Chapter 11

STATIC TRANSDUCER, TYPE B, Ref. No. 6A/6434

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General description

1. The static transducer, Type B (fig. 1), forms part of air data system Mk. 1B, and is housed in transducer mounting tray, Type B, Ref. No. 6A/5937, 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 unit measures approximately 6½ by 5 by 7 inches and weighs approximately 6 lb. This issue incorporates modifications ADS/27, 31, 38, 40, 54, 56, 75, 121 and 141.

2. Two 25-way plugs, ST1 and ST2, are mounted on the front panel, and an orifice labelled STATIC is provided for an adapter of ⅜ in. outside diameter. The adapter connects the unit to the static line from the aircraft's pressure head. The transducer is protected by a cover which may be removed after unscrewing two screws at the rear of the unit. 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 static transducer is a servomechanism designed to fulfil a requirement for the accurate measurement of linear height between –1000 and 50 000 ft within the temperature range –20°C to +50°C. The transducer provides a follow-up servo system delivering a height synchro output for transmission to the height section of certain display units, together with a further synchro output and a potentiometer output for use as primary signals in 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 9). 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.

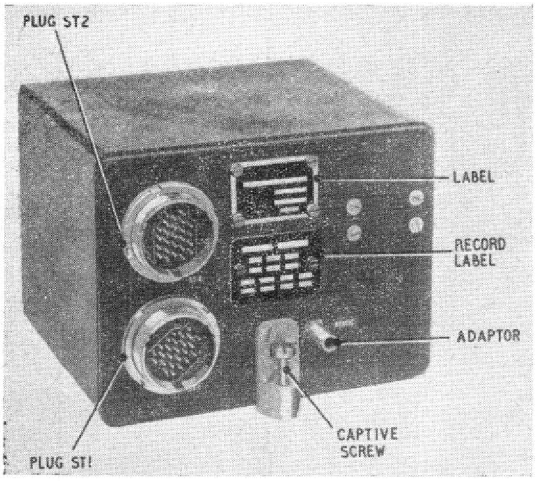


Fig. 1. Static transducer, Type B for ADS Mk. 1B

Transducers prior to modifications ADS/75 may be considered to consist of a static capsule unit (para. 21) and a servo system, this latter incorporating the following:—

(1) Servo amplifier comprising:—

(a) transistor amplifier (TA1) (3C5161),

(b) demodulator,

(c) magnetic amplifier (MA1) (3C635 or 3C635/1).

Note . . .
Although referred to as sub-assemblies, both the transistor amplifier and the magnetic amplifier are separate and replaceable units.

(2) Gear train incorporating:—

(a) adjustable cam,

(b) motor-tachogenerator,

(c) synchro transmitter CX1 and CX2,

(d) cam unit CU1A (controlling potentiometer RV3),

(e) precision potentiometer RV3 (log S output).

6. Transducers modified to ADS/75 vary from the foregoing in that they incorporate temperature compensation and harmonic and quadrature suppression units. These modifications involve the following changes:—

(1) A modified capsule unit, producing height error and sea level temperature correction signals.

(2) The insertion of the harmonic and quadrature suppression unit (para. 35) between the capsule unit outputs and the input to the servo amplifier.

(3) A modified servo-driven ganged potentiometer (RV3) giving a log S output (RV3a) and an output for altitude temperature compensation (RV3b).

7. In units prior to mod. ADS/75 four preset potentiometers other than the two bias potentiometers embodied in the magnetic amplifier 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 S output voltage from the wiper of RV3.

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

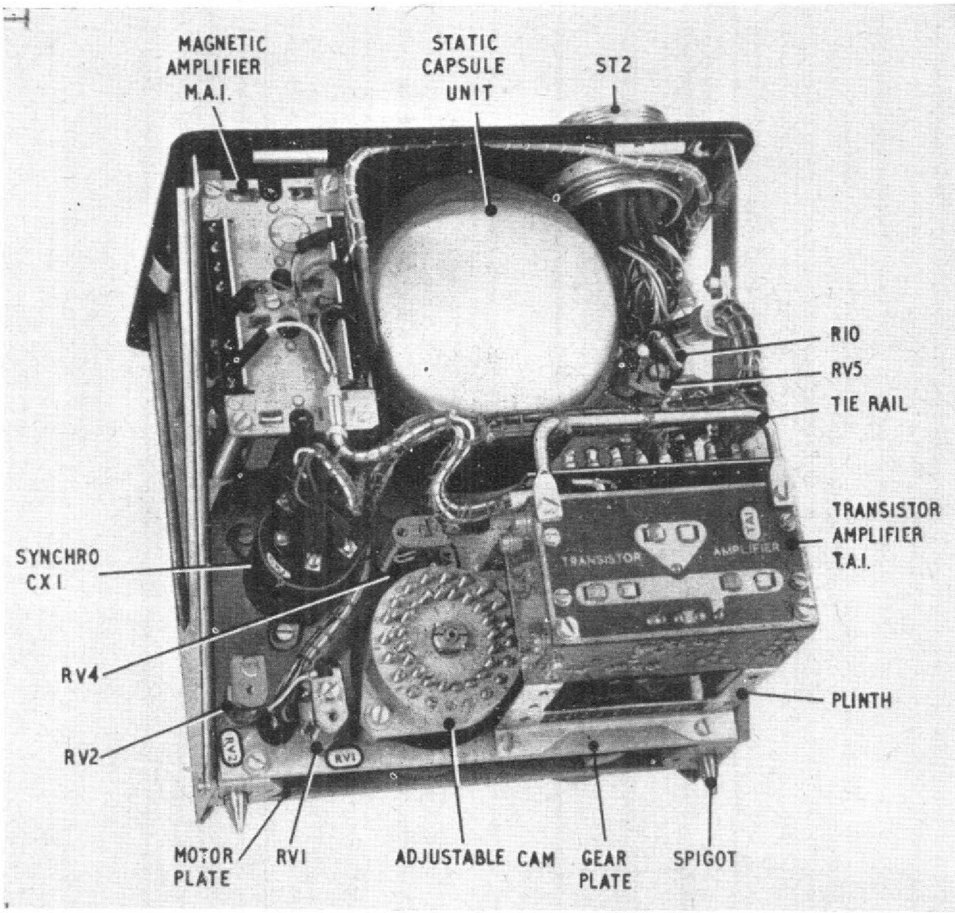


Fig. 2. Interior of transducer—pre-mod. ADS/75

8. In units modified to ADS/75 standard, five preset potentiometers other than the two bias potentiometers embodied in the magnetic amplifier are provided for adjustment purposes as follows:—

(1) RV2 and RV4, forming part of the potentiometer network associated with RV3a and adjusted during setting-up to provide the correct log S output voltage from the wiper of RV3a.

(2) RV102, for adjusting the datum voltage of the capsule unit for any temperature changes occasioned by the replacement of the capsule unit cover and at later stages in the life of the transducer, for the ageing of the E coils in the capsule unit pick-off.

(3) RV103, for adjusting the sensitivity of the capsule pick-off coils, and thereby the overall dynamic performance of the servo loop.

(4) RV104, for adjusting the output of the temperature sensor in the capsule unit to give a fine temperature correction at sea level.

9. Prior to modification ADS/75 a single component panel (fig. 7) supports the demodulator circuit (MR1, MR2 and R14), overall amplifier feedback resistors (R11, R12 and R13), and servo amplifier input resistors (R6 and R7).

10. On units modified to ADS/75 standard two component panels are incorporated in the transducer, TB1 (fig. 3) supports the components of the temperature compensation and harmonic and quadrature suppression units and TB2 (fig. 3 and 8) supports the servo amplifier demodulator circuit (MR1, MR2 and R14), overall amplifier feedback resistors (R11, R12 and R13), velocity feedback resistor R7, the servo amplifier input resistor R6 and the "datum adjust" centre tapped resistance network R113 and R114.

11. Connections are made to the base of the capsule unit (fig. 9) and the transistor and magnetic amplifier tag strips (fig. 7). In units prior to modification ADS/75 preset potentiometers RV1, RV2, RV4, RV5 are mounted on the upper side of the gear plate (fig. 2), RV5 supporting R10, and R9 being attached to stand-off insulators. In units modified to ADS/75 (fig. 12), RV2 and

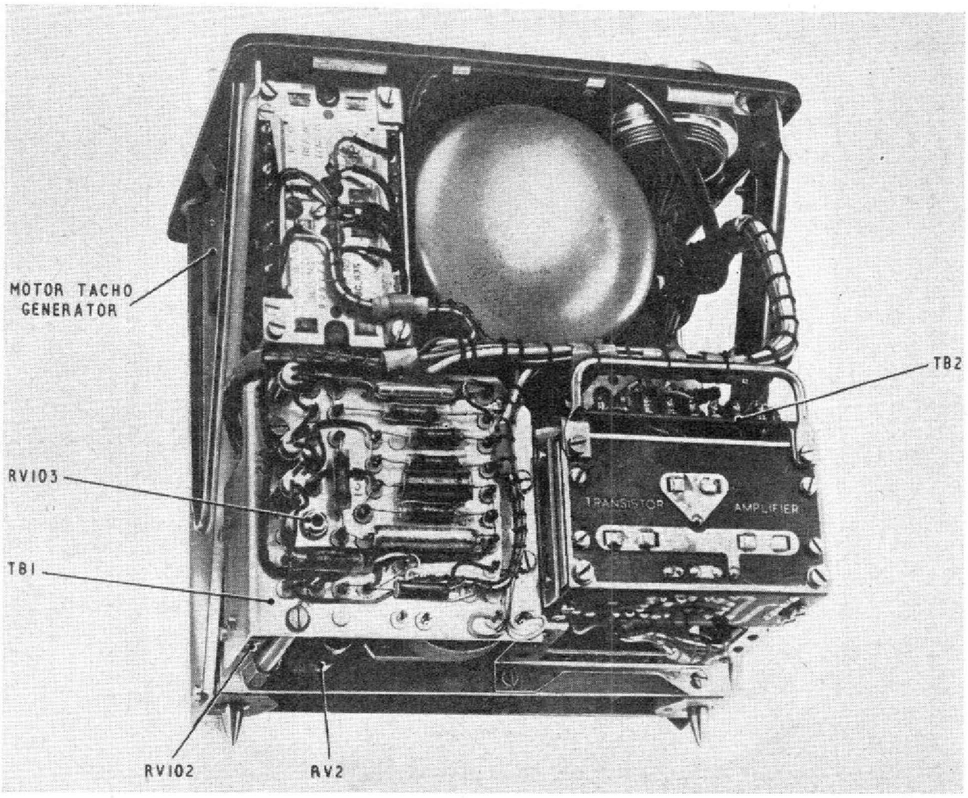


Fig. 3. Interior of transducer—post-mod. ADS/75

RV4 are mounted on the upper side of the gear plate: RV102, RV104 are mounted on the vertical side of TB1. R15 and R16 are mounted one above the other on a bracket on top of the gear plate close to RV2 (fig. 3). In all units capacitor C1 is mounted on the underside of the motor plate (fig. 9). Power supplies, input and output signals, etc., are distributed to and from the two plugs ST1 and ST2 and are listed in Table 4. It should be noted that for cabling economy certain functions associated with the pitot-static transducer appear on ST1 and ST2 and are listed in Table 3.

