AIR PUBLICATION

117K-0104-13D

(Formerly A.P.4837AG, Vol. 1)

OSCILLOSCOPE SET, CT536

GENERAL AND TECHNICAL INFORMATION AND SCALE OF SERVICING SPARES

BY COMMAND OF THE DEFENCE COUNCIL

L. T. Dunnett

Ministry of Defence

FOR USE IN THE
ROYAL AIR FORCE

(Prepared by the Ministry of Technology)

FOR OFFICIAL USE ONLY

A.L.2. July 68

AIR PUBLICATION

114E-0400-1

(Formerly A.P. 2890AC, Vol. 1)

GROUP 114: AIRBORNE RADAR EQUIPMENT
SUB-GROUP E: NAVIGATION RADARS

MARCONI AD2300 DOPPLER NAVIGATION EQUIPMENTS

ARI.23085/1 and ARI.23085/3

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

Ministry of Defence

FOR USE IN THE

ROYAL AIR FORCE

(Prepared by the Ministry of Aviation)

(A.L.24, Jan. 66)

LETHAL WARNING

EJECTION SEATS AND CANOPY JETTISON MECHANISMS

1. Ejection seats and canopy jettison mechanisms are sources of potential danger to personnel and of damage to the aircraft. Serious injury (possibly fatal) may result if any firing mechanisms are inadvertently operated whilst the aircraft is on the ground.

2. The following instructions are to be obeyed:—

R.N. **Safety precautions contained in A.P.(N).140—Naval Aircraft Maintenance Manual.**

R.A.F. **ALL PERSONNEL before entering the cockpit or cabin of an aircraft fitted with an ejection seat are to report to the N.C.O. immediately in charge of airframe servicing who is to ensure that all safety pins (or other safety devices) are correctly positioned to render the seat and canopy jettison firing mechanisms safe. On completion of servicing, tradesmen are to report to the N.C.O.**

3. Full instructions for rendering the firing mechanisms safe are contained in the A.P.4288 and A.P.(N.)1023 series, in Aircraft Servicing Schedules and in the A.D.5037 series.

NOTE TO READERS

The subject matter of this publication may be affected by Defence Council Instructions, Servicing schedules (Volume 4 and 5), or "General Orders and Modifications" leaflets in this A.P., or even in some others. If possible, Amendment Lists are issued to correct this publication accordingly, but it is not always practicable to do so. When an Instruction, Servicing schedule, or leaflet contradicts any portion of this publication, the Instruction, Servicing schedule, or leaflet is to be taken as the overriding authority.

The inclusion of references to items of equipment does not constitute authority for demanding the items.

Each leaf, except the original issue of preliminaries, bears the date of issue and the number of the Amendment List with which it was issued. New or amended technical matter will be indicated by black triangles, positioned in the text thus:—◀------▶ to show the extent of amended text, and thus:--▶◀ to show where text has been deleted. When a Part, Section, or Chapter is issued in a completely revised form, the triangles will not appear.

★ ★ ★

The reference number of this publication was altered from A.P.2890AC, Vol. 1 to A.P.114E-0400-1 in January, 1966. No general revision of page captions has been undertaken, but the code number appears in place of the earlier A.P. reference on new or amended leaves issued subsequent to that date.

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LIST OF MODIFICATIONS INCORPORATED

Note . . .

(1) *This list includes all modifications to items covered by this A.P., up to the latest A.L. No.*

(2) *Some of these modifications are of a purely mechanical nature and may not have necessitated any change or warranted an immediate change to text and/or illustrations; in such instances the mod. no., is enclosed in parentheses.*

(3) *All equipment modification details are given in -2 of this publication.*

Mod. No.	*Unit affected*	*Brief details*
6593/1 (on return to contiactor)	Chassis, electrical equipment Type M24 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	New component board added. Indicates failure of follow circuits.
6898/1 (on return to contiactor)	Navigation computer, sub-assembly (Ref. No. 10AD/4022), part of computer, frequency tracker (Ref. No. 10AD/3984).	Resistors added. Prevents voltage surge and relay chatter. **Note . . .** *This modification should be embodied concurrently with Mod.* 6593/1 *and Mod.* 6899/4.
6899/4 (on return to contractor)	Chassis, electrical equipment Type M24 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	Resistor and capacitor added. Prevents voltage surge and relay chatter. **Note . . .** *This modification should be embodied concurrently with Mod.* 6593/1 *and Mod.* 6898/1.
(6900/1) (on return to contractor)	Gear assembly, resolver (Ref. No. 10AR/5696), part of computer, navigational (Ref. No. 10AD/3998).	Plain bearings replaced by bearings.
6901/3	Chassis, electrical equipment M24 (Ref. No. 10D/23464), part of computer, frequency tracker (10AD/3984).	Relay changed. Improved reliability.
(6902/2) (on return to contractor)	Aerial, Type M31 (Ref. No. 10B/20083), part of aerial group M30 (Ref. No. 10B/20082).	Knuckle fixing removed. Maintains interchangeability of waveguide knuckles.
6903/1 (production modification)	Aerial, Type M31 (Ref. No. 10B/20083), part of aerial group M30 (Ref. No. 10B/20082).	Diodes changed. Improved noise factor. **Note . . .** *This modification should be embodied concurrently with Mod.* 6904/1, *Mod.* 6905/1 *and Mod.* 6910/1.
6904/1 (production modification)	Amplifier. intermediate frequency Type M131 (Ref. No. 10U/17631) part of aerial group M30 (Ref. No. 10B/22082).	Resistor changed. Improved noise factor. **Note . . .** *This modification should be embodied concurrently with Mod.* 6903/1, *Mod.* 6905/1 *and Mod.* 6910/1.

Mod. No.	*Unit affected*	*Brief details*
6905/1 (production modification)	Rack, electrical equipment, Type M19 (Ref. No. 10D/23420) part of transmitter-receiver, radio M3 (Ref. No. 10D/23419).	Negative bias removed from diode circuit. Improved noise factor. **Note . . .** *This modification should be embodied concurrently with Mod.* 6904/1, *Mod.* 6903/1 *and Mod.* 6910/1.
6906/1 (on return to contractor)	Gear assembly, integrator (Ref. No. 10AR/5698), part of computer, frequency tracker (Ref. No. 10AD/3984).	Slipping clutch added. Prevents damage due to abnormal speed of Speed Motor.
(6907/1)	Interconnecting box Type M5 (Ref. No. 10AD/3986), part of ARI23085.	Colour coding of sockets TC and TD2.
(6908/1)	Panel tuned circuit Type M108 (Ref. No. 10D/23466), part of computer, frequency tracker (Ref. No. 10AD/3984).	Diodes changed. Improved type.
(6909/2)	Chassis, electrical equipment Type M24 (Ref. No. 10D/23464) part of computer, frequency tracker (Ref. No. 10AD/3984).	Diodes changed. Improved type.
6910/1 (production modification)	Chassis, electrical equipment Type M25 (Ref. No. 10D/23482), part of test set, performance M29 (Ref. No. 10S/17822).	Test circuit changes. Increase of test voltage.
6920/5	Chassis electrical equipment Type M24 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	Stabilization of relay by changing the energizing voltage source.
6921/2	Interconnecting box, Type M5 (Ref. No. 10AD/3986), part of ARI23085.	Connecting link removed from socket. Prevents false speed indication.
7225/2	Rack, electrical equipment, Type M19 (Ref. No. 10D/23420), part of transmitter-receiver radio, M13 (Ref. No. 10D/23419).	Continuity of screening of coaxial cable and socket.
(7226/1) (on return to contractor)	Counter, electrical (Ref. No. 10AF/774), part of indicator, range M16 (Ref. No. 10Q/16727).	Counter reliability improved. Brass spindle replaced by stainless steel spindle.
(7227/3)	Aerial Type M31 (Ref. No. 10B/20083), part of aerial group M30 (Ref. No. 10B/20082).	Improved aerial switch contact.
7296/6	Chassis, electrical equipment, Type M24 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	Resistor and Screen H.T. lead added. Maintains F.F.I. specification and avoids spurious excitation.
7621/2	Chassis, electrical equipment, Type M25 (Ref. No. 10D/23482), part of test set, performance M29 (Ref. No. 10S/17822).	Log law potentiometer changed for linear law potentiometer.
7622/7	Chassis, electrical equipment Type M25 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	Additional inter-relay wiring to improve "In Flight" test.
(7623/8)	Chassis, electrical equipment Type M24 (Ref. No. 10D/23464) part of computer, frequency tracker (Ref. No. 10AD/3984).	Capacitors changed to improve reliability.

Mod. No.	Unit affected	Brief details
(7624/1)	Amplifier, velodyne, Type M152 (Ref. No. 10U/17645), part of computer navigation (Ref. No. 10AD/3998).	Capacitor changed to improve reliability.
(7625/1)	Amplifier, velodyne, Type M153 (Ref. No. 10U/17646), part of (a) amplifier, synchro signal (Ref. No. 5990-99-970-2380) and (b) test set, performance M29 (Ref. No. 10S/17822).	Capacitor changed to improve reliability.
7626/1 (production modification)	Power supply Type M73 (Ref. No. 10K/21865) part of (a) test set, performance M29 (Ref. No. 10S/17822) and (b) amplifier synchro signal (Ref. No. 5990-99-970-2380).	Resistor change to reduce tacho generator exitation voltage.
7627/1	Navigation computer, sub-assembly (Ref. No. 10AD/4023), part of computer, frequency tracker (Ref. No. 10AD/3984).	Change of capacitors to improve reliability.
7628	Aerial Type M31 (Ref. No. 10B/20083), part of aerial group M30 (Ref. No. 10B/20082).	Addition of tuning screws to obtain overall v.s.w.r. specification.
(7702)	Rack, electrical equipment, Type M19 (Ref. No. 10D/23420), part of transmitter-receiver, radio, M13 (Ref. No. 10D/23419).	Identity label changed.
7896	Generator, reference signal (Ref. No. 10K/21884), part of amplifier, synchro signal (N.S. No. 5990-99-970-2380) and test set, performance M29 (Ref. No. 10S/17822).	Replacement of phonic wheel disc (photo-emulsion) and flexible coupling by phonic wheel (etched glass) and dog-clutch coupling.
7897	Gear assembly (Ref. No. 10AR/5696), part of computer, navigational (Ref. No. 10AD/3998).	Replacement of phonic wheel disc (photo-emulsion) and flexible coupling by phonic wheel (etched glass) and dog-clutch coupling.
(8531/2)	Amplifier, audio frequency (Ref. No. 5826-99-970-8110), part of computer, frequency tracker (Ref. No. 10AD/3984).	Gain stabilization. Wiring change prevents feedback between amplifier stages.
8532/5	Rack, electrical equipment M19 (Ref. No. 10D/23420), part of transmitter-receiver, radio M13 (Ref. No. 10D/23419).	Capacitor added to prevent trim capacitor being set to near maximum.
(8533/3)	Rack, electrical equipment M19 (Ref. No. 10D/23419), part of transmitter-receiver, radio M13 (Ref. No. 10AR/5820).	Anti-backlash springs changed and cover support bracket added. Prevents overload of gear assembly.
(8586/5) (production modification or on return to contractor)	Aerial Type M31, (Ref. No. 10B/20083), part of aerial group, M30 (Ref. No. 10B/20082).	Washers fitted to switch assembly; two waveguide slots lengthened. Improved overall v.s.w.r.
(8587/9)	Chassis, electrical equipment M24 (Ref. No. 10D/23464), part of computer, frequency tracker (Ref. No. 10AD/3984).	Relays changed. Prevents large voltage spikes on a.g.c. control lines.

Mod. No.	Unit affected	Brief details
8591/1	Pulse modifier (Ref. No. 6625-99-970-8113), part of computer, frequency tracker (Ref. No. 10AD/3984).	Screened leads added to grid and anode of first valve in each channel. Stability improved.
(8826/2)	Indicator, range, Type M16 (Ref. No. 10Q/16727), part of ARI23085.	Counter, electrical changed. More robust.
(8920/6)	Aerial, Type M31 (Ref. No. 10B 20083), part of aerial group M30 (Ref. No. 10B/20082).	I.F. Amplifier Cable Assembly replaced. Prevents cable damage.
(8921/1) (on return to contractor)	Synchro assembly (Cat. No. 5990-99-944-5855), part of ARI23085 test equipment.	Special spring and washer fitted to synchro rotor. Prevents zero shift.
9147/3	Chassis, electrical equipment Type M25 (Ref. No. 10D/23482), part of test set, performance M29 (Ref. No. 10S/17822).	Mullard c.r.t. not available, replaced by G.E.C. type.
9190/2	Amplifier, velodyne, Type M152 (Ref. No. 10U/17645), part of computer, navigational (Ref. No. 10AD/3998).	Resistor value increased. Prevents velodyne loop oscillation.
9191/2	Amplifier, velodyne, Type M153 (Ref. No. 10U/17636), part of amplifier, synchro signal (Ref. No. 5990-99-970-2380) and test set, performance M29 (Ref. No. 10S/17822).	Resistor value increased. Prevents velodyne loop oscillation.
(9311/3)	Interconnecting box, Type M5 (Ref. No. 10AD/3986), part of ARI23085.	Mounting lugs replaced by mounting plate.
9508/6	Rack, electrical equipment Type M19 (Ref. No. 10D/23420), part of transmitter-receiver, radio M13 (Ref. No. 10D/23419).	Capacitor value changed. Improved interchange of R.F. oscillator M35.
(9595/7) (on return to contractor)	Aerial, Type M31 (Ref. No. 10B 20083), part of aerial group M30 (Ref. No. 10B 20082).	Reduction of electrical noise.
◀ 0679/1	Amplifier, photo electric cell Type M150, part of amplifier synchro signal (Ref. No. 10U/9702380) and computer, navigation (Ref. No. 10AD/3998).	Resistor 3R3 changed in vaule from 1·2 kilohms to 100 ohms. **Note . . .** *This modification should be embodied concurrently with Mod. No.*0680/2 *and Mod. No.* 0681/3.
(0680/2)	Generator, reference signal (Ref. No. 10K/21884), part of amplifier, synchro signal (Ref. No 10U/9702380) and test set, performance M29 (Ref. No. 10S/17822).	Photo electric cell 5V1(10E/13258) replaced by a new type (CV8478). **Note . . .** *This modification should be embodied concurrently with Mod. No.* 0679/1 *and Mod. No.* 0682/4.
(0681/3)	Gear assembly, resolver (Ref. No. 10AR/5696), part of computer, navigation (Ref. No. 10AD/3998).	Photo electric cell 5V1 (10E/13258) replaced by a new type (CV8478). **Note . . .** *This modification should be embodied concurrently with Mod. No.* 0679/1. ▶

Mod. No.	*Unit affected*	*Brief details*
◀ 0682 4	Chassis, electrical equipment (Ref. No. 10D/17646), part of test set, performance M29 (Ref. No. 10S 17822).	Resistor 1R97 changed in value from 1·2 kilohms to 100 ohms. **Note . . .** *This modification should be modified concurrently with Mod. No.* 0680/2.
0891 8	Aerial Type M31 (Ref. No. 10B/20083), part of aerial group Type M30 (Ref. No. 10B/20082).	Replacement of control transformer (synchro) 1X2 by a brushless type
(1356 1)	Chassis, electrical equipment (Ref. No. 10AR/5990-99-970-2381), part of amplifier synchro signal (Ref. No. 10U/5990-99-970-2380).	Spacers of plug PLH1 and collars of plug PLH2 have been reduced in length to ensure positive mating of the amplifier synchro signal with its backplate.
A2137 8	Rack, electrical equipment Type M19 (Ref. No. 10D/23420), part of transmitter-receiver, radio M13 (Ref. No. 10D/23419).	Thermal cut-out 1X4 introduced, to avoid risk of damage to 1V12 if motor IM01 fails. ▶

PART 1

GENERAL INFORMATION

SECTION 1

GENERAL

Chapter 1
AD2300 DOPPLER NAVIGATION EQUIPMENT

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LIST OF ILLUSTRATIONS

Introduction

1. The Marconi AD2300 Doppler navigation equipment (ARI.23085) is a self-contained, airborne, radio navigational aid operating in the X band. It is designed to combine high accuracy and fully automatic operation with the minimum of pre-flight setting up and alignment. Major units of the equipment are fitted in cases conforming to ATR sizes and require a 115V or 200V, 400 c/s, 3-phase a.c. supply from the aircraft system.

2. Two versions of the equipment are in service in the RAF. These are:

ARI.23085/1 which is the standard single-channel installation, providing ground speed, drift angle, distance flown and track guidance information on a simple or composite track flight plan. An ARI.23085/1 installation consists of eight units—transmitter-receiver, aerial, tracking unit, computer and display unit, two indicators and a junction box.

ARI.23085/3 which is the dual-channel installation. In effect, this consists of two of each of the major units used in ARI.23085/1 but does not include the computer and display unit. Instead, an amplifier, synchro signal (indicator drive unit) is fitted. In addition there is a combined switching unit and junction box. The ARI.23085/3 installation is coupled to the Decca GPI Mk. 7 described in A.P.1275B, Vol. 1, Sect. 16A.

3. In both installations ground speed and drift angle are instantaneously measured and displayed and these displays are continuous during the time the equipment is in operation. Hence, variations in speed and track caused by changing conditions are immediately apparent. The measures necessary to counter these changes can be applied instantly, thus making possible more accurate and simpler navigation.

4. Two test sets provide comprehensive test facilities. They may be used in the aircraft for performance checking or fault location and can be employed to advantage in the workshop when testing and aligning the equipment.

5. Salient features of the ARI.23085 equipments are:

(1) The use of a low-noise, frequency modulated carrier wave technique which, for all practical purposes, removes the difficulties encountered when using conventional carrier wave systems. These difficulties are usually associated with the cross-coupling effect resulting from the transmitted signal being fed direct to the receiver aerial and from spurious modulation of the transmitter caused by vibration.

(2) A signal-to-noise ratio circuit which continuously monitors the received Doppler

signal spectrum. If the signal-to-noise ratio falls below what is considered to be a usable level or if, for any reason, there is a temporary interruption of the received signal, a memory facility is brought into operation to ensure continuity of indication. While the system is operating under memory conditions, the ground speed and drift indicators continue to indicate the last recorded values until such time as a valid usable signal is received.

(3) An automatic search system so designed that the Doppler spectrum is continuously monitored, ensuring that the follow circuits are locked on to the correct signal without the necessity for manual adjustment of the equipment either at take-off or at any time during flight.

(4) The use of a simple, mechanical, moving aerial, thus simplifying the circuitry. This results in a higher degree of reliability as well as making servicing easier.

(5) There is no loss of signal due to the power of the sideband falling to zero when the aircraft is flying at one of the critical heights where the delay between transmission and reception of the frequency modulated signal is equal to a full cycle of the modulation frequency.

(6) A fan-shaped aerial beam ensures that the signals are spread over a considerable range and the use of a modulation signal whose frequency is varied (wobbulated) causes the position of the critical heights to vary. By these means it is possible to obtain a signal of satisfactory strength at all times, except under extremely unfavourable conditions, for instance, when flying at high altitude over a calm sea.

(7) The incorporation of test circuits which facilitate the functional checking of the equipment both on the ground and in flight. A further aid to pre-flight checking and to fault location is a portable test set. Comprehensive test facilities provided by the test set permit certain important circuit parameters to be checked rapidly and a fault can be traced to a specific unit without the necessity of access to any major unit. The plug-in sub-unit principle is employed throughout the equipment, thereby simplifying fault location, providing easy access to components and expediting periodic overhaul and inspection.

DETAILS OF UNITS

General

6. The two Service versions of the AD2300 equipment for which information is given in this publication are ARI.23085/1 and ARI.23085/3. ARI. 23085/1 is employed in single-channel installations to provide ground speed, drift angle, distance flown and track guidance information. A complete. ARI.23085/1 installation consists of the units listed below:

Transmitter-receiver, radio, Type M.13
Aerial group Type M.30
Computer, frequency tracker, air navigation
Indicator assembly Type M.15
Indicator, range, Type M.16
Navigation computer Type B
Indicator assembly, display head, Type M.14
Interconnecting box Type M.5.

7. ARI.23085/3 is similar to ARI.23085/1 but has two transmitter-receivers, two aerials and two tracking units. In addition, the navigation computer Type B is replaced by a two-channel amplifier, synchro signal (indicator drive unit) and a switching junction box replaces interconnecting box Type M.5. A Decca GPI Mk. 7 is used in conjunction with the dual-channel installation.

8. The equipments operate from a 115V or 200V, 400 c/s, 3-phase a.c. supply. Major units are designed for operation with ARINC cooling systems or for satisfactory cooling by convection. The plug-in unit principle of construction facilitates access to components for servicing purposes.

Transmitter-receiver Type M.13

9. This unit is housed in a long ¾ ATR case and is unpressurized. It consists of a two-deck chassis assembly with a hinged sub-chassis and contains three plug-in sub-units.

10. The transmitter klystron produces a c.w. output of approximately 1W at a nominal frequency of 8800 Mc/s frequency modulated by a 168 to 232 kc/s (200 kc/s $\pm 16\%$) signal, the modulation signal being swept between the limits of 168 to 232 kc/s at the rate of ten times per minute. From the klystron the r.f. output is waveguide-fed to aerial group Type M.30. A ferrite isolator assembly fitted in the transmitter-receiver isolates the klystron from reflections caused by any mismatch in the aerial or waveguide, thus ensuring stability of frequency and power output level.

11. The microwave assembly in the transmitter-receiver also contains a directional coupler into which is inserted a crystal detector. The crystal detects any amplitude modulation present on the output waveform and the resultant output is fed to the control, elec. freq. Type M.40 sub-unit in the transmitter-receiver. This sub-unit contains the automatic mode centring circuit for the klystron described in para. 42.

12. A series cascode regulator circuit is employed to provide a stable e.h.t. supply for the klystron and the klystron heater supply is smoothed d.c., this obviating spurious modulation of the klystron output.

13. The i.f. signal from the aerial-mounted first i.f. amplifier is amplified by a single amplifier stage in the receiver circuits before it is passed to a mixer bridge. The audio frequency output (the Doppler signal) resulting from the mixing of the i.f. signal and a swept-frequency signal (504 to 696 kc/s) generated in the transmitter-receiver is fed via a cathode follower to computer, frequency tracker, air navigation.

Aerial group Type M.30

14. Aerial Type M.31, which is the major component of aerial group Type M.30, is a simple moving aerial of the slotted-waveguide type and produces the four-beam transmission pattern necessary to obtain speed, drift and pitch information. It is mounted in a suitable position on the underside of the aircraft and is protected by a radome or panel as appropriate. Closed-loop servo control systems are used to align the array in the pitch and azimuth planes, the control signals being derived from the received Doppler signal.

15. The aerial array consists of two matched pairs of slotted waveguides lying parallel to one another in a directional horn assembly, with the axis of the aerials horizontal. Forward and rearward beams are obtained by feeding from each end of the transmitting waveguides in turn: two of the slotted waveguides are used for transmission and two for reception. The direction of feed is arranged by a rotary waveguide switch mechanism driven by a motor, cam and geneva mechanism.

16. Two plug-in units on the upper surface of the array contain the first i.f. amplifier and servo amplifier circuits. The servo amplifier amplifies the signals which are applied to the pitch and drift motors. Aerial Type M.31 has an operational swing of $\pm 30°$ in azimuth and $\pm 10°$ in the pitch plane. The i.f. signal, produced by mixing the received signal with a small proportion of the transmitted signal in a hybrid ring balanced mixer, is amplified by the first i.f. amplifier before passing to transmitter-receiver Type M.13.

Computer, frequency tracker, air navigation

17. The tracking unit is housed in an unpressurized long ½ ATR case. It consists of a main chassis assembly to which a number of components and a detachable sub-unit are secured. This chassis provides a mounting for six plug-in sub-units.

18. The unit contains the frequency comparison circuits for determination of ground speed, drift and pitch angles. Tracking of the signal is achieved by comparing the frequency of the received Doppler signal with that of a highly stable variable-frequency tone produced in navigation computer Type B or (in the dual-channel installation) in the amplifier, synchro signal. Circuit action within the tracking unit results in an automatic search of the Doppler spectrum and lock-on to a correct signal so that no manual setting of the tracking circuits to an estimated ground speed before or during flight is necessary. The signal resulting from the comparison of the two frequencies is used to control the speed integrator as well as the aerial azimuth and pitch drive circuits.

19. The integrator circuit controls the speed of a reference signal generator motor (in the computer or amplifier, synchro signal) and the speed of this motor is an analogue of the aircraft's ground speed. The azimuth drive circuit controls the movement of the drift drive motor in aerial Type M.31 to align the aerial array along the aircraft track and this provides a direct indication of drift angle. Similarly, the pitch drive circuit aligns the axis of the aerial with the aircraft's flight path.

20. Other circuits in the tracking unit produce the a.g.c. voltage which is applied to the aerial-mounted first i.f. amplifier; measure the signal/noise ratio of the received signal for automatic signal/memory operation; and control the application of the d.c. supply to the three-position flag indicator in indicator assembly Type M.15.

21. The tracking unit also contains a follow-failure circuit which monitors the drive to the follow system. If the drive signal falls below the level which permits satisfactory follow operation, the monitor circuit causes the flag indicator in indicator assembly Type M.15 to give the OFF indication.

22. The system incorporates test circuits which permit the in-flight checking of the tracking circuits while operating under signal conditions or of certain circuits in both tracking unit and transmitter-receiver when the system is operating under memory conditions.

Navigation computer Type B and indicator assembly

23. Navigation computer Type B and indicator assembly, display head, Type M.14 are interdependent and are used in the ARI.23085/1 installation. The computer is housed in an unpressurized short ½ ATR case and consists of a main chassis carrying six plug-in sub-units. The components of the indicator assembly are mounted on three light alloy plates (front panel, gearplate and backplate). All controls and indicators are brought out to the front panel, illumination for which is provided by a Plasteck panel and screw-in lamps.

24. The computer accepts

(1) Ground speed and drift signals, derived from the Doppler signal by the tracking unit.

(2) Heading reference signal from the aircraft's compass system.

(3) Desired track angle which is normally set in on the display unit.

25. The computed outputs are

(1) Distance flown along track. This signal drives the active distance (DIST) counter in the display unit towards zero, subtracting the distance flown along track from the total length manually set in.

(2) Distance displacement from track. This signal drives the across distance (ACROSS DIST) counter in the display unit to indicate the aircraft's displacement to left or right of the desired track. It can also be used to drive a

pilot's left-right steering indicator and is smoothed to provide the signal required for autopilot control.

(3) Track error angle. This output is not displayed but is available for autopilot control.

Other outputs are available for driving an indicator, range, Type M.16 and an indicator assembly Type M.15.

Amplifier, synchro signal

26. Amplifier, synchro signal (indicator drive unit) is used in the dual-channel installation (ARI. 23085/3) in lieu of computer Type B. The unit is housed in an unpressurized long $\frac{3}{8}$ ATR case and consists of a chassis assembly on which are mounted twelve plug-in sub-units. The inputs are speed and drift information derived from the Doppler signal by the tracking unit and from this information the amplifier produces 3-wire synchro outputs suitable for driving the pointer-type speed and drift displays. In addition, there is a further 3-wire synchro output which is used to control the drift servo system of the aerial. The variable frequency reference signal, which is fed to the tracking unit for frequency comparison purposes, is produced in amplifier, synchro signal.

27. Cam-operated contacts in the rèference signal generator assembly provide the pulsed d.c. supply necessary for the operation of the elèctro-magnetic counting mechanism in indicator, range, Type M.16. Since the speed of the reference signal generator motor is proportional to ground speed and the contacts are operated by a cam driven (through reduction gearing) by that motor, distance flown is given to the same degree of accuracy as ground speed.

Indicator, range, Type M.16

28. This unit gives a counter-type presentation of nautical miles flown up to a maximum of 9999·9 in 0·1 nautical mile increments. A $3\frac{1}{4}$ in. SAE case, modified slightly to accommodate the combined on/off switch and resetting control, houses the counting mechanism. Voltage pulses necessary for the operation of the electro-magnetic actuating mechanism are obtained from cam-operated contacts in either the reference signal generator assembly of the amplifier, synchro signal (ARI. 23085/3) or the resolver gearbox of computer Type B (ARI.23085/1).

Indicator assembly Type M.15

29. This unit, which is the speed and drift indicator, is a dual pointer, circular scale indicator housed in a modified $3\frac{1}{4}$ in. SAE case. Ground speed is indicated on the outer scale by the larger pointer while the smaller pointer indicates drift, to port or starboard, on the inner scale. The ground speed scale is graduated in 10-knot increments from 80 to 900 knots and the drift scale is graduated in 1° steps to a maximum of 30° in each direction from a centre zero position.

30. The two pointers are driven by synchro receivers, the stator windings of which are connected to the stator windings of the speed and drift synchro torque transmitters in computer Type B (ARI.23085/1) or in amplifier, synchro signal (ARI.23085/3).

31. A second function of the indicator is to provide, by means of a three-position magnetic indicator, information concerning the condition under which the system is operating. When signal conditions prevail, an all-black flag is visible and this gives way to a black M on a yellow background when the system is operating under search conditions. The third presentation is a black OFF on a red background, displayed when no power is applied to the installation or a failure of the follow system occurs.

32. A spring-loaded TEST button, fitted below the face of the indicator, is used to initiate a functional test of certain circuits of the equipment either prior to or in flight.

Junction boxes

33. Both single and dual-channel installations employ junction boxes. Interconnecting box Type M.5, used in ARI.23085/1, is a box of light alloy construction carrying eight plugs and sockets which mate with the unit interconnecting and power supply cables. The box used in ARI.23085/3 is similar in construction but has additional sockets to meet the requirements of the second channel. This box also carries a three-position switch providing channel 1, off, channel 2 selection.

SYSTEM DESCRIPTION

General

34. The object of the following paragraphs is to provide an overall picture of the functioning of a complete system. This description is based on the single-channel installation and the differences between ARI.23085/1 and 23085/3 are shown only in block diagram form.

Production of the Doppler signal

35. A block diagram of the ARI.23085/1 installation is given in fig. 1. The transmitter klystron produces a c.w. output of approximately 1 watt at a nominal frequency of 8800 Mc/s which is modulated by a swept frequency signal. This modulation signal, produced in the transmitter-receiver, is swept between the limits of 168 to 232 kc/s ten times a minute by the action of a motor-driven variable capacitor.

36. The klystron output is fed via a waveguide to the aerial array consisting of two transmission and two reception elements. The linear array, formed by four slotted waveguides mounted side by side in a reflector assembly, has in-phase and out-of-phase elements and a system of providing the four beams necessary to obtain ground speed, drift and pitch information. The method employed is to switch mechanically the direction of feed for the respective transmission and reception elements. The result of this switching is a transmission pattern which consists of four sequentially switched beams whose depression and broadside (or lateral) angles are 67° 14 min and 20° with a beamwidth of 3° 15 min × 26° at the 3dB points.

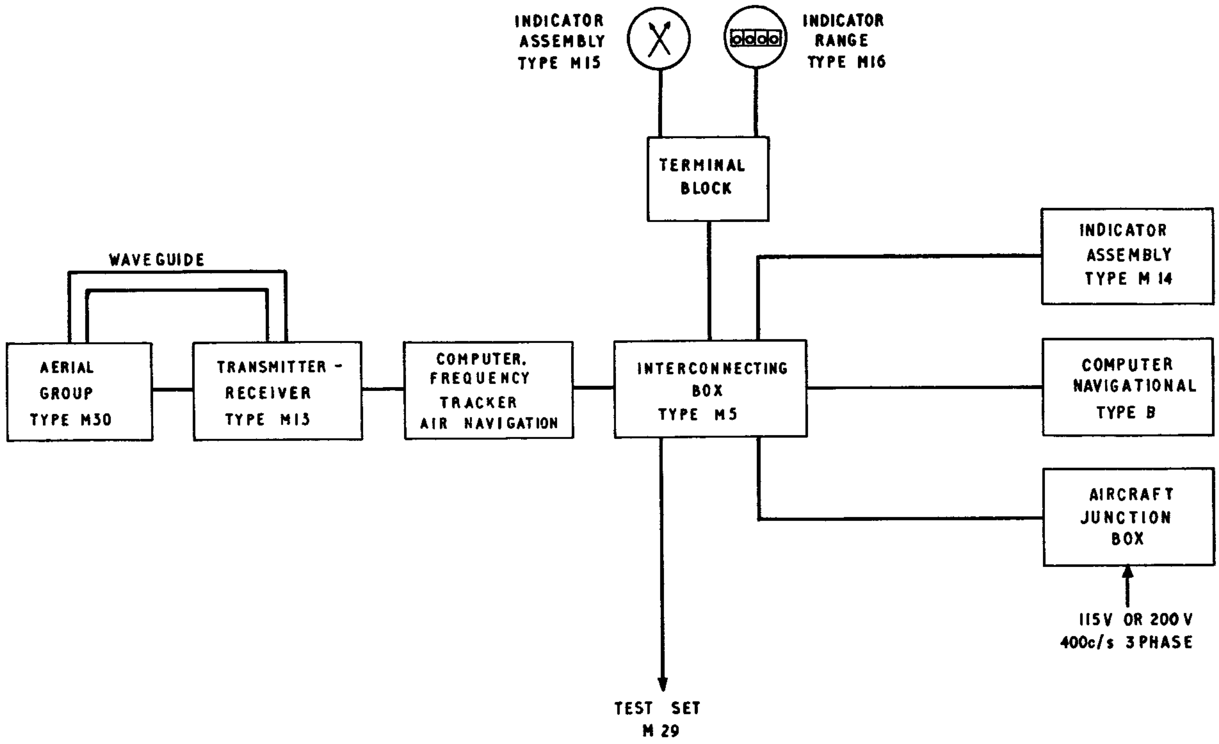

Fig. 1. ARI.23085/1: block diagram

37. The radiation and reception sequence of the signals is port forward, starboard aft, starboard forward, port aft, signals being transmitted and received for a period of 380ms in each direction. A complete switching sequence occupies a period of 2 seconds, signal blanking occurring for 120ms each time the waveguide switch moves from one position to the next. Thus, the transmitter signal is radiated towards ground and the reflected signal is received by the relevant reception element, since the switching is so arranged that when an in-phase transmission element is in use an out-of-phase element is employed for reception and vice versa.

38. The received signals are subject to Doppler shift; those from the forward beams are increased in frequency in proportion to the ground speed of the aircraft while those from the rear beams are decreased in frequency with respect to the original transmission frequency.

39. From the reception elements the signals pass, via the waveguide switch, to a hybrid ring mixer where they are mixed with a small preset proportion of the transmitter signal obtained via a directional coupler. The output of two suitably biased diodes, fitted in the hybrid ring, is fed to the first i.f. amplifier which is tuned to select the third sideband (504 to 696 kc/s). The delay of the rise in amplitude of this sideband provides rejection of near echoes and cross-coupled signals while the amplitude of the reflected signals remains at a workable level.

40. The first i.f. amplifier has a low-noise cascode stage followed by two normal stages with a.g.c. and produces an i.f. signal of high signal/noise ratio which is fed to the second i.f. amplifier in the transmitter-receiver.

41. In the second i.f. amplifier the i.f. signal (504 to 696 kc/s plus Doppler shift) is mixed with the third harmonic (504 to 696 kc/s) of the modulation signal and the output from the mixer bridge (the Doppler signal) is fed to the tracking unit.

42. To ensure that the transmitter klystron operates at the centre of its mode, an automatic mode centring circuit is incorporated in the transmitter-receiver. A signal from the modulation signal generator and a sample of any amplitude modulation present on the transmitter output waveform (due to the klystron not operating at the centre of its mode) are applied to a phase-sensitive rectifier. A d.c. output with polarity and magnitude dependent upon the phase difference of the two signals and the magnitude of the transmitter sample, is passed to a control valve forming part of the klystron e.h.t. regulator circuit.

43. The application of the d.c. output from the mode centring circuit to the regulator causes a change in the e.h.t. voltage applied to the klystron. This e.h.t. voltage is increased or decreased, as appropriate, to bring the klystron back to the centre of its mode so that, for all normal changes.

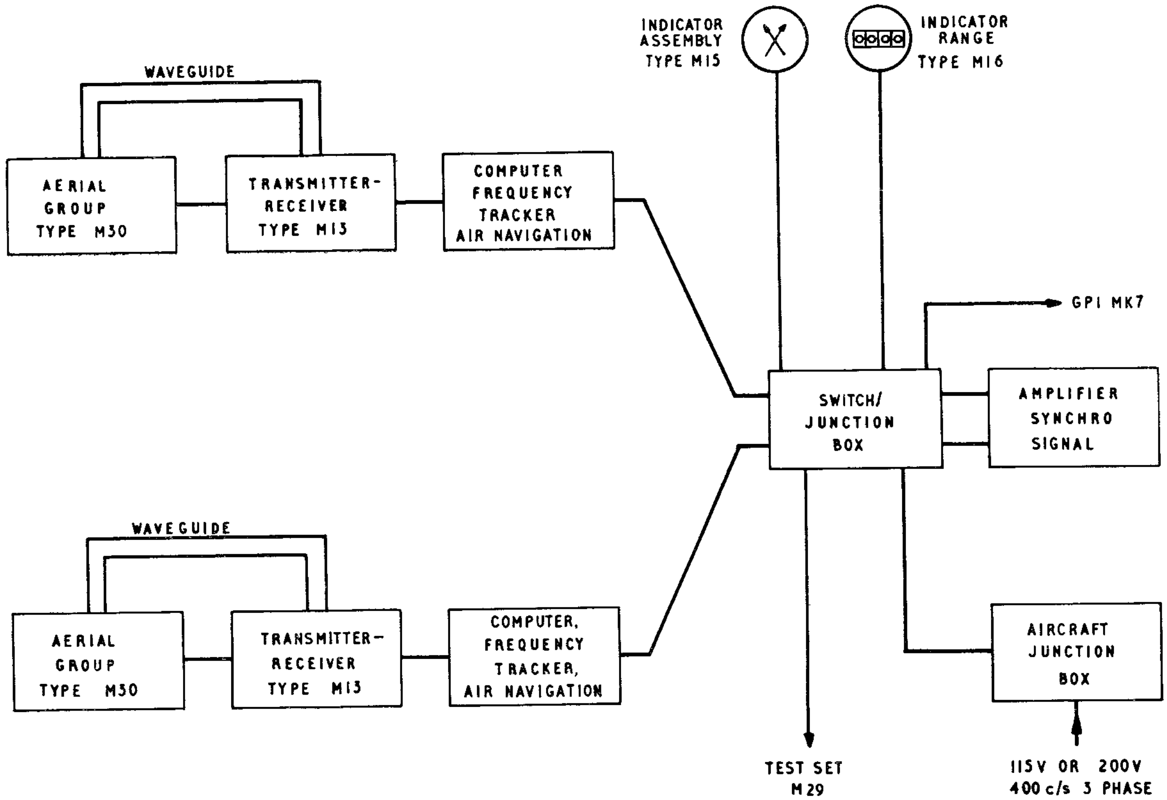

Fig. 2. ARI.23085/3: block diagram

of input voltage or output circuit loading, the regulator maintains the e.h.t. voltage at a constant level. Thus, changes in the mode of oscillation of the klystron are due solely to physical changes brought about, for instance, by ambient temperature variations.

44. The tracking unit controls, either directly or indirectly, the operation of all other units in the system. Normally, it functions under signal conditions (i.e. the unit is in receipt of a signal which is considered to be of an acceptable signal/noise ratio) and is able to make an automatic search of the Doppler spectrum and rapidly lock on to the correct signal. As soon as the unit has locked on to a signal the follow circuits become operative, the changeover being made automatically. For all normal flight manoeuvres and speed changes the follow circuits maintain effective control of the speed, drift and pitch servo control loops.

Search operation

45. Consider, first, the operation of the tracking unit and associated circuits under search conditions (fig. 3). The a.f. Doppler signal from the transmitter-receiver is amplifier and, from two cathode followers, divides to follow two distinct paths. The output of one cathode follower is fed to the tuned circuit panel where it is used for the production of the a.g.c. voltage and measurement of the signal/noise ratio. The output of the other cathode follower is passed to the frequency comparison (mixer) circuits and then to further amplifiers which provide control (or drive) signals for the speed, drift and pitch integrator motors. For the 120ms period when the aerial waveguide switch is moving from one position to the next, the output of the cathode followers is earthed by the contacts of a relay the operation of which is controlled by blanking contacts in the aerial waveguide switch and gearbox assembly.

46. When a difference exceeding 10% exists between the frequency of the reference signal generated in the computer and that of the Doppler signal, the dominant signal path is that containing the tuned circuits of the tuned circuit panel. Such a difference occurs when the equipment is switched on at the start of a flight leg with an aircraft ground speed of, say 300 knots, after it has been switched off at the end of a previous flight when the ground speed was, for instance, 200 knots.

47. The tuned circuit panel has a drive amplifier stage in whose cathode circuit is an untuned transformer while the anode load is formed by 18 tuned circuits (Part 2, Sect. 1, Chap. 2, fig. 17 and 18). The rectified outputs of the untuned transformer and the tuned circuits are fed to a signal comparator stage. Under signal conditions the output from the tuned circuits is greater than that from the untuned transformer with the result that the relay control valve conducts and in so doing energizes the primary and secondary signal/noise relays. As a result, a h.t. supply is applied to a power amplifier.

48. The 18 tuned circuits are tuned to frequencies contained in the band 800 c/s to 13 kc/s approximately and the resultant composite response curve is relatively flat over the entire spectrum, with individual response curves crossing at −3dB points. Thus, when the Doppler signal is fed to the tuned

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circuits, an output is produced by one of them. The circuit in which this occurs is dependent upon the frequency of the incoming Doppler signal which, in turn, is proportional to aircraft ground speed. Due to the action of the rectifiers in each tuned circuit, current pulses or pips are produced and these are fed, via relay contacts, to a bank of a.g.c. capacitors. Since the operation of the relays is controlled by cam-operated springsets in the aerial waveguide switch assembly, the capacitors are sequentially switched, one being in circuit for each direction of transmission and reception. During the time each capacitor is in circuit a negative charge is built up on it and is applied to a cathode follower. This negative potential varies in proportion to the power density of the Doppler signal and switching the capacitors ensures that an a.g.c. voltage at the correct level is fed to the first i.f. amplifier for each direction of reception.

49. Pips are also fed from the tuned circuit panel to the commutator section of a commutator potentiometer which has two segments, each maintaining contact with its own output brush over the whole of the effective rotation while the 16 input brushes are spaced evenly over the effective range. From the relevant output brush the pips pass to a pip amplifier. Here they are amplified and integrated and cause the search up or search down relay to be energized. As a result, 6·3V 400 c/s a.c. signals with a phase-quadrature relationship are fed to a pre-amplifier and then to a power amplifier. The output from the power amplifier is applied to the speed and pitch motors in the tracking unit and to the speed motor in computer Type B.

50. The speed motor in the tracking unit is coupled via a gear train to the commutator potentiometer and rotates until the drive signals are removed when the gap between the two segments of the potentiometer commutator wiper is opposite the pin from which pips were being fed to the pip amplifier. In this position no pips are fed to the amplifier, the search up or search down relay reverts to the de-energized state and the 400 c/s signals are no longer fed to the motors.

51. Since the commutator and resistive sections of the potentiometer are driven by a common shaft, the potentiometer wiper is also rotated as the tracking unit speed motor rotates and an increasing or decreasing potential (depending upon the direction of rotation of the motor which, in turn, depends upon whether the reference signal frequency lies above or below that of the Doppler signal) is fed to the speed servo circuits of computer Type B.

52. The 400 c/s a.c. signal fed to the computer is amplified in a speed amplifier and the output from this circuit energizes the control windings of the speed servo motor. This motor drives the shaft of the speed potentiometer as well as that of a synchro torque transmitter. A voltage derived from the speed potentiometer is fed to a velodyne amplifier and as a feedback potential to the speed amplifier. The result of any change of input to the velodyne amplifier is an increase or decrease in the reference signal generator motor speed and hence of reference signal frequency. Through the action of the speed servo control loop, the frequency of the reference signal is within 10% of that of the Doppler signal at the instant when drive is removed from the speed motor in the tracking unit. The follow circuits now become operative and for all normal flight conditions maintain control of the speed, drift and pitch circuits.

53. The synchro torque transmitter in the computer transmits a 3-wire synchro output to the speed pointer of the speed and drift indicator (indicator assembly Type M.15) and, once the system has locked on to a signal, the pointer indicates the actual ground speed of the aircraft.

54. While the tracking unit is operating under search conditions, a 28V d.c. supply is connected, via contacts on the search up or search down relay, to the flag indicator in indicator assembly Type M.15 and the memory flag is displayed. As soon as the system has locked on and control has passed to the follow circuits, this supply is removed from the memory flag circuit and connected to the signal flag circuit. The signal flag now becomes visible and remains displayed as long as the system is operating under signal conditions.

Follow operation

55. Once the system has satisfactorily locked on to the Doppler signal, the frequency comparison (mixer) circuits which form part of the follow system become operative. The amplified Doppler signal at the signal amplifier output is fed to bridge mixers (fig. 4) where it is mixed with the amplified reference signal applied via a phase splitting and quadrature network. Assuming that a frequency difference exists between the two inputs, an output, consisting of sum and difference frequencies, is fed from the mixers via contacts on the now de-energized search relays to the tracking unit pre-amplifier.

56. Here the difference frequencies are selected, amplified and passed to the power amplifier, the output from which is applied, as under search conditions, to the motors. Production of the a.g.c. voltage continues and, due to the predominance of the Doppler signal, the signal/noise relays are energized so that the h.t. supply is connected to the power amplifier.

57. The speed motor in the tracking unit responds to the drive signals applied and in so doing drives the wiper of the commutator potentiometer. The potentiometer output is thus varied and whenever there is a slight increase or decrease in ground speed the velocity of the reference signal generator motor is altered accordingly. Since the frequency of the reference signal is directly proportional to motor speed, the frequency increases or decreases until it is identical with the Doppler signal frequency. When this condition exists, no sum or difference frequencies are produced by the bridge mixers and there is no drive to the speed motor in the tracking unit.

58. Distance travelled information is provided by indicator, range, Type M.16 which receives d.c. impulses for the operation of its electro-magnetic counters from cam-operated contacts in the reference signal generator assembly of the computer. The cam which operates the contacts is coupled to the reference signal generator drive shaft. This shaft rotates at a speed proportional to the ground speed of the aircraft so that the contacts are operated at a rate which is a function of ground speed and distance flown is given to the same degree of accuracy as ground speed.

Aerial servo control

59. In order that the aerial array may be aligned along the aircraft's track in azimuth and along the flight path in the pitch plane, signals from the power amplifier in the tracking unit are applied to a drift motor in the computer and a pitch motor in the tracking unit. If the array is misaligned in azimuth due to drift, the Doppler signals from the port and starboard directions have a high/low frequency difference instead of having the same frequency which occurs when the array is aligned along the aircraft's track. The output from one pair of valves in the tracking unit power amplifier is applied direct to the drift integrator motor in the computer and the output from the other pair, in phase-quadrature, is fed to the motor via contacts on the drift sense relay. The operation of this relay is controlled by the drift sense contacts in the aerial waveguide switch and gearbox assembly, the on/off characteristic of the relay being 1 second in the energized state and 1 second in the de-energized state.

60. The direction of rotation of the motor is governed by the relative phasing of the signals applied to the motor. This phasing is dependent upon whether the difference frequency is obtained from a component of the Doppler signal which lies above or below the reference signal generator frequency. The motor thus rotates in a direction depending upon whether the aerial is misaligned to port or starboard of track and drives, via gearing, a synchro torque transmitter and control transmitter.

61. The torque transmitter has its stator windings connected to those of a synchro receiver which drives the drift pointer on indicator assembly Type M.15 while the control transmitter is connected to an aerial mounted synchro control transmitter whose output (the error signal) is fed to the drift servo amplifier.

62. This error signal causes the aerial drift motor to turn the aerial array until the Doppler signals from port and starboard are on the same frequency. When this condition exists there will be no net drive to the drift integrator motor and the aerial will be aligned along the true track.

63. Similarly, if the aerial array is not aligned along the flight path in the pitch plane, there is a frequency difference between the fore and aft Doppler signals which causes the pitch integrator motor in the tracking unit to rotate. The control signals for this motor are applied via contacts of the pitch sense relay, the operation of which is controlled by the pitch sense contacts in the aerial waveguide switch and gearbox assembly. These contacts make and break every half-second. Coupled to the motor is an a.c. pick-off and the output of this is fed to the pitch servo amplifier. This causes the pitch motor to be energized and the aerial array is elevated or depressed, as necessary, until the fore and aft Doppler signal frequencies are identical.

64. Mechanical linkages, attached to one end of the body of the aerial array and to the rotors of the control transformer and pitch a.c. pick-off, turn the rotors as the aerial is moved in the appropriate direction, thus providing a position feedback signal for each closed loop system.

Memory operation

65. Consideration has so far been given to the operation of the system under signal conditions but, in certain circumstances, operation may occur under what are termed memory conditions. In the event of the signal/noise ratio of the Doppler signal falling below an acceptable level, circuits within the tracking unit cause the system to change over automatically to memory operation.

66. Degradation of the signal/noise ratio may occur if the aircraft is flying at a considerable height over a very calm sea or if a fault occurs in the transmitter-receiver or signal amplifier circuits of the tracking unit. Test facilities incorporated in the system make it possible for the pilot to ascertain readily which factor is responsible for memory operation and the flag indicator in indicator assembly Type M.15 provides a visual indication of the condition under which the system is operating.

67. If, for one of the reasons given in the preceding paragraph, the incoming signal degenerates to the point where the Doppler signal content is small compared with the noise, the signal comparator circuit in the tracking unit causes the signal/noise relays to be de-energized. The h.t. supply to the power amplifier is removed and the signal from the mixer bridges, now with a preponderance of noise, cannot reach the integrator motors. The system thus cannot respond to the noise signal which would otherwise cause the production of erroneous speed and drift information. As there is now no drive signal fed to the speed, drift and pitch motors, the shafts of these motors and those of the synchros driven by the motors remain in the angular positions they occupied immediately before the removal of the drive signal.

68. While the speed motor in the tracking unit is in the quiescent state, the voltage fed to the computer from the resistive section of the commutator potentiometer remains constant at the value prevailing prior to the changeover to memory conditions. In consequence, the speed of the reference signal generator motor in the computer remains constant and the speed pointer continues to indicate the ground speed at which the aircraft was travelling at the time of the changeover. Since the rate of operation of the range indicator mechanism is related to the now constant speed of the reference signal generator motor, the indicator continues to operate at an unchanging rate until a Doppler signal of usable signal/noise ratio is again available.

69. Similarly, with no drive signal applied to the drift and pitch motors, the indicated drift angle remains constant and there is no change in the drive or error signals applied to the aerial drift and pitch servo amplifiers. The aerial array remains in the attitude it occupied relative to the aircraft fore and aft line and flight path before the change from signal to memory conditions.

70. Associated with the change over to memory operation there is a follow-failure circuit in the tracking unit. This derives its inputs, 90° out of phase, from the power amplifier stages and, provided both inputs are present, there is an output from the circuit. When one or both inputs disappears, the loss of output causes a relay to be de-energized so that the d.c. supply to the signal flag indicator in indicator assembly Type M.15 is broken and the flag moves to the OFF position.

Test facilities

71. Test circuits which facilitate instant and positive functional checks of the system both before and during flight are incorporated. These tests are initiated by depressing the TEST button on indicator assembly Type M.15 and the equipment may be checked during flight regardless of the condition (signal or memory) under which the system is operating. If the button is depressed when signal conditions prevail, the tracking circuits are checked. Depressing the button under memory conditions provides a check of the transmitter-receiver and certain circuits in the tracking unit.

72. During flight, with the system operating under signal conditions and all indicators showing normal indications, it may be desired to ascertain, particularly on a long distance flight leg, that the tracking circuits are operating correctly. Circuit action initiated by depressing the TEST button causes the speed and drift servo systems to be inched off. This produces corresponding movements of the ground speed and drift pointers in opposite directions to each other. On releasing the TEST button the received signals will, assuming all units of the equipment are serviceable, return the pointers to the true positions, i.e. the positions they occupied before the button was depressed. To minimize the error introduced by this check (in which the distance flown indicator receives false information) the button is again depressed and speed and drift inching now occurs in the opposite direction. In consequence, the two disturbances average out any error, providing equal displacement is introduced on each occasion.

73. If the system is operating under memory conditions, with the flag in indicator assembly Type M.15 showing OFF, the pilot can ascertain whether such operation has been brought about by deterioration of the Doppler signal or by a fault in the transmitter-receiver or tracking unit. On depressing the TEST button, the transmitter klystron is modulated by an 800 c/s signal. The small proportion of the transmitted signal which breaks through by cross coupling from the transmitting to the receiving waveguides is treated as a normal received Doppler signal and is fed from the transmitter-receiver to the tracking unit. Operation of the TEST button also causes an inhibiting voltage to be applied to the follow-failure circuit so that, assuming there to be no fault in the two units concerned, the signal flag is displayed until the TEST button is released. The pilot is thus assured that the changeover to memory conditions is not due to faulty equipment but to deterioration of the signal/noise ratio of the received signal.

74. It is important to note that the in-flight test facility provides evidence of the correct functioning of the basic sensing elements only. It is not comprehensive and must not be regarded as confirming the accuracy of the instruments.

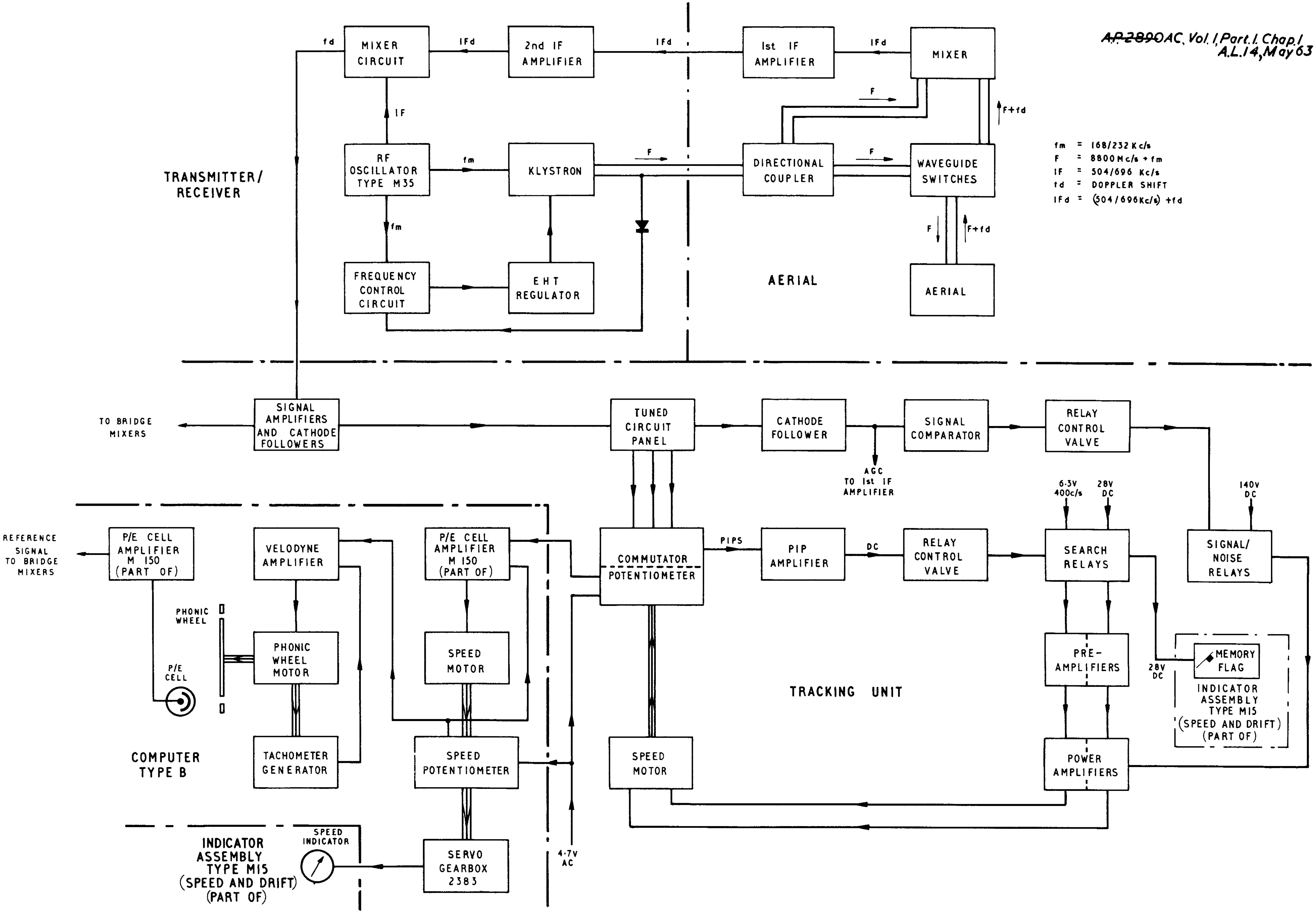


Fig. 3 Search operation: block diagram Fig. 3

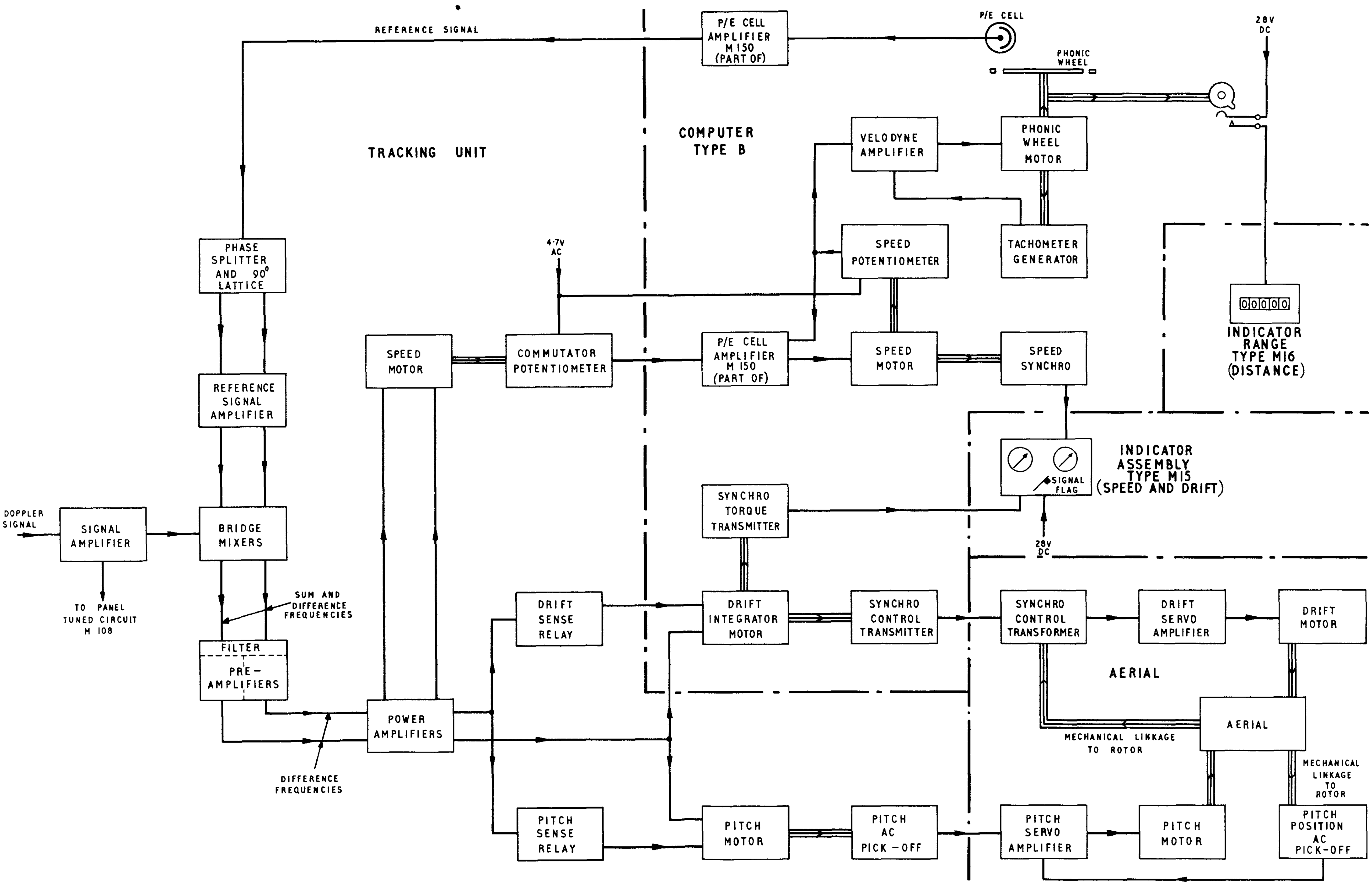


Fig. 4 Follow operation: block diagram Fig. 4

PART 2

TECHNICAL INFORMATION

SECTION 1

DETAILS OF INSTALLATION UNITS

Chapter 1

TRANSMITTER-RECEIVER RADIO TYPE M.13

(*Completely revised*)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Power supply	115 *or* 200*V* ±5%, 400 *c/s* ±5%, 3-*phase a.c.*
Power consumption	150 *watts*
Maximum temperature range	—40°*C* to +70°*C*
Operating temperature range	—40°*C* to +55°*C*
Altitude ceiling	30000 *ft. if no additional cooling is provided* 60000 *ft. when additional cooling at the rate of* 0·6 *lb/min at* 20°*C is provided*
Weight	34·5 *lb* (15·6 *kg*)
Overall dimensions	*Height* 7 25/32 *in.* (19·7 *cm*) *Width* 7 5/8 *in.* (19·4 *cm*) *Depth* 22 11/64 *in.* (56·4 *cm*)
Case size	*Long* 3/4 *ATR*
Type of mounting	*ARINC type shock-mounted tray*
Compass safe distance	8 *ft.*
Transmitter:	
Type of emission	*Frequency modulated c.w.*
Transmitting valve	*Klystron*
Output power	1 *watt* (*approximately*)
Frequency	8800 ±30 *Mc/s*
Modulation frequency	200 *kc/s* ±16% (*swept at* 10 *cycles per min.*)
Modulation index	2·5
Receiver:	
Type	*Superheterodyne with crystal mixer*
Intermediate frequency	600 *kc/s* ±16% (*swept*)
Output	*An a.f. Doppler signal fed to the tracking unit*

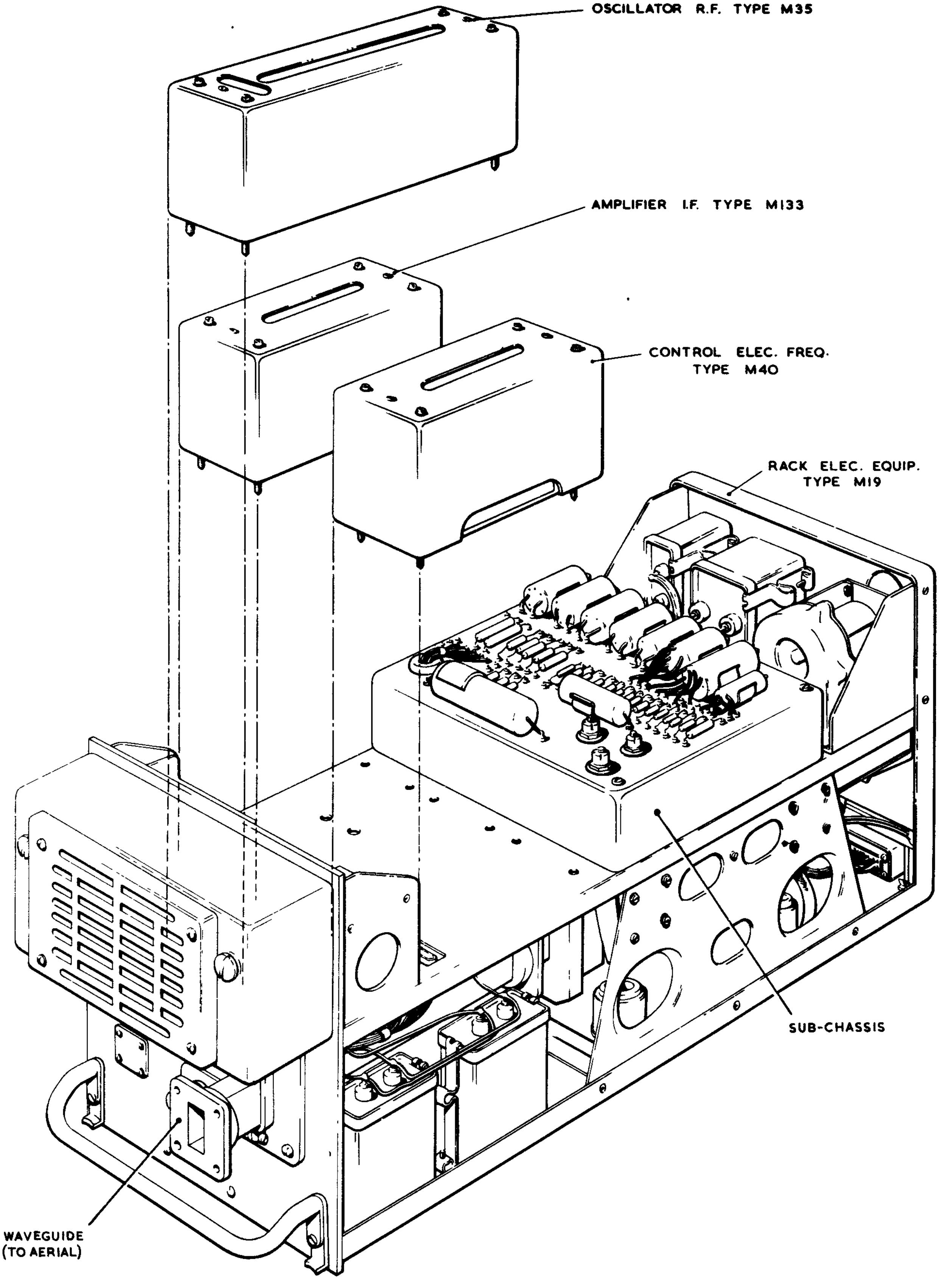


Fig. 1. General view of transmitter-receiver assemblies

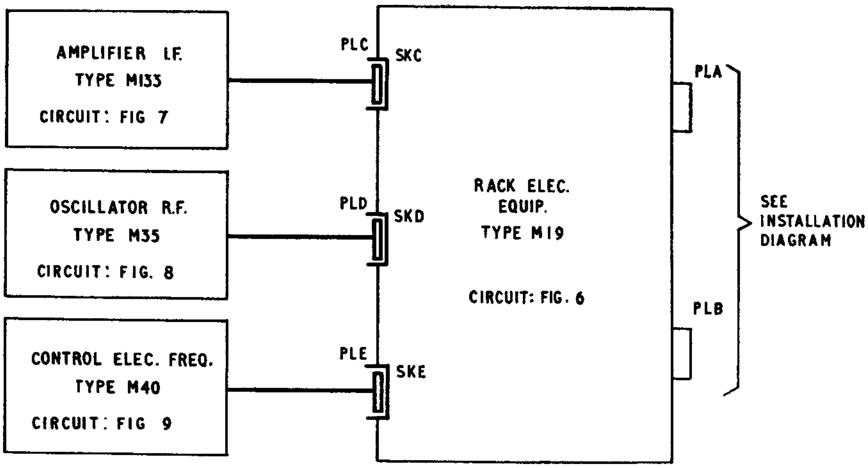


Fig. 2. Schematic arrangement of assemblies

Introduction

1. The principal functions of the transmitter-receiver are as follows:—

(1) The production of a frequency-modulated signal, at a power of approximately 1 watt, which is passed to the aerial for transmission.

