Chapter 4

HEIGHT LOCK TRANSDUCER, Type B, Ref. No. 6TD/812

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

Introduction

1. The height lock transducer, Type B (fig. 1), Ref. No. 6TD/812, is an aneroid instrument which forms part of the autopilot Mk. 20 system. It is basically similar to the static transducer of the air data system and is thus described in this handbook. The transducer can be switched to provide the autopilot with barometric height information at any chosen height, or it can be switched at heights below 5,000 feet, to accept a correcting radio height error signal. The signal is derived from a radio altimeter, via the autopilot, and is used to drive a servomechanism in the transducer and thus correct the barometric signal.

2. The height lock transducer is housed in a transducer mounting tray, Type B, Ref. No. 6A/5937, into which it is guided by locating dowels, fitted to the back of the chassis, which engage in bushes in the rear of the mounting tray. The transducer is secured in the tray by a captive screw attached to the front panel of the unit. The unit measures approximately 6 in. long, 6½ in. wide, 5 in. high, and it weighs 5½ lb.

3. A 25-way Plessey Mk. 4 plug, HL1, mounted on the chassis assembly within the transducer, passes through the front panel and is used for the transducer input and output connections. Details of the connections are listed in Table 1. Also passing through the front panel is an adapter of ⅜ in. outside diameter, identified STATIC, which connects the transducer to the static line from the aircraft's pressure head. The transducer is protected by a box-shaped cover which may be removed after unscrewing the two 6 B.A. ch. hd. retaining screws at the rear of the unit. No external controls are provided on the transducer.

Power Supplies

4. The power supplies are obtained from the autopilot computer and are listed, together with their application within the transducer, in Table 2. A warm-up period of three minutes is required prior to operational use.

SUMMARY OF OPERATION (fig. 2)

General

5. The height lock transducer is remotely controlled by a switch in the autopilot system and can be switched from the servo mode to operate in a barometric height lock mode or a radio height lock mode. The barometric height lock mode can be selected at any chosen height, but the radio height lock mode can be selected only at heights between 0 to 500 ft (low range) or 0 to 5,000 ft (high range). The transducer basically comprises a capsule unit, a pre-amplifier and a servo system. The

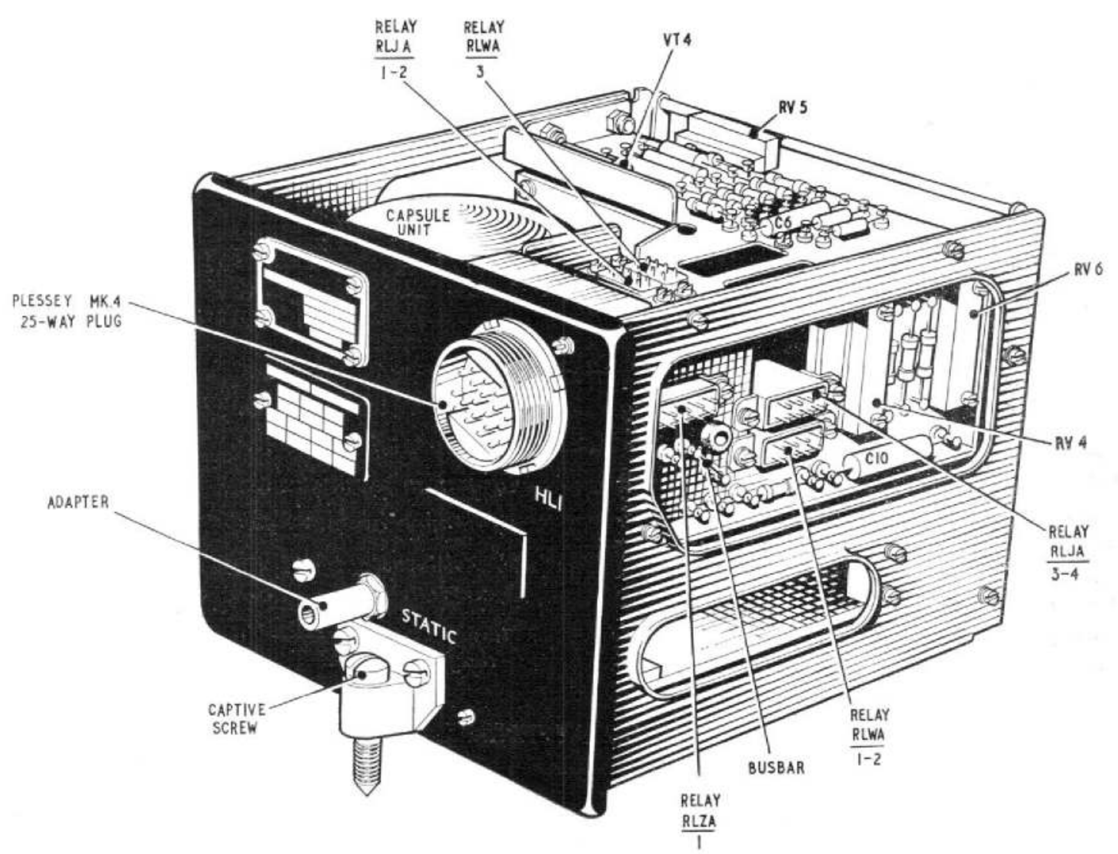


Fig. 1. Height lock transducer, Type B — cover removed

TABLE 1

Height lock transducer, Type B — connections to plug HL1

Connector type (a)	*No. of ways* (b)	*Orientation* (c)	*Pin* (d)	*Intelligence* (e)
Plessey Mk. 4 aluminium, fixed	25	4	A	115V, 400 c/s phase A
			B	115V, 400 c/s phase B
			C	115V, 400 c/s phase C
			E	Signal E - Bias E
			L	−6V
			M	+9V
			N	−9V
			U	Signal from radio altimeter store
			V	Relay common
			W	28V (Height lock relay RLWA supply)
			X	28V (High range radio height lock relay RLZA supply)
			Y	28V (Radio height lock relay RLJA supply)
			Z	Height error output to autopilot

capsule unit is connected to the static line of the pitot head, and changes in pressure are sensed within the capsule unit which produces a corresponding voltage output. This voltage output, or error signal, is then amplified in the pre-amplifier.