12. The function of the static transducer is summarized in para. 13 to 20 and a detailed description is given in subsequent paragraphs.

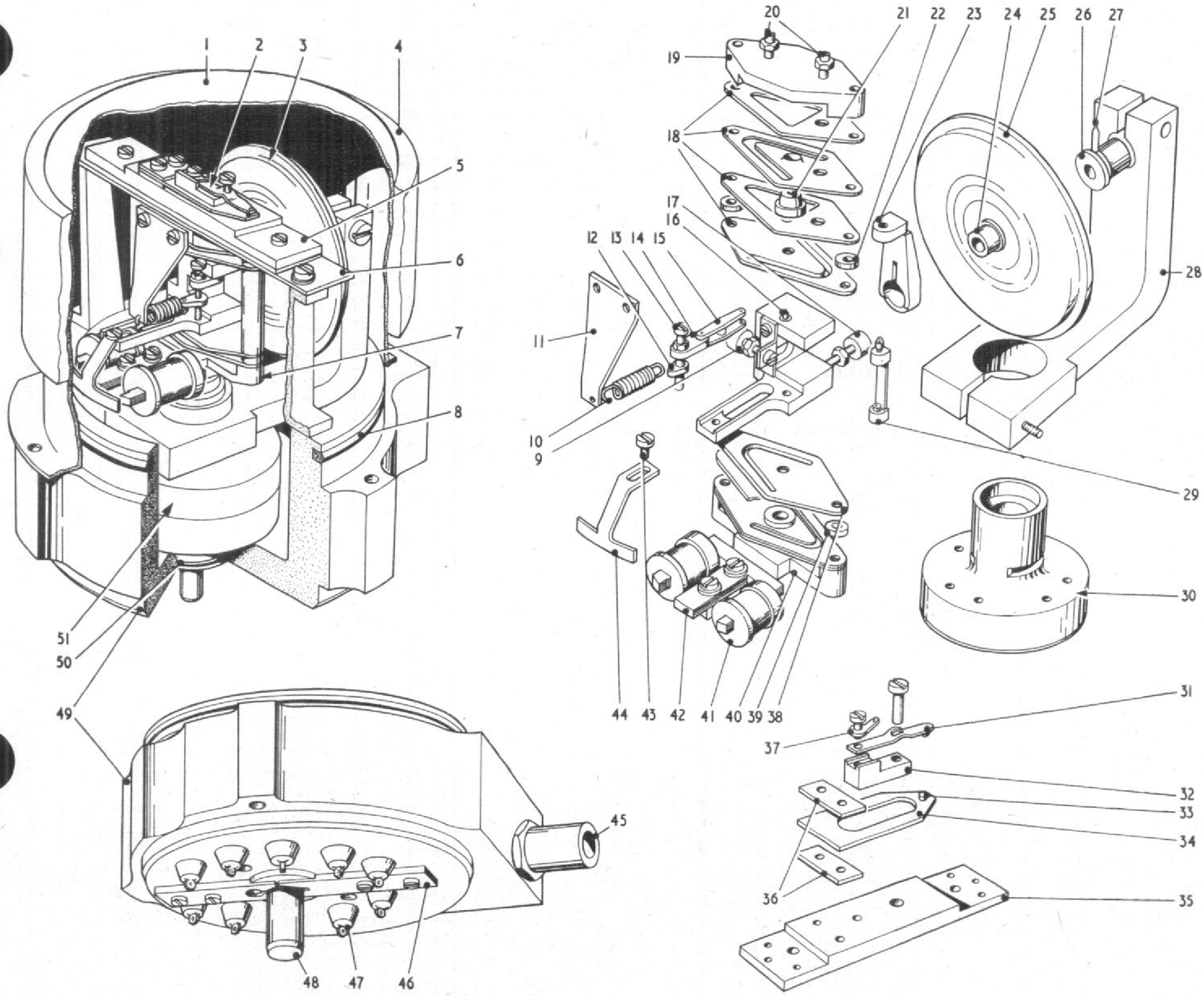
Summary of operation

13. The height information is derived from an aneroid capsule contained in a sealed chamber (static capsule unit) which is connected to the static line of the aircraft's pressure head. The capsule assembly is actuated by variations in static pressure (the displacement being virtually linear with height) and is connected by a linkage to the moving iron armature (the vane) of a variable reluctance pick-off. The output from this pick-off is the error signal.

14. In units modified to ADS/75 standard a second variable reluctance pick-off is mounted above the capsule pick-off. This is actuated by temperature changes and produces a sea level temperature correction voltage (tapped off from RV104), and an altitude temperature correction voltage tapped off from RV3b. These signals together with any required datum correction voltage tapped off from RV102 are roughly phased, summated and injected into the harmonic and quadrature suppression unit, the output from which is a corrected error signal.

15. The error signal or corrected error 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 capsule pick-off to rotate and follow the moving iron armature until a zero error or null position is found. The servo loop action then ceases. The angular rotation of the various shafts in the gear train is thus a measure of the deflection of the capsule plus any correction voltages which may have been added. The output synchros and potentiometer (pre-mod. ADS/75) or two-bank ganged potentiometer (post-mod. ADS/75), of the transducer, are also driven by certain of these shafts to produce output signals related to the capsule deflection.

16. Because of variation 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 capsule pick-off coils. This cam (para. 66) is calibrated to a high order of accuracy in order



1 COVER
2 BI-METAL SWITCH
3 STATIC 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 PLATE
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 STATIC CAPSULE
26 CAPSULE SUPPORT
27 SPIGOT
28 CAPSULE SUPPORT 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 VANE ARM ADJUSTING BOLT
44 VANE
45 ADAPTER
46 BEARING PAD
47 SEALED TERMINAL
48 SPINDLE
49 BASE ASSEMBLY
50 SPINDLE "O" RING
51 BEARING HOUSING

Fig. 4. Static capsule unit—exploded view—pre-mod. ADS/75

to compensate for any capsule non-linearity and its effect is such that approximate measurements of linear height from the capsule pick-off coils are converted into measurements of correct linear height throughout the gear train.

17. The tachogenerator stabilizes the servo-loop by providing an angular-velocity feedback signal and the servo amplifier system is further stabilized by overall amplifier feedback. The two synchro transmitters CX1 and CX2 provide linear height signals for use in the air data computer (CX1) and the display unit (CX2).

18. In units unmodified to ADS/75 the gear train via the logarithmic cam CU1A drives potentiometer RV3 to provide a voltage output equivalent to a logarithmic function of static pressure (log S). This is fed to the air data computer.

19. In units modified to ADS/75 the gear train via the logarithmic cam CU1A also drives potentiometer RV3. Here RV3 is a ganged two-bank potentiometer and provides two voltage outputs which are equivalent to:—

(1) A logarithmic function of static pressure (log S) (RV3a) which is fed to the air data computer.

(2) A correction for altitude temperature change (RV3b) fed to the summation point at the input to the harmonic and quadrature suppression unit.

20. The CX1 and log S outputs form two of the variables used for computation in the air data computer.

STATIC CAPSULE UNIT

Description (pre-mod. ADS/75)

General

21. The static capsule unit is illustrated in fig. 4. This unit consists of a chamber containing the capsule (3) and fitted with an adapter (45) which is the inlet for static 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) which is rendered ineffective below 10 500 ft as described in para. 24.

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

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

(2) Conversion of the capsule expansion and contraction into angular movement of a vane (44). As the capsule expands or contracts, the capsule adapter carries with it the capsule bracket (23) into which is screwed the bi-metal strip assembly (29). A link (15) engages a jewel bearing in the lower, or free end, of the bi-metal assembly and transmits capsule movement to a jewel mounting assembly (14) (ratio arm) mounted on and locked with a locknut to a ratio arm adjusting screw (13). This screw is mounted off centre in the block of the vane pivot arm (16) which is pivoted about a vertical axis and which swings about this axis in response to linear movements of the capsule adapter and linkage. A spring tag (12) 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 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 the 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° sector (fig. 10) which meshes with a 76T gear on axis 6A.

(4) Correction of errors arising from varying temperature coefficients and compensation of 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. The 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 a very low ambient temperature 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 the spring contact (31). The bi-metal switch switches on the heater at a nominal ambient temperature of 5°C, but is ineffective below 10 500 ft.

(b) Errors arising from 'g' forces are counterbalanced by the capsule balance weight (9) (which counterbalances the sag of the capsule along its axis when in a position other than upright), 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 cableforms. External connections are made by means of the sealed terminals (47).

Capsule (fig. 4)

23. The static pressure capsule (25) is constructed of corrugated beryllium-copper cheeks joined with non-corrosive solder and is integral with the support (26) and the adapter (24). A short length of copper tubing (spigot, 27) is crimped after the capsule has been evacuated to approximately $22{\cdot}5 \times 10^{-5}$ mm Hg. The total deflection of the capsule for a change of atmospheric pressure from 1082·35 mb to 10·16 mb

