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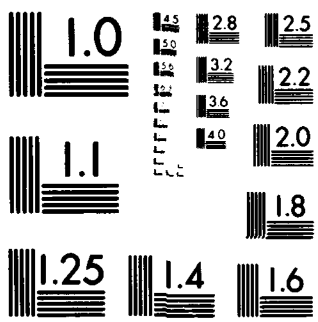

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Aerodynamics Technical Memorandum 322

TRANSDUCER INSTALLATION FOR THE SEA KING MK 50 MATHEMATICAL MODEL VALIDATION FLIGHT TESTS

D.T. HOURIGAN

Approved for Public Release.

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SUMMARY

The installation of transducers in a R.A.N. Sea King MK 50 helicopter is described. These transducers were used to obtain flight trials data for validating a mathematical model of the aircraft.

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16. ABSTRACT:

The installation of transducers in a R.A.N. Sea King MK 50 helicopter is described. These transducers were used to obtain flight trials data for validating a mathematical model of the aircraft.

CONTENTS

1. INTRODUCTION

Transducers were fitted to a RAN Sea King MK 50 helicopter to obtain flight data for validating a mathematical model of the aircraft. Data provided by these transducers supplemented those provided by the aircraft's equipment and systems.

This memorandum describes (i) the use of the transducers, (ii) their location in the aircraft, and (iii) any special installation or operation procedures to be followed, to facilitate re-installation of the transducers should repeat flights be necessary.

All the transducers described herein provide analogue electrical signals. These signals were processed and recorded on magnetic tape in digital form by the Aerodynamics Division Airborne Data Acquisition Package, A.D.A.D.A.P., (1), which was installed in the helicopter.

2. DETAILED DESCRIPTION

2.1 Boom Mounted Pitot Static Probe and Vanes for Fuselage Angles of Attack and Sideslip

This probe and vanes provide, (2), (i) static pressure, (ii) total pressure, (iii) electrical outputs to measure fuselage angles of attack and sideslip.

The boom assembly, Fig. 1, is 2 metres long, 76.2 mm dia. steel tube with the pitot static (P.S.) head and vanes attached to the front. It was suspended by means of a machined block from the bracket normally used for holding the electronics bay door open, and positioned by three stays made from 3/32" dia. 7 X 7 stainless steel control wire. Two of the stays were attached to the aircraft by brackets screwed to the frame securing the front side lower windows and the third stay to the forward sea anchor attachment eye hook. The other ends of the stays were attached to lugs welded 0.3 m back from the P.S. end of the boom. Turnbuckles on each stay were adjusted so that the boom was parallel within ±0.1 degrees to the floor, (which is a water-line datum). It was aligned laterally by measuring the distance on each side from the end of the pitot to the head of a window frame screw and adjusting to within ±2.5 mm of each other. The lower stay was terminated with a swaged thimble and connected to the sea anchor hook with a shackle. Removal of the shackle allowed the electronics bay door to be opened for the daily inspection of equipment in the bay. This shackle needs to be lockwired after replacement.

The tubing used for connecting the P.S. head to the pressure transducers for measuring altitude and airspeed was 6 mm O.D. X 3 mm I.D. polythene T.V.Q. It was fed down the inside of the boom around the front-side lower window frame where it was held in place with P-clips and through the partially opened port side window to the pressure transducers mounted inside the aircraft. The boom wiring connecting the A.D.A.D.A.P. and the potentiometers driven by the vanes was taped to the tubing and followed the same path. Links and electrical connectors were provided to allow the P.S. head or the boom assembly to be removed immediately.

After the boom assembly and pressure transducers were installed a leak test was performed. This consisted of the pushing a sheath connected to an airspeed indicator (A.S.I.) and pump over the pitot and applying a pressure equivalent to 130 m.p.h. After 1 minute the leakage was not to exceed 10 m.p.h. The A.S.I. was replaced with an altimeter, the sheath pushed further on to cover the static holes and a suction equivalent to 1000 ft. was applied. After 1 minute the leakage was not to exceed 150 ft.

