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WESTLAND WIDEYE

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ABSTRACT

Westland Helicopters have been active in the field of Remotely Piloted Vehicles since 1967. Feasibility studies for a surveillance and target acquisition system led to the proposal for a remotely piloted helicopter with co-axial twin rotors having plan symmetry. This paper describes the RPH WIDEYE the airborne component of the SUPERVISOR aerial surveillance system being jointly developed by WHL and Marconi Avionics for use by the British Army. It reviews the design history and summarises the current programme status.

1. Introduction

WIDEYE (Fig.1) is a remotely piloted helicopter produced by Westland Helicopters Ltd. (WHL). It is the airborne component of the SUPERVISOR unmanned aerial surveillance system which is being jointly developed by WHL and Marconi Avionics for use by the British Army. Flight trials of WIDEYE commenced in August 1978 and several aircraft are now engaged in contractors' and Ministry of Defence trials. This paper reviews WHL's activities with RPHs since the initial project studies through the MOTE and WISP hardware programmes to the design and testing of WIDEYE.

A film complementary to the description of WIDEYE will be shown during the oral presentation of this paper.

2. Design History

Design studies of future surveillance/reconnaissance systems which led to the concept of a radio controlled remotely piloted helicopter carrying a television sensor and transmitting real-time image data commenced at WHL in 1967. These studies resulted in the submission by WHL of a non-solicited proposal to the British Ministry of Defence in March 1968. A GST was issued by MoD in February 1971 against which WHL proposed the development of WIDEYE, a co-axial rotor plan-symmetric helicopter powered by a gas turbine derivable from conventional aircraft auxiliary power units. The reasons for the adoption of the plan-symmetric configuration have previously been reported (Ref.1).

A requirement to construct a representative system at low cost to partake in feasibility trials led to the 'PUPIL' proposal for a smaller aircraft utilising a piston engine developed for the American fixed wing RPV programme. Concurrently, in order to get early flying experience of small co-axial rotor helicopters and particularly to explore the problem of yaw control, WHL funded the construction of MOTE (Fig.2). MOTE was constructed initially from available aero-modelling components. It had a gross weight of 18lb, 5ft diameter 2-bladed teetering rotors and was powered by 1.5 bhp engines. MOTE first flew on Friday 13th June 1975 and commenced a series of trials to assess handling characteristics. The aircraft was found to be fully controllable in yaw though pitch and roll control required considerable piloting skill. The design was steadily developed to improve its integrity and reliability involving substitution of WHL designed components for most of the original model kit parts.

In the event the PUPIL programme was abandoned due mainly to the non-fulfillment of the engine in terms of power output and priority was given to the development of a short-range surveillance system based upon the MOTE concept. This aircraft which was named WISP (Fig.3) is described in detail in Ref.2. A twin-engine configuration driving simple 2-bladed teetering rotors by means of toothed belts and a dry gearbox was adopted for WISP as a direct development of the MOTE design. An electronic gyro-based Flight Control System was developed and flight tested on MOTE during which control system gains and damping coefficients were established in conjunction with computer simulation. Three flying aircraft were produced the first flying in December 1976 the 2nd and 3rd aircraft carried a ⅔in vidicon television camera trainable in elevation and stabilised in pitch and roll flew in May and August 1977 respectively. These latter two aircraft are now engaged in supporting trials of equipment and techniques appertaining to the SUPERVISOR project.

WHL took the view that the experience and knowledge gained during the design and development of MOTE and WISP should be capitalised on and proposed to MoD that their basic configuration and concept should be adopted for the feasibility trials phase air vehicle. The requirement of low cost was met by the continued use of piston engines, initially two of the type proposed for the PUPIL project, to be replaced early in the design phase by custom built engines derived from chain saw engine components. At this point consideration was given to designing in the capability of conversion to an operational design. Authorisation to proceed with the manufacture of 4 trials aircraft and 1 ground endurance test vehicle was received in 1977.

The aircraft, named WIDEYE by WHL, thus became a logical development of the MOTE/WISP line. It differed in size and weight from WISP by a factor of approximately 4. Fig.4 shows the three designs to the same scale.