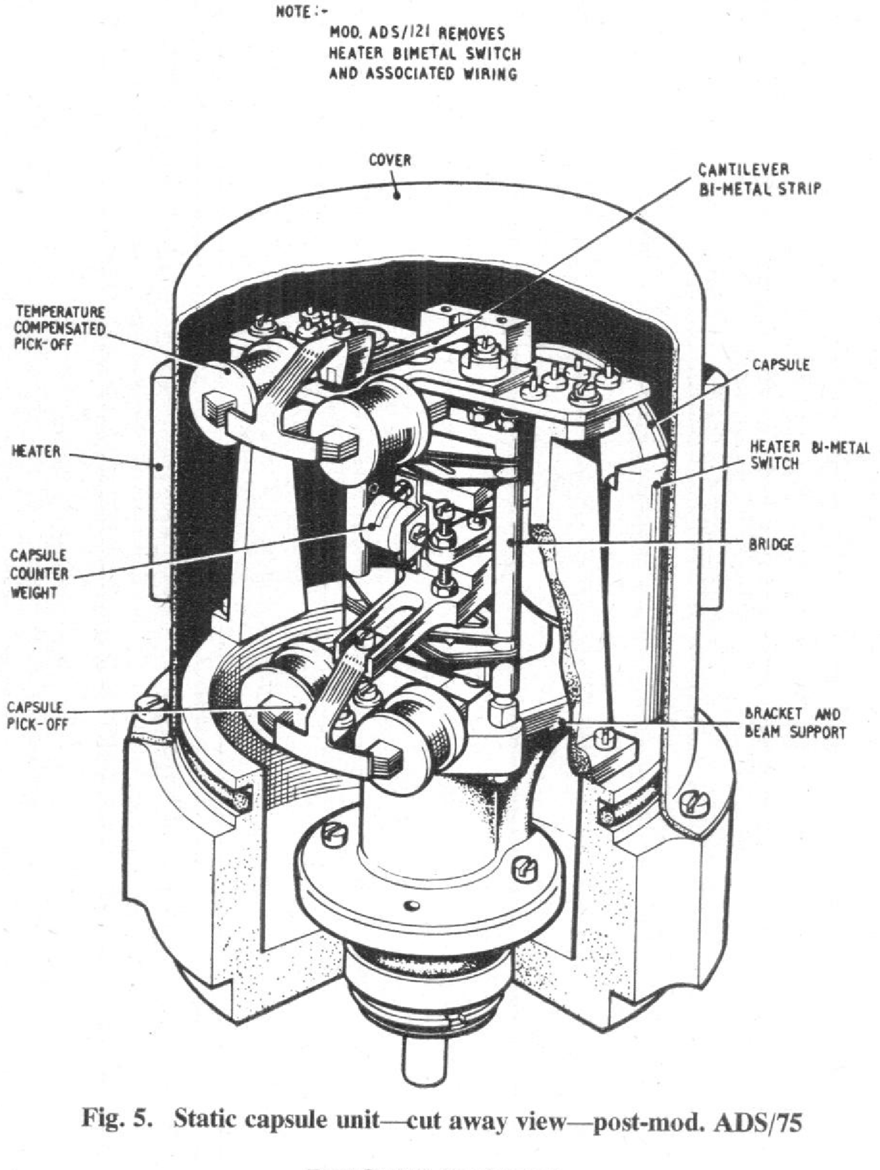


Fig. 5. Static capsule unit—cut away view—post-mod. ADS/75

(–1900 to 100 000 ft) is 0·100 in. Capsule sensitivity is 0·00001 in., which corresponds to a change of 10 ft in height at sea level or a change in pressure of 0·365 mb.

Heater circuit (pre-mod. ADS/121)

24. 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 supply, which is made or broken via contacts RLC/1 of the high-speed relay RLC located in the computer. The solenoid of RLC is operated by the –30V supply via two switches in series, the bi-metal switch located in the static 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.

25. The bi-metal switch is adjusted during calibration to close at a temperature of 5 $\pm$ 2°C.

Description (post-mod. ADS/75)

General

26. The static capsule unit is illustrated in fig. 5. In units modified to ADS/75 standard the construction is considerably altered although the provisions of the design are similar. The capsule bracket and bearing assembly (as modified by ADS/54) are cast as one unit and the bracket also incorporates a base for the lower (capsule) pick-off bridge to which it is locked on either side; the bridge therefore will not now move when the E-coils of the capsule pick-off are driven by the servomechanism action. As the bridge is locked the spring anchor plate, spring and tag have been dispensed with, being no longer required. The housing for the capsule support is now not an integral part of the bracket but a separately tooled item screwed to the bracket.

27. A temperature sensor is introduced which consists of a basically standard E-I pick-off, it is fitted in the position originally occupied by the heater bi-metal switch. The vane of this pick-off is attached to one end of a cantilever bi-metal strip, the other end of which is spot welded to a supporting bracket; the deflection of the vane due to the expansion or contraction of this bi-metal strip is thus proportional to temperature. The heater bi-metal switch is now mounted vertically at one side of the unit between the bridge and the capsule (pre-mod. ADS/121). A semi-circular flux screen approximately $\frac{1}{2}$ in. deep for the capsule pick-off is screwed to each side of the temperature sensor supports.

Capsule (fig. 5)

28. The capsule is identical with that of pre-mod. ADS/75 units (see para. 23).

Heater circuit (pre-mod. ADS/121)

29. The function of the heater circuit is identical with that described in para. 24.

Principle of operation (pre-mod. ADS/75)

30. When an aircraft changes altitude, either by increasing or decreasing height with respect to sea level, a corresponding change in barometric pressure results. The pressure change influences the aneroid capsule assembly which expands with increasing height and contracts with decreasing height. 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.

31. 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 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 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 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.

32. The circuit of the variable-reluctance pick-off is given in fig. 17. 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 R6. This null 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 R6. 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 that the direction of rotation of the motor is

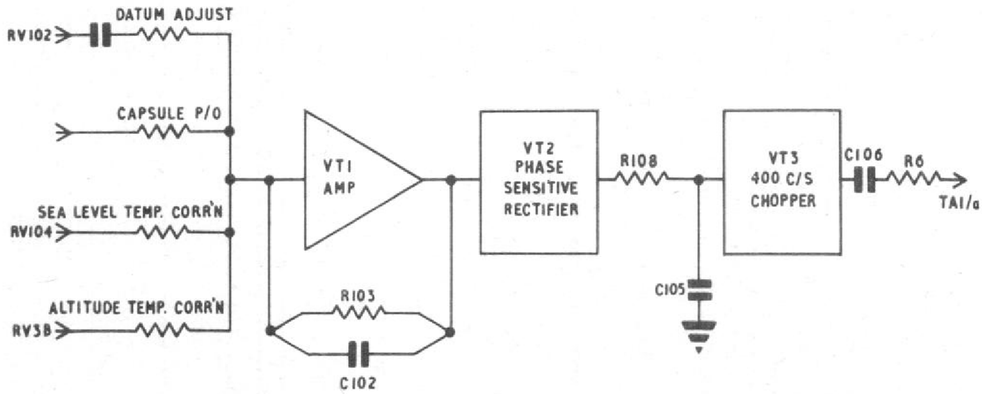


Fig. 6. Harmonic and quadrature suppression unit block diagram—post-mod. ADS/75

such as to cause the servo loop to seek the pick-off null.

Principle of operation (post-mod. ADS/75)

33. The principle of operation of these modified capsule units is fundamentally the same, so far as the capsule pick-off is concerned, as that described in para. 27 and 28. The main differences occur in the circuitry, functioning of the temperature sensor and routeing of the various outputs.

34. The circuit of the variable-reluctance pick-off is given in fig. 18. An alternating voltage of 400 c/s is applied to the primaries of each pick-off which are wound coaxially with the secondaries on the outer limbs of the E core. If the vanes are in their centre positions equal voltages are induced in the series-aiding secondary coils and null outputs of 400 c/s are produced across resistors R101 and R116. (This null of 400 c/s may however contain a small third harmonic signal of the order of 1 or 2mV. Suppression of this is dealt with in para. 35.) When a vane is moved either by a pressure change effect upon the capsule or a temperature change effect upon the cantilever bi-metal strip of the temperature sensor, the air gaps between the E–I coils are no longer equal and the voltage induced in one half of the secondary coil increases whilst that in the other half decreases. An output therefore appears across either R101 or R116. These outputs together with any datum voltage adjustments made during the setting up procedure are roughly phased, summated and injected into the harmonic and quadrature suppression unit, the output from which is power amplified in the servo amplifier, and fed to the control winding of the motor. This motor control signal is phase related to the motor reference voltage so that the direction of rotation of the motor is such as to cause the servo loop to seek the capsule pick-off null.

HARMONIC AND QUADRATURE SUPPRESSION CIRCUIT (post-mod. ADS/75)

35. As previously stated, the a.c. signals relevant to correct barometric height which are roughly phased and summed prior to the elimination of unwanted harmonic or phase quadrature signals are:—

(1) Capsule pick-off signal.

(2) Sea level temperature correction from the temperature sensor and tapped off from RV104.

(3) Altitude temperature correction from the temperature sensor and tapped off from RV3b; the wiper being controlled by the servo mechanism.

(4) A datum adjustment voltage obtained from RV102 during setting up procedures.

36. Harmonic and quadrature suppression is achieved by introducing a four stage unit which is shown in block diagram form at fig. 6. The circuit diagram is given in fig. 18. Third and higher harmonics are attenuated by the low gain amplifier (VT1) acting as a low pass filter by feedback via a CR parallel network. The output of this amplifier is phase sensitively rectified by a half wave transistor switch demodulator (VT2), the resulting d.c. signal, after filtering by R108 and C105, being mainly proportional to the fundamental, the quadrature component having been reduced to an average value of zero. This d.c. signal is then chopped at 400 c/s by a transistor switch modulator (VT3) and fed via C106 and R6 into the servo amplifier.

SERVO SYSTEM

Servo amplifier (fig. 16)