Servo mode

6. During the servo mode of operation, the amplified error signal from the capsule unit is fed via contacts of change-over relays RLWA/1-2 and RLJA/1-2, both de-energized, to the servo system, where it is further amplified and fed to the control winding of a motor-tachogenerator (M1). The reference winding of the motor is supplied 50V 400c/s via contacts of relay RLWA/3, de-energized. The resultant rotating field causes the motor to rotate at a speed proportional to the amplitude of the amplified signal, the direction of rotation being determined by the phase of the signal which may either lead or lag the reference voltage by 90°. The motor drives a d.c. feedback tachogenerator (TX1) and a gear train, to produce a follow-up system which maintains the capsule unit output voltage at a minimum. Velocity feedback is applied to the servo amplifier via an attenuator network.

Barometric height lock mode

7. Selection of the barometric height lock mode energizes relays RLWA/1-2 and RLWA/3. Contacts RLWA/1 disconnect the output of the pre-amplifier from the servo amplifier and transfer the output to the autopilot computer. Contacts RLWA/2 earth the input of the servo amplifier, and contacts of relay RLWA/3 disconnect the 50V supply to the motor. These conditions in effect, disconnect the servo loop which now becomes inoperative. Deviation of the aircraft from the locked height thus produces a voltage output from the capsule unit, which is directly proportional to the change in pressure. This output is processed in the autopilot computer to provide a corrective autopilot demand signal.

Radio height lock modes

8. When either radio height lock mode is selected the capsule unit and pre-amplifier will function as

TABLE 2

Height lock transducer, Type B power supplies

*HL*1 (a)	*Supply* (b)	*Application* (c)
A	115V A	Transformer T1 primary pin 3
B	115V B	Transformer T1 primary pin 1
C	115V C	Transformer T2 primary pin 1
L	−6V	Transistor amplifier TA1 pin j
M	+9V	Transistor amplifier TA1 pin d Microswitch MSW/1 Pre-amplifier
N	−9V	Transistor amplifier TA1 pin h Microswitch MSW/2 Pre-amplifier

described in para. 7. In addition, change-over relay RLJA/1-2 is energized. Contacts RLJA/1 switch a signal, derived from a radio altimeter, to the servo amplifier, whilst contacts RLJA/2 restore the 50V supply to the reference winding of the motor. The signal from the radio altimeter, which is variable by RV3, will drive the servo-mechanism at a rate dependent upon the amplitude of the signal, and in a direction dependent upon the phase of the signal. The signal thus gives correction to the height error output being fed from the capsule unit. Selection of the low range radio height lock mode also energizes relay RLJA/3-4, the contacts of which select the correct attentuation network in the d.c. tachogenerator feedback circuit. Similarly, high range mode selection energizes relay RLZA/1, also in the feedback circuit.

DETAILED DESCRIPTION

Construction

9. The transducer consists of a rectangular front panel to which is riveted two side frames. A chassis assembly (fig. 3) is secured between the side frames by 4-40 U.N.C. screws passing through the side frames into clinchnuts riveted to the chassis. Unit wiring is by cable looms which allow the chassis assembly to be hinged rearward to permit access to internal components. In the illustrations, the cable looms have been omitted for clarity. Supported between the side frames and by the front panel, is a gear plate and a motor plate, which are suitably formed and drilled to house or support the capsule unit (CX1), motor (M1), d.c. tachogenerator (TX1) and the various components, gears, bearings and spindles associated with the gear train. Mounted on the underside of the motor plate are two microswitches MSW1 and MSW2 (fig. 4).

10. The chassis assembly carries five 675-ohm double-contact normal duty electromagnetic relays, three transformers, T1, T2 and T3, the 25-way plug HL1 and the various components of the pre-amplifier and servo amplifier. A terminal board assembly, TB3, carrying two variable resistors, RV3 and RV7, and four fixed resistors, R36 to R39 is mounted on spacers and attached to the transistor amplifier by four 6 B.A. ch. hd. screws. Transistors VT6 and VT7 of the power amplifier output stage each have a heat sink which is carried on the inside of the rear of the chassis.

Note . . .

*Although a sub-assembly of the servo amplifier, the transistor amplifier TA*1 *(Elliott part number* 3C/5161) *is a separate and replaceable unit.*