(2) The amplification and detection of the i.f. signal, which is fed from the 1st i.f. amplifier, in order to produce a Doppler signal. This signal is then fed to the tracking unit.

Constructional details (fig. 1)

2. The unit consists of a two-deck chassis assembly (component prefix 1) with an integral back plate, and a front panel which is attached to the chassis assembly by screws and shakeproof nuts. The unit is housed in an unpressurized long ¾ ATR case which is retained by a single, quick-release fastener. Major components of the transmitter, and those of the power supply circuit, are located on the bottom deck of the chassis assembly, while the upper deck accommodates three plug-in sub-units, a hinged sub-chassis, and an air blower.

3. The three plug-in sub-units are:—

(1) Amplifier, intermediate frequency Type M.133 (component prefix 2)

(2) Oscillator, r.f. Type M.35 (component prefix 3)

(3) Control, elec. freq. Type M.40 (a.m.c.) (component prefix 4).

4. The hinged sub-chassis carries the components for the e.h.t. voltage regulator circuit. Each plug-in assembly is readily removable from the chassis assembly, electrical connections being effected by miniature plugs and sockets.

5. Protruding through the front panel and protected by a detachable cover are a variable capacitor and drive motor with associated gearing. A short length of waveguide, fitted with a square coupling-flange, also protrudes through, and is clamped to, the front panel. All other external connections are completed by means of two multi-pole plugs attached to the back plate.

6. Forced-air cooling of the klystron is effected by the use of a small air blower. The complete unit may be cooled by an ARINC cooling system or by normal convection cooling. A detachable nylon-mesh air filter is fitted in the front of the cover which protects the variable capacitor and drive motor.

7. Small components are either carried on tag-boards or attached to tags held by small insulated bushes which pass through the chassis. A few groups of functionally-associated small components are resin encapsulated. In all circuits, with the exception of the e.h.t. rectifier circuit, flying-lead base valves are employed. The e.h.t. rectifier valves are fitted in B7G-type bases in an inverted position on the underside of the upper deck.

8. The unit may be operated with an input power supply of 115 or 200 volts, 400 c/s, 3-phase a.c., provided that the connections to the primary windings of the three power transformers and to the two motors are correctly adjusted. A voltage indicating label (located on the front panel) should be fitted in such a manner that it shows the voltage to which the unit is adjusted.

Brief circuit description

9. The following brief circuit description should be read in conjunction with the block diagram of the transmitter-receiver (fig. 3).

10. The frequency-modulated continuous-wave output of the transmitter is produced by a forced-air cooled klystron 1V12, the modulation signal being generated by the swept-frequency oscillator 3V1 in the tone generator assembly. The klystron produces an output of 8800 Mc/s (nominal) frequency modulated by the 168-232 kc/s (200 kc/s ±16 per cent) signal, with a power output of approximately 1 watt. ◀A thermal cut-out IX4 mounted on the outer cooling fin of the klystron 1V12 and connected in series with the earth return connection of the e.h.t. relay IRLA, prevents possible destruction of the klystron and burn damage to adjacent wiring should the blower motor IMO1, supplying cooling air, fail. When the klystron overheats, 1X4 operates, breaking the earth connection, via holding contact IRLA1 to relay IRLA. Relay IRLA de-energizes and causes the e.h.t. supply to the klystron to be cut off, preventing further overheating and possible damage to the klystron. ▶

11. The oscillatory circuit of 3V1 is tuned between the limits 168 to 232 kc/s by a motor-driven variable capacitor, the rotor of which is continuously driven, via anti-backlash spur gears, at the rate of 10 revolutions per minute. From 3V1, the swept-frequency signal is fed, via a cathode-follower stage 3V2 and a filter circuit, to the cathode of 1V12 at a level determined by a preset potentiometer in the cathode circuit of 3V2.

12. A short waveguide-run from the klystron to the front panel is of rectangular cross-section and contains a ferrite isolator 1X3. The undirectional characteristics of the isolator are utilized to provide the klystron with a high degree of isolation from reflections caused by any mismatch which may occur in the aerial or waveguide, and yet cause an almost negligible loss of output power. Also fitted in the waveguide is a directional coupler into which is inserted a crystal 1MR6. The crystal detects any amplitude modulation that may be present on the output waveform, and this small proportion of transmitter output is fed to the a.m.c. assembly where, after amplification by 4V1 and 4V2, it is passed to the phase-sensitive rectifier circuit 4MR1, 4MR2.

13. A 168-232 kc/s switching (or reference) signal taken from the output of the tone generator filter circuit is fed, via the buffer amplifier 3V3, to the phase-sensitive rectifier circuit. The output of this circuit is zero positive d.c. or negative d.c. depending upon whether the klystron is operating at the centre of its mode of oscillation or at a point which is above or below the centre frequency. This output is fed to the control valve 1V14 which is, in effect, part of the potentiometer network of the e.h.t. voltage regulator circuit. Application of the voltage to the grid of 1V14 changes the d.c. impedance of the valve and, ultimately, the e.h.t. voltage is altered in such a sense that the klystron is brought to the centre of its mode.

14. It is essential that the klystron be supplied with a stable e.h.t. supply to prevent frequency instability. The regulated e.h.t. supply of —720 volts (nominal) is produced by the e.h.t. rectifiers 1V5, 1V6, 1V7 in conjunction with a series-cascode regulator circuit formed by valves 1V1, 1V8, 1V9. Any changes of the input voltage or load cause voltage variations in a potentiometer network, and these affect the double-triode 1V9, which is connected to form a cascode circuit. Simlarly, any change in the d.c. impedance of 1V14 (caused by the voltage from the a.m.c. phase-sensitive rectifier) affects 1V9, and in each instance the result is that the effective d.c. impedance of the parallel connected series regulator valves, 1V1, 1V8 is altered. This effects an appropriate increase or decrease of e.h.t. voltage, thus ensuring that the klystron receives a stable e.h.t. supply which permits it to operate at the centre of its mode of oscillation. Four series-connected neon stabilizer 1V2, 1V3, 1V10, 1V1 are used to produce the fixed reference voltage for the cathode of 1V9b, while a further stabilizer valve 1V4 provides a stabilized supply h.t. for the control valve 1V14. The h.t. supply for the other valves in the transmitter-receiver (and those of the aerial) is provided by 1MR1, 1MR2 from a secondary winding of the power supply transformer.

15. The receiver circuits consist of an amplifier stage 2V1 followed by a mixer bridge formed by 2MR1, 2MR2 and associated components. the out-put of which is fed via a cathode-follower stage 2V2 to the tracking unit signal amplifier circuits. The signal from the aerial-mounted 1st i.f. amplifier (504-696 kc/s plus Doppler shift) is amplified by 2V1 before being fed to the mixer bridge 2MR1, 2MR2. Here it is mixed with a swept-frequency signal (504-696 kc/s) produced by the 3rd harmonic amplifier 3V4 in the tone generator, and the resultant a.f. Doppler signal output is fed via cathode-follower 2V2 to the tracking unit (*Chap.* 2.).

16. The circuit diagrams of the four assemblies of the transmitter-receiver are in App. 1, Sect. 1. as shown in fig 2. Reference should be made to the appropriate diagram when reading the following descriptions.

Rack, electrical equipment Type M.19

17. The chassis assembly is basically a two-deck chassis with an integral back plate, and a front panel which is attached to the two decks. The front panel and back plate are suitably braced to produce a rigid mechanical struture on which are fitted the sub-units and components of the transmitter-receiver. Occupying positions on the right-hand side of the bottom deck are the transmitter klystron, ferrite isolator, and microwave assembly: four anti-vibration mountings in both the horizontal and vertical planes support the klystron and ferrite isolator. The remaining space on the bottom deck is taken up by components of the power supply circuits and the wiring to plugs PLA and PLB which are mounted at the rear of the chassis assembly.

18. Small sub-chassis, fitted one on each side at the front of the upper deck, carry a thermal delay switch 1X1 and a voltage stabilizer valve 1V4 respectively. The three assemblies, 2nd i.f. amplifier, tone generator, and a.m.c. assembly, plug in to three sockets which are attached to the underside of the upper deck. Behind these assemblies is the e.h.t. voltage regulator circuit arranged on a hinged sub-chassis which affords easy access to the components attached to the underside. Air, drawn into the unit by a three-phase motor blower through a detachable nylon-mesh filter, circulates around the assemblies on the upper deck and is directed downwards, by the blower, to the klystron. The blower motor, designed to operate on a 115-volt or 200-volt supply, is mounted at the rear of the upper deck, and adjacent to it are two capacitors which are part of the e.h.t. circuit. Protruding from the

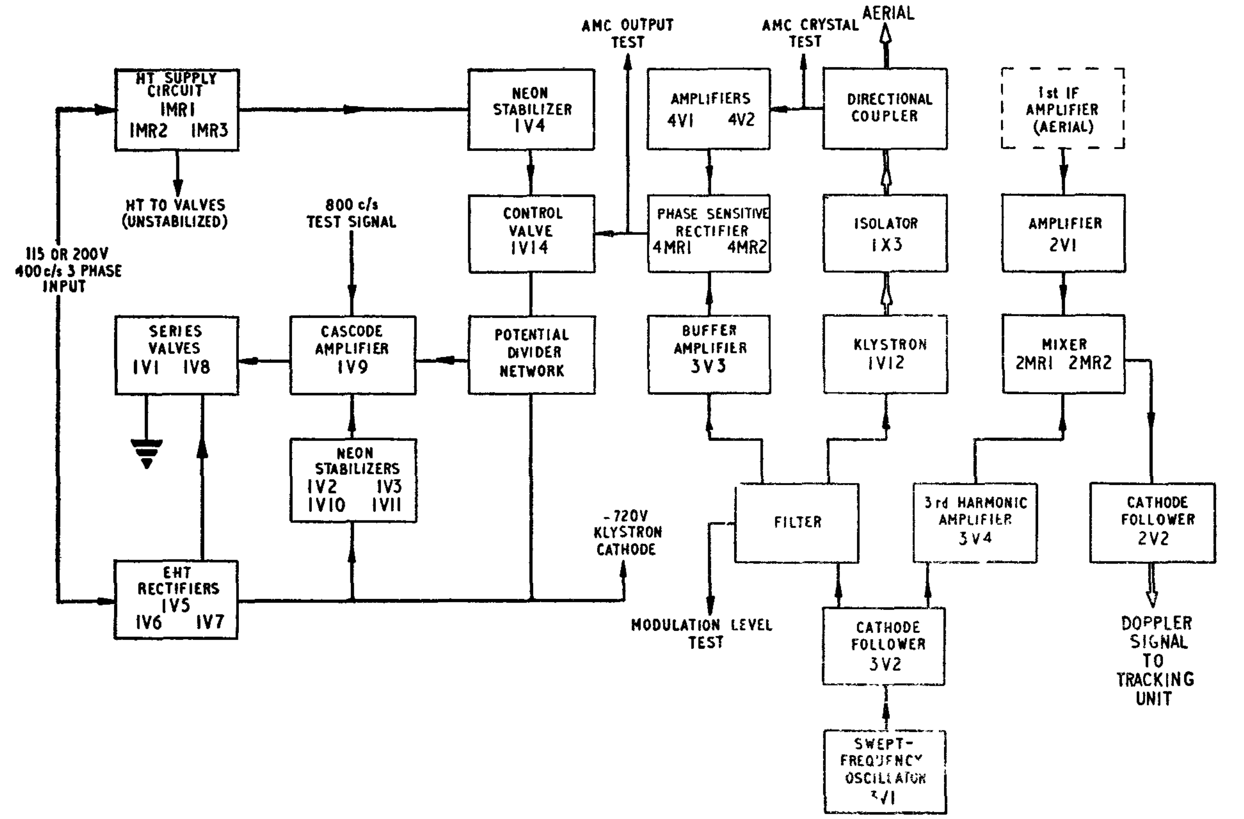


Fig. 3. Block diagram of transmitter-receiver

front panel are a variable capacitor, drive motor and associated gearing, and these items are protected by a detachable cover to which is fitted the nylon-mesh air filter and its cover.

19. A tagboard at the rear of the motor carries links which should be adjusted according to the supply voltage applied to the unit.

20. The chassis assembly circuits may be divided into those appertaining to the transmitter klystron and its associated microwave assembly, those concerned with power supply and regulation, and, finally, miscellaneous circuits.

21. The transmitter klystron 1V12 is a low-noise, two resonator klystron producing a c.w. signal at a frequency of 8800 Mc/s (nominal) which is frequency-modulated by a swept-frequency modulation signal. This modulation signal, produced in the tone generator by the swept-frequency oscillator (wobbulator) 3V1, is swept at the rate of 10 cycles per minute between the limits 168 and 232 kc/s by the action of the motor-driven variable capacitor 1C29. The peak deviation of the transmitted signal is 500 kc/s, which corresponds to the required optimum modulation index of 2·5.

22. There is no provision for mechanical tuning of the klystron, although a certain degree of control of the carrier frequency is obtained by varying the cathode potential, which is (nominally) —720 volts. It is by varying the e.h.t. voltage applied to the cathode that the a.m.c assembly holds the klystron to the centre of its mode of oscillation, as described in para. 31. To ensure that the klystron is stable in frequency, and its output free from unwanted modulation, a regulated filtered e.h.t. supply and an adequately smoothed d.c. heater supply are essential. The circuits provided to meet these requirements are described in para. 25–32.

23. The frequency-modulated output of the klystron (approximately 1 watt) is taken via a ferrite isolator 1X3 to a short length of rectangular waveguide which protrudes through the front panel. Unidirectional characteristics of 1X3 permit the transmitter signal to travel forward with negligible attenuation, while reflections caused by any mismatch which may occur in the waveguide and aerial are severely attenuated. The klystron is thus isolated from these reflections and, being presented with a load of constant impedance at all times, does not become liable to frequency instability. An insertion loss of 0·5 dB is caused by the isolator while the isolation afforded is greater than 30 dB. To ensure that the klystron is free from all vibration (which might cause spurious frequency modulation), both it and the isolator—to which it is mechanically connected—are supported by anti-vibration mountings in the horizontal and vertical planes, and they are mechanically isolated from the fixed waveguide by an air-gap coupling. An acoustic air filter assembly is fitted beneath the outlet of the blower 1MO1 to protect the klystron from buffeting.

24. A directional coupler is fitted in the short length of waveguide, and into the coupler is inserted a crystal rectifier 1MR6. The crystal holder projects through the front panel thus facilitating the removal and replacement of the crystal if this should become necessary. The function of 1MR6 is to detect any amplitude modulation which may be present on the transmitter output waveform, and its output, developed across 1R26, is fed to the a.m.c. assembly via socket SKE and plug PLE pins 4 and 5. To facilitate the checking of crystal current, an output (at a level set by 1RV4) is taken to plug PLB pin 19, and is ultimately connected to the test set. Provision is also made on the test set for the measurement of the forward and reverse currents of 1MR6, but for this test the crystal must be removed from the transmitter-receiver.

25. The power supply circuits employ three transformers 1TR1, 1TR2, 1TR3. The primary winding of 1TR1 is supplied with an input of 115 or 200 volts, 400 c/s single-phase a.c. via plug PLA pins 16 and 17. A centre-tapped h.t. secondary winding and associated rectifiers 1MR1, 1MR2 provide a 110-volt d.c. supply for the valves of the transmitter-receiver and those of the aerial-mounted 1st i.f. amplifier and servo amplifier assemblies, the supply being smoothed by the choke-input filter formed by 1L1, 1C4, 1C24. To provide a stabilized d.c. voltage for the control valve 1V14, and a bias supply for the aerial diode mixer when relay 1RLB is energized, the unsmoothed output of 1MR1, 1MR2 is fed to a peak rectifier circuit formed by 1MR3, 1C1, 1R1, and the output of this circuit is stabilized by 1V4 at a potential of +108 volts. Three secondary windings of 1TR1 provide 6·3-volt a.c. supplies for valve heaters and the heater of the thermal delay switch 1X1; a further secondary winding provides a 4-volt a.c. supply for the heaters of the e.h.t. rectifier valves 1V5, 1V6, 1V7.

26. To provide a warming-up period for the e.h.t. rectifier valves prior to the application of the e.h.t. voltage from the secondary windings of 1TR2, the input to the primary winding of 1TR2 is switched by contacts of relay 1RLA, the energization of which is controlled by a thermal delay switch 1X1. Approximately one minute after the application of the heater voltage to 1X1 (equipment switched on), it operates, and its contact completes the energizing circuit for 1RLA. A changeover contact 1RLA1 operates to act as a hold-on contact for the relay, and also breaks the heater supply circuit of 1X1. The remaining three contacts of the relay make and complete the three-phase supply circuit to the primary windings of 1TR2, which are delta-connected for an input supply of 115 volts and star-connected for a 200-volt supply. The output of the star-connected secondary windings of 1TR2 is rectified by the three half-wave rectifier valves 1V5, 1V6, 1V7, and smoothed by 1L2, the resulting d.c. voltage of approximately 900 volts being applied to the e.h.t. voltage regulator circuit.

27. For the efficient and accurate operation of the system it is essential that the klystron carrier frequency be held stable to within relatively fine limits. One of the factors most likely to affect the frequency stability is the e.h.t. supply, any slight variation of the voltage applied to the klystron cathode causing a relatively large change of frequency. Similarly, any a.c. ripple or hum superimposed on the e.h.t. supply causes undesirable modulation of the klystron output signal; consequently, in addition to being regulated, the supply must also be efficiently smoothed.

28. To satisfy these requirements, a series-cascode regulator circuit, incorporating suitable smoothing and hum-bucking circuits, is employed. The series valves 1V1, 1V8 are connected in parallel to produce the required current-handling capacity. Any change in output voltage is fed to the grid of the d.c. coupled cascode amplifier circuit 1V9a, 1V9b, the output of which alters the impedance of the series valves by changing the grid bias applied to them. The phases of the amplifier input and output voltages are such that any drop in regulator output voltage is compensated by a reduction in impedance of the series valves; this in turn reduces the voltage drop across them and the output voltage is returned to its original value. A rise in output voltage is compensated in a similar manner.

29. The input to the grid of 1V9b is obtained from the junction of 1R18, 1R19, these resistors forming part of a potentiometer chain, which is, in effect, connected between the stabilized 108-volt d.c. line and the negative 720-volt line. The series-connected stabilizer valves 1V2, 1V3, 1V10, 1V11, are used to produce a fixed reference voltage for the cathode of 1V9b. This fixed cathode voltage (approximately —170V) ensures that any change of grid voltage produces maximum change of grid-cathode potential and thus gives maximum control. The voltage drop across the four stabilizers is in the order of 600 volts. During setting-up operations the bias applied to the grid of 1V9a is set by the preset potentiometer 1RV2 to produce the required e.h.t. voltage at 1V12 cathode.

30. Capacitor 1C9, under normal operating conditions, acts as a by-pass capacitor for any a.c. ripple or noise which may appear on the potentiometer chain. Although the series-cascode type of regulator circuit is inherently free from a.c. ripple, a hum-bucking circuit is incorporated in the grid circuit of 1V9a to ensure that the ripple level of the e.h.t. line is reduced to less than 3 millivolts peak-to-peak. A voltage, obtained from the cathode of 1V5, is fed via 1R29 and 1RV3 to the grid of 1V9a and this results in the elimination of any ripple which would otherwise be superimposed on the e.h.t. voltage.

31. To ensure that the klystron is held to the centre of its mode, thus contributing to stability of both frequency and power output, the voltage derived from the phase-sensitive rectifier circuit of the a.m.c. assembly is applied to the grid of 1V14 (referred to as the control valve). This arrangement permits fine control of the e.h.t. voltage applied to the cathode of 1V12. The anode and screen grid potentials of 1V14 are obtained from the stabilized h.t. supply, while the cathode bias is controlled by preset potentiometer 1RV1. Resistor 1R4 and the control valve 1V14 are, in effect, part of the potentiometer network of the e.h.t. voltage regulator circuit, hence any change in the grid potential of 1V14 (causing a change in the effective d.c. impedance of the valve) results in a change of input to 1V9b. The resulting circuit action is as described for the regulation circuit, and ultimately the e.h.t. voltage for 1V12 is increased or decreased to bring the klystron to the centre of its mode of operation.

32. The d.c. heater supply for 1V12 (6·3V, 1·7A) is obtained from the centre-tapped secondary winding of transformer 1TR3. A choke-input filter formed by 1L3, 1C5, 1C6 is designed to remove any a.c. ripple from the supply after rectification by 1MR4 and 1MR5. If allowed to reach the klystron, this ripple would give rise to unwanted modulation of the carrier wave produced by the klystron.

33. Blower motor 1MO1 and the capacitor drive motor 1MO2 are supplied with a 115-volt or 200-volt three-phase supply via plug PLA pins 15, 16 and 17, the motor windings being delta- or star-connected depending upon the supply to be used. The capacitor drive motor turns the rotors of the 3-gang variable capacitor 1C29 at the rate of 10 revolutions per minute, drive from the motor being continuously transmitted via suitable gear-heads and spring-loaded anti-backlash gearing.

34. The relay 1RLB is a part of the test circuit, the description and operation of which is given in Chap. 2. Operation of the relay is controlled by the TEST button on the speed and drift indicator (*Chap.* 4), and if the button is depressed when M (memory) is shown on the indicator flag (secondary S/N relay 1RLE of tracking unit de-energized) the circuit for the operating coil of 1RLB is completed to earth via contacts 1RLG4 in the tracking unit. This results in the energization of 1RLB and the action of the contacts is as follows:—

(1) 1RLB1 makes and connects 1MR2 in the aerial assembly to the stabilized positive potential from 1V4.

(2) 1RLB2 changes over to disconnect one side of 1C9 from earth and connect it, via 1R22 and 1RLB3 (which makes), to the unsmoothed output of the h.t. rectifiers 1MR1, 1MR2. Consequently, the 800-cycle ripple at this point is fed via 1C9 to the grid of 1V9b and eventually modulates the klystron output. The small proportion of the transmission which is cross-coupled to the receiving elements of the aerial array is treated as would be a normal received Doppler signal (*Chap.* 2) and is used to check the operation of the receiver and certain circuits of the tracking unit.

Amplifier, intermediate frequency Type M.133

35. The function of the 2nd i.f. amplifier assembly is to amplify the signal from the aerial-mounted 1st i.f. amplifier, and then mix it with a 600 kc/s ± 16 per cent signal from the tone generator assembly. The a.f. signal resulting from the mixing of the two signals is the Doppler signal, and this is fed, via a cathode-follower stage, to the tracking unit (*Chap.* 2).

36. The assembly is built into a light-alloy chassis which is secured to the main chassis assembly by four captive screws. A 25-pole plug, PLC, carries the electrical connections to a mating socket on the chassis assembly. A dust cover, attached by two quick-release fasteners, can be lifted without removing the assembly from the transmitter-receiver, thus facilitating inspection of the components mounted on the two vertical tagboards. These tagboards are fixed one each side of the raised central portion of the chassis upon which three transformers are mounted.

37. An h.t. supply of 110 volts (nominal) for the two flying-lead base valves is obtained from the power supply circuits of the chassis assembly, and enters the unit on pin 1 of plug PLC. The heater supply for the valves is provided by a 6·3-volt secondary winding on 1TR1, and is fed to the valves via pins 2 and 3 of plug PLC.

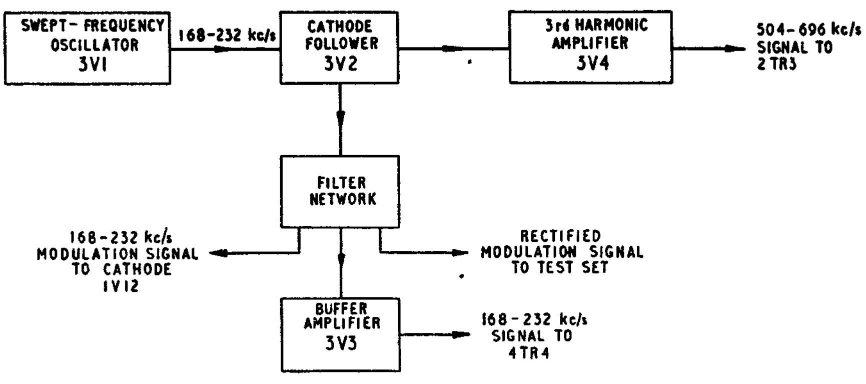


Fig. 4. Block diagram of tone generator assembly

38. From the aerial-mounted 1st i.f. amplifier (*Chap.* 3), a signal is fed by coaxial cable to pin A1 of plug PLA. This signal consists of a swept-frequency signal (504–696 kc/s) plus Doppler shift frequency. Passing by screened lead to pin 13 of plug PLC, the signal is then fed to one end of the primary winding of the iron-dust core tuned transformer 2TR1. The transformer is flatly tuned, and the output from the secondary winding is fed to the grid of the high-gain amplifier stage 2V1. The primary winding of 2TR2, in the anode circuit of 2V1, is tuned by one gang of the motor-driven variable capacitor 1C29 and associated trimmers 1C25, 1C27. This transformer is sharply tuned, and the secondary winding output is fed to the centre point of the mixer bridge formed by 2MR1, 2MR2 and associated components. The switching or reference signal for the bridge is obtained from the 3rd harmonic amplifier stage 3V4 in the tone generator and is fed to the primary winding of 2TR3.

39. Mixing of the two signals takes place in the bridge, and the resulting a.f. Doppler signal is applied to the cathode-follower 2V2. From 2V2 (a normal, low-impedance output stage) the Doppler signal is fed, via plug PLC pin 24 and plug PLB pin 7, to the signal amplifier sub-unit of the tracking unit (*Chap.* 2).

Oscillator, radio frequency Type M.35

40. The function of the oscillator assembly is to produce:—

(1) A swept-frequency (wobbulated) signal centred on 200 kc/s, which is free from unwanted harmonics and which is applied to the klystron cathode to frequency-modulate the carrier wave output of the klystron.

(2) An amplified version of this swept-frequency signal, which is used as the switching or reference signal for the phase-sensitive rectifier circuit in the a.m.c. assembly.

(3) An amplified signal, which is the 3rd harmonic of the fundamental 200 kc/s wobbulated signal. This is used as the switching or biasing signal for the mixer bridge circuit in the 2nd i.f. amplifier.

A block diagram of the assembly is given in fig. 4.

41. The basic construction, methods of connecting, and of securing the assembly are similar to those of the 2nd i.f. amplifier. All electrical connections to the assembly are effected by the miniature plug PLD, which mates with a socket attached to the chassis assembly, the h.t. supply for the valves being carried on pin 1 of the plug.

42. The four stages of the assembly, swept-frequency oscillator, cathode-follower, buffer-amplifier, and 3rd harmonic amplifier stages, utilize four similar flying-lead base pentodes. Valve 3V1 functions as a swept-frequency oscillator (wobbulator) to produce a signal whose instantaneous frequency is varied between the limits 168–232 kc/s at the rate of 10 excursions per minute. As the frequency deviation of the transmitted signal is proportional to the amplitude of the modulating signal, the output of the oscillator stage is, necessarily, of sensibly constant amplitude over the entire frequency range. In the grid circuit of 3V1, one winding of 3TR1 is tuned by one gang of the variable capacitor 1C29, which is continuously rotated at 10 revolutions per minute by the three-phase motor 1MO2. Across the tuned grid circuit are the resistors 3R1, 3R2, and from the junction of these resistors the swept-frequency signal is fed to the grid of a cathode-follower stage 3V2.

43. Connected in the cathode circuit of 3V2 is the preset potentiometer 3RV1, which is used to set the amplitude of the modulation signal applied to the cathode of the klystron 1V12. From the slider of 3RV1, a signal is fed at a pre-determined level to the filter circuit formed by 3L1, 3L2, 3L3 and 3C7 to 3C10 inclusive; he characteristics of the filter are such that signa s in the band 160–240 kc/s are able to pass without attenuation. while the harmonics of frequencies within this band are severely attenuated. From the junction of 3L3 and 3C10 the signal is fed to three points:—

(1) To the klystron cathode, via plug PLD pin 10, as a modulation signal.

(2) To the test set (*Sect.* 3, *Chap.* 1) via 3MR1 and associated components.

(3) To the grid of the buffer-amplifier 3V3.

44. The klystron modulation signal passes via PLD pin 10 to the circuit formed by 1L4, 1C14, 1C13, 1C12, and is fed to the cathode of 1V12, together with the e.h.t. voltage, where its frequency modulates the klystron output. The circuit acts as a load impedance for the modulation signal and also forms a rejector circuit to prevent the modulation signal being fed back into the e.h.t. supply circuit.

45. In order that the amplitude of the modulation signal may be checked without the necessity of access to the transmitter-receiver, rectifier 3MR1 is used to rectify the modulation signal and its output is fed, at a level determined by 3RV2, to the test set socket on the junction box for the system. The route for the rectified signal is from PLD pin 22 to PLB pin 22 and thence to PLM pin 22 of the tracking unit. Pin 22 of PLM is cross-connected to PLN pin 31 and from this point the signal is taken to the junction box.

46. The third circuit connection at the junction of 3L3, 3C10 is that taken to the potential divider 3R10, 3R11, from the junction of which the swept-frequency signal is fed to the grid of the buffer-amplifier stage 3V3. The object of feeding the grid of 3V3 from the junction of 3L3, 3C10 is to ensure that a correct phase-relationship is maintained between the klystron modulation signal and the output of 3V3, which is used as the switching or reference signal for the a.m.c. assembly phase-sensitive rectifier circuit. The anode load of 3V3 is formed by the parallel-tuned primary winding of the iron-dust core transformer 3TR2, whose secondary winding is used to couple the output of the amplifier to the transformer 4TR4 in the a.m.c. assembly.

47. Applied to the grid of the 3rd harmonic amplifier 3V4 is the output of cathode-follower 3V2. The primary winding of 3TR3 is tuned by one gang of 1C29 and the associated trimmer 1C28, consequently the anode is tuned in synchronism with the swept-frequency oscillator 3V1 and the anode circuit of 2V1. From the secondary winding of 3TR3 the 3rd harmonic of the swept-frequency signal (504 to 696 kc/s) is fed, via PLD pin 24 and PLC pin 10 to 2TR3 in the mixer circuit of the 2nd i.f. amplifier. Here, it is mixed with the incoming i.f. signal in order that the Doppler signal may be extracted, and fed to the tracking unit.

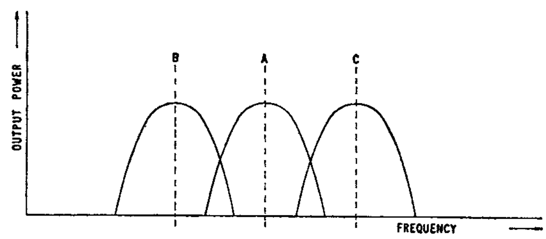


Fig. 5. Purpose of a.m.c. circuit

Control, electronic frequency Type M.40

48. The purpose of this assembly is to ensure that the klystron operates at the centre of its mode of oscillation at all times. It can be seen from fig. 5 that the sub-unit is a mode centring and not a frequency-control device. Although the mode may be shifted slightly due to physical changes in the klystron (brought about by temperature variation, for instance), the klystron is held to the centre of the mode by the action of the a.m.c. circuit. If, as shown in fig. 5, the klystron is operating at a centre frequency A, but due to mechanical changes in the klystron the mode is moved slightly in either direction, the a.m.c. assembly ensures that the klystron operates at the centre frequency B or C as appropriate. The a.m.c. circuit effects its control of the klystron by bringing about a suitable adjustment of the e.h.t. voltage applied to the cathode of the klystron.

49. The construction, layout, methods of securing and connection are similar to those of the 2nd i.f. amplifier. In the assembly, two signals are applied to a phase-sensitive rectifier circuit. One, from 1MR6 in the directional coupler, is a sample of the amplitude modulation present on the transmitter output waveform. The other is a switching or reference signal from the buffer-amplifier circuit in the tone generator. The phase-sensitive rectifier produces a d.c. output, the polarity of which depends on the phase relationship of the applied signals, and the magnitude of which is dependent on the power output of the klystron and the amount the klystron operating point is removed from the mode centre. The phase relationship existing between the signal from 1MR6 and the switching signal depends upon whether the klystron 1V12 is operating at a frequency above or below the centre of its mode. It should be noted that both the transmitter modulation signal and the switching signal are swept in synchronism between the limits 168 to 232 kc/s. The output of the a.m.c. circuit is fed to the grid of the control valve 1V14 and, as previously described, this results in an appropriate increase or decrease of e.h.t. voltage to bring the klystron to the centre of its mode of oscillation.

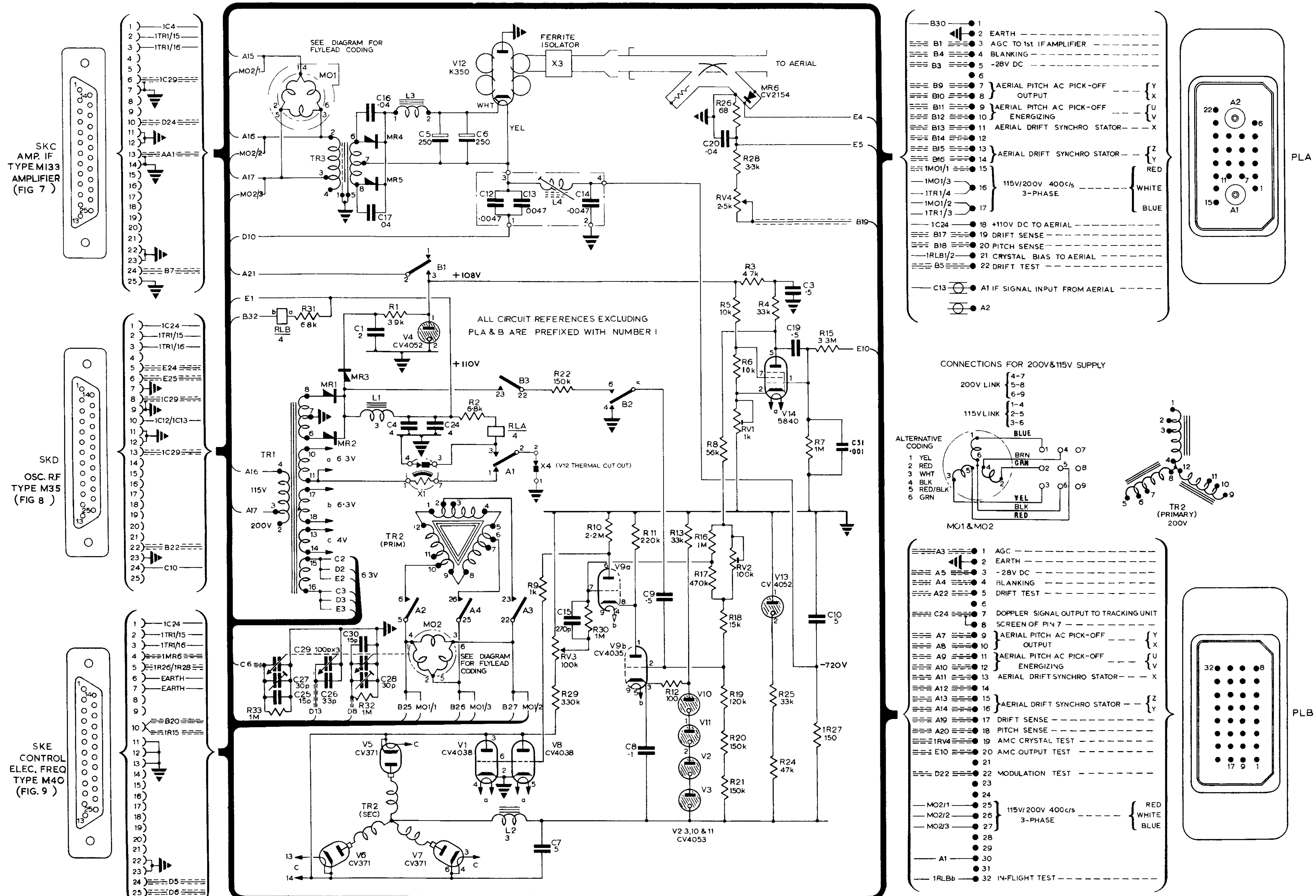
50. The output of 1MR6 is fed to the flatly-tuned input transformer 4TR1. From the secondary winding the signal passes to the grid of 4V1 and, after amplification, is fed to the grid of 4V2, where further amplification takes place.

51. Staggered tuning of the parallel-resonant anode circuits is employed; 4L1, 4C2 are tuned to 160 kc/s, while 4L2, 4C5 are tuned to give maximum response at 240 kc/s. From the anode of 4V2 the amplified signal is fed to the slider of the bridge balancing preset potentiometer, 4RV1, and then to the rectifiers 4MR1, 4MR2. Potentiometer 4RV1 is adjusted during setting-up and alignment operations to achieve bridge balance conditions.

52. From the buffer amplifier stage 3V3, the 168–232 kc/s swept-frequency signal is applied to the primary winding of 4TR4. The signal developed in the centre-tapped secondary winding, which is flatly tuned by 4C7, is the switching or reference signal for the rectifier circuit. The action of this circuit is that of a normal phase-sensitive rectifier circuit and, depending upon the phase relationship of the signals, capacitor 4C9 assumes a positive or negative potential which is fed, via plug PLE pin 10, to the grid of 1V14. If the klystron is operating at a point below the centre frequency a positive voltage is fed to 1V14; if it is operating at a point above the centre frequency a negative voltage is produced, but if the klystron is operating at the centre of its mode there is no output from the rectifier circuit.

53. The output of the a.m.c. assembly is also fed to plug PLB pin 20, and ultimately to the test set in order that the output of the circuit may be checked.

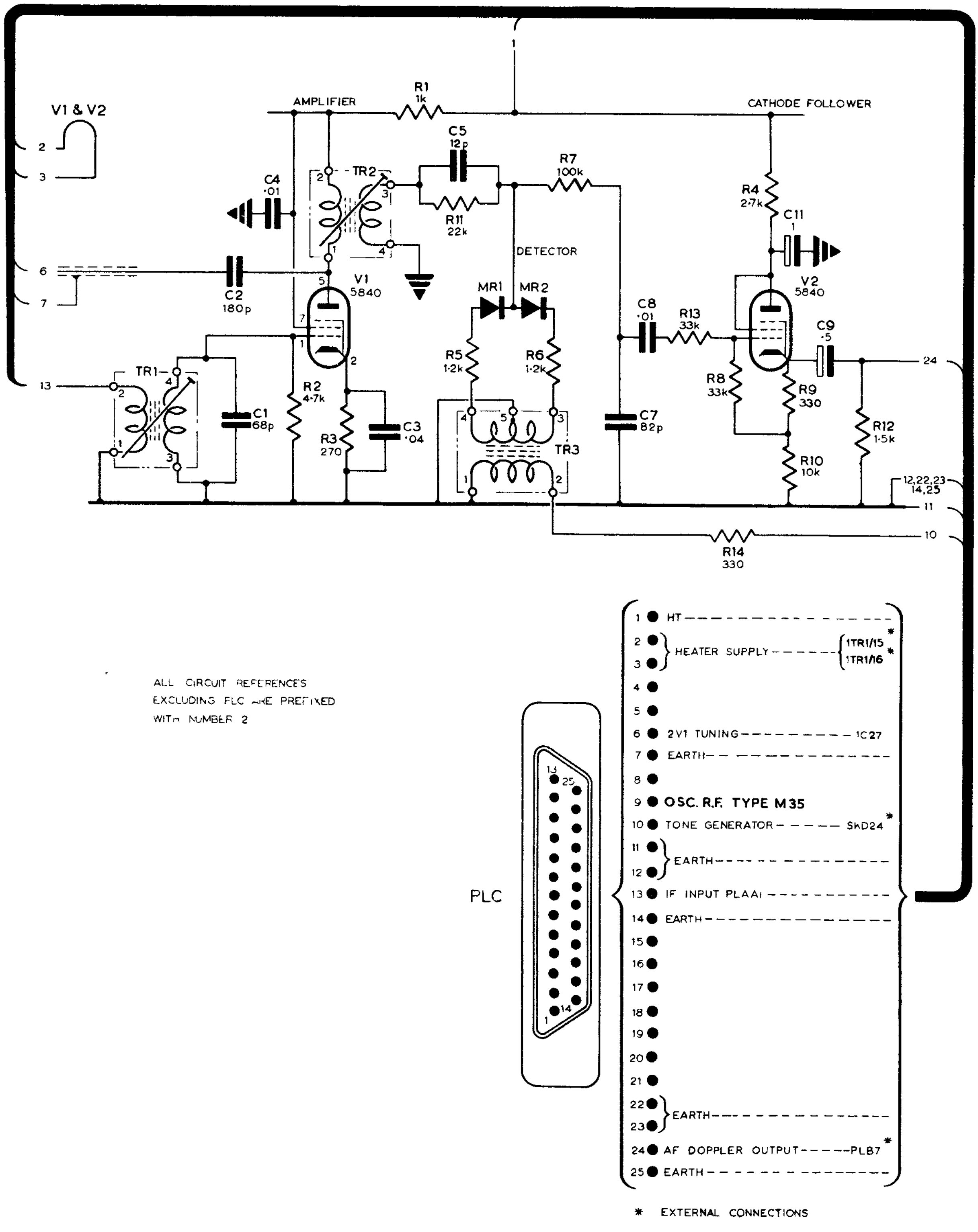
54. The h.t. and valve heater supplies for the assembly are obtained from the power supply circuits of the chassis assembly, and enter on pins 1, and 2 and 3 respectively of plug PLE.



Rack elec. equipment Type M19: circuit

Fig. 6

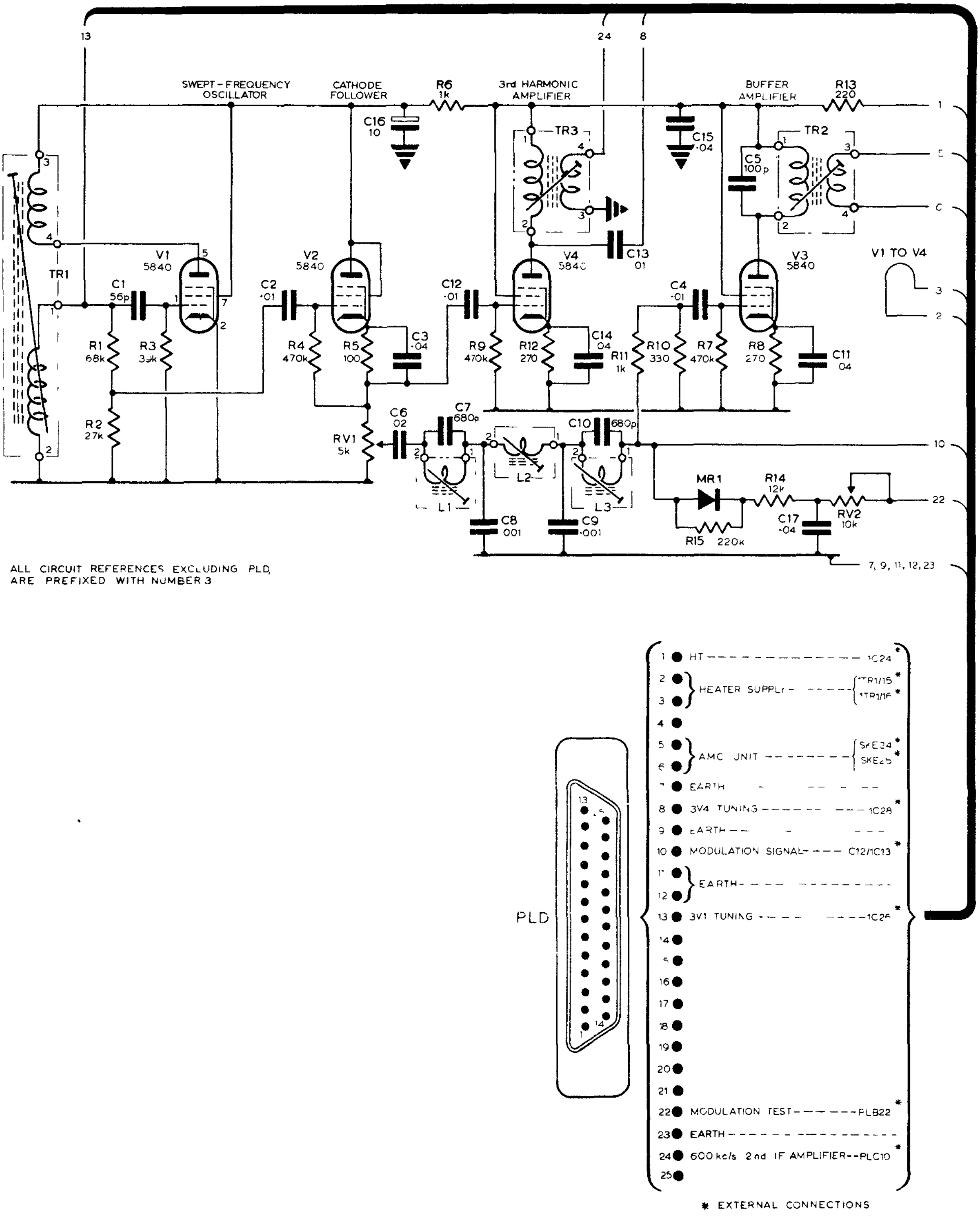
AIR DIAGRAM-MIN
114E-0400-MD11
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 2
Prepared by the Ministry of Technology



AIR DIAGRAM
6775B/MIN.

ISSUE 2 — PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

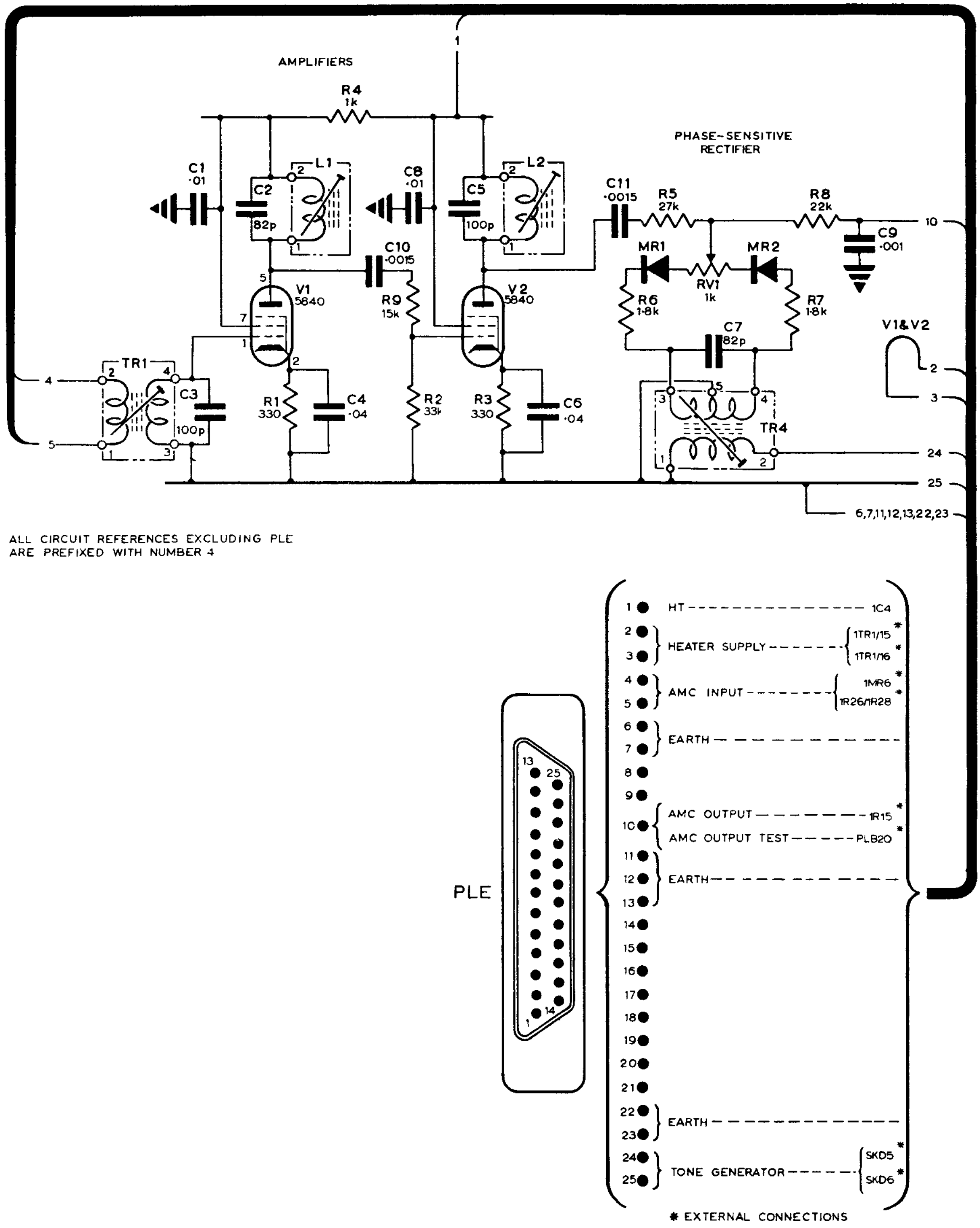
Amplifier I.F. Type M133: circuit — Fig. 7



AIR DIAGRAM 6775C/MIN.	
ISSUE 2	PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

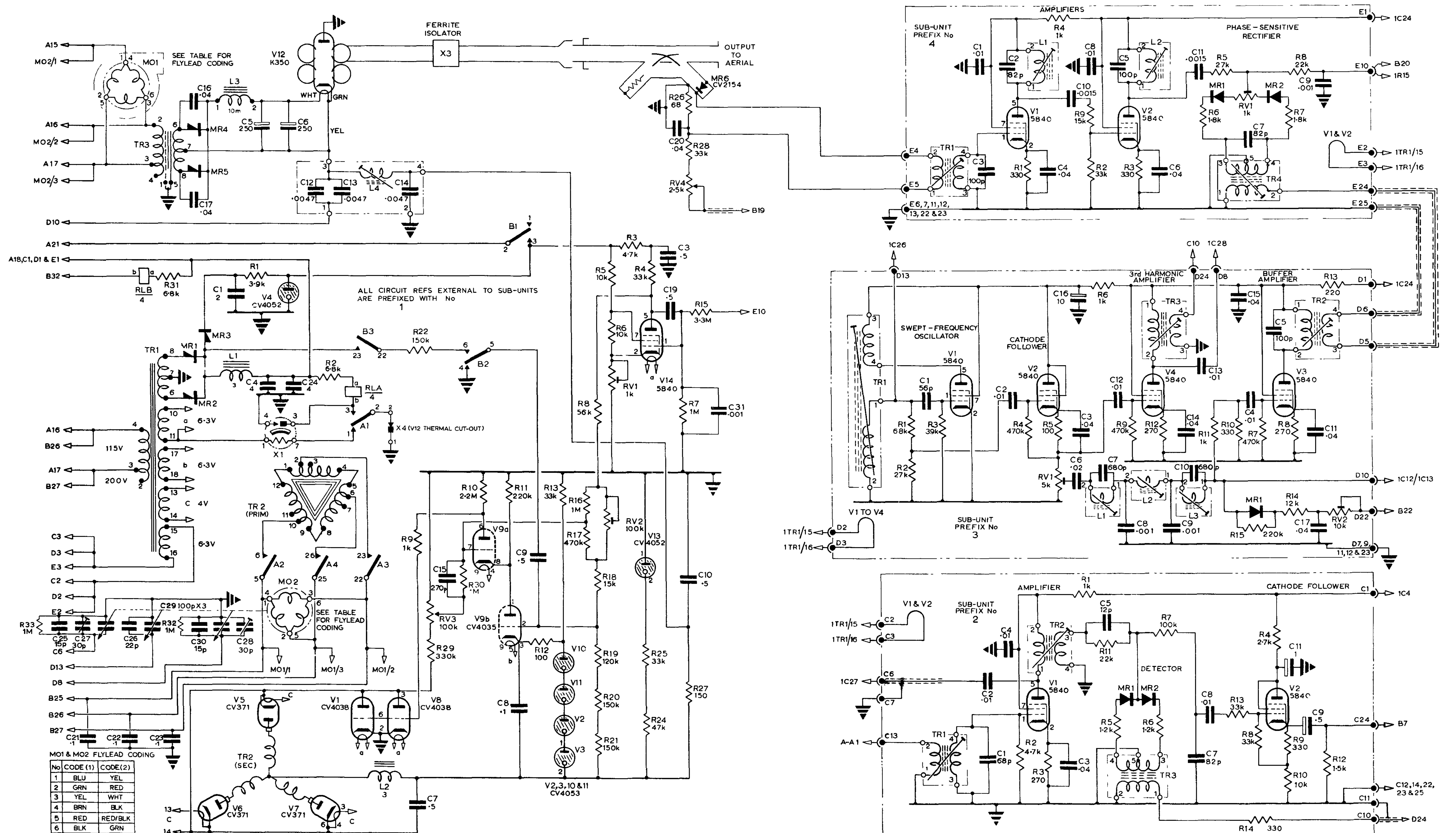
Oscillator R.F. Type M35 circuit

Fig. 8



AIR DIAGRAM 6775D/MIN.	
ISSUE 2	PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY ADMIRALTY

Control elec. freq. Type M40: circuit Fig. 9



MO1 & MO2 FLYLEAD CODING

No	CODE (1)	CODE (2)
1	BLU	YEL
2	GRN	RED
3	YEL	WHT
4	BRN	BLK
5	RED	RED/BLK
6	BLK	GRN

AIR DIAGRAM-MIN
114E-0400-MD12
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 3 Prepared by the Ministry of Technology

Transmitter-receiver radio Type M13: circuit

Fig.10

Chapter 2

COMPUTOR, FREQUENCY TRACKER, AIR NAVIGATION

(TRACKING UNIT)

(Completely revised)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Power supply	115 *or* 200*V* ± 5%, 400 *c/s* ± 5% *single phase a.c. (red and white of 3-phase supply)*
Power consumption	85*VA*
Ambient temperature range	−40°*C to* +70°*C*
Operating temperature range	−40°*C to* +55°*C*
Altitude ceiling	60 000 *ft*
Weight	23·8 *lb* (10·8 *kg*)
Overall dimensions	*Height* 7 25/32*in.* (19·7*cm*) *Width* 5*in.* (12·7*cm*) *Depth* 21 15/64*in.* (54*cm*)
Case size	*Long* ½ *ATR*
Type of mounting	*ARINC type shock-mounted tray*
Air cooling required	0·37 *lb/min at* 20°*C*
Compass safe distance	1·75 *ft*

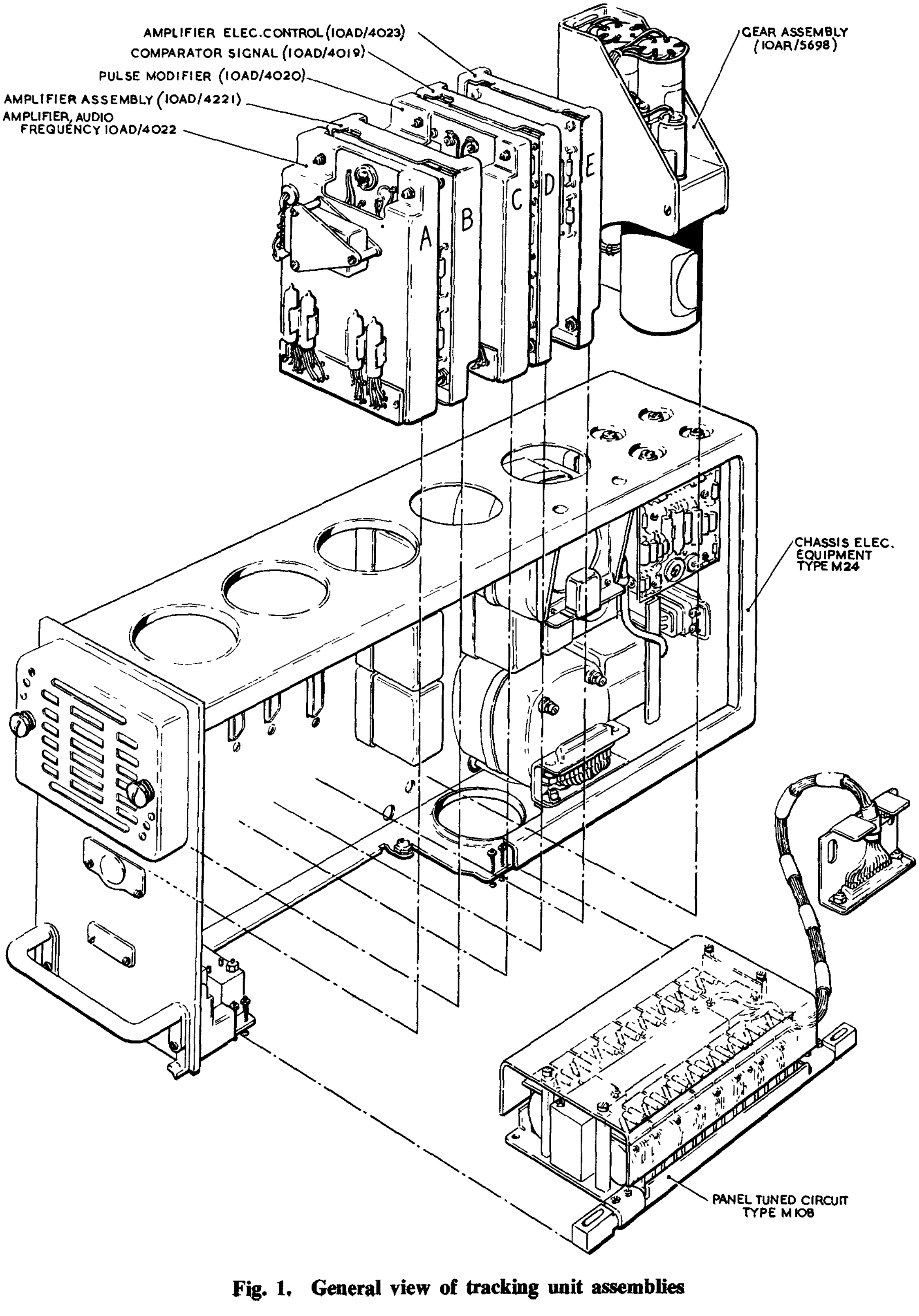


Fig. 1. General view of tracking unit assemblies

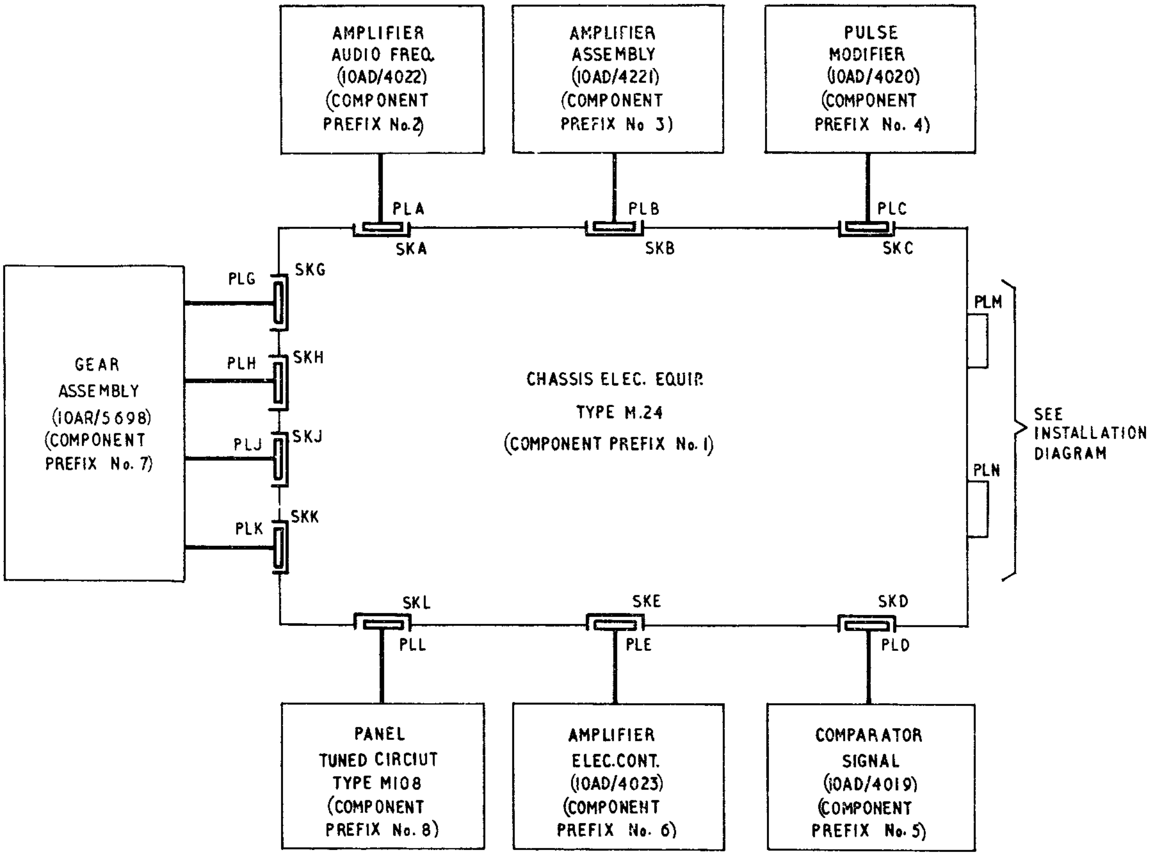


Fig. 2. Schematic arrangement of assemblies

Introduction

1. The tracking unit is fed with the Doppler signal output of the transmitter-receiver and, in conjunction with the aerial and amplifier, synchro signal (or computor), performs the following functions:

(1) Initially, automatic search of the Doppler spectrum to bring the follow circuits quickly to the correct part of the spectrum. When this operation has been accomplished, the equipment is said to be locked on.

(2) Production of an alternating voltage related to the ground speed of the aircraft.

(3) Production of an alternating drift error signal related to the degree of misalignment of the aerial in the drift plane. When the aerial is correctly aligned, this output is zero.

(4) Production of an alternating signal related to the pitch angle of the aerial.

(5) Production of an a.g.c. voltage for application to the aerial-mounted first i.f. amplifier.

(6) Measurement of the signal/noise ratio of the received Doppler signal with automatic changeover to memory operation if the signal/noise ratio falls below a predetermined value.

(7) Switching of the power supply to the three-position flag on the speed and drift indicator to show the state of the equipment.

2. The inputs to the unit are the Doppler signal from the transmitter-receiver, the phonic wheel tone from the amplifier, synchro signal (or computor) and the blanking, drift sense and pitch sense information from the cam-operated contacts in the aerial waveguide switch and gearbox assembly on the aerial.

Constructional details (fig. 1)

3. The unit is housed in an unpressurized long ½ ATR case and is designed for operation with ARINC cooling systems or for satisfactory cooling by convection. A welded, rectangular, light alloy frame supports the vertically mounted tray-type main chassis (component prefix 1) which runs from front to rear of the unit to divide the frame into two unequal compartments.

4. Housed in the smaller compartment are the fixed wiring, minor tagboard-mounted components, some encapsulated circuitry, securing screws and connecting sockets for the plug-in sub-units or valve decks. The larger compartment contains the seven plug-in sub-units, components of the power supply circuits and ten relays. Circuit connections to the plug-in sub-units are made by multi-pole miniature plugs and sockets with gold-plated contacts. From front to rear of the chassis six plug-in sub-units are arranged as follows:

Amplifier, audio frequency (10AD/4022) (valve deck A), component prefix 2
Amplifier assembly (10AD/4021) (valve deck B), component prefix 3
Pulse modifier (10AD/4020) (valve deck C), component prefix 4
Comparator, signal (10AD/4019) (valve deck D), component prefix 5
Amplifier, elec. control (10AD/4023) (valve deck E), component prefix 6
Gear assembly (10AR/5698) component prefix 7

5. The seventh sub-unit, the search panel (panel, tuned circuit Type M.108), component prefix 8, is mounted on a detachable section of the floor of the frame and circuit connections are completed by a 25-pole plug. The components of the panel are protected by a detachable perspex cover. All valves used in the tracking unit have flying-lead bases and, where practicable, groups of functionally connected small components are encapsulated. External connections to the unit are made via two 32-pole plugs. These are situated at the rear of the chassis and have gold-plated contacts. The upper plug is loosely mounted to facilitate mating with the mounting tray back-plate socket.

6. The unit may be operated from power supply sources of 115 or 200V, 400 c/s, provided the primary connections of the power transformer are appropriately adjusted. This transformer is fed from the red and white phases of the 3-phase supply.

Brief description

7. The tracking unit forms the heart of the AD2300 series of Doppler navigation equipments and controls, either directly or indirectly, the operation of all other units in the system. Components contained in the unit form parts of the speed, drift and pitch servo control loops and continuous monitoring of the Doppler signal input from the transmitter-receiver is also done by circuits within the tracking unit. These circuits, which are in the signal comparator (valve deck D), also produce the a.g.c. voltage applied to the penultimate and final stages of the aerial-mounted first i.f. amplifier.

8. Normally, the tracking unit functions under what are termed signal conditions, i.e. the unit is in receipt of a signal which is considered to be of an acceptable signal/noise ratio and it is able, initially, to make an automatic search of the Doppler spectrum and rapidly lock on to the correct signal. Once this operation has been accomplished the unit is said to be locked on in speed and the follow circuits are operative, the changeover being made automatically by valve controlled relays. Under normal flight conditions the follow circuits maintain effective control of the speed, drift and pitch servo control loops. When the system has locked on, indications of ground speed and drift are provided by the speed and drift indicator which is electrically driven by the amplifier, synchro signal (or computor). The three-position magnetic indicator, also contained in the speed and drift indicator, is controlled by relay contacts in the tracking unit. When the system is locked on under signal conditions an all black indicator is visible.

9. In the event of the signal/noise ratio of the Doppler signal falling below the acceptable level, the a.g.c and signal/noise circuits cause the system to operate under memory conditions. In these circumstances the h.t. supply to the search relay control valves and to the power amplifier unit is removed by relay operation and consequently drive is removed from the speed, drift and pitch integrator motors. The system then continues to operate on the information last received whilst operating under signal conditions. Thus, until such time as the tracking unit receives a usable signal, the speed and drift pointers continue to indicate the speed and drift last recorded. Similarly, the distance indicator continues to operate at the rate prevailing prior to the changeover to memory conditions. Additionally, in installations employing a computor, the along-track and across-track distance indicators continue to function on the information last available when the system was operative under signal conditions.