3. SUPERVISOR System

WIDEYE is the airborne component of the SUPERVISOR unmanned aerial surveillance system (Fig.5). This comprises in an operational form:

An Air Vehicle
A Ground Control Station
A Remote Tracker
A Launch and Recovery System.

The system is under joint development by Marconi Avionics and WHL. The responsibilities of each company in terms of the system elements are shown in Fig.6. The film to be shown during the oral presentation of this paper describes the features of all the system elements but this text covers only the air vehicle. The hardware described by the film and the text is that of the current feasibility trials standard. Design work is in hand by both contractors relative to the operational system details of which are subject to security restrictions.

4. WIDEYE Design

4.1. General Arrangement

The configuration of WIDEYE is shown in Fig.7. Its leading particulars are:

Rotor Diameter	2.3m
All Up Weight	125kg
Power Plant	2 x 18HP WESLAKE 274 engines
Payload	Stabilised Daylight TV Sensor and Command and Video Links

The aircraft comprises three distinct elements, the Mechanical Module, the Airframe Module and Payload Module which are disassembled as shown in Fig.8.

4.2. Mechanical Module

The Mechanical Module comprises the engines, transmission and rotor system. Each engine ostensibly drives one rotor via a toothed belt, a centrifugal clutch and freewheel and a spur gear reduction train. The train for the upper rotor includes an idler gear to provide contra-rotation. The two rotors are synchronised by a toothed belt cross-connecting the gearbox input shafts, this also enables both rotors to be driven by the surviving engine in the event of an engine failure.

The engine change units (ECUs) are based on the Weslake 274-5 derived from Stihl chainsaw engine components and developed by Weslake Aeromarine now part of the Westland Aircraft Group. They are opposed two cylinder two stroke engines utilising the cylinders, pistons and connecting rods of the Stihl engines but featuring a forced one-piece crankshaft and a crankcase of Weslake design. The ECUs feature cooling ducts, fan, flywheel and control actuators of WHL design and include a DC Starter/Generator designed and developed by Lucas Aerospace. The ECUs are mounted directly to the gearbox casing with shimming provision for drive belt adjustment.

The transmission features Synchroflex steel wire reinforced polyurethane toothed belts, centrifugal plate type clutches of WHL design and steel on tufnol dry gears utilising grease lubrication with regreasing facility. The light alloy gear casing is mounted from 'A' frames to the airframe structure via multi-directional AV mounts at 4 points. The rotor shafts are supported by the conical pylon containing the main lift bearings.

The rotor blades are of composite construction with unidirectional grp leading edges spars, foam filled trailing edges all enclosed by a grp shell. The rotor hubs incorporate angular contact ball bearings for the feathering hinges and are underslung from the rotor fork needle roller bearing teetering hinges. Teetering stops are incorporated to reduce the risk of blade strike during run-up and run-down of the rotor. Aerodynamic control of the rotors is invested in five channels, two axis of cyclic pitch for pitch and roll, collective pitch for vertical control differential collective for yaw control and engine throttle coupled with rotor speed governing. The actuators are of WHL design and comprise a mechanical reduction mechanism, a DC permanent magnet servo motor and a position feedback potentiometer. The cyclic actuators are mounted from the gearbox pylon and operate the blade pitch rods via an arrangement of swashplates. The collective and differential collective actuators are combined within a mechanical mixing unit located beneath the gearbox and operate the blade pitch rods via push rods passing up through the centre of the rotor shafts. The collective heads incorporate paddle bar stabilisers to augment the electronic stabilisation system during early development flying.

4.3. Airframe Module

The airframe comprises the structure of the air vehicle, the undercarriage and the body cowlings and fairings. It houses the avionics and mounts the mechanical module, the fuel tanks and the payload. The main structure is constructed from light alloy rivetted box sections. It is of a cruciform plan with a reinforcing open channel ring frame.