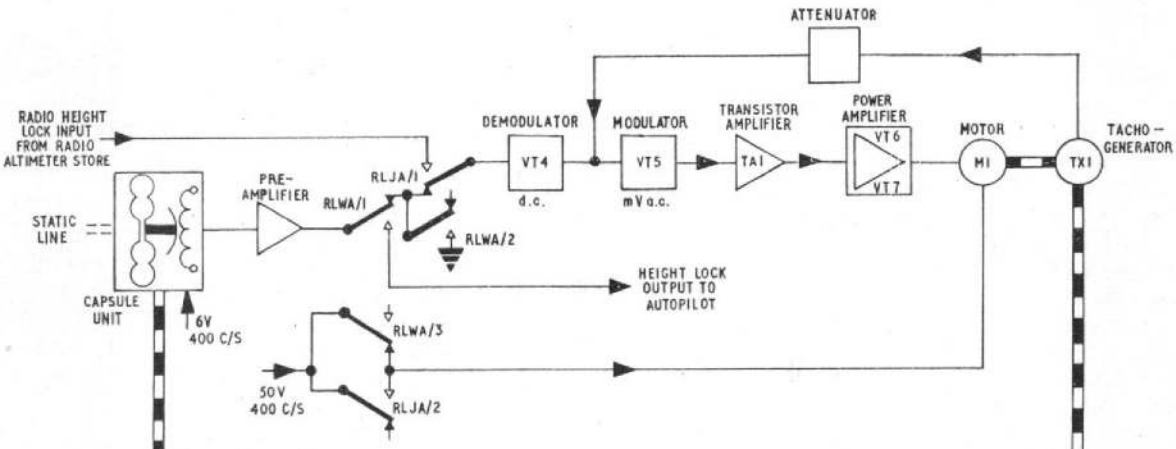


Fig. 2. Height lock transducer, Type B, block diagram

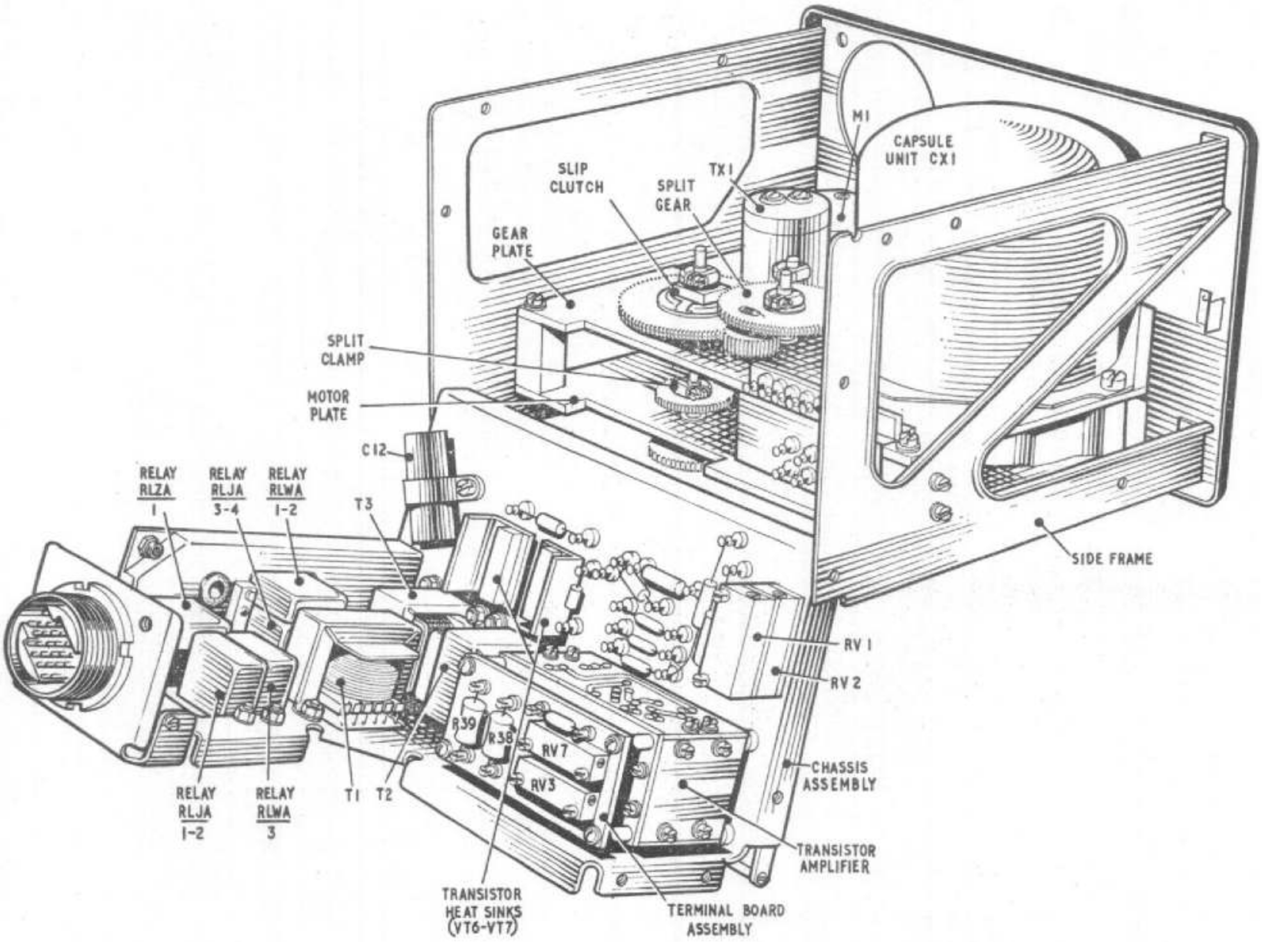


Fig. 3. Height lock transducer, Type B — interior view with chassis fitted

Static capsule unit

General (fig 5)

11. The static capsule unit, Type No. 81D3-A-1, consists of a static pressure capsule assembly and a pick-off assembly, which are mounted on a combined capsule bracket and spindle bearing housing attached to a base assembly (fig. 5(a)). Sealing between the housing and the base is effected by a rubber 'O' ring. The base assembly is fitted with an adapter, which is screwed and sealed into the front of the base assembly and provides the inlet for static pressure. The base contains sealed outlets for nine terminals (fig. 5 (b)), six of which provide the electrical connections for the pick-off coils. The remaining three are not used. The internal electrical connections to the pick-off coils are made by cableforms from two terminal boards, TB1 and TB2, attached to the base. A cylindrical, domed cover forms the sealed chamber for the capsule and pick-off assembly and is attached to the base assembly by three 4 B.A. ch. hd. screws. The cover is located by a shoulder on the base and sealed by an 'O' ring.

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

(1) The rigid support of the capsule by means of the combined capsule bracket and spindle bearing housing assembly, and the capsule support.