10. There is provision for in-flight testing of the system and, under signal conditions, operation of the TEST button on the speed and drift indicator initiates a functional check of the tracking circuits (speed and drift servo systems). A check of the transmitter-receiver and certain circuits of the tracking unit is made if the TEST button is operated when the system is functioning under memory conditions.

11. The following paragraphs give details of the individual assemblies of the unit, circuit diagrams of which are given in fig. 10 to 18. After the descriptions of the assemblies comes a more detailed description of the circuit functions of the unit as a whole under the various operational conditions.

Chassis, electrical equipment Type M.24

12. The circuits of the main chassis can be divided into six groups as follows:

(1) Power supply and associated circuits.

(2) The circuits appertaining to the eleven relays and associated components.

(3) Signal filter circuits.

(4) Phonic wheel tone splitter and phase shift circuit.

(5) Bridge mixer circuit.

(6) Follow failure indicator circuit.

Power supply

13. Transformer 1TR1, which delivers all the voltages for the tracking unit, is located at the rear of the larger compartment and is fixed to the chassis by a substantial triangulated frame. All terminals of the transformer are accessible from the smaller compartment via apertures in the chassis. The transformer is designed to accept a 115 or 200V, 400 c/s single phase input supply. To facilitate the selection of the correct tapping on the primary winding, a link and two fuse carriers are fitted at the lower rear end of the smaller compartment and the link must be placed in the fuse holder appropriate for the input voltage to be supplied. During testing and alignment operations a fuse of suitable rating may be fitted in place of the link.

14. From the seven secondary windings on 1TR1 are obtained the voltages necessary for the production of the following supplies:

(1) A h.t. supply of +140V d.c. The output of the 160-0-160V winding is rectified by 1MR1 and 1MR2 and the ouput from the rectifiers is then

(a) Smoothed by 1L1 and 1C3 to provide a h.t. supply for the valve decks A, B, C and D. This supply is also used as the energizing voltage for the primary signal/noise relay 1RLK and is fed, via 1TR5, 1TR6 to the anodes of the double triode 2V4.

(b) Smoothed by 1L2, and 1C2 to provide the energizing voltage for the operating coils of relays 1RLE, 1RLD and 1RLC. It also supplies the anodes and screens of the valves on valve deck E.

(2) −75V h.t. The voltage, rectified by 1MR3, 1MR4 and smoothed by 1C1, is used to bias 4V3 and 4V5 via a potentiometer network. It is also fed to the a.g.c. and signal/noise assembly.

(3) −75V relay supply. The output of the 56-0-56V winding is rectified by 1MR20, 1MR21, smoothed by 1C27 and used as the energizing supply for 1RLG, 1RLH and 1RLJ.

(4) 6·3V a.c. on terminals X and Y. This supply is distributed to the valve heaters via the 6-way tagstrip 1TS3. Also connected to this supply is an inching lattice consisting of 1R5, 1R6, 1R7 and 1C20.

(5) +28V d.c. for the magnetic indicator flag and the operating coils of relays 1RLA, 1RLB and 2RLA. The supply is obtained from the 27-0-27V secondary winding on 1TR1, rectified by 1MR5 and 1MR6.

(6) 15V a.c. on terminals 4 and 5. This supply is used as the energizing voltage for the aerial pitch a.c. pick-off 1X1.

(7) 15V a.c. on terminals 2 and 3. This supply is used as the energizing voltage for the pitch integrator a.c. pick-off 7X2 in the tracking unit.

(8) 15V a.c. on terminals 6, 7 and 8, 9. These outputs are not used.

Relays

15. The eleven relays which form part of the main chassis fixed equipment are of four different types. The functions and energizing voltage of each relay are as follows:

1RLA. Provides drift sense. Energized once per second by the cam-operated springset contacts 1SWB in the aerial waveguide switch gearbox. Also selects, in conjunction with 1RLB, the appropriate a.g.c. capacitor (1C4, 1C5, 1C6 or 1C7) depending upon the direction of transmission and reception. 28V operation.

1RLB. Provides pitch sense. Energized every half second by the cam-operated springset contacts 1SWC in the aerial waveguide switch gearbox. Also selects, in conjunction with 1RLA, the appropriate a.g.c capacitor. 28V operation.

1RLC. Designated the search up relay. Energized by the anode current of 4V5 during operation of the tracking unit under search up conditions. Energized by relays 1RLH and 1RLJ under test conditions. 140V operation.

1RLD. Designated the search down relay. Energized by the anode current of 4V3 during the operation of the tracking unit under search down conditions. Energized by relays 1RLH and 1RLJ under test conditions, 140V operation.

1RLK. Designated the primary signal/noise relay. Used to control the secondary signal/noise (h.t. control) relay 1RLE. Energized by the anode current of 5V4. 140V operation.

1RLE. Designated the secondary signal/noise relay. 140V operation. This relay has four functions:

(a) Switching of the h.t. supplies to the search relay control valves 4V3, 4V5 and to the power amplifier sub-unit via the windings of 7MO1, 7MO2 (1RLE1).

(b) Switching capacitor 1C8 to ensure that on receipt of a usable Doppler signal the equipment is slow in changing to signal condition operation, yet quick to revert to memory conditions when the signal deteriorates (1RLE2).

(c) Switching of the power supply to the magnetic indicator flag in the speed and drift indicator (1RLE3).

(d) Removal of the −75V energizing supply from the coil of the memory test relay 1RLG when the equipment is operating under signal conditions (1RLE4).

1RLG. Designated the memory test relay. Energized when the TEST button is pressed while the system is functioning under memory conditions. Contacts 1RLG4 complete the circuit to earth for the transmitter-receiver relay 1RLB, thus causing an 800 c/s modulating signal to be applied to the klystron for test purposes. 48V operation, supply obtained from the 75V line via 1R25.

1RLH, 1RLJ. These relays form a divide-by-two circuit to inch the tracking system up or down during the time that the TEST button is depressed while the equipment is functioning under signal conditions. 48V operation, supplies obtained from the 75V line via 1R24 and 1R23.

1RLL. Designated the follow failure indicator relay. Energized by the anode current of 1V1 when grid drive is applied from the power amplifier sub-unit. The relay contacts control the supply to the signal flag so that if the OFF flag appears during signal conditions a fault in the follow circuits is immediately indicated. 140V operation.

1RLN. Causes relay 1RLL to be energized when the TEST button is pressed while the system is functioning under memory conditions. The indicator flag changes from yellow to black and immediately reverts to yellow when the button is released. 75V operation.

Signal filter

16. The signal filter is of the band-pass type and consists of a group of capacitors in an encapsulated block (1X1) and two Ferroxcube inductors 1L3, 1L4. It is connected between the anode of 2V1 and the grid of 2V2 in the signal amplifier and its characteristics are such that it attenuates all signals outside the frequency band 800 c/s to 11·3 kc/s. Insertion of the filter between the two amplifier stages ensures that the Doppler signal spectrum applied to the mixer bridges and the search panel is contained in the frequency band between the two cut-off frequencies.

Tone splitter

17. Transformer 1TR4 is used as the phonic wheel tone splitter, while an encapsulated group of capacitors and resistors (1X2) forms a phase-quadrature lattice network. These components, 1TR4 and 1X2, are situated on the floor of the larger compartment adjacent to the front panel. Applied to the phase-quadrature network, via 1TR4, is the variable frequency tone of sinusoidal waveform developed by the phonic wheel assembly in the amplifier, synchro signal (or computor). The outputs of the network, taken from pins 3 and 4, have a 90° phase difference and are fed to the grids of the double triode amplifier for amplification before being applied to the mixer bridges.

Mixer bridges

18. The mixer bridge circuit consists of transformers 1TR5, 1TR6, auto-transformer 1TR3 and two balanced bridge modulators employing selenium rectifiers in a conventional bridge ring arrangement. The components of the bridge network are encapsulated in a resin block 1X3 which is positioned between 1TR5 and 1TR6 at the front of the smaller compartment.

19. Applied to the primary windings of 1TR5 and 1TR6 are the amplified outputs of the phase-quadrature lattice network 1X2 and these outputs are used as the switching or biasing voltages for the mixer bridges. Auto-transformer 1TR3 is supplied with the amplified Doppler signal spectrum from the cathode follower 2V3. As previously stated, the signal is contained in the band 800 c/s to 11·3 kc/s by the action of the band-pass filter 1X1, 1L3, 1L4. From 1TR3 the signal is fed to the two mixer bridges.

20. The outputs of the mixer bridges, taken from the centre-tapped secondaries of 1TR5, 1TR6, consist of the sum and difference frequencies which result from the mixing of the phonic wheel tone and the Doppler signal. The use of balanced modulators ensures that the outputs are free from phonic wheel tone and signal frequencies. The outputs of the two mixer bridges are in phase quadrature, the difference frequency of one bridge being 90° phase advanced or retarded with respect to the identical difference frequency produced by the other bridge. If the difference frequency is obtained from a component of the Doppler signal which lies above the phonic wheel tone, the phase difference is in one sense, but, if the component of the Doppler signal lies below the phonic wheel tone, then the phase difference is in the opposite sense. From the mixer bridges the sum and difference frequencies are fed, via relay contacts 1RLC1, 1RLD1, 1RLC2, 1RLD2 to the band-pass filters in the grid circuits of 3V1 and 3V3 on the pre-amplifier sub-unit.

Follow failure indicator

21. The follow failure indicator circuit is formed by the double-triode valve 1V1 and relay 1RLL. The two sections of the valve are connected in series with the relay coil between 1V1a cathode and 1V1b anode. 1V1a grid is returned to cathode while 1V1b grid is taken to the slider of a variable resistor 1RV1 which is connected in series with 1R36 between −75V and earth. 1RV1 serves as a level control allowing the d.c. bias on the 1V1b grid to be preset.

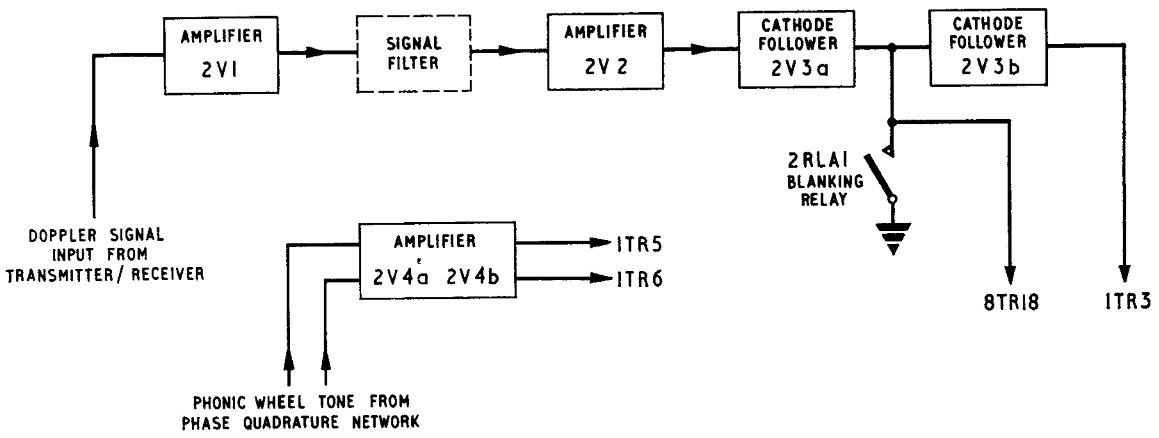


Fig. 3. Block diagram of amplifier audio frequency

22. The circuit derives its inputs from 6V2 via SKJ1 to 1V1a and from 6V4 via SKJ6 to 1V1b. Under normal signal conditions output voltages are always present at the anodes of the power amplifier valves and cause 1V1 to conduct with the result that the relay 1RLL is energized. In consequence, a 28V d.c. supply is fed via 1RLE3, 1RLD4, 1RIC4 and 1RLL1, then via PLN23 to the signal flag in the speed and drift indicator.

23. When the signal is lost, causing the circuits to change to the memory condition, there are no inputs to the follow failure indicator circuit and current through 1V1 is cut off so that 1RLL is de-energized. However, since 1RLE is also de-energized (para. 63) the 28V d.c. supply is connected to the memory flag via 1RLE3.

24. If the inputs to 1V1 disappear as the result of a fault occurring outside the signal circuits (e.g. in the phonic wheel circuit, pre-amplifier or power amplifier) 1RLL is de-energized but 1RLK and 1RLE remain energized. As a result the black OFF flag will be displayed, giving an immediate indication of a fault in the follow circuits.

25. To ensure that the follow failure indicator does not affect the operation of the memory test circuit, provision is made to render it inoperative when the TEST button is pressed. Operation of the TEST button when the equipment is functioning under memory conditions causes 1RLG to be energized and, since the coil of 1RLN is in series with that of 1RLG, 1RLN is also energized. Through the action of 1RLG1, the bias is removed from 1V1b grid which thus rises to earth potential. At the same time contacts 1RLN1 change over and connect 1V1a grid to the +140V line through 1R46. Under these conditions the valve conducts continuously and 1RLL is held in the energized state.

Amplifier, audio frequency

26. Amplifier, audio frequency (10AD/4022) which is the signal amplifier, is used to amplify the Doppler signal (fed from the transmitter-receiver) and the phonic wheel tone (produced by the phonic wheel in either the amplifier, synchro signal or computor) prior to their application to the mixer bridges. Blanking of the Doppler signal for approximately 120 milliseconds every half second also takes place in this sub-unit.

27. The assembly, which is of book-type chassis construction, is secured at the front of the main chassis by two captive screws. Circuit connections are completed to the fixed wiring by a miniature 25-pole plug. The four valves are of the sub-miniature type with flying leads. Relay 2RLA, designated the blanking relay, and the associated suppression diode 2MR2 are held in position by a triangular, pillar-supported, clamp plate. All other components are mounted in a conventional manner on a hinged synthetic resin-bonded fibre tagboard which is normally held in the closed position by two screws.

28. A block diagram of the unit is shown in fig. 3. The Doppler signal is a narrow-band signal centred about a frequency in the band 800 c/s to 11 kc/s approximately, the freqency being dependent upon the ground speed of the aircraft. This signal, fed from the transmitter-receiver to pin 7 of PLM on the tracking unit, is passed via an attenuator 1R20, 1R21 to the primary winding of the 5·4 : 1 ratio step-up transformer 1TR2. From the secondary winding of 1TR2 the signal passes via pin 5 of PLA to the grid of 2V1. Connected between the anode of this valve and the grid of the second amplifier 2V2 is the signal filter and a preset gain control 2RV1.

29. Two cathode follower outputs are provided by the double-triode 2V3. From 2V3a the amplified signal is fed, via pin 20 of PLA, to the search panel and also to pin 6 of PLN for signal test purposes (Sect. 3, Chap. 1). The other output, from 2V3b, is passed to the mixer bridge auto-transformer 1TR3 via pin 8 of PLA.

30. The single pole changeover relay 2RLA performes two functions and its operation is controlled by the cam-operated springset mounted in the aerial waveguide switch gear-box. When the relay is in the de-energized state the moving contact completes the circuit to earth for the −70V potentiometer chain in the pulse modifier (pip amplifier). With the relay in the energized condition the moving contact earths the Doppler signal, the blanking period being 120 milliseconds every half second. The blanking period coincides with the transition period of the aerial waveguide switch so ensuring that signals are fed to the mixer bridges and search panel only for the time that the waveguide switch is in alignment with one of the four waveguide entries and can pass the received signal to the hybrid ring mixer. By rendering the tracking unit inactive for the period that the waveguide switch is moving from one position to the next the possibility of interference being fed to the circuits is reduced.

31. The phonic wheel tone outputs from the phase-quadrature lattice 1X2 are amplified by the double-triode amplifier 2V4. These amplified phonic wheel tones, having a phase difference of 90° are fed to the primary windings of transformers 1TR5 and 1TR6 where they are used as the switching or biasing signals for the mixer bridges.

32. Valve heater and h.t. supplies for the unit are obtained from the power supply circuits contained on the main chassis and enter on PLA pins 2, 3 and 4.

Amplifier assembly (valve deck B)

33. The function of this sub-unit, which is the pre-amplifier, is to amplify and filter the outputs of the mixer bridges and feed these amplified outputs, via phase splitters, to the power amplifier unit.

34. The unit is similar to the signal amplifier in construction, method of securing and method of connection to the main chassis.

35. Three sub-miniature valves are connected to form two identical amplifier circuits with phase splitter outputs to the power amplifier. As previously stated, the output of each mixer bridge is composed of the sum and difference frequencies which result from the mixing of the received Doppler signal and the phonic wheel tone. The output of 1TR5 is fed, via contacts 1RLC1, 1RLD1 and a filter network, to the control grid of the pentode amplifier 3V1. The filter is of the non-critical low frequency band-pass type centred on 150 c/s and is designed to select the difference frequency. In consequence, the output from the anode circuit of 3V1 fed to the phase splitter 3V2a is an amplified version of the difference frequency waveform. This is then passed via PLB pins 7 and 8 to the power amplifier.

36. Similarly, from the centre tap on the secondary winding of 1TR6 a signal, having a 90° phase difference with respect to that from 1TR5, is passed via contacts 1RLC2, 1RLD2 and a filter network to the grid of 3V3. The circuit action is similar to that described in the preceding paragraph and from 3V2b the output is fed via PLB pins 9 and 10 to the power amplifier.

37. It should be noted that although the signal inputs to 3V1 and 3V3 are always in phase quadrature, the difference signal in one channel (say 3V1) may be 90° phase advanced or retarded with respect to the same difference signal in the other channel (3V3). The sense of the phase difference depends upon whether the component of the Doppler signal lies above the phonic wheel tone or is below it.

38. Each circuit has a gain of approximately 15 and all power supplies are obtained from the main chassis.

39. The input signals are passed via the changeover relay contacts 1RLC1, 1RLC2, 1RLD1, 1RLD2 in order that a 400 c/s signal may be applied to the pre-amplifier when the system is operating under search conditions and also for test purposes.

Pulse modifier

40. The pips produced by the search panel tuned circuits are fed, via the commutator section of the commutator potentiometer 7X3, to the pulse modifier (pip amplifier). In this unit the pips are amplified and then integrated, the resulting d.c. potential being applied to valves which have the operating coils of the search up relay 1RLC and the search down relay 1RLD connected in their anode circuits.

41. The unit is similar in construction to the signal amplifier and identical methods of securing and connection are employed.

42. Five sub-miniature valves are connected to form two identical circuit configurations. Each circuit consists of a pentode amplifier, a triode amplifier and a double-triode relay control valve with the two sections connected in parallel to produce the current handling capacity necessary for the control of the relay coil in the anode circuit.

43. The action of the search down circuit formed by 4V1, 4V2a, 4V3 and the associated components is as follows. Pips produced by the tuned circuits of the search panel are fed to the commutator section of the commutator potentiometer 7X3. Under search conditions, when pips are being fed from the wiper of 7X3 to PLG pin 1, the pips are passed via PLC pin 18 to the primary winding of 4TR1. This is a 1 : 31 ratio step-up input transformer the

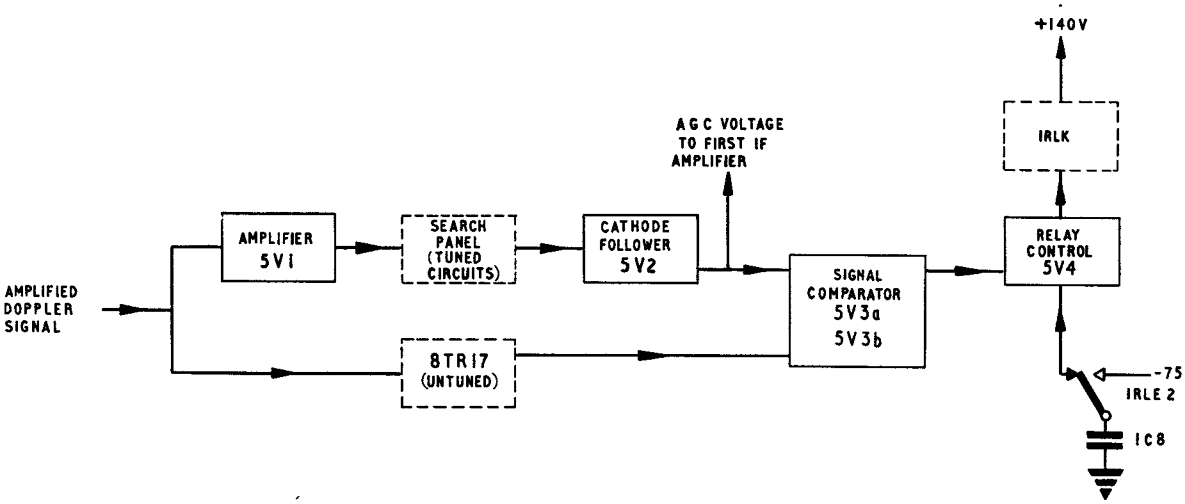


Fig. 4. Block diagram of signal comparator

secondary winding of which is connected to the grid of 4V1. After amplification by 4V1 the pips are passed to the grid of 4V2a which is one half of a double-triode.

44. The relay control valve 4V3 has a negative bias of approximately 8V applied to its grid, the bias voltage being derived from the −75V line via 4R12 and the preset potentiometer 4RV1. The output of 4V2a is applied to the integrating circuit formed by 4R10 and 4C6. The capacitor becomes charged and the application of this voltage to the grid of 4V3 causes the valve to conduct heavily. The resultant anode current energizes relay 1RLD, the search down relay.

45. The application of a negative bias to 4V3 grid ensures that the valve does not conduct and cause 1RLD to be energized until several search pips have been integrated and 4C6 has charged to a potential sufficient to overcome the bias. Thus, random pips resulting from a sporadic burst of noise or signal do not cause 4V3 to conduct and 1RLD remains de-energized.

46. The action of the search up circuit formed by 4V4, 4V2b, 4V5 and the associated components is similar to that of the search down circuit. The input to 4TR2 consists of the pips selected by the wiper of 7X3 and fed to pin 9 of PLH. The operating coil of the search up relay 1RLC is connected in the anode circuit of 4V5 and is energized by the anode current of that valve.

47. Power supplies for the sub-unit are derived from the power supplies on the main chassis and all connections are effected via the 25-pole plug PLC.

Comparator, signal

48. The signal comparator sub-unit performs two functions:

(1) It produces, in conjunction with the search panel, an a.g.c. voltage which is used to control the gain of the first i.f. amplifier to maintain a reasonably constant signal strength in the receiver and tracking unit.

(2) It measures the signal/noise ratio of the incoming signal and limits the operation of the equipment to signals above a certain signal/noise ratio.

49. The unit controls the operation of the primary signal/noise relay 1RLK and, in consequence, the operation of the secondary signal/noise (h.t. control) relay 1RLE. When a Doppler signal of satisfactory signal/noise ratio is being received the anode current of valve 5V4 energizes relay 1RLK and the system operates under signal conditions. If the signal/noise ratio falls to a point where the Doppler signal is considered unusable, 5V4 is rendered non-conducting and the system functions under memory conditions. A block diagram of the sub-unit is shown in fig. 4.

50. The sub-unit is mechanically similar to the signal amplifier and electrical connections are completed via a 25-pole plug.

51. A simplified circuit diagram of the unit and parts of other functionally associated circuits is shown in fig. 9. The signal fed from the cathode follower 2V3a to the primary winding of transformer 8TR18 in the search panel is the Doppler signal from the transmitter-receiver, suitably amplified by the signal amplifier circuits and confined to the frequency spectrum 800 c/s to 11·3 kc/s by the signal filter. The signal output from the secondary winding of 8TR18 passes via a signal shaping network 5R2, 5R3, 5C2 to the grid of the search drive valve 5V1. The function of this network is to attenuate the high frequency signals received when the aircraft is flying at a ground speed in the upper part of the range 80 to 900 knots. The bandwidth of the received signal is a function of the ground speed of the aircraft as is the frequency of the signal. To ensure that the follow circuits are supplied with signals of constant power per cycle, the higher frequency signals are attenuated, resulting in a reduced a.g.c. voltage and increased signal. As aircraft ground speed increases the signal bandwidth increases and the amplitude falls, for the power received remains constant. The 18 transformers which form the anode load of 5V1 are tuned to frequencies in the range 800 c/s to 13 kc/s approximately and the resulting composite response curve is relatively flat over the entire spectrum. From pin 24 of PLL the rectified output from the tuned circuits is fed, via contacts 1RLA1, 1RLB1 and 1RLB2, to the a.g.c. capacitors 1C4, 1C5, 1C6 and 1C7 where it is smoothed.

52. The operation of relays 1RLA and 1RLB is controlled by the contacts of the cam-operated springsets 1SWB, 1SWC fitted in the aerial waveguide switch and gearbox assembly (Chap. 3). Relay 1RLA (drift sense relay) is switched once per second and 1RLB (pitch sense relay) twice per second. The a.g.c. capacitors are thus sequentially switched and each one is in circuit for a period of approximately 500 milliseconds as shown in Table 1. The output at pin 24 of PLL is negative in polarity and varies in proportion to the power density of the received Doppler signal. The switching of the capacitors ensures that an a.g.c. voltage at the correct level is applied to the first i.f. amplifier for each of the four directions of reception.

TABLE 1

AERIAL DRIFT CONTACTS 1SWB	—	—	Open	—	—	—	Closed	—
TRACKING UNIT RELAY 1RLA	—	—	Released	—	—	—	Operated	—
AERIAL PITCH CONTACTS 1SWC	—	Closed	—	Open	—	Closed	—	Open
TRACKING UNIT RELAY 1RLB	—	Operated	—	Released	—	Operated	—	Released
A.G.C. CAPACITOR IN CIRCUIT	—	1C6	—	1C7	—	1C4	—	1C5
TIME IN SECONDS	0	—	0·5	—	1·0	—	1·5	—

53. By normal cathode follower action, a voltage is developed at the cathode of 5V2 and it is this voltage which is immediately applied to the penultimate and final stages of the first i.f. amplifier as an a.g.c. voltage. The voltage is fed to the aerial-mounted first i.f. amplifier via pin 1 of PLM and is also fed, via pin 4 of PLN, to the system junction box. This permits the a.g.c. voltage to be monitored by means of test set Type M.29 which may be connected to the junction box.

54. The cathode of 5V2 is also directly coupled to the grid of 5V3a, one half of the double-triode 5V3 which operates as a cathode-coupled paraphase amplifier (long-tailed pair). This valve is used to compare the output of the tuned circuits on the search panel with the output of the untuned transformer 8TR17 and is referred to as the signal comparator.

55. The anode of 5V3a is connected to the grid of 5V4 through a resistive coupling network and variations in 5V3a anode potential thus control the flow of current through 5V4. In turn, 5V4 controls the operation of the primary signal/noise relay 1RLK. Contacts on 1RLK cause 1RLE to be energized. Capacitor 1C8 is so switched to the grid of 5V4 that the system must receive a usable signal for a certain minimum time before changing from memory to signal operation, yet will revert to memory operation very quickly when the signal deteriorates.

56. To understand the operation of the signal comparator 5V3 and relay control valve 5V4 it is necessary to consider the action of these two valves and their associated circuits under two distinct conditions. These are:

(1) When a Doppler signal of satisfactory signal/noise ratio is being received, as a result of which the system operates under signal conditions.

(2) When a Doppler signal of low signal/noise ratio is being received and the system functions under memory conditions.

Under both conditions the signal comparator has potentials applied to its grids and these potentials are derived from two separate circuits. That applied to 5V3a grid is the negative potential which is developed at 5V2 cathode and is, in effect, the a.g.c. voltage. As previously stated, this voltage is proportional to the power density of the received Doppler signal. That fed to 5V3b grid via 1RLG3 is the negative potential derived from the output of the untuned transformer 8TR17 (effectively in series with the 18 tuned circuits) and is proportional to the mean power density of the total signal.

Signal conditions

57. When a Doppler signal of satisfactory signal/noise ratio is applied to the tuned circuits, a relatively large negative a.g.c. voltage is fed to 5V3a grid. The Doppler signal is also applied to 8TR17 which, since it is untuned, has a flat response curve over the entire Doppler frequency spectrum and its rectified negative voltage output under signal conditions is small compared with that from the tuned circuits. This voltage is applied to the grid of 5V3b. The signal comparator thus has negative potentials applied to both grids and under signal conditions the current through 5V3a is comparatively low. In consequence, 5V3a anode potential approaches h.t. and, by virtue of the direct coupling, 5V4 grid voltage is raised sufficiently to cause the valve to conduct heavily. The resultant flow of anode current energizes 1RLK the primary signal/noise relay.

58. The energizing of 1RLK has the following effects:

(1) Contacts 1RLK1 connect the −75V supply to the coil of 1RLE, causing the secondary signal/noise relay to be energized.

(2) Contacts 1RLK2 short-circuit 5R19 and connect 5V4 grid to the slider of the preset potentiometer 5RV4. This has the effect of making 5V4 grid still more positive and ensures definite relay operation.

59. Energizing 1RLE has the following effects:

(1) Contacts 1RLE1 make, so applying +140 d.c. to the anodes of the search control valves 4V3, 4V5 through the coils of 1RLC, 1RLD (the search up, search down relays) via contacts 1RLG2, directly to the screen grids of the power amplifier valves and to the anodes of these valves through the centre tapped control windings of 7MO1, 7MO2.

(2) Contacts 1RLE change over to disconnect 1C8 from the grid of 5V4 and connect it to −10V at the junction of 5R26, 5R27. Since the other plate of 1C8 is earthed via contacts 1RLG4, the capacitor commences to charge.

(3) Contacts 1RLE3 change over and connect the +28V d.c. supply to the signal flag circuit in the speed and drift indicator via 1RLD4, 1RLC4 and 1RLL1.

(4) Contacts 1RLE4 change over, thus disconnecting the −75V supply from the coils of relays 1RLG, 1RLN and preventing these relays from being energized if the TEST button is pressed.

60. The system is now functioning under signal conditions and the state of the a.g.c. and signal/noise circuits may be summarized as follows:

(1) An a.g.c. voltage, proportional to the power density of the received Doppler signal, is produced at 5V2 cathode and is fed to the first i.f. amplifier. 5V4 is conducting due to its high grid potential.

(2) Relays 1RLK and 1RLE are energized. In consequence, h.t. is applied to the anodes of 4V3 and 4V5 via the coils of 1RLD and 1RLC. It is also applied to the screen grids and anodes of the power amplifier valves. One plate of capacitor 1C8 is connected to a point which is at a potential of approximately −10V and a +28V d.c. supply is connected to the appropriate flag indicator which now indicates that the system is functioning under signal conditions.

Memory conditions

61. In the event of the signal/noise ratio of the received signal degenerating to the point where it is considered to be unusable since the Doppler signal content is small and the noise content comparatively high, the operation of the signal comparator and relay control valves is as follows.

62. Due to the predominance of the noise component of the received signal, the negative potential produced by 8TR17 is lower than when a strong Doppler signal is being received and the current through 5V3a increases, causing a corresponding fall in anode voltage. 5V4 grid follows this fall until the grid potential is too low for the valve to conduct and 1RLK is de-energized due to the cessation of anode current. As a result, contacts 1RLK1 break and cause the secondary signal/noise relay 1RLE to be de-energized, while contacts 1RLK2 break and disconnect 5V4 grid from the slider of 5RV4, bringing about a further fall in grid potential.

63. De-energizing 1RLE has the following effects:

(1) Contacts 1RLE1 break, so removing the +140V supply from 4V3, 4V5 and from the screens and anodes of the power amplifier valves.

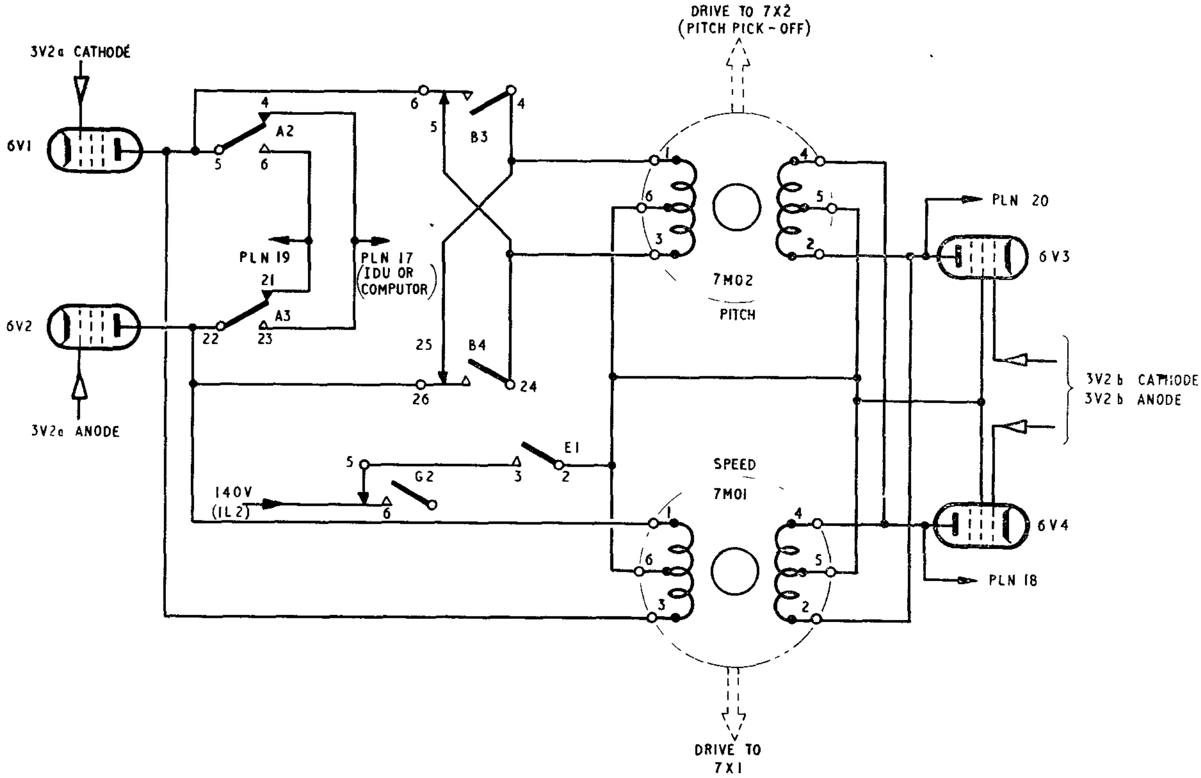


Fig. 5. Connections from power amplifiers to servo motors

(2) Contacts 1RLE2 change over and connect 1C8, which has charged to approximately −10V, to the grid of 5V4. Since the discharge path for 1C8 is 5R18 and 5R19 in series, 5V4 grid is held below cut-off for several seconds immediately after switching, thus avoiding relay flutter.

(3) Contacts 1RLE3 change over, removing the 28V supply from the signal flag circuit and connecting it to the memory flag circuit.

(4) Contacts 1RLE4 change over and reconnect the −70V supply to the coils of the memory test relays 1RLG and 1RLN.

64. The system is now functioning under memory conditions and the state of the a.g.c. and signal/noise circuits may be summarized as follows:

(1) 5V4 is cut off. Capacitor 1C8 is connected to the grid and is discharging very slowly through a high resistance path so that on receipt of a satisfactory signal the system will wait for several seconds before reverting to operation under signal conditions.

(2) H.t. is removed from the screens and anodes of the power amplifier valves. Thus there is no drive to motors 7MO1, 7MO2 in the tracking unit and 6MO1 in the amplifier, synchro signal (or computor).

(3) The +140V supply is disconnected from the search control valves and associated relays.

(4) The 28V supply is applied to the memory flag circuit.

65. 6·3V a.c. for the valve heaters, −75V bias and +140V h.t. supplies for the signal comparator sub-unit are obtained from the power supply circuits contained on the main chassis, all connections being made through the 25-pole plug PLD.

Amplifier, electronic control

66. To effect control of the integrator motors 7MO1, 7MO2 in the tracking unit and the drift integrator motor 6MO1 in the amplifier, synchro signal (or computor), the outputs from the pre-amplifier (amplifier assembly 10AD/4021) are applied to the grids of the power amplifier valves in amplifier, electronic control. The centre tapped windings of 7MO1, 7MO2 are connected in the anode circuits of the power amplifiers.

67. The assembly is of book-type construction similar to that of the signal amplifier and the same methods of connecting and securing are used.

68. The sub-unit contains two identical push-pull amplifier circuits with the inputs to the grids of 6V1, 6V2, 6V3, 6V4 applied via pins 5, 6, 9 and 10 of PLE. The 140V h.t. supply for the valves is derived from the power supply circuits on the main chassis, switched by contacts 1RLE1, h.t. being applied to the valves when the relay is energized. As previously stated, 1RLE is energized when the system is functioning under signal conditions so that h.t. is applied to the valves only during the time that a signal of satisfactory signal/noise ratio is being received. The supply is connected directly to the screens of the valves but via the centre tapped windings of 7MO1, 7MO2 to the anodes. For this reason it is important to note that the tracking unit must never be switched on without the gear assembly (10AR/5698) in place.

69. The signal inputs to the unit are the mixer bridge frequencies suitably amplified by the pre-amplifier. The two inputs are in phase-quadrature with the difference frequency in one channel 90° phase advanced or retarded with respect to the same difference frequency in the other channel. The sense of the phase difference depends upon whether the component of the Doppler signal lies above the phonic wheel tone or is below it.

70. The signals are amplified by the push-pull amplifiers, each stage having an overall gain of approximately 5, and the outputs are used to control the movements of 7MO1, 7MO2 and the drift integrator motor 6MO1 of the amplifier, synchro signal (or computor). The direction of rotation of the motors is dependent upon the sense of the phase difference between the voltages applied to the windings.

71. The outputs of 6V1 and 6V2 are connected as follows:

(1) To one winding of 7MO1 via pins 7 and 8 of PLE and pins 1 and 3 of PLJ.

(2) To one winding of the drift integrator motor 6MO1 (amplifier, synchro signal or computor) via 1RLA2, 1RLA3 and pins 17, 19 of PLN.

(3) To one winding of 7MO2 via 1RLB3, 1RLB4 and pins 7, 9 of PLJ.

(4) From 6V2 to 1V1a grid via pin 8 of PLE and SKJ/1.

72. The outputs of 6V3 and 6V4 pass via pins 11 and 12 of PLE to:

(1) The second windings of 7MO1, 7MO2 (in parallel) via pins 4 and 6 of PLJ.

(2) The second winding of the drift integrator motor via pins 18 and 20 of PLN.

(3) From 6V4 to 1V1b grid via pin 12 of PLE and SKJ/6.

73. Relay 1RLA is switched once per second by the action of the cam-operated drift sense contacts 1SWB in the aerial waveguide switch and gearbox unit. Similarly, 1RLB is controlled by the pitch sense contacts 1SWC which operate every half second.

74. Preset potentiometers 6RV1 and 6RV2 are used to balance the anode currents of the pairs of valves during alignment. The 6·3V heater supply is obtained from the XY winding of 1TR1 on the main chassis.

Gear asssembly

75. Gear assembly (10AR/5698) (speed and pitch integrator) is a plug-in sub-unit consisting of a gearbox assembly on which are mounted two 2-phase motors and gearheads, a commutator potentiometer assembly, an a.c. pick-off, microswitch assembly and associated components. The sub-unit is secured in position on the main chassis by means of three fixing screws and all electrical connections are made by four 9-pole plugs, the mating sockets for which are attached to the main chassis.

76. The commutator potentiometer 7X3 is gear driven and is a combination of a log-law potentiometer and commutator switch assembled on a common drive shaft. Maximum effective rotation of the shaft is limited to 159° ± 1°. The total resistance of the potentiometer section is 1000 ohms ± 10°. The commutator has two segments each maintaining contact with its own output brush over the whole of the effective rotation while the 16 input brushes are spaced evenly over the effective range.

77. The potentiometer section of 7X3 receives a 4·7V a.c. energizing supply from 5TR1 in the amplifier, synchro signal (or computor) which is fed to terminals 19 and 20 via pins 3 and 32 of PLN and the output from the slider returns, via pin 1 of PLN, to the amplifier or computor Applied to the commutator section are the pips produced in the search panel and these are fed, via either PLG pin 1 or PLH pin 9, to the amplifier assembly (10AD/4021).

78. In the gearbox there are two separate gear trains, one driven by motor 7MO1 and the other by 7MO2. Fitted to 7MO1 is a gearhead of 150:1 reduction ratio and drive is transmitted from the gearhead to 7X3 via a 45 : 1 reduction gear train and slipping clutch. Drive from 7MO2 is transmitted to the rotor of the pitch a.c. pick-off 7X2 via a gearhead of 300 : 1 ratio reduction and a 22½ : 1 reduction gear train. One winding of each motor is energized by the output of 6V3, 6V4 in the power amplifier. The second windings are energized by the output of 6V1, 6V2 (which is in phase-quadrature with that from 6V3, 6V4), the signal to 7MO2 being switched every half second by the action of the pitch sense relay 1RLB.

79. Microswitch 7SW1, operated by the cam and cam follower assembly, switches out the main tuning capacitors 7C1, 7C2 for the upper half of the speed range in order to improve the follow pull-in characteristics at the higher frequency energizing voltages associated with high speed flight. The gear drive for the cam is arranged in such a manner that the angle of rotation of the cam is twice that of the shaft of 7X3.

80. Preset potentiometer 7RV2 controls the output of the pitch a.c. pick-off 7X2 and is adjusted during testing and alignment to equate the output with that of the aerial-mounted a.c. pick-off 1X1. The 15V a.c. energizing supply for 7X2 (terminals U and V) is obtained from the power supply transformer 1TR1.

Panel, tuned circuit Type M.108

81. The function of the tuned circuit (or search) panel is to produce

(1) The a.g.c. voltage and

(2) trains of pips which are fed to the pip amplifier, via the commutator potentiometer 7X3, for operation of the search system. These pips are produced by the 18 tuned circuits formed by 8TR1 to 8TR16 and 1TR7, 1TR8 on the main chassis.

Also located on the search panel are the signal feed transformer 8TR18 and the untuned transformer 8TR17. 8TR17 forms part of the signal comparator circuit.

82. The components of the search panel are mounted on a detachable section of the floor of the light alloy frame and are protected by a Perspex cover. This cover is pillar supported and is readily detachable. The 16 Ferroxcube pot core assemblies 8TR1 to 8TR16 inclusive are arranged in two rows and mounted between the rows are, from front to rear, 8TR18, 8X1 (consisting of 8C1 to 8C16 encapsulated in a resin block) and 8TR17. The remaining circuit components are soldered to the tags of the pot core assemblies. Electrical connections to the panel are made via a 25-pole plug PLL and a short flexible cableform.

83. Transformer 8TR18 is a 1 : 1 ratio transformer to the primary of which the amplified Doppler signal is applied. This signal has passed through the signal filter so that it is within the frequency spectrum 800 c/s to 11·3 kc/s and the frequency of the signal is related to the ground speed of the aircraft. By the action of relay 2RLA in the signal amplifier, the signal is blanked for a period of 120 milliseconds every half second.

84. The output from the secondary winding is fed, via a signal shaping network, to the grid of the search drive valve 5V1 whose anode load is formed by the series-connected primary windings of 1TR7, 1TR8 and 8TR1 to 8TR16 inclusive. These transformers form part of 18 frequency selective tuned circuits which cover the frequency band 800 c/s to 13 kc/s approximately. Connected in parallel with each of the secondary windings is a capacitor of suitable value to effect the required tuning while a degree of damping is afforded by a 15k resistor across each winding.

85. This arrangement of tuned circuits produces a relatively flat composite response curve with individual response curves crossing at the −3dB points. Current pulses to feed the common line (PLL pin 24) are produced in the tuned circuits (by the action of the rectifiers), the circuit in which this occurs being dependent upon the frequency of the Doppler signal applied to the primary windings of the transformers. Although it is possible for pips to be produced simultaneously in two tuned circuits (as occurs when the Doppler signal frequency is approximately midway between the centre frequencies to which any two adjacent circuits are tuned) this does not affect the operation of the

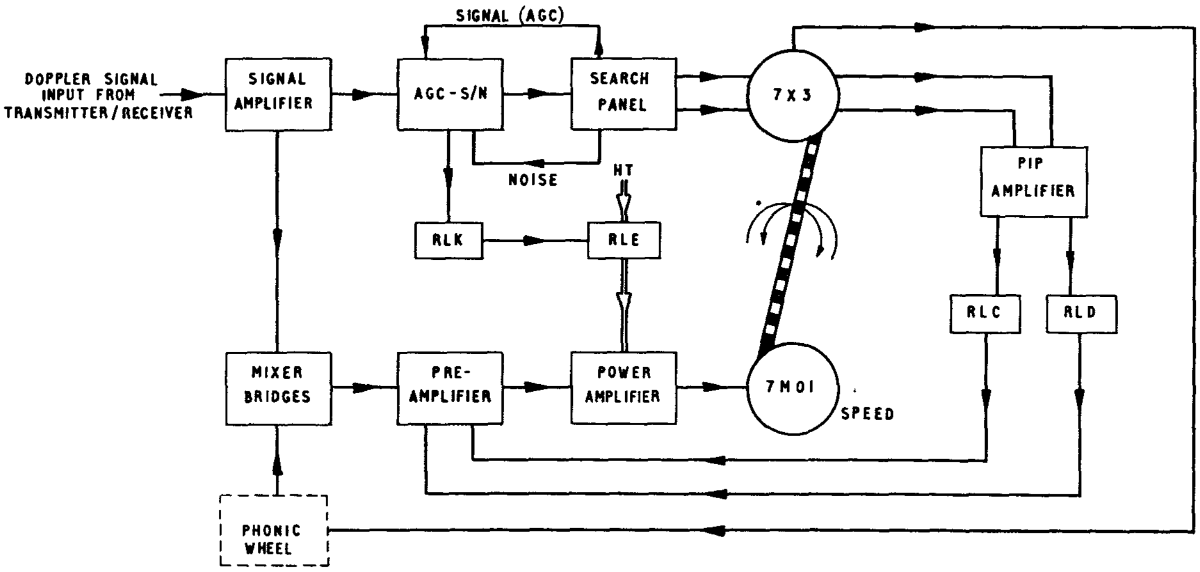


Fig. 6. Block diagram of search and follow circuits

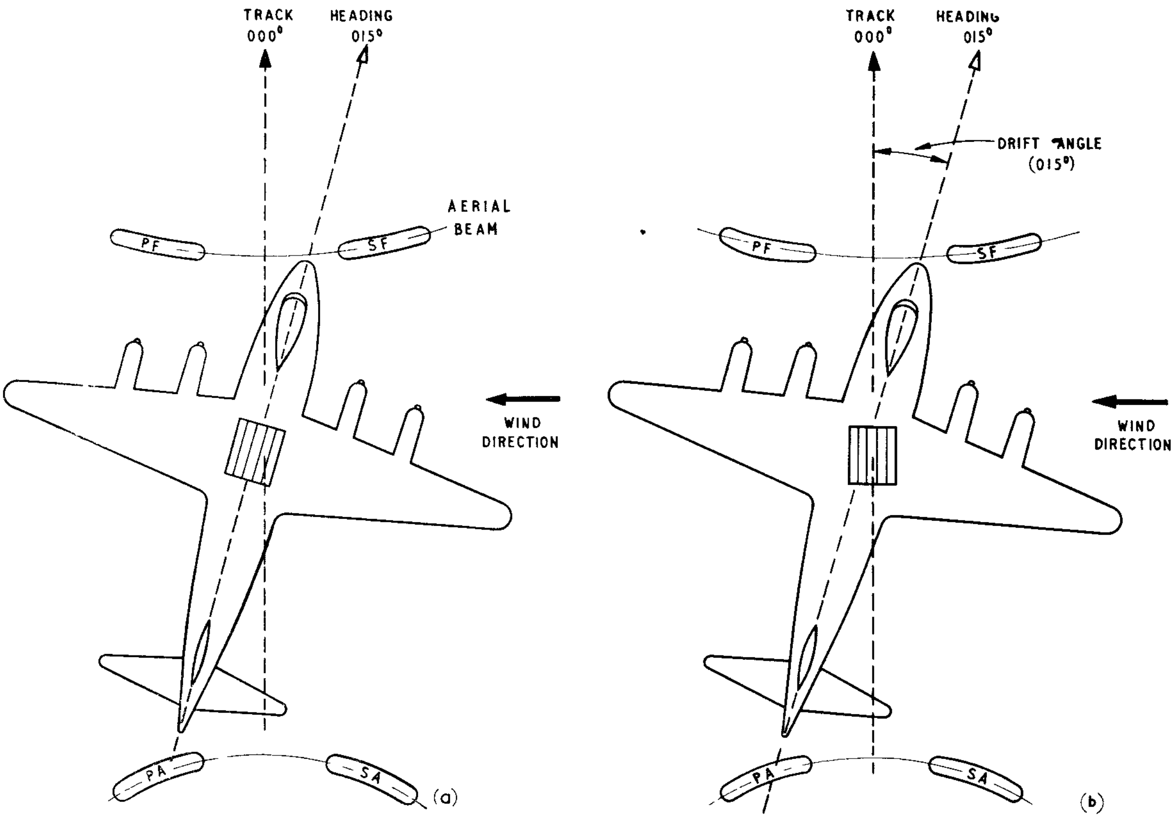


Fig. 7. Alignment of aerial in azimuth

search panel circuit or the circuits to which the pips are fed. Since the output of all the tuned circuits are connected to a common point (PLL pin 24) they combine to give the same effect as that produced by a single tuned circuit which alone handles the full Doppler signal input.

86. Transformer 8TR17 is untuned and the amplified Doppler signal across 5RV2 is applied to its primary. The secondary output is rectified by the action of 8MR33, smoothed by 5C8 and fed to the grid of 5V3b via contacts 1RLG3. This circuit is described in para. 57.

OPERATION OF THE TRACKING UNIT UNDER SIGNAL CONDITIONS

87. Under all operational conditions, the Doppler signal is amplified in the signal amplifier, filtered and passed to the mixer bridges via auto-transformer 1TR3 and to 5V1 via transformer 8TR18. One output from 5V1 is developed across the bank of tuned circuits which forms the anode load. A second output from the cathode is fed to the untuned transformer 8TR17.

88. Pips are produced by one of the tuned circuits in 5V1 anode and are rectified for use as the a.g.c. voltage. To supply the aerial-mounted first i.f. amplifier with the correct a.g.c. voltage for each of the four directions of transmission and reception, four separate reservoir capacitors 1C4 to 1C7 are provided. These are switched into circuit sequentially by contacts on the drift and pitch sense relays 1RLA and 1RLB controlled by the cam-operated springsets in the aerial waveguide switch and gearbox assembly (Table 1). Each capacitor is in circuit for approximately 500 milliseconds. During the time a capacitor is in circuit, a negative potential is built up and thus appears at the grid of the cathode follower 5V2. The voltage at the cathode of 5V2 is fed to the first i.f. amplifier as the a.g.c. voltage.

89. The voltage is also directly coupled to the grid of 5V3a which is one section of the signal comparator stage. To the grid of the other section 5V3b is fed the output from the untuned transformer 8TR17 which is also a negative potential. Under signal conditions the negative voltage produced by the tuned circuits is large compared with that produced by the untuned transformer and so the current through 5V3a is low. A resistive network couples the high positive potential at 5V3a anode to the grid of 5V4 the relay control valve. 5V4 conducts heavily and the flow of anode current is sufficient to energize 1RLK the primary signal/noise relay.

90. Contacts 1RLK1 complete the energizing circuit for 1RLE (h.t. control relay) and this relay is energized. As a result, 140V h.t. is applied direct to the screens of the power amplifier valves, to the anodes via the centre tapped windings of 7MO1, 7MO2 and to the anodes of 4V3, 4V5.

Search

91. The tracking unit operates under search conditions when the difference in frequency between the received Doppler signal and the local phonic wheel tone exceeds 15%. This occurs when the equipment is switched on while the aircraft is flying at a ground speed which differs substantially from that at which it was flying when the equipment was switched off.

92. The speed of the phonic wheel motor in the amplifier, synchro signal (or computor) and consequently the phonic wheel tone is controlled by the potential at the slider of the 7X3 potentiometer and the position of the slider is, in turn, a function of the ground speed of the aircraft. Suppose that the aircraft is flying at a ground speed of 300 knots at the instant the equipment is switched on and that at the time the equipment was switched off the ground speed was 100 knots. The frequency of the received Doppler signal, which depends upon the aircraft's ground speed, is 3·498 kc/s while the frequency of the phonic wheel tone, being related to the last recorded speed of the aircraft, is 1·166 kc/s. The 3·498 kc/s Doppler signal causes pips to be produced by the appropriate tuned circuit in the anode of 5V1.

93. From the tuned circuit the pips are fed to the commutator section of 7X3 and, in this instance, via the wiper, PLH pin 9 and PLC19 to 4TR2 in the pip amplifier. After amplification and integration the pips cause 4V5 to conduct and the search up relay 1RLC is energized. When 1RLC is energized the functions of its contacts are as follows:

(1) Contacts 1RLC1 and 1RLC2 change over and the outputs of the mixer bridges are disconnected from the grids of 3V1, 3V3 in the pre-amplifier as shown in fig. 8.

(2) A 6·3V 400 c/s supply from 1TR1 is fed via the 90° phase shift network and 1RLC1, 1RLD1 to the grid of 3V1. The 6·3V supply is also fed, without phase shift, to the grid of 3V3 via 1RLC2.

(3) Contacts 1RLC4 change over, disconnect the 28V d.c. supply from the signal flag indicator circuit and complete the circuit for the memory flag indicator via contacts 1RLD4 and 1RLE3.

94. The 400 c/s signals are amplified in the pre-amplifier, then fed to the power amplifier and finally applied to the windings of 7MO1, 7MO2 and to 6MO1 in the amplifier, synchro signal (or computor). Conseqently 7MO1 rotates and, via the gear train, drives the commutator potentiometer 7X3. 7MO1 continues to rotate until the gap between the two segments of the commutator is opposite the appropriate tuned circuit (the one which is producing pips due to the 300-knot signal). When this occurs, the circuit to the pip amplifier is broken and pips are no longer fed to 4TR2. 4V5 is cut off, 1RLC is de-energized and the 400 c/s signal is removed from the grids of 3V1 and 3V3. Search drive is now removed from 7MO1.

95. Since the commutator and potentiometer sections of 7X3 are coupled to a common drive shaft, the potentiometer section is also rotated and, as 7MO1 rotates, an increasing potential is fed via PLN pin 1 to the amplifier, synchro signal (or computor). This causes the speed of the phonic wheel motor to increase and, since the frequency of the phonic wheel tone is proportional to the speed of the motor, the frequency of the tone increases. At the moment when search drive to 7MO1 is removed, the phonic wheel tone and Doppler signal frequencies will differ by less than 15% and from then on the tracking unit operates under follow conditions.

96. If the equipment is switched on when the aircraft is flying at a ground speed of 300 knots and it was flying at a higher speed when the equipment was switched off, similar search action results, but in the opposite direction. Pips fed from the appropriate tuned circuit to 7X3 are applied in this instance via PLG pin 1 to 4TR1 in the pip amplifier. 4V3 conducts and energizes the search down relay 1RLD. Contacts 1RLD1 change over to feed the 6·3V 400 c/s signal without phase shift to 3V1 grid while contacts 1RLD2 change over to feed the same signal in phase quadrature to 3V3 grid. Motor 7MO1 now rotates in the reverse direction until the gap between the commutator segments is opposite the appropriate tuned circuit. Simultaneously, the potential fed from the potentiometer section of 7X3 to the amplifier, synchro signal (or computor) decreases, thus causing a decrease in the frequency of the phonic wheel tone. Again, when search drive to 7MO1 is removed, the phonic wheel tone and Doppler signal frequencies differ by less than 15% and the tracking unit begins to operate under follow conditions.

Follow

97. When the tracking unit is in receipt of a Doppler signal of sufficiently high signal/noise ratio and is also locked on in speed, drift and pitch after functioning under search conditions, the follow circuits are operative and control the system. These circuits maintain effective control for all normal increases or decreases of ground speed and search drive is not applied to the speed servo loop provided the difference between the centre frequency of the incoming Doppler signal and that of the phonic wheel tone does not exceed 5%.

98. Assume that the system is functioning under signal conditions and is locked on in speed, drift and pitch with normal indications displayed on the speed and drift indicator, the distance indicator and the computor display unit. The operation of the relevant circuits is as follows.

Speed

99. Both the Doppler signal input and the phonic wheel tone input are amplified in the signal amplifier, the signal passing via the signal filter network and the phonic wheel tone having passed through the phase splitter and quadrature circuits. The amplified signal is fed to 1TR3 and the amplified phonic wheel tone is fed to 1TR5, 1TR6 in the double balanced bridge mixer circuit. Here mixing takes place and the resultant sum and difference frequencies are fed to the pre-amplifier via contacts on relays 1RLC and 1RLD. These relays are de-energized since the commutator section of 7X3 is so positioned that there is no pip input to the pip amplifier and valves 4V3, 4V5 are not conducting. In the pre-amplifier the difference frequencies are selected, amplified and then fed from two identical phase splitter stages to the twin channel push-pull amplifier circuits in the power amplifier before being used to control the speed, drift and pitch integrator motors.

100. At the same time, the amplified Doppler signal from the signal amplifier is fed to the search drive valve 5V1 in the signal comparator unit. The grid circuit of 5V1 consists of a filter network giving a falling amplitude characteristic to the signal with increasing signal frequency of approximately 7dB per decade. From 5V1 anode the signal is fed to the 18 tuned circuits and from the cathode circuit to 8TR17, the untuned transformer on the search panel. The rectified output of 8TR17 is fed to one grid of the signal comparator 5V3 while the rectified output of the tuned circuits (in effect, the a.g.c. voltage) is fed to the other grid.

101. The valve, functioning as a cathode-coupled paraphase amplifier, has a high positive potential at the anode of 5V3a under signal conditions due to the predominance of the Doppler signal. This potential is coupled, via a resistive coupling network, to the grid of the relay control valve 5V4 and causes the valve to conduct sufficiently to energize the primary signal/noise relay 1RLK. Contacts on 1RLK cause the secondary signal/noise (h.t. control) relay to become energized, resulting in the completion of the 140V h.t. supply to the screens and anodes of the power amplifier valves as well as to the anodes of the search relay control valves 4V3 and 4V5. In consequence, the power amplifiers amplify the signals fed from the pre-amplifier. The power amplifier outputs, in phase quadrature, are then applied to the three motors, 7MO1, 7MO2 in the tracking unit and 6MO1 in the amplifier, synchro signal or computor.

102. Motor 7MO1, part of the speed servo loop, rotates in a direction dependent upon the sense of the phase difference between the signals and drives the shaft of the commutator potentiometer 7X3. The output from the potentiometer section is thus varied and an increasing or decreasing potential is fed to the amplifier, synchro signal (or computor) whenever there is a slight increase or decrease in ground speed. The pointer of the speed and drift indicator shows the ground speed of the aircraft and closely follows any change.

Drift

103. In order that the drift angle may be determined, the transmitted beam is displaced to port and then to starboard of the fore and aft line of the aerial array (fig. 7) the displacement sequence being controlled by the aerial waveguide switch. If the aerial is not aligned along the track, the Doppler signals received from the port and starboard directions are of differing frequencies, the difference being dependent upon the degree of misalignment. The drift measurement is obtained by moving the aerial in azimuth until identical Doppler signals are received from the port and starboard beams. When this condition exists, the aerial is aligned along the track (fig. 7b) and the angle θ, being a measure of the difference between aircraft heading and track, is the drift angle.

104. Assume that the aircraft heading is 015° but, due to the effect of the prevailing wind, the track actually made good is 000° and the fore and aft lines of the aerial array and aircraft are coincident. The transmitted beam is switched every half second, the switching sequence being

Port forward PF	Starboard aft SA	Starboard forward SF	Port aft PA

Under these conditions the frequency of the Doppler signal received by the tracking unit, relative to the frequency of the phonic wheel tone, is

PF—high SA—high SF—low PA—low

105. The signals are amplified in the signal amplifier and are then mixed with the phonic wheel tone in the mixer bridges. The difference frequencies are selected and used to control the rotation of 7MO1, 7MO2 and the drift integrator motor (amplifier, synchro signal or computor) via the pre and power amplifiers. The phase sense of the signals applied to these motors is dependent upon whether the difference frequency is obtained from a component of the Doppler signal which lies above or below the phonic wheel tone and this phase sense governs the direction of rotation of the motors.

106. For the period (one second) that the centre frequency of the received Doppler signal is higher than that of the phonic wheel tone, 7MO1 rotates in one direction then, for one second when the Doppler signal frequency is lower than that of the phonic wheel tone, the motor rotates in the opposite direction. Conseqently, when the system is locked on for speed, the difference in frequency of the Doppler signals due to drift has no net effect on the speed circuits and the frequency of the phonic wheel tone remains unaltered.

107. The outputs of 6V3, 6V4 in the power amplifier are fed via PLN pins 18 and 20 direct to one winding of the drift integrator motor (amplifier, synchro signal or computor) while the outputs of 6V1, 6V2 are fed to the same motor via relay contacts 1RLA2, 1RLA3 (operated once per second) and PLN pins 17 and 19. The high Doppler signals cause the motor to rotate in one direction. After one second 1RLA is energized and 1RLA2, 1RLA3 change over (fig. 5). Thus, the phase sense of the signals applied to the motor is unaltered (at the anodes of 6V1, 6V2 the phase sense is reversed due to the application of a low Doppler signal to the amplifiers) and the motor continues to rotate in the same direction.

108. The drift integrator motor is coupled electrically to the aerial and the aerial begins to swing towards the aircraft track. As the divergency of the aerial is reduced, the difference in frequency between the Doppler signals received from port and starboard directions becomes less and finally, when the frequencies are identical, the drift motor ceases to turn. The aerial array is now aligned along the aircraft's track and the drift circuits are locked on for existing conditions. Any further deviation from track due to a change in the prevailing conditions results in the initiation of similar circuit action.

109. The drift angle is shown on the speed and drift indicator which is connected electrically to the drift integrator circuits in the amplifier, synchro signal or computor.

Pitch

110. The aerial is stabilized in the pitch plane by the system and this arranges that the aerial array shall move in pitch until the Doppler signals received by the tracking unit from the fore and aft beams are of the same frequency. When this condition exists, the aerial is aligned along the aircraft flight path in pitch and the angle between the aircraft horizontal axis and the flight path is determined. This angle is called the pitch angle and is the angle of attack of the aircraft in the absence of head or tail winds. If the aerial is not aligned along the flight path in the pitch plane, the angle between the flight path and the rearward beam differs from the angle between the flight path and the forward beam. In consequence, the frequencies of the fore and aft Doppler signals are different, the difference depending upon the degree of misalignment.

111. Relative to the frequency of the phonic wheel tone, the frequencies of the signals received from the four directions of transmission and reception may be

Port forward—low	Starboard aft—high
Starboard forward—low	Port aft—high

These signals, after amplification in the signal amplifier, are mixed in the mixer bridges with the phonic wheel tone. The resultant difference frequencies are amplified by the pre-amplifier and then by the power amplifier before application to motor 7MO2. The phase sense of the signals applied to the motor is dependent upon whether the difference frequency fed to the pre-amplifier is obtained from a component of the Doppler signal which lies above or below the phonic wheel tone and it is this phase sense which governs the direction of rotation of the motor.

112. One winding of 7MO2 is energized by the outputs of 6V3, 6V4. The other winding is energized by the outputs of 6V1, 6V2, these outputs being applied to the motor via relay contacts 1RLB3 and 1RLB4. Relay 1RLB is energized every half second by the action of the aerial-mounted pitch sense contacts. Consequently, the signal received from the port forward direction causes 7MO2 to rotate in one direction. The signal from the starboard aft direction would, if applied direct to winding 1-6-3 of the motor, cause it to rotate in the opposite direction but, due to the switching action of 1RLB3 and 1RLB4, the motor continues to turn in the same direction. A similar action results from the application of the signals from the two remaining directions.

113. Mechanically coupled to 7MO2 is an a.c. pick-off 7X2, energized by a 15V supply from 1TR1. The output of 7X2 is compared with the output of the aerial-mounted pitch a.c. pick-off 1X1 and the potential difference which appears across the pitch servo amplifier input transformer is, after amplification, used to control the aerial pitch motor 1MO2. Rotation of 7MO2 causes a variation in the output from 7X2 and, as a result, the aerial is moved in the pitch plane until it is aligned along the flight path and the received signals are of identical frequency. When these conditions prevail, there is no net drive to 7MO2, the outputs of the two a.c. pick-offs are balanced and the aerial is stationary with its axis aligned along the flight path. It can be seen that the pitch error signals have no net effect on the speed motor 7MO1 and the drift motor in the amplifier, synchro signal (or computor) due to the pitch sequence of frequencies in the Doppler signal.

OPERATION OF THE TRACKING UNIT UNDER MEMORY CONDITIONS

114. In the event of the signal/noise ratio of the received signal falling below the acceptable level (as determined by 5V3 in the signal comparator sub-unit) the tracking unit automatically changes over to operation under memory conditions. Reduction of the signal/noise ratio may be due to the fact that the aircraft is flying at considerable height over very calm sea or, alternatively, a fault in the transmitter-receiver or certain circuits of the tracking unit can produce a similar reduction in signal/noise ratio. As described in para. 127, in-flight test facilities incorporated in the system permit the pilot to ascertain which factor is responsible for the reversion to operation under memory conditions.

115. Assume that the system is functioning under signal conditions with the follow circuits operative as previously described. If the received signal degenerates to the point where the Doppler signal content is small and the noise content comparatively high, the negative potential produced by 8TR17 and the associated circuit becomes large compared with that produced by the tuned circuits. The negative potential fed to 5V3a grid is now smaller than when a signal of high signal/noise ratio is being received and the current through 5V3a increases. There is a corresponding drop in voltage at 5V3a anode and the lower potential fed to the grid of 5V4 causes that valve to be cut off. Relays 1RLK, 1RLE are de-energized so that the 140V h.t. supply is removed from the anodes of 4V3, 4V5 in the pulse modifier and from the screens and anodes of the valves in the power amplifier. The power amplifier unit is now inoperative and the signal from the pre-amplifier, which has a preponderance of noise, cannot reach the three integrator motors. At the same time, drive to 1V1 ceases and relay 1RLL is de-energized. As there is no drive to the speed, drift and pitch motors the shafts of these motors remain in the angular positions they occupied prior to the removal of the drive signal. The system thus cannot respond to the noise signal and is said to be operating under memory conditions.

116. When the speed motor 7MO1 is in the quiescent state, the voltage fed from the wiper of the potentiometer section of 7X3 remains constant at the figure prevailing immediately prior to the changeover to memory conditions. Hence the speed of the phonic wheel motor remains constant and the speed indicator continues to show the ground speed at which the aircraft was travelling at the moment of changeover. The distance indicator continues to operate at a rate determined by the speed of the phonic wheel motor which is now unchanging.

117. Similarly, with no drive applied to the drift and pitch motors, the indicated drift angle remains unaltered and, in ARI.23085/1, there is no change in the drift information fed to the computor. The computor thus continues to operate on the information last made available prior to the changeover from signal to memory conditions.