The undercarriage is of the bending leg type and is retractable by means of a single actuator powered by four DC electric motors driving individual lead screws and linkages for each leg. The legs are of grp laminate construction in solid trapezoidal section tapering in length and terminating in a moulded shell foot. The undercarriage is designed to react loads resulting from a vertical impact of 2 m/s and provides a reaction factor of 4 with $\frac{2}{3}$ rotor lift applied.

The cowlings are grp panels stiffened with foam strips. The two engine bay cowls and payload fairing are fitted with quick release fasteners.

An independent fuel supply is provided for each engine. The two baffled light alloy tanks are each located in a supporting frame immediately above the main structural element. The fuel, which is a 25:1 mix of petrol and 2-stroke lubricant, is fed to each engine via diaphragm pumps incorporated in the engine carburettors. Fuel level measuring devices are incorporated in each tank.

4.4. Avionics

The primary source of electrical power is provided by two DC starter/generators driven via gear trains by each engine and provide 700 watts combined output continuously or 700 watts individually under short term failure conditions. A limited capacity standby battery is provided to maintain essential supplies on landing during shut down. It is a 28 volt system with DC/DC converters provided to derive specialist flight control system and payload system supplies. The distribution system consists of a primary and a secondary busbar. On landing the secondary busbar is automatically disconnected from the supply so that the standby battery only supports the essential primary busbar to extend battery life. In the engine starting mode prime power is drawn from a 14 cell 28 volt battery via an umbilical cable featuring solenoid actuated disconnection.

The Flight Control System is of WHL design and includes an analogue computer unit providing auto-stabilisation, ancillary functions, auto-pilot modes and test facilities. The unit's basic function is a three-channel attitude demand system in pitch roll and yaw, the latter featuring heading hold. Each channel derives its reference data from the Payload stabilised platform comparing this with the demand signal to give position error. Rate terms are derived in pitch and roll and a rate gyro is employed to provide the yaw term. The pitch and roll channels also include trim or feed forward loops in parallel with the error loops. The ancillary functions include rotor speed governing and engine speed limiting and the necessary logic for control of engines, undercarriage retraction, battery switching and engagement of autopilot modes. These modes currently comprise a height hold and a link-loss/fail-safe facility. The height data is obtained from a barometric device for altitudes above 50m and from a laser device, which is being trialled on WISP, for low level. The link-loss facility is a fail-safe device where the command link is continually monitored and loss of the link initiates a timed sequence to put the controls to preset positions followed by engine ignition switch off to abort the mission which can also be activated by direct command from the ground station. The timing is determined by range safety requirements and protection against inconsequential short-term signal interruptions. The unit includes the facilities to enable the aircraft to be operated by a Pre-Flight console and umbilical link to ensure that the aircraft is functionally satisfactory to fly and to carry out the engine start-up, rotor engagement and hand-over to radio link procedures.

4.5. Payload

The Payload (Fig.9) produced by Marconi Avionics Ltd. consists of a platform, stabilised in pitch and roll and rotatable and stabilised in yaw, carrying a downward looking ½ inch Vidicon daylight television camera. Besides the surveillance sensor the payload includes the radio command link receiver, the video link transmitter and a telemetry transmitter.

The mechanical interface with the airframe structure consists of four quick release lever type fasteners. The electrical signal interface is in a parallel analogue form comprising two multipin connectors. It conveys command data and aircraft attitude signals from the payload to the Flight Control System Computer Unit and aircraft condition data from the aircraft to the payload for onward transmission to the Ground Station. There are 46 channels in total. In addition the electrical interface carries electrical power supplies to the payload. The facility is available to accommodate up to 40 channels of instrumentation telemetry data.

5. Programme Status

Five complete aircraft with associated payloads have been produced of which four constitute the SUPERVISOR system demonstrator flight hardware (Fig.10). The fifth aircraft is being used for extensive endurance rig testing. One ground control station has been manufactured by Marconi Avionics for long range tracked flights (Fig.11). It is complemented by two sets of ground support equipment for test flying and data collection within visual range. A complete mission simulator was built specifically to develop and optimise the ground station computer software. It is also used to train controllers in handling skills and operating procedures.