2.2 Absolute and Differential Pressure Transducers

These two pressure transducers, shown in Fig. 2, providing electrical outputs proportional to absolute and dynamic pressures, were mounted on an aluminium plate clamped across a lightening hole in the rear sloping panel of the co-pilots i.e. left hand (L.H.) seat. The tubing interconnecting the P.S. head and the transducers was pushed over machined fittings which adapt the T.V.Q. tubing to the conventional AN flared fittings used in the transducers.

2.3 Trailing Pitot Static Probe

The pitot static probe mounted on the boom projecting from the nose of the aircraft is subject to a position error due to the proximity of the fuselage and rotor downwash, especially at very low forward airspeeds. A trailing P.S. suspended below the helicopter during a calibration flight was used to measure this error.

A triangulated frame shown in Fig. 3 was attached to the starboard (STB) side of the fuselage aft of the sliding door. It projects outwards and has fixed at its apex a block which secures the winch cable and hook in a position convenient to attach the 45.72 M (150 ft.) 7 X 7 S.S. control cable used for suspending the trailing P.S. The two 6 mm X 3 mm T.V.Q. tubes interconnecting the trailing P.S. and two pressure transducers inside the aircraft were taped to the cable at about 0.3 M intervals.

At the end of each flight ground personnel caught the probe to prevent damage, which would otherwise occur, by the cone striking the ground. (See Fig. 4). Before catching the probe it was discharged using an earthing rod to remove any static charge built up during the flight.

The aircraft is equipped with a cartridge operated with cable cutter to enable the pilot to jettison the cable and trailing P.S. should an instability develop in flight. Connecting links in the polythene T.V.O. tubing allow it to separate should jettison be necessary.

When the trailing probe and its transducers were installed a similar leak test to that described in section 2.1 was performed on the pitot. In the case of the static leak check it was necessary to avoid damage to the transducer by removing the line from the broom static and installing a short line and T-piece to connect the positive pressure port and the reference ports together before performing the test as described in section 2.1.

2.4 Differential Pressure Transducers for Calibration Purposes

These two differential pressure transducers were used during the calibration flight to provide electrical outputs proportional to (i) the difference in static pressure sensed by the broom and the trailing probe, and (ii) the dynamic pressure ($\frac{1}{2}\rho V^2$) of the trailing probe.

They were mounted on a plate shown in Fig. 5 attached to the top right hand (R.H.) corner of the STB side of the sonar operator's console frame. The transducer used for the measurement of the difference between the statics had its reference port connected to the trailing probe and its positive pressure port to the broom static via a T-piece.

The aircraft's 28 VDC supply was reduced to 24 VDC for these transducers by means of a resistor and zener diode mounted on the plate beside the transducers.

2.5 Control Position Indication Meters

These provided the pilot with a visual indication of the position and the limits of authority of the controls. They were useful during manoeuvres when pulse and doublet inputs were applied to the controls and the automatic flight control system (A.F.C.S.) was switched off. The four indications provided were:

(i) Cyclic pitch graduated over range 0-100% zero representing cyclic stick fully forward and 100% fully backwards.

(ii) Cyclic roll graduated over range 0-100% zero representing cyclic stick fully to port while 100% was fully to starboard.

(iii) Collective pitch graduated over range 0-25 degrees the 25 degrees representing the change of collective stick angle when moved from fully lowered to the fully raised position.

(iv) Tail Rotor pitch graduated over the range +24° to -5°. This is the range the tail rotor blade pitch moves when the yaw pedals are pushed from one extreme to the other.

The pack shown in Fig. 6 containing the four 2" diameter moving coil meters is bolted, using existing holes, under the framework that forms the intersection of the R.H. windscreen, the upper front side window and the RH overhead window and above the magnetic compass.

2.6 <u>Collective Stick Position Transducer</u>

A bridge type slide wire transducer clamped to the collective pitch lever varied its resistance as the collective lever was raised and lowered in flight.