118. While the memory conditions persist there is no change in the potential across the primary windings of the aerial drift and pitch servo amplifier transformers since 7X2 in the tracking unit and the drift synchro control transmitter in the amplifier, synchro signal or computor are stationary. In consequence there is no drive to the aerial pitch and drift motors and the aerial remains in the attitude that last existed under signal conditions. De-energization of the secondary signal/noise relay 1RLE causes contacts 1RLE3 to change over and the 28V d.c. supply is switched to the memory flag circuit. The signal flag circuit is inoperative since 1RLL is de-energized immediately the drive to 1V1 is removed. When 1RLE is de-energized a negative 75V supply is made available to the operating coils of the memory test relays 1RLG, 1RLN through the action of contacts 1RLE4.

TEST CIRCUITS

119. The test circuits incorporated in the tracking unit enable a quick check of the system to be made under the following conditions.

(1) In flight during normal signal conditions to ensure that the speed and drift servo circuits are operating correctly.

(2) In flight under memory conditions to ensure that the equipment has changed to memory operation because of deterioration of the received Doppler signal and not because of an equipment failure.

(3) Before flight, or when bench testing, as a general check. The test is then identical with that made in flight under memory conditions.

120. The principal components controlling the testing operations are relays 1RLG, 1RLH, 1RLJ, 1RLN in the tracking unit, relay 1RLB and the 800 c/s tone source in the transmitter-receiver and the TEST push-button switch SWA on the speed and drift indicator.

In-flight test under signal conditions

121. If, during flight, the operator wishes to ascertain that the tracking circuits are functioning correctly when the system is working under signal conditions, he presses the TEST button and observes the speed and drift indicator. Operation of the button causes the speed and drift servo systems to be inched off producing corresponding movements of the speed and drift pointers. When the TEST button is released, the received signal returns the pointers to the true positions if all the units are serviceable. During this check the distance flown indicator and the computor receive false information and, to minimize the error introduced, the TEST button is again pressed and inching occurs in the opposite direction. Consequently, if equal speed displacement is introduced on each occasion, the two disturbances cancel.

122. The circuit action initiated by this check is as follows (fig. 9). With the system operating under normal signal conditions the primary and secondary signal/noise relays 1RLK and 1RLE are energized. Contacts 1RLE4 are thus open and the memory test relays 1RLG and 1RLN cannot be energized. When the TEST button is first pressed, relay 1RLH is energized from the −75V supply via contacts 1RLG1, resistor 1R24, contacts 1RLH2 and the TEST button to earth. Relay 1RLJ cannot be energized since the coil is short-circuited via contacts 1RLJ1. Energizing 1RLH has the following effects:

(1) The hold-on contacts 1RLH2 maintain the supply so that the relay remains energized when the TEST button is released.

(2) Contacts 1RLH1 change over and prevent relay 1RLD being energized.

(3) Contacts 1RLH3 complete the energizing path for 1RLC from the 140V supply via contacts 1RLG2, contacts 1RLE1 (operated), contacts 1RLH3 (operated) and contacts 1RLJ3 to earth.

(4) Contacts 1RLH4 change over and cause the drift sense relay 1RLA to be energized.

123. When the search up relay 1RLC is energized, a 400 c/s signal derived from the lattice formed by 1R5, 1R6, 1R7 and 1C20 is fed, via contacts 1RLC1, 1RLC2, to the pre-amplifier. This signal causes the speed servo to be inched up and the speed indicator registers increasing speed until the TEST button is released. At the same time, due to the drift sense relay being energized, continuous drive is applied to the drift integrator motor in the amplifier, synchro signal (or computor) and the drift pointer on indicator assembly Type M.15 moves to port.

124. When the TEST button is released, the short-circuit is removed from 1RLJ and this relay is now energized through contacts 1RLG1, resistor 1R23 and contacts 1RLH2 to earth. Relay 1RLH remains energized. Through the action of the changeover contacts 1RLJ3, 1RLC is de-energized removing the search drive from the pre-amplifier. At the same time contacts 1RLJ4 break the circuit of 1RLA and the drift sense relay is also de-energized. The system will now revert to signal conditions and, if all the units are functioning properly, the speed and drift pointers will return to their correct positions.

125. However, during the time the TEST button is pressed, incorrect information is fed to the distance indicator and to the computor and the errors thus introduced are not corrected automatically. To compensate for these errors the TEST button must be pressed a second time and the system allowed to inch down by an equal number of knots.

126. When the TEST button is pressed the second time, 1RLH is short-circuited through the action of contacts 1RLJ1 and the relay is de-energized. The sequence of events is now

(1) Contacts 1RLH1 change over and the search down relay 1RLD is energized via 1RLG2, 1RLE1, 1RLH1 and 1RLJ3.

(2) Contacts 1RLJ4 cause the drift sense relay 1RLA to be re-energized.

The 400 c/s signal, reversed in phase, is again fed to the pre-amplifier and the speed servo is inched down so that the speed indicator shows decreasing speed. Similarly, continuous drive in the reverse direction is applied to the drift integrator motor and the drift pointer moves to starboard. On releasing the TEST button the speed and drift pointers will return to their original positions. Failure of either or both pointers to return to the correct positions indicates a fault in the system.

In-flight test under memory conditions

127. If the system is operating under memory conditions, the operator may wish to check that the equipment has reverted to memory conditions because of deterioration of the received Doppler signal and not because of an equipment fault. To check the transmitter-receiver as well as the signal amplifier and signal comparator in the tracking unit, the transmitter klystron is modulated by an 800 c/s signal derived from the 400 c/s power supply. A small proportion of the transmitted signal breaks through to the receiver and takes the place of the normal Doppler signal which, when the system is operating under memory conditions, is unusable. If the various circuits are all functioning correctly, the memory flag on the speed and drift indicator disappears and the signal flag is displayed. Relay switching arrangements are incorporated to ensure that the test signal does not interfere with the speed, drift or pitch integrator circuits.

128. The circuit action of the test is as follows (fig. 9). With the system receiving an unusable signal the primary and secondary signal/noise relays 1RLK and 1RLE are de-energized. Since 1RLE is de-energized a −75V supply is available at the coil of 1RLN via contacts 1RLE4 and diode 1MR19 and depression of the TEST button completes the circuit to earth for the coils of 1RLN and 1RLG. These relays are now energized and remain in that condition as long as the button is pressed with the following effects:

(1) Contacts 1RLG1 change over and remove the −75V supply from relays 1RLH and 1RLJ. This prevents the relays being energized so that the tracking circuits cannot be inched up or down. The contacts also provide a hold-on circuit for 1RLN and 1RLG to ensure that these relays remain energized when 1RLE is energized due to the signal comparator receiving the test signal.

(2) Contacts 1RLG2 change over and break the h.t. circuit through 1RLE1 to the search relay control valves and power amplifier. This ensures that the speed, drift and pitch integrator circuits are inoperative

considerable height over very calm sea or, alternatively, a fault in the transmitter-receiver or certain circuits of the tracking unit can produce a similar reduction in signal/noise ratio. As described in para. 127, in-flight test facilities incorporated in the system permit the pilot to ascertain which factor is responsible for the reversion to operation under memory conditions.

115. Assume that the system is functioning under signal conditions with the follow circuits operative as previously described. If the received signal degenerates to the point where the Doppler signal content is small and the noise content comparatively high, the negative potential produced by 8TR17 and the associated circuit becomes large compared with that produced by the tuned circuits. The negative potential fed to 5V3a grid is now smaller than when a signal of high signal/noise ratio is being received and the current through 5V3a increases. There is a corresponding drop in voltage at 5V3a anode and the lower potential fed to the grid of 5V4 causes that valve to be cut off. Relays 1RLK, 1RLE are de-energized so that the 140V h.t. supply is removed from the anodes of 4V3, 4V5 in the pulse modifier and from the screens and anodes of the valves in the power amplifier. The power amplifier unit is now inoperative and the signal from the pre-amplifier, which has a preponderance of noise, cannot reach the three integrator motors. At the same time, drive to 1V1 ceases and relay 1RLL is de-energized. As there is no drive to the speed, drift and pitch motors the shafts of these motors remain in the angular positions they occupied prior to the removal of the drive signal. The system thus cannot respond to the noise signal and is said to be operating under memory conditions.

116. When the speed motor 7MO1 is in the quiescent state, the voltage fed from the wiper of the potentiometer section of 7X3 remains constant at the figure prevailing immediately prior to the changeover to memory conditions. Hence the speed of the phonic wheel motor remains constant and the speed indicator continues to show the ground speed at which the aircraft was travelling at the moment of changeover. The distance indicator continues to operate at a rate determined by the speed of the phonic wheel motor which is now unchanging.

117. Similarly, with no drive applied to the drift and pitch motors, the indicated drift angle remains unaltered and, in ARI.23085/1, there is no change in the drift information fed to the computor. The computor thus continues to operate on the information last made available prior to the changeover from signal to memory conditions.

118. While the memory conditions persist there is no change in the potential across the primary windings of the aerial drift and pitch servo amplifier transformers since 7X2 in the tracking unit and the drift synchro control transmitter in the amplifier, synchro signal or computor are stationary. In consequence there is no drive to the aerial pitch and drift motors and the aerial remains in the attitude that last existed under signal conditions. De-energization of the secondary signal/noise relay 1RLE causes contacts 1RLE3 to change over and the 28V d.c. supply is switched to the memory flag circuit. The signal flag circuit is inoperative since 1RLL is de-energized immediately the drive to 1V1 is removed. When 1RLE is de-energized a negative 75V supply is made available to the operating coils of the memory test relays 1RLG, 1RLN through the action of contacts 1RLE4.

TEST CIRCUITS

119. The test circuits incorporated in the tracking unit enable a quick check of the system to be made under the following conditions.

(1) In flight during normal signal conditions to ensure that the speed and drift servo circuits are operating correctly.

(2) In flight under memory conditions to ensure that the equipment has changed to memory operation because of deterioration of the received Doppler signal and not because of an equipment failure.

(3) Before flight, or when bench testing, as a general check. The test is then identical with that made in flight under memory conditions.

120. The principal components controlling the testing operations are relays 1RLG, 1RLH, 1RLJ, 1RLN in the tracking unit, relay 1RLB and the 800 c/s tone source in the transmitter-receiver and the TEST push-button switch SWA on the speed and drift indicator.

In-flight test under signal conditions

121. If, during flight, the operator wishes to ascertain that the tracking circuits are functioning correctly when the system is working under signal conditions, he presses the TEST button and observes the speed and drift indicator. Operation of the button causes the speed and drift servo systems to be inched off producing corresponding movements of the speed and drift pointers. When the TEST button is released, the received signal returns the pointers to the true positions if all the units are serviceable. During this check the distance flown indicator and the computor receive false information and, to minimize the error introduced, the TEST button is again pressed and inching occurs in the opposite direction. Consequently, if equal speed displacement is introduced on each occasion, the two disturbances cancel.

122. The circuit action initiated by this check is as follows (fig. 9). With the system operating under normal signal conditions the primary and secondary signal/noise relays 1RLK and 1RLE are energized. Contacts 1RLE4 are thus open and the memory test relays 1RLG and 1RLN cannot be energized. When the TEST button is first pressed, relay 1RLH is energized from the −75V supply via contacts 1RLG1, resistor 1R24, contacts 1RLH2 and the TEST button to earth. Relay 1RLJ cannot be energized since the coil is short-circuited via contacts 1RLJ1. Energizing 1RLH has the following effects:

(1) The hold-on contacts 1RLH2 maintain the supply so that the relay remains energized when the TEST button is released.

(2) Contacts 1RLH1 change over and prevent relay 1RLD being energized.

(3) Contacts 1RLH3 complete the energizing path for 1RLC from the 140V supply via contacts 1RLG2, contacts 1RLE1 (operated), contacts 1RLH3 (operated) and contacts 1RLJ3 to earth.

(4) Contacts 1RLH4 change over and cause the drift sense relay 1RLA to be energized.

123. When the search up relay 1RLC is energized, a 400 c/s signal derived from the lattice formed by 1R5, 1R6, 1R7 and 1C20 is fed, via contacts 1RLC1, 1RLC2, to the pre-amplifier. This signal causes the speed servo to be inched up and the speed indicator registers increasing speed until the TEST button is released. At the same time, due to the drift sense relay being energized, continuous drive is applied to the drift integrator motor in the amplifier, synchro signal (or computor) and the drift pointer on indicator assembly Type M.15 moves to port.

124. When the TEST button is released, the short-circuit is removed from 1RLJ and this relay is now energized through contacts 1RLG1, resistor 1R23 and contacts 1RLH2 to earth. Relay 1RLH remains energized. Through the action of the changeover contacts 1RLJ3, 1RLC is de-energized removing the search drive from the pre-amplifier. At the same time contacts 1RLJ4 break the circuit of 1RLA and the drift sense relay is also de-energized. The system will now revert to signal conditions and, if all the units are functioning properly, the speed and drift pointers will return to their correct positions.

125. However, during the time the TEST button is pressed, incorrect information is fed to the distance indicator and to the computor and the errors thus introduced are not corrected automatically. To compensate for these errors the TEST button must be pressed a second time and the system allowed to inch down by an equal number of knots.

126. When the TEST button is pressed the second time, 1RLH is short-circuited through the action of contacts 1RLJ1 and the relay is de-energized. The sequence of events is now

(1) Contacts 1RLH1 change over and the search down relay 1RLD is energized via 1RLG2, 1RLE1, 1RLH1 and 1RLJ3.

(2) Contacts 1RLJ4 cause the drift sense relay 1RLA to be re-energized.

The 400 c/s signal, reversed in phase, is again fed to the pre-amplifier and the speed servo is inched down so that the speed indicator shows decreasing speed. Similarly, continuous drive in the reverse direction is applied to the drift integrator motor and the drift pointer moves to starboard. On releasing the TEST button the speed and drift pointers will return to their original positions. Failure of either or both pointers to return to the correct positions indicates a fault in the system.

In-flight test under memory conditions

127. If the system is operating under memory conditions, the operator may wish to check that the equipment has reverted to memory conditions because of deterioration of the received Doppler signal and not because of an equipment fault. To check the transmitter-receiver as well as the signal amplifier and signal comparator in the tracking unit, the transmitter klystron is modulated by an 800 c/s signal derived from the 400 c/s power supply. A small proportion of the transmitted signal breaks through to the receiver and takes the place of the normal Doppler signal which, when the system is operating under memory conditions, is unusable. If the various circuits are all functioning correctly, the memory flag on the speed and drift indicator disappears and the signal flag is displayed. Relay switching arrangements are incorporated to ensure that the test signal does not interfere with the speed, drift or pitch integrator circuits.

128. The circuit action of the test is as follows (fig. 9). With the system receiving an unusable signal the primary and secondary signal/noise relays 1RLK and 1RLE are de-energized. Since 1RLE is de-energized a −75V supply is available at the coil of 1RLN via contacts 1RLE4 and diode 1MR19 and depression of the TEST button completes the circuit to earth for the coils of 1RLN and 1RLG. These relays are now energized and remain in that condition as long as the button is pressed with the following effects:

(1) Contacts 1RLG1 change over and remove the −75V supply from relays 1RLH and 1RLJ. This prevents the relays being energized so that the tracking circuits cannot be inched up or down. The contacts also provide a hold-on circuit for 1RLN and 1RLG to ensure that these relays remain energized when 1RLE is energized due to the signal comparator receiving the test signal.

(2) Contacts 1RLG2 change over and break the h.t. circuit through 1RLE1 to the search relay control valves and power amplifier. This ensures that the speed, drift and pitch integrator circuits are inoperative

and that the test signal cannot give rise to spurious information. The contacts also connect capacitor 1C46 to 1R42.

(3) Contacts 1RLG3 change over and transfer the grid of 5V3b from 8TR17 to a preset potential of the order of −7V at the slider of 5RV3 to simulate low noise conditions.

(4) Contacts 1RLG4 change over, disconnect capacitor 1C8 from earth and, at the same time, complete the energizing circuit for relay 1RLB in the transmitter-receiver to apply the 800 c/s modulating signal to the klystron.

(5) Contacts 1RLN1 change over and connect 1V1a grid through 1R46 to a positive potential. Since the negative bias has already been removed from 1V1b grid through the action of contacts 1RLG1, relay 1RLL is energized.

(6) Contacts 1RLN2 change over and disconnect 1R43 from earth.

129. When relay 1RLB in the transmitter-receiver is energized the action of its contacts causes the transmitted signal to be modulated with the 800 c/s tone. The portion of this signal which breaks through to the receiver forms the test signal and is fed into the signal amplifier. From there it passes to the signal comparator which, due to the circuit changes brought about by the contacts on 1RLG, functions as though a normal input of acceptable signal/noise ratio were being applied.

130. On receipt of the test signal the anode potential of 5V3a rises and causes 5V4 to conduct. As a result relay 1RLK is energized. Contacts 1RLK2 cause 5V4 grid to be raised to the potential at the slider of 5RV4 while contacts 1RLK1 complete the energizing circuit for 1RLE. When 1RLE is energized, contacts 1RLE1 change over and apply +140V to one plate of 1C8 via 1R42. Contacts 1RLE2 change over and connect the other plate of 1C8 to a source of approximately −10V. Since 1RLG is energized, the +140V supply is also connected, through contacts 1RLG2, to one plate of 1C46, the other plate of this capacitor being at the same potential as 5V3b grid, i.e. −7V. Both 1C8 and 1C46 are thus charged.

131. The flag on the speed and drift indicator may flash 3 or 4 times as the a.g.c. voltage builds up, i.e. as capacitors 1C4, 1C5, 1C6 and 1C7 are charged up in turn, but eventually the signal flag will be displayed steadily.

132. When the TEST button is released, relays 1RLG and 1RLN are de-energized. Through the action of contacts 1RLG2 the +140V supply is momentarily connected via 1RLE1 to the search and follow circuits but, since relay 1RLE is de-energized immediately after 1RLG, the duration of this h.t. pulse is too short to have any significant effect.

133. With 1RLE de-energized, the +140V supply is disconnected from 1C46 and as 1R43 is now returned to earth through contacts 1RLN2, a large negative pulse is applied to the grid of 5V3b. This brings about a fall in potential at 5V3a anode which causes 5V4 to be cut off. In consequence, relays 1RLK and 1RLE are de-energized.

134. During the time the TEST button is depressed a very large a.g.c. voltage may be produced by the strong test signal. This voltage must be given time to leak away before the comparator valve is allowed to control the signal/noise circuits again and thus the positive plate of 1C8 is re-connected to earth when 1RLG is de-energized and the negative plate to 5V4 grid when 1RLE is de-energized.

135. Before 1RLG was de-energized, capacitor 1C8 was charged to approximately 150V. In the short interval of time between the de-energizing of relays 1RLG and 1RLE part of the charge on 1C8 will have leaked away through 5R26 but when the capacitor is re-connected to 5V4 grid, through the action of contacts 1RLE2, the remaining charge can only leak away through resistors 5R19 and 5R18. As a result, 5V4 is held in the cut-off condition for a period of approximately 20 seconds before a signal of satisfactory signal/noise ratio can be accepted.

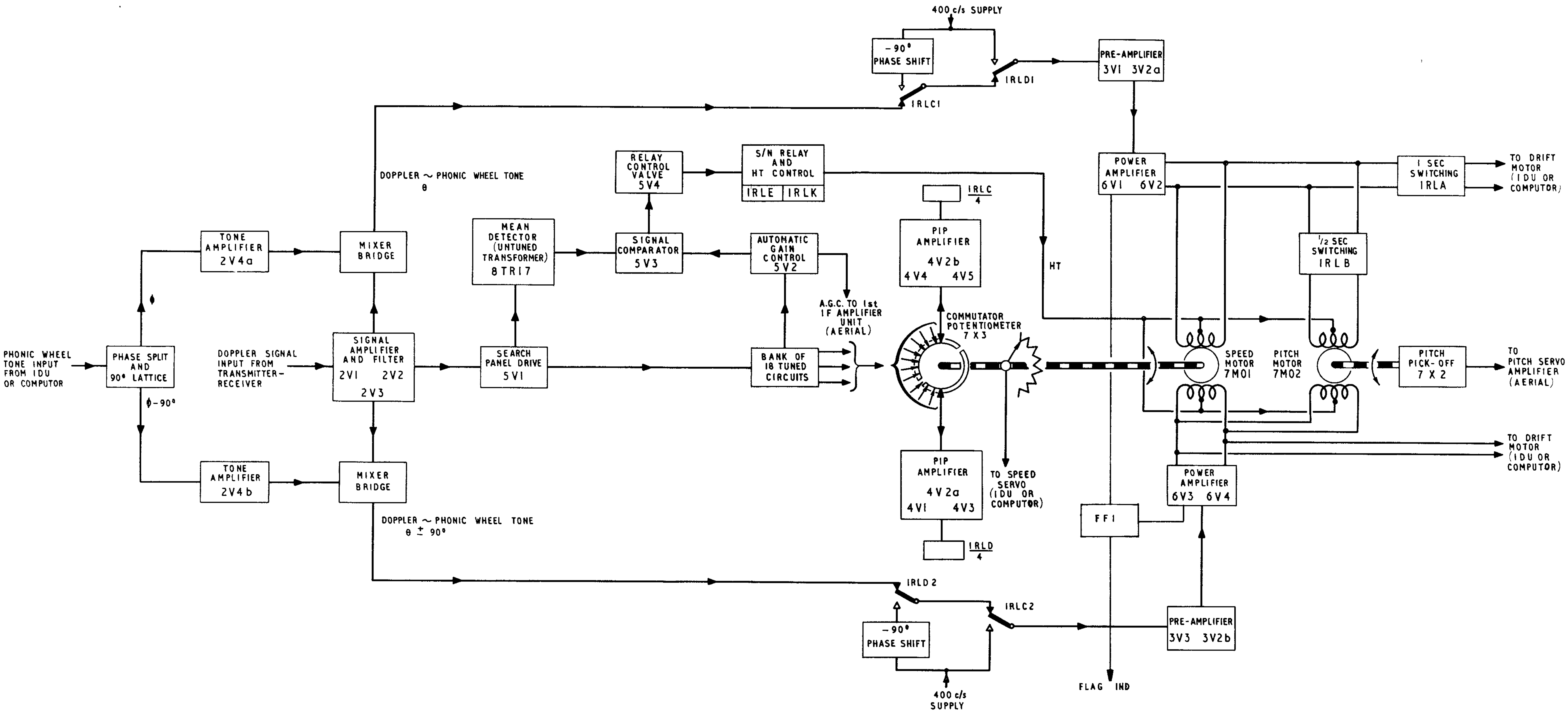


Fig. 8 Tracking unit : block diagram Fig. 8

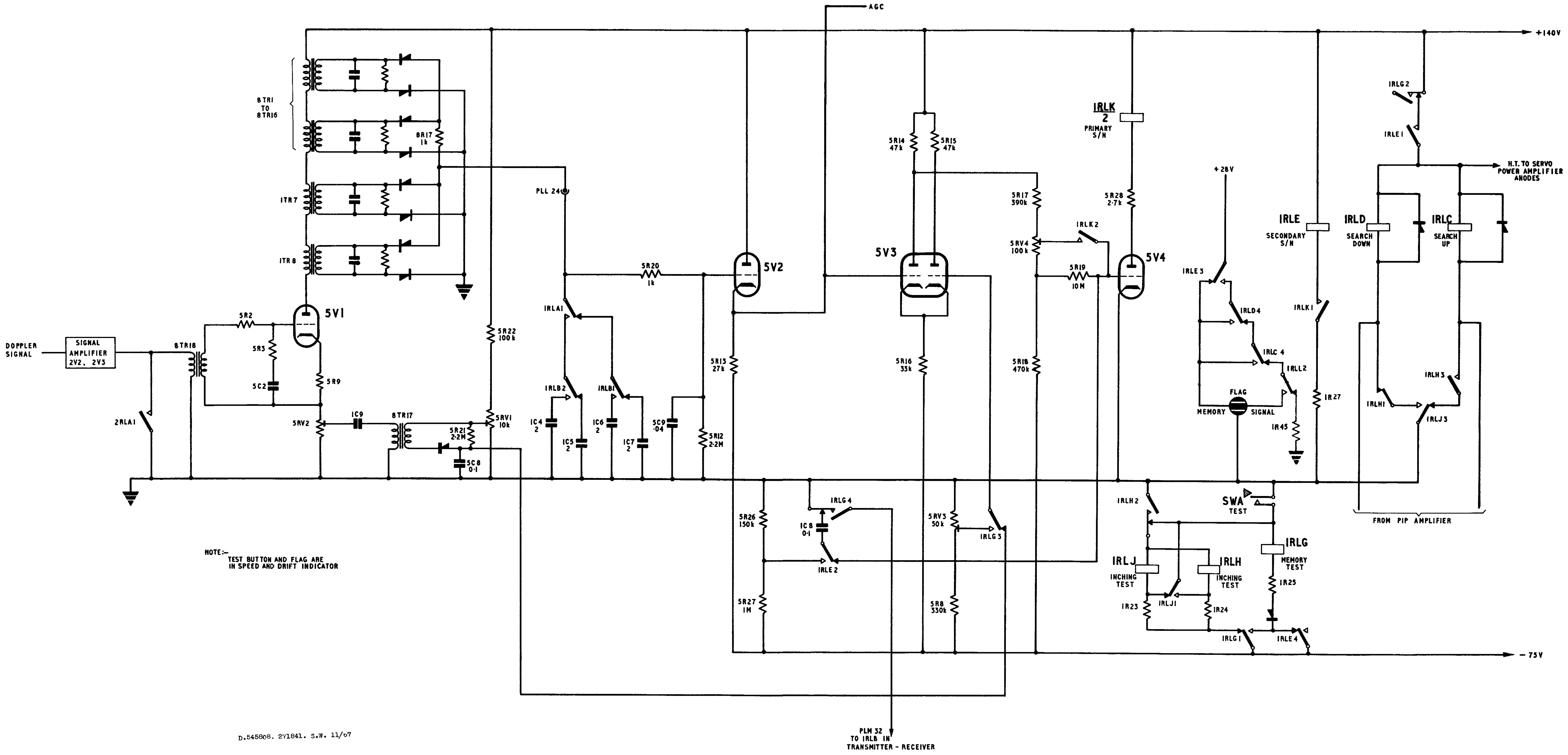
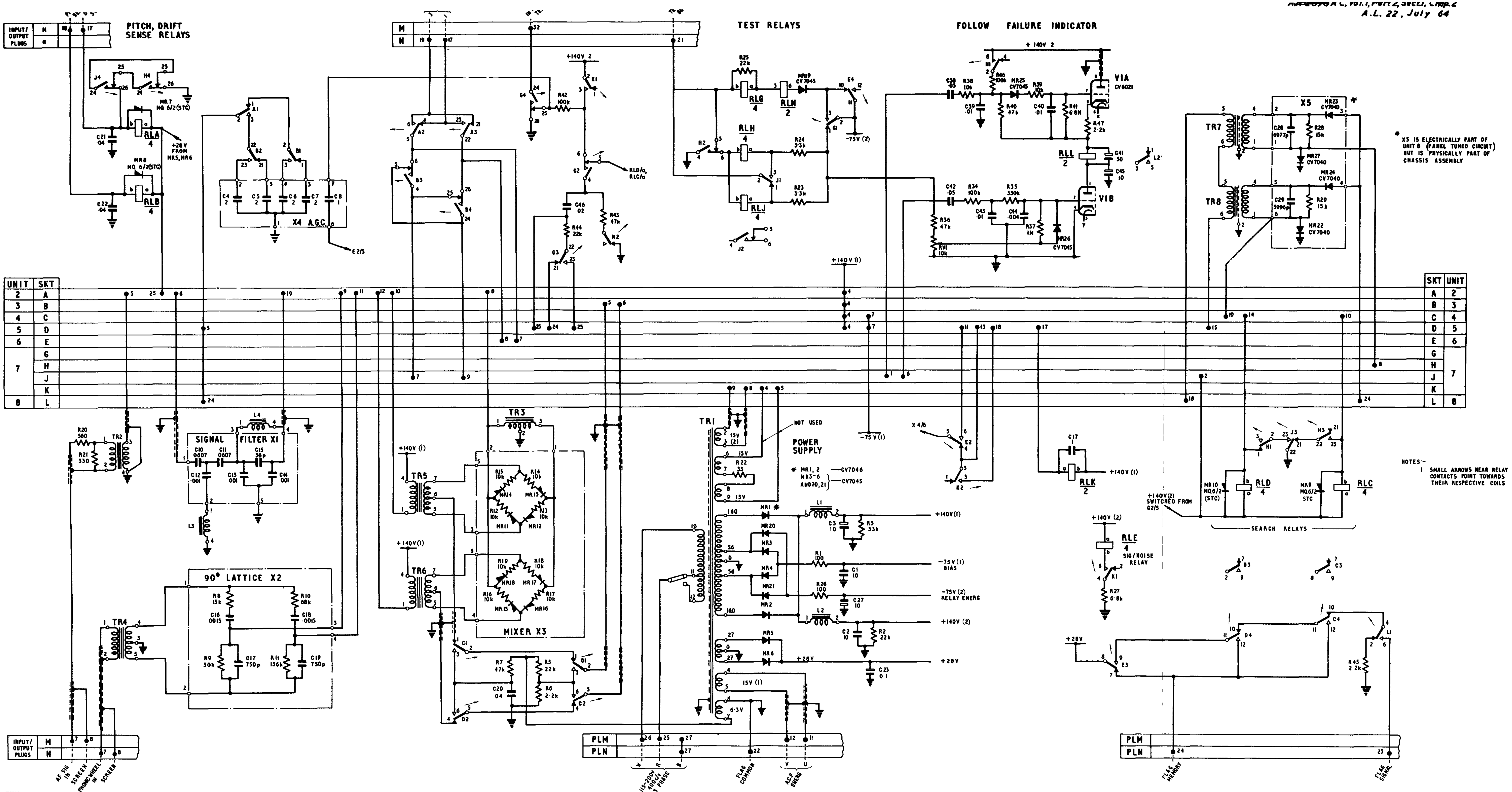


Fig. 9 Simplified a.g.c. and S/N circuits, and test relays Fig. 9

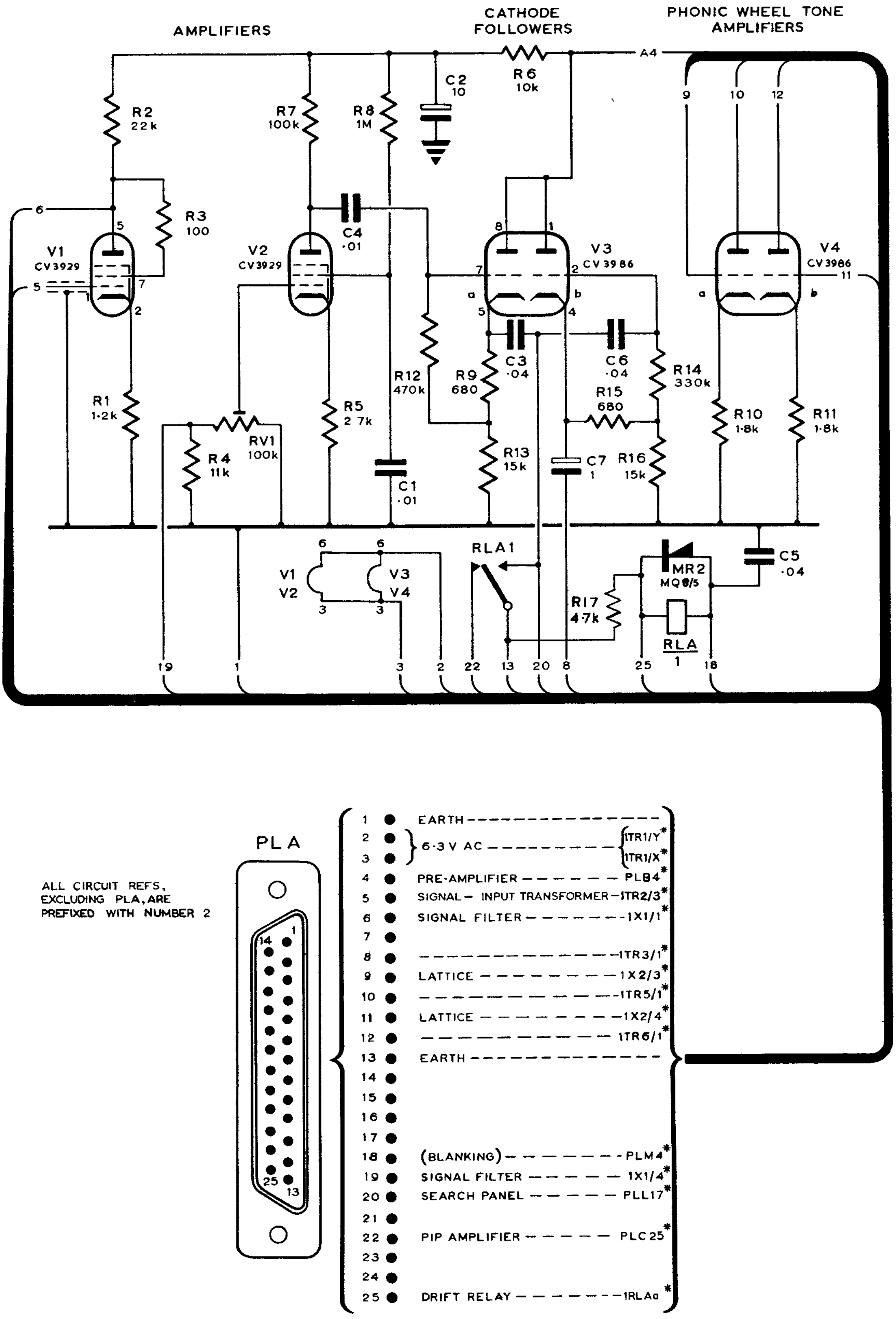


Chassis, electrical equipment Type M.24: circuit

Fig. 10

AIR DIAGRAM
6775 V/MIN.
ISSUE 2
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE (Prepared by the Ministry of Aviation)

88162/573171/23/3/66 J. T. & S.



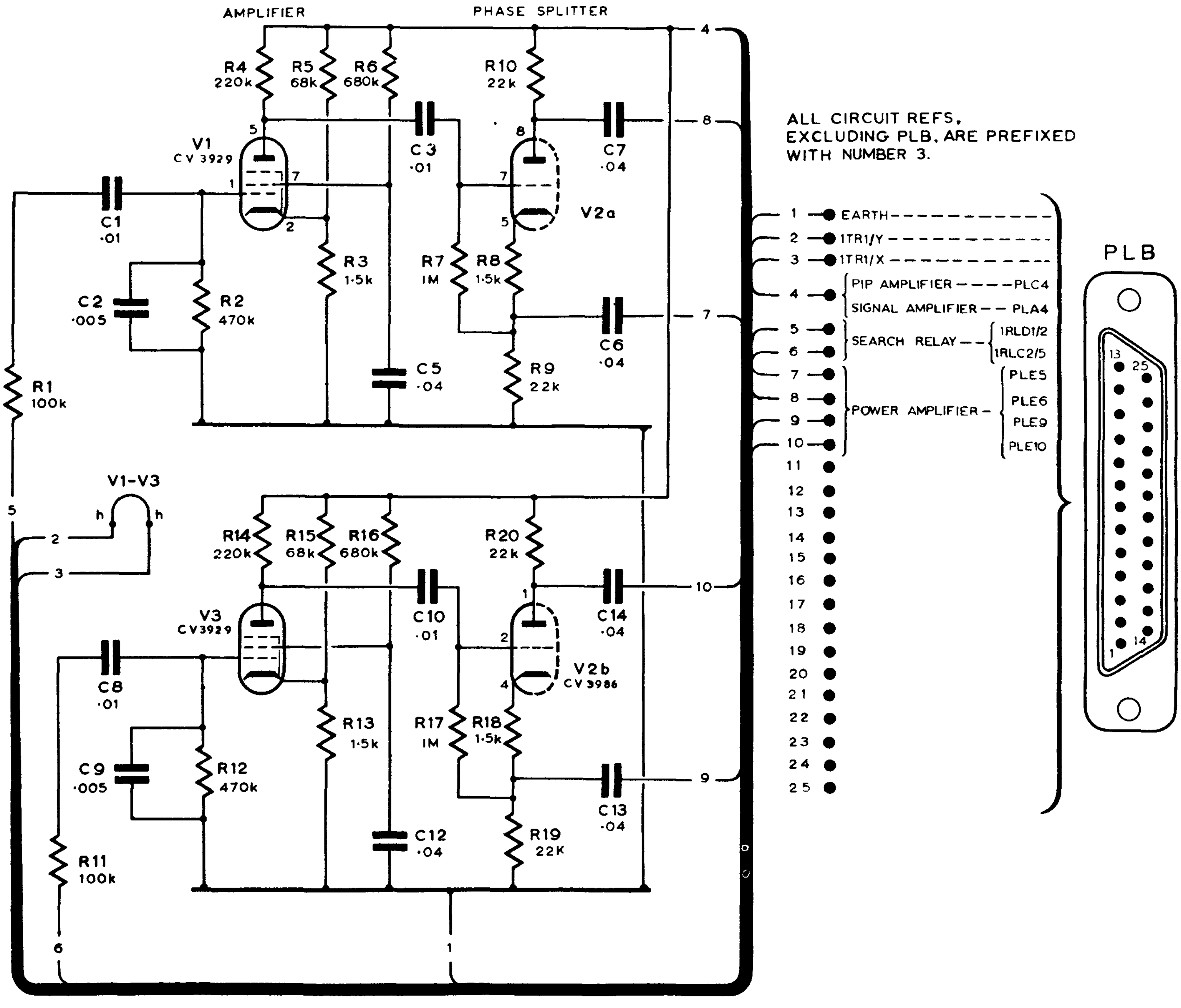
* EXTERNAL CONNECTIONS

AIR DIAGRAM 6775 W/MIN.
ISSUE 3 — PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Amplifier audio frequency 10AD/4022 : circuit Fig.11

COMPUTOR FREQUENCY TRACKER AIR NAVIGATION

D.460199 300 12/66 A.(C)Ltd Gp. 956/3 231M



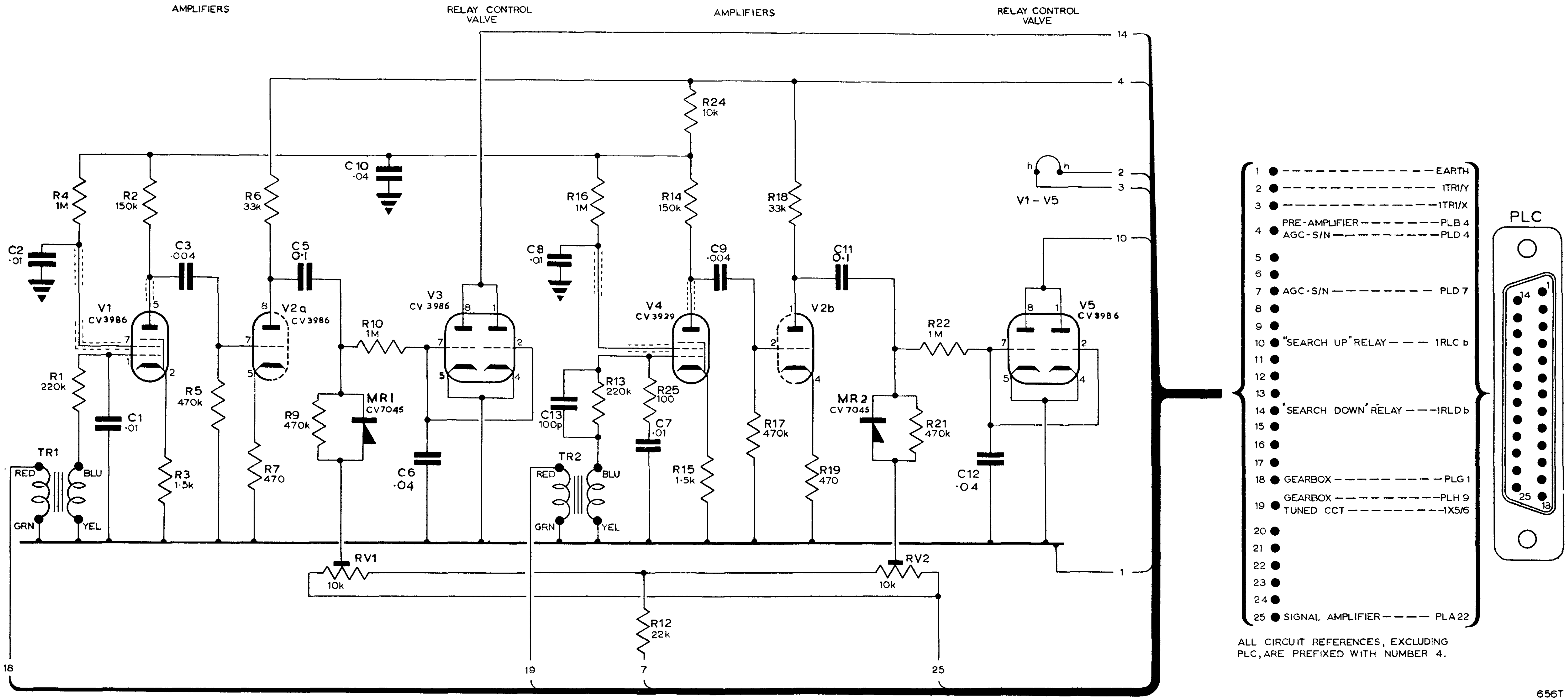
AIR DIAGRAM
6775X/MIN.

ISSUE 2

PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Amplifier assembly (10AD/4021): circuit

Fig.12

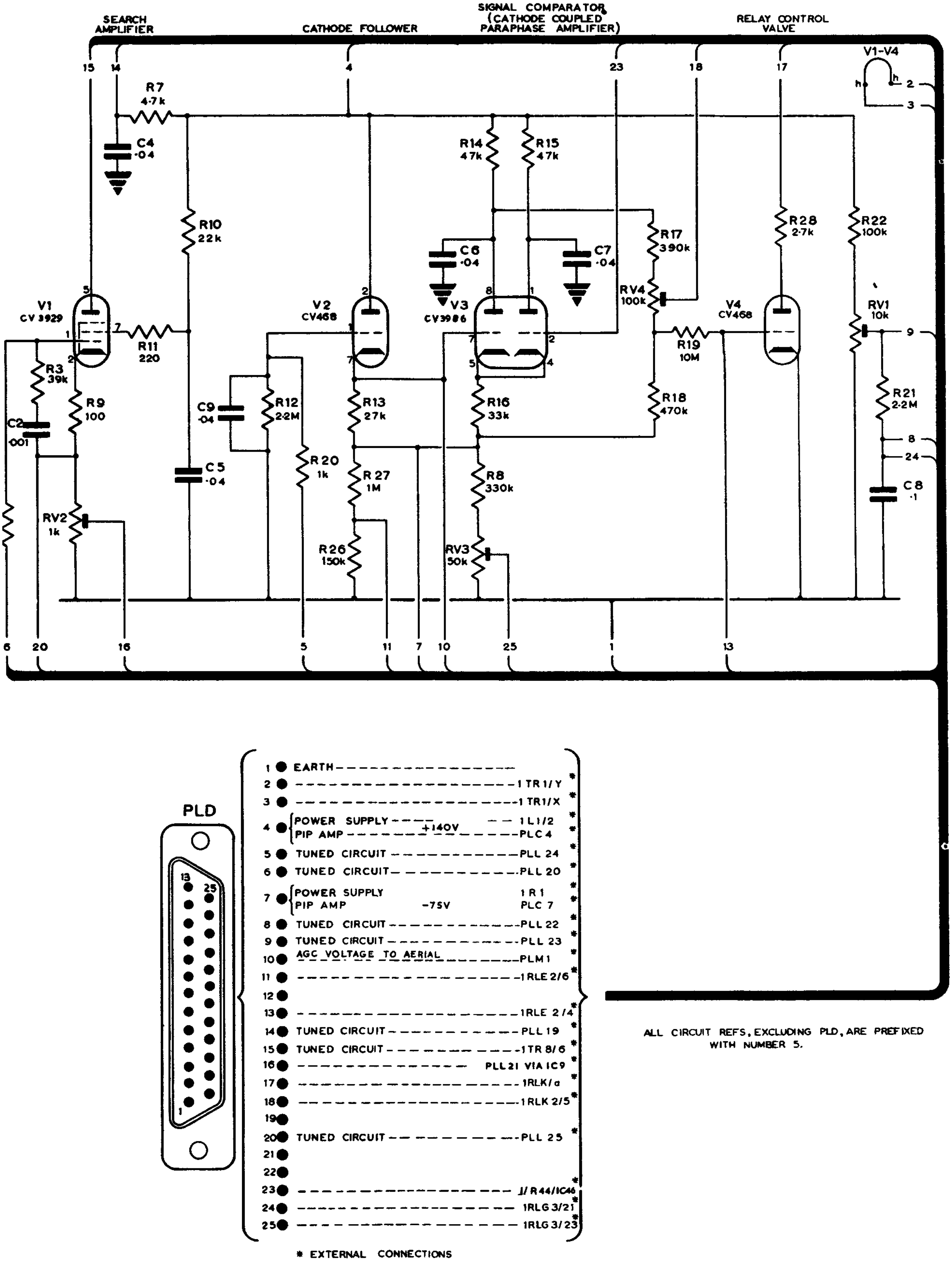


AIR DIAGRAM	
6775 Y /MIN.	
ISSUE 3	PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Pulse modifier 1OAD/4020 : circuit

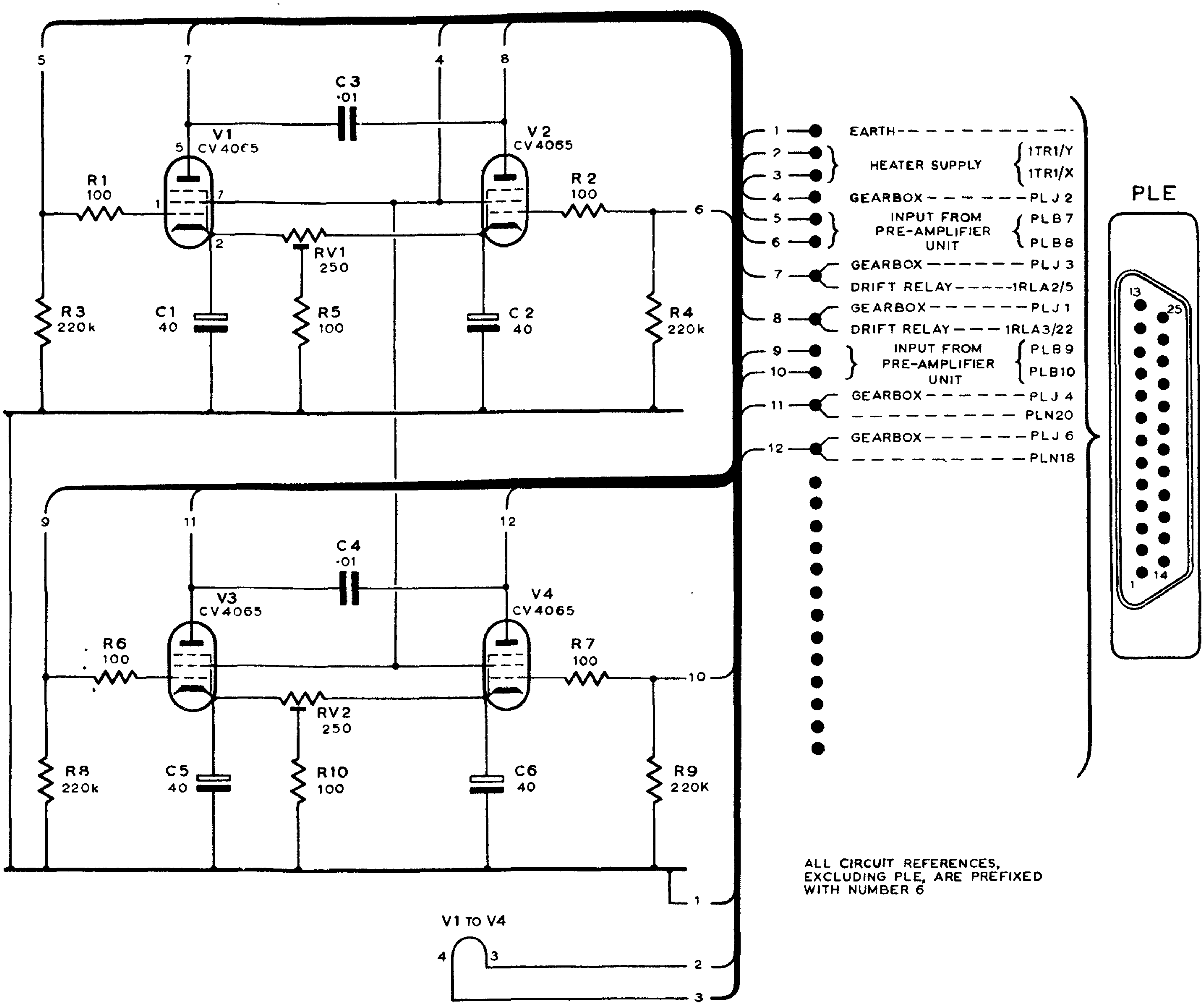
Fig. 13

D 460199 300 12 66 A (C)Ltd Gp 956/3 231M



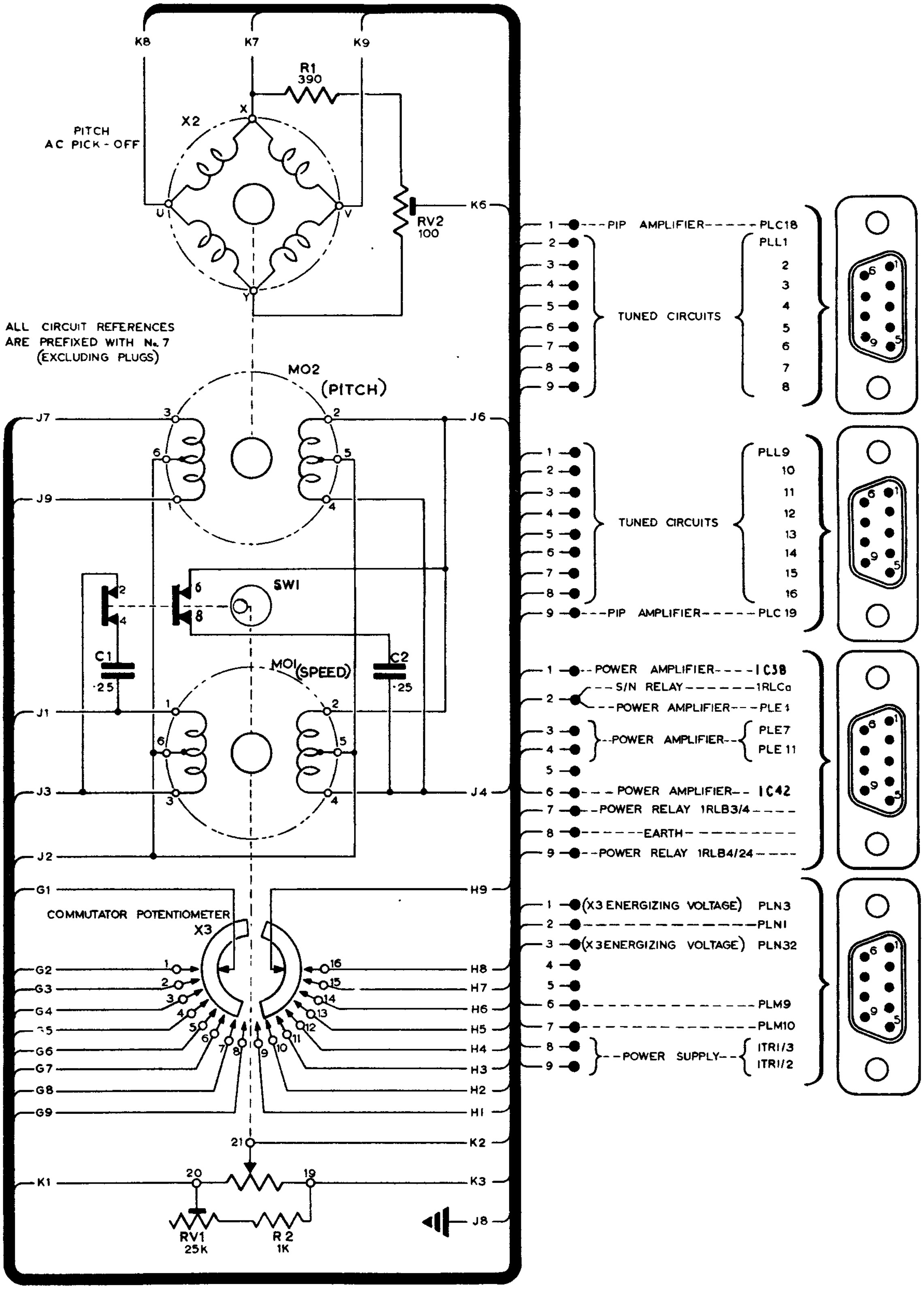
PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Comparator signal (10.AD/4019): circuit Fig.14



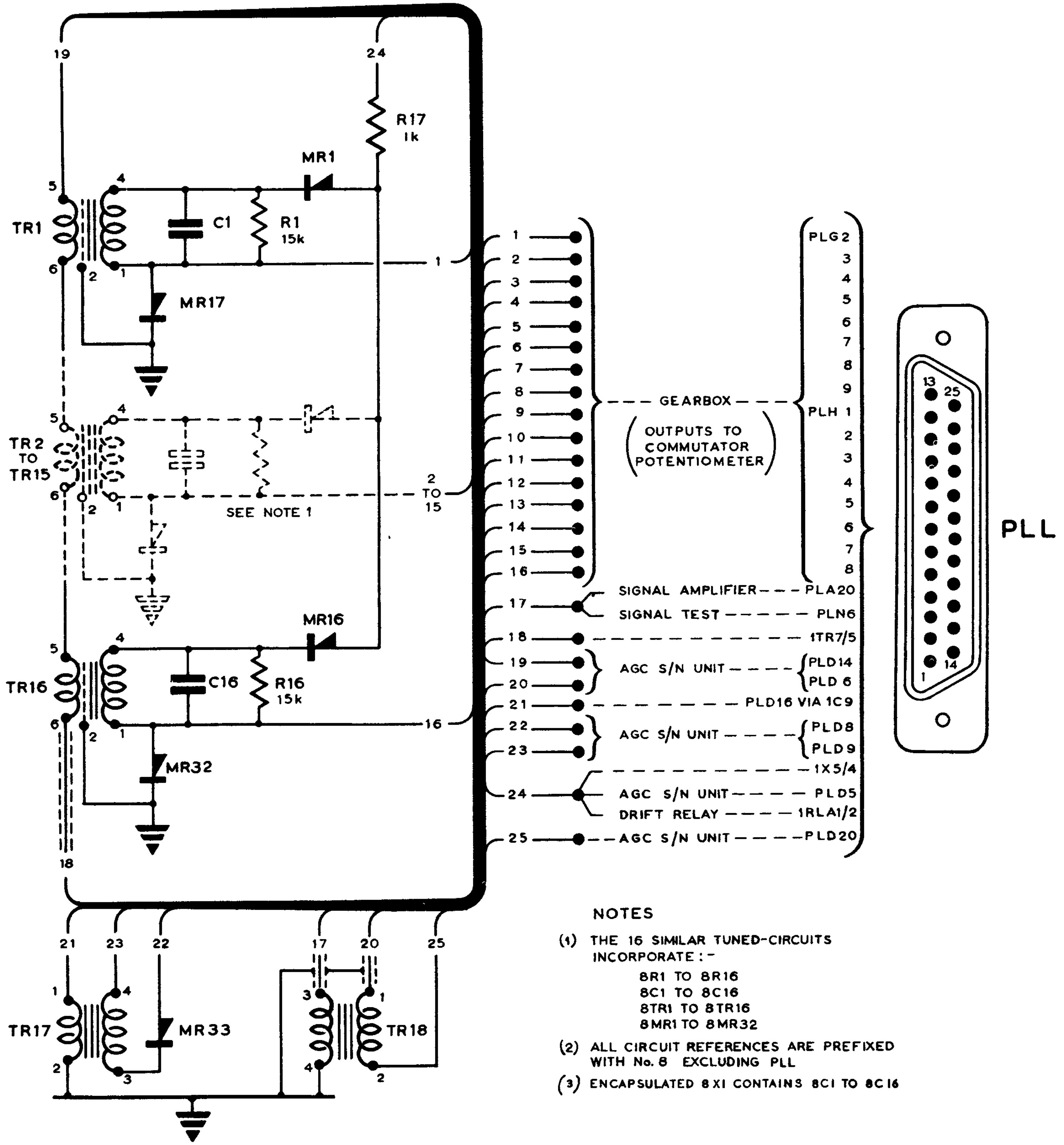
AIR DIAGRAM
6775AA/MIN.
PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY
ISSUE 2

Amplifier electronic control 10AD/4023 : circuit Fig. 15



AIR DIAGRAM 6775 AB /MIN.	
ISSUE 2	PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Gear assembly 10AR/5698: circuit   Fig. 16



NOTES

(1) THE 16 SIMILAR TUNED-CIRCUITS INCORPORATE :-
8R1 TO 8R16
8C1 TO 8C16
8TR1 TO 8TR16
8MR1 TO 8MR32

(2) ALL CIRCUIT REFERENCES ARE PREFIXED WITH No. 8 EXCLUDING PLL

(3) ENCAPSULATED 8X1 CONTAINS 8C1 TO 8C16

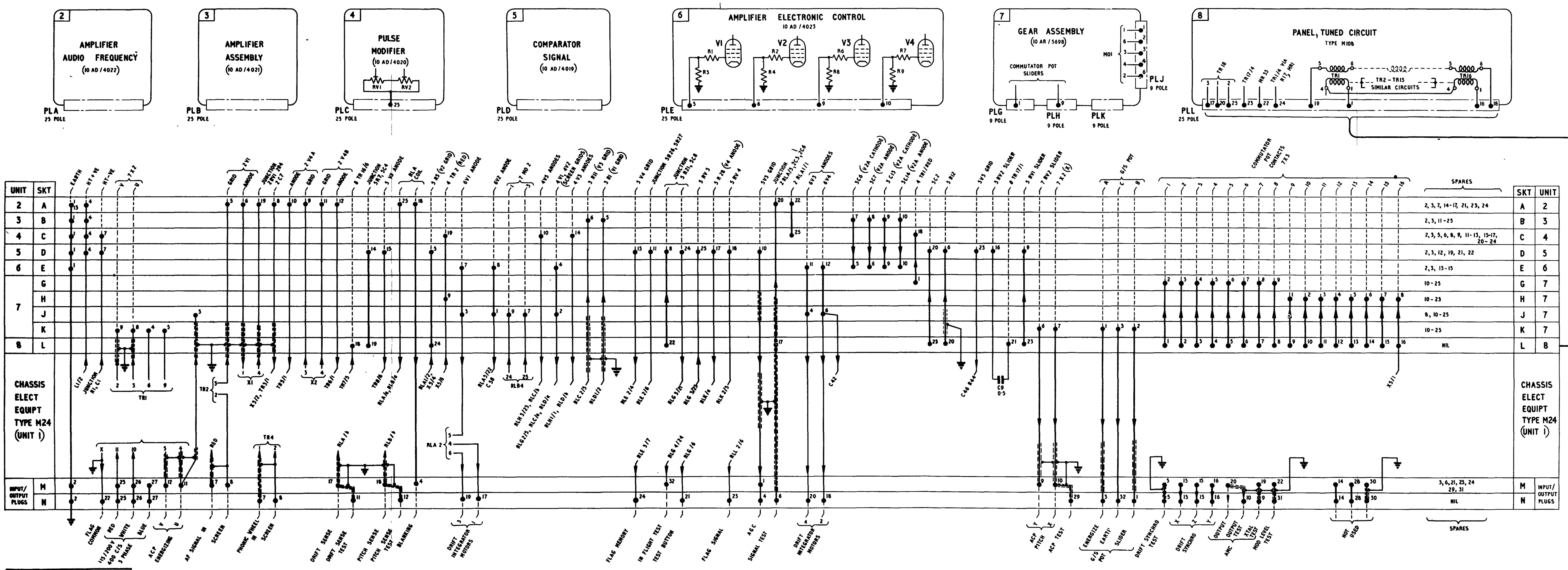
AIR DIAGRAM 6775AC/MIN.

ISSUE 2

PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Panel tuned circuit Type M.108: circuit

Fig.17



NOTES:-

1. CONNECTIONS TO PINS ON SUB-UNIT PLUGS CORRESPOND WITH SOCKET PINS ON CHASSIS, AND PLUG PINS SHOWN IN SUB-UNITS ARE ALSO INCLUDED IN BODY OF INTER CONNECTIONS. THIS METHOD IS USED TO SHOW THEIR DESTINATION WITHOUT EXPANDING DRAWING LENGTH.

Computor, frequency tracker, air navigation: interconnections

Fig. 18

AIR DIAGRAM 6775AX/MIN.

ISSUE 1

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

D.88162. 573172. S.W. 4/66

Chapter 3

AERIAL GROUP TYPE M.30

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Power supply	115 *or* 200 *volts* ±5% 400 *c/s* ±5% 3-*phase a.c.*
Power consumption	28 *watts at* 115V *a.c.*
Maximum temperature range	—60°*C to* +70°*C*
Operational temperature range	—40°*C* to +55°*C*
Altitude ceiling	60,000 *feet*
Weight	30·5 *lb* (13·8 *kg*)
Overall dimensions	*Height* 10 *in.* (25·4 *cm*) *Width* 12½ *in.* (31·8 *cm*) *Depth* 26⅛ *in.* (66·4 *cm*)
Air cooling	*Not normally required*
Location	*Underside of aircraft*
Beamwidth	3 *degrees* 15 *minutes at* 3*dB points*
Beam depression angle	67 *degrees* 15 *minutes*
Operational movement	
In pitch plane	±10 *degrees*
In azimuth plane	±30 *degrees*
Compass safe distance	1 *foot*

Introduction

1. The aerial is a moving aerial of the slotted-waveguide type, and it produces the four-beam transmission pattern required to obtain both the ground speed and drift information. The principal function of the aerial is to transmit groundwards the frequency-modulated c.w. signal produced by the transmitter-receiver and to receive the reflected signal. The received signal is mixed with a small proportion of the transmitter signal in the hybrid ring balanced mixer, which forms part of the aerial assembly, to produce an i.f. signal. To ensure that a signal of relatively high signal-to-noise ratio is fed to the transmitter receiver, the signal is amplified in the 1st i.f. amplifier which is a plug-in sub-unit mounted on the aerial assembly. Closed-loop servo control systems stabilize the aerial in the pitch and azimuth planes.

2. In order that the drift and pitch angles of the aircraft may be resolved, it is essential that the transmitted beam should be directed alternately forward and backward of the aircraft, and additionally, the beam must be successively displaced to port and starboard. This is achieved by the use of end-fed, slotted-waveguide elements and adjacent reflectors. The direction of feed of the transmitting elements is arranged by a rotary waveguide switch driven by a motor via a cam and geneva mechanism. Likewise, the elements used for reception must be switched and this is done by a contra-rotating cam and geneva mechanism driven by the same motor. Stabilization of the aerial in the pitch and drift planes is accomplished by the use of two servo amplifier-controlled motors with associated gearboxes and gear segments.

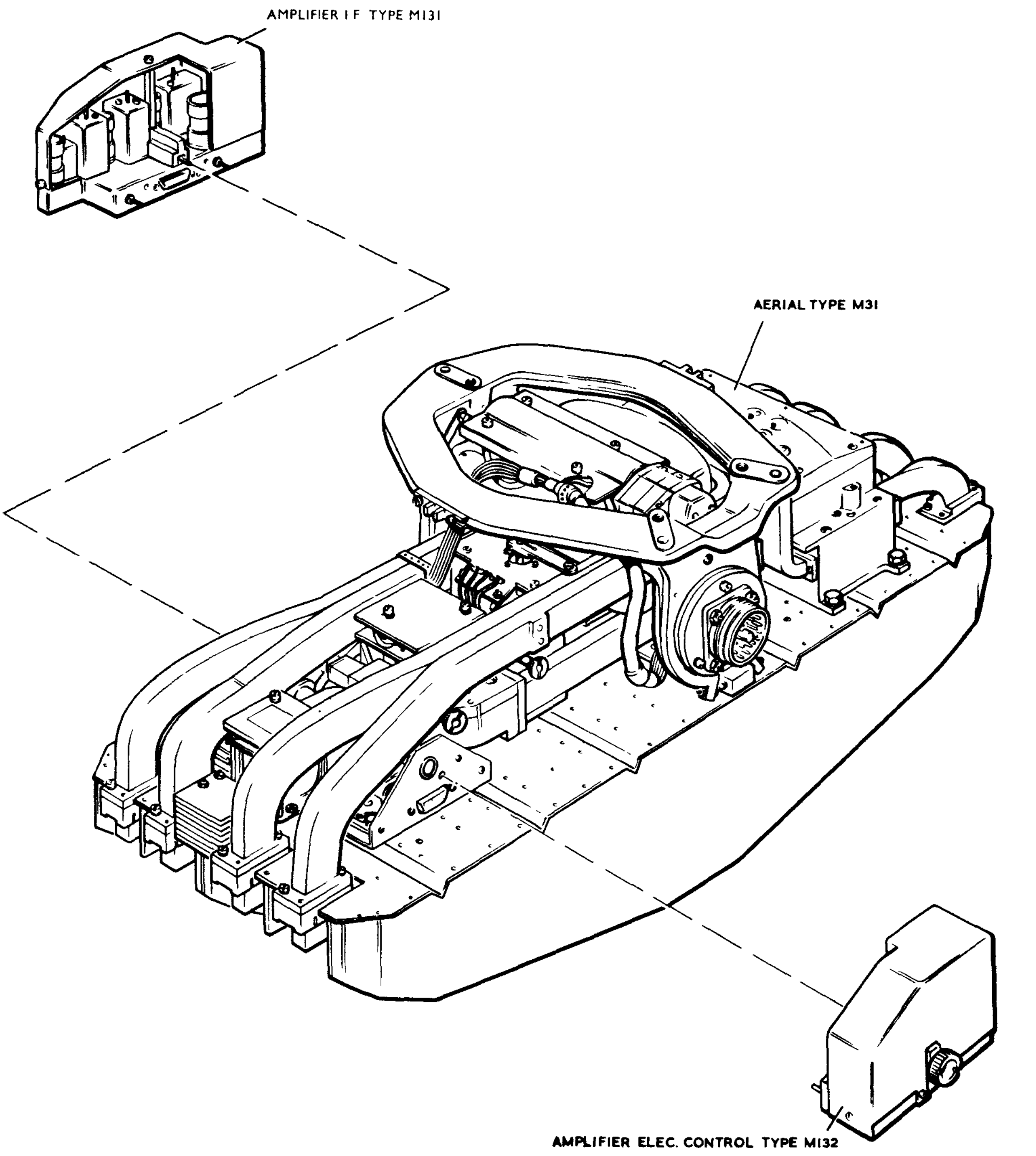


Fig. 1. General view of aerial assemblies

Constructional details (fig. 1)

3. Mechanically the aerial assembly consists of two major assemblies: the gimbal and hub assembly, and the main aerial body or hood assembly. The complete assembly is attached to a mounting plate, which is accurately aligned and secured to the aircraft structure. Dowel pins ensure that the assembly is correctly positioned with respect to the mounting plate; thus, providing the position of the mounting plate remains unaltered, the aerial assembly can be readily replaced without the necessity for realignment.