The first aircraft flew in August 1978 and the second aircraft first flew in April 1979. Stabilised Flight from the ground station including transmission of sensor imagery has been achieved. The third and fourth aircraft have recently joined the trials programme.

The stability and ease of handling allows the aircraft to be flown "hands-off" with directional control applied via trim controls only. This enables relatively untrained personnel to control the aircraft once it has been initially trimmed out.

A further batch of aircraft to basically the same design standard are in manufacture to flight test elements of the proposed operational system for which design work is well underway. Additionally two company funded demonstrator aircraft and associated systems are under construction.

6. Conclusion

The successful outcome of the MOTE and WISP projects laid the foundation for subsequent generations of RPHs. WIDEYE was the next logical development which as part of the SUPERVISOR system will provide an essential part of NATO capability by providing real time surveillance and target acquisition facilities.

7. References

1. Control Aspects of the Plan-Symmetric Remotely Piloted Helicopter by A.J. Faulkner.
Paper No.25 presented to AGARD Symposium, Avionics Guidance and Control for Remotely Piloted Vehicles Florence, Italy October 1976.
WHL Brochure B1026.

2. Westland WISP by M.J. Breward.
Paper No.23 presented to AGARD Flight Mechanics Symposium on Rotorcraft Design. AGARD Conference Proceedings No.233.
NASA Ames California, USA, May 1977.