General

37. 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 ampli-

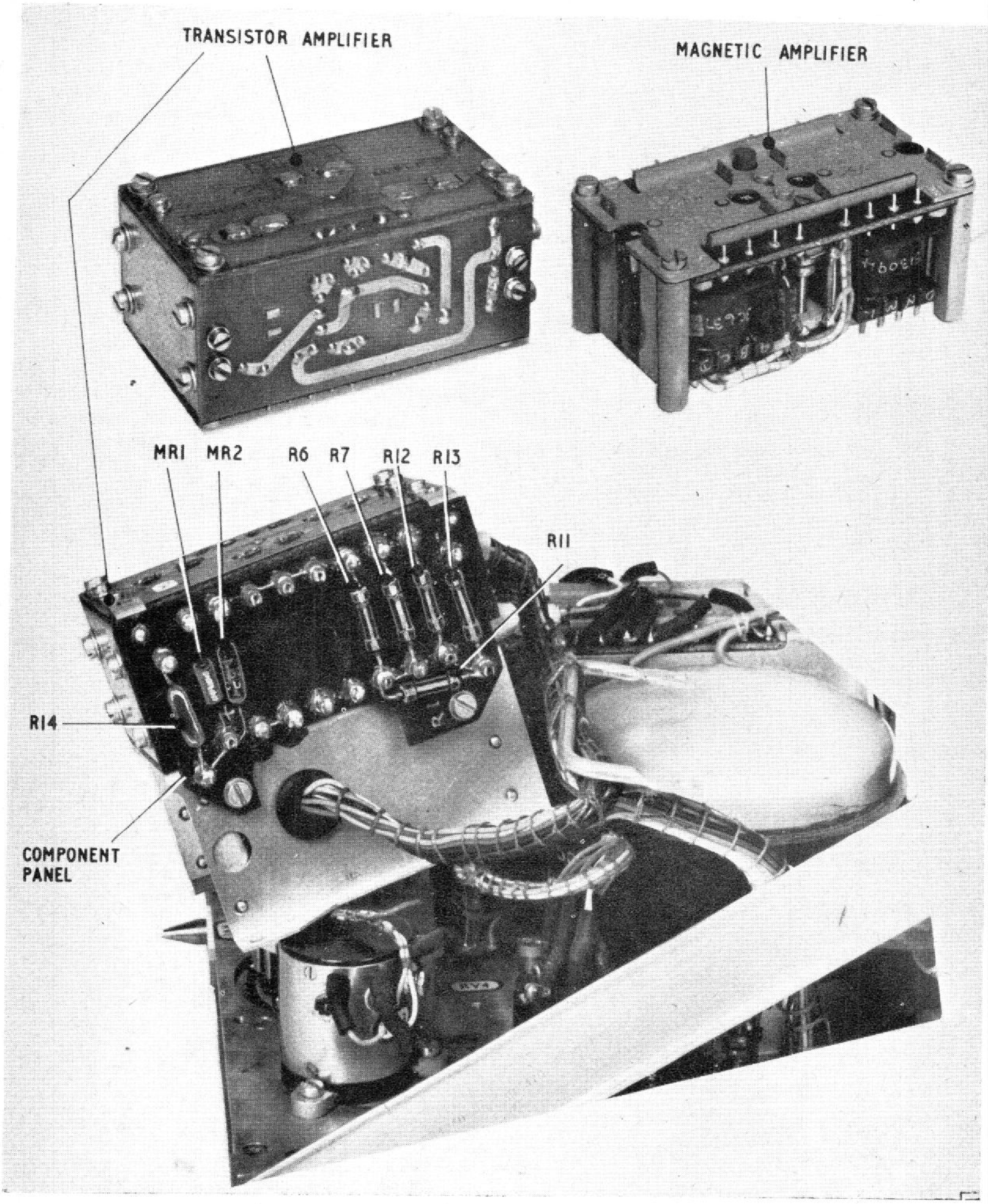


Fig. 7. Transistor amplifier, magnetic amplifier and component panel—pre-mod. ADS/75

fier, a phase-sensitive demodulator and a magnetic amplifier; the overall gain, with feedback, being in the region of 130 000. It should be noted that identical transistor amplifiers and identical magnetic amplifiers are used in the transducers and computer. Inputs to the servo amplifier are discussed in para. 47 and 48.

Transistor amplifier Elliott Part No. 3C5161

38. The transistor amplifier (fig. 7) is a printed-circuit sub-assembly secured by four screws to a plinth which raises it above potentiometer RV3, the main component panel (in post-mod. ADS/75 units designated TB2) 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 is provided for the associated cable-form. It is necessary to remove the transistor amplifier and plinth (four screws) in order to gain access to potentiometer RV3.

39. The circuit (fig. 16) 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 impedance is 800 ohms, and the input signal is fed to the base of VT1 (OC73), which has +9V bias applied to the emitter via R4 decoupled by C2, and -6V (A) to the collector via R2 and R3 decoupled by C1. R1 provides constant bias for VT1 which is resistance-capacitance coupled via C3 and R6 to VT2 (OC73), which operates with the same emitter and collector voltages as VT1, its emitter being 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 controlling device, it compensates for any change in base-emitter junction temperature and limits the emitter current, thus preventing instability in VT3 and VT4 (OC 72's).

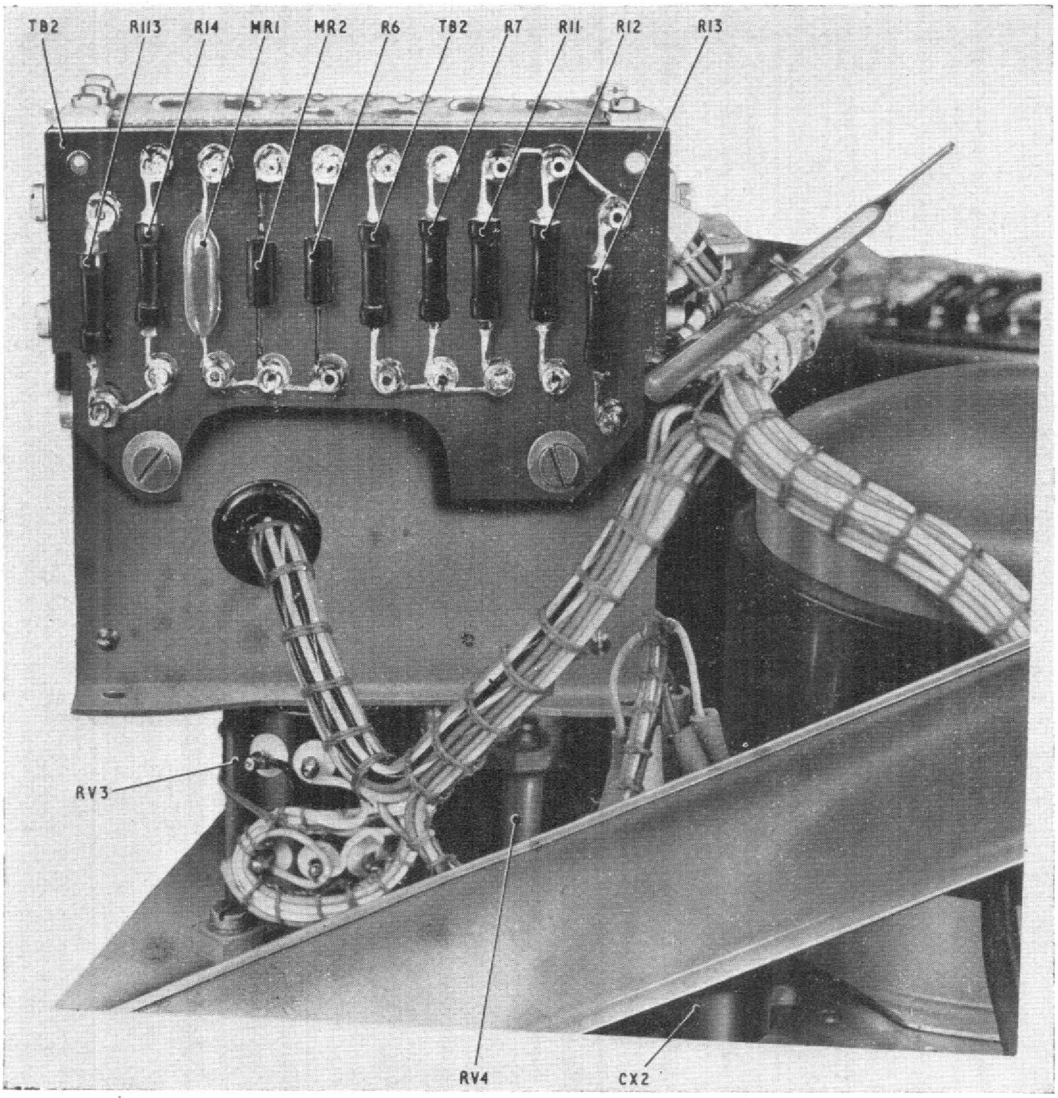


Fig. 8. Static transducer—tagboard 2—post-mod. ADS/75

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

40. The demodulator circuit (fig. 16) 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. 7 and 8).

41. 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 anti-phase to the reference signal, but will not respond to any quadrature voltages which may be present.

42. The demodulator converts the a.c. output from the transistor amplifier into a uni-directional 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 Elliott Part No. 3C635 or 3C635/1

43. The magnetic amplifier (fig. 7) 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. This output is tuned to 400 c/s by capacitor C1 in parallel with the control winding. The sub-assembly is mounted on pillars and must be removed to provide access to the motor-tachogenerator.

44. The circuit (fig. 16) 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) control-

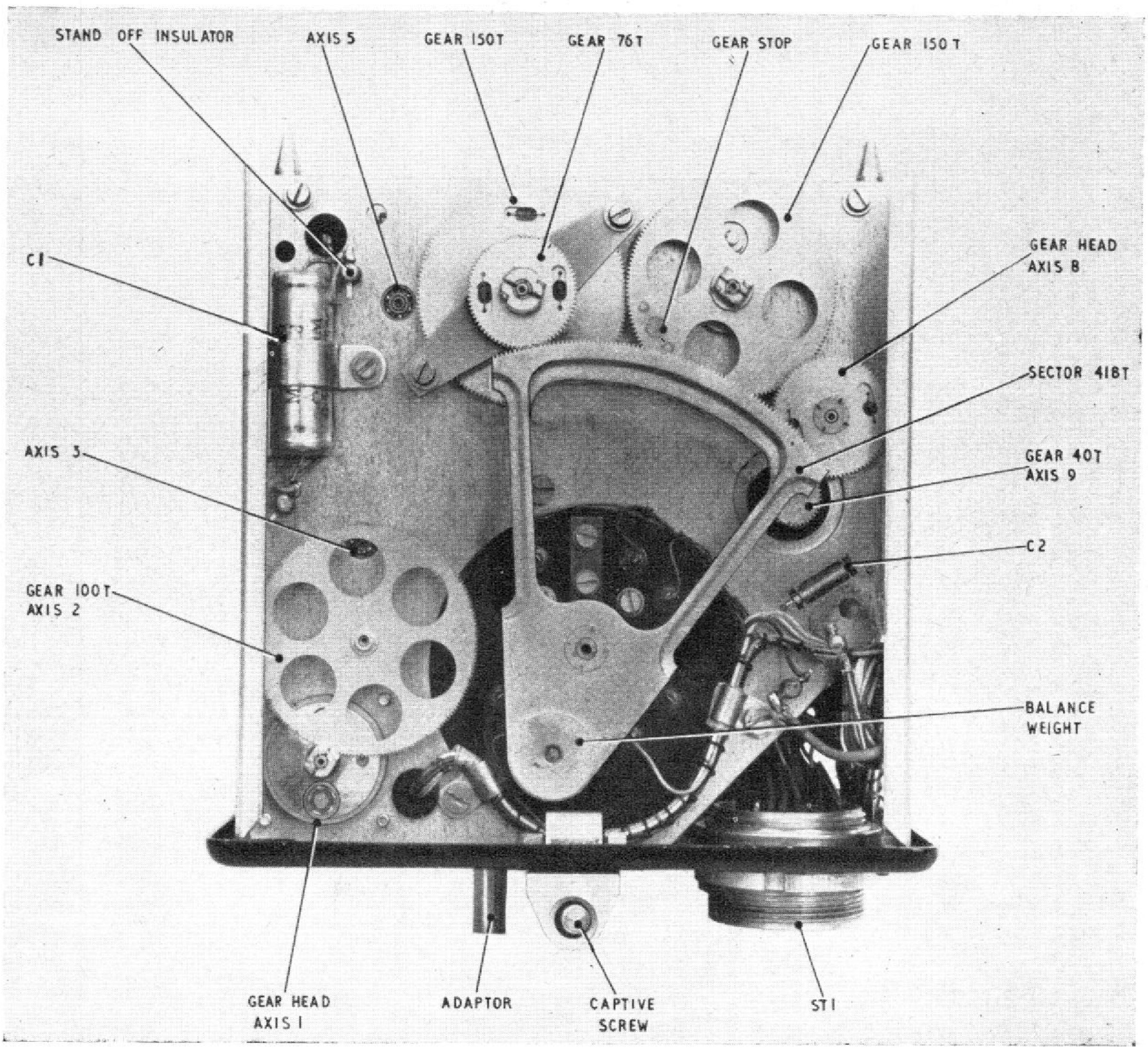


Fig. 9. Underside of motor plate

ling 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.