4. The gimbal and hub assembly includes the pitch and drift motors with their associated gearboxes, a.c. pick-off and synchro control transformer, respectively, and the pitch-plane waveguide joint. Basically, the hood assembly is a light-alloy structure which has two matched pairs of slotted-waveguide elements and three aluminium honeycomb reflectors attached to its underside. The upper surface of the assembly carries the waveguide switch and gearbox, 1st i.f. amplifier, servo amplifier, the hybrid ring and waveguide sections, and

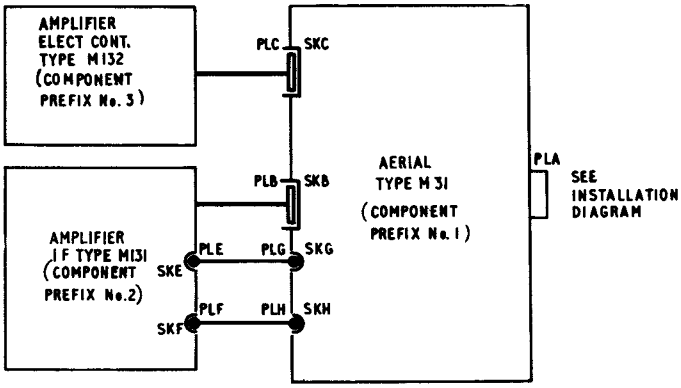


Fig. 2. Schematic arrangment of assemblies

the gimbal and hub assembly, which is attached to it at the longitudinal centre.

5. The function and operation of the various sub-assemblies and components of the aerial are dealt with under the following headings:—
- Waveguide assembly and aerial drive motors (component prefix No. 1)
- 1st i.f. amplifier assembly (component prefix No. 2)
- Servo amplifier assembly (component prefix No. 3)

6. The waveguide assembly consists of the slotted-waveguide aerial array, waveguide switch and gear-box unit, hybrid ring, feeder waveguides and joints. Four, accurately slotted, aluminium waveguides, lying parallel to one another and between aluminium honeycomb reflectors, form the directional horn aerial array. Centrally placed in the array is a longitudinal screen which greatly reduces cross-coupling between the pair of waveguides used for transmission and the pair utilized for reception of the reflected signal. The axis of the aerials is horizontal.

7. A three-phase motor, with associated cams and geneva mechanisms, is used to drive the contra-rotating sections of the waveguide switch, the cams and geneva mechanism being fitted in a gearbox which is mounted above the switch assembly.

8. The hybrid ring is a milled alloy component into which are inserted two germanium diodes. It isolates the receiving elements of the aerial array from the transmitter while allowing the mixing of the received signal and a small proportion of the transmitted signal in the low noise mixer circuit formed by the two diodes.

9. In conjunction with the slotted waveguides, the feeder waveguides form complete longitudinal loops round the hood assembly, the cross-sectional area of the feeder waveguides being greater than that of the slotted waveguides. To effect mechanical continuity of the waveguide during movements of the aerial in the pitch and azimuth planes respectively, a rotating joint and a knuckle joint are used.

10. Servo amplifier-controlled aerial drive motors move the aerial in the pitch and azimuth planes via associated gearboxes and segment-gears. Spring-loaded stops are fitted to prevent the aerial travelling beyond pre-determined limits in the two planes of movement.

11. The output of the transmitter is connected to the aerial assembly by a waveguide, all other external connections being effected by a 24-pole plug. From the 1st i.f. amplifier, which is a small plug-in assembly attached to an anti-vibration chassis assembly on the upper face of the hood assembly, the i.f. signal is fed, via coaxial cable, to the receiver. The servo amplifier is a chassis similar to the 1st i.f. amplifier and is also secured to the anti-vibration chassis assembly by a single captive screw.

Brief circuit description

12. When reading the following brief description of the circuits and operation of the aerial assembly, reference should be made to the block diagram, fig. 3.

13. The frequency-modulated c.w. signal produced by the transmitter is fed by a waveguide to the aerial assembly. Here it passes via the directional coupler to the transmit section of the waveguide switch. This section has four connections to the two slotted waveguides used for transmission, switching being accomplished by the use of a rotating waveguide connector. The signal is fed to each end of the slotted waveguides in sequence, the duration of feed to each end being 380 milliseconds, while the entire switching cycle occupies a period of

2 seconds. One of the slotted waveguides functions as an in-phase element, and radiates a signal in the direction of the feed. The other, operating as an anti-phase element, transmits the signal in a direction opposite to that of the feed. By switching the direction of the feed, and by the use of reflectors parallel to, and to the side of, the radiating elements, directional properties are produced in the aerial assembly. These directional properties result in the transmitted signal being radiated forward, rearward and, concurrently, to port and starboard of the aircraft.

14. The reflected signal is received by an identical slotted-waveguide array, switching being so arranged that when an in-phase transmission element is in use, an anti-phase element is employed for reception of the reflected signal, and vice versa. The output of the reception elements is connected by the receive section of the waveguide switch to the hybrid ring balanced mixer. Mixing of the received signal and a small preset proportion of the transmitter signal, the latter being obtained via the directional coupler, takes place in the balanced mixer. The output of the diodes 1MR1, 1MR2 is fed to the 1st i.f. amplifier. This consists of a high gain, low noise, cascode amplifier stage followed by two normal a.g.c. controlled amplifier stages. The amplified 600 kc/s $\pm 16\%$ i.f. signal is fed, via a coaxial cable, to the 2nd i.f. amplifier in the transmitter-receiver (Chap. 1).

15. Control of the pitch and drift motors is effected by the use of two almost identical servo amplifier circuits, each consisting of a push-pull amplifier stage with a signal input transformer connected to the grids. The control voltage, or error signal, applied to the primary winding of the pitch servo amplifier input transformer is the difference voltage existing between the pitch a.c. pick-off mounted on the aerial assembly and the a.c. pick-off 7X2 in the tracking unit (Chap. 2). The voltage fed to the primary winding of the drift servo amplifier input transformer is the output of the rotor winding of the drift synchro control transformer.

16. In the event of the aerial not being aligned along the aircraft flight path in the pitch plane, a difference of potential exists between the two a.c. pick-offs associated with the pitch servo system. This difference voltage is amplified by the servo amplifier and applied to the pitch motor. As a result, the hood assembly is moved in the appropriate direction until the aerial is correctly aligned and no potential difference exists between the two a.c. pick-offs, the direction of rotation being dependent upon the phase relationship of the signal from the servo amplifier. Transformer 1TR1 in the tracking unit produces the energizing voltage for the aerial-mounted a.c. pick-off.

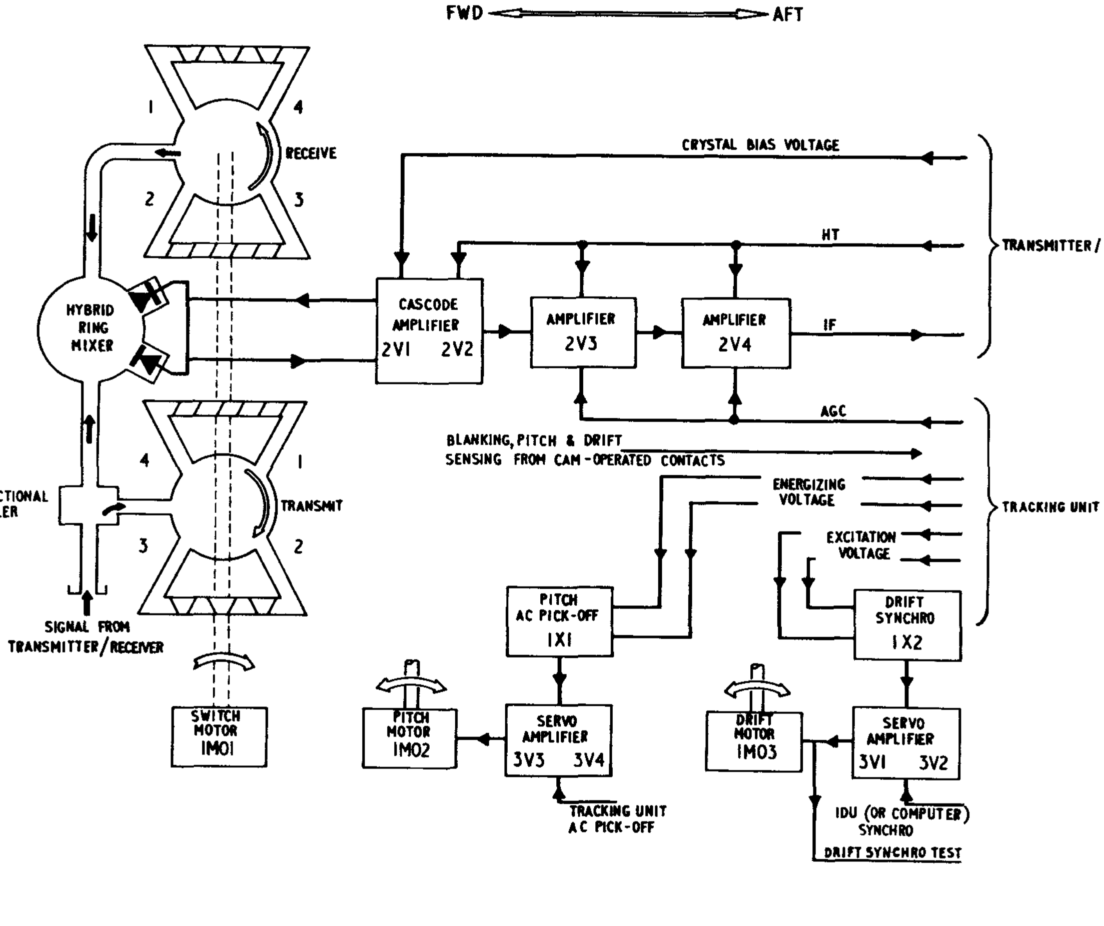


Fig. 3. Block diagram of aerial

17. Similarly, if the aerial is not correctly aligned in the azimuth plane, an error voltage is fed from the drift synchro control transformer to the servo amplifier input transformer, and the aerial is rotated until it is correctly aligned and no error voltage exists.

18. Fitted in the waveguide switch and gearbox assembly are three cam-operated springsets which provide blanking, drift, and pitch sense control for the tracking unit.

19. The h.t. and crystal bias supplies are obtained from the transmitter-receiver, and valve heater supplies are provided by the aerial-mounted transformer 1TR1. A three-phase a.c. supply of 115 or 200 volts for the primary of 1TR1, and for motors 1MO1, 1MO2, 1MO3, enters the unit on pins 15, 16, 17 of plug PLA.

20. The circuit diagrams of the waveguide assembly and aerial drive motors, and of the other two assemblies are in ◀ fig. 8, 9 and 10. ▶ Reference should be made to the appropriate diagram when reading the following descriptions.

Waveguide assembly and aerial drive motors

21. The functions of the waveguide assembly are the feeding, switching, transmission, reception and mixing of the transmitter and reflected signals. The aerial drive motors form part of two closed-loop servo systems designed to align or stabilize the slotted-waveguide aerial array in the pitch and azimuth planes.

22. The component parts of the waveguide assembly are the slotted-waveguide aerials, which, with the associated feeder waveguides, form a complete longitudinal loop round the hood assembly, the waveguide switch and gearbox assembly, and the hybrid ring. Aluminium waveguide of rectangular cross-section is used throughout the waveguide assembly. Two matched pairs of accurately slotted waveguides, which form the radiating and receiving elements of the aerial array, are arranged symmetrically on the underside of the hood assembly. The narrow face of the waveguides is slotted, thus producing inclined shunt-coupled slots; these waveguides are of smaller cross-sectional area than the feeder waveguides.

23. Precision-machined flanged joints are used to join the various sections of fixed waveguide, while a knuckle joint is employed to permit movement of the aerial in the azimuth plane to compensate for drift of the aircraft, and a rotating joint provides continuity of the waveguide at the gimbal and hub assembly to permit movement in the pitch plane. Connected adjacent to the knuckle joint, in the waveguide run to the transmit section of the waveguide switch, is the directional coupler. This contains a variable card attenuator which is used to set the level of transmitter output signal fed to the hybrid ring balanced mixer.

24. The hybrid ring is a milled alloy component, the mean circumference of which is equal to one-and-a-half times the wavelength of the feeder waveguide. This device isolates the transmitter signal from the reception elements of the aerial array, while permitting the mixing of the received signal and a small preset proportion of the transmitter signal in a low-noise mixer arrangement. Of the four waveguide arms which form series junctions with the ring, one is connected to the receive section of the waveguide switch, and one to the directional coupler. A germanium diode is inserted in each of the remaining arms and it is here that the mixing takes place. The diodes 1MR1, 1MR2 are inserted in relative positions such that each receives signals of the same level and phase from the directional coupler. Access to the two diodes is via two knurled retainers, the collets of which carry the diodes.

25. A test aperture in the waveguide connecting the receive section of the waveguide switch to the hybrid ring is covered by a small, detachable plate.

26. Waveguide switch 1SWE, 1SWF is contained in a machined alloy block which is attached to the horizontal portion of the hood assembly. Secured above the switch is a plug-in drive section consisting of the driving motor 1MO1 and gearbox assembly. The motor drive terminates in two offset cam wheels which mesh with two geneva mechanisms. These mechanisms are attached to the drive shafts of the two sections of the switch, thus providing drive to the switches at times determined by the cams and geneva mechanisms. The supply connections of the three-phase synchronous motor 1MO1 are brought out to a tagboard to facilitate the setting of the tappings of the windings for use on either a 115-volt or a 200-volt a.c. supply. Also incorporated in the switch box are three springsets 1SWA, 1SWB, 1SWC which are operated by cams attached to the geneva mechanism drives. The contacts of these springsets provide blanking, drift, and pitch sense control, respectively, for the tracking unit.

27. The aerial system is driven in the pitch and azimuth planes by two 115-volt, two-phase motors 1MO2, 1MO3 via their respective gearheads and gear segments. The motors are controlled by individual servo amplifiers; these form the servo amplifier assembly.

28. The pitch motor 1MO2 is secured to the gearbox assembly by two L-clamps. The gearbox has a reduction ratio of 6000 : 1, and is secured to the hub assembly by three screws. The driving gear-assembly of the gearbox meshes with a phosphor-bronze gear segment mounted on the gimbal assembly, thus producing drive about the segment for pitch movement. A locking pin is fitted so that the aerial may be locked in the zero pitch position during transportation, and during alignment in the aircraft. Spring-loaded stops on the hub assembly, in conjunction with the adjustable stops on the gimbal assembly, limit the operational pitch movement to ± 10 degrees.

29. Mounted on the hub assembly, on the side remote from the pitch motor, is the pitch a.c. pick-off 1X1. This has movement imparted to its rotor by means of a lever assembly and link, the latter having its outer end attached to the gimbal assembly. Any movement of the gimbal assembly is, therefore, transmitted to the rotor by the lever assembly, the leverage of which produces a 3 : 1 increase of angular movement at the pick-off. The drift motor 1MO3 and gearbox assembly are secured to the base casting. The driving gear assembly meshes with, and drives on, a gear segment attached to the hub assembly. The gearbox has a reduction ratio of 4000 : 1. The operational drift movement is limited to ±30 degrees by spring-loaded stops, and the aerial can be locked in the zero drift position by the insertion of a locking pin. Mounted in a position adjacent to the hybrid ring, and between the feeder waveguides, is the drift synchro control transformer 1X2. Movement is transmitted to its rotor by means of an arm and link assembly which has its outer end attached to the hub assembly. Hence, any movement of the aerial in the azimuth plane is transmitted to the rotor of the synchro control transformer.

Waveguide switching

30. The frequency-modulated c.w. signal (8800 Mc/s nominal) from the transmitter-receiver is coupled to the aerial assembly by a waveguide, the length of which is kept to a minimum in order to reduce the overall attenuation of the transmitter signal. The signal enters the directional coupler from where, apart from a small preset proportion which is coupled to the hybrid ring, it is fed to the transmit section of the waveguide switch 1SWF.

31. In the circuit diagram the switch is shown feeding the signal to number 4 waveguide entry. This is an entry to an in-phase slotted-waveguide element, and the signal is, therefore, radiated in the direction of feed. The reflectors fitted parallel to, and at each side of, the element cause the signal to be radiated rearwards and to starboard of the aircraft's track (assuming the system is locked-on in the drift and pitch planes). It should be noted that although indication of the forward and aft directions has been made on the block diagram (fig. 3), this is purely an aid to description, and the aerial may, in fact, be mounted in the reverse direction.

32. The receive section of the waveguide switch 1SWE switches the signal received by the anti-phase receiving element (in the instance number 4 entry is open) to the hybrid ring. The number 4 entries are open for a period of 380 milliseconds, and at the end of this time the cam wheels, driven by the motor 1MO1, engage the geneva mechanisms and move the contra-rotating switch sections (in the directions indicated by the arrows) until position 1 is reached.

33. The direction of feed to the in-phase transmitting element is then reversed, and the signal is transmitted in a starboard-forward direction for a period of 380 milliseconds. Similarly, the reflected signal is received by the anti-phase element from the starboard-forward direction, and passes via number 1 entry to the hybrid ring.

34. During the 120 milliseconds when the waveguide switch is rotating, resulting in the waveguide entries being blanked, the contacts of springset 1SWA are closed by the action of a cam. The closure of 1SWA completes the operating circuit for relay 2RLA in the tracking unit, thus providing blanking information at the appropriate times (Chap. 2).

35. The third position of the waveguide switch brings into operation the number 2 entries, and the signal is radiated to, and received from, the port-aft direction. In the fourth position, the signals travel to and from the port-forward direction via the number 3 entries. Motor 1MO1 is constantly rotating, consequently the direction of radiation and reception of the signal is continuously and sequentially switched. The sequence is starboard-aft, starboard-forward, port-aft, port-forward. Control of drift and pitch sense circuits in the tracking unit is effected by the use of cam-operated contacts 1SWB and 1SWC. The timing sequence of switches 1SWA, 1SWB, 1SWC, 1SWE and 1SWF is shown in fig. 4.

Mixing

36. The received signals are mixed in the hybrid ring balanced mixer with a small, pre-determined proportion of the transmitter signal. The level of transmitter signal fed to the hybrid ring from the

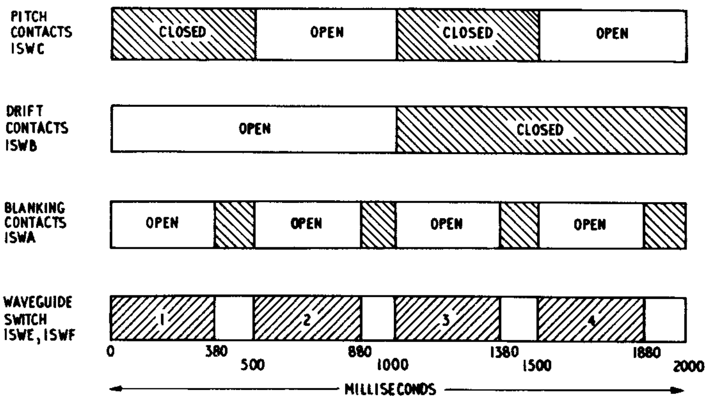


Fig. 4. Sequence of waveguide and sensing switches

directional coupler is adjusted, by means of a variable card attenuator, to give a current of 1·8 to 1·9 milliamps in each diode. The two germanium diodes 1MR1 and 1MR2 are connected with reversed polarities to form a balanced mixer with a high signal-to-noise ratio. The application of a positive bias voltage of 0·16 $\pm$ 0·02 volts to each diode also tends to improve the signal-to-noise ratio. The bias voltages are fed from the transmitter-receiver and enter the aerial on plug PLA pins 18 and 21. The output of the mixer diodes is fed via coaxial cables to the 1st i.f. amplifier, both cables being terminated at each end by a miniature coaxial plug.

Servo systems

37. To align the transmitting and receiving elements in the pitch and azimuth planes, two servo amplifier-controlled motors are used to provide the requisite movement. These are 1MO2 and 1MO3, which are 115-volt, two-phase a.c. motors. The reference winding of each motor is supplied with 115 volts, 400 c/s a.c., while the control windings of each motor are connected to form the anode loads for the valves of the respective servo amplifiers. Resistors 3R6, 3R12 and rectifiers 3MR1, 3MR2 in series with the reference windings provide a degree of damping to counteract any tendency of the motors to overshoot.

Pitch servo

38. The primary winding of the pitch servo amplifier input transformer 3TR2 is connected in series with the output of the a.c. pick-off 1X1 and with the output of the pitch integrator a.c. pick-off 7X2 in the tracking unit, as shown in the simplified circuit diagram fig. 5. If a potential difference exists across the primary winding of 3TR2 (this occurs when the aerial is not correctly aligned along the aircraft flight path), the difference voltage is amplified by 3V3, 3V4 and the pitch motor rotates.

39. An energising voltage of 15 volts a.c., obtained from a secondary winding of 1TR1 in the tracking unit, is fed to terminals U, V of 1X1 via pins 9 and 10 of plug PLA. Any movement of the array in the pitch plane causes the rotor of 1X1 to be rotated, and this sets up an unbalance of the inductance bridge formed by the windings of the pick-off. As a result of this, an error voltage is produced, the phase of which is dependent upon the direction of rotation of the rotor.

40. The action of the pitch closed-loop servo control system, as shown in the block diagram fig. 6, is as follows If the aerial array is not aligned along the aircraft flight path in the pitch plane, the angle between the flight path and the rearward transmission beam differs from the angle between the flight path and the forward beam. Consequently, the frequencies of the fore and aft Doppler signals differ by an amount dependent upon the degree of misalignment, and, as a result of the circuit action which takes place in the tracking unit, motor 7MO2 in that unit rotates. Mechanically coupled to this motor is the rotor of the pitch integrator a.c. pick-off 7X2, hence an error voltage (nominally 0·165 volt per degree of rotor displacement) is produced across terminals X, Y of the pick-off when the rotor is displaced from its zero (or null) position. This voltage appears across the primary winding of transformer 3TR2, is amplified by 3V3 and 3V4, and causes the pitch motor 1MO2 to rotate. The motor, via its associated gearing, elevates or depresses the array, the direction of movement being dependent upon the phase of the error signal produced by 7X2, which in turn is dependent upon the relationship of the Doppler signals received from the fore and aft directions.

41. As previously stated, the rotor of 1X1 is mechanically coupled to the gimbal assembly by a lever and link assembly, and movement of the array is, therefore, transmitted to the rotor. The resultant error voltage produced across terminals XY of 1X1 is applied to the primary winding of 3TR2. The magnitude of this voltage increases with rotor (or shaft) displacement angle until the voltages produced by 7X2 and 1X1 are of equal magnitude but opposite phase. Under these conditions there is no potential difference across the primary winding of 3TR2 and continuous drive is removed from 1MO2.

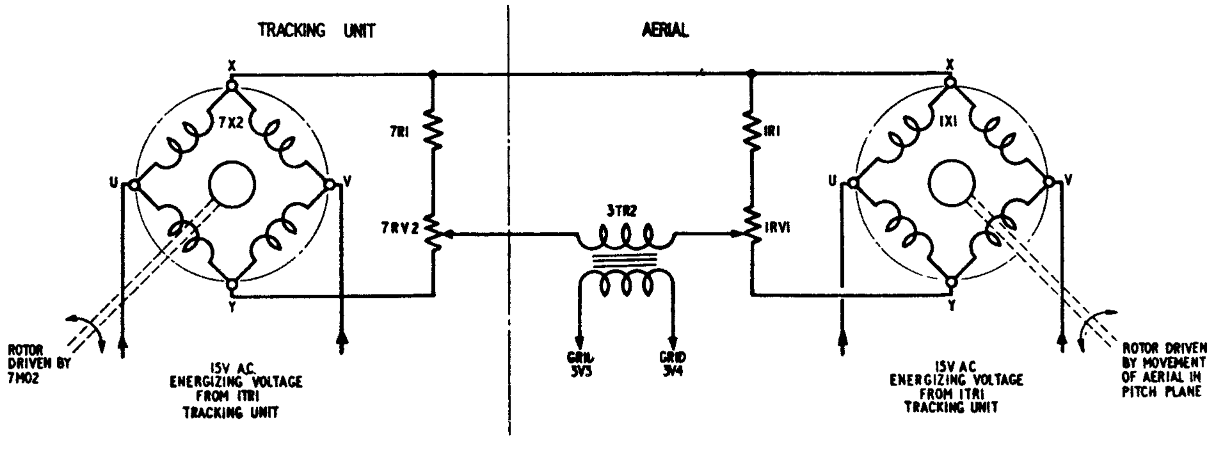


Fig. 5 Pitch control circuit

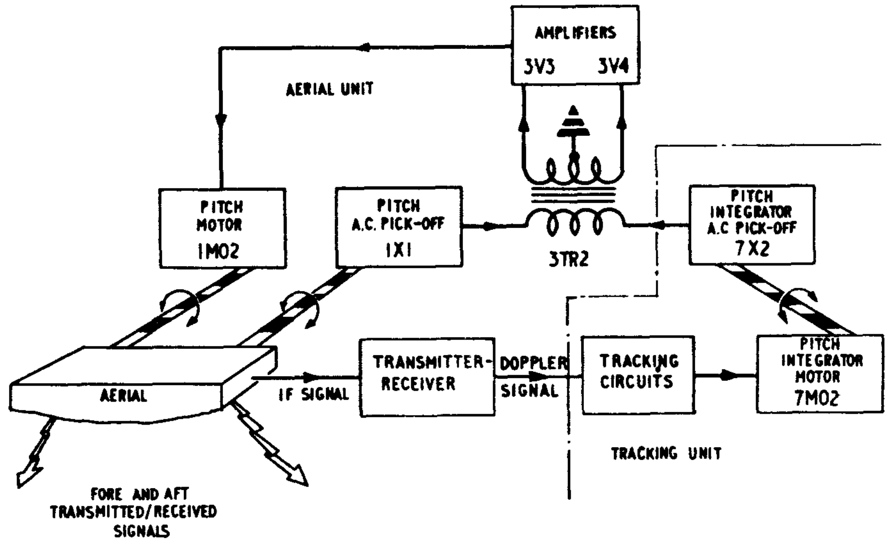


Fig. 6 Block diagram of pitch servo

42. During the time that the array is being elevated or depressed, the difference in frequency between the Doppler signals from the fore and aft directions is continually decreasing. At the point where the outputs of 7X2 and 1X1 are balanced, the Doppler signal frequencies are identical and, because of this, there is no net drive to 7MO2 in the tracking unit. Thus the aerial array now has its axis aligned along the aircraft flight path, the fore and aft Doppler signals are of equal frequencies, the outputs of 1X1 and 7X2 are balanced, and there is no continuous drive to motors 1MO2 and 7MO2. Any further deviations of the aerial axis from the aircraft's flight path due to a change in aircraft attitude cause similar circuit action to take place and the aerial remains correctly aligned along the flight path whenever the system is operating under signal conditions.

Drift servo

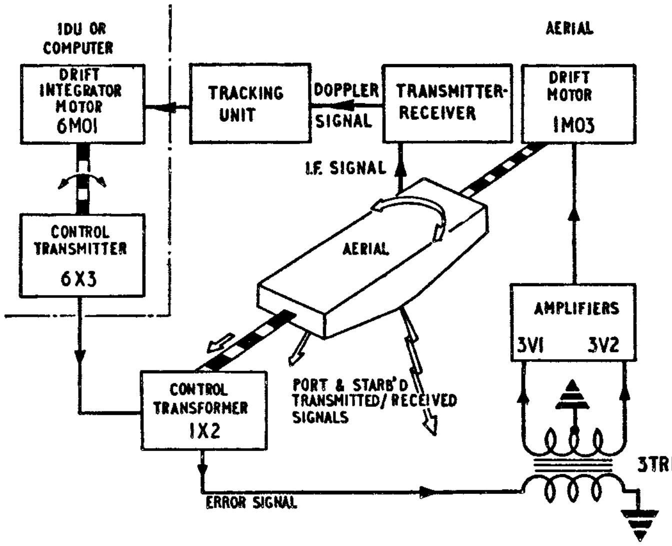
43. To the primary winding of the drift servo amplifier input transformer 3TR1 is fed an error signal which is derived from the rotor winding of the synchro control transformer 1X2. In the event of the aerial array not being aligned along the aircraft's track, due to the aircraft being subjected to drift conditions, an error signal is developed in 1X2; this is suitably amplified and used to control the drift motor 1MO3. The operation of the drift servo control system, which is shown in the block diagram fig. 7, although similar to that of the pitch servo control system, differs insofar as synchro elements are used in place of the a.c. pick-offs employed in the pitch system. The operation of the system is as follows. If the aerial array is not aligned along the aircraft's track, circuit action in the tracking unit causes the drift integrator motor 6MO1 in the indicator drive unit (or computor, depending upon which unit is fitted) to rotate. The direction of rotation of the motor is dependent upon whether the aerial is misaligned to port or starboard of the track.

44. Mechanically-coupled to 6MO1 is the rotor of a synchro control transmitter 6X3, and movement of the rotor results in the production of an error voltage; the phase of the error voltage is dependent upon the direction of rotation, while the amplitude is related to the angular displacement of the rotor. The stator windings of 6X3 are electrically-coupled to the stator windings of the aerial-mounted transformer 1X2, via pins 11, 13, 14 of plug PLA. Consequently, an error signal is induced in the rotor winding of 1X2 and is fed to the primary winding of 3TR1. The output from the secondary winding of the transformer is amplified in the push-pull servo amplifier 3V1, 3V2, and this amplified signal controls the drift motor 1MO3. The motor rotates and, via associated gearing, drives the aerial array in the appropriate direction until the Doppler signals received from the port and starboard directions are of identical frequencies. When this condition obtains, steady drive in one direction is removed from 6MO1 and 1MO3, and the aerial is correctly aligned along the aircraft's track.

45. A mechanical linkage between the hub assembly and the rotor of 1X2 imparts any movement of the aerial array to the rotor, and the condition when the Doppler signal frequencies are identical coincides with the null or zero error signal position of the rotor. Thus, as the aerial moves, the error signal fed to 3TR2 becomes gradually less (due to the rotor being moved towards the null position), until no error signal is produced by 1X2, drive is removed from 1MO3, and, as previously stated, the aerial is aligned along the aircraft's track. To facilitate the checking of the error signal produced in the rotor winding of 1X2, a drift synchro test connection is taken from the R1 terminal of 1X2 to pin 22 of PLA and ultimately to the test set.

1st i.f. amplifier assembly

46. The 1st i.f. amplifier is a high-gain, low-noise amplifier used to amplify the i.f. signal from 1MR1 and 1MR2 in the hybrid ring balanced mixer. This ensures that a signal of high signal-to-noise ratio is fed to the 2nd i.f. amplifier in the transmitter-



◀**Fig. 7. Block diagram of drift servo.**▶

receiver which, in some aircraft, may be mounted a considerable distance from the aerial.

47. The components of the plug-in amplifier are mounted on a tray-type alloy chassis, which is secured to an anti-vibration chassis assembly by a single captive screw. A drip-proof cover is attached to the unit by two screws. The unit is spigot-located, and a 15-pole plug, mating with a socket on the anti-vibration chassis assembly, effects the electrical connections to the amplifier. Four flying-lead base valves are used in the assembly. They are screened and supported by spring-loaded metal sleeves.

48. The i.f. signal of 600 kc/s $\pm 16\%$ (swept at 10 excursions per minute) produced by 1MR1 and 1MR2 is fed by coaxial cable, via SKE and SKF, to the split-primary windings of the flatly-tuned signal transformer 2TR1. From the secondary winding the signal is fed to the grid of 2V1, which with the earthed-grid valve 2V2 forms a low-noise, cascode input stage. ◀2L1 is tuned to minimum inductance,▶ and 2L2, 2C9 and 2L3, 2C14 are stagger-tuned to low and high frequencies respectively. Two further amplifier stages follow the cascode stage, and from the anode circuit of 2V4, which is tuned to 600 kc/s, the amplified i.f. signal is fed, by coaxial cable, to the 2nd i.f. amplifier in the transmitter-receiver. Applied to the grids of 2V3 and 2V4 is an a.g.c. voltage that is produced in the a.g.c. and S/N assembly of the tracking unit and fed to the valves via pin 3 of PLA. A rectifier 2MR1 ensures that no positive a.g.c. voltage is applied to 2V4 grid.

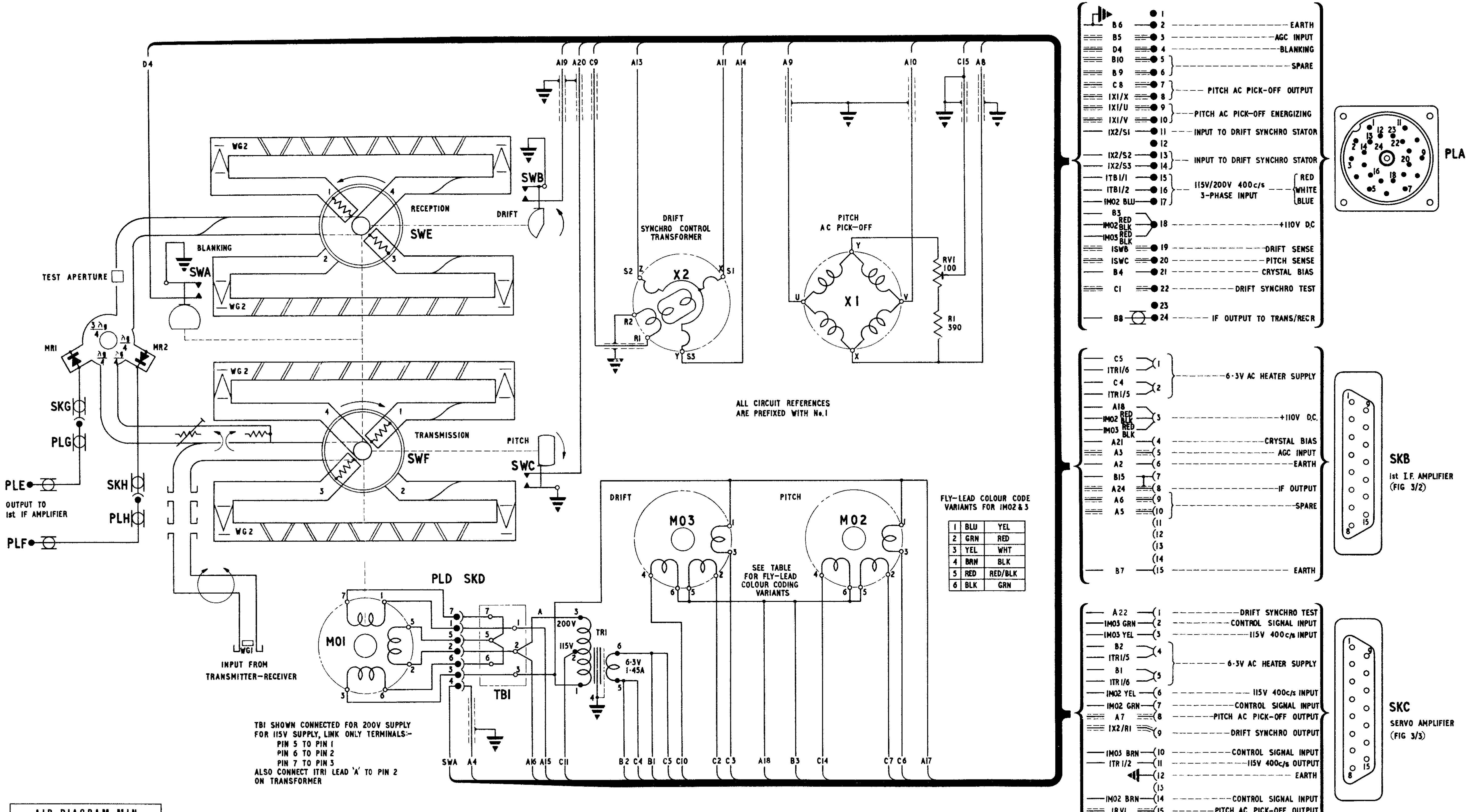
49. The 110-vo.t h.t. supply for the valves is produced by the power supply circuits of the transmitter-receiver and is fed to the unit via pin 18 of plug PLA. Transformer 1TR1, which is mounted adjacent to the 1st i.f. amplifier, provides the 6·3-volt heater supply for the valves.

Servo amplifier assembly

50. The function of the servo amplifier circuits is to amplify the error signals applied to them from the pitch a.c. pick-off and drift synchro control transformer. The amplified signals are then used to control the pitch and drift motors.

51. The construction and lay-out of the assembly are similar to those of the 1st i.f. amplifier. The assembly is mounted on the side of the anti-vibration chassis assembly remote from the 1st i.f. amplifier, and is secured by a single captive screw.

52. Two almost identical push-pull amplifier circuits form the servo amplifier. Applied to the grids of 3V1 and 3V2 is the error signal produced in the rotor winding of the synchro control transformer 1X2 after it has been stepped-up by the input transformer 3TR1. Similarly, the pitch error signal is stepped-up by 3TR2 and fed to 3V3, 3V4 for amplification, the anode loads for the valves being the centre-tapped control winding of 1MO2. The h.t. and valve heaters supply circuits are the same as for the 1st i.f. amplifier.



1	BLU	YEL
2	GRN	RED
3	YEL	WHT
4	BRN	BLK
5	RED	RED/BLK
6	BLK	GRN

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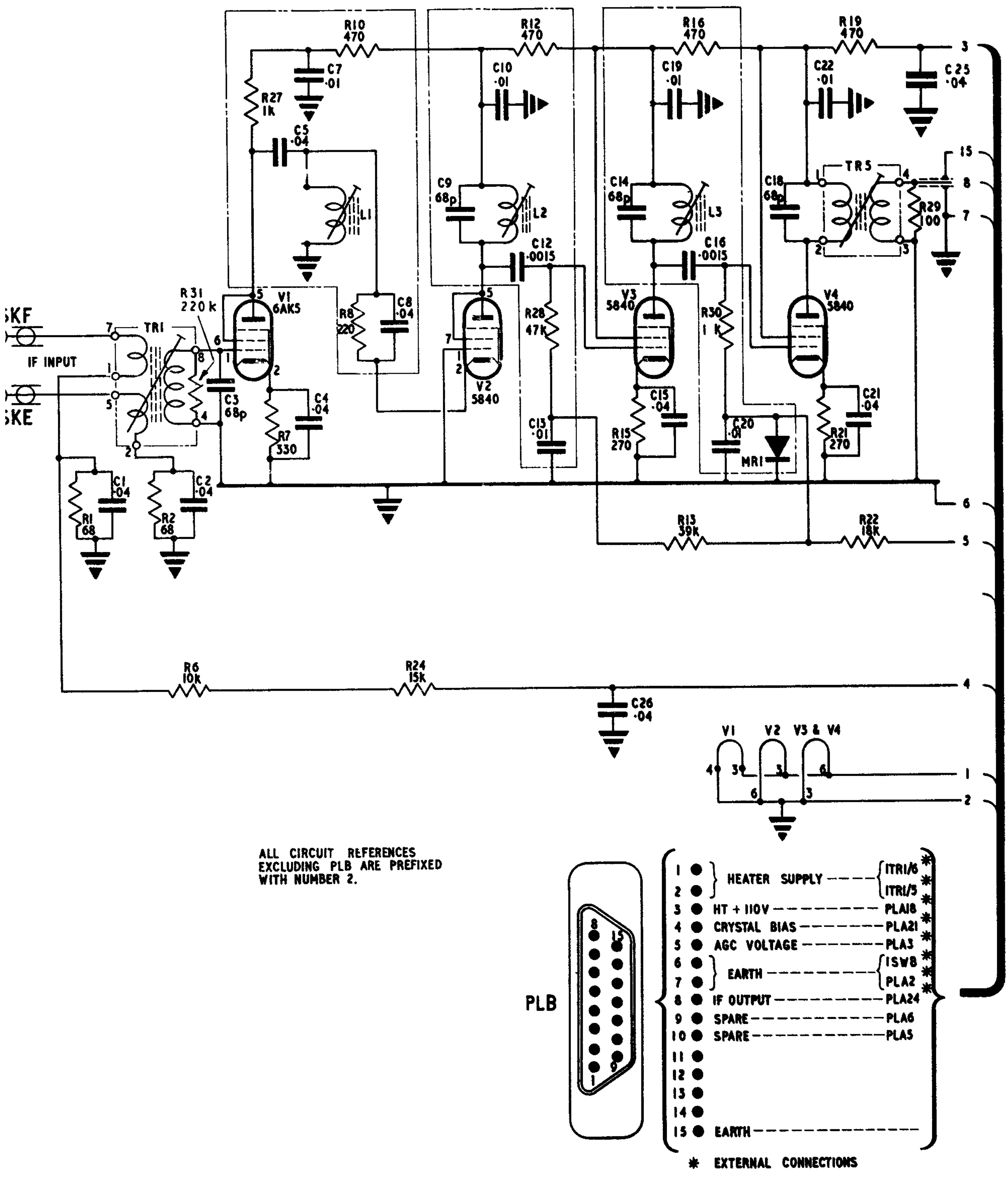
Waveguide assembly and aerial drive motors: circuit

Fig 8

AERIAL GROUP TYPE M30



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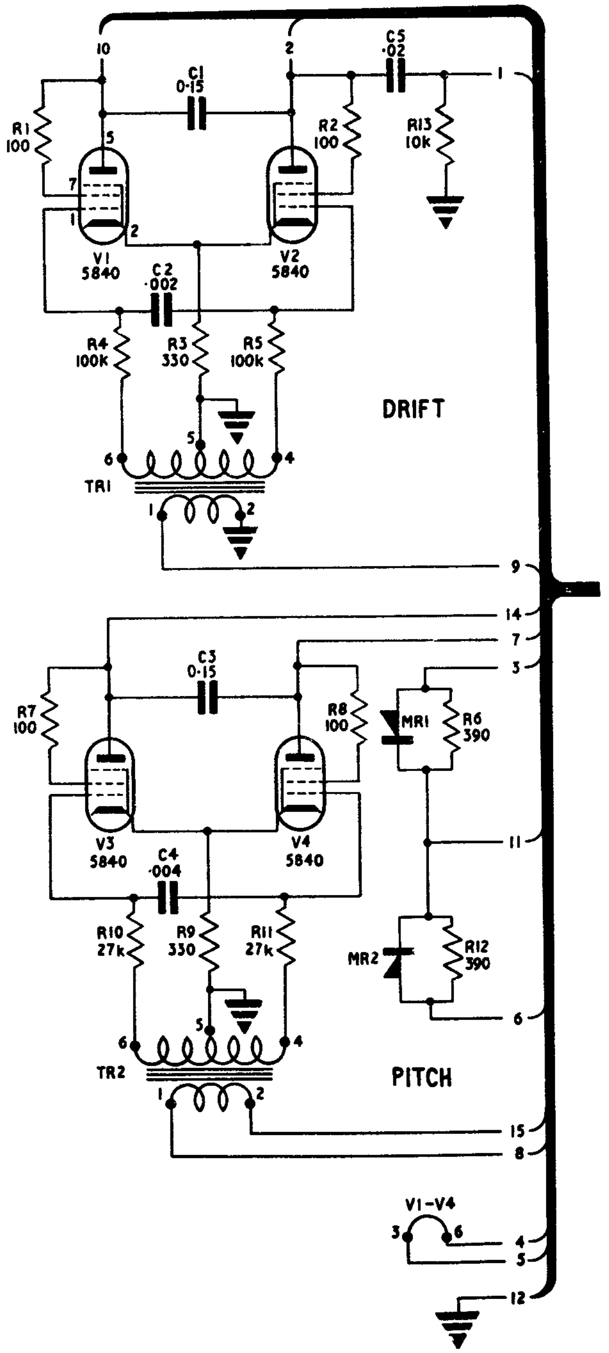
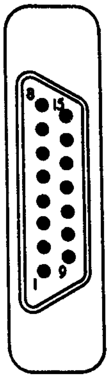
Amplifier, I.F. Type M.131: circuit Fig. 9



- - - - - - - - - - - - - - - - PLA22 ●1
OUTPUT TO 1M03/GREEN - - - - - - ●2
115V 400c/s INPUT TO 1M03/YELLOW - ●3
6·3V AC HEATER SUPPLY SKC 4 ●4
SKC 5 ●5
115V 400c/s INPUT TO 1M02 YELLOW - ●6
OUTPUT TO 1M02/GREEN - - - - - - - ●7
PITCH AC PICK-OFF OUTPUT - - PLA7 ●8
INPUT FROM 1X2/R1 - - - - - - - - - ●9
OUTPUT TO 1M03/BROWN - - - - - - - ●10
115V 400c/s INPUT - - - - - - 1TR1/2 ●11
EARTH - - - - - - - - - - - - - - - ●12
●13
OUTPUT TO 1M02/BROWN - - - - - - ●14
INPUT FROM 1RV1 - - - - - - - - - ●15



ALL CIRCUIT REFS, EXCLUDING PLC, ARE PREFIXED WITH NUMBER 3.

FOR ALTERNATIVE COLOUR CODING OF 1M02 & 1M03 FLYLEADS SEE FIG 3/1

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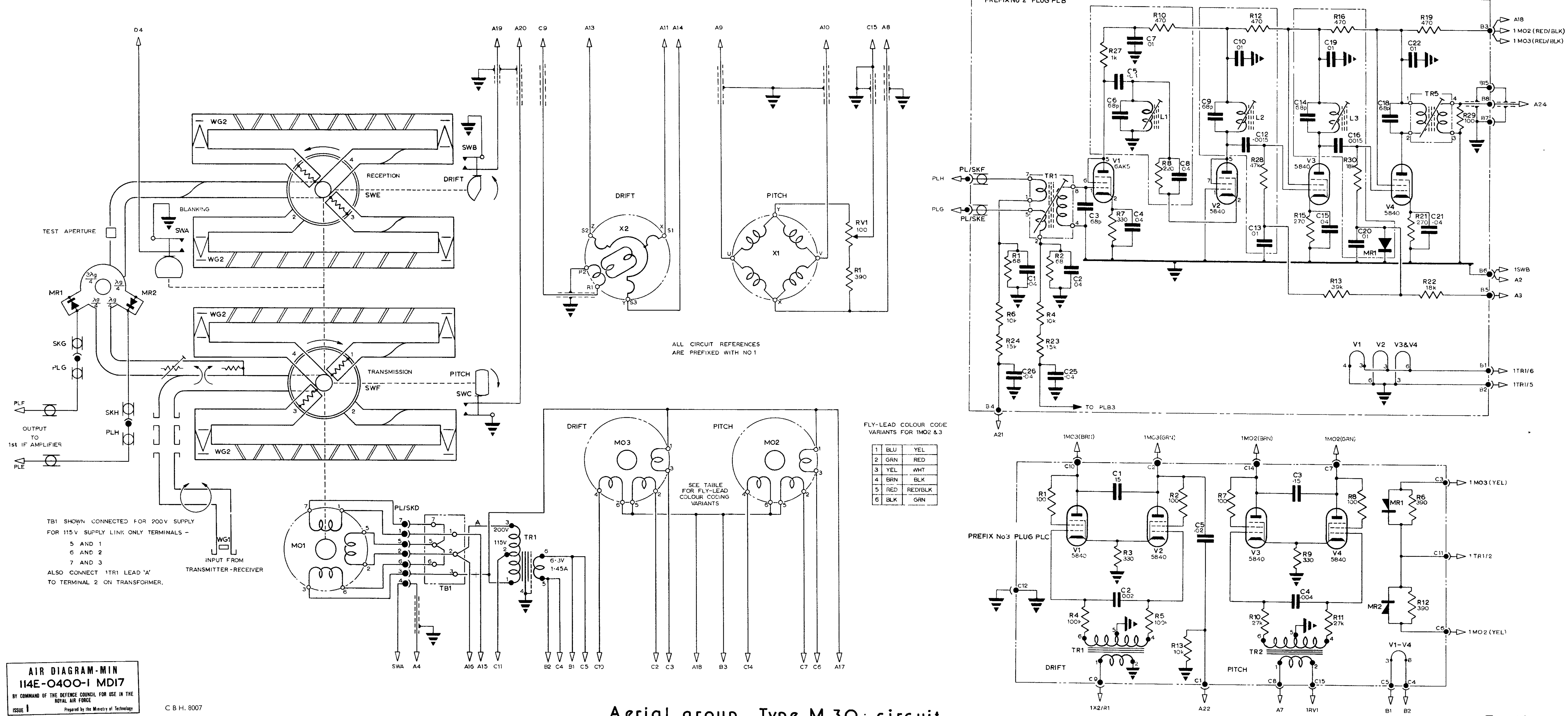
Amplifier, elec. control Type M132: circuit

Fig. 10



FLY-LEAD COLOUR CODE VARIANTS FOR 1MO2 & 3

1	BLU	YEL
2	GRN	RED
3	YEL	WHT
4	BRN	BLK
5	RED	RED/BLK
6	BLK	GRN

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Aerial group Type M.30: circuit

Fig.11

Chapter 4

INDICATOR, RANGE TYPE M.16

(DISTANCE INDICATOR)

and

INDICATOR ASSEMBLY TYPE M.15

(SPEED AND DRIFT INDICATOR)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

DISTANCE INDICATOR

Scale	0 *to* 999·9 *nautical miles in* 0·1 *nautical mile increments*
Operating voltage	30 ±2 *volts d.c.*
Maximum temperature range	—40°C *to* +70°C
Operational temperature range	—40°C *to* +55°C
Altitude ceiling	60,000 *feet*
Weight	1 *lb* (0·45 *kg*)
Case size	3¼ *SAE*
Diamensions	*Flange* 3¼ *in.* (8·26 *cm*) *Case depth* 2 25/32 *in.* (7·06 *cm*) *Bezel diameter* 3⅛ *in.* (7·94 *cm*)
Mounting	*Three* 6–32 *ANC screws*
Compass safe distance	2·5 *ft* (0·762 *m*)

SPEED AND DRIFT INDICATOR

Scales	80–900 *knots and* 30° *port to* 30° *stbd*
Maximum temperature range	—40°C *to* +70°C
Operational temperature range	—40°C *to* +55°C
Altitude ceiling	60,000 *feet*
Weight	1·5 *lb* (0·68 *kg*)
Case size	*Flange* 3¼ *in.* (8·26 *cm*) *Case depth* 3 29/32 *in.* (9·92 *cm*) *Bezel diameter* 3⅛ *in.* (7·94 *cm*)
Mounting	*Three* 6–32 *ANC screws*
Compass safe distance	4*in.* (10·2 *cm*)

DISTANCE INDICATOR

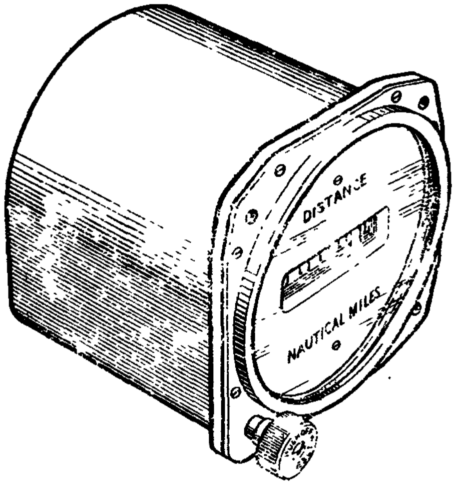


Fig. 1 General view of distance indicator

Description

1. The distance indicator gives a counter presentation of nautical miles flown up to a maximum of 9,999·9 in 0·1 nautical mile increments. The voltage impulses necessary for the energization of the electro-magnetic operating mechanism are produced by cam-operated contacts in the phonic wheel assembly of the indicator drive unit, or the resolver gearbox of the computor.

2. The mechanism is housed in a 3¼ inch SAE case, which is slightly modified to accommodate the combined on-off switch and resetting control. The instrument is normally anti-vibration panel mounted, and secured by three No. 6–32 ANC screws. To suit various types of aircraft, the socket which carries the electrical connections to the plug fitted at the rear of the instrument may be of either the straight or angled type, with a choice of three different angles being available. A combined on-off switch and resetting control with a milled-edge, engraved, knob is fitted to the front face of the instrument. If the distance flown indication is not required, the knob should be pressed fully inward, when it will remain in this position due to the action of the pinion shaft and hollow spindle, which become locked by a spring-loaded ball. The circuit to the impulse counter is broken by the action of a cam on the hollow spindle, which depresses the plunger of a miniature microswitch, thus opening the normally closed contacts.

3. If it is desired to reset the counters in flight, or on completion of a flight, the engraved knob, which will be in the operating position (fully extended), must be depressed to break the electrical circuit to the counter mechanism, and then turned in a counter-clockwise direction. This rotary action is transmitted via a gear and pinion train, and miniature bevel gears, to reset the counter wheels of the integrating mechanism. Inadvertent mileage subtraction by reverse rotation of the reset knob is prevented by ratchet action in the integrating mechanism.

4. The integrating mechanism consists of five plastic wheels, each one numbered around its periphery, and pivoted on a central spindle. Each wheel has moulded teeth on the right-hand face to enable it to be rotated. The operating mechanism is electro-mechanical, and consists of two 500-ohm bobbins connected in parallel and mounted on a common former. Pivoted between the pole-pieces of the former is an armature which is spring-loaded out of magnetic alignment, and carries a scissor-type operating cam which engages the projections on the right-hand (1/10 nautical mile) counter.

5. When the ◀ 30V ±2V ▶ d.c. impulses are received from the cam-operated contacts 5SWA in the phonic wheel assembly of the i.d.u. or the resolver gearbox of the computor, via the on-off microswitch SWA in the instrument, the two coils are energized. This causes the pivoted armature to align with the pole pieces, and the scissor cam rotates the red wheel one-tenth of a turn for each impulse received. As each wheel turns a full revolution, it operates the wheel adjacent to its left-hand face one-tenth of a revolution by means of small plastic pinions mounted on a separate spring-tensioned spindle.

6. Manual operation of the reset control sets the counter wheels to zero by rotating the rotary ratchet plates which are fitted between each wheel.

7. The flying leads of the counter are connected to a small tagboard which is fitted on the instrument structure. A silicon diode MR1 is connected in parallel with the coils of the integrating mechanism to facilitate a rapid pulse decay and to ensure positive operation of the mechanism.

SPEED AND DRIFT INDICATOR

Description

8. The speed and drift indicator is a dual pointer, circular-scale indicator housed in a modified 3¼ inch SAE case, providing an indication of groundspeed, and port or starboard drift angle. The larger pointer indicates groundspeed on the outer scale, which has a range graduated in 10 knot increments from 80 to 900 knots. while the smaller pointer indicates drift to port or starboard on the inner scale. This scale is graduated in 1 degree steps to a maximum of 30 degrees in each direction from a centre zero position.

◀ 9. As described in Part 1, Sect. 1, Chap. 1, the system can operate under search, follow or memory conditions. Alternatively, it may be inoperative due to a failure of the power supply, to the power supply switch being in the off position or to a failure of the follow system. When the aircraft is in flight and the system is functioning under search conditions, the

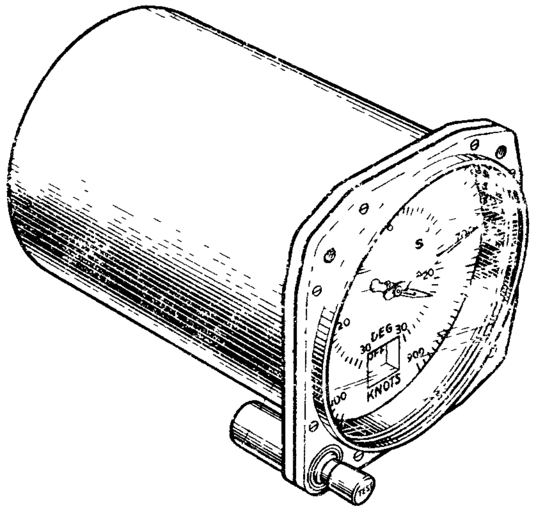


Fig. 2 General view of speed and drift indicator

indicator flag displays a black M on a yellow background. Once the system has locked on to a signal a black flag is displayed. In the event of the received Doppler signal becoming of such a low signal/noise ratio as to cause the equipment to change to the memory condition, a black OFF on a red background is presented. This also occurs when no power is applied to the installation. ▶

10. A spring-loaded in-flight TEST button is fitted below the front face of the instrument. If this button is pressed when a normal signal is being received (indicator black) the groundspeed pointer inches up or down the scale until the button is released, whereupon circuit action of the speed servo system of the tracking unit causes the pointer to return to its original position. If the button is now depressed a second time, the groundspeed pointer inches in the opposite direction until the button is released, when the pointer is again returned to its original position, thus proving that the tracking circuits (speed servo system) are operating correctly. Should the equipment be functioning under memory conditions with no usable Doppler signal being received when the button is operated, the magnetic indicator changes from OFF to black (assuming the transmitter-receiver is functioning correctly) until the button is released, but there is no movement of groundspeed and drift pointers

11. The construction of the instrument takes the form of a circular, machined, light-alloy casting, which houses two gear trains, and supports the groundspeed synchro receiver X3, the drift synchro receiver X2, and the magnetic indicator X1. Attached to the casting are four circular pillars, which provide a rigid mounting for the plugplate. This houses the twelve-pole connector plug, and provides attachment for the instrument outer cover.

12. The spindle assembly consists of three concentric spindles, the inner drives the groundspeed pointer, the hollow outer spindle drives the drift pointer, and the intermediate hollow spindle, which is anchored to the bearing support plate, acts as a bearing tube. The outer spindle is secured by a spring circlip. The counterbalanced groundspeed pointer is a press fit on a tapered inner spindle, which is driven by the synchro torque receiver X3 through a simple 1 : 1 ratio gear train. The drift counter, which is also counterbalanced, is a press fit on the tapered outer spindle. The spindle is rotated in either direction by the synchro torque receiver X2 driving a 1 : 1 gear train, in a similar manner to the groundspeed pointer. It should be noted that both pointers and the scale markings are non-luminous, and are normally illuminated by panel-type lighting.

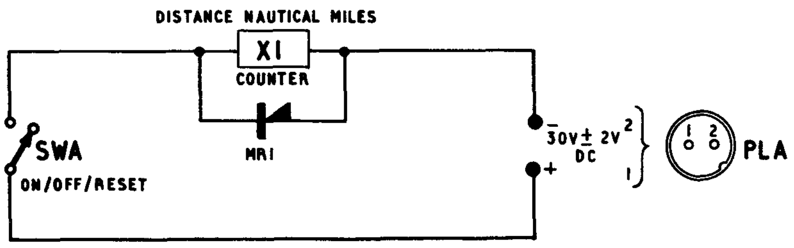
13. The gear train of each synchro is similar, and consists of a gearwheel secured to the splined synchro shaft by a nut and drive washer, meshing with a flat gear wheel which in turn drives the pointer spindle gearwheel. The gear mechanism and spindles are assembled dry, and should remain unlubricated.

14. The excitation windings (R1–R2) of both synchro receivers are paralleled across pins 1 and 2 of the connecting plug PLA, and are energized by a 26-volt a.c. supply from the power assembly in either the i.d.u. or computor. The stator windings of the drift pointer synchro X2 are connected to the drift integrator synchro torque transmitter 6X2 in the i.d.u. or 6X1 in the computor; in either case 5 degrees of rotation of X2 is equivalent to 1 degree of drift. This system ensures that the drift pointer accurately follows all rotational changes of X2, hence aerial array movement in azimuth.

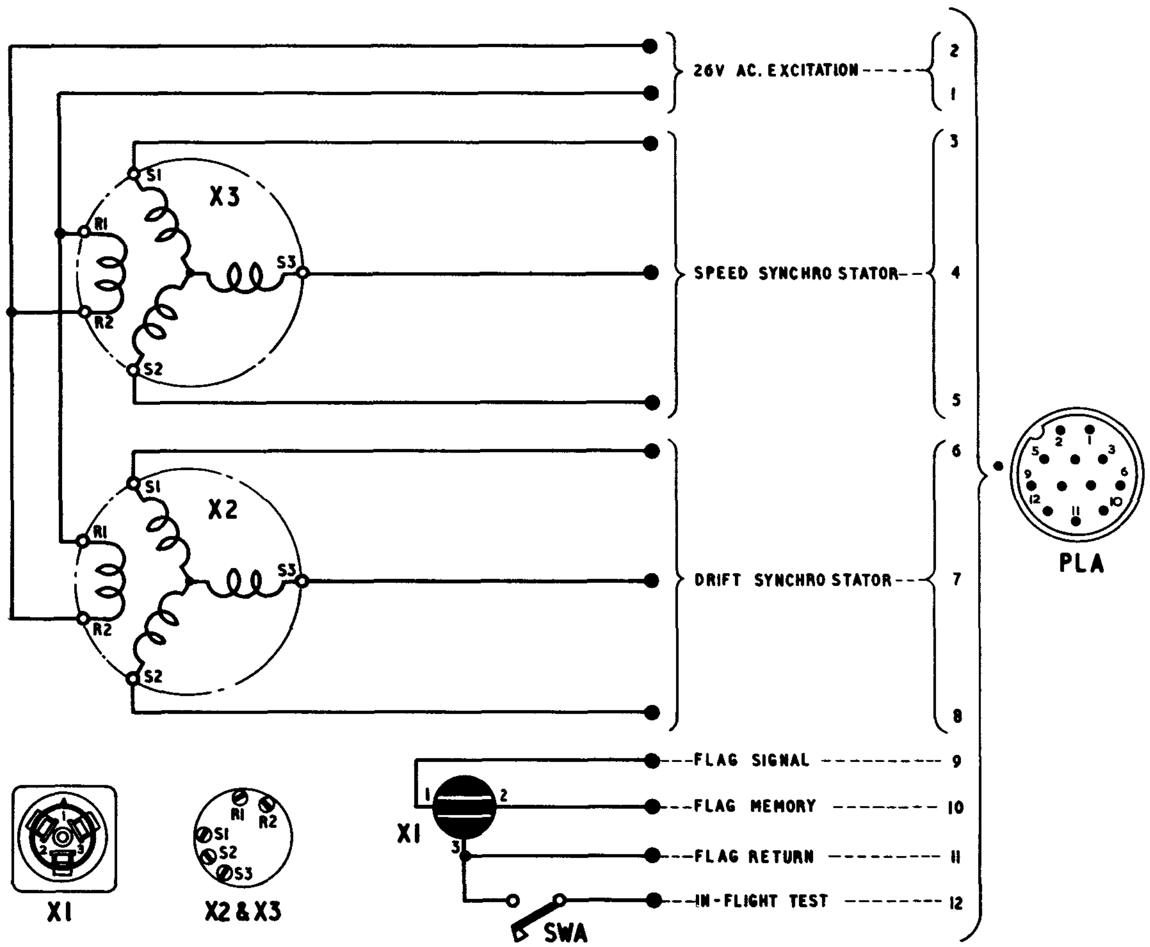
15. The stator windings of the groundspeed pointer synchro X3 are connected to the speed servo synchro torque transmitter 7X3 in the i.d.u. or 6X5 in the computor, which provides a 3-wire synchro output of 36 degrees rotation per 100 knots of groundspeed. Consequently the speed display pointer accurately monitors all speed variations, after the speed circuits have locked on.

16. All pointer indications are dead-beat and, as no return springs are fitted, the pointers will remain in the relative positions occupied when power is switched off.

17. The d.c. power supplies for the operation of the magnetic indicator are switched by contacts of the secondary S/N relay 1RLE in the tracking unit. The common terminal (3) of the magnetic indicator is returned to earth via the transformer 1TR1 in the tracking unit. A description of the magnetic indicator control circuits is in Chap. 2. The TEST button mounted on the front face of the instrument is a spring-loaded push switch SWA with the normally broken contacts, 3 and 4, utilized. Operation of the button completes the earth connection to the tracking unit relays 1RLG, 1RLH and 1RLJ, dependent on whether the equipment is functioning under signal or memory conditions. A full description of the action of the TEST button is also in Chap. 2.



