Chapter 2

PITOT-STATIC TRANSDUCER, TYPE A, Ref. No. 6A/5550

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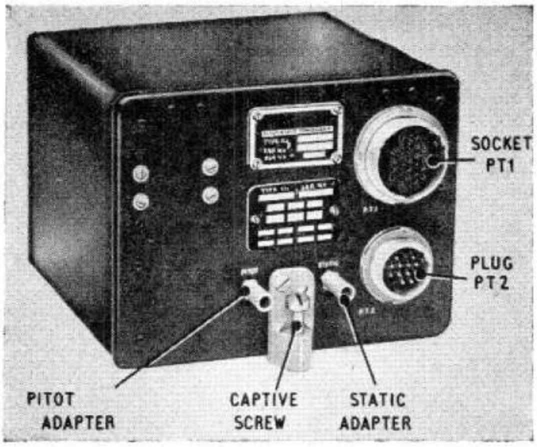


Fig. 1. Pitot-static transducer, Type A

General description

1. The pitot-static transducer, Type A (fig. 1) forms part of the air data system Mk. 1A, and is housed in a transducer mounting tray, Type A, Ref. No. 6A/5934 into which it is guided by means of locating dowels fitted to the rear of the chassis, and to which it is secured by the captive screw mounted on the front of the chassis. The transducer measures approximately 7 by 5 by 7 inches and weighs approximately 5½ lb.

Note . . .

*This issue of the chapter incorporates information on modifications ADS/*9, 57, 68, 101 *and* 122.

2. A 25-way socket, PT1, and a 12-way plug, PT2, are mounted on the front panel. Two orifices, labelled PITOT and STATIC, are provided for the two adapters which connect the transducer to the appropriate lines from the aircraft's pressure head. The static pressure adapter is of $\frac{3}{8}$ in. outside diameter and the pitot pressure adapter of $\frac{5}{16}$ in. outside diameter. The transducer is protected by a cover which may be removed after unscrewing two screws at the rear. No external controls are provided.

3. All power supplies are derived from the power supply unit of the air data system, and these supplies are listed, together with their application within the transducer, in Table 1. A warm-up period of three minutes is required prior to operational use.

4. The pitot-static transducer is a servo-mechanism designed to fulfil a requirement for the accurate measurement of indicated air speed (I.A.S.) between 100 and 750 knots within the temperature range —20 degrees C to +50 degrees C. The transducer provides a follow-up servo system delivering a synchro output corresponding to I.A.S. for transmission to the F.C.S. together with a potentiometer output for use as a primary signal associated with the air data computer. The output signals are listed in Table 2.

5. The transducer consists of a front panel, pillar and side bracket assembly supporting a gear plate (fig. 2) and motor plate (fig. 2 and 6). The gear plate and motor plate are suitably drilled to house or support the various components, bearings and drive spindles associated with the gear train. The transducer consists of a pitot-static capsule unit (para. 13) and a servo system, the servo system incorporating the following:—

(1) servo amplifier comprising:—

(a) transistor amplifier

(b) demodulator

(c) magnetic amplifier

Note . . .

*Although referred to as sub-assemblies, both the transistor amplifier TA*1 (3*C*5161) *and the magnetic amplifier MA*1 (3*C*635) *are separate and replaceable units.*

(2) gear train incorporating:—

(a) adjustable cam

(b) motor-tachogenerator

(c) transmitter synchro CX1

(d) cam unit CU8 (controlling synchro CX1, I.A.S. output)

(e) precision helical potentiometer RV3 (log (P-S) output)

(f) microswitches MSW1, MSW2 and MSW3.

6. Four preset potentiometers are provided for adjustment purposes as follows:—

(1) RV1, for setting up the velocity feedback signal from the tachogenerator.

(2) RV2 and RV4, forming part of the potentiometer network associated with RV3 and adjusted during setting-up to provide the correct log (P-S) output voltage from the wiper of RV3 (para. 40).

(3) RV5, for setting up a balanced output from the pick-off coils.

7. A component panel (fig. 5) supports the demodulator circuit (MR1, MR2, R14), R8 in parallel with RV2 (20V (X) supply), pick-off bridge resistors (R9 and R10) associated with RV5, servo amplifier input resistors (R5, R6), and overall feedback resistors (R11, R12, R13).

8. Connections are made to the base of the capsule unit (fig. 6) and the transistor and magnetic amplifier tag strips (fig. 5). Preset potentiometers RV1, RV2, RV4 and RV5 are mounted on the upper side of the gear plate (fig. 2), capacitor C1 on the underside of the motor plate (fig. 6) and C2 on the upper side of the motor plate. Power supplies, input and output signals etc., are distributed directly to and from the socket PT1 and the plug PT2 and are listed in Table 3.

9. The function of the pitot-static transducer is summarized in paragraphs 10 to 12 and a detailed description is given in subsequent paragraphs.