45. 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 alternating currents flowing in the transductors. The transductors are fed from the opposite ends of an 85V-0-85V 400 c/s supply (AC1, AC2) and the phase of the load current is therefore reversed when the direction of the d.c. control current reverses.

46. 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. Modification ADS/141 introduces a Zener diode into the bias circuit (fig. 16); this has a stabilizing effect upon the performance of the magnetic amplifier, and therefore the associated servo. The modified unit will function satisfactorily with bias supply variations from –26 to –34V. Magnetic amplifiers so modified are classified 3C635/1.

Inputs to servo amplifier (pre-mod. ADS/75) (fig. 16)

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

(1) The error signal derived from the pick-off coils of the capsule unit is fed to the amplifier via the load resistor R6. This voltage is approximately 0·065mV per foot change in height, i.e. for a change in height of 100 ft the instantaneous voltage will be 6·5mV.

(2) An angular-velocity feedback signal (damping signal) is derived from RV1, which is across the output winding of the tacho-generator (para. 51).

(3) An overall amplifier 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.

Inputs to servo amplifier (post-mod. ADS/75) (fig. 16)

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

(1) Corrected error, being the output from the final stage of the harmonic and quadrature suppression unit fed to the amplifier via C106 and R6.

(2) An angular velocity feedback signal derived from the output winding of the tacho-generator, and fed to the amplifier via R7.

(3) An overall amplifier feedback signal derived from the output of the servo amplifier and fed back via the resistive network R11, R12 and R13.

Motor-tachogenerator

49. The motor-tachogenerator consists of a 2-phase squirrel cage motor with an induction tacho-generator mounted on the same shaft. The reference winding of the motor section is energized by the 50V 400 c/s quadrature supply, and the control winding is fed with the power amplified command signal from the output of the magnetic amplifier, this latter voltage being in quadrature with the reference winding 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 reference voltage by 90°. The motor spindle is connected via a 4·1 gearhead and pinion to the gear train.

50. 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.

51. The output from the generator is used as velocity feedback and is fed to the input of the servo amplifier via the load resistor R7. In units pre-mod. ADS/75 a preset potentiometer RV1 is connected across the generator output winding to enable the maximum velocity feedback signal to be varied between zero and approximately 2·75V r.m.s. 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 overdamped and sluggish. RV1 is adjusted during setting-up to provide a satisfactory measure of velocity feedback. In units modified to ADS/75 preset potentiometer RV1 has been dispensed with, and R7 instead of being 150K ohms is selected on test from the range 330K to 1M ohms.

Outputs from servo system

52. The motor-tachogenerator drives a gear train from which are derived the outputs from (a) synchro transmitters CX1 and CX2, and (b) potentiometer RV3.

Synchro transmitters CX1 and CX2

53. The synchro control transmitter CX1 (fig. 2 and 10) feeds corrected height signals to the computer. This synchro makes approximately seven and a half turns in the range 0 to 75 000 ft, but its full range is 10 turns. The synchro control transmitter CX2 (fig. 8) feeds corrected height signals to the display unit. This synchro makes three complete turns in the range 0 to 75 000 ft, but its full range is 4 turns.

54. The synchro transmitters each have a single-phase rotor which is energized by the 115V phase A and B supply, applied by means of sliprings 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. The stator windings are spaced 120° apart, and the rotor flux links each stator coil according to the position of the rotor. The three line voltages S1, S2 and S3 thus have a magnitude and phase which define the position of the shaft with respect to the stator. These voltages are applied to a synchro transformer at the appropriate destination.

Potentiometer RV3 (pre-mod. ADS/75)

55. The output of potentiometer RV3 (fig. 11) is controlled by a cam unit CU1A to provide the logarithmic function of static pressure which is fed to the computer. This output (log S) is one of the primary variables used to resolve mathematical equations in the computer.

56. The log S voltage is derived from the 20V phase (Y) supply and is developed across the potentiometer chain RV2, R16, RV3, RV4 and R15, of which RV3 is the servo-driven potentiometer. RV3 has a nominal value of 1K, and during calibration RV2 is preset to compensate for any discrepancy in this value. RV4 is preset to bring the voltage at the junction of RV3/RV4 to a specified value so that the log S output voltage from RV3 ranges between 14·75V at –1 000 ft and 7·53V at 75 000 ft. This voltage is applied to the servo amplifiers associated with the log Mach number and height gearboxes of the computer.

Potentiometer RV3 (post-mod. ADS/75)

57. RV3 is a ganged two bank potentiometer, the outputs of which are controlled by cam unit CU1A to provide the logarithmic function of static pressure (log S) which is fed to the computer and a correction voltage for altitude temperature changes.

58. The log S voltage is derived from the 20V (Y) supply and is developed across the potentiometer chain RV2, R16, RV3a, R15 and RV4, of which RV3a of nominal value 1K is the servo driven potentiometer. The output from RV3a, adjusted by RV4 during calibration, ranges from 14·75V at –1 000 ft. to 7·53V at 75 000 ft.

59. The altitude temperature correction voltage developed across RV3b, again of nominal value 1K, is derived from one output of the series-aiding secondary coils of the temperature sensor in the capsule unit. It is arranged to be zero at –2 000 ft and a maximum at 100 000 ft.

Gear train

General

60. The gear train is accommodated between a gear plate (fig. 2) and a motor plate (fig. 9), certain parts of the gear train protruding 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 two synchros CX1 and CX2, potentiometer RV3, the motor-tachogenerator and the associated gear system. Split clamps facilitate the removal of gears or components, and clamps provided on the gear plate for CX1 and RV3, and on the motor plate for CX2, enable the zero positions of these components to be adjusted during setting-up.

61. The gear train (fig. 16) consists of ten axes, axis 1 being the drive from the motor-tachogenerator. Aluminium alloy is 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 the spindle. Split gears (para. 64) are introduced on axes 5, 6 and 8 to counteract backlash. To protect the gear train, a slip clutch (para. 62, pre-mod. ADS/38; para. 63, post-mod. ADS/38) is fitted at axis 3, and a gear stop (para. 65) at axis 7.

Slip clutch

62. *Pre-mod. ADS/38.* The slip clutch (fig. 10) 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 150T gear being freely mounted on the slip clutch base 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.

63. *Post-mod. ADS/38.* The ball clutch type assembly (fig. 13) comprises a flanged hub, gear pressure plate, spring and five steel balls. The gear is a bearing fit on the split lower spigot of the hub and is retained by the retaining plate. Equally spaced drillings in the hub flange accommodate the balls which also rest in corresponding indentations in the upper face of the gear. The pressure plate is recessed and bears upon the balls by pressure from the spring, and all the components are retained by the spacer and the spring adjusting clamp when the latter is tightened around the upper spigot. The complete assembly is mounted upon the spindle of axis 3 in the gear train and is secured by the split clamp. The gear train drive is transmitted via the gear, balls and hub to the spindle. When the spindle load exceeds the predetermined clutch loading, the balls ride out of the gear indentations, the spring is compressed and the gear rotates relative to the hub. Clutch loading is governed by the position of the upper clamp, which regulates contact pressure existing between the gear, balls, lift plate and spring.

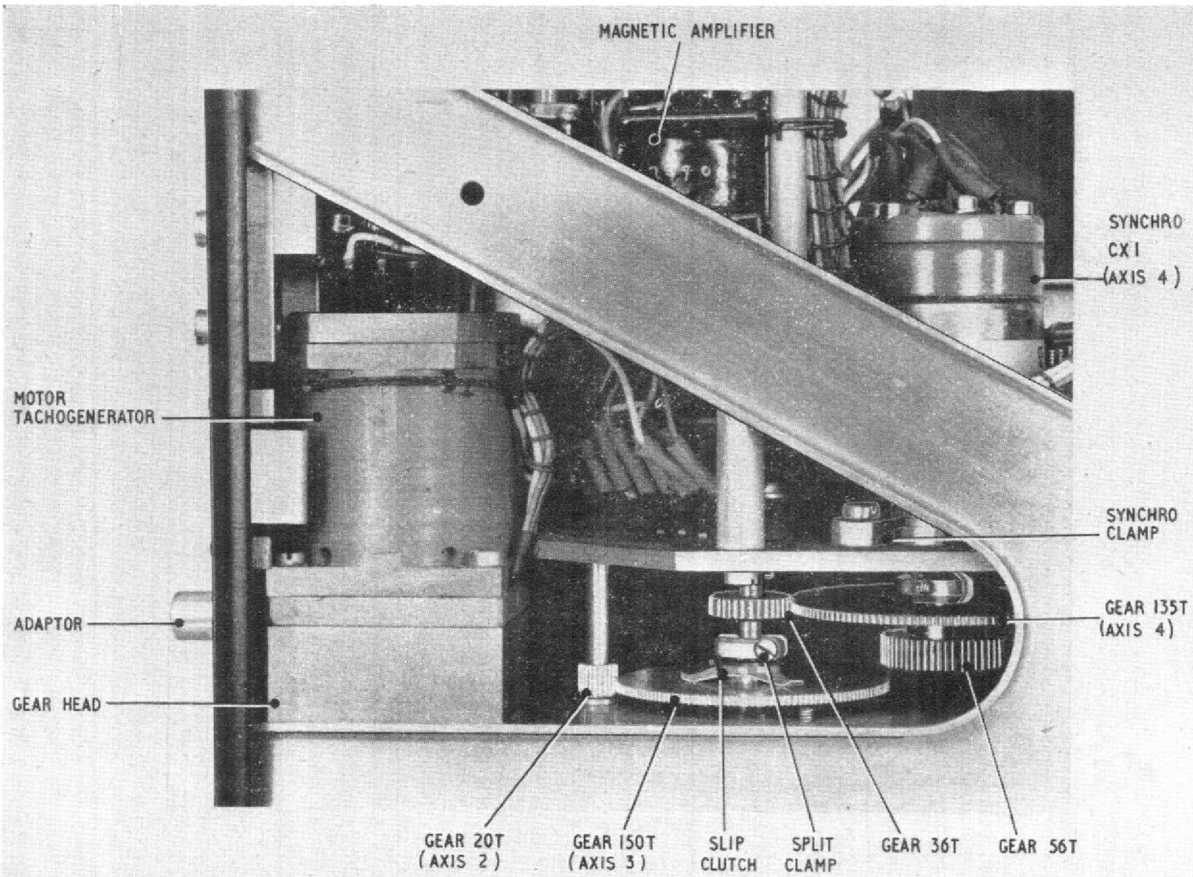


Fig. 10. Gear train, gear head and slip clutch—pre-mod. ADS/38

Split gear

64. The 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 closer together, 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

65. A gear stop is provided on the 150T gear 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. 11, 12 and 14)

66. 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 76T split gear meshing with the sector. The adjustable cam follower is driven by the 150T split gear located above the motor plate, which meshes with the 30T pinion at axis 5.

