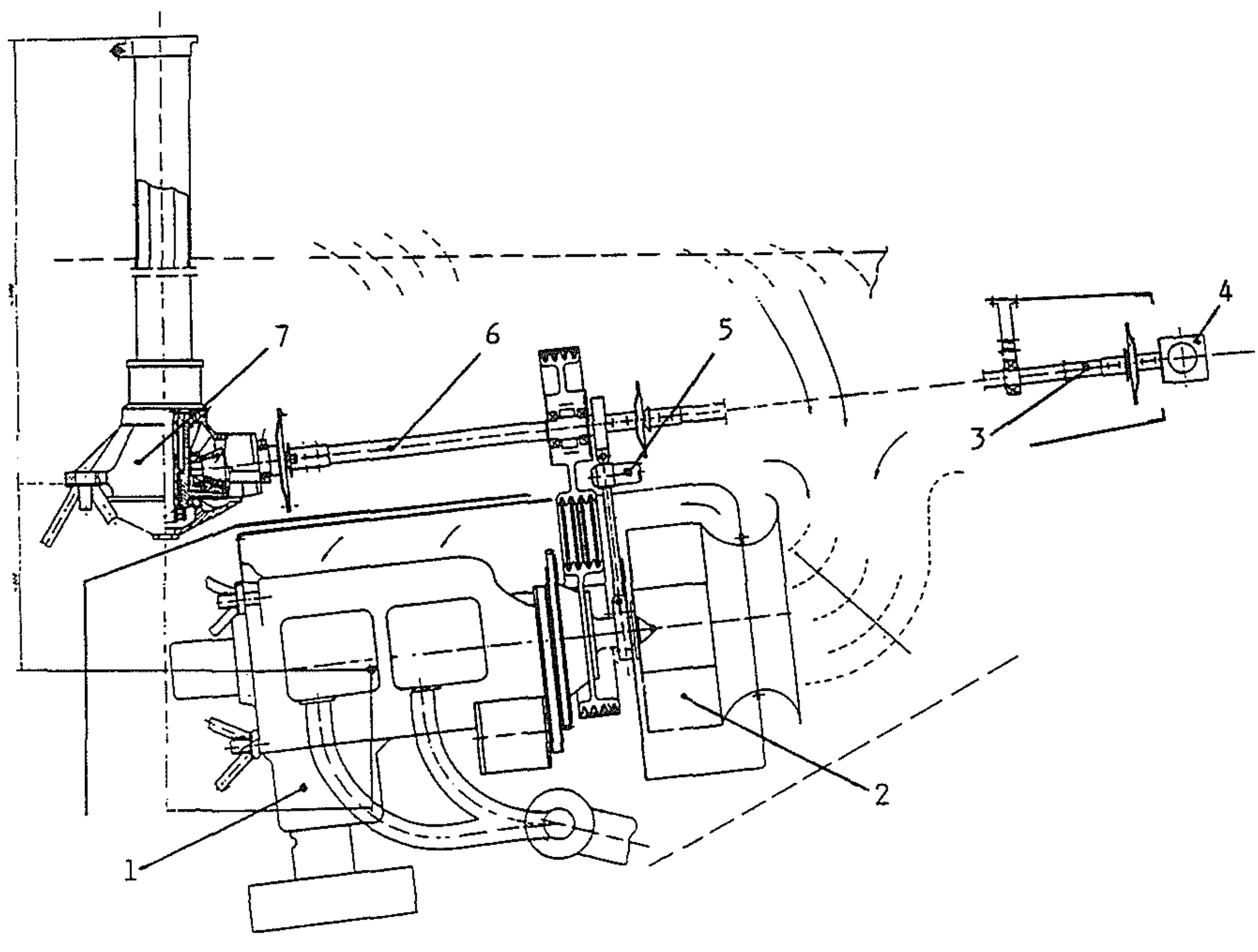


Fig. 8

The powerplant tests are conducted at the Institute of Aviation in Warsaw. Special stand has been built for the tests of V-belt drive.

Instrument panel

Standard version of „*IS-2*" is equipped in the following instruments (Fig. 9): altimeter (1), variometer (2), engine and main rotor tachometer with counter of flight hours (3), turn co-ordinator (4), speedometer (5), manometer of fuel before carburettor (6), clock (7), thermometer of surrounding air (8), NAV/COMM (9), and combined instrument (10) containing ammeter, cylinder head thermometer, carburettor air thermometer, fuel gauge, oil thermometer and oil manometer. In addition there are switches, and warning devices: lights and buzzer.

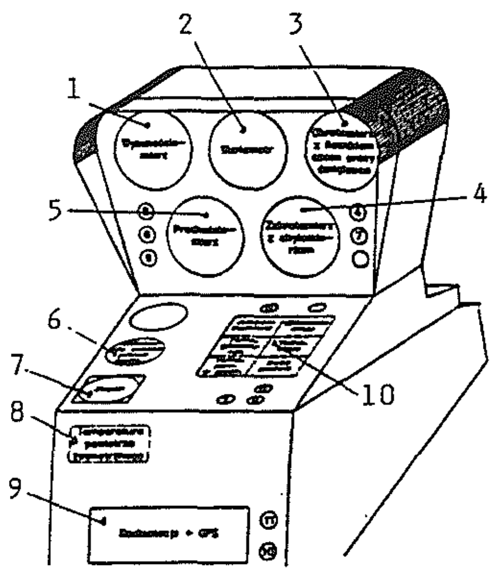

Fig. 9

For more advanced versions of „*IS-2*" additional instruments are provided, for instance:

- Artificial Horizon
- Automatic Direction Finder (ADF)
- Directional Giro
- Encoding Altimeter
- Transponder

and others.

Among the warning systems one is connected to the V-belt actuator and the lights successively go on when the length of V-belts exceeds given values.

Time-table of testing the prototypes

Till the end of 1998 three „*IS*-2" prototypes should be completed.

The first one is provided for static tests which should begin in Spring 1998. It will have a mock-up of the power plant which substitute only its mass and stiffness characteristics.

The second one should be ready for tests in the middle of the next year. The ground tests with the engine running will be performed.

Third prototype, scheduled for the end of 1998, is provided for the flight tests.

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