It was clamped to the pilots (i.e. R.H. side) lever. A cable attached to the slider protrudes from one end and was terminated in an eyelet fixed under a screwhead in the friction nut. Lowering of the collective lever caused the friction nut to slide along the lever towards the hand grip and pulled the cable and slider with it; a spring in the transducer pulled the slider back when the stick was raised.

After fitting this transducer it is necessary to apply ground hydraulics to the aircraft and raise and lower the collective lever to check for complete and free travel of the control. The length of cable between the transducer and the eyelet was adjusted so that the transducer operated in its mid range. The loose end of the cable was taped down to tidy the installation. The diagram in Fig. 7 depicts the arrangement.

2.7 <u>Broom Cupboard Linear Variable Differential Transformers (L.V.D.T.)</u>

Four L.V.D.T.s were used to measure the movement of the auxiliary servo jack push rods.

With the broom cupboard door removed the bracket containing the L.V.D.T.s, the plate holding the alignment guides and pulleys and the bar securing the return springs were mounted across the opening as shown in Fig. 8. The four 10-32 UNF corner screws holding the member in front of the mixer unit were removed and the bracket and spacers for the LVDT were attached to the anchor nuts in broom cupboard frame using longer screws. The upper section containing the guides and pulleys over which the LVDT operating cables pass was bolted to the brace in front of the auxiliary servo jack push rods at a hole in each end. The LVDT operating cables were then clamped to each push rod. As the push rods were lowered the cables pull the LVDT cores upwards. Return springs attached to a bar fastened at the bottom of the broom cupboard pull the LVDT cores downwards when the push rods are raised.

The position of the LVDT core was set in the middle of its operating range with the appropriate control centralised by sliding the cable through the clamp on the push rod. The pulley guides are adjustable in height, depth and azimuth to align the cable with the push rods. When the installation was completed ground hydraulics were applied and each control operated over its entire range in turn and the transducer checked for smooth and complete freedom of movement.

2.8 Yaw Pedal L.V.D.T.

This LVDT was used to measure the movement of the rod connecting the two sets of yaw pedals.

It was mounted as shown in Fig. 9 on a bracket which was bolted to a stiffening bulkhead in the electronics bay. The core extension rod was clamped to the pedal connecting rod and a piece of solder was used as a shear link at the coupling. The transducer bracket was positioned and the three holes for the mounting bolts were drilled in the bulkhead on its port side in aircraft 910, (3). With the yaw pedals centralised, the clamp holding the core could be slid sideways along the coupling rod so that the LVDT core was in the centre of its range.

2.9 Triaxial Accelerometers

Three linear accelerometers screwed to a trixial mount were used to measure the vertical, longitudinal and lateral accelerations of the aircraft.

The mount containing the accelerometers was pushed into an open ended tube which is a vertical member of the navigational equipment rack at a point approximately midway between STN 277.5 and STN 290 and approx. 12" to port of ℄ and 48" above the floor (Fig. 10). The triaxial mount was able to swivel to align the sensitive axis of the longitudinal accelerometer in azimuth with the aircraft's longitudinal axis, the other being fixed.

2.10 Outside Air Temperature Sensor

A platinum resistance sensing element was used for measuring the outside air temperature (O.A.T.).

It was enclosed in an aerodynamicly shaped fibreglass reinforced plastic case and was clamped to the handle used to pull out the port side cockpit window from the outside (Fig. 11).

2.11 Pitch and Roll Rate Gyroscopes

The two gyros were used for measuring the pitch rate and roll rate as the aircraft pitched and rolled around its lateral and longitudinal axis.

They are mounted on a platform, see Fig. 12, bolted to the A.D.A.D.A.P. at a point approximately 3½" aft STN 243.5 (STN 247), 30" above floor and 24" to port of ℄. The platform had the ability to swivel so that the sensitive axis of the roll gyro could be aligned with the aircraft axis.

3. CONCLUSION

The instrumentation described was installed in Sea King aircraft R.A.N. N16-125 during December 1978. At the conclusion of the flight programme in August 1979 it was removed after having provided a comprehensive set of flight data for validating the mathematical model of the aircraft.