67. Integral with 150T split gear, referred to in the preceding para., is a collar (12, fig. 14) 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 76T split gear (19) which meshes with the 418T sector driving the spindle (axis 10) to which is attached the pick-off bridge and E coils. Integral with the spindle (10) is a spring-loaded yoke (7, 8) mounted on which, and hinged on the horizontal plane, is an arm (25), bearing (22a) and cam-follower (23). The cam-follower traverses the underside of the cam (6) which is a drilled disc of polished nickel-plated beryllium-copper form-

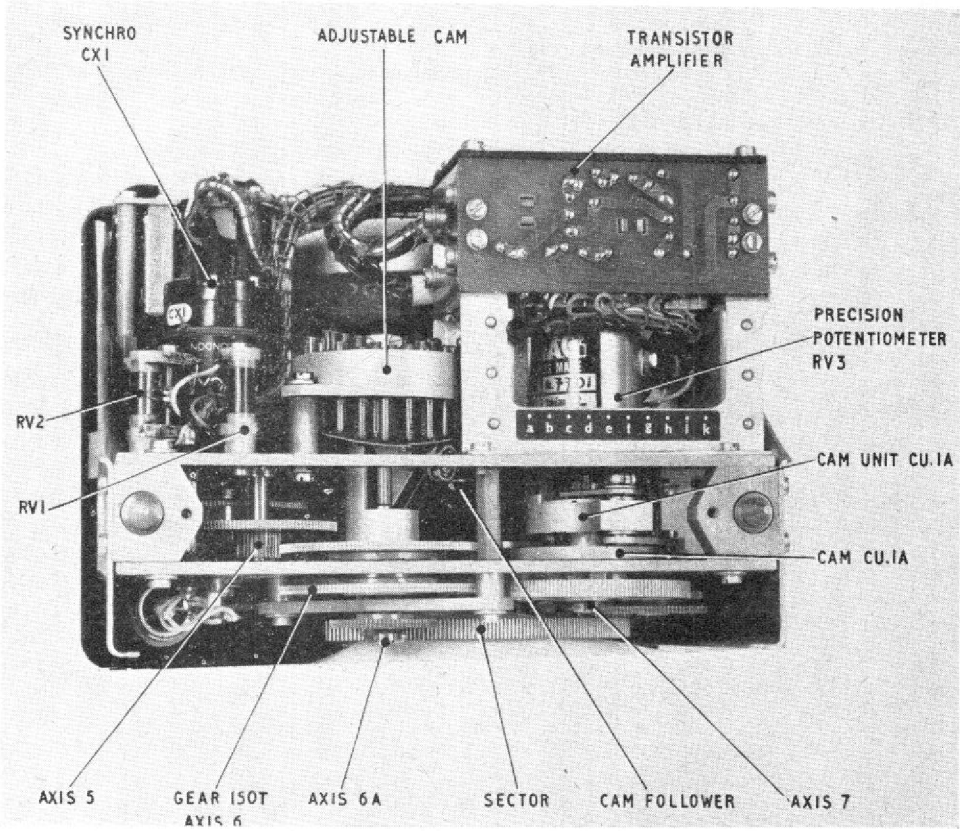


Fig. 11. Rear view of transducer—pre-mod. ADS/75

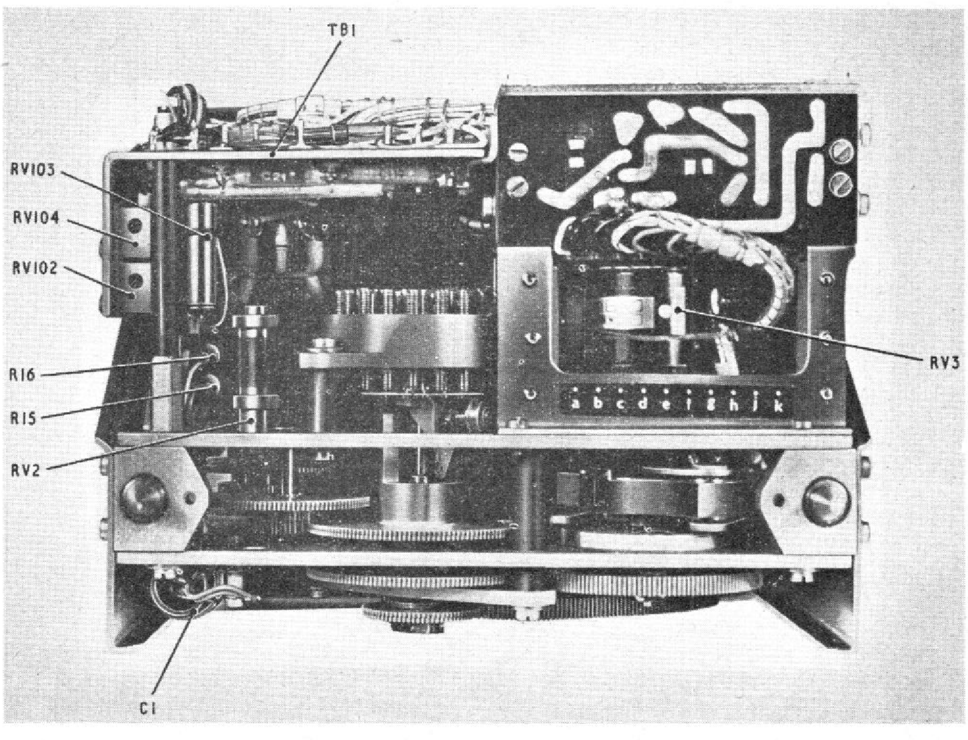


Fig. 12. Rear view of transducer—post-mod. ADS/75

ing a circular track, approximately ¼ 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, i.e. 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.

68. 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.

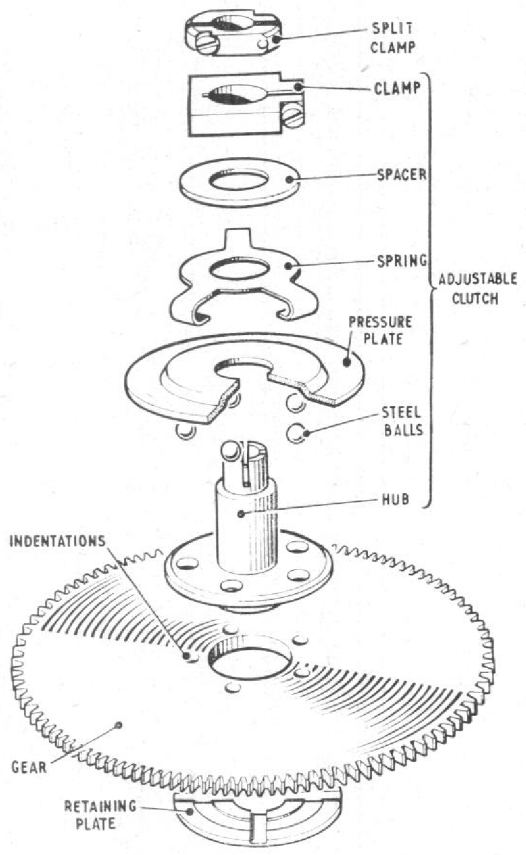


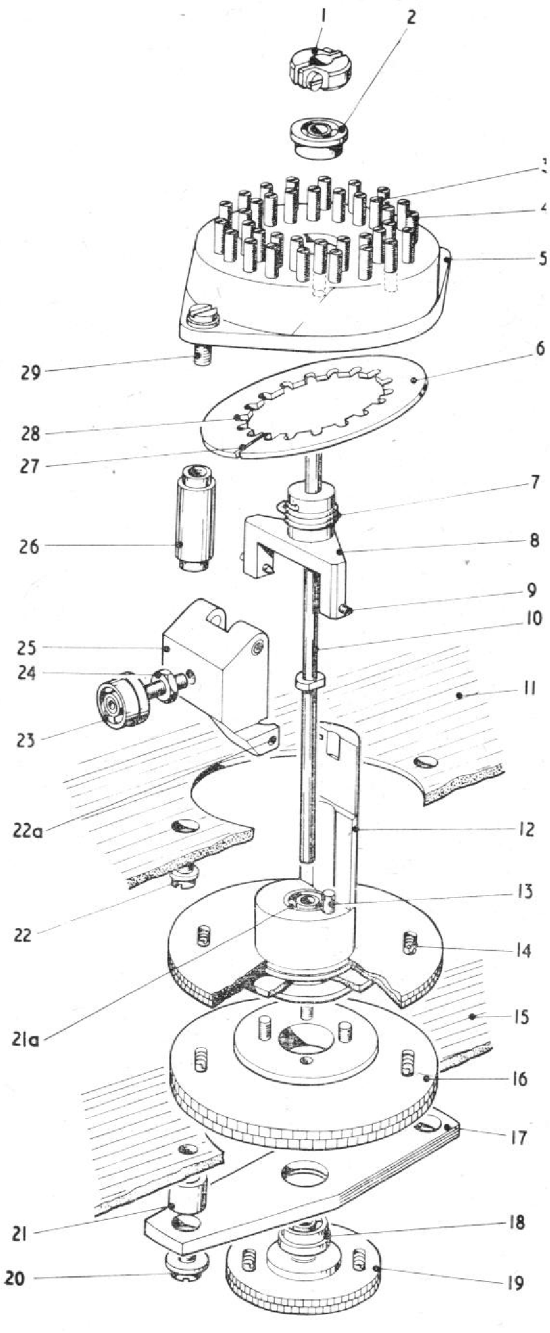
Fig. 13. Slip clutch (ball type)—post-mod. ADS/38

Calibration of the static transducer over the height range of –1 000 to 75 000 ft is obtained by the adjustment of the screws, and this causes the cam to become distorted spirally. The cam-follower wheel, in following the cam face, causes the spring loaded yoke to advance or retard axis 6A by the amount preset during calibration. Thus the advance/retard action of axis 6A is transferred to the capsule unit spindle, so hastening or delaying the nulling of the capsule pick-off by an amount proportional to the calibrated error of the cam, i.e. the variable gear compensates the servo loop for any non-linear characteristics of the capsule linkage.