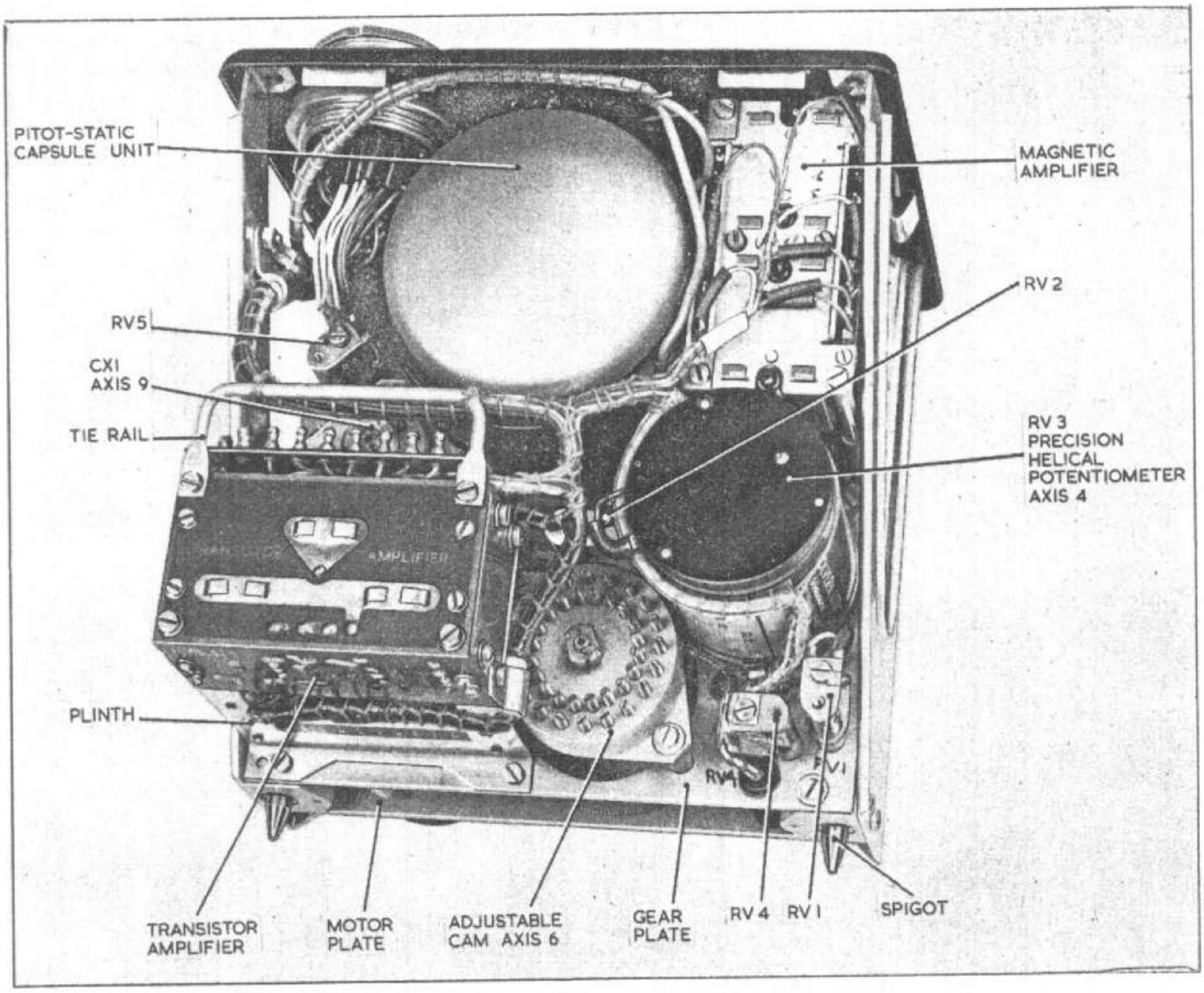


Fig. 2 Interior of transducer

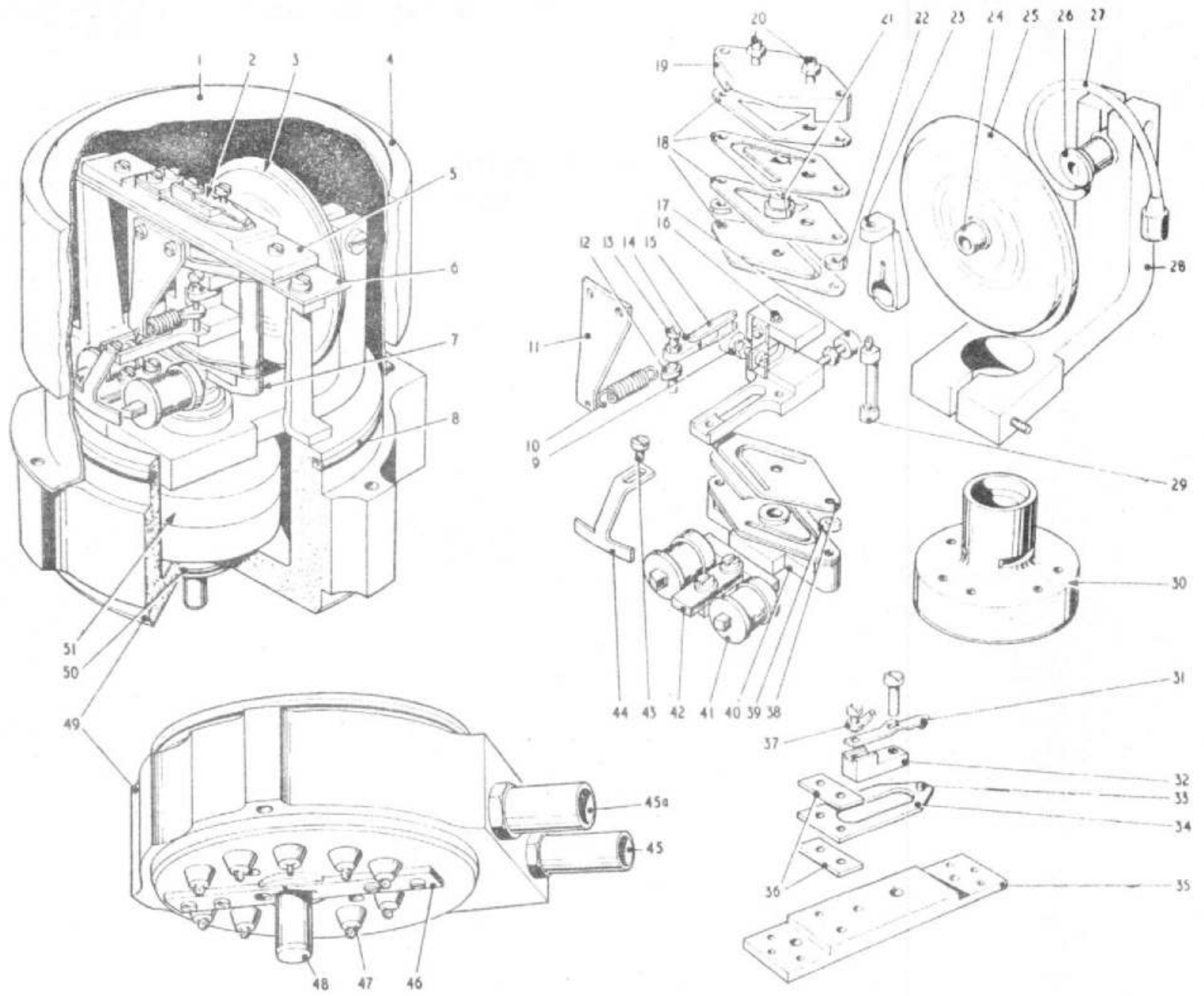
◀(R15/R16 mounted on RV4 post-mod. ADS/57)▶

Summary of operation

10. The I.A.S. information is derived from a sensitive differential air pressure gauge consisting of a capsule contained in a sealed chamber, the inside of the capsule being connected to the static line and the sealed chamber being connected to the pitot line from the aircraft's pressure head. It is reasonable to state that in flight, the pitot or dynamic pressure is greater than the static pressure by an amount depending upon the square of the air speed, and this causes the capsule to contract with increasing air speed, the deflection of the capsule being proportional to the log of pitot minus static pressure (log P-S). The capsule is connected by a linkage to the moving-iron armature of a variable-reluctance pick-off. The output from the pick-off coil is the error signal and this signal is amplified in the servo amplifier and used to drive the motor-tachogenerator. This in turn drives a suitable gear train which causes the coil of the pick-off to rotate and follow the moving-iron armature until a zero error signal or null position is found. The servo loop action then ceases and the angular rotation of the various shafts in the gear train is thus a measure of the deflection of the capsule. The output synchros and potentiometer of the transducer are driven by certain of these shafts and therefore produce signal outputs related to the capsule deflection.

11. Because of variations between the deflection/pressure characteristics of individual capsules, an adjustable cam—effectively a variable gear—is incorporated in the gear train between the motor and the pick-off coils. This cam is calibrated to a high order of accuracy in order to compensate for any capsule non-linearity (*para.* 46), and its effect is such that approximate measurements of log (P-S) pressure from the pick-off coils are converted into measurements of correct log (P-S) pressure throughout the gear train.

12. The tachogenerator stabilizes the servo-loop by providing an angular velocity feedback signal and the servo amplifier system is further stabilized by overall feedback. The servomechanism drives the transmitter synchro CX1 and the precision potentiometer RV3. The output of synchro CX1 is made proportional to I.A.S. up to 150 knots



1 COVER
2 BI-METAL SWITCH
3 CAPSULE
4 HEATER ELEMENT
5 INSULATED BLOCK
6 BRACKET AND PLATE
7 BRIDGE
8 COVER 'O' RING
9 CAPSULE BALANCE WEIGHT
10 SPRING
11 SPRING ANCHOR
12 SPRING TAG
13 SCREW AND LOCKNUT
14 JEWEL MOUNTING
15 LINKAGE ASSEMBLY
16 VANE PIVOT ARM
17 VANE ARM BALANCE WEIGHT
18 LEAF SPRING ASSEMBLY
19 BRIDGE
20 ADJUSTMENT SCREW
21 PIVOT JEWEL MOUNTING
22 SPACER
23 CAPSULE BRACKET
24 CAPSULE ADAPTER
25 CAPSULE
26 CAPSULE SUPPORT
27 CAPSULE PIPING
28 CAPSULE BRACKET
29 JEWEL MOUNTING ASSEMBLY (including bi-metal strip)
30 BEARING ASSEMBLY
31 SPRING CONTACT
32 BLOCK
33 BI-METAL CONTACT
34 SWITCH BI-METAL
35 INSULATED BLOCK
36 PACKER
37 SOLDER TAG
38 LEAF SPRING
39 SPACER
40 PICK-OFF BRIDGE
41 E COILS
42 LAMINATIONS
43 BOLT, VANE ARM ADJUSTING
44 VANE
45 ADAPTER, STATIC PRESSURE
45a ADAPTER PITOT-STATIC PRESSURE
46 BEARING PAD
47 SEALED TERMINAL
48 SPINDLE
49 BASE ASSEMBLY
50 SPINDLE 'O' RING
51 BEARING HOUSING

Fig. 3. Pitot-static capsule unit—exploded view (pre-mod. ADS/68)

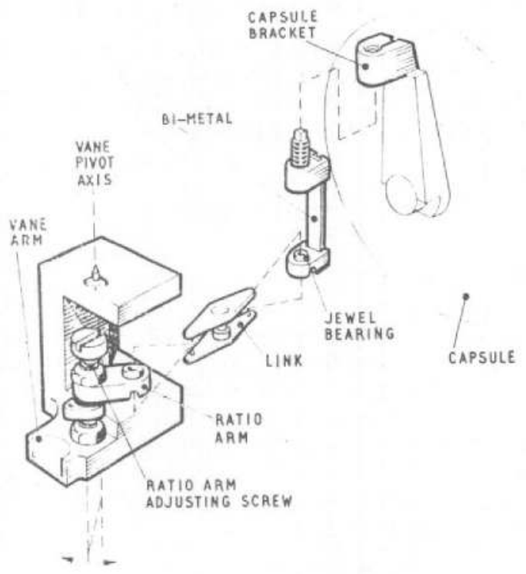


Fig. 4. Capsule unit linkage

(after which it is logarithmic) by the suitable coupling of a fixed cam in the gear train, and this output is applied to the flight control computer. A voltage output proportional to log (P-S) is provided by RV3 for use in the air data computer. Microswitch MSW3 has its contacts set so that at speeds below 65 to 72 knots this switch effectively reverses the motor and the servo thus runs on and off the gear stop position (*para.* 45).