(2) Conversion of the capsule expansion and contraction into angular movement of the moving-iron armature (vane) of the variable reluctance pick-off, thus producing an error signal from the coils of the pick-off. As the capsule expands or contracts, the capsule adapter carries with it the clamp bracket, into which is screwed the jewel mounting assembly, which employs a bi-metal strip for temperature error correction (fig. 5(a)). A link engages a jewel bearing in the lower, or free end of the jewel mounting and transmits capsule movement to a jewel mounting sub-assembly mounted on an arbor within the pick-off bridge assembly. Also mounted on the arbor, at right angles to the jewel mounting sub-assembly, is a slotted vane arm which

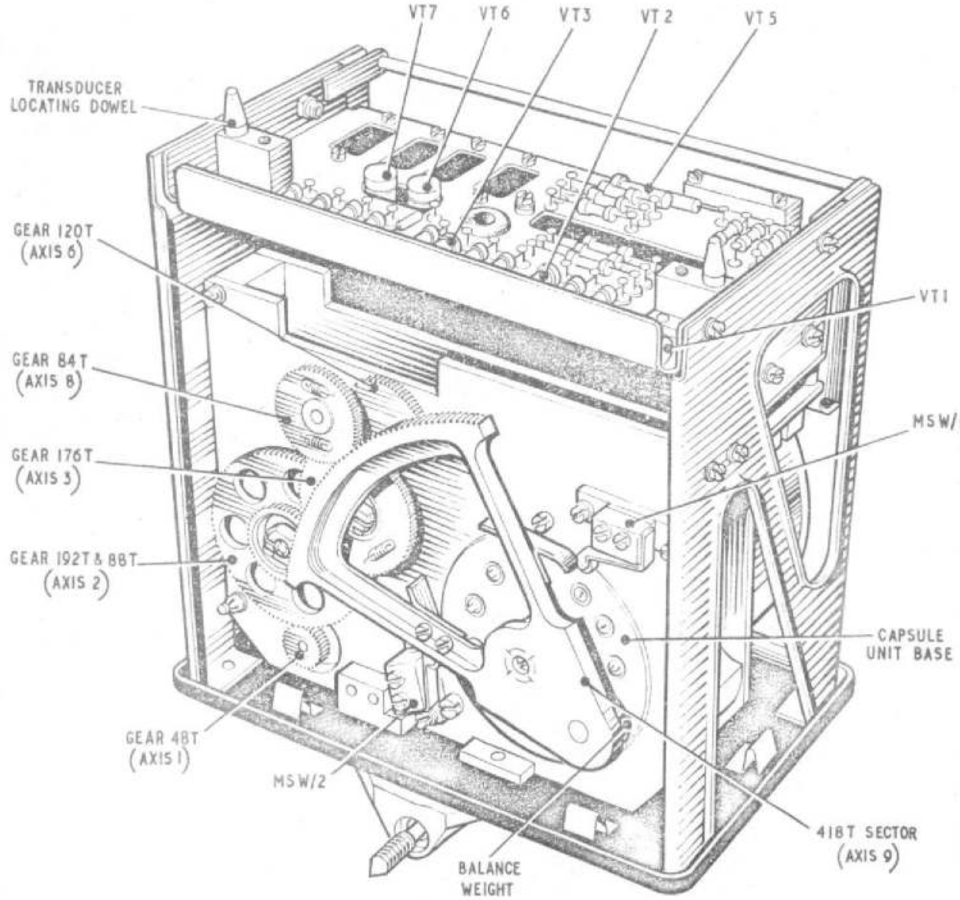
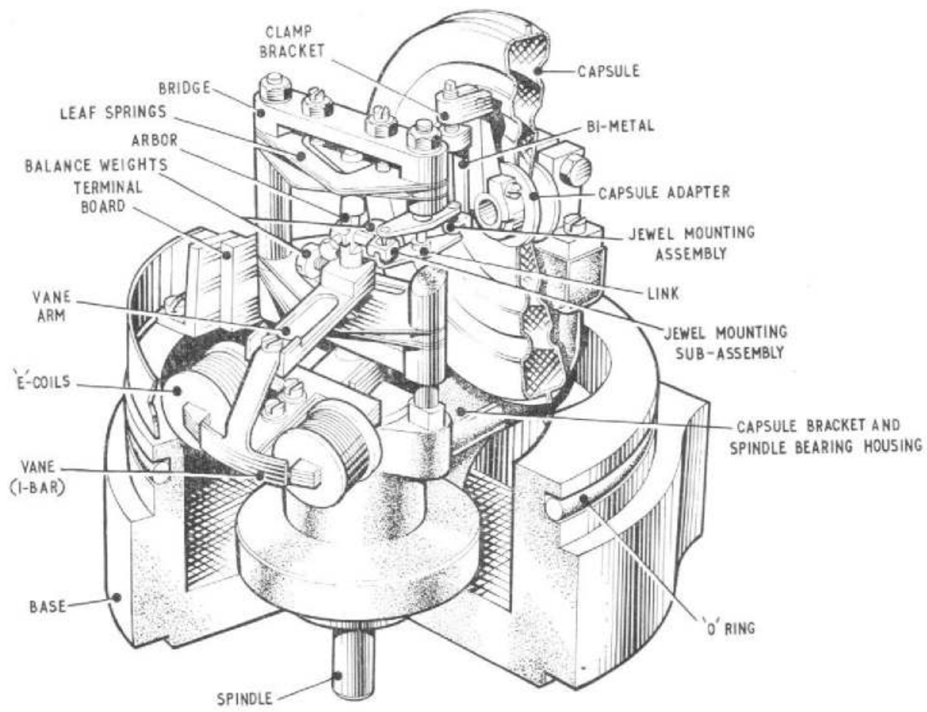


Fig. 4. Height lock transducer, Type B — view of rear and underside

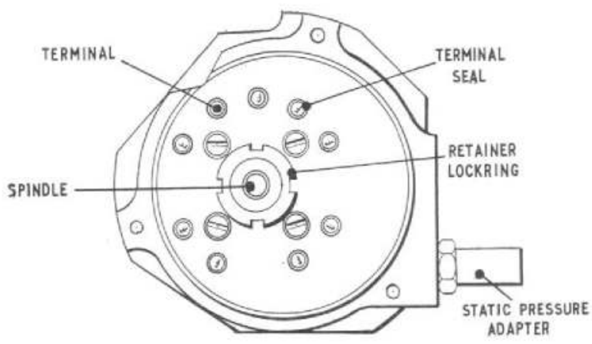
swings about a vertical axis in response to movements of the capsule adapter and linkage. Clamped in the end of the slotted vane arm is a vane, the outer end of which, is bent downwards so that it lies in close proximity to the poles of the pick-off coils; the gap between the vane and poles may be adjusted by moving the vane in the slot before clamping with the screw. Expansion or contraction of the capsule, therefore, will cause the vane to swing about the vertical axis of the arbor.