FIG. 1 WIDEYE

FIG. 2 MOTE

FIG. 3 WISP

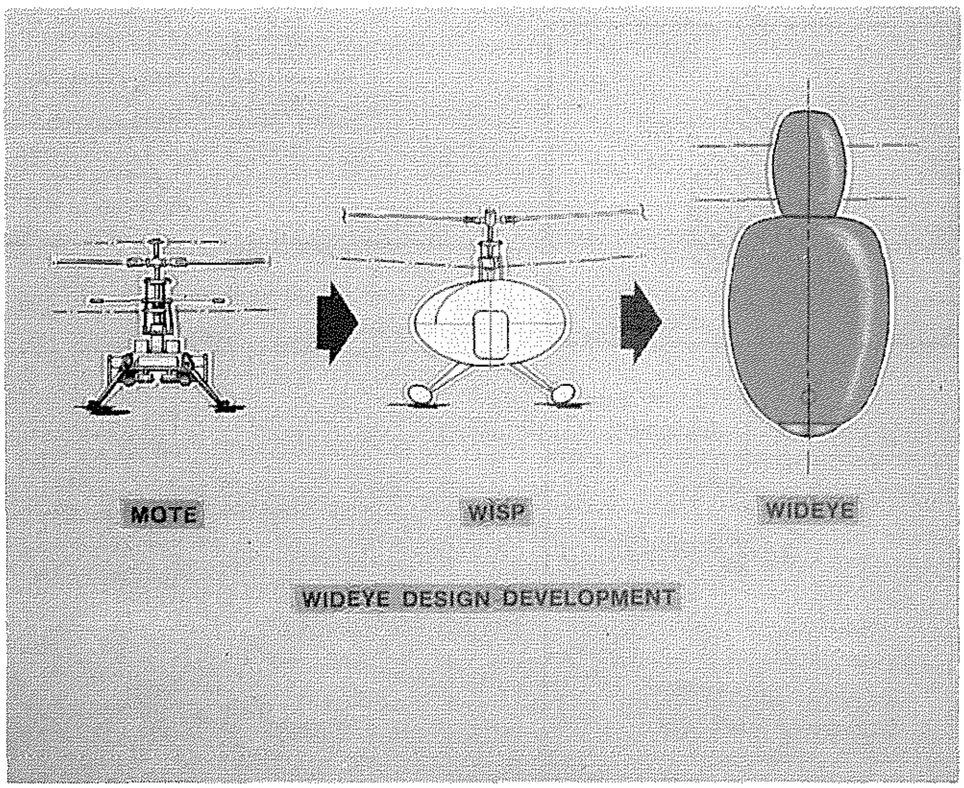

FIG. 4

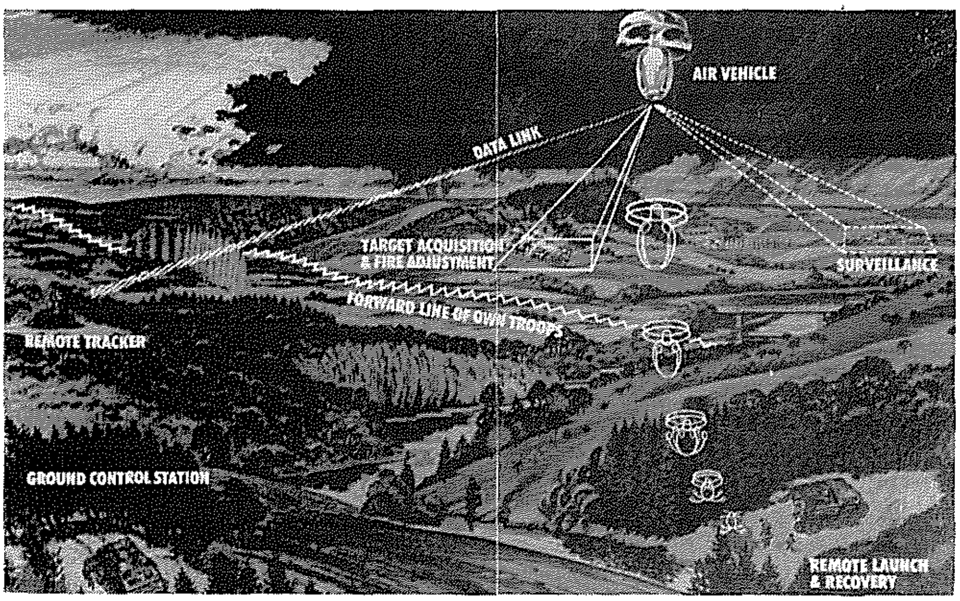

FIG. 5 SUPERVISOR SYSTEM