PITOT-STATIC CAPSULE UNIT

Description

General

13. The pitot-static capsule unit is illustrated in fig. 3. This unit consists of a chamber containing the capsule (3) and fitted with two adapters, one of which is the inlet for static pressure (45) and the other (45a) the inlet for pitot pressure. Sealed outlets are provided in the base (49) for terminals (47) through which are routed the electrical connections for the thermostat switch and pick-off coils. A further outlet in the base, sealed by a synthetic rubber 'O' ring (50), is provided for the spindle (48). A detachable cover (1), also sealed by an 'O' ring (8), fits over the collar of the base-plate and a 40-watt heater element (4) surrounds the cover. The heater is controlled by the internal bi-metal switch (2) as described in para. 16.

14. The design of the capsule unit provides for the following:—

(1) The rigid support of the capsule (25) by means of the capsule bracket (28) and capsule support (26).

(2) Conversion of the capsule expansion and contraction into angular movement of the vane (*fig.* 4). As the capsule expands or contracts the capsule carries with it the capsule bracket into which is screwed the bi-metal assembly. A link engages a jewel bearing in the lower, or free end of the bi-metal assembly and transmits capsule movement to a ratio arm mounted on and locked with a locknut to a ratio arm adjusting screw. This screw is mounted off centre in the block of the vane pivot arm which is pivoted about a vertical axis and which swings about this axis in response to linear movements of the capsule adaptor and linkage. A spring tag (12, *fig.* 3) is also mounted on the ratio arm adjusting screw and a coiled spring (10) connected between this tag and a spring anchor plate (11), takes up any play which might result if the vane pivot block bearings were damaged by shock. The vane (44) is clamped in a slotted extension arm of the vane pivot block and its outer end is bent downwards so that it lies in close proximity to the poles of the pick-off coil assembly (41, 42); the gap between the vane and the poles may be adjusted by moving the vane in the slot before clamping with the screw (43). As the capsule expands or contracts the vane thus swings about the vane pivot axis, the degree of movement of the vane being controlled by the ratio arm, which may be rotated on the screw (before being locked with the locknut) to adjust the effective radius of the linkage attachment point.

(3) Conversion of the movement of the vane into an error signal by means of the variable-reluctance pick-off. The E coils (41) on their laminations (42) are attached to the spindle (48) by means of a pick-off bridge (40). The spindle and E coils are free to rotate over a limited arc, and are supported by two sets of bearings, the lower bearing being contained in a bearing housing (51). Superimposed on the bearing housing is a diaphragm which acts as an expansion joint. The spindle axis is further stabilized by means of vee-blocks and a bearing pad (46), and the spindle protrudes through the base assembly (49) via the synthetic-rubber 'O' ring seal. The lower end of the spindle is clamped to the 72 degree sector (*fig.* 6) which meshes with gear 76T on axis 6A.

(4) Correction of errors arising from varying temperature coefficients, and compensation for errors arising from 'g' forces.

(a) Temperature error correction. The bi-metal strip assembly is adjusted, during the calibration of the capsule unit, to compensate for the net error arising from the effects of temperature changes at sea level on all parts of the unit. The bi-metal bends with changing temperature resulting in horizontal movement of the jewel bearing at its lower end; the component of this movement, which is transmitted through the linkage, is controlled by the direction in which the bi-metal strip faces, and rotation of the bi-metal assembly (before clamping in the bracket) is thus a means of adjusting the temperature correction. The heater (4) improves the efficiency of the transducer at very low ambient temperatures by stabilizing the error signals and eliminating wide variations in the torque required for the sealed spindle, it also reduces the calibration spread at extreme temperatures. The heater is controlled by the bi-metal switch (2) which consists of an insulated block (35) on which is mounted the switch bi-metal (34) and contact (33) and spring contact (31). The bi-metal switch switches on the heater at a nominal ambient temperature of 5 degrees C but is ineffective below 10 500 ft.

(b) Errors arising from 'g' forces are counter-balanced by the capsule balance weight (9) for axial forces, the vane arm balance weight (17) for lateral forces and the leaf spring assembly (18) supporting jewel mountings in which pivots the vane arm.

(5) Electrical interconnections by means of the internal cable-forms. External connections are made by means of the sealed terminals (47).

◀ **15.** Modification ADS/68 introduces a new capsule bracket and bearing assembly cast as one unit, which also incorporates in the casting a base for the pick-off bridge to which it is locked on either side. The bridge therefore does not move when the E coils are driven by the servomechanism action, and the spring anchor, spring and tag have been dispensed with as no longer required. The housing for the capsule is no longer an integral part of the bracket but is a separately tooled item screwed to the bracket. ▶

Capsule (*fig*. 3)

16. The pitot-static capsule (25) is constructed of corrugated beryllium-copper cheeks joined with non-corrosive solder, the capsule being integral with the support (26) (shown detached from the capsule) and the adapter (24). A spiral of copper tubing (27) connects the inside of the capsule to the static adapter (45a). The (P-S) pressure varies between 16·33 mb at an I.A.S. of 100 knots and 1240·23 mb at 750 knots.

Heater circuit

17. The sealed volume of the capsule unit is temperature controlled by means of the bi-metal thermostat switch contained in the unit, and the associated heater element surrounding the removable cover. The heater element consists of a non-inductive winding positioned in its insulated covering so as to place the element in close proximity to the cover and thus provide maximum heat transference to the capsule unit, and minimum heat dissipation in other directions. The heater is connected to the 115V, 400 c/s phase A and B supply, which is made or broken via contacts RLB/1 of the high-speed relay RLB located in the computer. The solenoid of RLB is operated by the −30V supply via two switches in series, the bi-metal switch located in the capsule unit and a height switch located in the height gearbox of the computer. The height switch closes at and above an altitude of 10 500 ft, the bi-metal switch being ineffective and the heater remaining disconnected below this altitude.

18. The bi-metal switch is adjusted during calibration to close at a temperature of 5 degrees C ± 2 degrees C. and to open within 2 degrees C. of the temperature at which it closed.

◀ **Note . . .**

*Modification ADS*122 *removes the heater, switch and wiring.* ▶

Principle of operation

19. The inside of the capsule is subjected to the pressure of still air while the dynamic or pitot pressure is applied to the sealed chamber containing the capsule, the pressure differential causing the capsule to contract with increasing air speed. This movement is magnified in the linkage system and transmitted to the rotating arm to which the moving-iron armature (vane) of the variable-reluctance pick-off is attached.

20. The variable-reluctance pick-off uses magnetic coupling in order to measure the difference between the position of the vane (source of motion) and the spindle (source of error signal) and this forms the error detector of the transducer servomechanism. It consists essentially of the two magnetic structures, one in the shape of an E (pick-off coil) and the other in the shape of an I (vane). In the absence of pressure change, no movement is imparted by the capsule, the vane (assuming the servo follow-up action is complete) is symmetrically positioned in relation to the pick-off coil and the output from the pick-off is a minimum signal or null. A change of pressure results in the movement of the vane away from the null position, and a consequent output signal from the pick-off coils. This output is amplified and used to drive the motor-tachogenerator in a null-seeking direction.

21. The circuit of the variable-reluctance pick-off is given in fig. 12, from which it can be seen that an alternating voltage is applied to the primary, which is wound coaxially with the secondary on the outer limbs of the E core. If the vane is in its centre position, equal voltages are induced in the series-aiding secondary coils, the bridge network is therefore balanced (RV5 being adjusted to this condition) and a "null" output is produced across the load resistor R5. This output may contain a third harmonic signal of the order of 1 or 2mV. When the vane is moved the air gaps between the E and I cores are no longer equal, increased flux is carried in the limb having reduced reluctance and decreased flux is carried in the limb having increased reluctance. In this manner the voltage induced in one coil increases while that induced in the other decreases. The bridge is no longer balanced and an output voltage of a certain magnitude and phase appears across the load resistor R5. This error signal is power-amplified in the servo amplifier and fed to the control winding of the motor, the reference winding of which is supplied with 50V, 400 c/s in quadrature with the control voltage. The phase of the pick-off voltage is also related to the reference voltage, so