Computation cam unit (fig. 15)

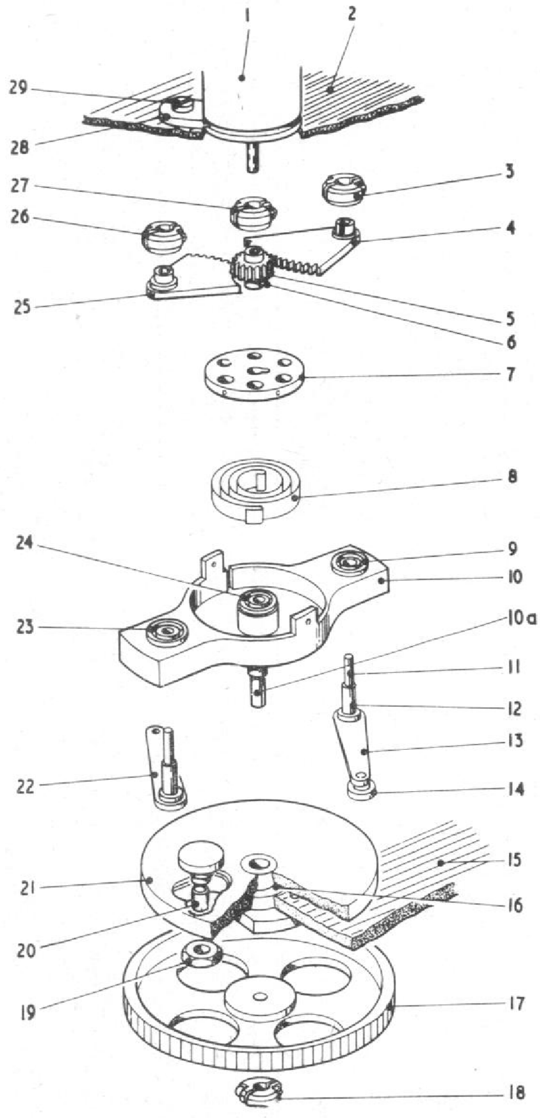
69. The computation cam unit is fundamentally a mechanical differential, the cam being designed to modify or correct the angular rotation of a spindle to a new function. The cam unit comprises a fixed cam (11) and a cam follower (10) attached to a follower arm (9). The follower arm is pivoted in a cross head (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.

70. 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 inward or outward, 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.



1 SPLIT CLAMP
2 BEARING
3 CAM ADJUSTING SCREW
4 CAM SUPPORTING SCREW
5 HOUSING
6 ADJUSTABLE CAM
7 SPRING
8 YOKE
9 PIVOT SCREW
10 SHAFT (Spindle)
11 GEAR PLATE
12 BODY (collar)
13 STOP PIN
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 BEARING
24 CAM FOLLOWER
25 ARM
26 PILLAR
27 SPLIT IN CAM
28 SLOT
29 PILLAR SCREW

Fig. 14. Adjustable cam—exploded view



1 POTENTIOMETER RV3
2 GEAR PLATE
3 SPLIT CLAMP
4 GEAR SEGMENT
5 GEAR (30T) AND PIN
6 KEY
7 INNER SPRING HOUSING
8 SPRING
9 BEARING
10 SPINDLE AND SPRING HOUSING
10a SPINDLE
11 ROLLER ARM SPINDLE
12 ROLLER ARM SPINDLE
13 ROLLER ARM
14 BEARING SPINDLE AND BEARING
15 MOTOR PLATE
16 BEARING HOUSING
17 GEAR 150T AND BOSS
18 SPLIT CLAMP
19 4BA NUT
20 ADJUSTER
21 CAM CU1A
22 ROLLER ARM AND SPINDLE
23 BEARING
24 BEARING
25 GEAR SEGMENT
26 SPLIT CLAMP
27 SPLIT CLAMP
28 POTENTIOMETER CLAMP
29 CLAMP SCREW

Fig. 15. Cam unit CU1A—exploded view

TABLE 1

Power supplies

PL ST1 Pin	PL ST2 Pin	Sub-unit and supply	Function
		Motor-tachogenerator	
	H	50V $\underline{/90^\circ}$	Motor reference supply
	J	8V a.c.	Tachogenerator excitation supply
		Transistor amplifier	
M	O	+9V	Emitter bias, VT1 and VT2
L	P	—6V (A)	Collector voltage, VT1 and VT2; Emitter bias, VT3 and VT4
Q	S	—6V (B)	Collector voltage, VT3 and VT4
		Demodulator	
W		Ref. 1 (25V)	
		Magnetic amplifier	
	G	—30V	Transductor bias windings: capsule heater bi-metal switch, pre-mod. ADS/121
	D	AC1 (85V)	Transductor load windings
	E	AC2 (85V)	Transductor load windings
		Capsule unit	
	C	3V (X)	Pick-off coil(s), primary excitation
	B	3V (Y)	Pick-off coil(s), primary excitation
B		—30V	Operation of heater relay RLC in computer via bi-metal switch, pre-mod. ADS/121
		Synchro transmitters	
C	Q	115V (A)	CX1 and CX2 rotors; Heater element, pre-mod ADS/121 (phase A only)
K	W	115V (B)	CX1 and CX2 rotors; Heater element, pre-mod ADS/121 (phase A only)
		Potentiometer RV3	
	N	20V (Y)	Log S voltage
		Harmonic and quadrature suppression unit	
	J	8V a.c.	Base voltage for VT2 and VT3
M	O	+9V	Emitter voltage VT1
		Miscellaneous	
S	R		Signal earth
	F		Bias earth

TABLE 2

Outputs

ST1 Pin		Function
R		Potentiometer RV3, log S
G	S1	CX1 height synchro—computer
H	S2	CX1 height synchro—computer
J	S3	CX1 height synchro—computer
N	S1	CX2 height synchro—display
O	S2	CX2 height synchro—display
P	S3	CX2 height synchro—display

TABLE 3

Pitot-static transducer, junctioned facilities

ST1 Pin	ST2 Pin	Function
A	A	(P-S) heater to RLB/1 height gearbox
U	L	Log (P-S)
V	K	(P-S) bi-metal to RLB height gearbox
X	X	I.A.S. synchro
Y	Y	I.A.S. synchro
Z	Z	I.A.S. synchro

TABLE 4

Connections to plugs ST1 and ST2

PL ST1 Pin	Function	PL ST2 Pin	Function
A	(P-S) heater to RLB/1 height gearbox	A	(P-S) heater to RLB/1 height gearbox
B	Bi-metal to RLC in height gearbox	B	3V (Y)
C	115V (A)	C	3V (X)
D	S heater to RLC/1 height gearbox	D	AC 1 (85V)
E		E	AC 2 (85V)
F		F	Bias earth
G	CX1 10T height synchro	G	—30V
H	CX1 10T height synchro	H	50V
J	CX1 10T height synchro	J	8V
K	115V (B)	K	(P-S) bi-metal to RLB height gearbox
L	—6V (A)	L	Log (P-S)
M	+9V	M	—
N	CX2 4T height synchro	N	20V (Y)
O	CX2 4T height synchro	O	+9V
P	CX2 4T height synchro	P	—6V (A)
Q	—6V (B)	Q	115V (A)
R	Log S	R	Sig. E
S	Sig. E	S	—6V (B)
T	P.E. correction (not applied)	T	
U	Log (P-S)	U	
V	(P-S) bi-metal to RLB height gearbox	V	
W	Ref. 1 (25V)	W	115V (B)
X	I.A.S.	X	I.A.S.
Y	I.A.S.	Y	I.A.S.
Z	I.A.S.	Z	I.A.S.