REFERENCES

1. Farrell, A.J. The Aerodynamics Division Airborne Data Acquisition Package MK 1. Aerodynamics Note 386. February 1979.

2. Hourigan, D.T. and Williams, M.J. Pressure Probe and Directional Vane Instrumentation. (In Draft).

3. A.R.L. Drawing No. 52829 R. (R.A.N. Letter of approval, REF. ANC 789-23-004, dated 6 December 1977).

TABLE 1

Transducer	Manufacturer
Boom pitot static head and vanes	A.R.L.
Trailing pitot static	A.R.L.
Absolute pressure	Setra Systems
Differential pressure (Boom)	" "
Differential pressure (Trail)	" "
Differential pressure (Statics)	" "
Control position indicators (Pitch)	Master Instruments
" (Roll)	" "
" (Coll)	" "
" (Tail Rotor)	"
Collective Stick	Saab
L.V.D.T. (Roll)	Hewlett Packard
" (Coll)	Schaevitz Engineering
" (Pitch)	" "
" (Yaw)	" "
L.V.D.T. (Yaw Pedal)	Schaevitz Engineering
Accelerometer (Long)	Schaevitz Engineering
(Lat)	" "
(Vert.)	" "

TABLE 1 (CONTD.)

Type	Range
	0-220 FT/sec., ±45°
	0-220 FT/sec.
Model 236	85-110 KPa
" "	0.2 PSID
" "	0.5 PSID
" 237	0.2 PSID
SHSR 20	0-90° 100Ω
"	" "
"	" "
"	" "
U.M.N.	0-4" ±2"
70 C.D.T. - 3000	
5000 HR	±5"
" "	"
" "	"
1000 H.C.D.	±1"
L.S.B.C. - 10	±10 g
"	"
"	"

TABLE 1 (CONTD.)

TRANSDUCER	MANUFACTURER	TYPE	RANGE
Temperature Sensor	MATTHEY	THERMOFILM GRADE 2	-10 to 40°C
Rate Gyroscopes (Pitch)	LOUIS NEWMARK (U.K.)	6141	±30°/sec.
" (Roll)	GENERAL DESIGN (U.S.A.)	7735	±57.3°/sec.