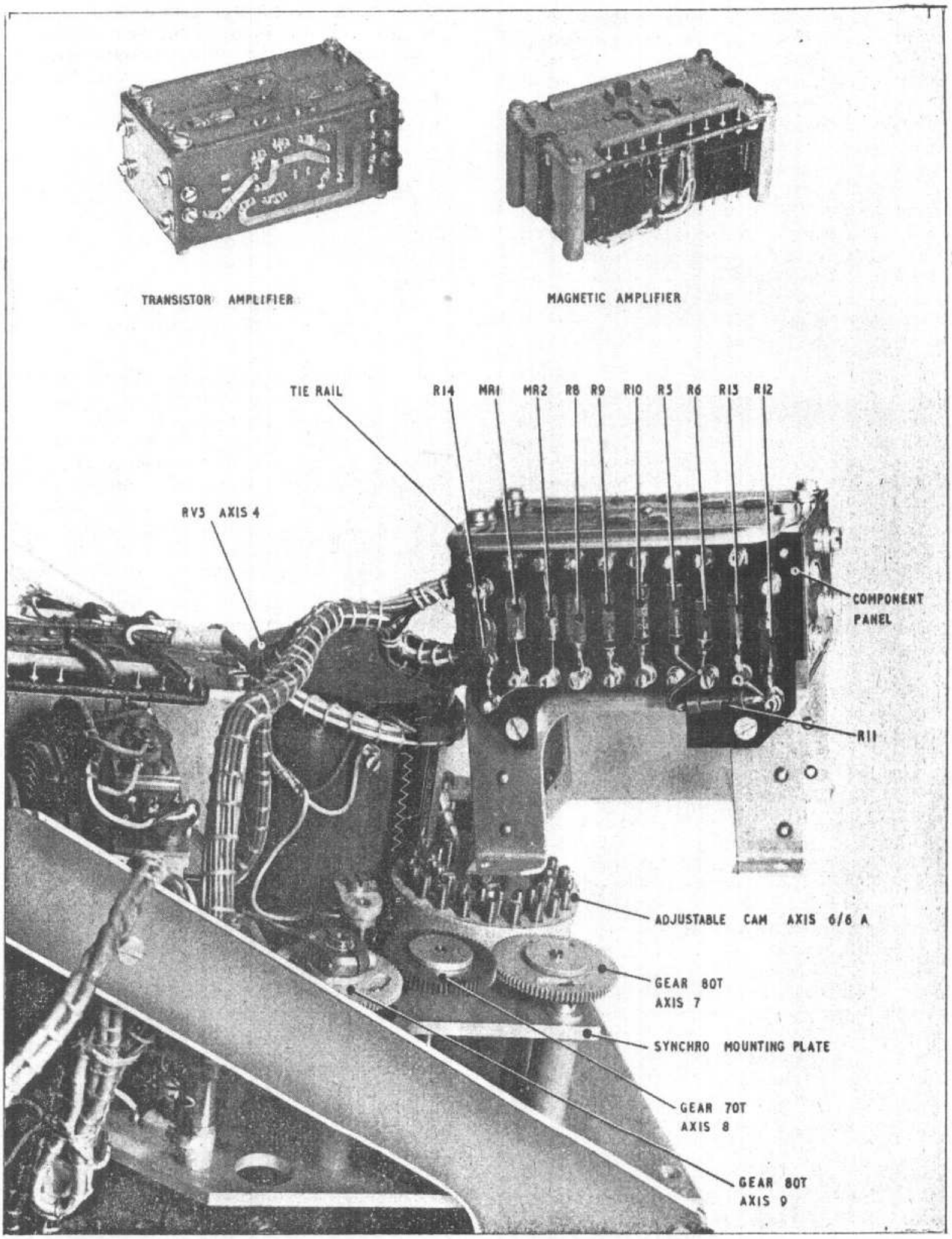


Fig. 5. Transistor and magnetic amplifiers and component panel

that the direction of rotation of the motor is such as to cause the servo-loop to seek the pick-off null.

SERVO SYSTEM

Servo amplifier (*fig.* 11)

22. The purpose of the servo amplifier is to provide a suitable a.c. power output which is related in amplitude and phase to the error signals from the capsule unit, the output from the servo amplifier being the command signal driving the motor-tachogenerator and associated gear train. The servo amplifier consists of a transistor amplifier, a phase-sensitive demodulator, and a magnetic amplifier, the overall gain being in the region of 130 000. It should be noted that identical transistor amplifiers and identical magnetic amplifiers are used throughout the transducers and computer of the air data system. Inputs to the servo amplifiers are discussed in para. 31.

Transistor amplifier (3C5161)

23. The transistor amplifier (*fig.* 5) is a printed-circuit sub-assembly secured by four screws to a plinth which raises it above the synchro mounting plate, the main component panel also being secured to the transistor amplifier by means of small brackets held by the two front securing bolts. The amplifier tag strip (labelled at the base of the plinth) is accessible at the lower rear, and a tie rail (*fig.* 2 *and* 5) is provided for the associated cable-form.

24. The circuit (*fig.* 11) consists of an input stage, resistance-capacitance coupled to a driver stage, coupled by a phase-splitter transformer to a Class B push-pull output stage.—Germanium PNP junction transistors are used throughout. The input signal is fed to the base of VT1 (OC73), which has +9V applied to the emitter, via R4 decoupled by C2, and −6V (A) to the collector via R2, decoupled by C1. R1 provides constant bias for VT1 which is resistance-capacitance coupled via R3, C3 and R6 to VT2 (OC73). VT2 operates with the same emitter and collector voltages as VT1 and is biased via R7, decoupled by C5. The phase-splitter transformer T1 couples VT2 to the output stage, the primary being tuned by C4 and C6 to give maximum gain at 400 c/s. A germanium junction diode, MR1, is used as a current and controlling device, it compensates for any change in base/emitter junction temperature and limits the emitter current, thus preventing instability in VT3 and VT4 (OC72's). Bias for the emitters is derived from the currents through R10 and R11 respectively. The collectors are fed with −6V(B) via the centre tap of the primary of T2, which is tuned by C7 for maximum gain at 400 c/s. T2 matches VT3 and VT4 into the output load.

Demodulator (*fig.* 11)

25. The demodulator circuit consists of the silicon diode rectifiers MR1 and MR2 and the 2·2k resistor R14, all of which are mounted on the main component panel (*fig.* 5).

26. The demodulator is a phase-sensitive device which operates from a 400 c/s signal and a 400 c/s reference supply. It will respond to signals which are either in phase with, or in anti-phase to, the reference signal, but will not respond to any quadrature voltages which may be present.

27. The demodulator converts the a.c. output from the transistor amplifier into a unidirectional signal for application to the magnetic amplifier. The polarity of this d.c. level depends upon the phase of the a.c. input to the demodulator, the amplitude of the d.c. output being proportional to the amplitude of the a.c. input from the transistor amplifier.

Magnetic amplifier (3C635)

28. The magnetic amplifier (*fig.* 5) is a sub-assembly of conventional design which delivers 5 watts a.c. power to the control-phase winding of the motor-tachogenerator. The input resistance is 74 ohms, the current gain at 4mA d.c. input is 20, and a maximum output of 120mA r.m.s. is available as a command signal to the motor-tachogenerator, which is tuned to 400 c/s by capacitor C1 in parallel with the control winding.

29. The circuit (*fig.* 11) of the magnetic amplifier consists of two matched transductors each with two silicon diode rectifiers (MR1-MR4), with R1 and two preset resistors, RV1 and RV2, controlling the bias circuit. All components are suitably mounted on a metal chassis. Internal connections are made via tagboards located at each side of the chassis and these are labelled on the chassis. The sub-assembly is provided with a flux shield protecting the capsule unit.

30. The sub-assembly functions as a Class B magnetic amplifier connected in such a manner as to provide a load current which is the difference between the a.c. currents flowing in the transductors. The transductors are fed from the opposite ends of an 85V-0-85V, 400 c/s supply (AC1 and AC2), and the phase of the load current is therefore reversed when the direction of the d.c. control reverses.

31. The transductor operating points are set independently by means of the internal preset resistors, RV1 and RV2, the bias current being derived from the −30V d.c. supply. These bias control potentiometers are adjustable through two access holes in the chassis.

Inputs to servo amplifier

32. The inputs to the servo amplifier are summated at tag 'a' on the transistor amplifier and consist of error, damping, and overall feedback signals as follows:—

(1) The error signal derived from the pick-off of the capsule unit is fed to the amplifier via the load resistor R5.

(2) An angular-velocity feedback signal (damping signal) is derived from RV1, which is across the output winding of the tachogenerator (*para.* 35).

(3) An overall feedback signal is developed from the servo amplifier output via the T-network comprising R11, R12 and R13. This signal stabilizes the gain of the servo amplifier, improves the low frequency response, and removes unwanted time lags from the servo loop.

Motor-tachogenerator

33. The motor-tachogenerator consists of a 2-phase squirrel cage motor with an induction tachogenerator mounted on the same shaft, the motor being designed for 400 c/s operation. The reference winding of the motor section is energized by the 50V quadrature supply, and the control winding is fed with the power-amplified command signal from the output of the magnetic amplifier, this voltage being in time phase quadrature with the excitation voltage. The resultant rotating field causes the motor to rotate at a speed proportional to the amplitude of the command signal, the direction of rotation being determined by the phase of the command signal voltage, which may either lead or lag the excitation voltage by 90 degrees. The motor spindle is connected by a pinion to the gear train.