Indicator range Type M.16 : circuit Fig. 3



Indicator assembly Type M.15 : circuit Fig. 4

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Chapter 5

COMPUTOR NAVIGATIONAL

(Computor B)

and

INDICATOR ASSEMBLY TYPE M.14

(Display Unit)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Supply voltage	115 *or* 200 *volts*, 3-*phase*, 400 *c/s a.c.* (±5% *tolerance on voltage and frequency*)
Power consumption at 115 *volts*	80 *watts max.* (*Figure taken on slewing.*) *Power factor* 0·6
Power consumption at 26 *volts* (*auto-pilot phase*)	7·5 *watts max. Power factor* 0·35
Compass safe distance	
Computor	15 *in.*
Display unit	12 *in.*
Maximum temperature range	—40 *to* +70°*C*
Operational temperature range	—40 *to* +55°*C*
Altitude ceiling	60 000 *ft*
Weight	
Computor (*with all sub-assemblies*)	17·7 *lb*
Display unit	7·4 *lb*
Case size	
Computor	*Short* ½ *ATR*
Display unit	*To ARINC Characteristic No.* 543
Type of mounting	
Computor	*ARINC racking*
Display unit	*Panel mounting employing Dzus fasteners*
Overall dimensions	
Computor	
Height	$7\frac{25}{32}$ *in.*
Width	5 *in.*
Depth	$14\frac{1}{4}$ *in.* (*exclusive of plug receptacle*)
Display unit	
Height	$4\frac{33}{64}$ *in.*
Width	$5\frac{49}{64}$ *in.*
Depth	6 *in.* (*exclusive of plug receptacle and locating pins*)

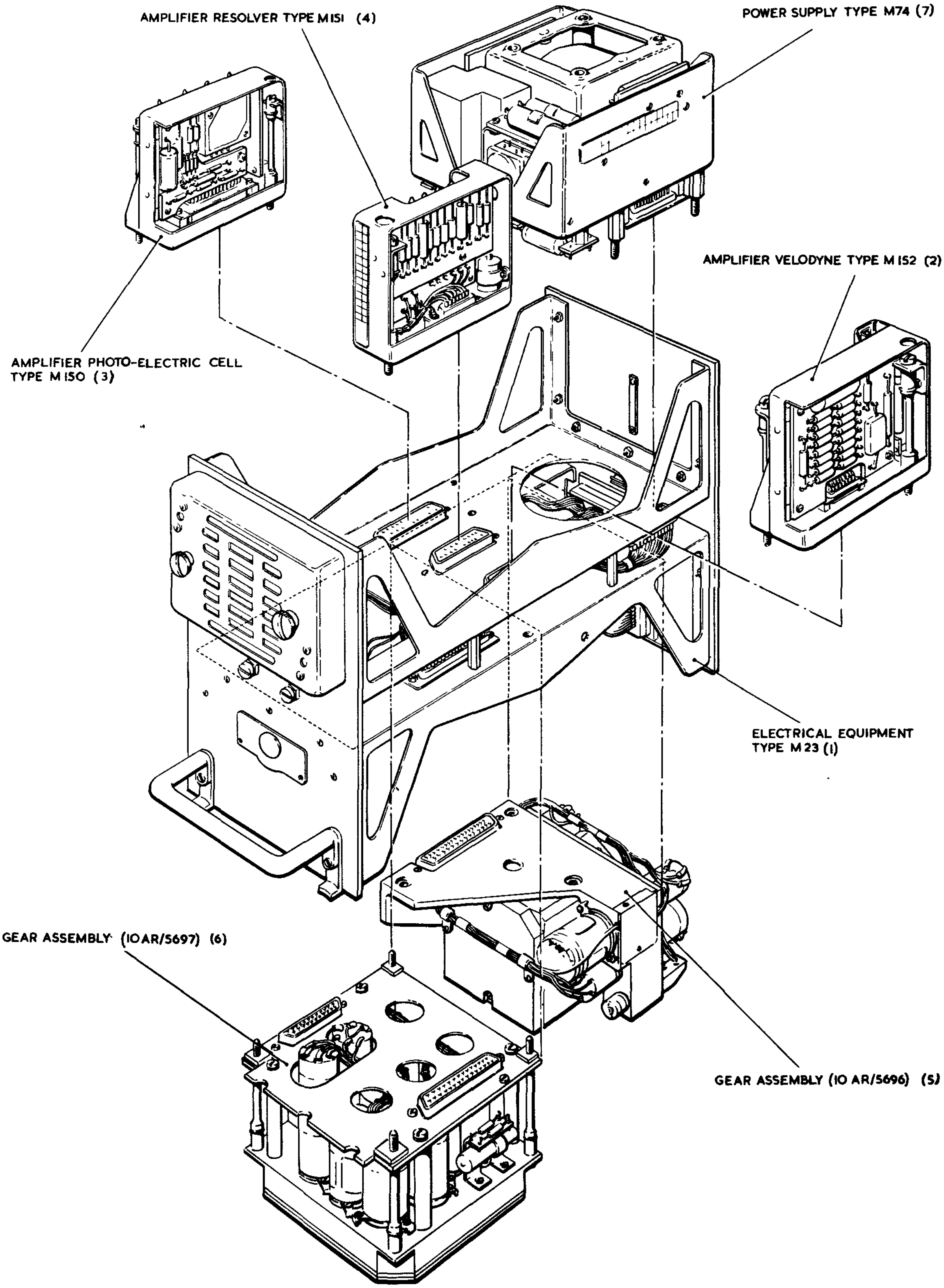


Fig. 1. General view of computor assemblies

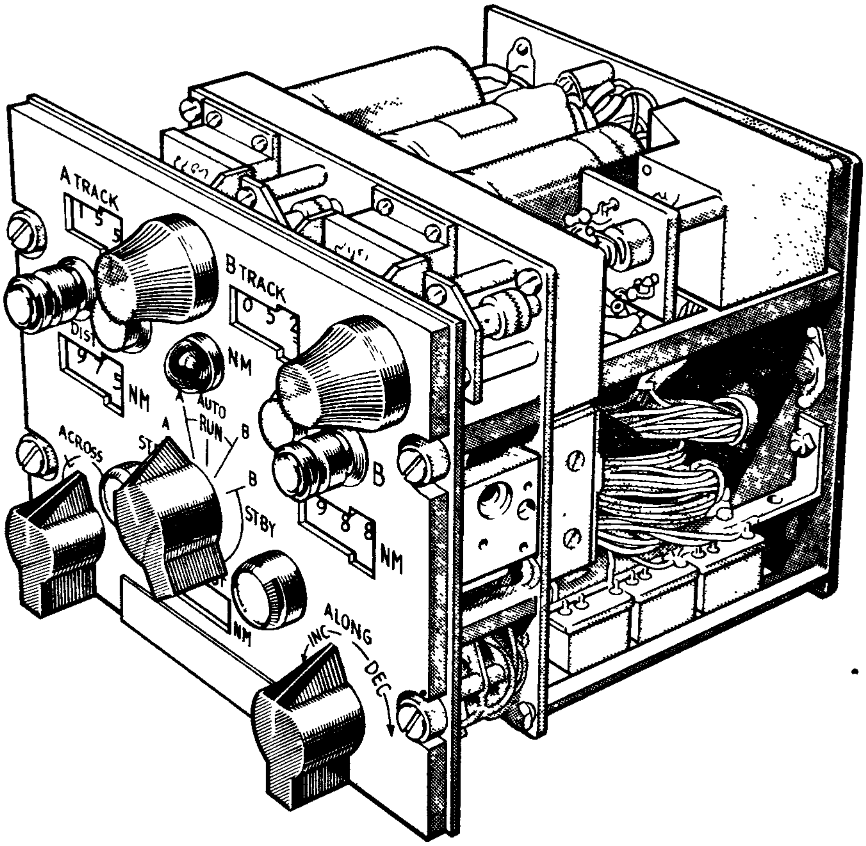


Fig. 2 General view of display unit

Introduction

1. The principal functions of the computor are as follows:—

(1) To convert the groundspeed and drift information derived from the Doppler signal by the tracking unit into forms suitable for driving the pointer-type displays in the speed and drift indicator and the counting mechanism in the distance flown indicator.

(2) Using the same groundspeed and drift information together with heading information from the aircraft gyro-compass system to compute both the distance-to-go to the end of the current leg of the flight and the transverse distance from the planned track. These two distances, which are referred to as the 'along' and 'across' distances respectively, are continuously indicated on the display unit, which because of its close association with the computor, is also described in this chapter. It should be noted that whereas the distance indicator (*Chap.* 4) shows at any moment, the total distance already flown, the display unit shows the remaining distance to be flown to a previously-decided point.

(3) To provide an error signal for the drift servo loop, and the phonic wheel tone for the speed servo loop. In addition, an 'across' output is available from the display unit for autopilot operation or for a pilot's left/right steering indicator when this is provided on the aircraft.

Constructional details: computor (fig. 1)

2. The computor is housed in an unpressurized short $\frac{1}{2}$ATR case and consists of the following sub-assemblies:—

Chassis, electrical equipment Type M.23	(component prefix 1)
Amplifier, velodyne Type M.152	(component prefix 2)
Amplifier, photo-electric cell Type M.150	(component prefix 3)
Amplifier, resolver Type M.151	(component prefix 4)
Gear assembly (10AR/5696	(component prefix 5)
Gear assembly (10AR/5697)	(component prefix 6)
Power supply Type M.74	(component prefix 7)

3. The main chassis consists of two similar decks mounted back-to-back with sufficient space between them to accommodate the fixed wiring looms and the miniature sockets by which the sub-assemblies are connected. The external connections to the complete computor are made by two 57-pole plugs mounted in receptacles on the backplate. Two fuses (FS1, 2·5A, and FS2, 4A) are mounted on the front panel.

4. A welded, light-alloy cover is fitted over the chassis and is secured by an Oddie fastener at the rear. The computor is designed for operation with ARINC cooling systems or for satisfactory cooling by convection. For the former method, an air vent

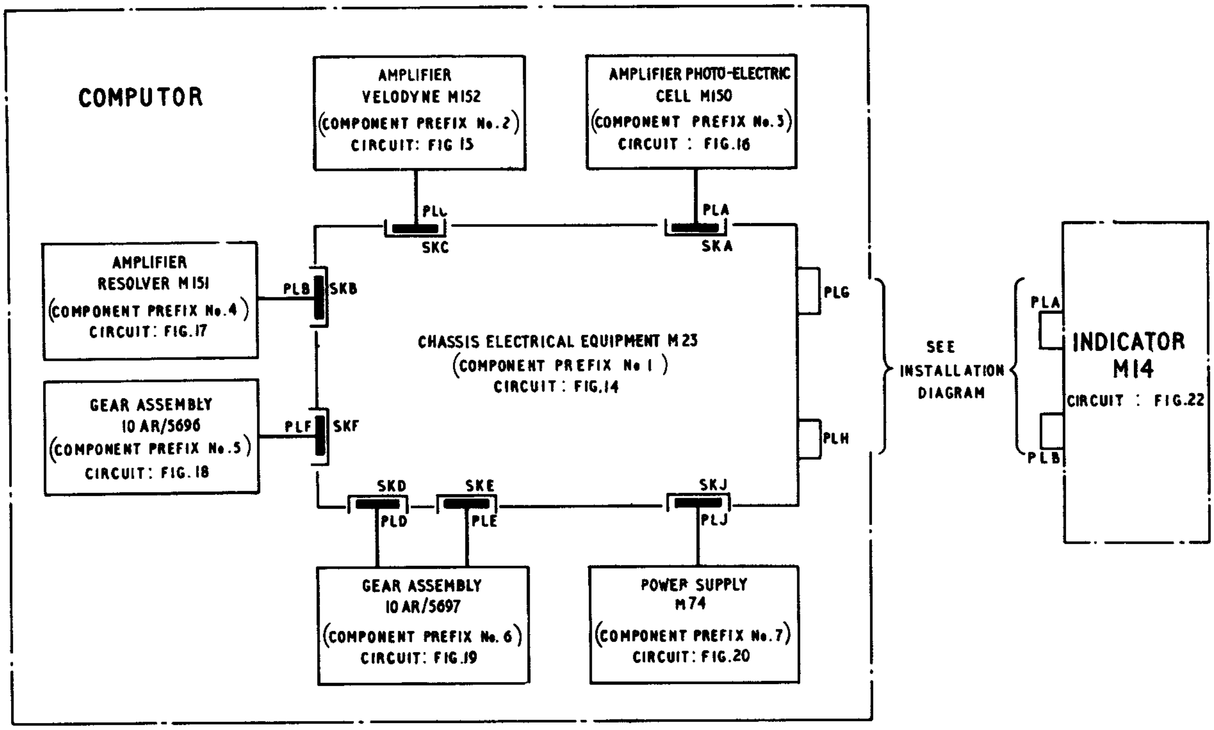


Fig. 3. Schematic arrangement of assemblies

for the ARINC suction coupling is provided on the underside of the cover, and an air intake, complete with an air filter and filter cover, is fitted on the front panel. For convection cooling an alternative cover with ventilation holes is provided.

Constructional details: display unit (fig. 2)

5. The components of the display unit are assembled on three parallel light-alloy plates, a front panel, a gear-plate, and a backplate, which are secured and spaced apart by means of hexagonal mounting pillars. A welded, light-alloy cover is fitted from the rear of the unit to butt against the panel and is secured by two snap fasteners riveted to the backplate. The unit is arranged for panel or rack mounting. Two Dzus fasteners are fitted at each side of the front panel (which extends beyond the cover to form mounting flanges), and two locating pins for aligning the connectors are fitted to the backplate. Two 37-pole plugs, PLA (top) and PLB (bottom), are mounted in receptacles at the rear of the unit for inter-connection purposes. The unit is not pressurized and does not require cooling.

6. The desired track gearbox, the distance along track gearbox, and the distance across track gearbox are mounted on the rear of the central gear-plate together with all the synchros. The Ledex switch SWA, the output transformer TR1 (and the synchroverter RLC, when fitted) are mounted on the backplate by means of distance pieces. The three distance counters, the two desired track angle counters and desired track angle reset mechanism are fitted on the forward face of the gearplate. The three manual switches, SWB, SWC, and SWD, are carried on the front panel. An engraved panel with clear windows for the counter scales is fitted over the front panel and is secured by the screw-in panel illumination lamps and also by the securing nuts of the controls.

Brief description

7. The controls on the display unit enable two consecutive legs of a composite flight plan to be set up in terms of track angle and distance. They are arranged so that, if desired, the computor will automatically change to the second leg on completion of the first. The form of track angle set in (i.e. true or magnetic) must be the same as the heading input.

8. As progress is made along the first leg, the display unit shows the computed distance to travel to the turning point, and also any departure from the desired track in terms of transverse distance in nautical miles (fig. 4) to the left or the right. A warning lamp lights approximately 10 nautical miles from the end of the leg, and when the aircraft is over the turning point, as indicated by a zero miles reading on the distance counter, the computor changes to the second leg automatically if desired. Details of the third leg can then be set in, also with automatic changeover if required. In this manner any number of flight stages can be accommodated. If a change of plan becomes necessary during flight, the controls can be reset accordingly.

Functions of the controls (fig. 5)

9. The controls and other items mounted on the front of the display unit are as follows:—

(1) A TRACK and B TRACK counters. These are three-digit counters calibrated in half-degrees. They are set manually by item (2).

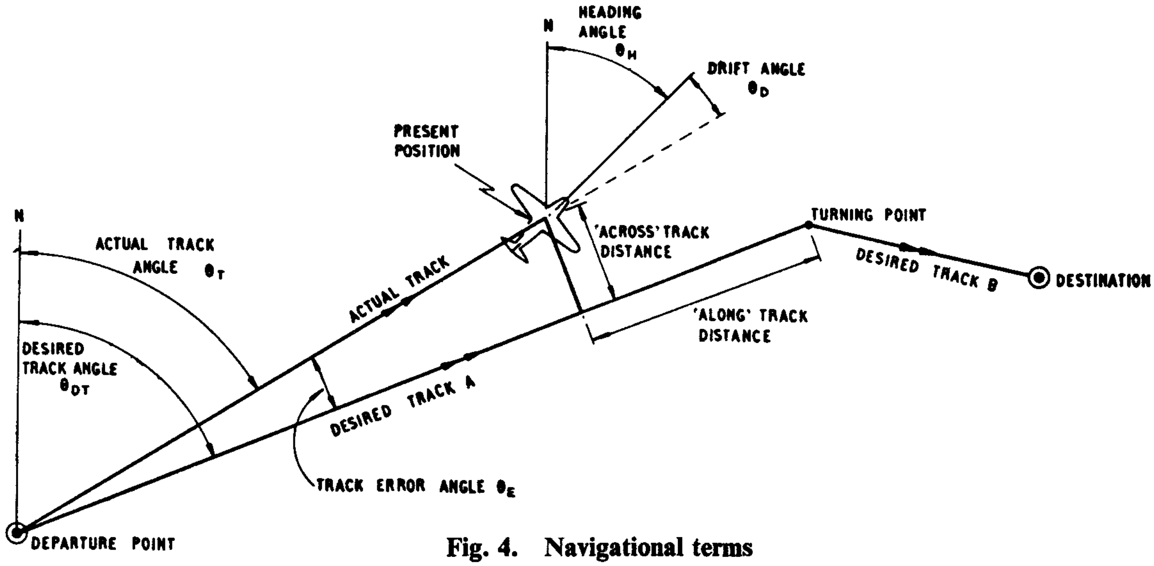


Fig. 4. Navigational terms

(2) Desired track reset knobs. These are mounted to the right of the A TRACK and B TRACK counters, respectively, and are used to set the counters to the desired track angles. They are not engraved.

(3) A DIST and B DIST counters. These are three-digit counters calibrated in nautical miles up to 999. They are initially set manually by item (5) to display the lengths of two consecutive legs of the flight. During flight, the counter appropriate to the leg being flown runs down, and thus shows, at any moment, the distance-to-go to the end of the leg.

(4) ACROSS DIST counter. This is a two-digit counter calibrated in nautical miles, together with a left-right indicator. It is normally reset to zero at the beginning of a leg, and thereafter shows the transverse distance the aircraft is, at any moment, from the planned track up to a maximum of 89 n.m. left or 90 n.m. right.

(5) ALONG reset switch (SWC). This is a rotary switch which is used to reset either the A DIST or B DIST counter, depending on the position of the selector switch, item (7). It is spring-tensioned to an'off'position in the centre.

(6) ACROSS reset switch (SWD). This is also a rotary switch, spring-tensioned to a centre 'off' position. It is used to reset the ACROSS DIST counter.

(7) Selector switch (SWB). This is a 360° rotary switch labelled from left to right, A STBY, A RUN, AUTO RUN, B RUN, B STBY. The switch controls a Ledex switch (SWA) in the display unit. Its functions are described later.

(8) A and B indicator lamps. These are fitted above the corresponding A and B DIST counters. One or the other glows to show which leg is active. The covers are blue in colour, and incorporate adjustable dimming irises and "press-to-test" devices.

(9) 10 NM warning lamp. This lamp, which has an amber-coloured cover, lights when the aircraft is 10 nautical miles from the end of the current leg of the flight. It incorporates a "press-to-test" device.

(10) Illumination lamps. There are four panel illumination lamps, each fitted beneath a removable cover.

10. The ALONG and ACROSS switches, which are used to set the corresponding counters, control motor-driven resetting systems in the computor. The ACROSS switch can be used at any time to reset the ACROSS DIST counter regardless of the positions of the other controls, whereas the ALONG switch resets either the A DIST or B DIST counter, depending upon the position of the selector switch. Two driving speeds are available for resetting the counters; a high speed, for coarse control, and a low speed, for fine adjustment. They are selected by full or half-way movement of the control knobs.

Functions of the selector switch SWB (fig. 6)

11. In the A STBY position (A standby) the output of the computor is disconnected and the ALONG control resets the A DIST counter.

12. In the A RUN position, Doppler groundspeed and drift angle, heading, and the desired track angle as set on the A TRACK counter are fed to the computor. The computed distance flown along track counts down the A DIST counter, and the 'across' track distance drives the ACROSS DIST counter. The A indicator lamp glows, and when the A DIST counter reads approximately 010 the 10 n.m. warning lamp glows until the counter reads zero. If the aircraft maintains a constant track, the A DIST counter runs through 000 to 999, 998 and so on. Note that with the selector switch in this position, operation of the ALONG control resets the B DIST counter.

13. If the switch is turned through the A RUN position to AUTO RUN, the computor operates as in

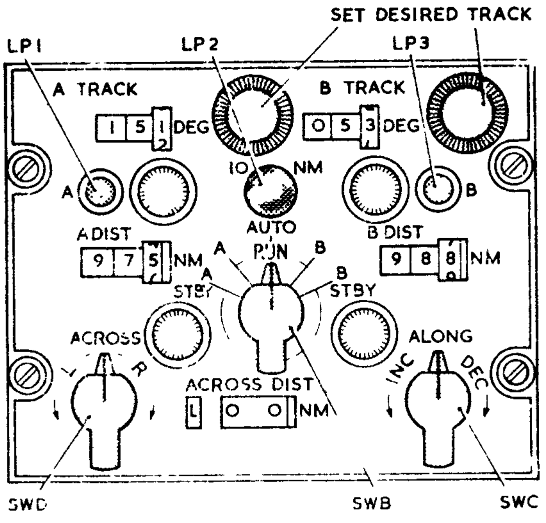


Fig. 5 Display unit controls

para. 12 above until the A DIST counter reads 000, when the desired track angle input to the computor is automatically switched from A TRACK to B TRACK. As this occurs, the A indicator lamp is extinguished and the B lamp illuminated, and the computor distance drive is transferred from the A DIST counter to the B DIST counter. Operation of the ALONG control then resets the A DIST counter.

14. In the B RUN position, the B stage is coupled to the computor and the B indicator lamp glows. The ALONG control resets the A DIST counter.

15. Switching to the B STBY position disconnects the output of the computor and the ALONG control resets the B DIST counter.

16. It should be noted that when the AUTO RUN facility is required, that is, the changeover from one leg to the next is to be automatic, the stage first brought into use is dependent upon the order in which the switch positions are selected. If the switch is turned through A RUN to AUTO RUN, the A stage is made active first, and if the switch is turned through B RUN to AUTO RUN, the B stage is made active first. Once the AUTO RUN position is selected, the switch is not normally touched again during the flight. On completion of the first leg, the data for the third leg is set into the inactive stage using the ALONG control and the desired track reset knob for that stage; on completion of the second leg, data for the fourth leg is set in, and so on.

17. Should a change of flight plan become necessary, a revised track may be set into the inactive stage. At the point selected for the commencement of the new leg, the changeover is effected manually by turning the selector switch to the required RUN position. This overrides the automatic switching obtained in the AUTO RUN position.

PRINCIPLES OF OPERATION

Speed servo (*fig.* 8)

18. The purpose of the main speed servo loop is to track the Doppler signal frequency, and in doing so, to produce a number of outputs suitable for computing and indication. The loop is a position servo in which the frequency of the output of a phonic wheel generator is compared with the frequency of the Doppler signal, any difference between the two causing the potentiometer 7X3 in the tracking unit to be re-positioned until equality is obtained. The phonic wheel is a transparent plastic disc bearing black radial lines near its periphery. It is driven by a motor 5MO1, and it revolves between a light source, lamp 5LP1, and a photo-electric cell, 5V1. As the disc rotates, the light shed on the cell by the lamp is interrupted by the black lines, and the corresponding variations in the output of the cell are amplified in the photo-cell amplifier 3V1, 3V2 to become the phonic wheel tone.

19. The motor 5MO1 is part of a velodyne arrangement which includes the amplifier 2V1, 2V2, 2V3, 2V4 and the tacho generator 5X1. The input to the velodyne is a fixed-frequency, variable-amplitude alternating voltage which is proportional to groundspeed and which is related to the output from commutator potentiometer 7X3 in the tracking unit. The output from the velodyne is a mechanical shaft rotation, the speed of the shaft being proportional to the amplitude of the input voltage and hence to the groundspeed of the aircraft. As the speed of the shaft is related to groundspeed, the total angle through which the shaft turns during a flight is proportional to the total distance flown.

20. There are effectively three outputs from the velodyne. The first is the drive to the phonic wheel, already described, the second is to the distance indicator, and the third is to the computing mechanical resolver. The distance indicator counting mechanism is actuated by a cam-driven contact unit 5SWA which interrupts a 28V d.c. supply at a rate determined by the groundspeed. This steps the counter which thus continuously indicates the distance flown. The output to the mechanical resolver is one of the three principal inputs to the computing sequence (*fig.* 10) and is dealt with in para. 25.

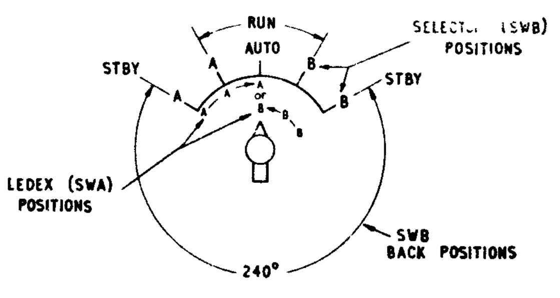


Fig. 6 Selector switch positions

21. Included in the main speed loop is a position servo comprising the amplifier 3V3, 3V4, the motor 6MO2 and the potentiometer 6X7. The input is the fixed-frequency alternating voltage of amplitude proportional to groundspeed from the commutator potentiometer 7X3 in the tracking unit, and the output is a mechanical shaft angular position which is proportional to the input voltage and hence to groundspeed. This shaft drives the rotor of transmitter 6X5 which delivers a 3-wire output to the speed indicator, and also a pick-off pot 6X7 which passes an alternating voltage back to the input of the amplifier for comparison with the speed voltage from the tracking unit.

22. A change of aircraft speed causes the frequency of the received Doppler signal to differ from that of the phonic wheel tone, and this causes the tracking unit circuits to move the slider of potentiometer 7X3. The change of voltage from 7X3 is conveyed to the input of the speed amplifier 3V3, 3V4, and the speed motor 6MO2 begins to turn, resetting the wiper of potentiometer 6X7. Thus, in turn, the velodyne amplifier input is changed, and the speed of the phonic wheel motor 5MO1 is altered to bring the frequency of the phonic wheel tone again into coincidence with that of the Doppler signal. When this condition is reached there is no further drive to the potentiometer 7X3 in the tracking unit. The voltage delivered to the speed amplifier becomes constant, the speed motor 6MO2 ceases to turn when the feedback voltage from potentiometer 6X7 equals the input voltage, and the phonic wheel motor 5MO1 rotates at constant speed. The new shaft position of motor 6MO2 is conveyed by the synchros to the speed indicator, and the new speed of rotation of motor 5MO1 is applied to the mechanical resolver and to the pulsing contacts for the distance indicator.

Drift servo (*fig.* 9)

23. The purpose of the drift servo is to align the aerial with the path of the aircraft over the ground and, in doing so, to measure the angle between this path and the fore-and-aft axis of the aircraft, *i.e.* the drift angle. The operation of the complete loop is described elsewhere; the following brief description is restricted to the portion concerned in the computing functions.

24. In the computor is the motor 6MO1 which is coupled by shafting to transmitter 6X3. If the aerial is displaced, motor 6MO1 is energized by the tracking unit and turns the shaft. The change of angle of the shaft is conveyed to the aerial by the transmitter 6X3, where the motor 1MO3 begins to turn the aerial into alignment. When this condition is reached, controlling signals from the tracking unit cease, motor 6MO1 stops, and the angular position of the motor shaft represents the drift angle. This information is conveyed to the drift indicator by transmitter 6X1 for display, and to the differential transmitter 6X2 for computing purposes.

Computing (*fig.* 10)

25. The inputs to the computing sections of two units are as follows:

(1) Drift angle. Form: shaft angular position from drift integrator motor 6MO1.

(2) Heading angle. Form: 3-wire stator from aircraft's compass system.

(3) Desired track angle (A and B legs). Form: shaft angular position set in manually by the desired track reset knobs.

(4) Distance flown. Form: shaft rotating at rate proportional to aircraft's groundspeed from phonic wheel motor 5MO1.

26. The outputs from the computing sections of the unit are:—

(1) Distance-to-go to the end of the leg of the flight in progress. Displayed on A and B leg digital counters, consecutively, on the display unit.

(2) Transverse distance of the aircraft from the desired track. Also displayed by digital counter on display unit, together with flag showing L for left or R for right.

27. The drift angle input shaft (*fig.* 10) positions the rotor of the differential transmitter 6X2 one way or the other from zero depending upon the sense (port or starboard) of the drift angle. Since the input to the stator represents heading angle, the output from the rotor represents the sum of the heading and drift angles when the drift is to starboard, or the difference when the drift is to port. This is the actual track angle, and it is passed to the display unit.

28. In the display unit, the track angle information is conveyed to the stator of either the A leg differential transmitter X1 or the B leg transmitter X2 by contacts of the Ledex switch SWA (*para.* 45). The positions of the rotors of these transmitters are pre-set manually by the desired track setting knobs, and the output from the rotor of the transmitter to which the track angle is switched represents the difference between the desired track angle and the track angle actually being made good. This error angle is sensed in relation to the desired track angle, and it is passed back to the computor.

29. In the computor the form of the track error angle is converted from a 3-wire synchro signal to a shaft angle by a position servo consisting of motor 5MO2, amplifier 4V1, 2, 3 and 4, and synchro control transformer 5X4. The input signal feeds the stator of the control synchro, and the amplified output of the rotor controls the motor, which, in turning the shaft, drives the synchro rotor to the null position, when the rotor output falls to zero and the motor stops. The angular position of the shaft then represents the track error angle, and this provides one of the two inputs to the mechanical resolver, the other being the speed shaft, which positionally represents distance flown.

30. The mechanical resolver converts the computed information regarding the aircraft's movement, relative to the planned track, from polar

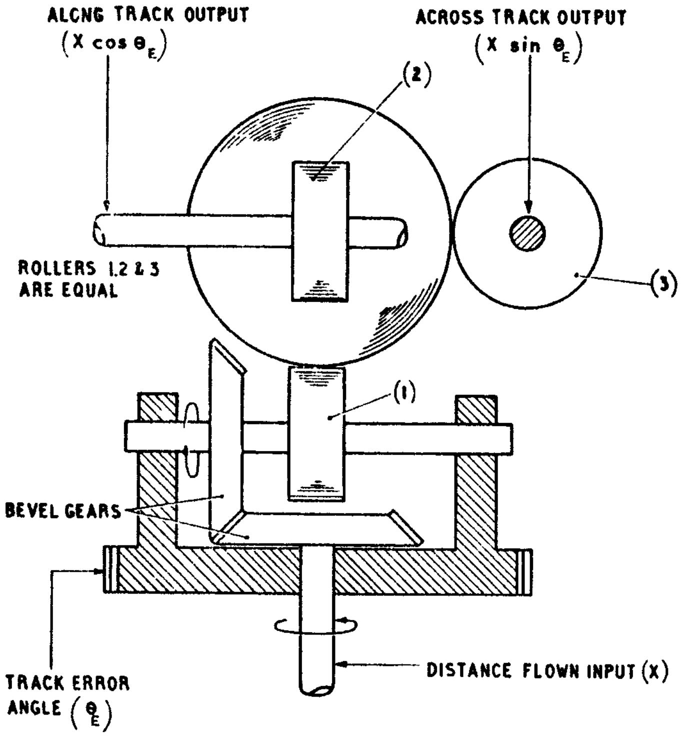


Fig. 7 Principle of mechanical resolver

co-ordinates into rectangular co-ordinates. Referring to fig. 4, let the distance flown along the actual track, as represented by the speed shaft, be X n.m., and let the error between the track actually flown and the desired track, as represented by the error angle shaft, be θ_E degrees. In rectangular co-ordinates, X cos θ_E n.m. is the equivalent distance measured along the required track, and X sin θ_E n.m. is the transverse departure from the required track ('across' track distance).

Mechanical resolver

31. The resolver is illustrated diagrammatically in fig. 7. It consists of a hardened steel sphere supported by an input roller (1), two output rollers (2) and (3), and two spring-tensioned idling rollers which are not shown in the illustration. The distance drive X is transmitted through bevel gearing to impart rotation to the sphere by means of roller (1), while the error angle drive θ_E rotates the carriage containing the axis of the shaft of roller (1). These two inputs are arranged concentrically, the distance drive shaft passing through the error drive gear to the bevel gears. The output shafts are positioned mutually at right-angles, and the two idling rollers press the ball against the input and output rollers to provide operating friction.

32. When the error angle is zero, the carriage is in the position shown, and the distance drive is conveyed to roller (2), the other roller remaining stationary. When the error is not zero, the axis around which the sphere rotates is displaced, and motion is imparted to both rollers (2) and (3) in the required relationship.

33. The sine output shaft, roller (3), drives the rotor of transmitter 5X2, while the cosine output, roller (2), drives the rotor of transmitter 5X3. The outputs from the stators of these two transmitters, representing the 'across' track distance and the distance flown along track, respectively, are fed to the display unit to drive the counters.

Counter drive and resetting (*fig.* 11)

34. The 'across' distance information is fed to the 'across' receiver X7 via contacts on the ACROSS reset switch SWD and on the selector switch SWB, which is arranged such that the drive is connected only in the RUN positions. The purpose of the SWD/3 contacts is described in para. 37. Receiver X7 drives the ACROSS DIST counter.

35. The distance flown along track information is also connected only when the selector switch (SWB/1) is in one of the RUN positions, when it is passed to contacts of the Ledex switch SWA. This is set to the A position when the selector switch is set to A STBY or A RUN, and remains in the A position if the selector is turned from A RUN to AUTO. Conversely, it is set to the B position if the selector switch is set to B STBY or B RUN, and remains in the B position if the selector is turned from B RUN to AUTO. (The circuit arrangements of the Ledex switch are described later.) Thus the distance flown along track is passed either to the A leg receiver X3 or the B leg receiver X4. The counters which are driven by these receivers are pre-set to the full leg lengths, and the direction of drive is arranged to count the readings down, so that at any given moment, the counter of the active stage displays the 'along' distance to go to the end of the leg in progress.

36. To reset the 'along' and 'across' distance counters, a motor-driven 3-wire transmitter 6X8 is fitted in the computor. When either the ALONG or the ACROSS reset switch is turned, an a.c. supply is connected to the motor, and simultaneously, the output of 6X8 is connected to the appropriate counter receiver. The direction of the drive is determined by SWC/1 and SWD/1, which reverse two of the three wires when turned from INC to DEC or from L to R, respectively.

37. Considering the across track resetting drive, when the ACROSS knob is turned to L, SWD/4 connects the a.c. supply to motor 6MO3, and SWD/1 connects the drive from 6X8 to receiver X7. At the same time, SWD/3 disconnects the computor input; the across resetting facility can thus be used at any time.

38. If the ACROSS switch is turned to R, similar switching actions occur except that, because of the sense reversing connections on SWD/1, the direction of the drive is reversed.

39. Considering the along track resetting drive, when the ALONG knob is turned to INC, SWC/3 connects the a.c. supply to motor 6MO3, and SWC/1 connects the drive from 6X8 to either receiver X3 or X4, depending on the positions of the main selector switch SWB and the Ledex switch SWA. If the selector is in either standby position, the resetting drive is switched through to the corresponding receiver and the computor input is cut off by SWB/1. When the selector is in any RUN position, the resetting drive is connected to the idle receiver. Thus, when switched to A RUN or to AUTO from A RUN, the resetting drive is fed to the B leg receiver X4, and when switched to B RUN or to AUTO from B RUN, the resetting drive is applied to the A leg receiver X3. If the ALONG switch is turned to DEC, similar circuit considerations apply except that the sense reversing connections on SWC/1 reverse the direction of the drive.

Counter resetting speed control (*fig.* 12)

40. Two driving speeds are available for resetting the 'along' and 'across' distance counters. They are selected by half-way or full movement of the ALONG and ACROSS knobs in either direction of rotation. Fig. 12 shows the circuit arrangements. It is complete except that, for clarity, only one-half of the control switch functions are included. Rotation on the switches in the opposite direction has the same effect on the circuit elements shown: reversal of the direction of the drive is obtained by reversing two of the three wires from transmitter 6X8 as previously explained.

41. Control of the resetting speed is effected by two simultaneous circuit changes, one in the a.c. supply circuit to motor 6MO3 and the other in the rotor excitation circuit of receiver X3, X4 or X7.

42. In either slow position of either the ALONG (SWC) or ACROSS (SWD) switch, the 115V supply to the control winding 2, 4 of motor 6MO3 is applied through a ·02μF capacitor C8. When either switch is further rotated to the fast position, an additional capacitor, C7, is added to C8, making the total capacitance ·12μF. Thus, in either position, the supply circuit is completed, but in the slow position the smaller capacitor produces a lower voltage across the motor control winding, a smaller phase difference between the currents in the two windings and, hence, slower running. When both switches are in the central, off, position, neither capacitor is connected and the motor is not energized.

Note . . .

In an aircraft installation where long cables are used between the display unit and the computor, stray capacitance may cause 6MO3 to rotate slowly when the switches are in the off positions. This effect is not important because, as previously explained, the 3-wire drive from transmitter 6X8 is cut off.

43. Considering first the 'across' resetting circuit, when the ACROSS switch SWD is in the centre (off) position, resistor R5 is short-circuited, and the full 26V is applied to the rotor of X7 so that it functions normally in response to the input from the computor. When SWD is turned to either slow position, R5 is introduced and the voltage across the rotor falls to 2·5V. For fast resetting, R5 is again short-circuited.

44. The supply to the rotors of the along receivers X3 and X4 is reduced by resistors R3 and R4 in a similar manner, but a Ledex switch pole, SWA/5 is included to ensure that during run conditions the 26V energizing supply to the active receiver is not disturbed when the inactive counter is reset. Thus, supposing the B leg counter is reset during flight on an A leg, resistor R4 is switched in or out by SWC/4 while resistor R3 is held out of circuit by SWA/5 through contacts RLD1 Conversely, during flight on a B leg, R4 is shorted out by SWA/5, and SWC/3 switches R3. Relay RLD is included to break the short-circuit provided by SWA/5 under standby conditions. When the selector switch is in any of the three RUN positions, relay RLD is energized from the 28V supply through SWB/6. In either standby position RLD is released, and SWC is effective on both R3 and R4. Under these conditions, however, there is no input from the computor, and only that receiver being fed by the reset transmitter 6X8 is affected, the other remaining idle.

Ledex switch SWA (*fig.* 13)

45. The purpose of the Ledex switch is to select the appropriate synchros and indicator lamps for the A and B flight legs. It is controlled by the main selector switch SWB, and when energized it steps three positions (90°). Consecutive operations of the switch change the circuit connections from A to B to A and so on.

46. The basic circuit of the Ledex switch consists of the operating solenoid, the interrupter contacts, wafer SWA/2, and wafers 5 and 6 on the selector switch SWB. In fig. 13, wafers SWB/5 and SWB/6 are shown separated into separate functions to clarify the circuit. The Ledex switch is drawn in the A leg position. Suppose SWB is turned to either of the B positions. The Ledex solenoid is energized from +28V, through SWB/6a, SWB/5a, SWA/2/9, SWA/2/1, and thence through the solenoid to earth. This causes the Ledex to step three positions, when the circuit is opened at SWA/2/9. If SWB is next turned to an A position, the Ledex solenoid is again energized, but through SWA/2/12 instead of /9, and the switch shaft once more rotates through 90°. Thus, whenever SWB is turned from A to B, or from B to A, the Ledex turns in the same direction through three positions.

47. The wafers SWA/5 to 10 (not shown in fig. 13) switch the A and B leg synchros. They are arranged as six two-pole two-way changeover switches, and successive 90° rotation of the shaft changes the connections to synchro X1 to X6 so that those appropriate to the A and B stages are made active alternately.

48. On wafer SWA/4, contacts 1, 2, and 3 are arranged as a changeover switch, and either the A or the B lamp is lit to indicate the active stage under RUN conditions. When SWB is set to a standby position, the +28V supply is cut at SWB/6b.

49. Also on SWA/4, contacts 4, 5 and 6 connect the 10 n.m. warning lamp in readiness for the +28V supply which is applied by the appropriate counter switches when the "hundreds" and "tens" dials reach zero.

50. The remaining contacts on SWA/4 maintain the +28V supply to the Ledex solenoid independently of the selector switch SWB once the Ledex begins to turn. This is to prevent the Ledex from stopping in an intermediate position if SWB is not left in a selected position long enough for it to complete its 90° movement.

51. The purpose of SWB/6a is to open the Ledex drive circuit when SWB is turned through the back positions from one standby setting to the other. This is necessary because the switch wafers used are actually of the shorting type, and unwanted connections, not apparent in the simplified circuit, arise when SWB/5 turns through the back positions.

Automatic changeover (*fig.* 13)

52. When the selector switch SWB is turned from a RUN position to the AUTO position, the +28V supply to the Ledex drive circuit is cut at SWB/5a and the Ledex remains in its former position. Thus, on turning directly from A RUN to AUTO, the Ledex stays in the A position, and on turning from B RUN to AUTO, the Ledex stays in the B position (*fig.* 6). Simultaneously, the Ledex drive circuit is offered to the +28V supply by SWB/5b and c in readiness for the subsequent operation of the distance counter switches X9 and X10. These switches are associated with the A and B leg distance counters, and their contacts are closed in sequence when the hundreds, tens, and units digits are in turn reduced to zero as the flight proceeds. SWB/6b is included to disconnect the automatic changeover circuit under standby conditions.

53. To follow the operation of the circuit, assume that leg lengths of over 100 miles have been set on both counters, and SWB turned from A RUN to AUTO. As the A distance counter runs down, the sequence proceeds as follows:—

(1) The "hundreds" switch closes when the "hundreds" scale reaches zero, extending the +28V supply to the "tens" switch.

(2) When between 10 and 9 miles remain, the "tens" switch closes, extending the +28V supply to SWA/4 terminal 6 and thence through the switch to the 10 n.m. warning lamp, which lights.

(3) At the end of the leg, the "units" switch closes and connects the +28V supply through RLA1 and SWB/5 to terminal 9 of SWA/2 and thence through the switch to the Ledex solenoid. This causes the Ledex to drive to the B position, when the circuit is interrupted at terminal 9 as previously described.

54. When a B leg is being flown, and the A counter is set up in readiness for the following leg, a similar sequence of events occurs. The 10 n.m. warning lamp is energized by the closure of the 'tens" switch on the B leg distance counter, and, at zero miles, the Ledex is energized by the "units" switch through RLB1 and SWB/5. The Ledex then drives to the A position. Relays RLA and RLB are included in the circuit to give the automatic over-run facility.

Automatic over-run on AUTO (*fig.* 13)

55. When SWB is in the AUTO position, an electrical interlock provides automatic over-run on either 'along' distance counter when zero miles is reached and the alternative distance counter is also at zero. In this condition, the switching reverts, in effect, to the manual sequence in which the 'along' counters over-run when zero is reached. To obtain this facility, relays RLA and RLB are connected to the output side of the distance counter switches so that closure of all three leg A switches disconnects the leg B drive circuit of the Ledex switch, and closure of all three leg B switches disconnects the leg A drive circuit of the Ledex.

56. Suppose the B distance counter is at zero and an A flight leg is in progress. Relay RLA is energized because all the B distance counter switches are closed, and contacts RLA1 are, therefore, open. Thus, when the A distance counter "units" switch closes at zero miles, the Ledex switch is unaffected and remains in the A position. The A distance counter over-runs the zero position, therefore, and continues to count down from 999.

57. When the A distance counter is at zero and a B leg is being flown, relay B is energized by the A counter switches. The B energizing circuit for the Ledex switch is open at RLB1, and when zero miles is reached, the B counter over-runs.

'Across' track output for external purposes

58. In addition to driving the 'across' distance counter, the receiver X7 in the display unit also drives the transmitter X8 at one revolution per 100 miles. From X8, two 'across' track outputs are available as follows:—

(1) 2-wire a.c. 'across' output. The X and Y lines of X8 stator are connected to the tapped primary of TR1. This provides a variable 400 c/s output from the secondary winding terminals 12 and 13 for autopilot purposes. The output range is nominally from 1·2 to 4·5 volts per mile, depending on the tapping selected, and on the load.

(2) 3-wire synchro 'across' output. The three stator lines of X8 are also brought out to the plug to provide a 3-wire output for use when required.

'Across' track limit switch SWE

59. To operate an external flag warning, confidence light, or other warning that the 'across' track limit has been reached, a cam-operated switch SWE is installed in the across track gearbox in the display unit. This switch is normally closed, and it feeds a +28V supply to PLB pin 5. The supply to the switch is taken through SWB/6 which connects only on the three RUN positions.

60. The switch is opened when the aircraft is approximately 40 miles off track in either direction, and the flag or lamp is extinguished. 40 miles is chosen because the 'across' track synchro transmitter X8 rotates one revolution per 100 miles, and at 50 miles in either direction, therefore, there is a change of sign in the 'across' track output to the flight system. Before either of these positions is reached, the limit switch SWE is opened by the cam on the X8 gear drive to give warning to the pilot that the 'across' track output has become incorrect.

61. The mechanical design is such that the switch is closed again by the cam from approximately 60 miles to approximately 140 miles across track, but this is irrelevant for operational purposes.

62. It should be noted that the output provided by SWE is limited to the three RUN conditions and is not present on STBY, nor outside the stated limits, nor if the d.c. supply fails. In the absence of this indicating voltage, confidence should not be placed in the steering indicator (if fitted), and the autopilot (if coupled) should not be engaged.

Provision for additional facilities

63. Space provision is made in the computor for the installation of four additional synchros which can be driven by the existing gears. The wiring for these synchros is completed, but the connections for those not fitted are turned back and insulated. The additional synchros are shown in the main circuit diagram for completeness. They are planned to provide the following services:—

(1) Drift angle output for autopilot. Transmitter 6X4 may be fitted in the speed and drift gearbox to provide a 3-wire synchro output of 1° rotation for 1° drift angle for autopilot operation. The rotor connections of 6X4 are wired to plug PLH.

(2) Error angle output for autopilot. Control transformer 6X6 may be fitted in the speed and drift gearbox to provide a 2-wire output of approximately 200mV per 1° of track error angle for autopilot operation. The rotor shaft of this synchro is fixed to the chassis so that the rotor is immobilized.

(3) Error angle output for indication purposes. An additional output of track error angle can be provided by transmitter 5X5 in the resolver gearbox. This is designed to give a 3-wire output of 1° synchro rotation per 1° of track error for indication purposes.

(4) Provision for use of computor with alternative sensor. It is possible that the computor may be required to operate from signals produced by a sensor of alternative manufacture. Since certain types of sensor utilize a 3-wire synchro output for the speed signal provision is made for the installation of synchro 6X9 in the speed and drift gearbox for operation of the speed servo. To make use of this facility, other modifications would also be necessary.

64. In the Service version of the computor, the drift angle output transmitter 6X4 is fitted; the other three mentioned above are not. The excitation voltage for this synchro is 115V.

65. Space provision is made in the display unit for the installation of two additional synchros, X5 and X6, which can be driven by the existing gearing, and also for the installation of a synchroverter, RLC. The wiring for these components is completed, but the connections are turned back and insulated. The synchros and synchroverter are shown in the main circuit diagram for completeness. They are planned to provide the following services:—

(1) Distance-to-go output for indication purposes. Transmitters X5 and X6, when installed in the distance along gearbox, are driven through 100 : 1 reduction gears by the leg A and leg B receivers X3 and X4 respectively. They provide an output of distance-to-go on either leg in the form of a 3-wire synchro output for external applications such as additional indication for a crew position, operation of a roller map, etc. The 26V rotor excitation supply is connected by the Ledex switch SWA/5 to either X5 or X6 depending on the leg selected. The outputs from the stators are also switched by the Ledex SWA/6 and the selected output is connected to plug PLB.

(2) D.c. across track output for autopilot. To produce a d.c. 'across' track output for use with certain types of autopilot, or for the operation

66. The output from the centre-tapped winding of TR1, which is fed by the 'across' transmitter X8, is rectified by the synchroverter and smoothed by R2 and C1. The synchroverter is energized at 400 c/s by a 6·3V supply. The d.c. output may be adjusted by the tappings on the primary windings of TR1 to give scalings of 10 to 50 mV per nautical mile, limited at 150mV by the reference diodes MR1 and MR2.

67. Because only one adjustment point is provided, namely, the tappings on TR1, the a.c. and d.c. output scalings cannot be varied independently.

68. The display unit used in ARI.23085/1 does not have the additional synchros X5 and X6 (para. 65) but the synchroverter is fitted.

COMPUTOR ASSEMBLIES

Main chassis assembly

69. The main chassis is of two-deck construction and consists of two welded-up, light-alloy cradles which are bolted back-to-back on to distance-pieces to provide a space between decks for inter-unit wiring. Both cradles are also bolted to an alloy backplate and an alloy front panel.

70. The sub-assemblies are secured by captive screws which engage in anchor nuts fitted to the base of each section of the chassis. The lower deck houses the speed and drift gearbox (incorporating the counter reset gearbox) and the resolver gearbox while the three "book" type amplifiers and the power assembly are mounted on the upper deck. Also, on the upper deck, space provision is made for the addition of a wind memory unit. Circuit connections between the plug-in assemblies and the fixed wiring of the chassis are effected by miniature plugs and sockets, the sockets being bolted to the chassis. External connections to the computor are made by means of two 57-pole plugs mounted in receptacles on the backplate. All plugs and sockets are fitted with gold-plated contacts.

Velodyne amplifier

71. The essential function of the velodyne amplifier is to control the speed of the velodyne motor 5MO2 which drives the phonic wheel. Of "book" type construction, the amplifier has three tagboards for component mounting and connection, one being hinged for ease of access and one being used for the flying leads of 2V1, 2V2, 2V3, and 2V4. The complete assembly is connected to the computor wiring by a 9-pole miniature plug and is secured by two shouldered captive fixing screws.

72. A 400 c/s a.c. voltage of amplitude equivalent to 5 millivolts per knot (nominal) is derived from the slider of the potentiometer 6X7 (terminal 3) in the speed servo and is fed via S1–S2 of the tacho-generator 5X1 to the grid of 2V1 after the variable a.c. voltage from the tacho-generator 5X1 (which is in phase opposition) is deducted from it. 2C1 and 2R1 are arranged in parallel with the tacho-generator winding to load it so that its scaling is equal to the output of the potentiometer 6X7.

73. 2V1 and 2V2 are arranged as an amplifier and phase-splitter respectively to form the input to 2V3 and 2V4 which are connected to provide a push-pull output, the anode load being the control winding of the velodyne motor 5MO1 (terminals 2–4). Anode voltage for 2V3 and 2V4 is supplied via the centre tapping of the control winding (terminals 5 and 6). 2C3 provides positive feedback to improve stage gain. The reference winding of the motor 5MO1 (terminals 1–3) is continuously energized by a 115-volt, 400 c/s supply from TR1 in the power assembly.

74. Thus, the speed of the velodyne motor 5MO1 is directly controlled by the output of the high gain (75 dB) circuits of the velodyne amplifier, and a small input voltage drives the motor at the speed required to make the output of the tacho-generator 5X1 closely approximate the slider potential of the speed potentiometer 6X7. The motor 5MO1, the tacho-generator and the phonic wheel all rotate at 5 rev/min per knot under these conditions.

Note . . .

Whilst the velodyne amplifier used in amplifier, synchro signal and also in test set Type M.29 is generally similar to the velodyne amplifier in the computor, it is NOT interchangeable. In the i.d.u. and the test set velodyne amplifiers, the valve heaters are supplied in two pairs from two separate windings whereas, in the computor velodyne amplifier, all valve heaters are supplied from one winding (J5–J17) of 7TR1.

Photocell/speed amplifier

75. The photocell/speed amplifier comprises two separate amplifier circuits which perform different functions. Signals from the photo-electric cell 5V1 of the phonic wheel assembly are amplified by one circuit; and the input to the speed servo motor is amplified by the other.

76. The components of the assembly are mounted on a "book" type sub-chassis by means of three tagboards, the largest of which is hinged to facilitate access. The pentodes 3V1, 3V2, 3V3, 3V4 are of identical type and are connected by flying leads to one of the fixed tagboards.

Photocell circuit

77. The interrupted d.c. output of the photo-electric cell 5V1 is fed into the amplifier via 3C1 and 3TR1, and the resulting a.c. signal is applied to the grid of 3V1 for further amplification. The resulting signal is fed to a cathode-follower 3V2, and is then passed to the tracking unit for comparison with the Doppler frequency. The resistance network 3R1, 3R2, 3R3 is arranged to provide a bias of 4·7 volts on the photo-electric cell. Because of the very low level signal input, the decoupling capacitor 7C6 (fitted in the power asrembly) is included to cut down 400 c/s ripple and improve the signal-to-noise ratio.

Speed circuit

78. The function of the speed amplifier circuit is to energize and control the speed servo motor 6MO2. An a.c. voltage, within the range 400 millivolts to 4·7V, proportional to the speed of the aircraft, is fed from the commutator potentiometer 7X3 in the tracking unit to one side of the primary winding of the transformer 3TR2, and an a.c. feedback voltage from the speed servo potentiometer 6X7 is fed to the other side. The potentiometer 6X7 has a supply of 4·75 volts, 400 c/s, obtained from 7TR2 in the power assembly, and its slider is driven by the motor 6MO2 via a gear train to provide a servo voltage. The motor 6MO2 reference winding (terminals 1–3) is continuously energized by a 115-volt a.c. supply from the power assembly. Rectifier 7MR2 in the power assembly introduces a certain amount of viscous damping to obviate instability.

79. As the tracking unit integrator motor 7MO1 turns, the tracking unit commutator potentiometer 7X3 output varies, and a potential is developed across the primary of 3TR2. This signal is stepped up by 3TR2 and is fed to the push-pull valves 3V3 and 3V4 for further amplification to energize the speed motor 6MO2. When the motor rotates, it drives the slider of the speed potentiometer 6X7 until it is at the same potential as the tracking unit speed output. Under this condition, there is no potential across 3TR2 primary and the motor stops; only when a voltage is applied to the amplifier input grid does the motor run.

80. Circuit connections are such that the error signal across 3TR2 is phase-dependent on the relative positions of both speed potentiometer and commutator potentiometer sliders in order to obtain correct direction of motor rotation.

Resolver amplifier

81. · The function of the resolver amplifier is to energize and control the resolver motor 5MO2 to produce a shaft angle proportional to any angle of error which exists.

82. Construction of the amplifier is generally similar to the velodyne amplifier. Components are mounted and connected by means of three fixed tagboards. The four identical pentodes (4V1, 4V2, 4V3, and 4V4) are clip-mounted and one tagboard is used for connection of the flying leads. The assembly is connected to the computor fixed wiring loom by a 7-pole miniature plug and is secured by two shouldered captive fixing screws.

83. A 3-wire synchro output of 1° rotation per 1_o of error angle (θ_E) is fed from a differential transmitter in the display unit to the control transformer 5X4 in the resolver gearbox. This produces a variable a.c. voltage output (terminal R1) which is connected via the amplifier terminal B4 and 4R1 to the grid of 4V1.

84. 4V1 and 4V2 are arranged as an amplifier and phase splitter to feed a suitable input into 4V3 and 4V4 which are connected to provide a push-pull output. The anode load is the control winding of the motor 5MO2 (terminals 2–4). Anode voltage for 4V3 and 4V4 is supplied through the centre tapping of the control winding (terminals 5 and 6). The reference winding of 5MO2 is continuously energized by a 26-volt, 400 c/s supply from the aircraft's auto pilot supply phase via 7MR1 and 7R1 in the power assembly. The rectifier 7MR1 is provided for damping purposes and is accommodated in the power assembly for convenience.

85. The motor 5MO2 is fitted with a 300 : 1 gearhead and drives the control transformer 5X4 through a further 15 : 1 reduction gear, thus completing the servo-loop which controls the motor to a position directly proportional to the angle of error.

Resolver gearbox

86. The resolver gearbox assembly consists of a mechanical resolver with two input and two output drive shafts, together with its two separate drive systems and its two output torque transmitters.

87. A machined, die-cast gearcase of light alloy forms the body of the assembly. To this, a machined light-alloy gearplate is fitted and secured by five cheese-headed screws to form a closed gearbox. All the geartrains are housed in the box with the exception of the 300 : 1 gearhead fitted to 5MO2. Integral with the body are two side-plates, one of which forms the mounting base and is fitted with three anchor nuts for attachment to the computor chassis. A 37-pole miniature plug for inter-connection is recess-mounted in the plate and is secured by two screws and stiffnuts.

88. On the gearcase, the resolver, the tacho-generator 5X1 and the resistor 5R1 are mounted. The resolver and the tacho-generator are each secured by three standard clamps which engage in mounting recesses on the components and are screwed to the gearcase.

Note . . .

The tacho-generator 5×1 *and the resistor* 5*R*1 *are supplied as a pair matched for temperature compensation. Neither should be replaced independently.*

89. The remaining components are mounted on the gearplate, the synchros being each secured by two clamps and motor 5MO2 by three clamps. Two brackets are fitted for mounting 5C1, 5R2, and 5C2, 5R3, and are screwed to the gearplate. A blanking plate, secured by clamps, is fitted over the drive aperture provided for control transmitter 5X5. The motor 5MO1 is mounted on the gearplate opposite the tacho-generator 5X1 to which it is directly connected through a dog clutch coupling. The tacho-generator shaft also carries the phonic wheel and the driving gearwheel for the cam-operated total distance switch 5SWA.

90. A spring-loaded split gear is utilized in the gear drive between the control transmitter 5X4 and the mechanical resolver to obviate backlash in the error angle drive. This is arranged so that the torque required to compress the spring loading is slightly greater than the torque necessary to rotate the resolver drive.

91. A hinged door of synthetic resin-bonded fibre is fitted to the gearcase over the phonic wheel. The photo-electric cell 5V1 is mounted in a clip, which forms the negative connection, in a recess in the outside of the door; the positive connection is soldered to a tag also provided in the recess.

Note . . .
This lead must not be shortened as damage to the photocell may occur during soldering.

92. The light source 5LP1 is fitted in an alloy-block holder mounted behind and secured to the phonic wheel door. The lamp is energized from the 6·3V heater supply and has the resistance 5R2 wired in series. A filter screen designed to improve waveform is also screwed to the inside of the door. With the door closed, the components are correctly aligned with the phonic wheel which rotates between the light source and the photo-electric cell. As the phonic wheel has 140 translucent and 140 opaque radial sections arranged alternately near the periphery, the light input to the cell is interrupted at a frequency which varies with the speed of rotation. The output from the cell is then amplified by the photocell amplifier to form the phonic wheel tone.

93. Provision is made for adjusting the pea lamp position to peak up the cell output. The lamp holder is secured by two small screws to the phonic wheel door and the screw holes in the door are slotted to allow movement of the lamp holder to the optimum position. The phonic wheel door is secured in the closed position by a countersunk screw. A small window is provided in the door for visual checking of the light source when the unit is on the workbench.

Functions of the resolver gearbox

94. The functions of the gearbox are as follows:—

(1) To convert the error angle 3-wire synchro input to a shaft angle.

(2) To convert the speed signal voltage to a shaft rotation in which shaft velocity is proportional to aircraft groundspeed and the total angular position is proportional to distance travelled.

(3) To apply the two above shaft angles to the mechanical resolver to produce shaft angle outputs representing distances along and across track.

(4) To convert the above shaft angles to 3-wire synchro outputs suitable for transmission to external units for indication purposes.

(5) To drive the phonic wheel to produce a signal at a frequency directly related to the velocity of the shaft rotation (2), above, for feeding back to the tracking unit for comparison with the Doppler frequency.

(6) To drive the cam-operated switch 5SWA by the shaft rotation, (2) above, via a 30 : 1 reduction gear, for operation of the total distance flown counter.

Speed and drift gearbox

95. The three motors and the synchros, which form the main components of the speed and drift gearbox, are clamp-mounted on a machined light-alloy gearcase. A machined light-alloy gearplate is fitted to the gearcase and is secured by four screws, thus forming a gearbox which contains all the gearing except for the gearheads fitted to the motors 6MO1 and 6MO2. To close the gearbox, an alloy dust coverplate is then fitted over the gearplate, which is webbed and is secured by six small screws. A webbed mounting plate is fitted parallel to the gearcase by means of four distance pieces screwed to the gearcase. The mounting plate is then secured to the distance pieces by four cheese-headed screws. The 37-pole and 25-pole miniature interconnection plugs are each secured to the mounting plate by two screws and stiffnuts. Four shouldered fixing screws for securing the assembly to the computor chassis are held captive between flanges on the gearcase and the mounting plate.

96. Since the speed and drift drives are both position servos, travel is limited in each drive in each direction by stop pins fitted in the gearing. A spring-loaded slipping clutch is, therefore, incorporated in each drive to permit overrun of the motors without damage to the gears resulting. In the drift drive, the motor gearwheel contains the clutch; whilst, in the speed drive, the clutch is fitted in the second intermediate gearwheel from the motor.

97. Space provision is made for the three additional synchros, 6X4, 6X6 and 6X9, the apertures in the gearcase being fitted with alloy blanking plates secured by mounting clamps.

98. 6RV2, the output adjustment for the potentiometer 6X7, and 6R2 are mounted on a bracket screwed to the gearcase. The diode 6MR1 and the resistor 6R3, which provide a d.c. current for damping the counter reset motor 6MO3, are mounted, together with 6C1, on a bracket screwed to the gearcase.

Functions of the speed and drift gearbox

99. The speed and drift gearbox comprises the following three separate systems: the electro-mechanical components of the speed servo system, the drift integrator system, and, also, the counter reset gearbox which is incorporated for convenience in the computor instead of the display unit.

(1) The speed servo. The operation of the speed servo is dependent on the speed amplifier section of assembly No. 3 which completes the servo loop. The functions of the servo are to supply an a.c. voltage (a position feedback) proportional to the speed of the aircraft to operate and control the velodyne amplifier associated with the resolver gearbox; and also to supply a 3-wire synchro output to operate the groundspeed section of the speed and drift indicator.

(2) The drift integrator. The drift angle information from the tracking unit consists of the outputs of two identical push-pull amplifiers whose inputs are in quadrature, one leading or lagging according to the direction of drift error. These outputs drive and control the drift integrator motor 6MO1, each output being connected to one winding of the motor. The direction of rotation of the motor is dependent upon the phase relationship of the voltages applied to the windings, i.e. the direction of drift error. The functions of the drift integrator are as follows:—

(*a*) To convert the drift angle information to a 3-wire synchro output of 5° of rotation per 1° of drift angle for indication purposes.

(*b*) To add the drift angle signal to a heading reference signal from the aircraft's gyro-compass system to produce a 3-wire synchro output of 1° of rotation per 1° of track angle.

(*c*) To provide a 3-wire synchro output as an error feedback to control the aerial unit drift servo system to correct any angle between the aerial axis and the line of the aircraft's track.

(3) Counter reset gearbox. The counter reset gearbox is accommodated in the speed and drift gearbox for space considerations. The gearbox comprises the reset motor 6MO3 and the torque transmitter 6X8 which it drives through 4 : 1 reduction gears to provide a synchro output for resetting the along track and across track distance counter systems in the display unit. Control of the system is by switches on the display unit.

100. Control of the reset motor drive supply and the output for resetting either of the along track distance counters is by the ALONG switch. The reset output is automatically switched to the leg counter not in use by the Ledex changeover switch during resetting under RUN conditions.

101. Control of the across track distance counter is by the ACROSS switch. With the switch in the central position, the across track distance output from the torque transmitter 5X2 in the resolver gearbox is connected to the torque receiver X7 in the display unit. When the switch is operated to L or R, the across track distance signal is disconnected and the reset output is connected by one wafer, and the motor drive supply is connected by another wafer.

Note . . .

The ALONG *distance and* ACROSS *distance reset controls should never be operated simultaneously.*

Power assembly

102. The power assembly provides all except one of the necessary a.c. and d.c. supplies for all the sub-assemblies of the computor and for the display unit. The exception is the 26-volt, 400 c/s reference supply to the resolver motor 5MO2; this supply is obtained from the autopilot phase of the aircraft's 26-volt, 400 c/s supply system.

103. All major components are mounted directly, and minor components indirectly by means of tag-boards, on a tray-type chassis of pressed and welded aluminium-alloy sheet. Three hexagonal mounting pillars containing captive fixing screws are provided for securing the assembly to the computor chassis. The transformer 7TR1, the power transformer, is mounted through the base-plate of the chassis. The single-phase, 400 c/s supply from the aircraft's a.c. system may be either 115 volts or 200 volts, the voltage adjustment being made at the soldered terminal pins of 7TR1 primary, 4–7 and 4–8 respectively.

104. Five secondary windings provide the following outputs:—

(1) Terminal pins 2–3. A 6·3 volt output for valve heaters.

(2) Terminal pins 5–1–6. An h.t. supply for amplifier anodes, rectified by 7MR5 and 7MR6 and smoothed by 7L1, 7C1, and 7C2 to produce 145 volts d.c. (nominal) at J4.

(3) Terminal pins 10–11. 40 volts a.c. Through the series resistor 7R3 this is dropped to a 24-volt output at J15 for energizing the primary of the tacho-generator 5X1. The network 7L2, 7L3, 7L4 and 7C3, 7C4, 7C5 constitutes a 400 c/s filter. Through the transformer 7TR2 an output of 4·75 volts is provided at J14 for the speed potentiometer 6X7 in the speed and drift gearbox.

(4) Terminal pins 13–15–14. A 28-volt output, rectified by 7MR3 and 7MR4 to produce a 28-volt d.c. output at J16 for operation of the total distance flown indicator through the cam-operated switch 5SWA. This supply is used to energize the Ledex switch SWA in the display unit.

(5) Terminals 12–16. A 26-volt a.c. output for synchro operation.

105. The following components of external circuits are accommodated in the power assembly for space considerations.

(1) Capacitors 7C7 and 7C8, wired to terminals J9, J10 and J11, are provided for "fast-slow" control of the counter reset system. The common end of the two capacitors is connected, via J9 and D24, in series with one winding (terminal 2) of the reset motor 6MO3 in the speed and drift gearbox. The appropriate capacitor is selected by the "fast-slow" switching on the display unit, *i.e.* 7C8 provides a smaller phase shift than 7C7

and, hence, a lower voltage and a consequently lower motor speed.

(2) The rectifier 7MR2 and resistor 7R2, connected to J13–J24, provide a d.c. damping current for 6MO2, in the speed and drift gearbox, from the 115-volt a.c. input.

(3) The rectifier 7MR1 and resistor 7R1, connected to J12 and J23 provide a d.c. damping current for 5MO2 in the resolver gearbox. The requisite a.c. supply is taken from the aircraft's 26-volt a.c. autopilot phase.

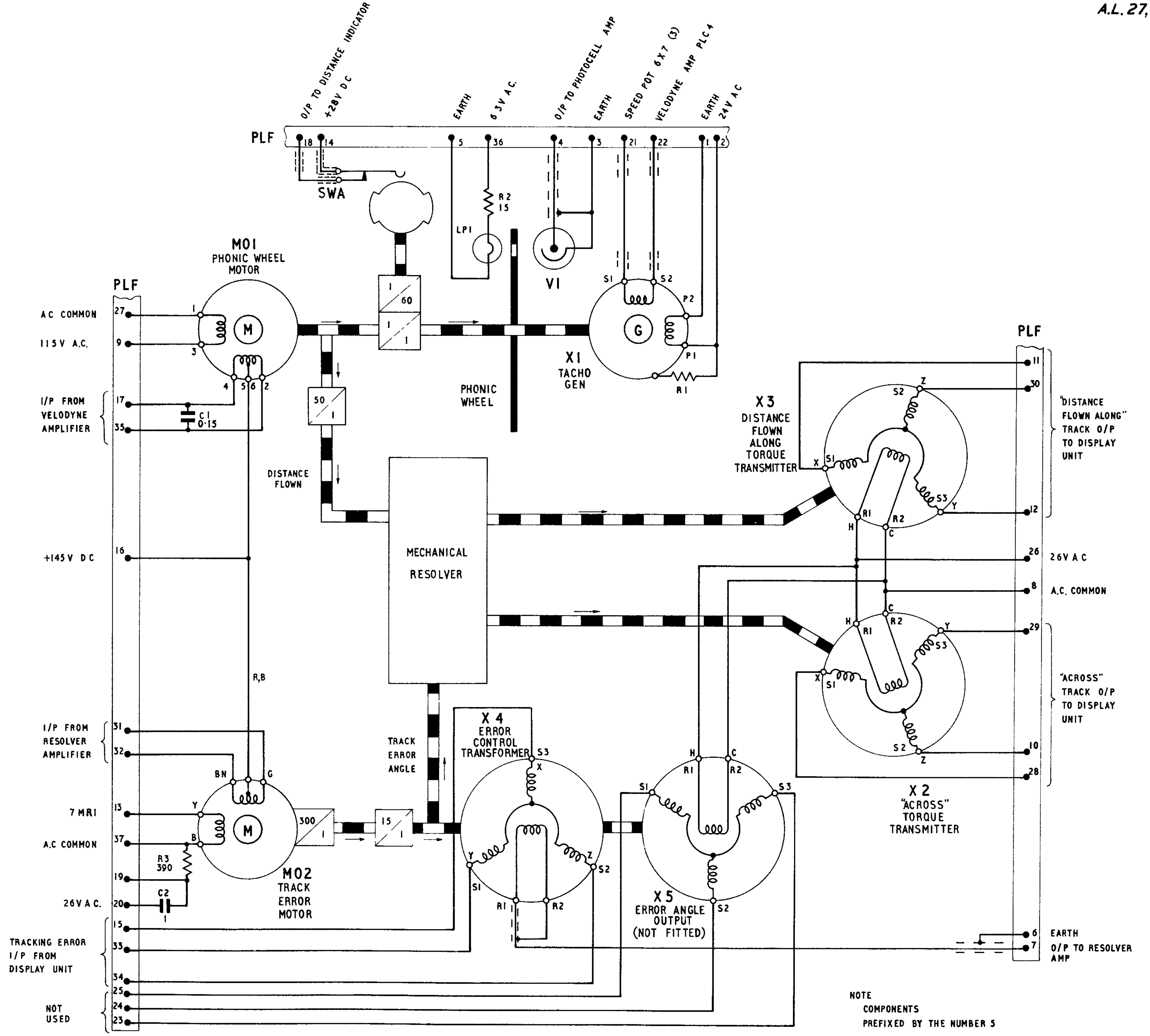
(4) The capacitor 7C6, wired between J21 and earth, is connected via A9 to 3R1, 3R2 in the photocell amplifier for decoupling purposes.