FIG. 1. BOOM AND PITOT STATIC ON NOSE OF AIRCRAFT

FIG. 2. PRESSURE TRANSDUCERS FOR NOSE BOOM BEHIND COPILOT'S SEAT

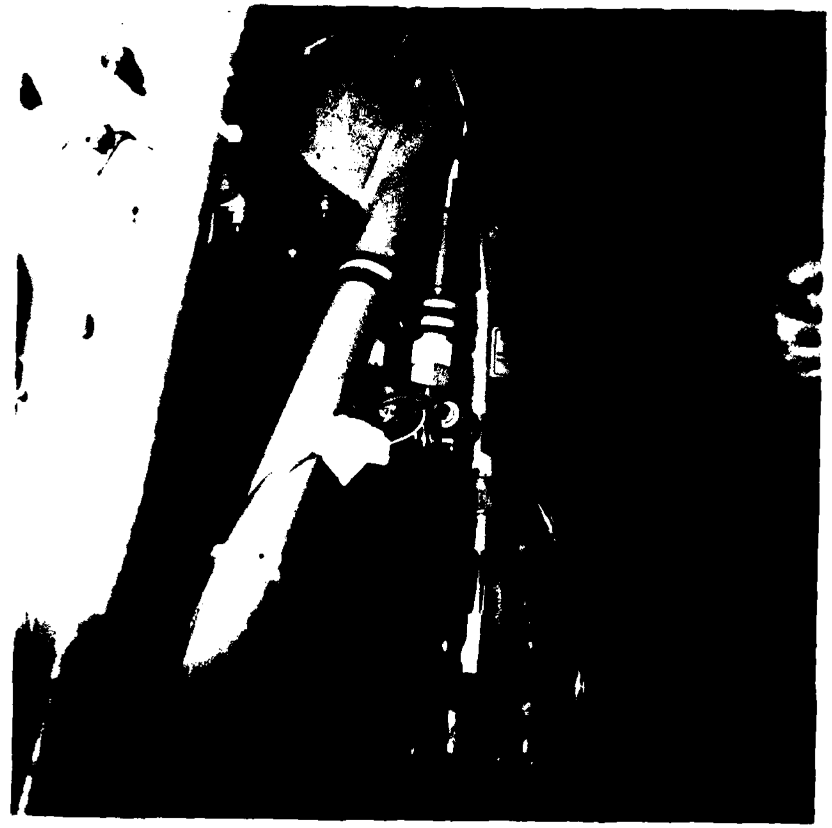

FIG. 5. PRESSURE TRANSDUCERS FOR TRAILING PITOT STATIC ON SONAR FRAME