34. The tachogenerator provides a sinusoidal voltage of constant frequency, but with an amplitude proportional to the angular velocity of the shaft. The generator has two stator windings—excitation and output, the excitation winding being fed with 8V a.c.

35. The output from the generator is used as velocity feedback and is fed to the input of the servo amplifier via the load resistor R6. A preset potentiometer RV1 is connected across the generator output winding to enable the maximum velocity feedback signal to be varied between zero and 2·75V r.m.s. approximately. If the signal is inadequate, any disturbance will cause the servo to oscillate or hunt, whereas if the signal is too large the servo will be over-damped and sluggish. RV1 is adjusted during setting-up to provide a satisfactory measure of velocity feedback.

◀ **Outputs from servo system** (*fig.* 12)

36. The motor-tachogenerator drives, through a gear train, a synchro control transmitter CX1 and a potentiometer RV3 to provide the required outputs of I.A.S. and log (P-S). In addition, microswitches MSW1 and MSW2 are operated at 300 and 400 knots respectively to energize relays in the F.C.S. computer and change the control gearing ratio.▶

Synchro transmitter CX1

37. Synchro control transmitter CX1 feeds I.A.S. signals to the flight control computer, and its shaft is controlled by cam unit CU8 to provide an output proportional to I.A.S. up to 150 knots, after which the output is logarithmic up to 750 knots.

38. The synchro transmitter has a single-phase rotor which is energized by the 115V phase A and B supply, applied by means of slip-rings and brushes. When the rotor winding is thus excited by the a.c. applied to the two input leads, R1 and R2, voltages are induced in the stator windings by transformer action.

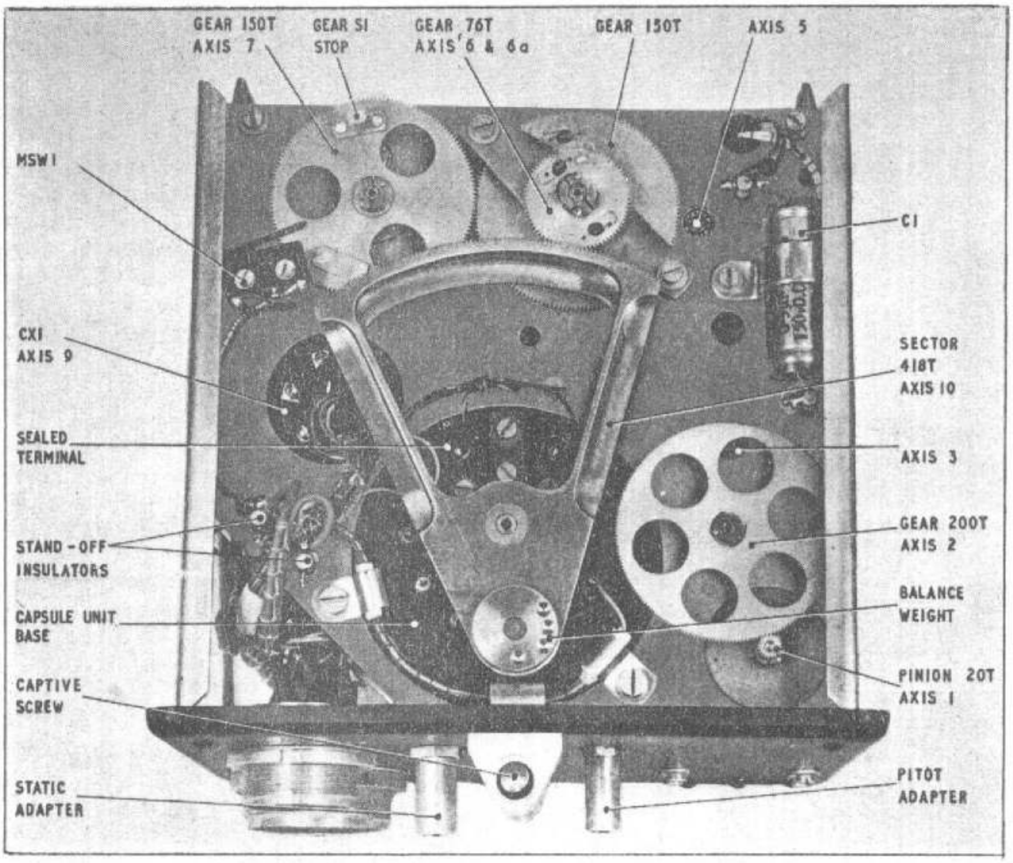


Fig. 6. Underside of motor plate

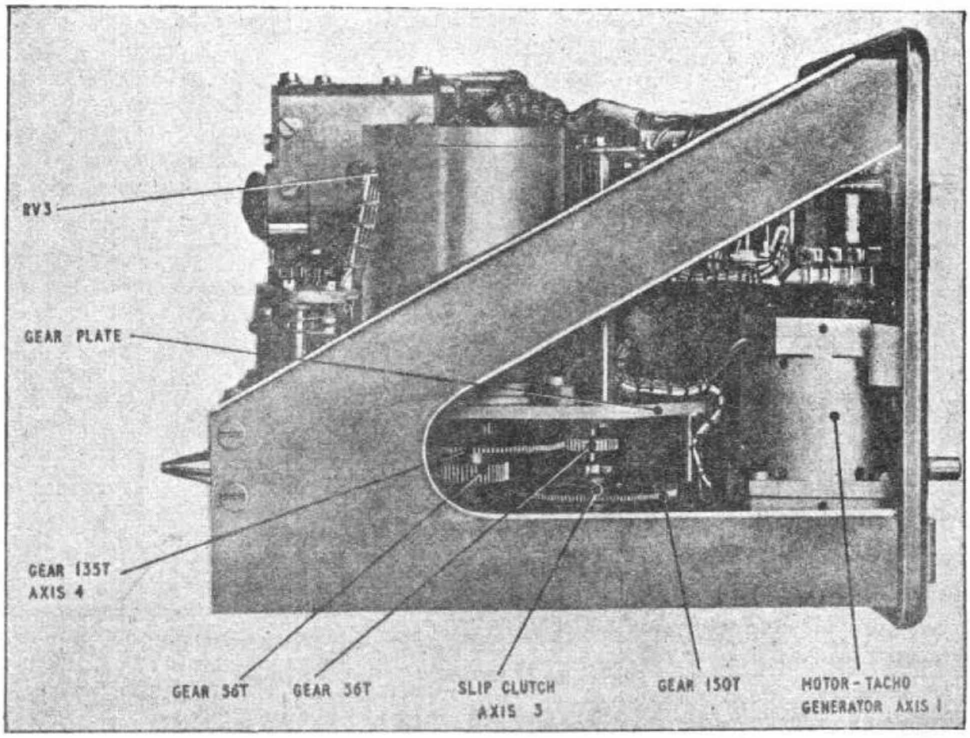


Fig. 7. Gear train, gear head and slip clutch

39. Two phases only of the synchro transmitter output are used (S1 and S3); these are routed via the static transducer and the air data computer to the flight control computer.

Potentiometer RV3

40. The output of potentiometer RV3 is known as log (P-S) and forms one of the primary variables fed to the air data computer. The log (P-S) voltage is derived from the 20V (X) supply and is developed across the potentiometer network RV2, R8, RV3, RV4, R15 and R16. RV3 is a ten-turn helical potentiometer which has a nominal value of 1k. During calibration, RV4 is preset to compensate for any discrepancy in the nominal value of RV3, and RV2 is preset to bring the voltage at the junction of RV3 and RV4 to a specified value so that the log (P-S) voltage from RV3 wiper ranges between approximately 6V at 100 knots and 15V at 750 knots ((P-S) pressure 16·33 and 1240·23mb respectively). This voltage is applied to the servo amplifier of the log Mach number servo gearbox in the air data computer.

Gear train

General

41. The gear train (*fig.* 12) is accommodated between a gear plate (*fig.* 2) a synchro mounting plate (*fig.* 5) and a motor plate (*fig.* 6), certain parts of the gear train protruding above the gear plate or beneath the motor plate. The gear and motor plates are drilled to house the capsule unit base, which is bolted between the two plates, and also the synchro CX1, potentiometer RV3, the motor-tachogenerator, and the associated gear system, suitable bearings being provided for the various gear spindles, Split clamps facilitate the removal of gears or components, and clamps provided on the gear plate for RV3, and on the synchro mounting plate for CX1, enable the zero positions of these components to be adjusted during setting-up.

42. The gear train consists of ten axes, axis 1 being the drive from the motor-tachogenerator. Aluminium alloy is the material used for the gears and stainless steel for pinions and spindles. All bearings are flanged ball bearings and are a light push fit in their housings and on their spindles. Split gears are introduced on axes 5 and 6 to counteract backlash (*para.* 44). To protect the gear train, a slip clutch (*para.* 43) is provided at axis 3, and a gear stop (*para.* 45) is fitted at axis 7.