Supply fuses

106. The two fuses, mounted on the front panel of the computor, are connected to the power assembly as follows:—

(1) FS1, 2·5 amps. In series with 115-volt, 400 c/s supply to 7TR1. Connected between PLG54 and J22 on power assembly.

(2) FS2, 4 amps. In series with 26-volt output from 7TR1 to synchros. Connected between PLG52 and J18 on power assembly.



Gear assembly (10AR/5696): circuit

Fig.18

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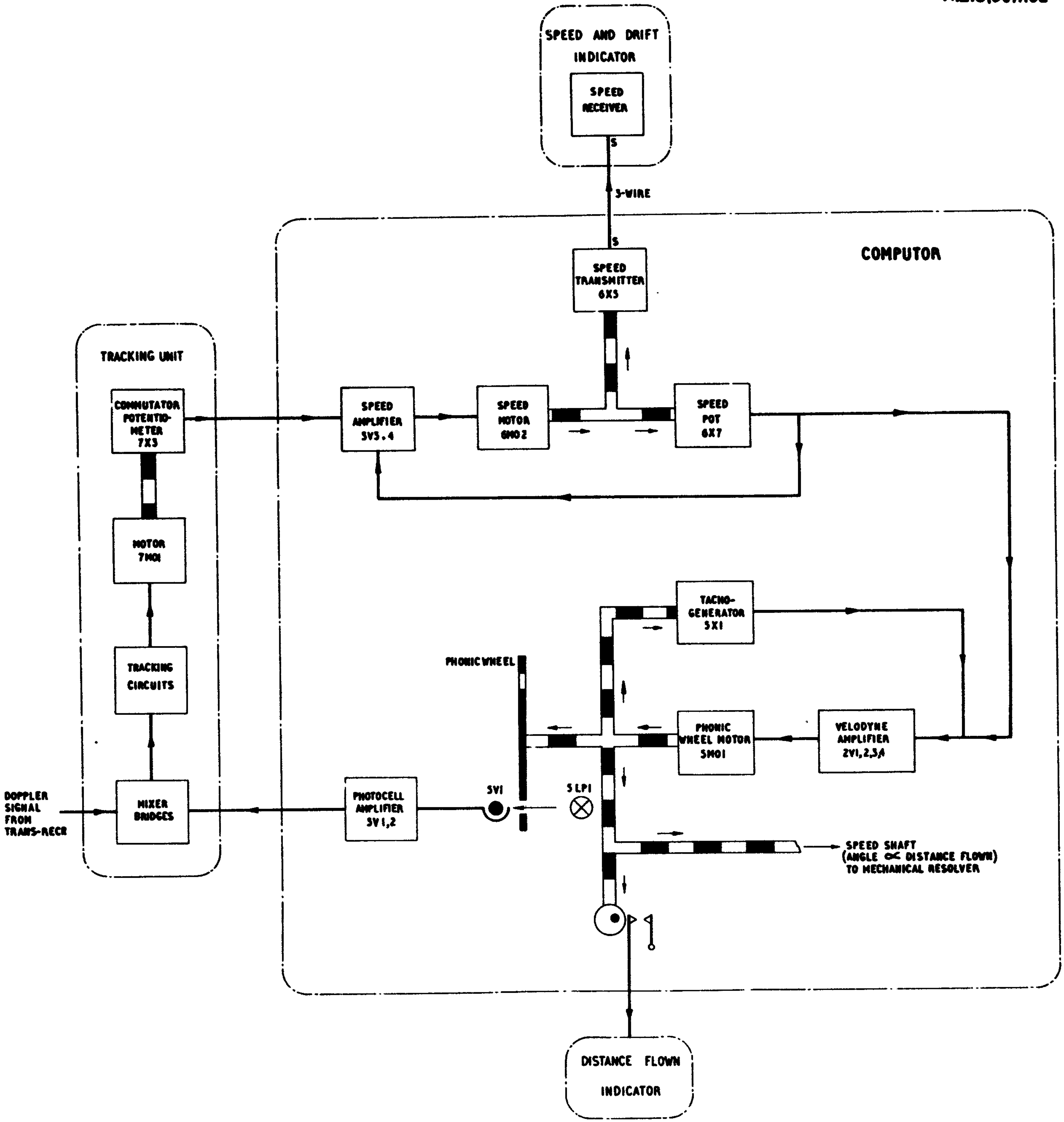

Fig. 8 Speed servo : block diagram Fig. 8

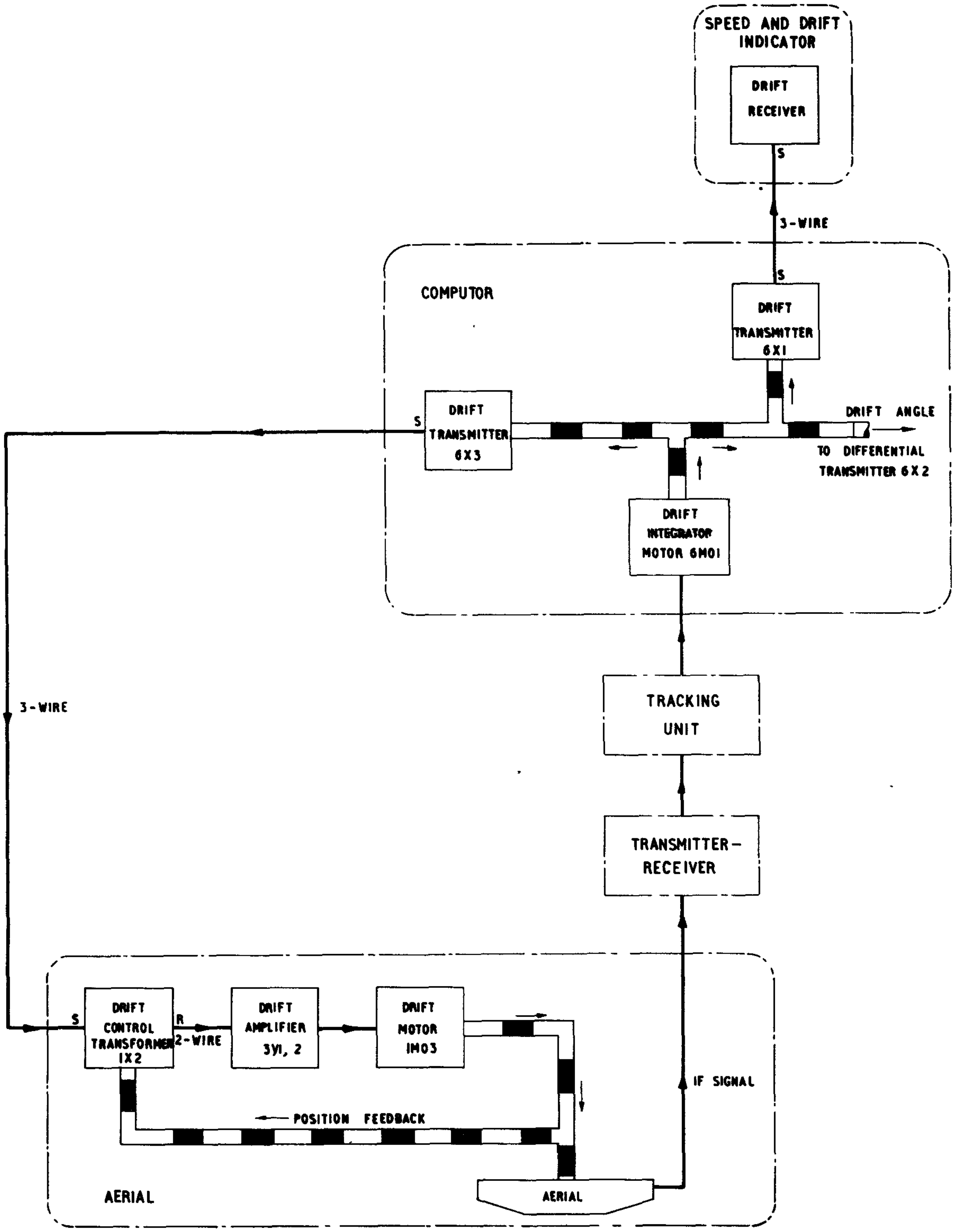

Fig. 9 Drift servo: block diagram Fig. 9

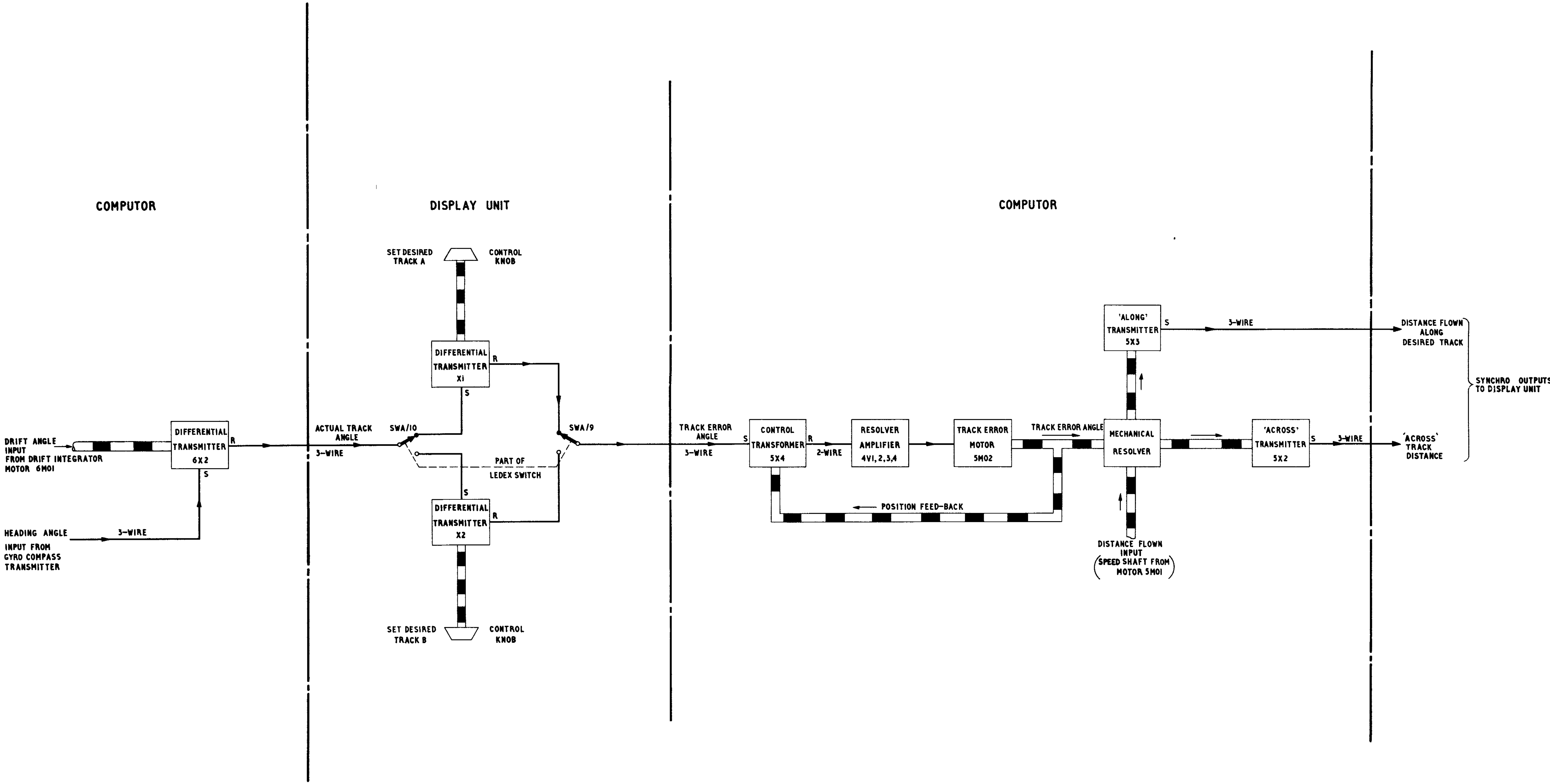

Fig. 10 Computing sequence : block diagram Fig.10

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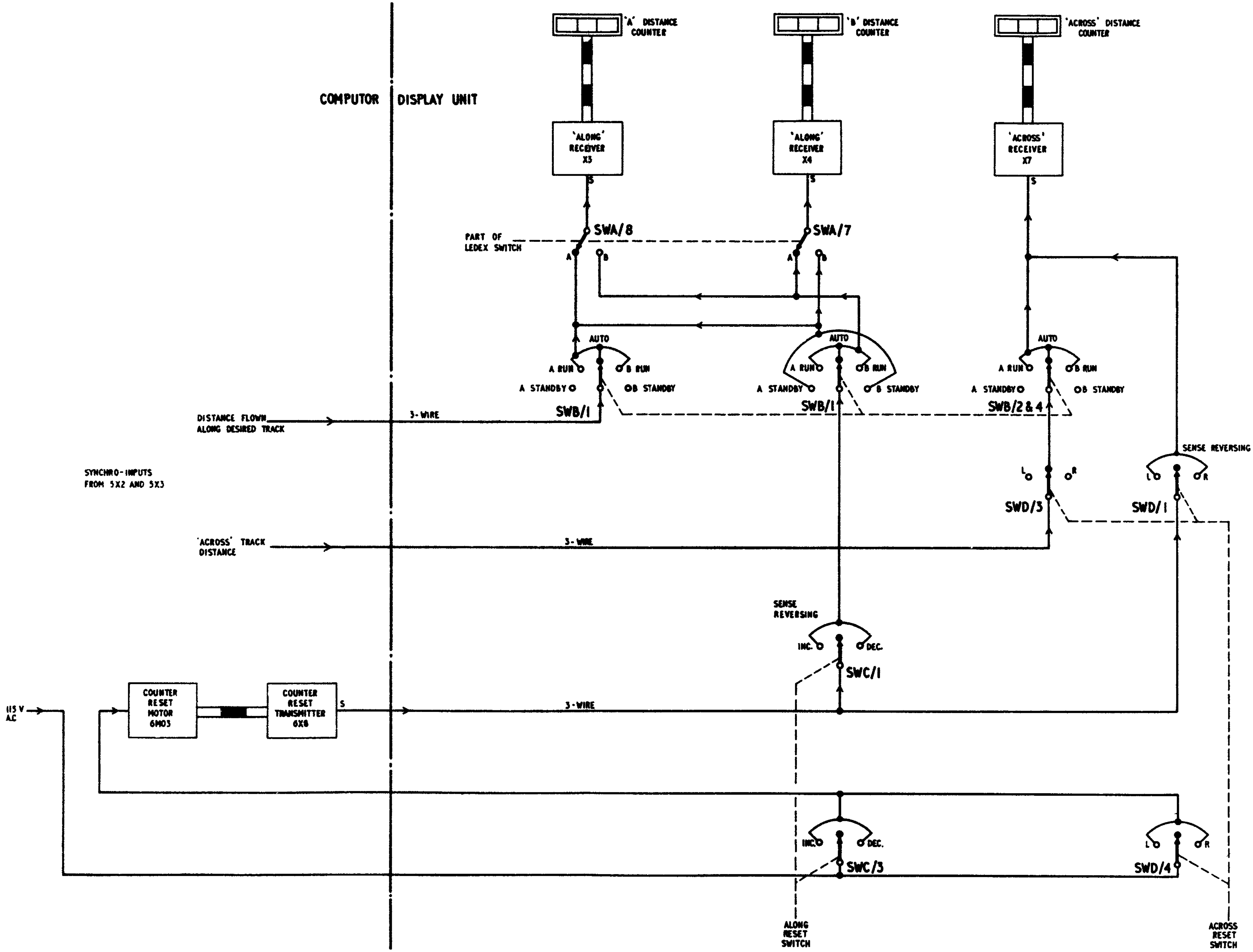


Fig. 11 Counter drive & resetting: block diagram Fig. 11

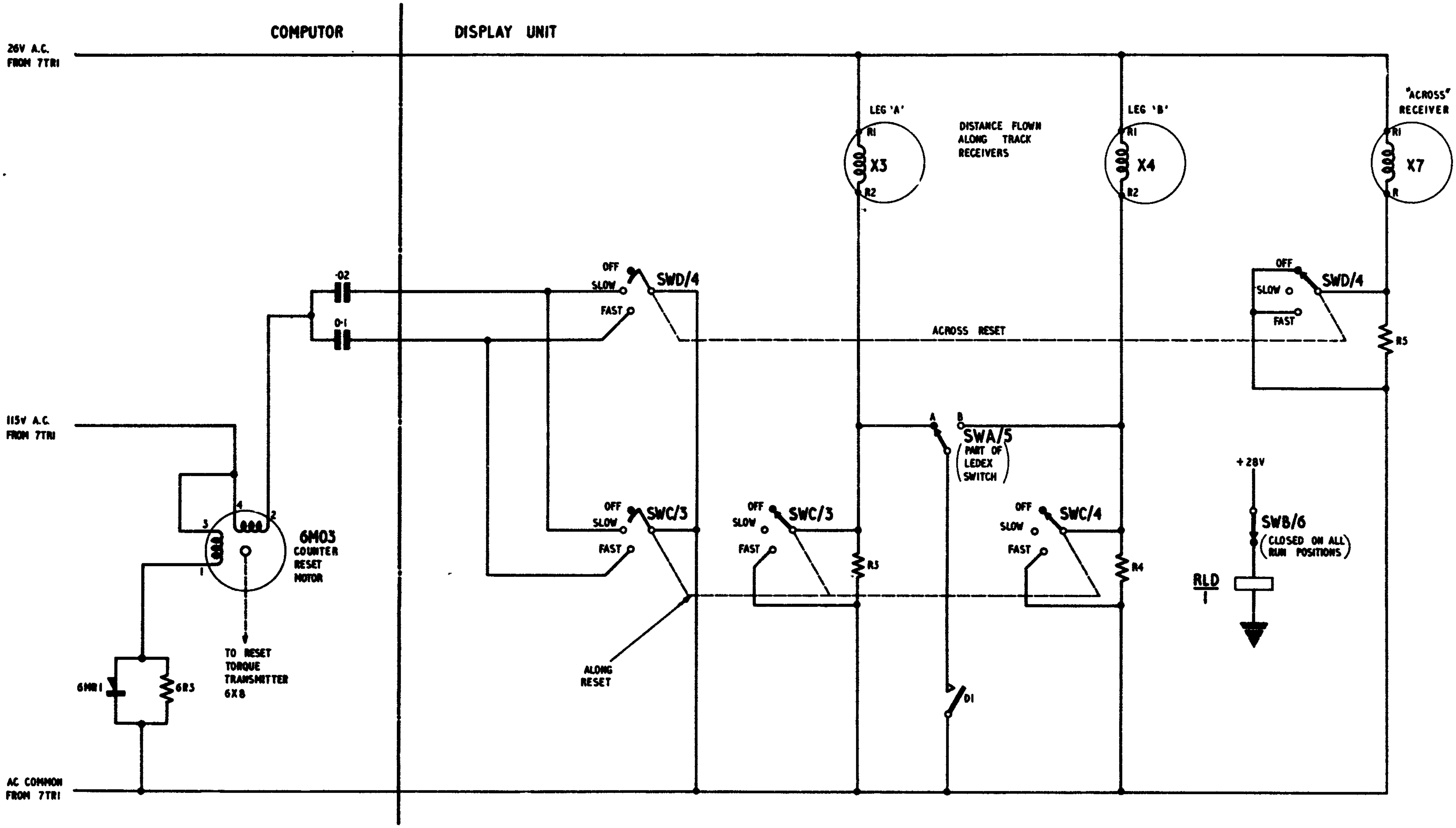


Fig. 12 Counter reset motor control circuit Fig. 12

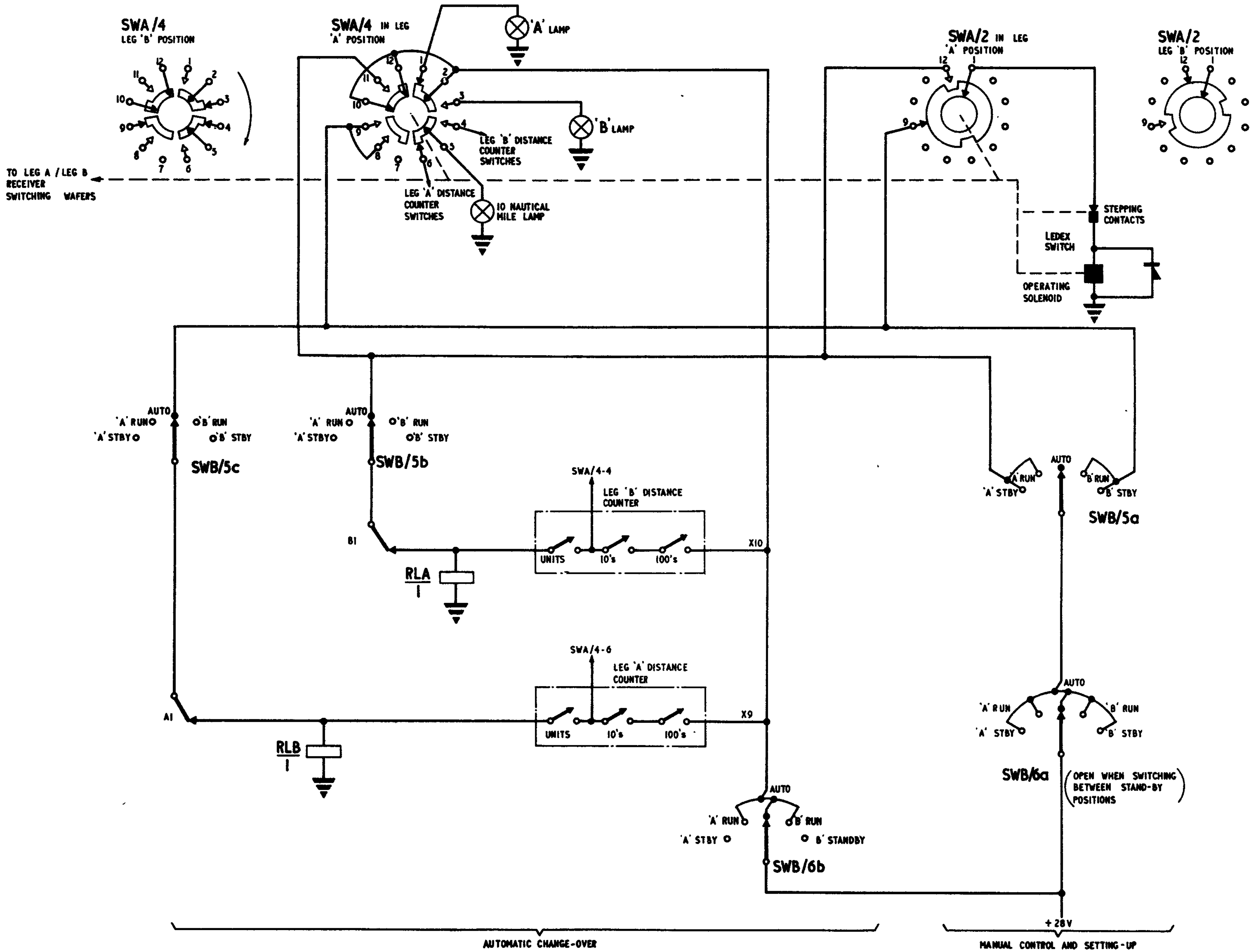
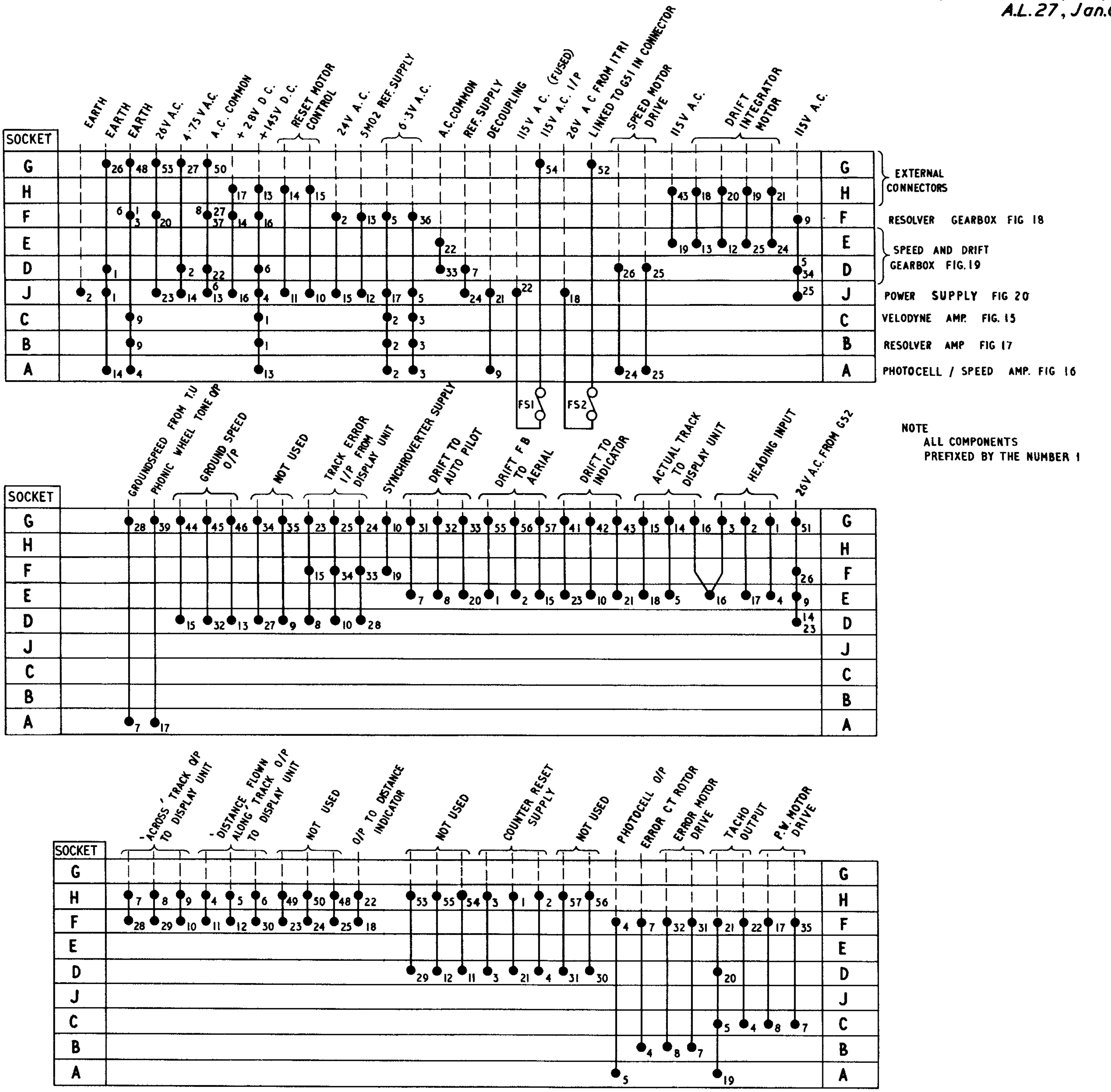


Fig. 13 Ledex switch control: circuit Fig. 13



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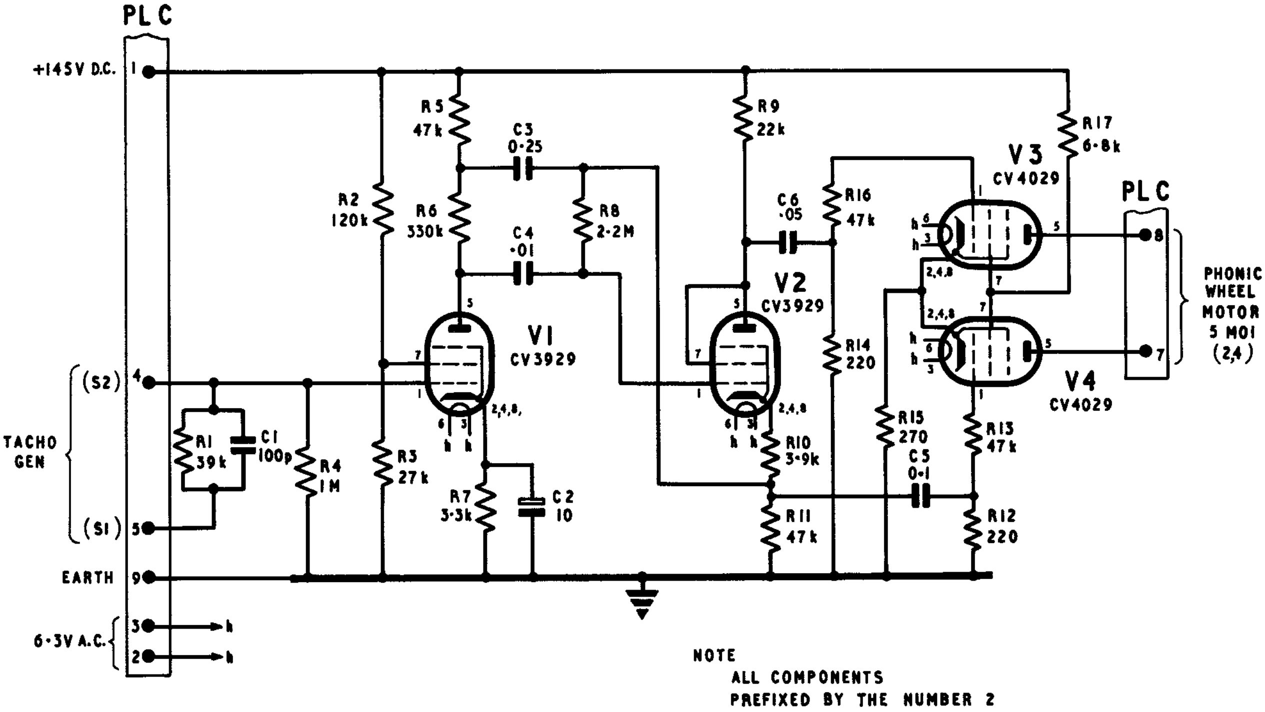
Chassis, electrical equipment Type M23: circuit Fig.14



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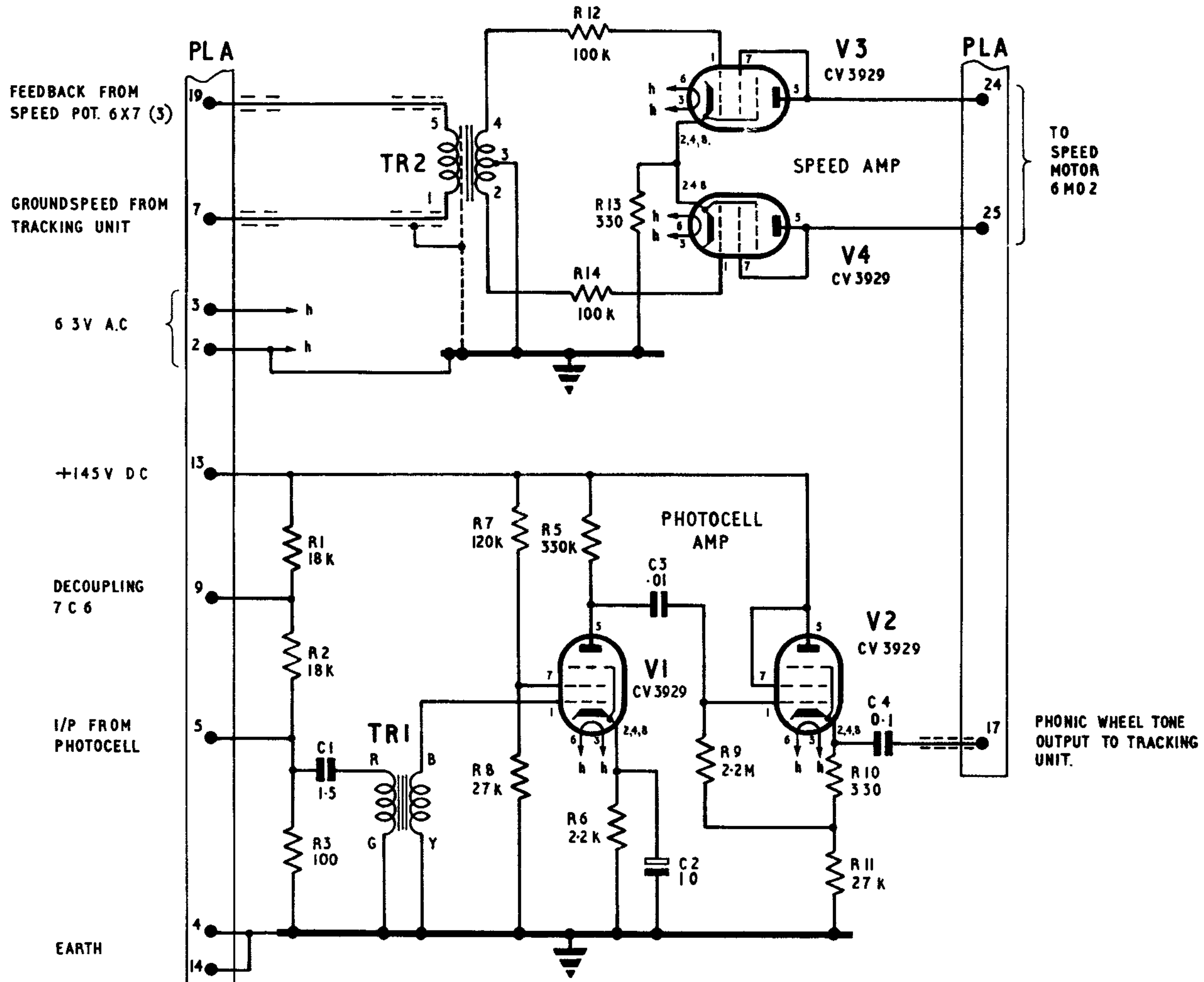
Amplifier, velodyne Type M152: circuit Fig.15



NOTE
ALL COMPONENTS
PREFIXED BY THE NUMBER 3

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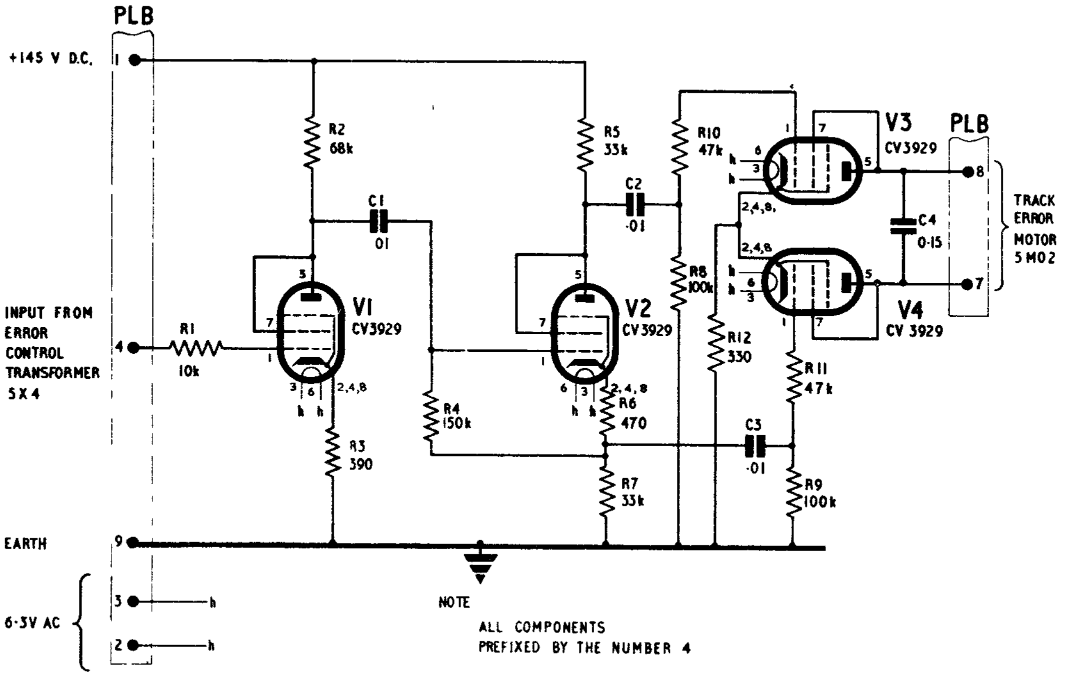
Amplifier photo electric cell
Type M150: circuit

Fig.16



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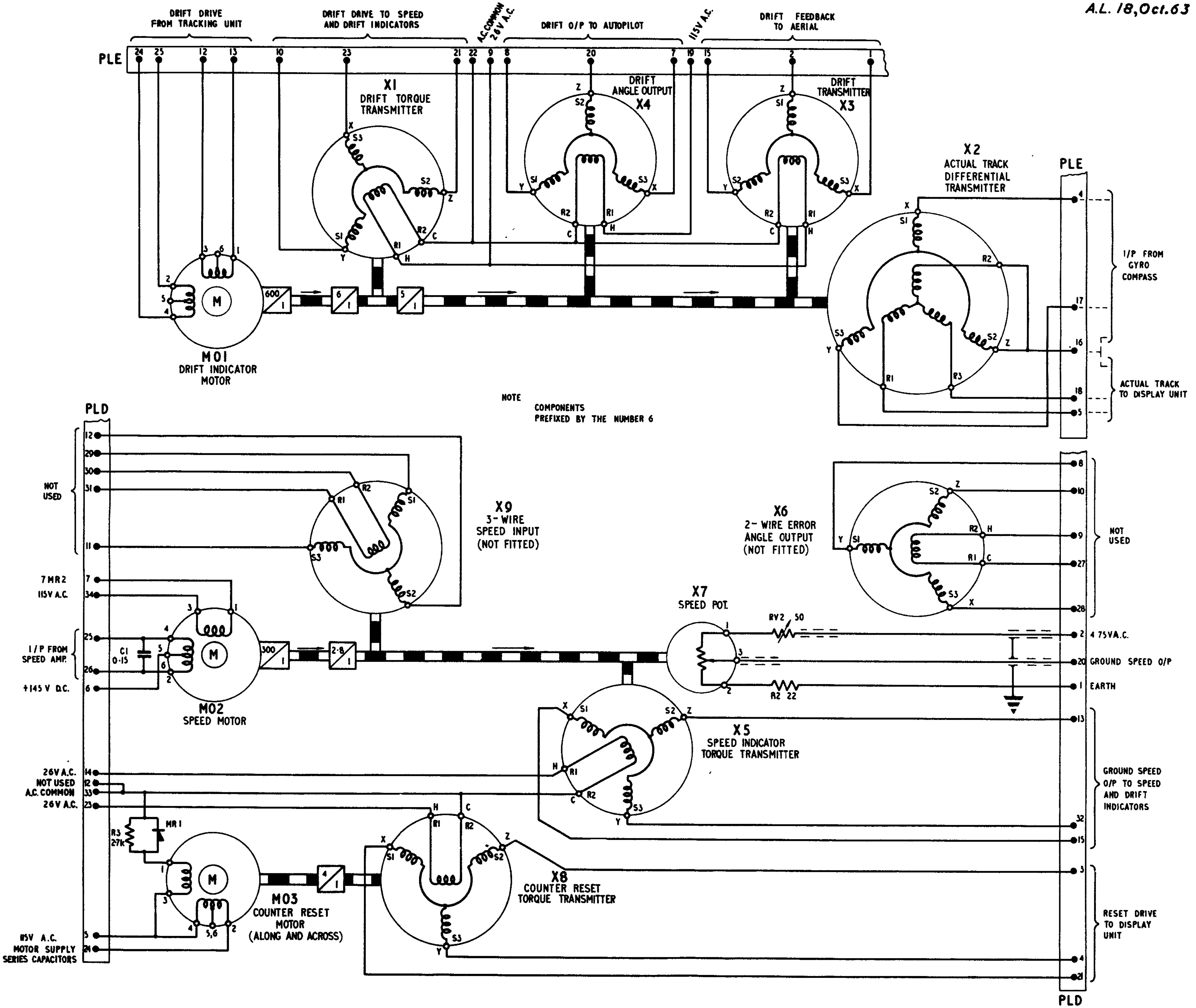
Amplifier, resolver Type.M151: circuit

Fig. 17



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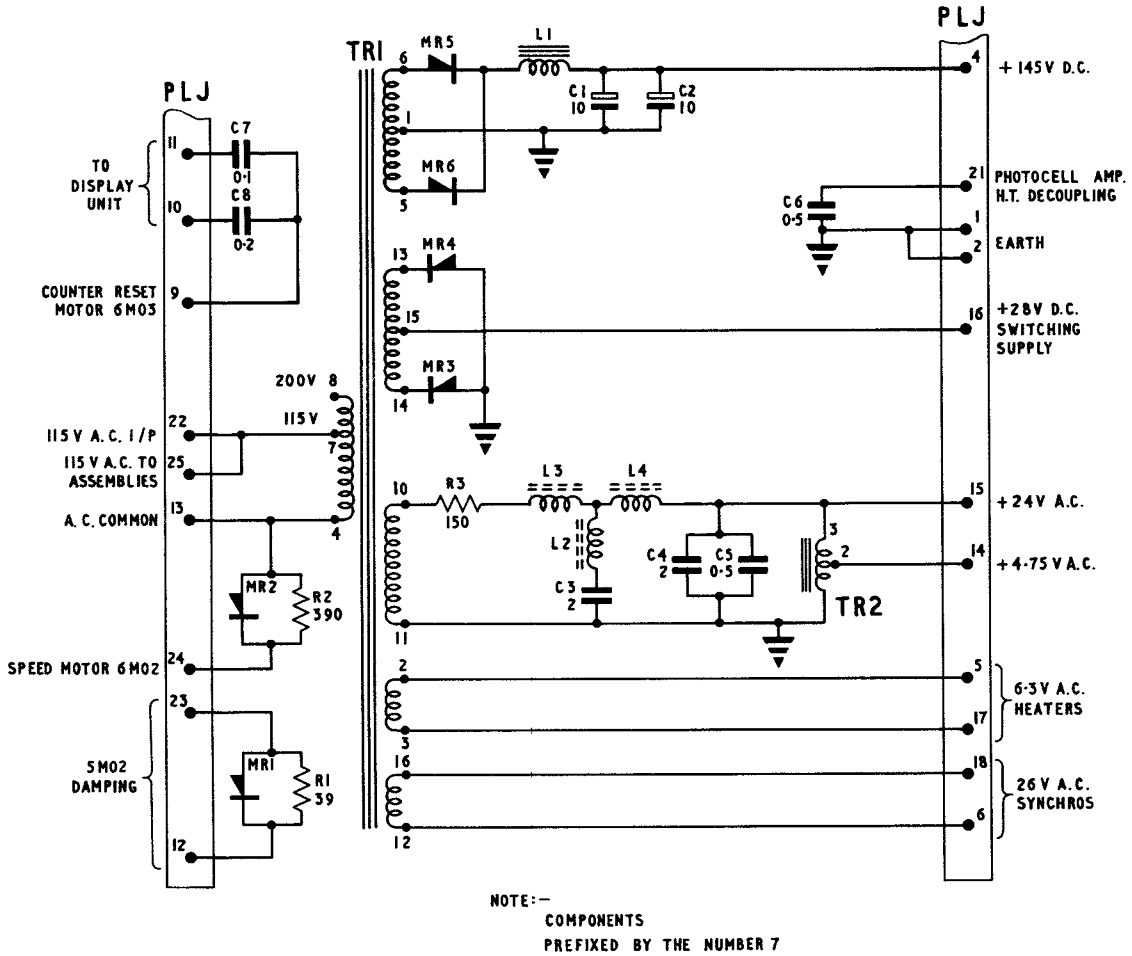
Gear assembly (10AR/5697): circuit

Fig. 19



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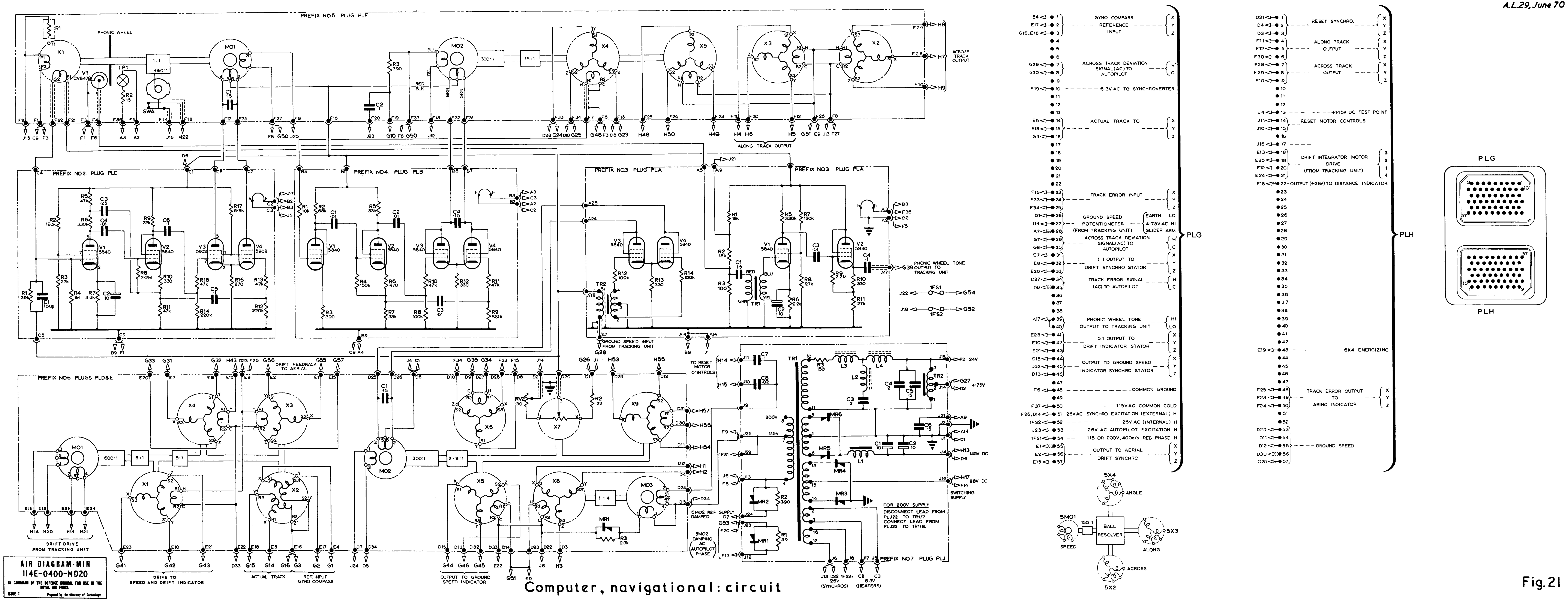
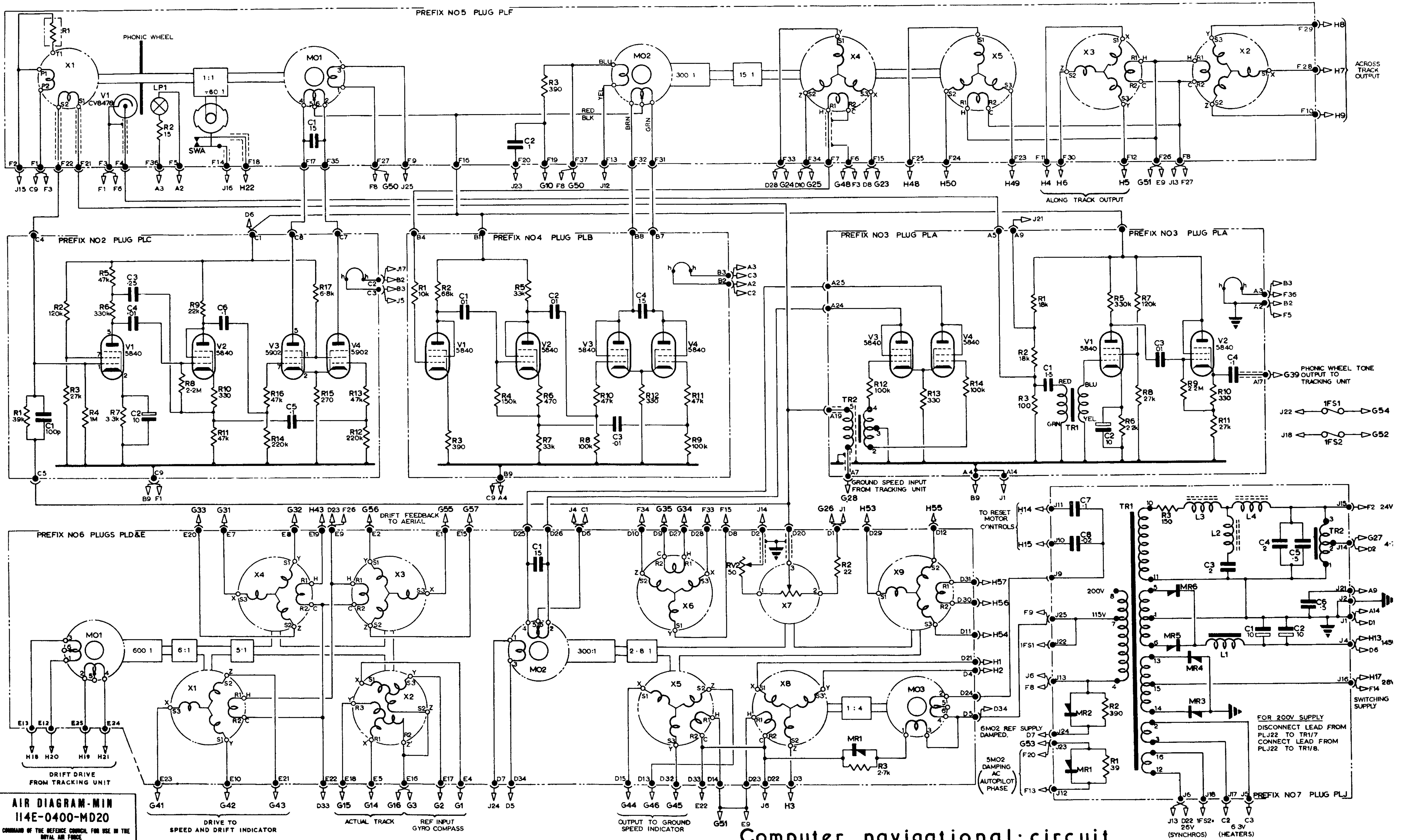
Power supply Type M74: circuit Fig. 20



Computer, navigational: circuit

Fig. 21



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Computer, navigational: circuit

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Indicator assembly Type M14 : circuit

Fig. 22

Chapter 6

AMPLIFIER, SYNCHRO SIGNAL

(Indicator drive unit)

(Completely revised)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Power supply	115*V or* 200*V* ±5%, 400 *c/s* ±5% 3-*phase a.c.*
Power consumption	100*VA at* 115*V a.c.*
Maximum temperature range	—40°*C to* +70°*C*
Operating temperature range	—40°*C to* +55°*C*
Altitude ceiling	60 000 *feet*
Weight	22 *lb* (10·0 *kg*)
Overall dimensions	*Height* 7 25/32 *in.* (19·7 *cm*) *Width* 3 11/16 *in.* (9·4 *cm*) *Depth* 21 15/64 *in.* (54 *cm*)
Case size	*Long* 3/8 *ATR*
Type of mounting	*ARINC type shock-mounted tray*
Air cooling required	0·22 *lb/min at* 10°*C when ambient temperature exceeds* 60°*C*
Compass safe distance	2 *feet*

Outputs (in duplicate)

Drift angle

Form: 3-*wire synchro stator,* 11·8*V leg to leg,* 400 *c/s*

Scale: 1° drift per 5° synchro rotation
Positive rotation reference
Zero index at zero drift

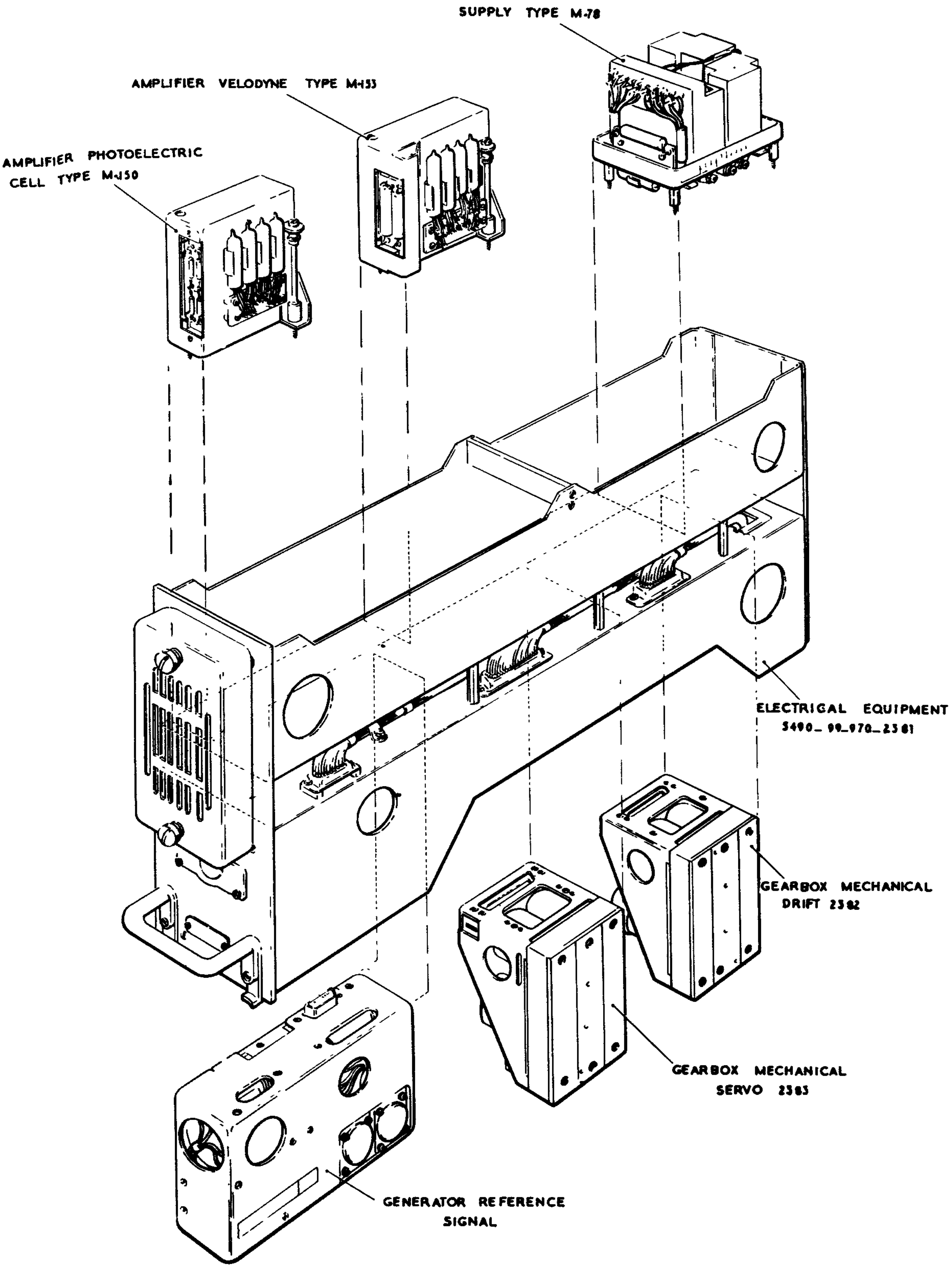


Fig. 1. General view of amplifier, synchro signal assemblies

Drift error signal

Form: 3-*wire synchro stator*, 11·8*V leg to leg*, 400 *c/s*

Scale: 1° *drift per* 1° *synchro rotation*

Positive rotation reference

Zero index at zero drift

Ground speed

Form: 3-*wire synchro stator*, 11·8*V leg to leg*, 400 *c/s*

Scale: 100 *knots per* 36° *synchro rotation*

Positive rotation reference

Zero index at zero knots

Maximum load: Two torque receivers

Distance travelled

Form: Single wire earth return, 30*V* ±2*V d.c.*

Scale: 1 *pulse per* 0·1 *nautical mile*

Maximum load: Two indicators

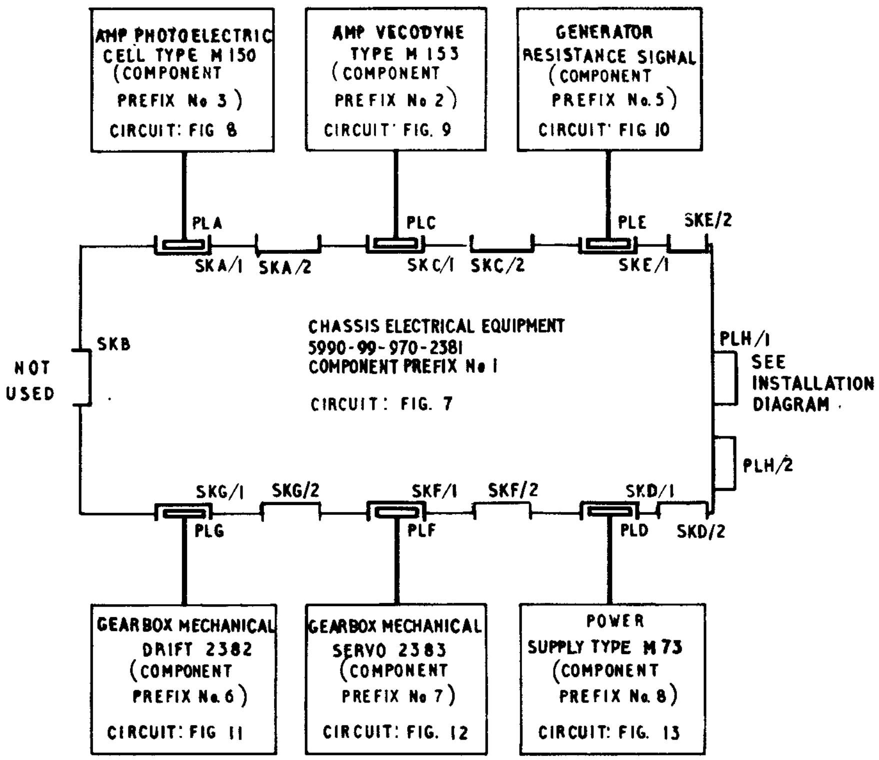


Fig. 2. Schematic arrangement of assemblies

Introduction

1. The principal function of amplifier, synchro signal (indicator drive unit) is to convert the ground speed and drift information derived from the Doppler signal by the tracking unit into forms suitable for driving the pointer-type displays in the speed and drift indicator and the counting mechanism in the distance indicator. It also provides an error signal for the drift servo loop and the phonic wheel tone for the speed servo loop. Provision is made for optional facilities but these are not used in ARI.23085/3.

Constructional details (fig. 1)

2. The unit is housed in an unpressurized long $\frac{3}{8}$ ATR case and is designed for operation with ARINC cooling systems or for cooling by convection. For the first method, an air vent for the ARINC suction coupling is provided on the underside of the case and an air intake, with a nylon-mesh air filter and filter cover, is fitted on the front panel. For convection cooling, an alternative case with suitably placed ventilation holes is provided.

3. The unit consists of a two-deck main chassis assembly (component prefix 1) upon which are mounted the following plug-in sub-units:—

Amplifier, velodyne Type M.153	(component prefix 2)
Amplifier, photoelectric cell Type M.150	(component prefix 3)
Generator, reference signal	(component prefix 5)
Gearbox, mechanical, drift 2382	(component prefix 6)
Gearbox, mechanical, servo 2383	(component prefix 7)
Power supply Type M.73	(component prefix 8)

4. The main chassis is designed to accommodate two complete sets of assemblies so that only one indicator drive unit is required for the dual sensor installation.

5. The unit may be operated with an input power supply of 115 or 200V, 400 c/s, 3-phase a.c., provided that the connections on the power unit are correctly adjusted.

Brief circuit description

General

6. The following brief description should be read in conjunction with the block diagram of the unit (fig. 3) and the block diagrams of the drift and speed servos (fig. 4 and 5).

7. The inputs to the unit are:—

(1) Drift drive. An a.c. signal varying in phase and magnitude with the degree of misalignment of the aerial in the drift plane, derived from the power amplifier in the tracking unit.

(2) Speed drive. An a.c. voltage, which varies in magnitude with the aircraft's ground speed, derived from the potentiometer section of the commutator potentiometer 7X3 in the tracking unit.

8. From these inputs the indicator drive unit produces the following outputs:—

(1) Drift angle. A 3-wire synchro output used to drive the drift display pointer.

(2) Ground speed. A 3-wire synchro output used to drive the ground speed display pointer. These two displays are contained in the speed and drift indicator.

(3) Distance travelled. A pulsed 30 $\pm$2V d.c. output used to drive the counting mechanism of the distance indicator.

(4) Drift error signal. A 3-wire synchro output used to drive the aerial into alignment in the drift plane.

(5) Phonic wheel tone. An a.c. signal employed in the main speed servo loop.

Drift angle

9. Drift information is fed in from the power amplifier of the tracking unit in the form of an a.c. signal of variable phase and magnitude. This signal is fed to the windings of the drift integrator motor 6MO1 which, through 600 : 1 and 6 : 1 reduction gears, drives the synchro torque transmitter 6X2 (fig. 4). An electrical analogue of shaft angle is presented by 6X2 in the form of a

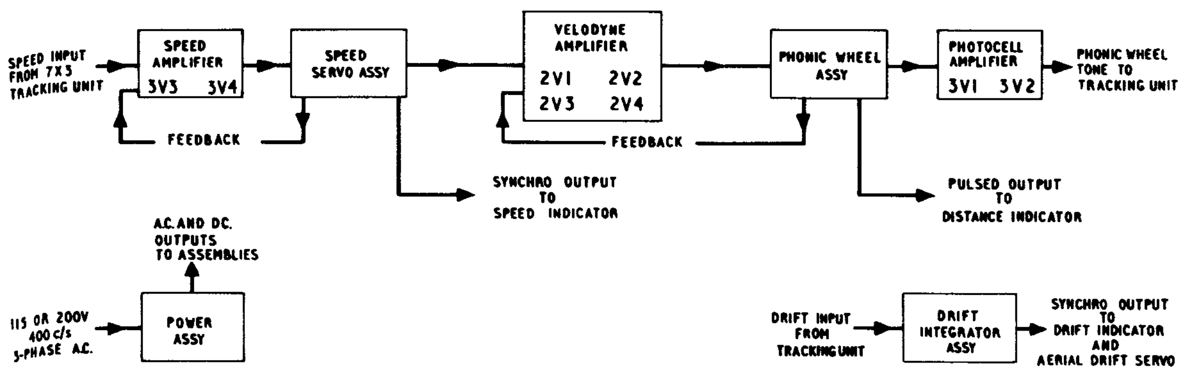


Fig. 3. Block diagram of amplifier, synchro signal

3-wire synchro output (5° rotation per degree of drift) which is connected to the drift angle section of the speed and drift indicator.

10. The same drive shaft, through a further 5:1 reduction gear train, drives the synchro control transmitter 6X3. This provides a 400 c/s a.c. voltage as an error feedback signal to the aerial-mounted synchro control transformer which is part of the aerial drift motor servo loop. This signal varies in phase and magnitude according to the degree of misalignment of the aerial to port or starboard of the aircraft's track and causes the fore-and-aft axis of the aerial to be aligned along the aircraft's track. The operation of the aerial drift servo loop is described in Chap. 3.

Ground speed

11. Ground speed information is obtained by means of a position servo system consisting of a servo motor 7MO1 which drives a synchro torque transmitter 7X3 and a speed potentiometer 7X4 through a 300:1 reduction gearhead and 2·8:1 reduction gear train (fig. 5).

12. From the commutator potentiometer 7X3 in the tracking unit a 400 c/s a.c. voltage, proportional to the ground speed of the aircraft, is fed to the speed amplifier circuit (part of the photoelectric cell amplifier M.150) in the indicator drive unit. The output of the amplifier energizes the control windings of 7MO1, the reference windings of which are supplied with a 115V 400 c/s supply from the power supply. Motor 7MO1 rotates and drives 7X3 and 7X4, a servo feedback voltage being fed from 7X4 to the speed amplifier circuit. The shaft angle of the motor is then proportional to the input voltage from the tracking unit and thus to the frequency of the received Doppler signal and the speed of the aircraft.

13. A 3-wire synchro output of 36° shaft rotation per 100 knots of ground speed is provided by the synchro torque transmitter 7X3 and this is fed to the ground speed section of the speed and drift indicator.

Distance travelled

14. Distance travelled information is derived from the ground speed information by the use of a velodyne integrator servo loop (fig. 5). The input to the velodyne is the voltage from the slider of the speed potentiometer 7X4 and this voltage is proportional to ground speed. The velodyne contains a motor 5MO1 which continuously drives a tachometer generator 5X1. By comparing the output of the generator 5X1 with the input from the slider of 7X4, the speed of rotation of the drive shaft is made proportional to ground speed. Associated with the motor shaft is a pair of cam-operated contacts 5SWA and these pulse a 30V ±2V d.c. supply to actuate the counting mechanism of the distance indicator.

Phonic wheel tone

15. The shaft of motor 5MO1 also drives directly the phonic wheel (fig. 5), ◄an etched glass disc,► which revolves between the light source 5LP1 and the photoelectric cell 5V1. As the disc rotates, the light shed on the cell by the lamp is interrupted by the ◄etchings► and the output of the cell is thus interrupted at a frequency related to the speed of 5MO1.

16. The sinusoidal output of 5V1 is amplified in the photoelectric cell speed amplifier and the output of this amplifier, termed the reference signal or phonic wheel tone, is fed to the tracking unit for frequency comparison with the received Doppler signal. Any frequency difference causes a change in the a.c. voltage output from 7X3 in the tracking unit to the indicator drive unit speed servo circuit.

Chassis assembly (fig. 1)

17. The main chassis, which is housed in a long $\frac{3}{8}$ ATR case, consists of two similar decks mounted back to back and suitably braced to produce a rigid structure. There is sufficient clearance between the horizontal decks, which are attached to front and back plates, to accommodate the fixed wiring and connecting sockets. Connection to each of the plug-in units is by miniature sockets and external connections to the indicator drive unit are effected via 40-pole plugs.

18. On the upper deck are fitted, from front to rear, the photoelectric cell amplifiers M.150, the velodyne amplifiers M.153, and power supply units M.73. In inverted positions on the lower deck are the reference signal generators, the servo gearboxes 2383 and the drift gearboxes 2382.