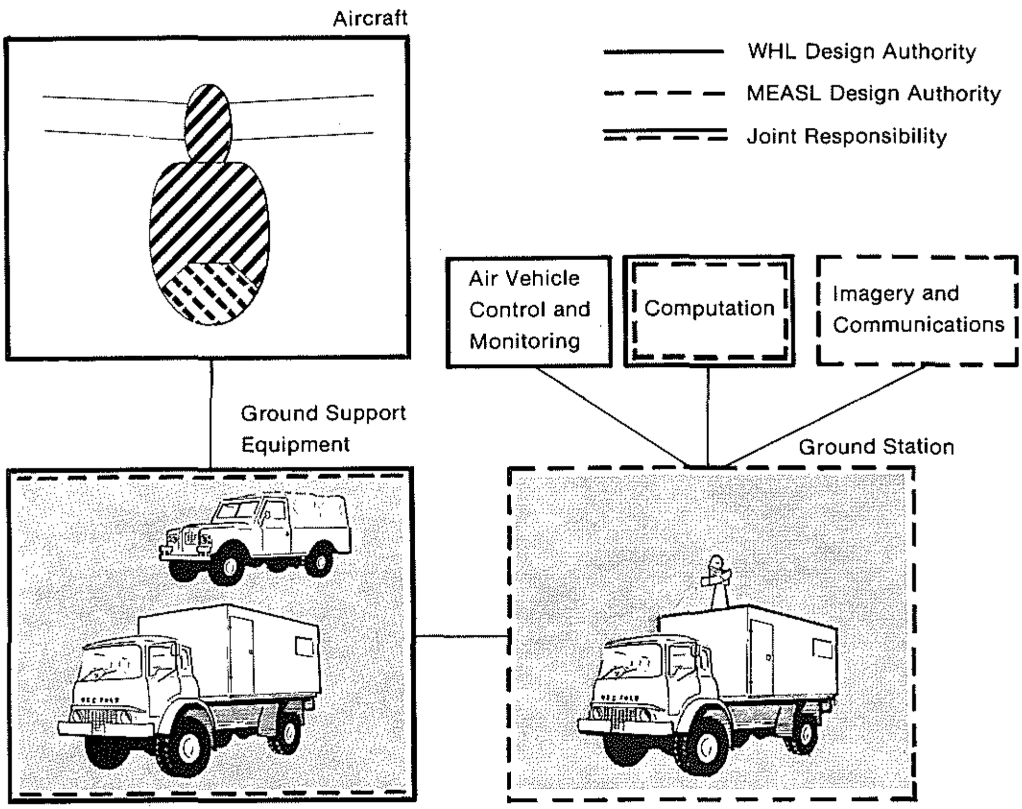

FIG.6 SYSTEM DESIGN RESPONSIBILITIES

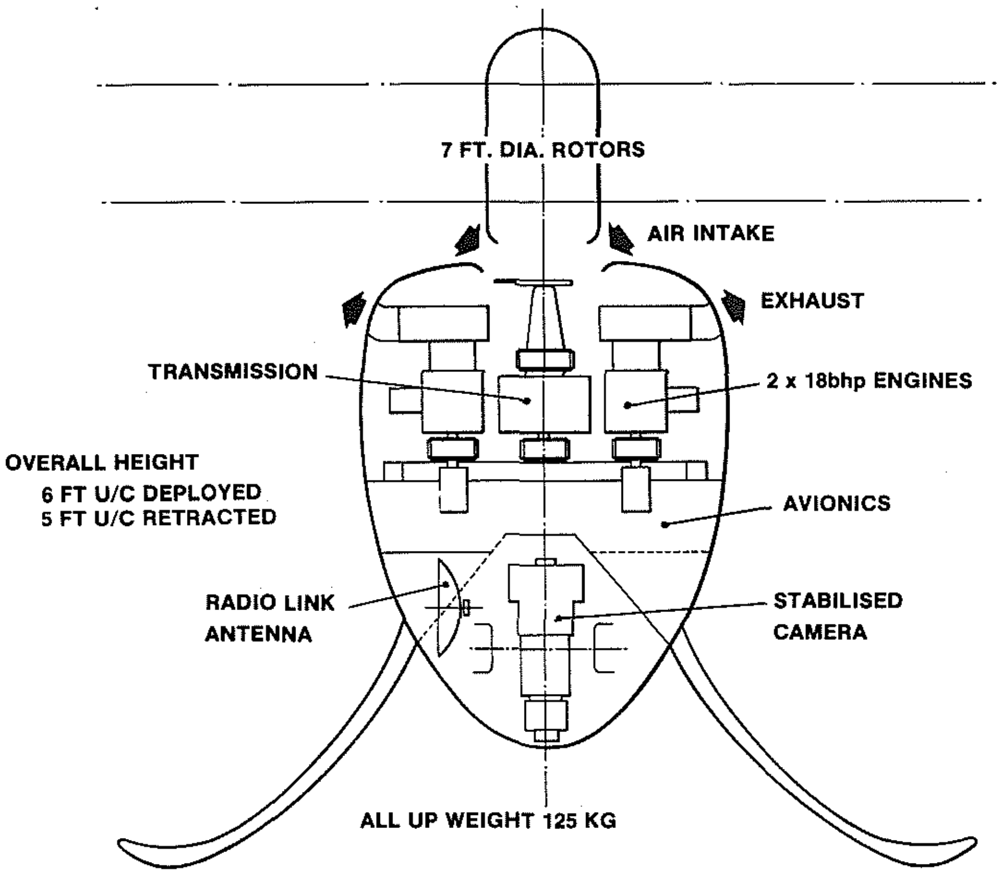

FIG. 7 WIDEYE - SCHEMATIC DRAWING