(3) The means to rotate the pick-off coils in the required direction to obtain a null condition. The pick-off coils, on their laminations are attached to an arm which is clamped to a spindle. The spindle and coils are free to rotate over a 60° arc, the spindle being supported by two sets of bearings housed in the capsule bracket and spindle bearing housing assembly. The lower bearing retainer screws into the bottom of the bearing housing and can be adjusted to prevent end float of the spindle. The retainer is locked by a slotted outer lock ring (fig. 5(b)). A rubber 'O' ring above the upper bearing, seals the spindle which protrudes through the base of the capsule assembly and has clamped to it the 418T sector (fig. 4). The sector is driven by an 84T gear on axis 8 of the transducer's gear train during the servo follow-up action, to reposition symmetrically the pick-off coils in relation to the vane, thus producing a null condition.

(4) Mechanical correction of errors arising from the variations in temperature. Mechanical correction is applied to the linkage, by means of the bi-metal strip assembly, to compensate for error arising from the effects of temperature changes on all parts of the capsule unit. The bi-metal bends with changes in temperature, resulting in horizontal movement of the jewel bearing at its lower end. The degree and direction of this movement is controlled by the direction in which the bi-metal strip faces, and rotation of the bi-metal assembly (during calibration and before clamping in the bracket) is thus a means of adjusting the temperature correction. Electrical temperature compensation is catered for by R38 and R39 in the voltage supply line to the pick-off coils, para. 28.



(a) VIEW WITH COVER REMOVED



(b) VIEW OF UNDERSIDE OF BASE

Fig. 5. Static capsule unit

(5) Compensation of errors arising from 'g' forces. The axial 'g' forces acting on the capsule are counterbalanced by the capsule balance weight. The vane arm balance weight compensates for lateral forces, and the leaf spring assembly, supporting the jewel mountings in which the arbor assembly pivots, provides overall protection to the capsule linkage.

Capsule

13. The static pressure capsule is constructed of corrugated beryllium-copper cheeks joined with non-corrosive solder and fitted with the capsule support and adapter. A short length of copper tubing, within the capsule support, is crimped and soldered after the capsule has been evacuated to approximately $22{\cdot}5 \times 10^{-5}$ mm Hg.

Principle of operation

14. When an aircraft changes altitude, either increasing or decreasing height with respect to sea level, the corresponding change in barometric pressure influences the capsule which expands with increasing height and contracts with decreasing height. This movement is magnified in the linkage system and transmitted to a rotating arm to which the moving-iron armature (vane) of the variable-reluctance pick-off is attached.

15. 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 servo mechanism. The pick-off consists essentially of two magnetic structures, one in the shape of an E (pick-off coils) and the other in the shape of an I (vane). In the absence of pressure change, no movement is imparted by the capsule, and the vane, assuming the servo follow-up action is complete, is positioned symmetrically in relation to the pick-off coil and the output from the pick-off is a minimum signal or null. A change of barometric pressure results in the movement of the vane away from the null position and a consequent output signal from the pick-off coils. In the servo mode this output is amplified by the pre-amplifier and the servo amplifier and used to drive the motor, which in turn drives the servo loop in the null seeking direction. When the height lock mode is selected the output is fed out of the transducer, via the pre-amplifier, to the autopilot computer as a height error signal.

Pre-amplifier

16. The function of the pre-amplifier is to amplify the signal from the capsule unit to an acceptable value for application to the autopilot computer, and to form an integral part of the servo amplifier during the servo mode of operation. The input impedance is approximately 400 ohms and the amplifier has a gain of approximately ◀ 300. ▶ The components of the pre-amplifier are carried on both sides of the rear of the chassis assembly.

Servo system

General

17. The servo system consists of a servo amplifier, a motor, a gear train and a d.c. feedback tachogenerator. During the servo mode the function of the servo system is to maintain the E-coils in a null pick-off position. When the barometric height lock mode is selected, the servo system is inoperative. With the selection of radio height lock modes, a signal derived from a radio altimeter is applied to the servo amplifier and used to drive the servomechanism to correct the error signal from the capsule unit.

Servo amplifier

18. The servo amplifier provides a suitable a.c. output, which is related in amplitude and phase to the error signal. This output is used to drive the motor and the associated gear train. The amplifier consists of a transistorised demodulator/modulator stage, transistor amplifier TA1, and a power amplifier output stage. The overall gain of the servo amplifier, with feedback, is approximately 50,000.

Demodulator/modulator stage

19. The transistors and their associated components which form the demodulator/modulator stage are mounted on the top and rear of the chassis assembly. The base of demodulator VT4 is fed with a reference voltage from T1, and the 'switching' action of the transistor produces a rectified voltage of the correct relationship (plus or minus d.c.) to the input to the modulator. The action of modulator VT5, which is also fed the reference voltage, is to convert this d.c. to a.c. by producing an output on alternate half cycles of the reference voltage.

Transistor amplifier TA1

20. The transistor amplifier, Ref. No. 3C/5161, is a printed circuit sub-assembly and is secured by four 6B.A. ch. hd. screws to the inside of the rear of the chassis assembly, fig. 3. The input and output connections to the amplifier are to eight terminals on the side of the unit which protrude through the rear of the chassis assembly. The input impedance of the amplifier is 800 ohms.

Power amplifier

21. The output stage of the servo amplifier basically consists of two class B connected transistors and transformer T3. The transistors are coupled to the primary of T3, the secondary of which produces the phase-related output of the servo amplifier. The components of the power amplifier are carried on the rear and the top of the chassis assembly.