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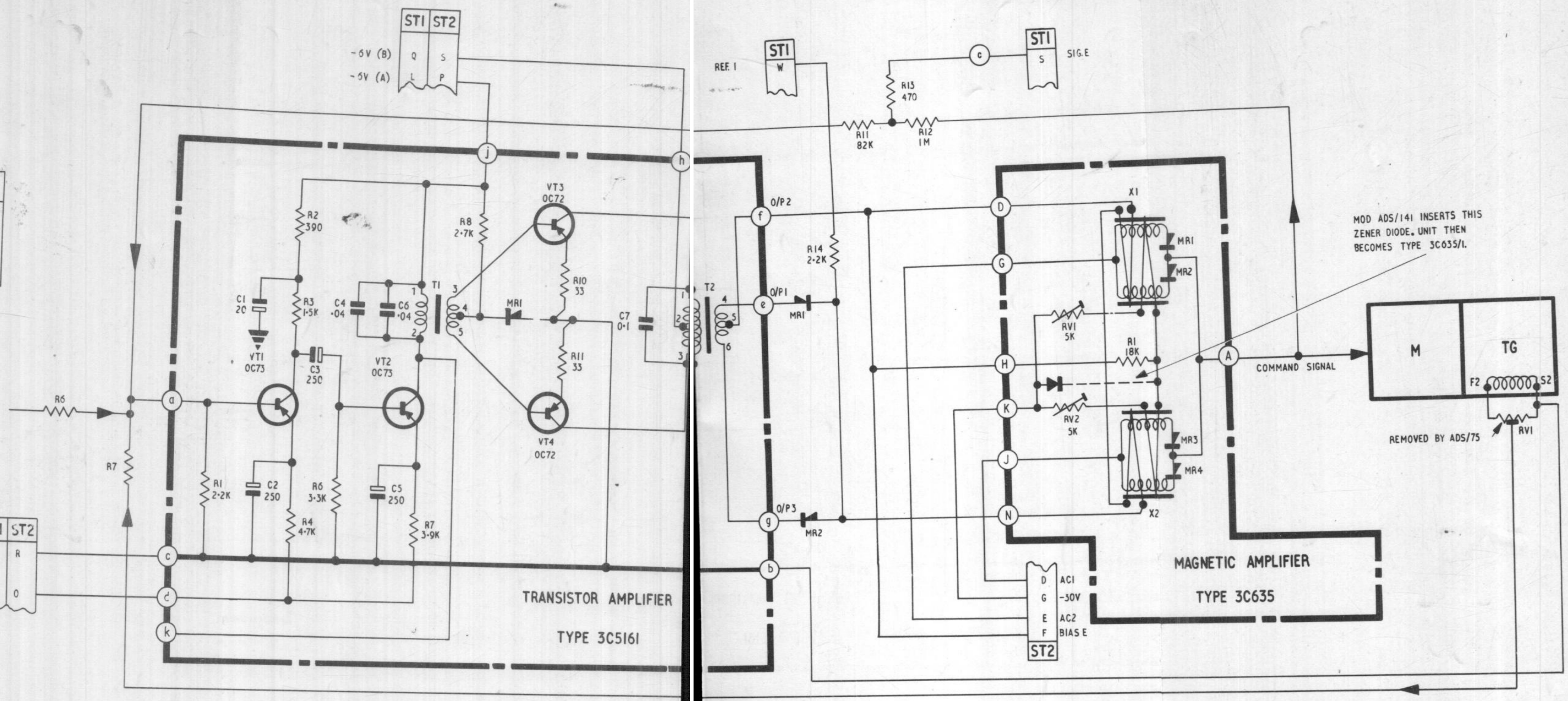
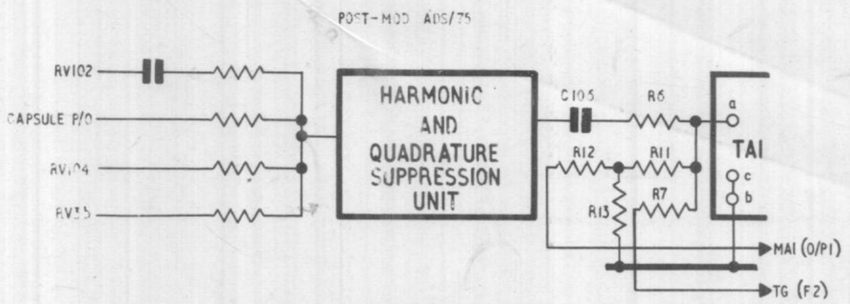
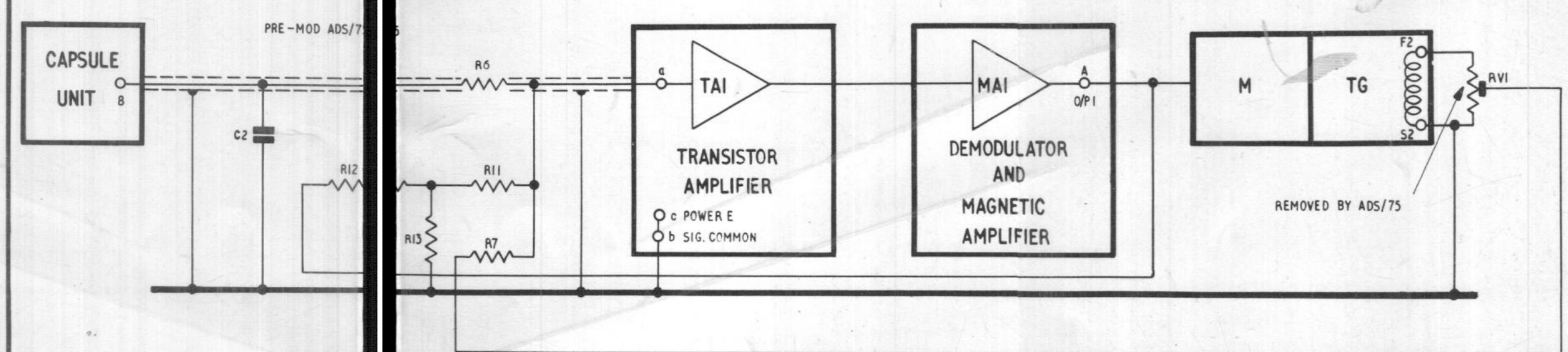
COMPONENT VALUES

	PRE ADS/75	POST ADS/75
R6	5·6K	3·9K
R7	150K	330K TO 1M
RV1	2·5K	NIL



CIRCUIT DIAGRAM FIG. 16 A





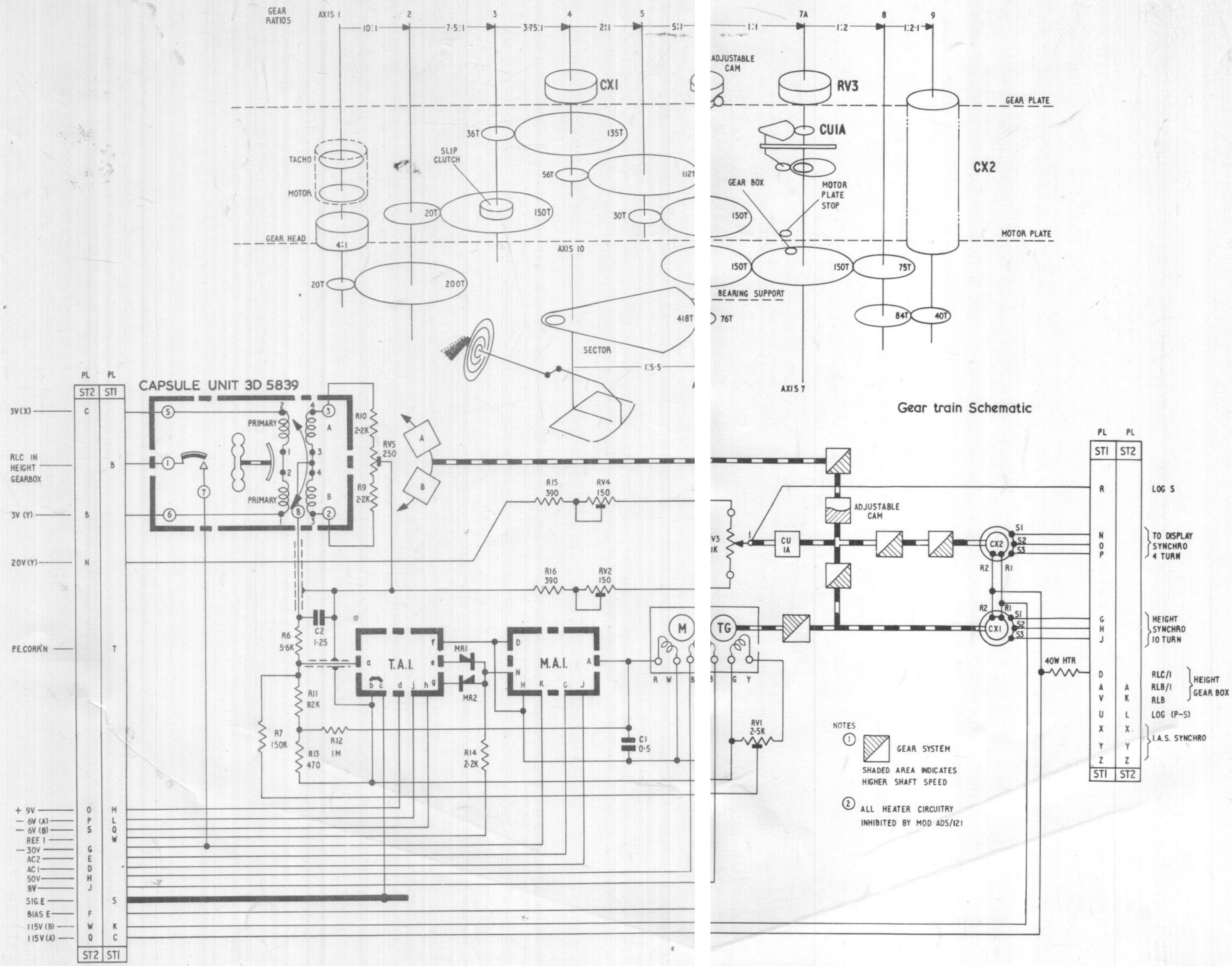
BLOCK DIAGRAM FIG. 16B

AIR DIAGRAM 6320AC/MIN	
ISSUE 2	BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE NAVAL SERVICE/ROYAL AIR FORCE (Prepared by the Ministry of Aviation)

D.1397. 373843. S.W. 10/64

A.D.S. Mk. IB Static transducer servo amplifier

Fig. 16



AIR DIAGRAM 6320 AD/MIN

ISSUE 2

BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE NAVAL SERVICE/ROYAL AIR FORCE (Prepared by the Ministry of Aviation)

A.D.S. Mk. 1B, Static transducer, Type B, No. 6A/6434, circuit diagram (pre-mod. ADS

Fig. 17

D.1397. 373843. S.W. 10/64

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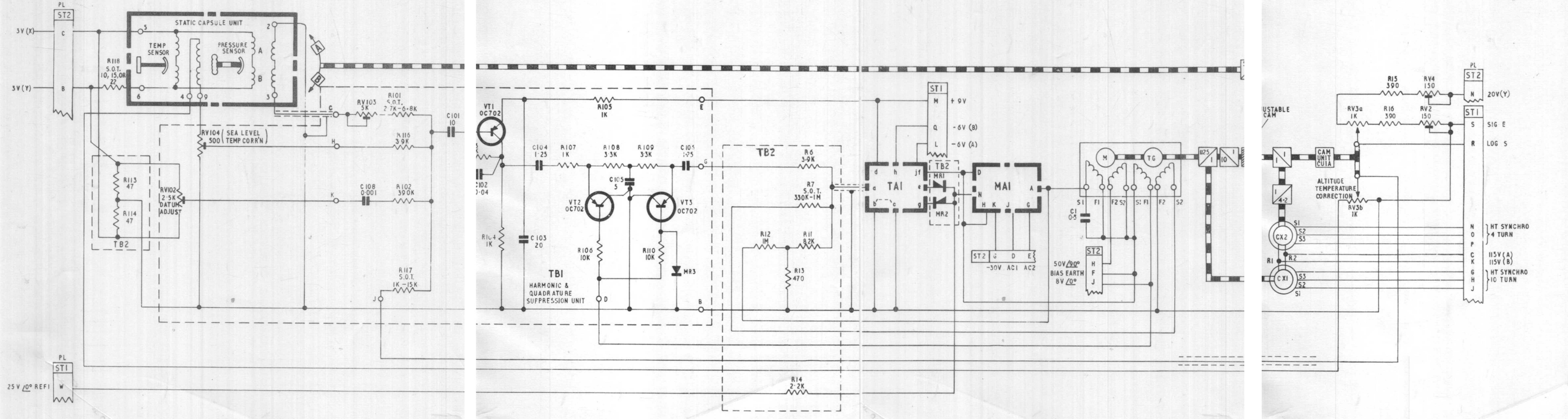

AIR DIAGRAM
6320BS/MIN

ISSUE 1

BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE NAVAL SERVICE ROYAL AIR FORCE (Prepared by the Ministry of Aviation)

D.1397. 373843. S.W. 10/64

.S. Mk. 1B static transducer Type B, Ref. No. 6A/6434 - circuit diagram - post-mod. ADS/75

RESTRICTED

Fig. 18

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