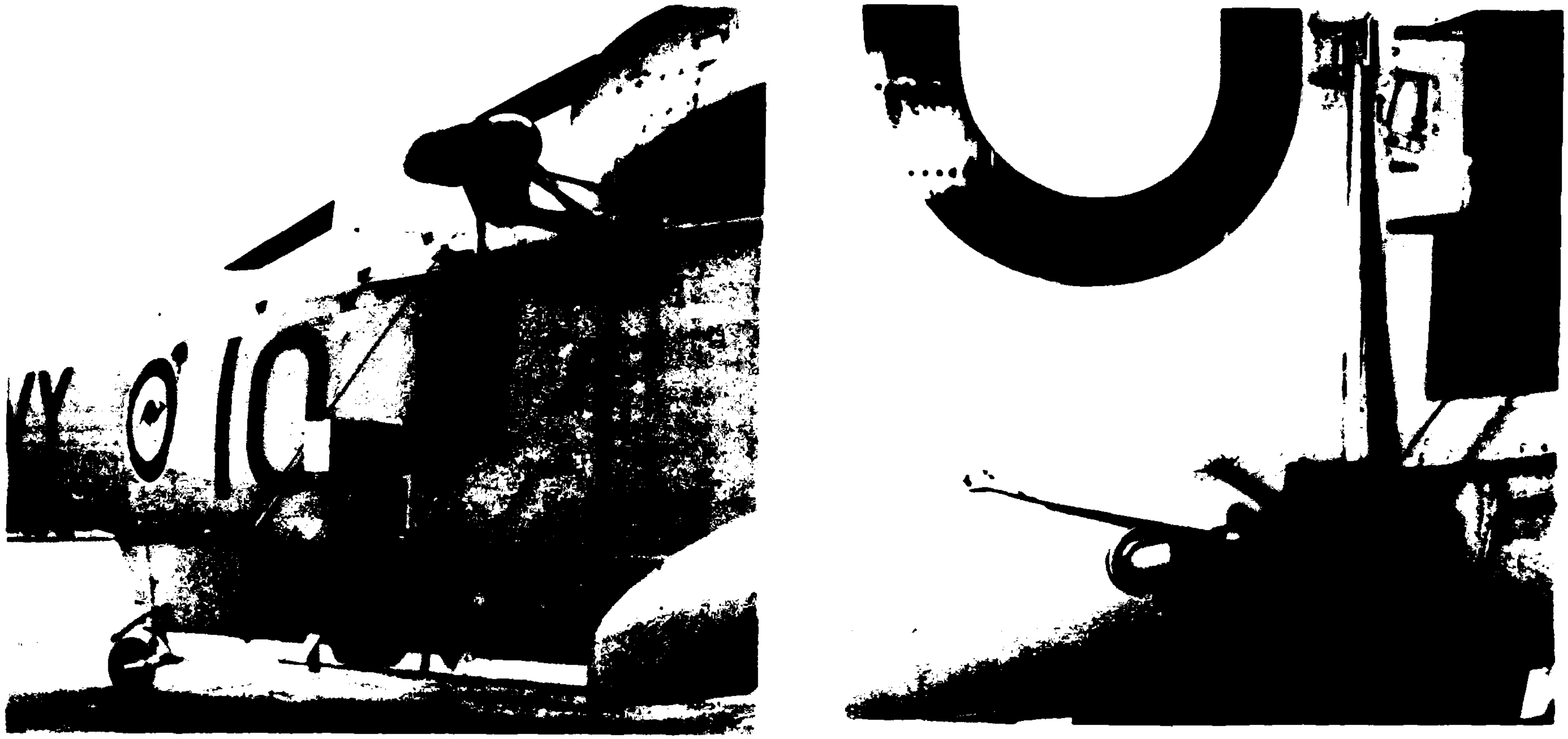

FIG. 3. ATTACHMENT FOR TRAILING PITOT STATIC PROBE

FIG. 4. LANDING WITH TRAILING PITOT STATIC PROBE

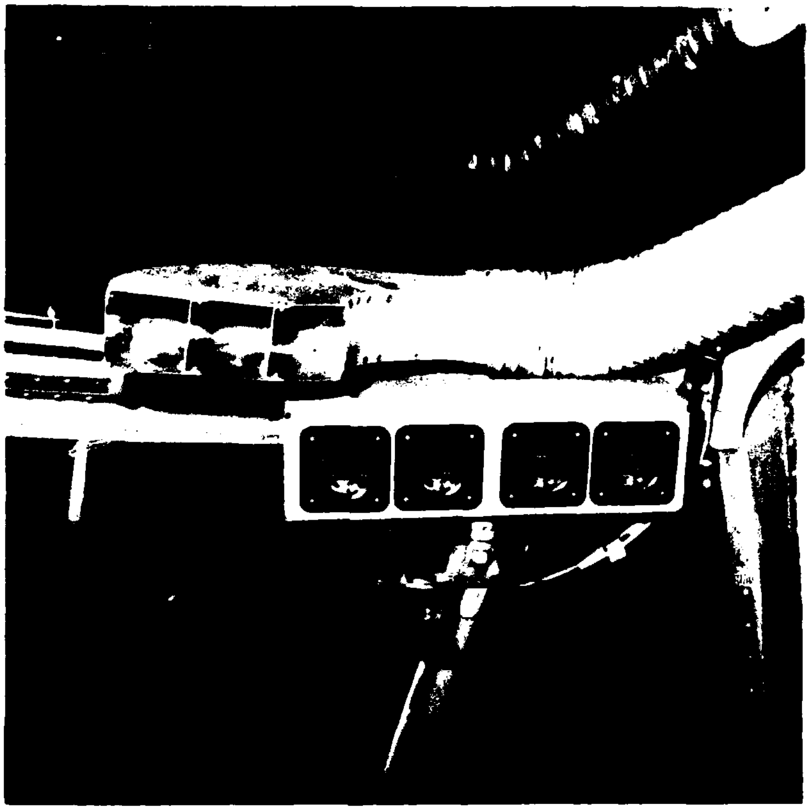

FIG. 6. INDICATORS FOR CONTROL POSITIONS

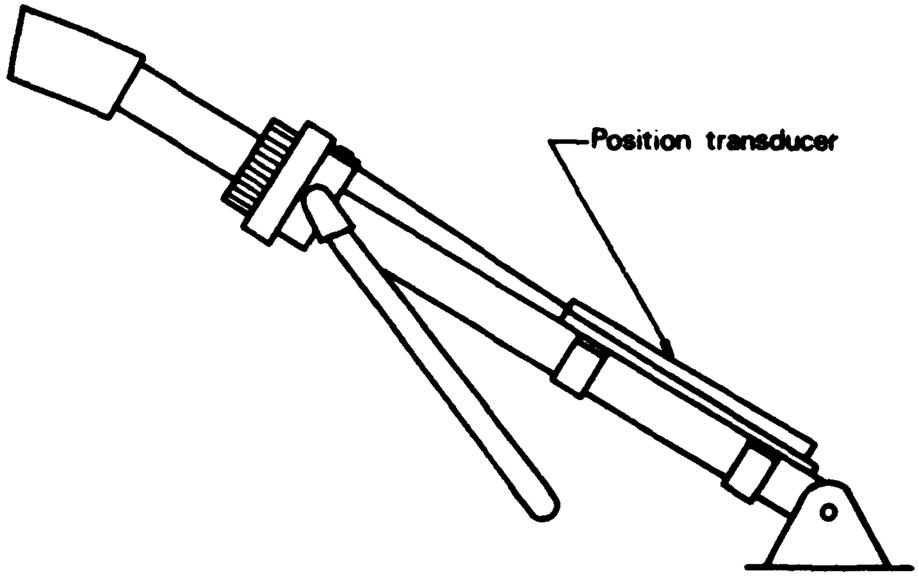