Motor M1

22. The motor of the height lock transducer is a motor-tachogenerator (Sperry Type No. 21829-0) consisting of a 2-phase squirrel cage motor with an a.c. induction tachogenerator mounted on the same shaft. The tachogenerator section is not used. The motor is carried on the motor plate of the gear train and the drive is by a 48T gear which is clamped to the motor spindle. The gear meshes with the 192T gear clamped to the d.c. tachogenerator, and the motor mounting plate beneath the motor enables the backlash between the gears to be adjusted.

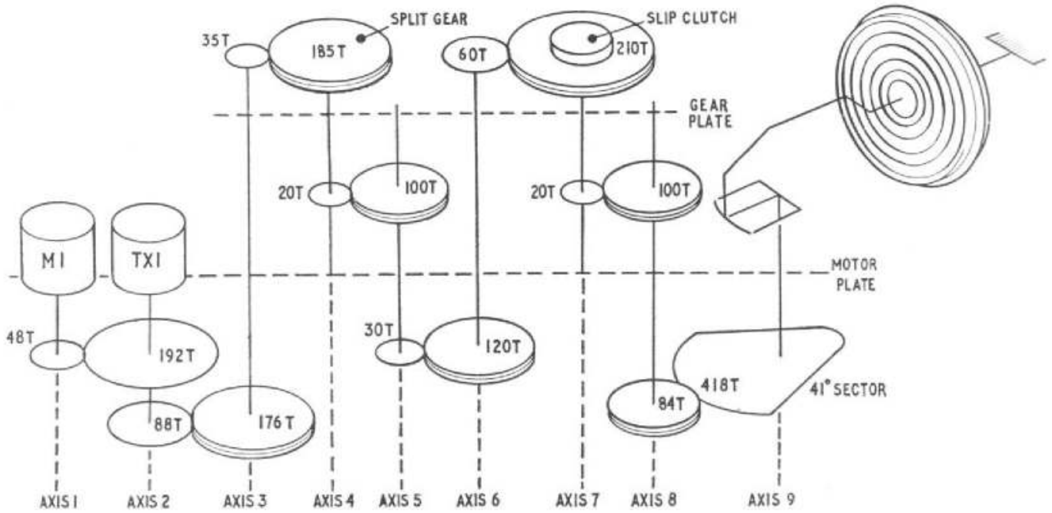


Fig. 6. Gear train schematic

D.C. tachogenerator TX1

23. The d.c. tachogenerator is a feedback generator (Electro Methods, Type 931) and produces a 4 ± 0·2V d.c. output per 1,000 rev/min. This output is applied, via an attenuator circuit, as velocity feedback to the servo amplifier. The tachogenerator is mounted on the motor plate of the gear train and is secured by three clamps attached by 4-40 U.N.C. pan hd. screws. Drive is by a gear and pinion assembly clamped to the tachogenerator spindle. The 192T gear meshes with a 48T gear on the motor spindle, and the 88T pinion meshes with a 176T split gear on axis 3 of the gear train and transmits the drive from the motor to the gear train.

Gear train

General

24. The components of the gear train (fig. 6) are accommodated partly between, and on the outside of, a gear plate and a motor plate. The base of the capsule unit is secured between the plates, whilst the motor and the d.c. tachogenerator are mounted on the top of the motor plate. All the spindles are mounted in flanged ball bearings which are a light push fit in their housings and on the spindles. The gears are of aluminium alloy and the pinions and spindles of stainless steel.

25. The gear train consists of nine axes, axis 1 being the drive from the motor-tachogenerator and axis 9 the spindle of the capsule unit carrying the 418T sector. To protect the gear train in the event of overload, a slip clutch (para. 26) is provided at axis 7. Two micro-switches, MSW1 and MSW2, mounted on the underside of the motor plate and actuated by the 418T sector (fig. 4), function as electrical stops and prevent gear train over-run, thus affording protection to the motor and E-coils Before the 418T sector reaches the limit of its movement, in either direction, one of two brackets attached to the sector contacts the roller arm of a microswitch and operates the microswitch. The operation of a microswitch applies +9V (MSW1) or −9V (MSW2) to the demodulator which swamps the servo amplifier signal and reverses the direction of rotation of the motor driving the gear train. To counteract backlash, split gears (para. 27) are fitted on axes 3 to 8.

Slip clutch

26. The slip clutch (fig. 7) consists of a ball clutch and gear assembly and is set to slip when the load applied to the gear at the pitch circle diameter reaches 30 ± 5 gm. The split gear and hub assembly is free to rotate on a boss which is clamped to the spindle (axis 7) by a split clamp. A thrust washer supporting the gear assembly is staked to the lower end of the boss. Five steel balls, accommodated in holes in the boss, engage indentations in the gear hub and are retained by a pressure plate which is tensioned by a three-legged dished spring. The whole are retained on the boss, and the spring tension adjusted by a second split clamp. This clamp is adjusted so that the rotation of the spindle is transmitted to the gear on normal loads, but slips when a load exceeding the setting is reached.

Split gear

27. A split gear consists of two similar gears mounted coaxially on a boss, one staked to the boss and the other free to rotate. The gears are

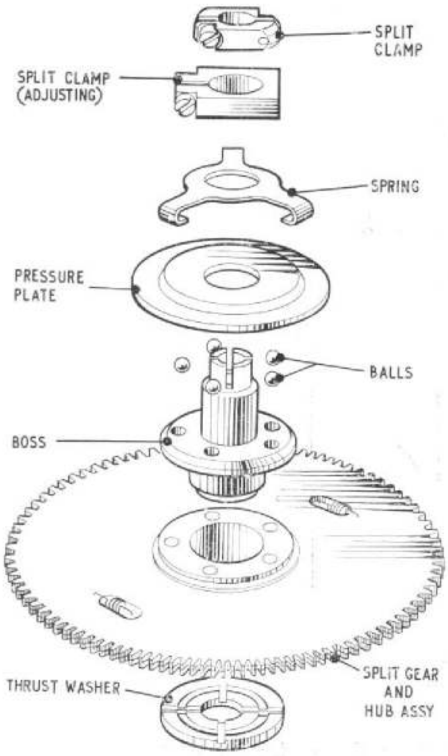


Fig. 7. Slip clutch assembly

interconnected by two spiral tension springs attached to each gear and contained in two diametrically opposed slots in the gears. Rotation of the free gear against the spring tensions the springs, and engagement of the split gear assembly in this condition with a normal gear, forces the teeth of the split gear into contact with both sides of the teeth of the normal gear, thus eliminating backlash.