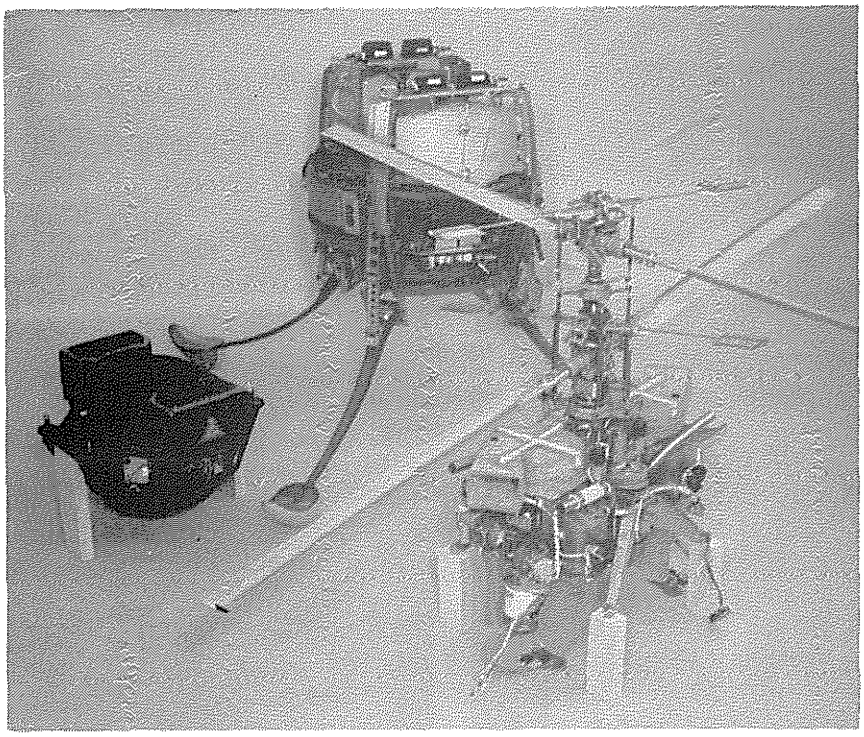

FIG. 8 WIDEYE MODULAR CONSTRUCTION

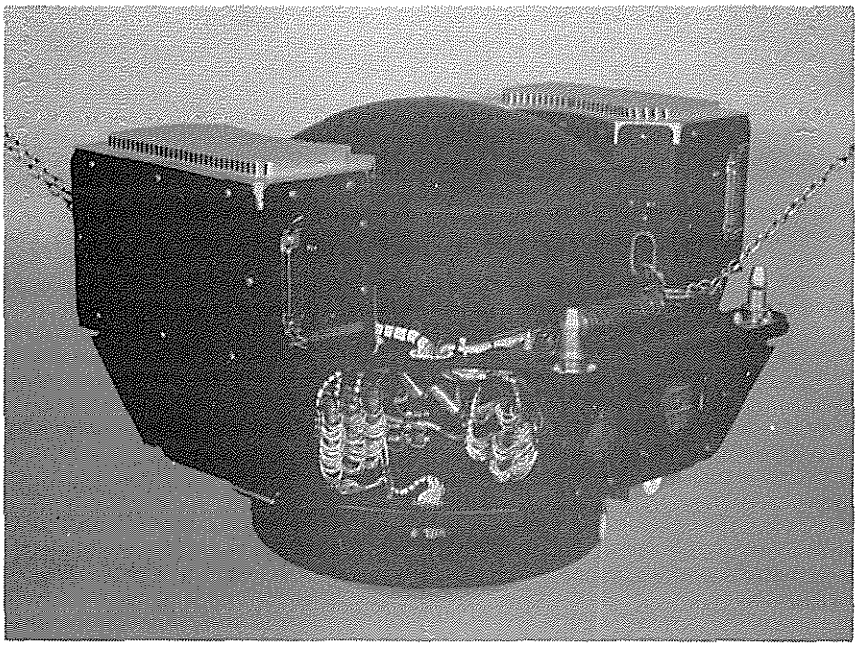

FIG. 9 PAYLOAD