FIG. 7. COLLECTIVE CONTROL LEVER WITH TRANSDUCER

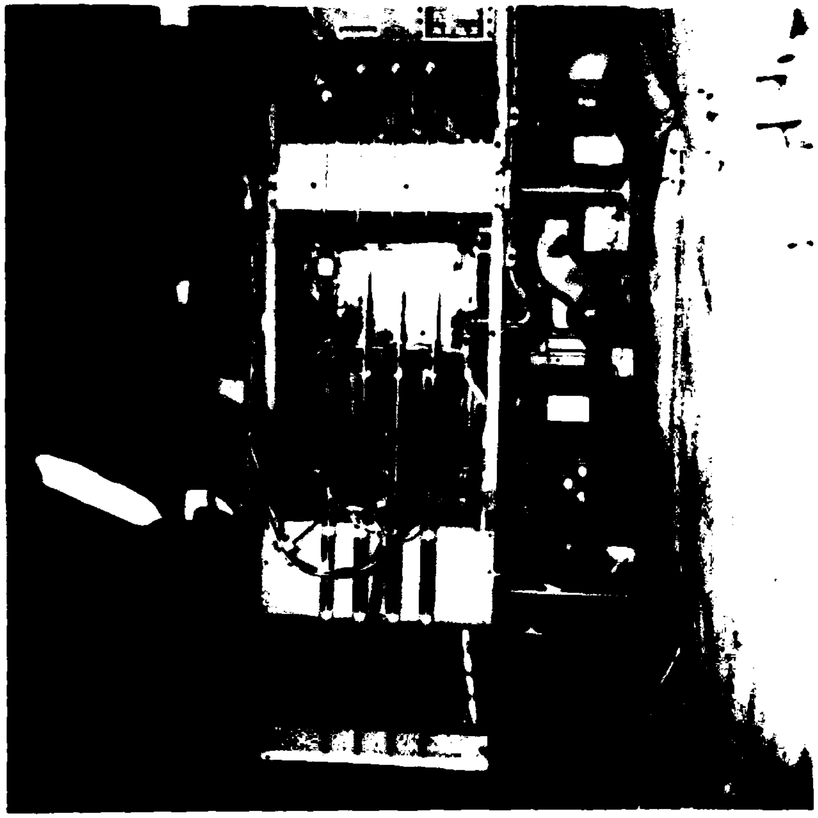

FIG. 8. AUXILIARY SERVO JACK POSITION TRANSDUCERS (L.V.D.T.S.) ON BROOM CUPBOARD

FIG. 9. YAW PEDAL POSITION TRANSDUCER (L.V.D.T.S.)