Circuit description

Capsule unit

28. The 6V, 400 c/s supply required for the primary windings of the E-coils of the variable reluctance pick-off is derived from a 48V supply from the secondary windings of transformer T1. The primary of T1 is fed with 115V phase A and B. The 48V supply is fed to the coils via the high wattage voltage dropping resistors R38 and R39. This method of obtaining the supply for the E-coils reduces the error arising in the output from the pick-off caused by the varying resistance of the coils with changes in temperature.

29. When the vane is in its centre position equal voltages are induced in the series-aiding secondary coils and no output is produced from the pick-off, the variable resistor RV2 being adjusted to this condition. When the vane is moved, due to capsule expansion or contraction, increased flux is carried in the coil having reduced reluctance and decreased flux is carried in the limb having increased reluctance and a voltage output of a certain magnitude and phase is produced. Adjustment during calibration, of RV7 in the resistance network connected across the input to the E-coils, ensures a symmetrical output from the coils for an equal amount of capsule expansion or contraction. Capacitor C5 eliminates unwanted higher harmonics and gives phase correction so that the height error output to the autopilot is of the phase required. The output from the capsule unit is approximately ◀8▶ mV per 100 ft change in altitude.

Pre-amplifier

30. The pre-amplifier is a resistance-capacitor coupled three stage amplifier employing three silicon PNP junction transistors (OC201's). The amplifier gain is variable by RV1. Low frequency stability and current feedback of first and second stages is by auto-bias resistors R1 and R5, and d.c. stability of the third stage by conventional bias chain R40 and R41. High frequency stability is ensured by capacitor C3 and gain stability is obtained by overall negative feedback via R10. Supplies to the pre-amplifier are +9V and −9V.

Demodulator/modulator stage

31. The input to the servo amplifier is applied to the emitter of the silicon PNP junction transistor, VT4 (OC202), via C6 and R16. The reference supply to the base of VT4 and VT5 (OC 202) is obtained from transformer T1. The 40V-0-40V supply from T1 is clipped by Zener diodes MR1 to MR4 producing an approximate square waveform of 18V p.p. The silicon diode MR5 limits the VT5 base voltage to prevent damage to the transistor. Both collectors are connected to earth. VT4 will conduct on alternate half cycles of the reference voltage producing a rectified voltage at the emitter which is integrated through the three networks R17-C7, R18-C8 and R19-C9. The rectified voltage is fed via R21 to VT5 emitter. The effect of the reference voltage at the base of VT5 and the d.c. voltage applied to the emitter is to produce a square waveform output. This output, which is related to the phase of the reference voltage, is applied via C11 and RV5 to the input of the transistor amplifier. RV5 is used during setting-up to adjust the overall gain of the servo amplifier.

Transistor amplifier (fig. 8)

32. The transistor amplifier is a three stage amplifier employing germanium PNP junction transistors throughout. The amplifier input stage VT1 is resistance-capacitor coupled to a driver stage VT2. R1 provides constant bias for VT1. The emitter bias and collector voltages for both stages are obtained from the +9V and −6V supplies to the amplifier respectively. The phase-splitter transformer T1 couples VT2 to the output stage. T1 primary is tuned by C4 and C6 to give maxi-

Printed for Her Majesty's Stationery Office by Ezra Sidebotham Ltd., Wigan.
471350/Wt.52018/D.2375 625 5/65 Gp.375/7