Slip clutch

43. The slip clutch (*fig.* 7) protects the gear train in the event of overload. It consists of a dished spring fitted on the intermediate gear spindle at axis 3, the gear (150 teeth) being freely mounted on the slip clutch boss and clamped against the spring by a split clamp. The split clamp is adjusted so that the rotation of the spindle is transmitted to the gear on normal loads, but slips when the load is slightly below the overload rating for the motor.

Split gear

44. A split gear is a combination of two gears mounted coaxially, with abutting wheel faces, one gear being staked to a boss and the other free to rotate on the boss. The relative rotary position of the two gears is controlled by two coiled springs, each accommodated in a pair of slots in the gears. The pairs of slots are diametrically opposite and one end of each spring is attached to each gear; with minimum tension on the springs the teeth of the two gears do not coincide. When meshed, the teeth of the two wheels of the split gear are forced more nearly into coincidence, increasing the tension on the springs and rotating the free gear slightly relative to the fixed gear. Thus both sides of the meshing teeth are in contact and backlash is reduced to a minimum.

Gear stop

45. A gear stop is provided on the gear 150T located under the motor plate at axis 7. The gear stop engages with a motor plate stop at the extreme limits of the gear train travel. These extreme limits are well beyond the normal operating limits of the gear train.

Adjustable cam (*fig.* 8 *and* 9)

46. As stated in para. 11, because of variations between the deflection/pressure characteristics of individual capsules, it is necessary to introduce a variable gear to compensate for this error. An adjustable cam is therefore introduced at axis 6, the action of the cam being transmitted to axis 6A which carries the gear 76T meshing with the sector. The adjustable cam is driven by the split gear 150T located above the motor plate, which meshes with pinion 30T at axis 5.

47. Integral with split gear 150T referred to above, is a collar (12, *fig.* 9) fitted with a stop (13). The base of the collar supports a spindle (10) in a bearing (21a). This spindle protrudes beneath the motor plate and carries a boss and split gear 76T (19) which meshes with the sector 418T driving the capsule unit spindle (axis 10) to which is attached the pick-off bridge and E coils. Integral with the spindle (10) is a spring-loaded yoke (8) mounted on which, and hinged in the horizontal plane, is an arm (25), bearing (22a) and cam-follower (24). The cam-follower traverses the underside of the cam (6) which is a drilled disc of polished nickel-plated beryllium copper forming a circular track, approximately $\frac{1}{4}$ in. wide, for the cam-follower. The cam is split (27) to allow for adjustment in the vertical plane, and slots (28) cut in the inner periphery of the cam engage with the waists of the cam adjusting screws (3) of which there are 20, the waist of each adjusting screw being inset in a slot and thus retaining the cam in position. A further 20 supporting screws (4) bear on the outer periphery of the cam and are adjusted to maintain the plane of the cam at right angles to the cam-follower to prevent the cam flexing. The supporting screws and cam adjusting screws are threaded through a housing (5) spaced above the gear plate by two pillars (26). The screws are locked in the housing by means of a nylon lock washer inset in the base.

48. The action of the adjustable cam is such that if all cam adjusting screws and supporting screws are wound so that the cam presents a horizontal surface to the cam-follower, then a 1 : 1 gear ratio will exist between axis 6 and axis 6A. Calibration of the pitot-static transducer over the I.A.S. range of 100 to 750 knots is obtained by the adjustment of the screws, and this causes the cam to become distorted spirally. The cam-follower wheel, in following the spiral, advances or retards the arm (25) and yoke (8) and consequently axis 6A by the amount preset during calibration. The yoke stop (13) drives against the bearing (22a) thus transferring the advance/retard action to axis 6A and so to the capsule spindle, thus hastening or delaying the nulling of the capsule

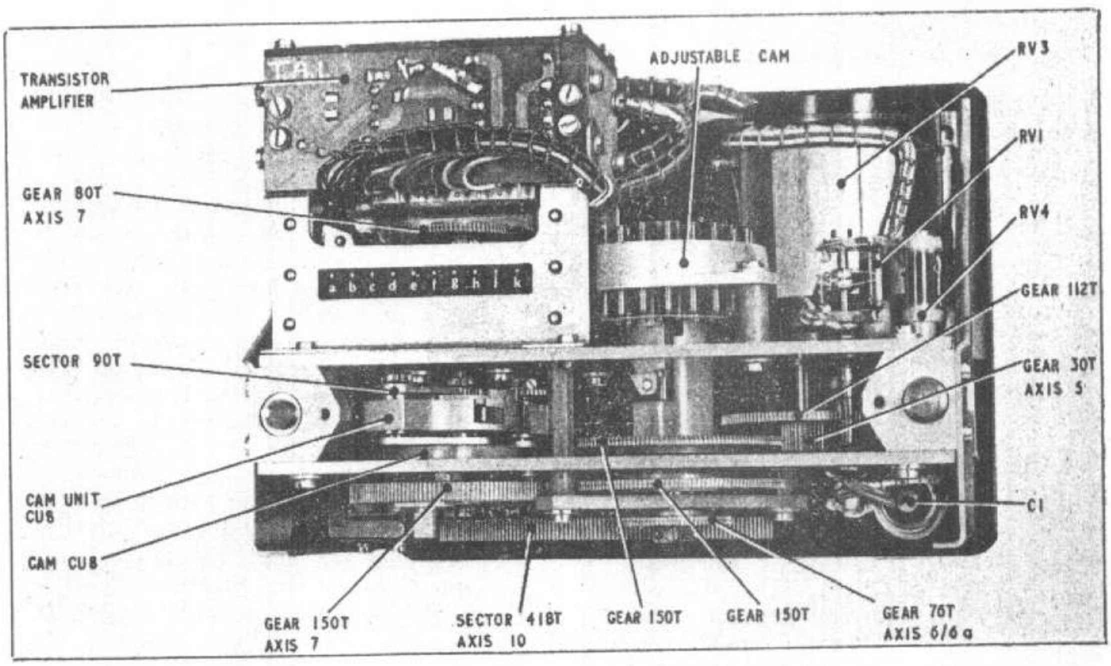


Fig. 8. Rear internal view of transducer

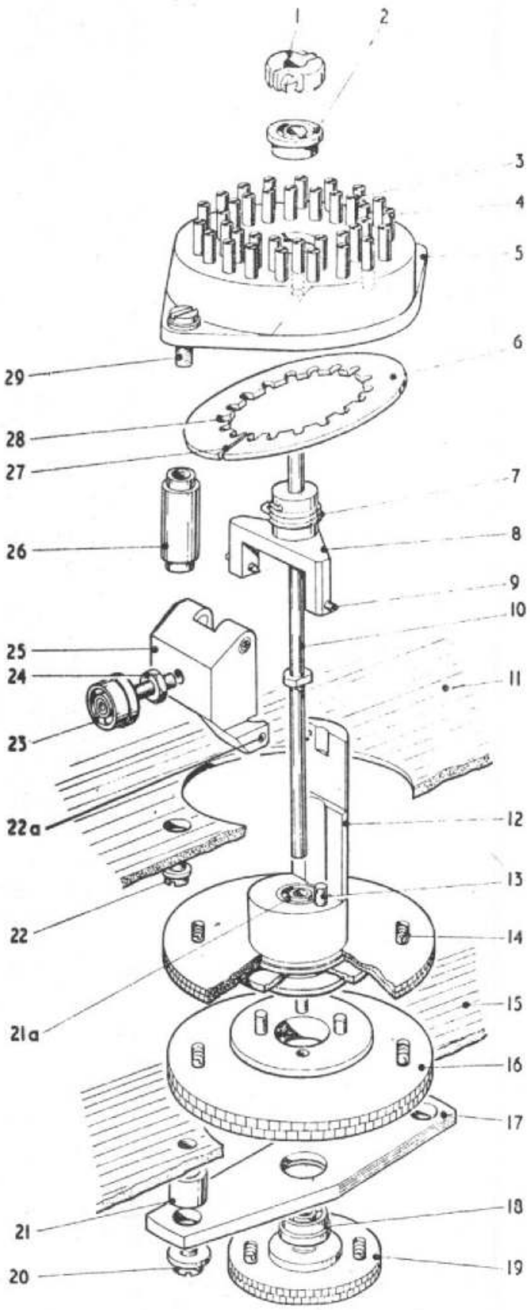


Fig. 9. Adjustable cam—exploded view

Key to Fig. 9

1 SPLIT CLAMP
2 BEARING
3 CAM ADJUSTING SCREW
4 SCREW (CAM SUPPORTING)
5 HOUSING
6 ADJUSTABLE CAM
7 SPRING
8 YOKE
9 PIVOT SCREW
10 SPINDLE
11 GEAR PLATE
12 BODY (COLLAR)
13 PIN (STOP)
14 SPRING
15 MOTOR PLATE
16 BOSS AND SPLIT GEAR 150T
17 BEARING SUPPORT
18 BEARING
19 BOSS AND SPLIT GEAR 76T
20 PILLAR SCREW
21 PILLAR
21a BEARING
22 PILLAR SCREW
22a BEARING
23 CAM FOLLOWER
24 LOCKNUT
25 ARM
26 PILLAR
27 SPLIT IN CAM
28 SLOT
29 PILLAR SCREW

pick off by an amount proportional to the calibrated error of the cam: the variable gear compensating the servo loop for any non-linear characteristics of the capsule.▶