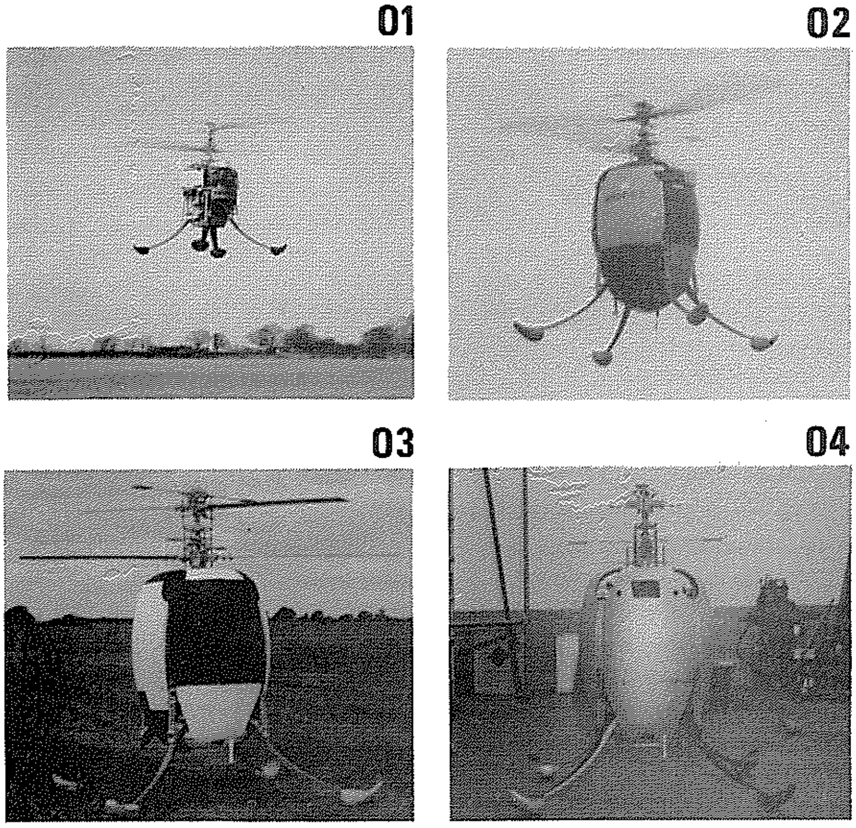

FIG. 10 WIDEYE - FLIGHT HARDWARE

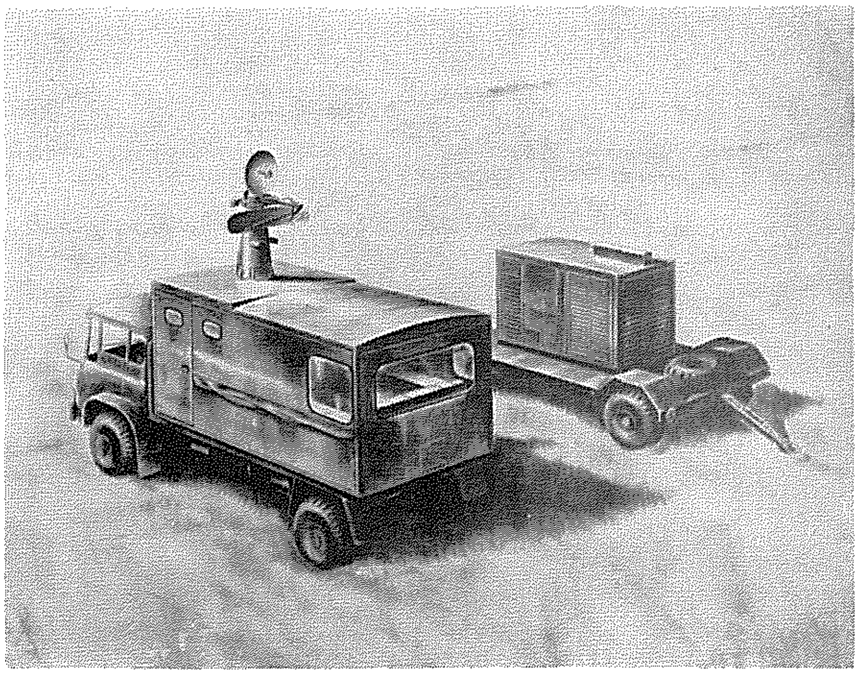

FIG. 11 GROUND CONTROL STATION