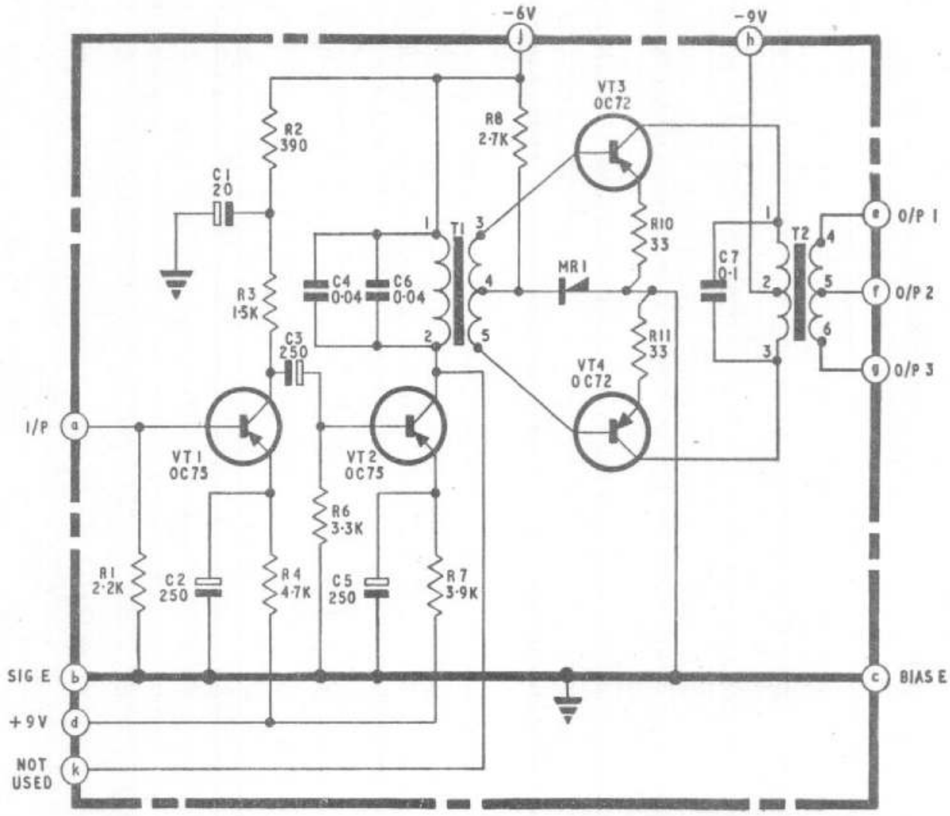


Fig. 8. Transistor amplifier, Type 3C5161 — circuit diagram

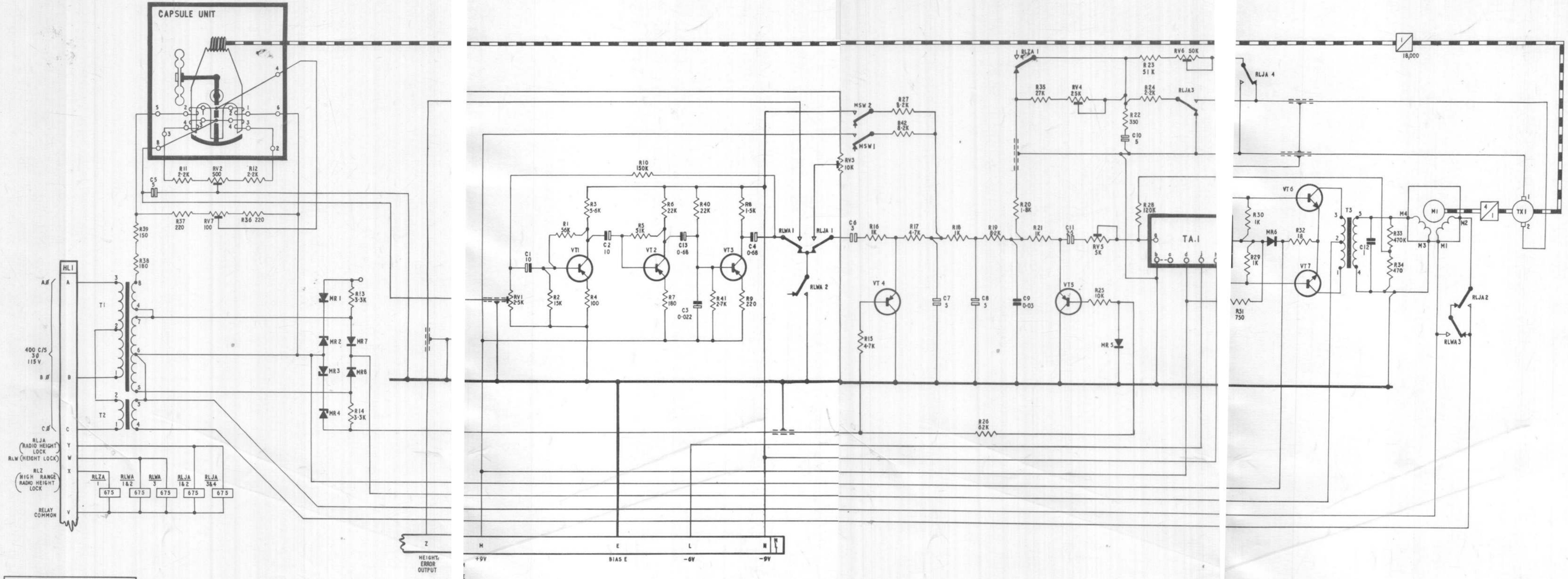
mum gain at 400 c/s. Bias for VT3 and VT4 emitters is derived from the currents through R10 and R11 respectively. A germanium junction diode MR1 is used as a current controlling device, to compensate for any change in base/emitter junction temperature. MR1 also limits the emitter current thus preventing instability in VT3 and VT4. The collectors are fed from the −9V supply, via the centre tap of transformer T2 primary. The primary of T2 is tuned by C7 for maximum gain at 400 c/s. Gain stability of the amplifier and output stage is ensured by a feedback voltage derived from R33 and R34 connected across the output of the servo amplifier and fed to the transistor amplifier via R28.

Power amplifier

33. The power amplifier output stage consists of two silicon NPN transistors, VT6 and VT7 (2S020's), coupled to the primary of transformer T3. The collectors are fed with a 40V peak full wave rectified voltage from the primary of T3, the voltage being derived from the secondary of T1 via the full wave rectifiers MR7 and MR8. Emitter bias is obtained from the +9V supply, via R31, MR6 and R32. The silicon diode MR6 ensures thermal stability of the bias. Resistors R29 and R30 prevent 'ringing' of the transistors by swamping unwanted high frequencies. The secondary of T3 is tuned by C12 to give maximum gain at 400 c/s, and the output fed to the control winding of the motor.

Attenuator

34. The d.c. output from the tachogenerator is applied via loops of an attenuator network as velocity feedback for the servo amplifier. During the servo mode the feedback is routed via relay RLJA/4 (de-energized), RV6, R23, relay RLZA/1 (de-energized) and R20. RV6 is used to adjust the feedback for the servo mode. The voltage is smoothed by C10, via R22. Selection of the radio height lock mode low range energizes RLJA/3-4, and the feedback is routed via RLJA/3, R24, relay RLZA/1 (de-energized) and R20. When radio height lock mode high range is selected relay RLZA/1 is energized. This opens the short circuit and forces the feedback to pass through RV4 and R35. RV4 is used to set the feedback for the high range radio height lock mode.



AIR DIAGRAM
6320DT/MIN.

ISSUE 1

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

Height lock transducer, Type B, Ref. No. 6TD/812 - circuit diagram

RESTRICTED

Fig. 9


UV LIGHTING
LOW