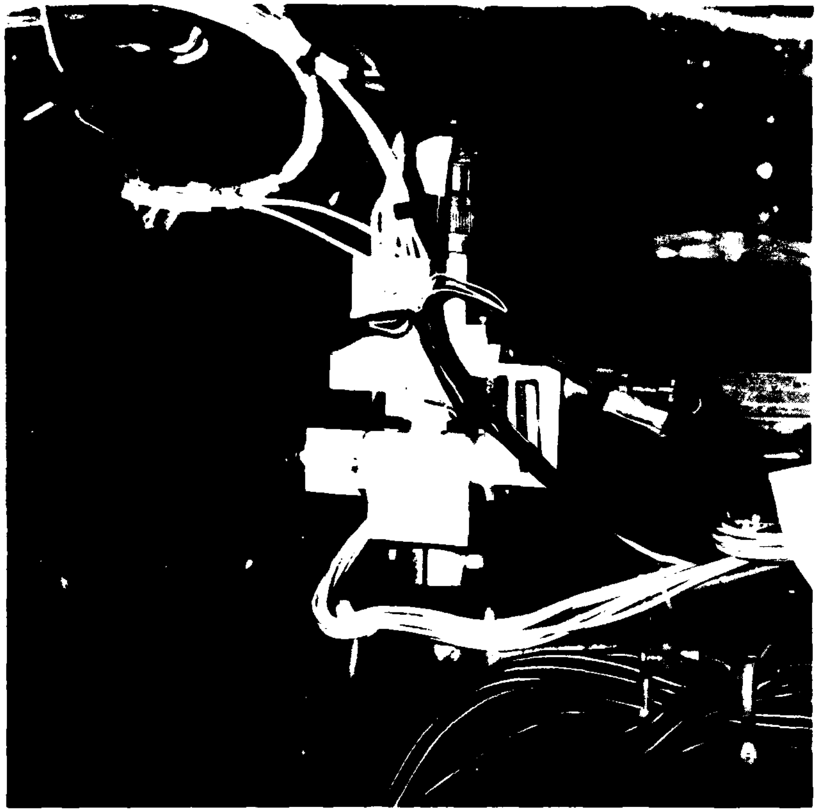

FIG. 10. TRIAXIAL ACCELEROMETERS

FIG. 11. O.A.T. SENSOR

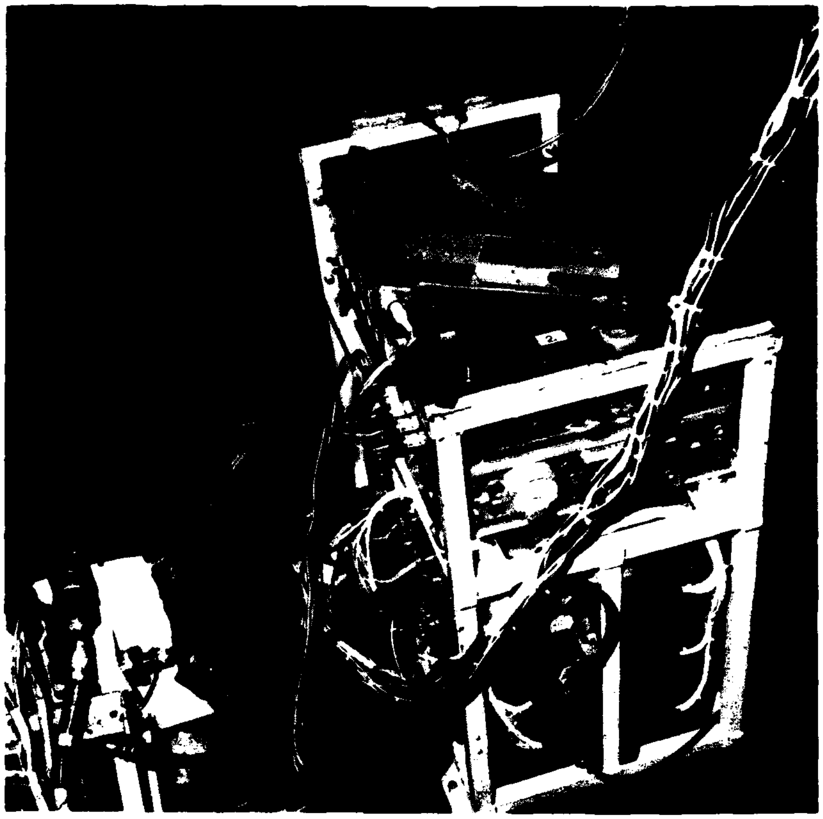

FIG. 12. A.D.A.D.A.P. WITH RATE GYROS ATTACHED

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