Computation cam unit (*fig.* 10)

49. A computation cam unit is fundamentally a mechanical differential, the cam being designed to modify or correct the angular rotation of a spindle to a new function. The cam unit comprises a fixed cam (11) and a cam follower (10) attached to a follower arm (9). The follower arm is pivoted in a spring housing (7) which is pinned to the input shaft (19). The outer end of a spiral spring (6) contained in the housing engages in a slot in the housing and its inner end in a slot in an inner housing (5). A pinion (4) on a short spindle is located in the inner housing by means of a key (21) and the upper end of the pinion spindle is clamped to the output shaft (2). Rotation of the input shaft is therefore transmitted via the housing, spring, inner housing and pinion spindle to the output shaft.

50. When a torque is applied to the input shaft the spring housing is rotated carrying the cam-follower round the cam. The drive is also transmitted through the spiral spring to the pinion. The pinion engages a sector (3) clamped to the upper end of the follower arm spindle and, if the follower arm spindle is not free to rotate, a positive drive from the housing to the pinion will result. Follower arm movement is controlled by the shape of the cam; as the follower moves inwards or outwards the follower arm spindle is rotated and the sector drives the pinion relative to the spring housing. An angular movement of the pinion and output shaft is therefore added to or subtracted from the angular movement transmitted from the input shaft through the spring housing. The spring is sufficiently strong to keep the follower in contact with the periphery of the cam at all times. A dummy follower arm (18), which does not engage the cam, is mounted in the opposite end of the spring housing, complete with spindle and sector (22), as a counter-balance.

SERVICING

51. Full instructions for setting up the pitot-static transducer will be issued later. The following is a summary of the basic setting-up requirements:—

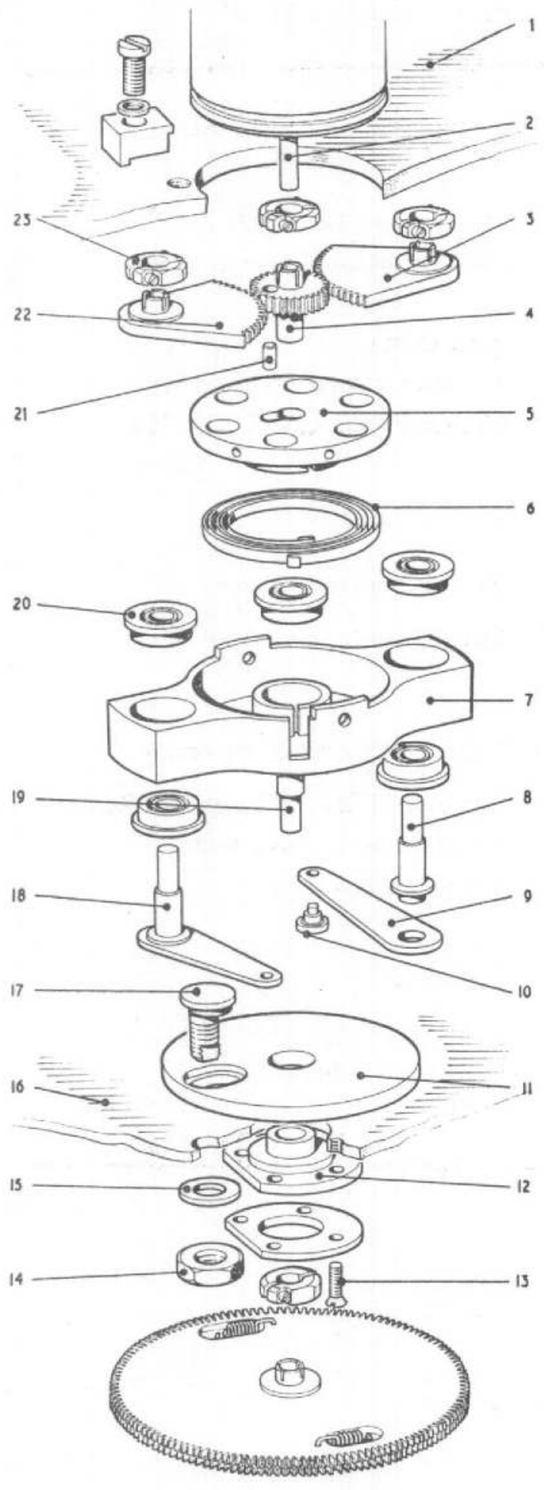


Fig. 10. Cam unit CU8—exploded view

Key to Fig. 10

1 GEAR PLATE
2 OUTPUT SHAFT (RV3)
3 GEAR SECTOR
4 PINION AND SPINDLE
5 INNER SPRING HOUSING
6 SPIRAL SPRING
7 SPRING HOUSING
8 FOLLOWER ARM SPINDLE
9 FOLLOWER ARM
10 CAM FOLLOWER
11 FIXED CAM
12 BEARING AND HOUSING
13 SCREW 10BA
14 NUT 4BA
15 WASHER 4BA
16 MOTOR PLATE
17 ADJUSTER
18 DUMMY FOLLOWER ARM AND SPINDLE
19 INPUT SHAFT
20 BEARING
21 PINION KEY
22 GEAR SECTOR
23 SPLIT CLAMP

(1) Capsule unit

(a) bearing assembly—fitting of assemblies and bearings, greasing etc., checking of intermediate and total permissible torque.

(b) bi-metal linkage-correct adjustment to compensate for errors due to temperature changes. Adjustment of linkage ratio to give required deflection

(c) heater circuit—correct setting-up of bi-metal switch to prescribed temperature limits

(d) error signal output—physical symmetry of vane and E coils. Adjustment of RV5 to produce optimum null signal.

(2) Servo response—checking of servo stability and adjustment of velocity feedback.

(3) Adjustable cam—calibration of cam over specified I.A.S. range.

(4) I.A.S. synchro output—calibration check of the rotation of CX1 over the specified I.A.S. range.

(5) Log (P-S) voltage output—setting-up of RV2, RV3, RV4 network, adjustment of CU8 and calibration of potentiometer RV3 voltage output over specified I.A.S. range.

TABLE 1

Power supplies

PT1	PT2		
		Motor-tachogenerator	
H	K	50V (90 degrees in advance)	Motor reference supply
J	M	8V (anti phase)	Tachogenerator excitation supply
		Transistor Amplifier	
O		+9V d.c.	Emitter bias
P		−6V(A) d.c.	Collector voltage, VT1 and VT2
S		−6V(B) d.c.	Collector voltage, VT3 and VT4
		Demodulator	
	J	Ref. 1 (25V)	
		Magnetic Amplifier	
G	F	−30V d.c.	Transductor bias windings
D	D	AC1 (85V, in-phase)	} Transductor load windings
E	E	AC2 (85V, anti-phase)	
		Capsule Unit	
C	A	3V(X) (anti-phase)	} Pick-off coil, primary excitation
B	C	3V(Y) (in-phase)	
G	F	−30V d.c.	Operaton of heater circuit relay RLB in computor via bi-metal switch
Q		115V (A) — (C)	Heater element
		Transmitter Synchro CX1	
Q		115V (A) R2	} CX1 rotor
W		115V (B) R1	
		Potentiometer RV3	
	L	20V (X) (anti-phase)	Log (P—S) voltage
N	H	20V (Y) (in-phase)	

TABLE 2

Outputs

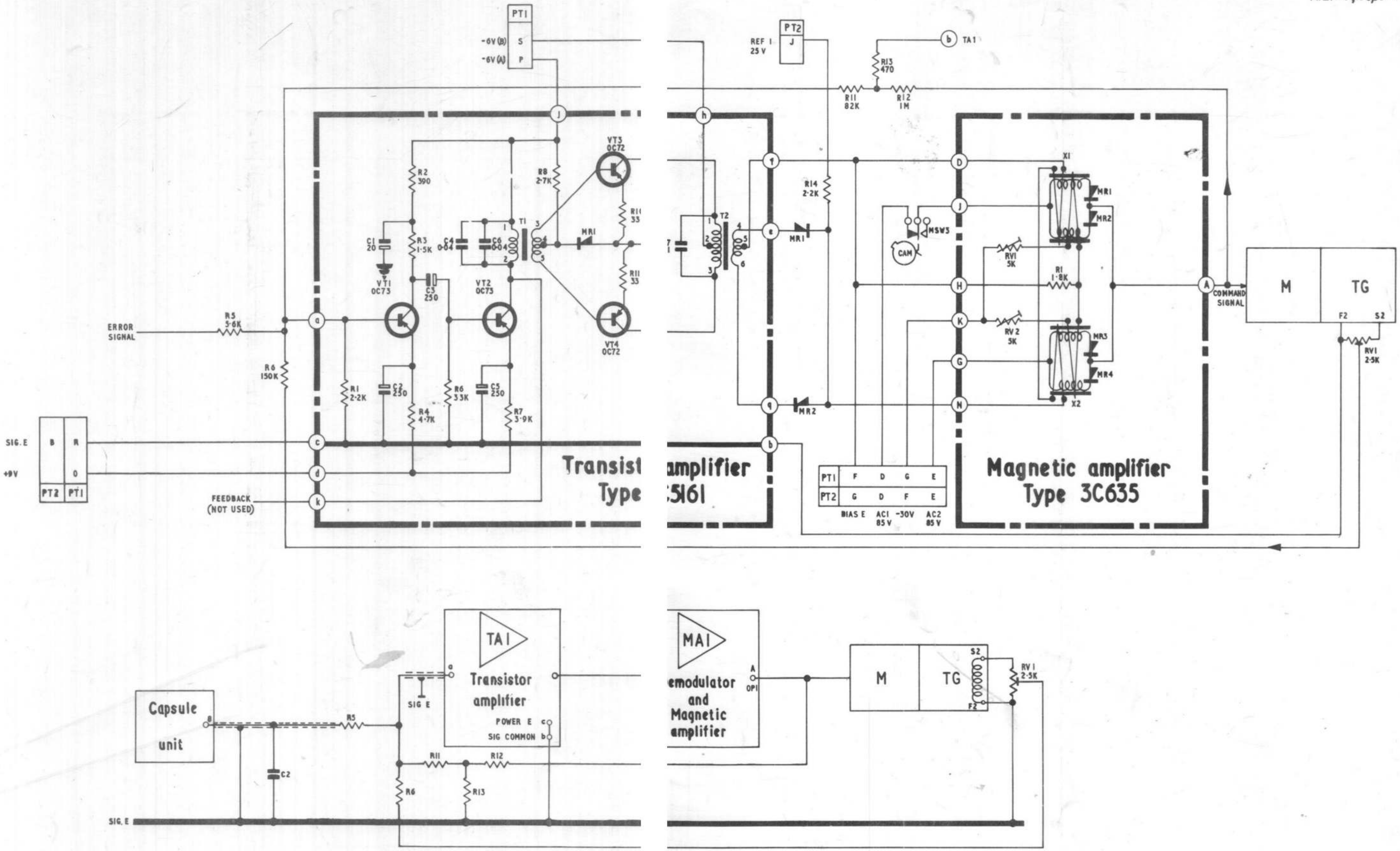
PT1		
L		Potentiometer RV3, Log (P—S) (to computer)
X	S1	} CX1, I.A.S. Synchro (to F.C.S. via computer)
Y	S2	
Z	S3	

Note . . .
S2 terminates at pin Y, plug ST2 of the static transducer.

TABLE 3

Connections to PT1 and PT2

PT1		PT2	
A	RL V/1 in computer	A	3V (X)
B	3V (Y)	B	Sig. earth
C	3V (X)	C	3V (Y)
D	AC1 (85V)	D	AC1(85V)
E	AC2 (85V)	E	AC2(85V)
F	Bias earth	F	−30V
G	−30V	G	Bias earth
H	50V	H	20V (Y)
J	8V	J	Ref. 1
K	RLB in Computer	K	50V
L	Log (P—S)	L	20V (X)
M		M	8V
N	20V (Y)		
O	+9V		
P	−6V (A)		
Q	115V (A)		
R	Sig. earth		
S	−6V (B)		
T	MSW1 (300 kt)		
U	Common		
V	MSW2 (400 kt)		
W	115V (B)		
X	S1 } I.A.S. synchro to F.C.S.		
Y	S2 } I.A.S. synchro to F.C.S.		
Z	S3 } I.A.S. synchro to F.C.S.		



A.D.S. Mk.IA—pitot-s c transducer, servo amplifier circuit diagram

Fig. 11

AIR DIAGRAM
6320 AW/MIN
ISSUE 2 — PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

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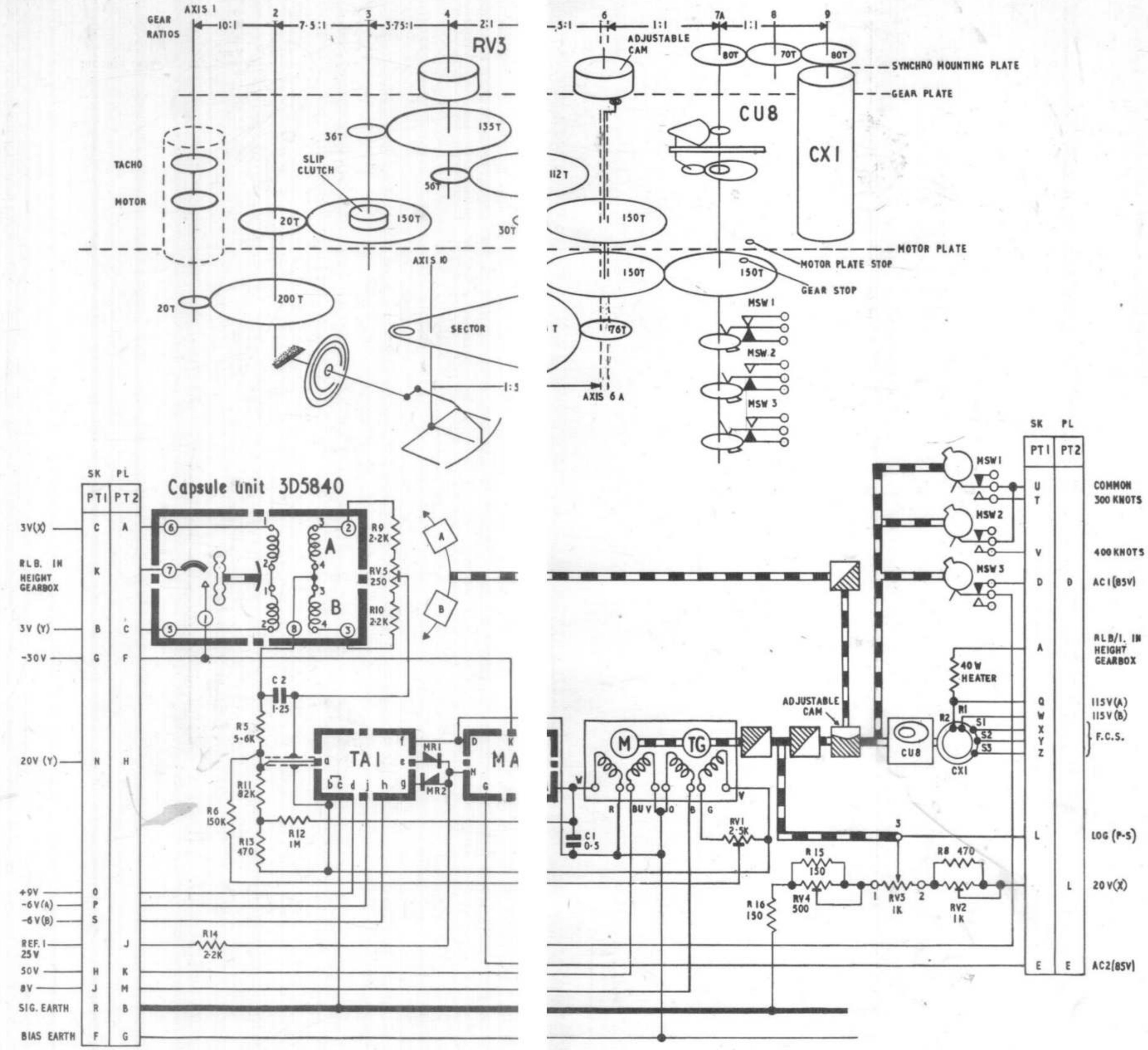
NOTE :-
GEAR SYSTEM
SHADED AREA INDICATES
HIGHER SHAFT SPEED

MOD. A.D.S. 122 REMOVES HEATER, BI-METAL SWITCH, AND ASSOCIATED WIRING



AIR DIAGRAM
6320 AX/MIN
ISSUE 2
PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

A.D.S. Mk.1A—pitot-static transducer Type A, Ref. No. 6A/5550, circuit diagram

Fig. 12

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