Amplifier, velodyne Type M.153

19. The function of the velodyne amplifier is to amplify, to a suitable level, the a.c. voltage used to control the speed of the phonic wheel drive motor 5MO1 and, consequently, the frequency of the reference signal. The components of the assembly are mounted on three synthetic resin-bonded tagboards secured to a book-type plug-in chassis. The largest tagboard is hinged to facilitate access to components and connections and the four flying lead base pentodes are clip-mounted on one of the fixed tagboards. The complete assembly is secured to the main chassis by two shouldered captive screws. The assembly is identical with that used in test set Type M.29 but not with that used in the computer.

20. The amplifier together with the phonic wheel motor 5MO1 and the tachometer generator 5X1 forms an electro-mechanical integrator system. Applied to the grid circuit of amplifier 2V1 (fig. 8) are a variable amplitude a.c. voltage in the order of 3·5 millivolts per knot of ground speed, which is derived from the slider of the speed potentiometer 7X4, and a further variable amplitude a.c. voltage (1 millivolt/rev/min) from the tachometer generator 5X1 (terminals S1, S2). In the steady state, the voltage fed back from 5X1 is of opposite phase but of equal magnitude to that fed from 7X4, the output of 5X1 being proportional to shaft speed. Components 2R1, 2C1, 2R4 form the load for the output winding of 5X1. The difference voltage which exists between the two inputs is amplified by 2V1 and then fed to a phase-splitter stage 2V2, the outputs from the anode and cathode of 2V2 being passed to the push-pull amplifiers 2V3, 2V4. The anode loads of these valves are formed by the centre-tapped control winding of the phonic wheel motor 5MO1, h.t. being applied to the valves via the centre tap. The reference winding of 5MO1, terminals 1 and 3, is continuously energized by a 115V, 400 c/s supply from the power unit. Thus, the speed of the phonic wheel motor is controlled directly by the output of the high gain circuits of the velodyne amplifier and a small input voltage drives the motor at a speed necessary to make the output of 5X1 closely approximate the slider potential of speed potentiometer 7X4. Under these conditions the motor drives 5X1 and the phonic wheel at a rate of 5 rev/min/knot of ground speed.

21. The 6·3V a.c. heater supply for the valves is obtained from the centre-tapped secondary winding S, TQ, R of 8TR1 in the power unit (fig. 13); the supply to 2V1, 2V2 is fed via pins 3 and 6 of the 9-pole miniature plug PLC while the supply for 2V3, 2V4 is fed via pins 2 and 6 of the plug. The h.t. supply for 2V1, 2V2 and the screen grids of 2V3, 2V4 is obtained from the power unit and enters the amplifier unit on pin 1 of plug PLC.

Amplifier, photoelectric cell Type M.150

22. The photoelectric cell amplifier contains two separate amplifier circuits. One amplifies the signal from the photoelectric cell 5V1 in the reference signal generator unit (the phonic wheel tone) prior to its being fed to the tracking unit. The other is used to amplify any potential difference existing across the primary winding of transformer 3TR2 to which, as shown in fig. 6, the slider potentials of the speed potentiometer 7X4 and the tracking unit commutator potentiometer 7X3 are applied. The output of this amplifier circuit is used to control the speed motor 7MO1 in the speed servo assembly.

23. The components of the amplifier are mounted on three synthetic resin-bonded fibre tagboards which are mounted on a book-type plug-in chassis. To facilitate access to the components and connections, the largest tagboard is hinged. Four flying lead base pentodes 3V1 to 3V4 are of the same type and are clip-mounted on one of the fixed tagboards. Two captive screws secure the unit to the main chassis and a 25-pole plug PLA, which mates with socket SKA on the main chassis, effects the electrical connections. The assembly is identical with that employed in the computer.

Photoelectric cell circuit

24. The photoelectric cell amplifier circuit consists of a single amplifier stage 3V1 and a low impedance cathode follower output stage 3V2. Applied to the primary winding of the step-up transformer 3TR1 is the sinusoidal output of the photoelectric cell 5V1 (phonic wheel assembly) and from the secondary winding the signal is fed to the grid of 3V1 for amplification. From the anode of this valve the amplified signal is fed, via the cathode follower stage 3V2, to the tracking unit for comparison with the Doppler signal.

25. A bias of 4·7V d.c. is fed to the photoelectric cell from a potential divider network R1, R2, R3, connected between the h.t. line and earth. The decoupling capacitor for the divider network is 8C1 in the power unit, which is connected through PLA, pin 9.

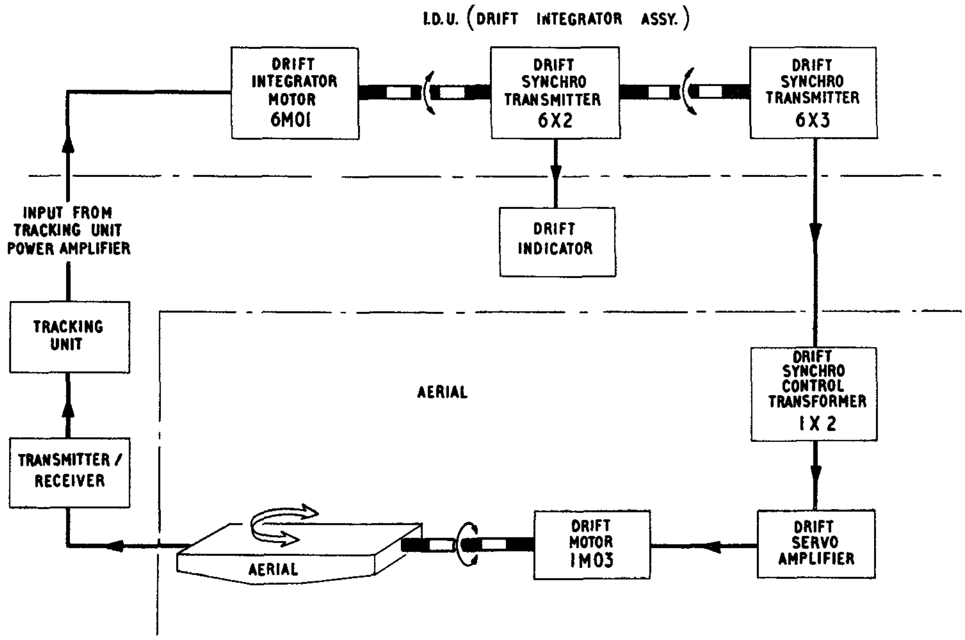


Fig. 4. Block diagram of drift servo

Speed amplifier circuit

26. The speed amplifier circuit consists of two pentodes connected in push-pull, the anode loads being formed by the centre-tapped control windings of speed motor 7MO1. These valves amplify any potential difference which exists across the primary winding of 3TR2, the amplified signal being used to control the movement of 7MO1.

27. As shown in fig. 6, the slider potential of the speed potentiometer 7X4 is connected to one end of the primary winding while the slider potential of the commutator potentiometer 7X3 in the tracking unit is fed to the other end. Applied to these potentiometers is a common excitation supply of 4·7V a.c. derived from transformer 5TR1 in the power unit. Any difference in potential which exists between the two slider potentials appears across 3TR2 primary, is stepped up by the transformer and fed to the grids of 3V3, 3V4, the outputs of which are applied to the control windings of 7MO1. Mechanically coupled to this motor is the slider of 7X4 and as the motor rotates, the slider of the potentiometer is driven until it is at the same potential as the slider of 7X3 in the tracking unit. As a result, there is no potential difference across 3TR2 primary and the motor stops. Circuit Connections are such that the error signal across 3TR2 is phase dependent on the relative positions of both speed and commutator potentiometer sliders in order to obtain the correct direction of rotation of the motor to reduce the error.

Generator, reference signal

28. The phonic wheel assembly forms part of the speed servo loop (fig. 5) and generates a tone of sinusoidal waveform which is amplified in the photoelectric cell amplifier. The amplified tone, referred to as the reference signal or phonic wheel tone, is compared with that of the Doppler signal. When the system is locked on in speed, the frequency of the phonic wheel tone is directly proportional to the speed of the aircraft. The unit also produces the pulsed supply necessary for the operation of the distance indicator.

29. All components are mounted in an enclosed plug-in assembly fitted with two hinged access doors which are secured by screws. Electrical connections to the assembly are completed by means of a 25-pole miniature plug. The two-phase phonic wheel motor 5MO1, the phonic wheel and tachometer generator 5X1 are mounted in line. Motor drive to the phonic wheel and 5X1 is direct. ►◄ The phonic wheel is coupled to the tachometer generator through a dog clutch to minimize axial overloads on the generator. A rigid, light alloy box structure supports 5MO1 and 5X1 and houses the 30:1 ratio simple reduction gear train which drives the concentrically mounted ball bearing cam to operate the springset contacts 5SWA.

30. The phonic wheel, which is ◄an etched glass disc,► revolves between the light source 5LP1 (a midget 6V lamp) and the photoelectric cell 5V1 which form the projector assembly. A filter screen is fitted over the photoelectric cell aperture to improve the output waveform and a small ◄hole► in the synthetic resin-bonded fibre cover permits a visual check of the light source to be made when the unit is being serviced. Lamp 5LP1 is energized by a 6·3V a.c. supply obtained from the secondary winding of 8TR1 in the power unit.

31. The reference winding of motor 5MO1 is continuously energized by a 115V a.c. supply from the power unit and the control winding is energized by the output of the velodyne amplifier. This output is, in effect, an amplified version of any difference of potential which exists between the slider of the speed potentiometer 7X4 and the feedback voltage from the tachometer generator 5X1.

32. Light from 5LP1 is projected through the phonic wheel and focused upon 5V1, the light being interrupted by the radial lines on the phonic wheel as it is rotated by 5MO1. A bias voltage of +4·7V d.c., obtained from the photoelectric cell amplifier, is applied to the photoelectric cell. The output of 5V1 is a sinusoidal waveform and is of a frequency dependent upon the speed of the motor which is, in turn, proportional to the ground speed of the aircraft (assuming the system is locked on in speed). This signal is amplified by the photoelectric cell amplifier and is fed to the mixer bridge circuits of the tracking unit where its frequency is compared with that of the Doppler signal.

33. The tachometer generator 5X1 is used to produce a voltage output proportional to the speed of rotation of its shaft suitable for velocity (derivative) feedback to the velodyne amplifier. The phase of the alternating output, which is dependent on the direction of rotation, is opposite to that of the speed potentiometer 7X4 (tracking unit) input to the velodyne amplifier. A 26V a.c. energizing supply is applied to the P1-P2 winding of 5X1, the supply being obtained from secondary winding VU of 8TR1 in the power unit via resistor 8R2 and the narrow-band filter formed by 5L1, 5L2, 5L3 and 5C1, 5C2. This filter has sharp cut-off characteristics and also ensures that the voltage applied to the P1-P2 winding is in quadrature with that applied to the reference winding of 5MO1. The tachometer generator is driven by 5MO1 at a speed such that, when the system is operating under follow conditions, the output of the tachometer generator is closely equated to the slider potential of 7X4. Under these conditions, 5X1 rotates at 3·41 rev/min/knot with an output of 1 millivolt/revolution.

34. In order that the output of 5X1 may be of constant amplitude for any given speed of rotation over a wide range of ambient temperatures, the temperature-compensating resistor 5R1 is fitted (5X1 and 5R1 form a matched pair). Transformer

5TR1 is tapped to provide the 4·7V a.c. excitation supply common to the speed potentiometer 7X4 in the speed servo assembly and the commutator potentiometer 7X3 in the tracking unit.

35. A 30V ±2V d.c. supply from the power unit is applied to the contacts of the springset 5SWA via pin 13 of plug PLE. Consequently, as the contacts operate by the motion of the phonic wheel gearbox and cam wheel at a speed determined by the phonic wheel motor 5MO1, a pulsed supply is fed to the counter unit of the distance indicator every one-tenth nautical mile.

Gearbox, mechanical, drift 2382

36. The functions of the drift integrator unit are as follows:—

(1) To convert the drift angle information to a 3-wire synchro output of 5° synchro shaft rotation per degree of drift suitable for driving the drift indicator section of the speed and drift indicator.

(2) To provide a 3-wire synchro output as an error feedback signal to control the aerial drift servo system and so ensure that the aerial is aligned along the aircraft's track (fig. 4).

37. Components forming the assembly are mounted on a machined, light alloy base, which has removable covers, and a triangulated light alloy frame.

38. A two-phase induction motor 6MO1, a synchro torque transmitter 6X2 and a synchro control transmitter are mechanically linked by a gear train. A 600:1 ratio reduction gearhead fitted to 6MO1 transmits drive to a 6:1 ratio reduction gear train that drives 6X2; a further 5:1 reduction gear train drives 6X3. Total travel of the gear train is limited to ±150° from the zero position and the travel of the rotor of 6X3 is limited to ±30°. A slipping clutch device is fitted in the gearbox to prevent mechanical damage should the aerial array be displaced to maximum in azimuth.

39. The windings of 6MO1, the drift integrator motor, are energized independently by the outputs of the power amplifier in the tracking unit. The direction of rotation of 6MO1 is dependent upon the phase relationship existing between the signals applied to the motor and this, in turn, depends upon whether the difference frequency amplified by the tracking unit circuits is obtained from a component of the Doppler signal which lies above or below the frequency of the phonic wheel tone. Again, this relationship is dependent upon whether the aircraft is drifting to port or starboard.

40. If a difference exists between the aircraft heading and track (that is, the aircraft is subject to drift) motor 6MO1 rotates in the relevant direction by virtue of the signals applied to its windings from the tracking unit. The rotor of 6X2 is thus rotated and the signal induced in the stator windings is transmitted to the synchro torque receiver X2 in the speed and drift indicator, which indicates the port or starboard drift angle. Similarly, 6X3 rotor is rotated and an error signal is induced in the stator windings which are connected to those of synchro control transformer 1X2 in the aerial. The resultant signal induced in the rotor winding of 1X2 is applied to the aerial drift servo amplifier and, after amplification, is used to drive the aerial drift motor. Thus, the aerial is aligned along the aircraft track and, as a result, there is no net drive to 6MO1 until a change of drift angle arises.

41. The rotors of 6X2, 6X3 are energized by a 26V a.c. supply obtained from 8TR2 in the power unit.

Gearbox, mechanical, servo 2383

42. The functions of the speed servo assembly are to provide an accurate synchro signal for the operation of the ground speed pointer in the speed and drift indicator and to produce an a.c. voltage proportional to ground speed which is fed to the velodyne amplifier to control the speed of the phonic wheel motor 5MO1. Ground speed information is provided by a synchro torque transmitter 7X3 while the a.c. voltage is obtained from the slider of speed potentiometer 7X4.

43. A light alloy sub-chassis houses the 37-pole connecting plug PLF while a machined light alloy base accommodates the gear train and supports the speed servo motor 7MO1, synchro torque transmitter 7X3 and speed potentiometer 7X4. Access to the gear train is gained by the removal of two covers, each secured by two screws.

44. The reference winding of 7MO1 is energized by a 115V a.c. supply from the power unit and a degree of damping is afforded to the motor by 8MR1, 8R1, also in the power unit. The control winding is energized by the signal from the speed amplifier section of the photoelectric cell amplifier and this signal is, in effect, the amplified potential difference between the voltage from the commutator potentiometer 7X3 in the tracking unit and that at the slider of 7X4. When a difference exists between these two voltages, a signal is fed to the control winding of 7MO1 so that the motor rotates and drives a 300:1 ratio reduction gearhead and a 2·8:1 gear train before actuating the synchros and potentiometer. Rotation of the gear train is limited by mechanical stops and a slipping clutch mechanism prevents damage to the gear train.

45. As the rotor of 7X3 is rotated, a signal is induced in the stator windings which are connected to a synchro receiver X3 in the speed and drift indicator so that the rotor of X3, to which the speed pointer is attached, follows changes of speed and direction of rotation of 7MO1. The rotor of 7X3 is energized by a 26V a.c. supply from 8TR2

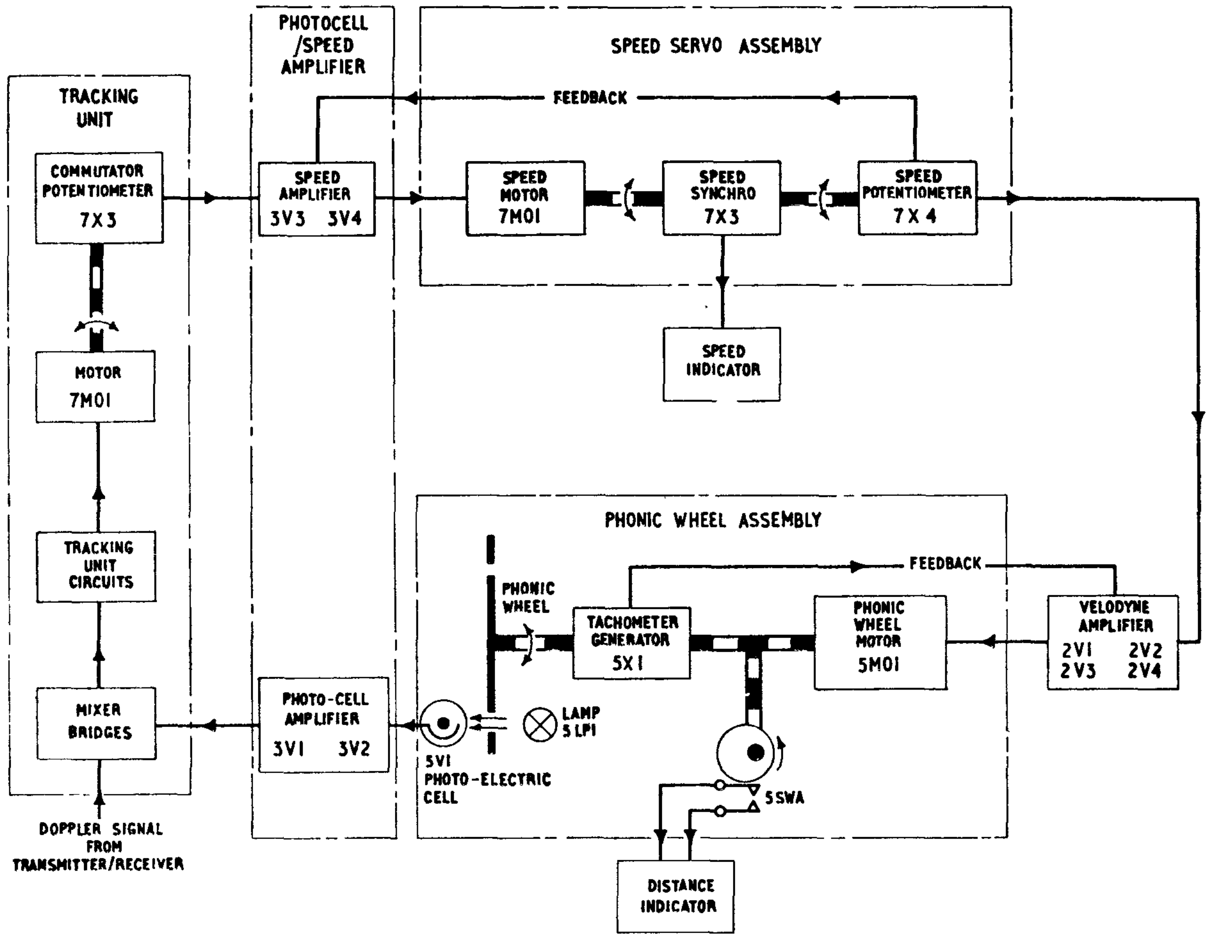


Fig. 5. Block diagram of speed servo

in the power unit and 7X3 provides a 3-wire synchro output of 36° shaft rotation per 100 knots of ground speed.

46. The preset potentiometer 7RV1 is adjusted during alignment operations to set the output of 7X4 to a stipulated level. The h.t. supply for the valves of the speed amplifier circuit is obtained from the power unit and is applied via the centre loop of the control windings of 7MO1.

Power supply Type M.73

47. The power supply unit provides the necessary a.c. and d.c. supplies for the indicator drive unit. The power unit consists of a tray-type chassis on which are mounted the two transformers 8TR1, 8TR2 and the choke 8L1 together with 8R2, all the remaining components being mounted on two tagboards on the underside of the chassis. Four screws secure the unit to the main chassis and all electrical connections are made through a miniature 25-pole plug. The power unit is identical with that used in test set Type M.29.

48. The primary winding of 8TR1 may be delta or star-connected according to whether the 3-phase 400 c/s input supply is 115 or 200V (nominal), the necessary voltage adjustment being obtained by the changing of links on the tagboard under the chassis. For an input of 115V, terminals 1–4, 2–5, 3–6 are linked to produce a delta arrangement whilst an input of 200V necessitates the linking of terminals 4–7, 5–8, 6–9 to obtain star connection of the windings.

49. Secondary windings ST, QR provide heater supplies of 6·3V ±0·3V a.c. for the valves in the velodyne and photoelectric cell amplifiers and for the light source 5LP1 in the phonic wheel assembly. The winding VU produces 40V a.c. which is fed via 8R2 to provide an excitation voltage of 26V ±2V at the P1, P2 winding of the tachometer generator 5X1.

50. The output of the star-connected secondary winding PLMN is rectified by germanium diode rectifiers 8MR5, 8MR6, 8MR7 to provide a 30V ±2V d.c. supply for the cam-operated contacts 5SWA to produce the impulses for the distance indicator.

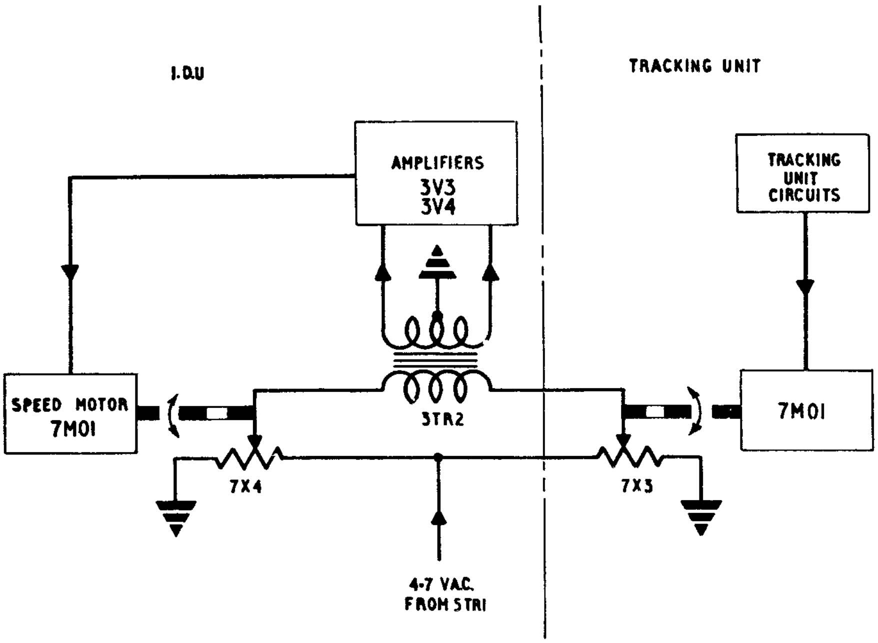
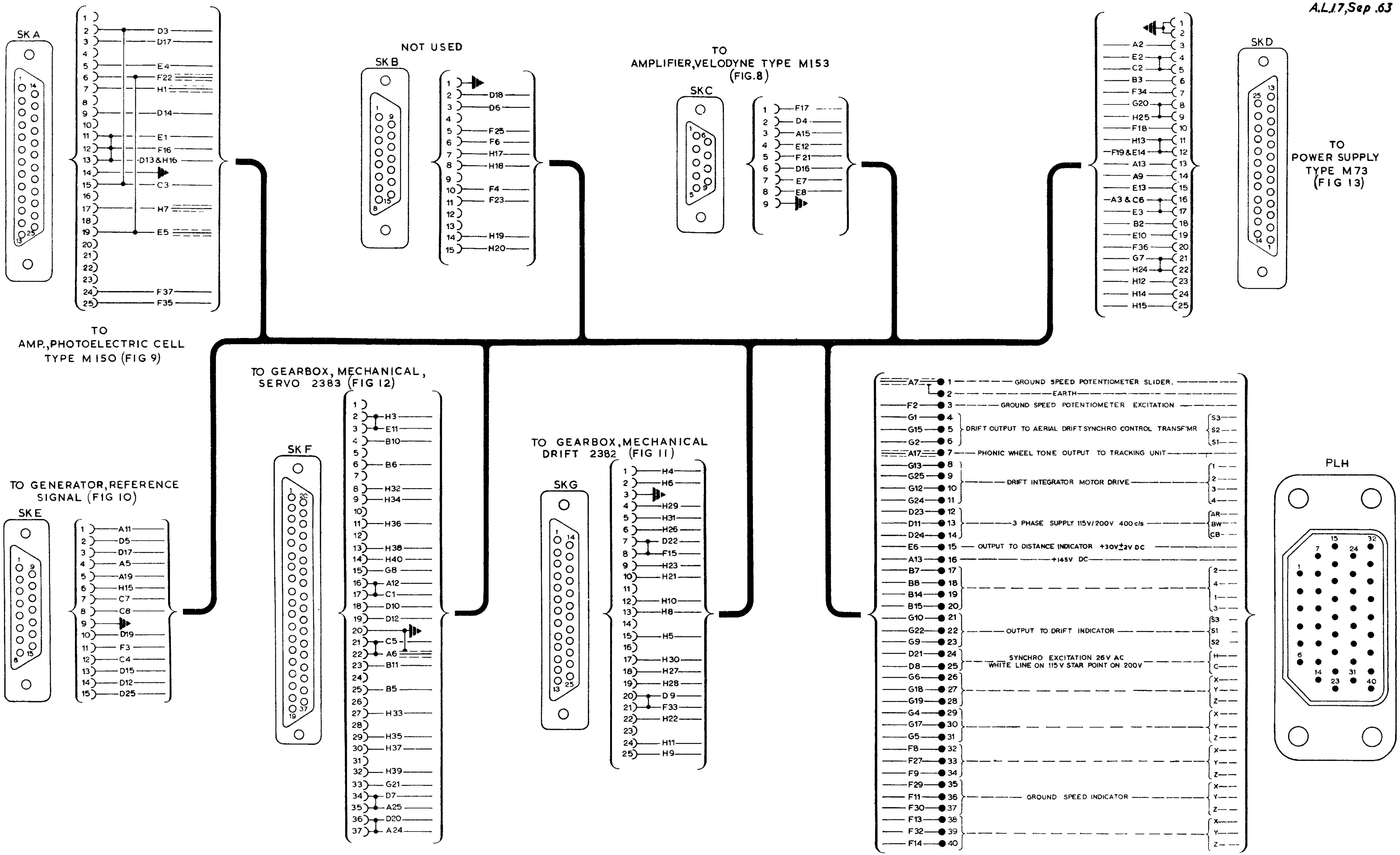


Fig. 6. Inputs to speed amplifier

51. A h.t. supply of + 145V ±5V is produced by rectifiers 8MR2, 8MR3, 8MR4 from the output of the secondary winding WXYZ and is smoothed by the choke-input filter formed by 8L1, 8C3. This supply is used by all the valves in the indicator drive unit.

52. The primary winding of the single-phase transformer 8TR2 is tapped to provide a synchro excitation supply of 26V ±1·5V a.c. and the secondary winding produces a 6·3V ±0·3V a.c. heater supply which is not normally used. Capacitor 8C1 (fitted in the power unit owing to the lack of space in the photoelectric cell amplifier) is the decoupling capacitor for the photoelectric cell excitation supply produced in the photocell amplifier. Resistor 8R1 and rectifier 8MR1 provide a degree of damping for the speed motor 7MO1, thus obviating hunting.

53. The normal total power required by the indicator drive unit is approximately 100 watts.

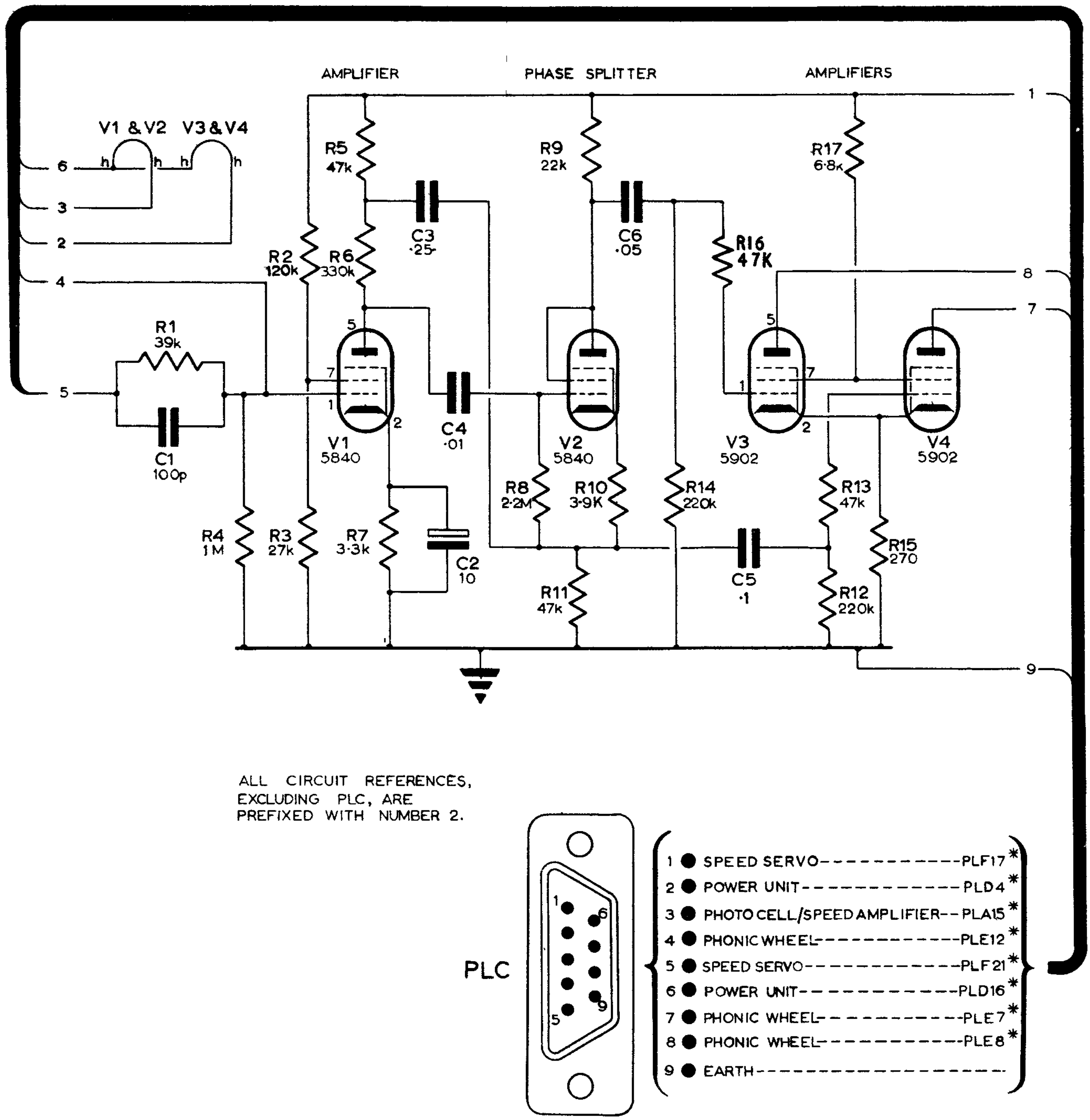


AIR DIAGRAM
6775M/MIN.
ISSUE 2
PREPARED BY MINISTRY OF AVIATION FOR PROMULGATION BY AIR MINISTRY

Chassis, electrical equipment: circuit

Fig. 7

INDICATOR DRIVE UNIT



* EXTERNAL CONNECTIONS

AIR DIAGRAM
6775N/MIN.
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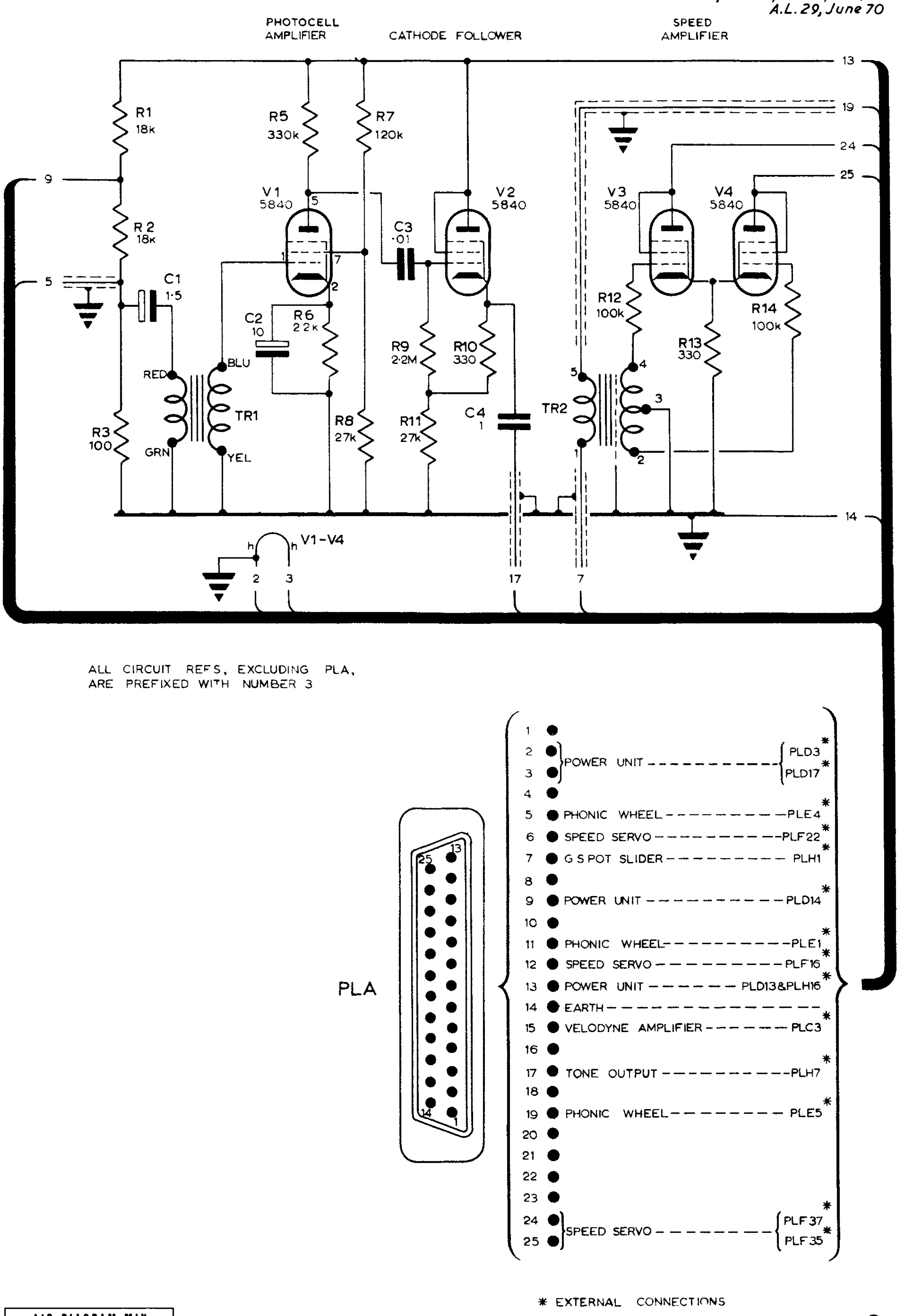
Amplifier, velodyne Type M153: circuit

Fig.8

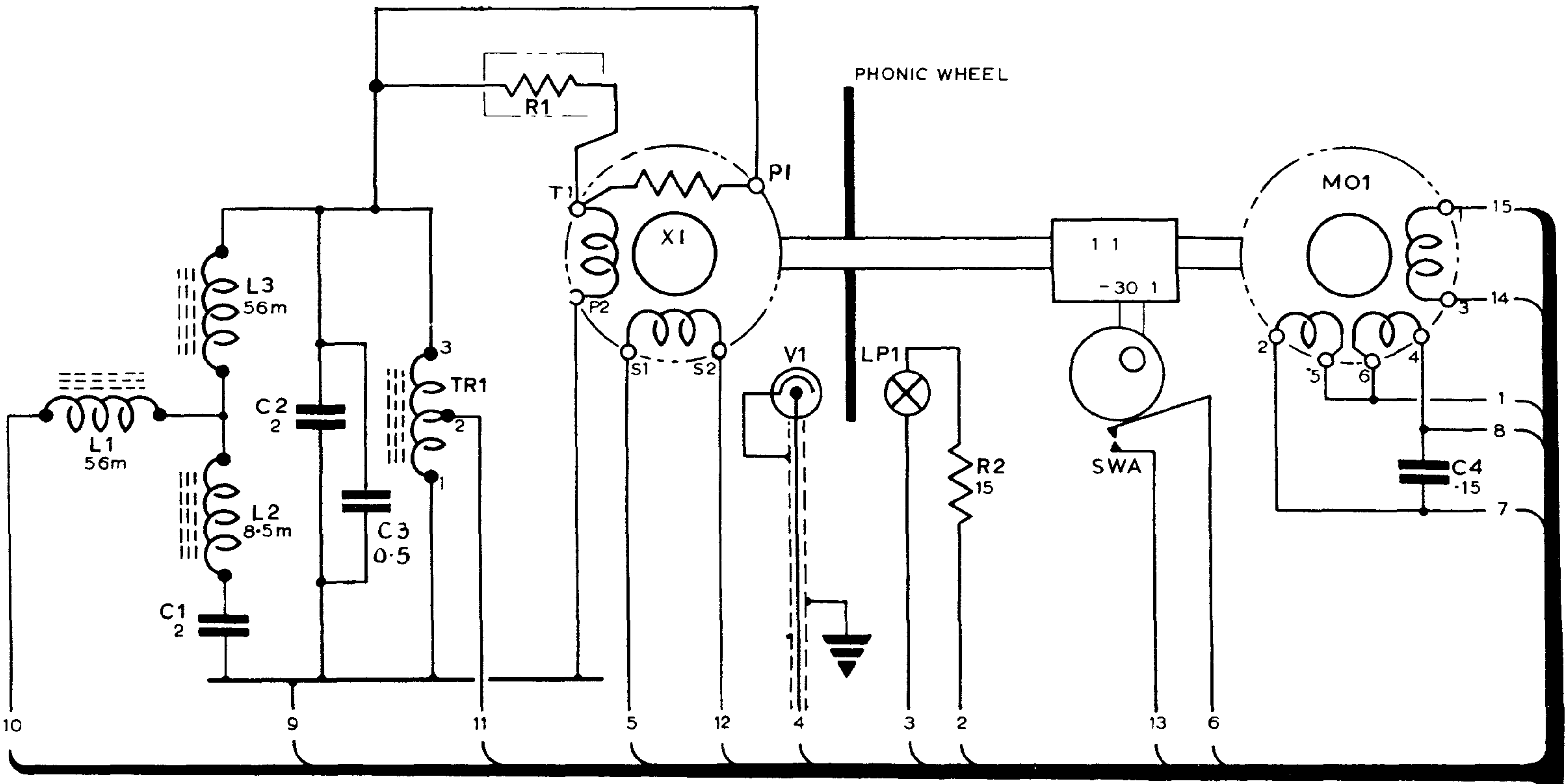
INDICATOR DRIVE UNIT



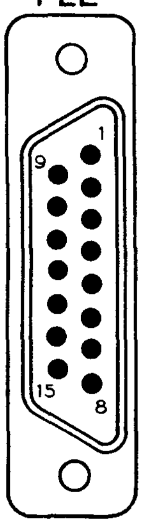
AIR DIAGRAM-MIN
114E-0400-MD21
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 Prepared by the Ministry of Technology

Amplifier, photo electric cell Type M150 :circuit Fig. 9

INDICATOR DRIVE UNIT



PLE



1 HT 140V DC — PLA11*
2, 3 POWER UNIT 6·3V AC — PLD5*, PLD17*
4, 5 PHOTOCELL/SPEED AMPLIFIER — PLA5*, PLA19*
6 TO DISTANCE INDICATOR PLH15*
7, 8 INPUT FROM VELODYNE AMPLIFIER — PLC7*, PLC8*
9 EARTH
10 POWER UNIT 26V — PLD19*
11 SPEED SERVO UNIT 4·7V AC PLF3*
12 VELODYNE AMPLIFIER — PLC4*
13 28V DC — PLD15*
14, 15 115V AC — PLD12*, PLD25*

* EXTERNAL CONNECTIONS

MO1 LEADS

No	COLOUR	ALTERNATIVE
1	BLU	YEL
2	GRN	RED
3	YEL	WHT
4	BRN	BLK
5	RED	RED/BLK
6	BLK	GRN

ALL CIRCUIT REFERENCES EXCLUDING PLE, ARE PREFIXED WITH NUMBER 5.

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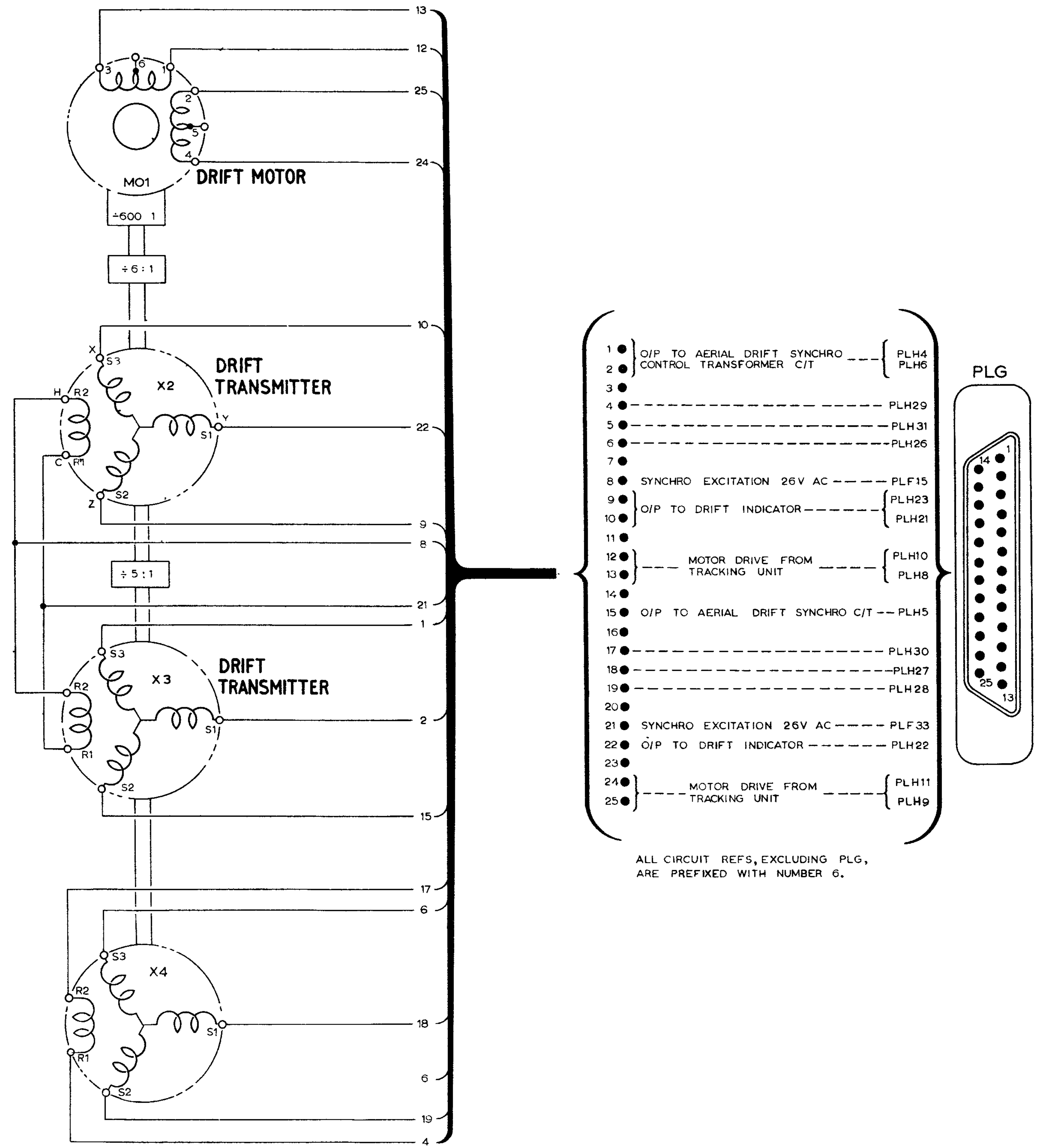
Generator, reference signal: circuit

Fig. 10

INDICATOR DRIVE UNIT



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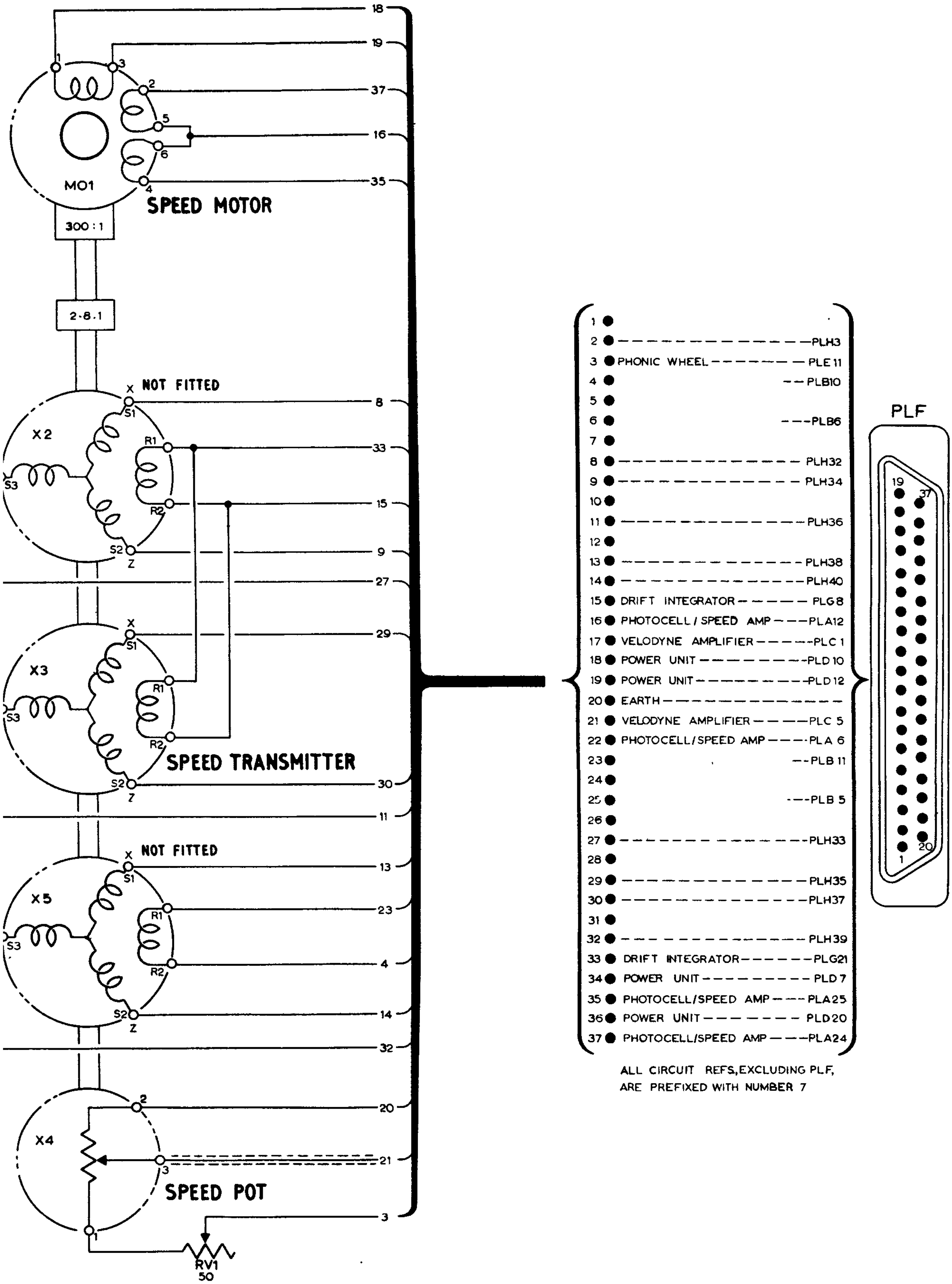
Gearbox, mechanical drift 2382: circuit

Fig. 11

INDICATOR DRIVE UNIT



ALL CIRCUIT REFS, EXCLUDING PLF, ARE PREFIXED WITH NUMBER 7

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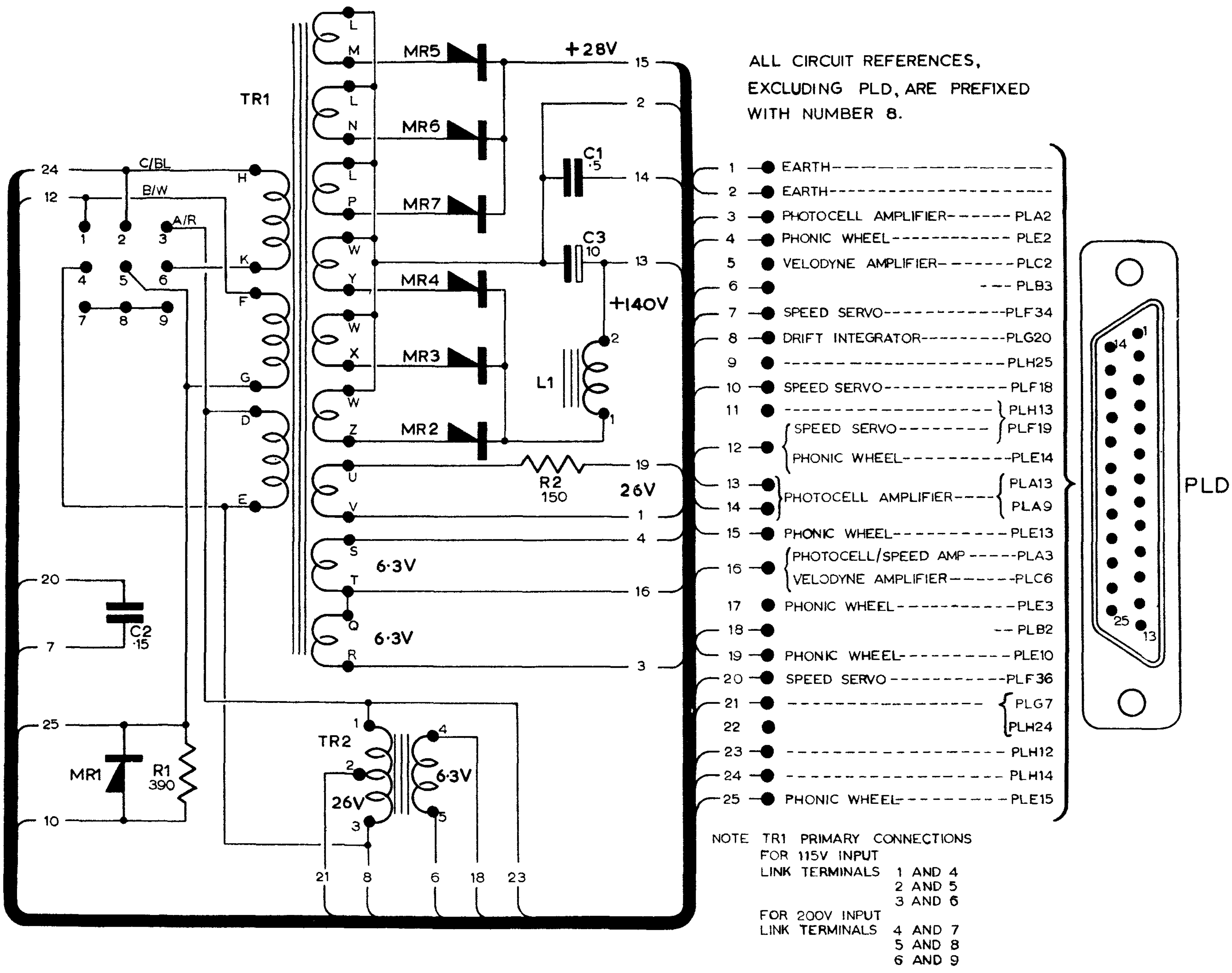
Gearbox mechanical, Servo 2383: circuit

Fig. 12

INDICATOR DRIVE UNIT



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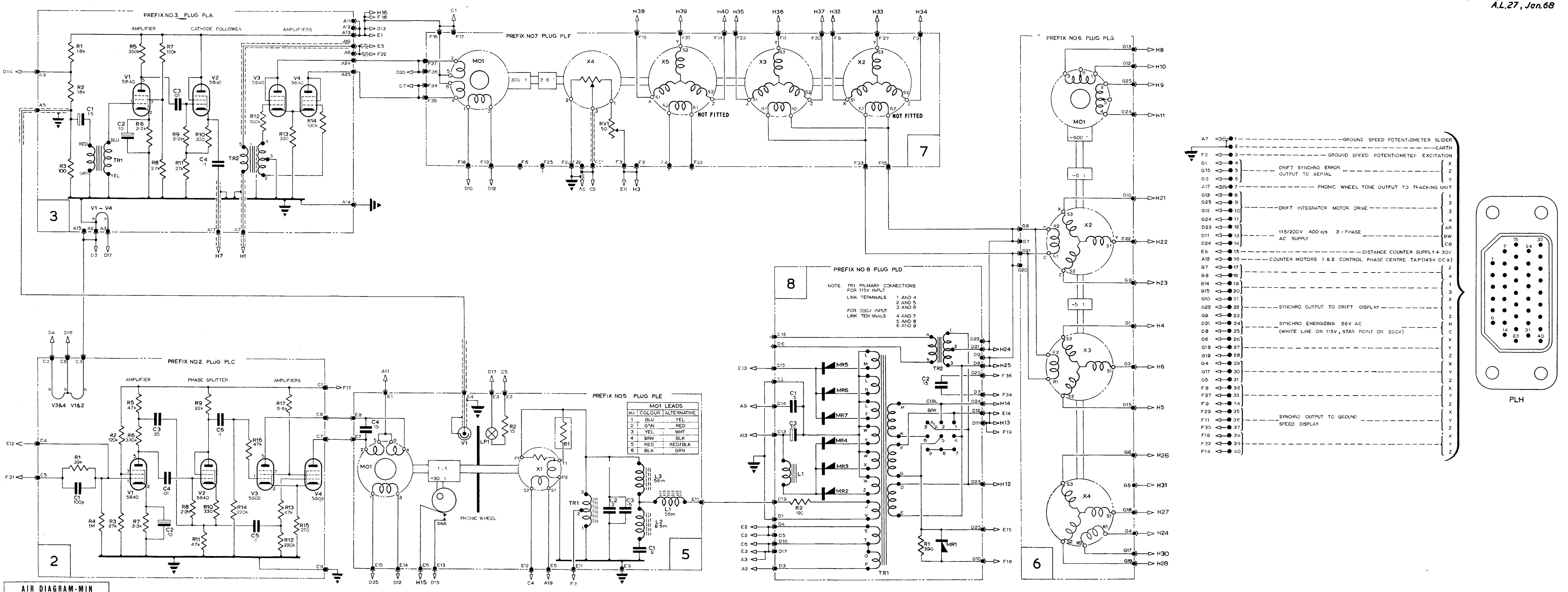
Power supply Type M73 : circuit

Fig. 13

INDICATOR DRIVE UNIT



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Amplifier synchro signal: circuit

Fig.14

Chapter 7

SWITCH BOX (10F/21420)

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LIST OF ILLUSTRATIONS

Description

1. Switch box (10F/21420) is the system junction box employed in dual sensor installations (ARI. 23085/3). The box, which is illustrated in fig. 1, is of light alloy construction and measures 5 in. wide × 6 in. high × $3\frac{3}{8}$ in. deep excluding the plug and socket projections. The front plate is extended at the sides to form mounting flanges, each $\frac{3}{8}$ in wide. Four holes are provided for mounting purposes at centres of $4\frac{1}{8}$ in. and 5·365 in. The front plate carries a three-position switch, two panel lights and two sockets (SKE and SKF), providing outputs for test set, performance Type M.29. All other plugs and sockets are mounted on the back of the unit.

2. A dual sensor installation has two aerials, two transmitter-receivers, two tracking units and a two-channel amplifier, synchro signal (indicator drive unit) with common indicators. Normally, only one set of equipment is in operation, the other set forming a standby. The junction box switch allows either channel to be selected and has a centre OFF position in which both channels are inoperative. It should be noted that the switch is fitted with special wafers having contacts rated at 5A at 250V a.c. to permit switching of the 115V, 400 c/s supply.

3. A circuit diagram of the box is given in fig. 2 and details of its application can be found by reference to the installation diagram in Sect. 2, fig. 2.

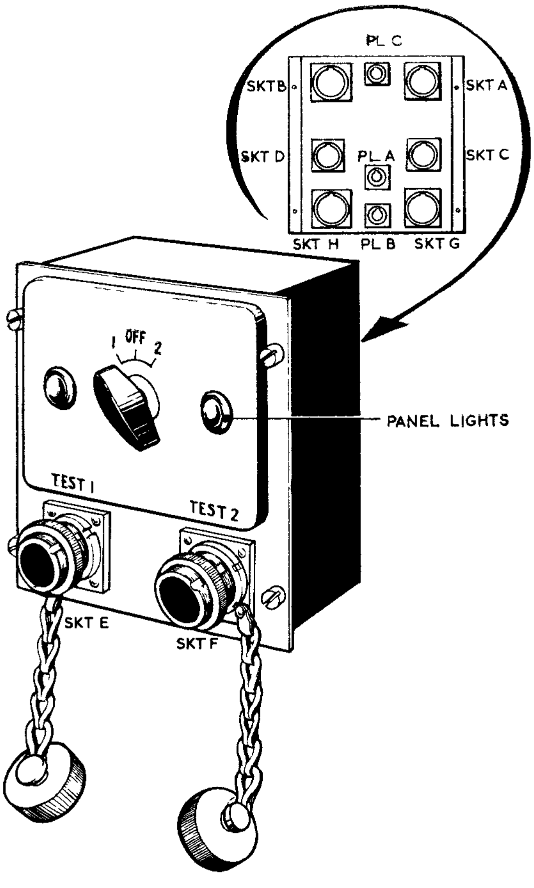

Fig. 1. Switch box (10F/21420): general view

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Switch box (10F/21420): circuit

Fig. 2

Chapter 8

INTERCONNECTING BOX TYPE M.5

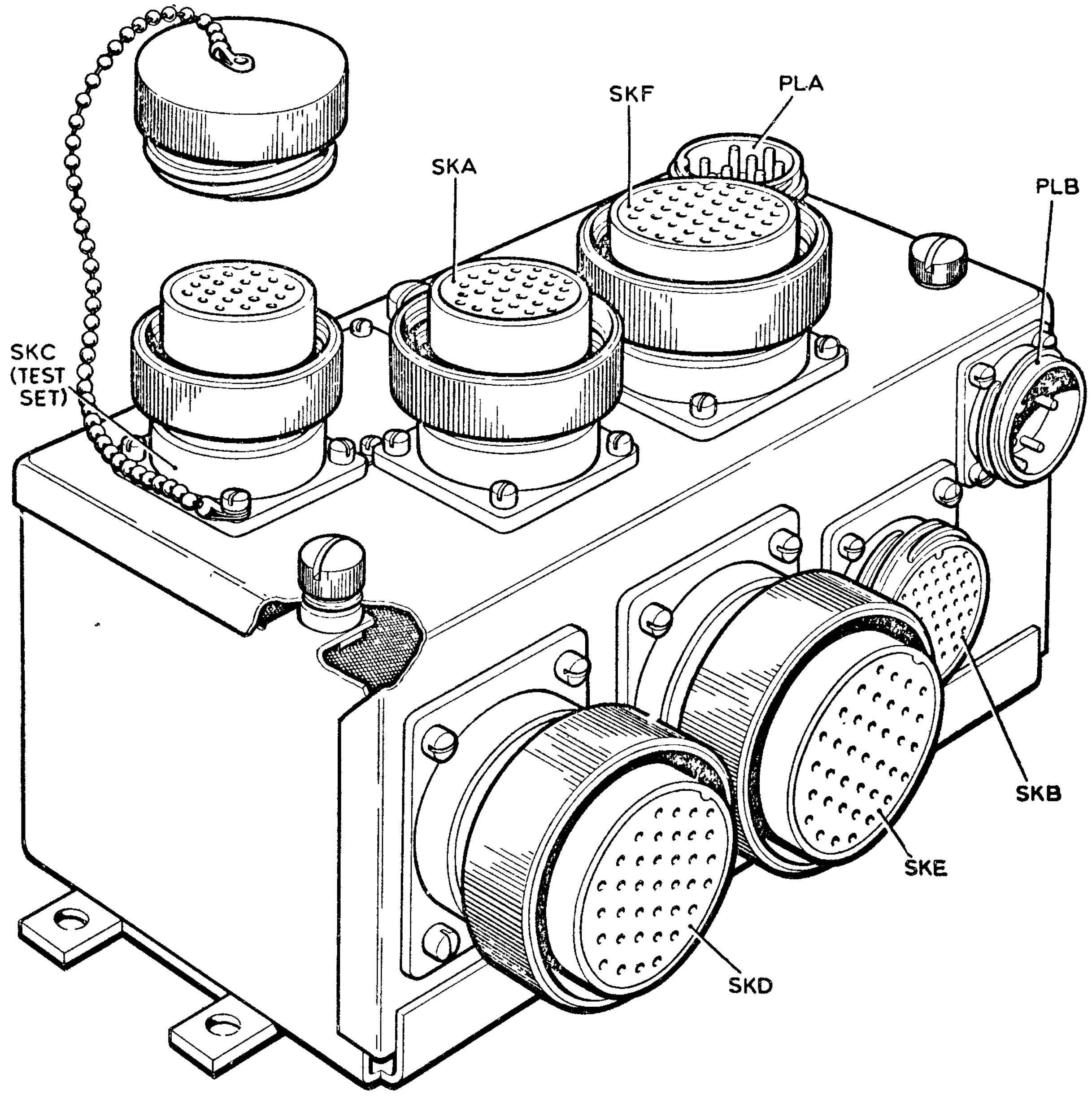
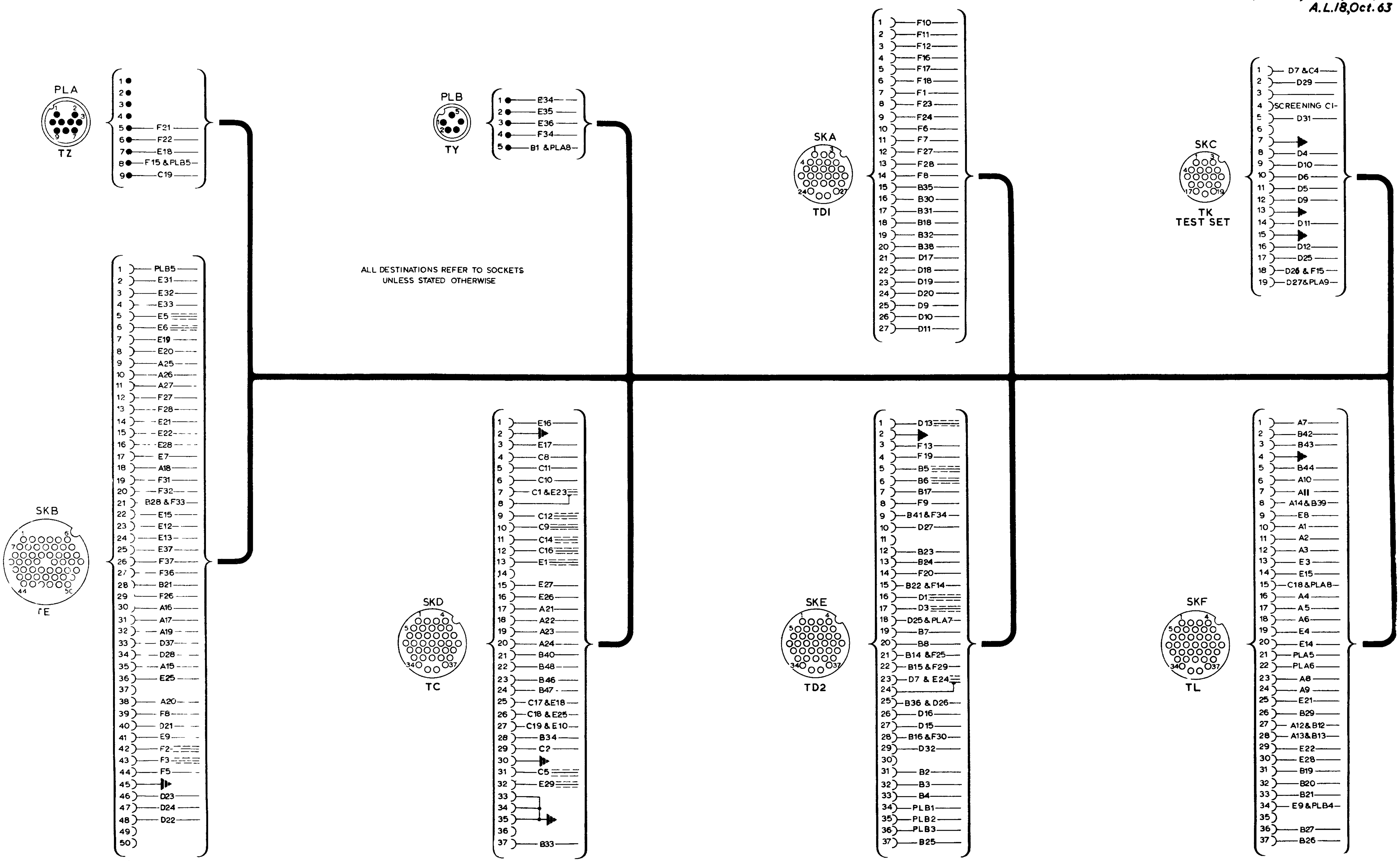


Fig. 1. Interconnecting box Type M.5: general view

1. Interconnecting box Type M.5 is the system junction box employed on single installations (ARI.23085). It consists of an aluminium case fitted with two multi-pole plugs and six sockets. One of the sockets, SKC, provides access for the test set performance Type M.29. This socket is sealed by a captive cover when not in use. The internal connections are shown in the circuit diagram, ◀fig. 2.▶ For details of the destinations of the cables associated with the unit, reference should be made to the appropriate installation diagram in ▶◀ Sect. 2.

2. The principal dimensions of the body of the unit, viewed as in fig. 1, are: length $7\frac{15}{16}$ in., width 4 in., depth $2\frac{29}{32}$ in. Four $\frac{5}{32}$ in. diameter fixing holes are provided, spaced on centres $8\frac{3}{8}$ in. by 2 in. ◀These are drilled in a mounting plate which extends approximately $\frac{1}{2}$ in. beyond the ends of the case.▶

3. The weight of the unit is ◀2 lb 13 oz (1·27 Kg).▶



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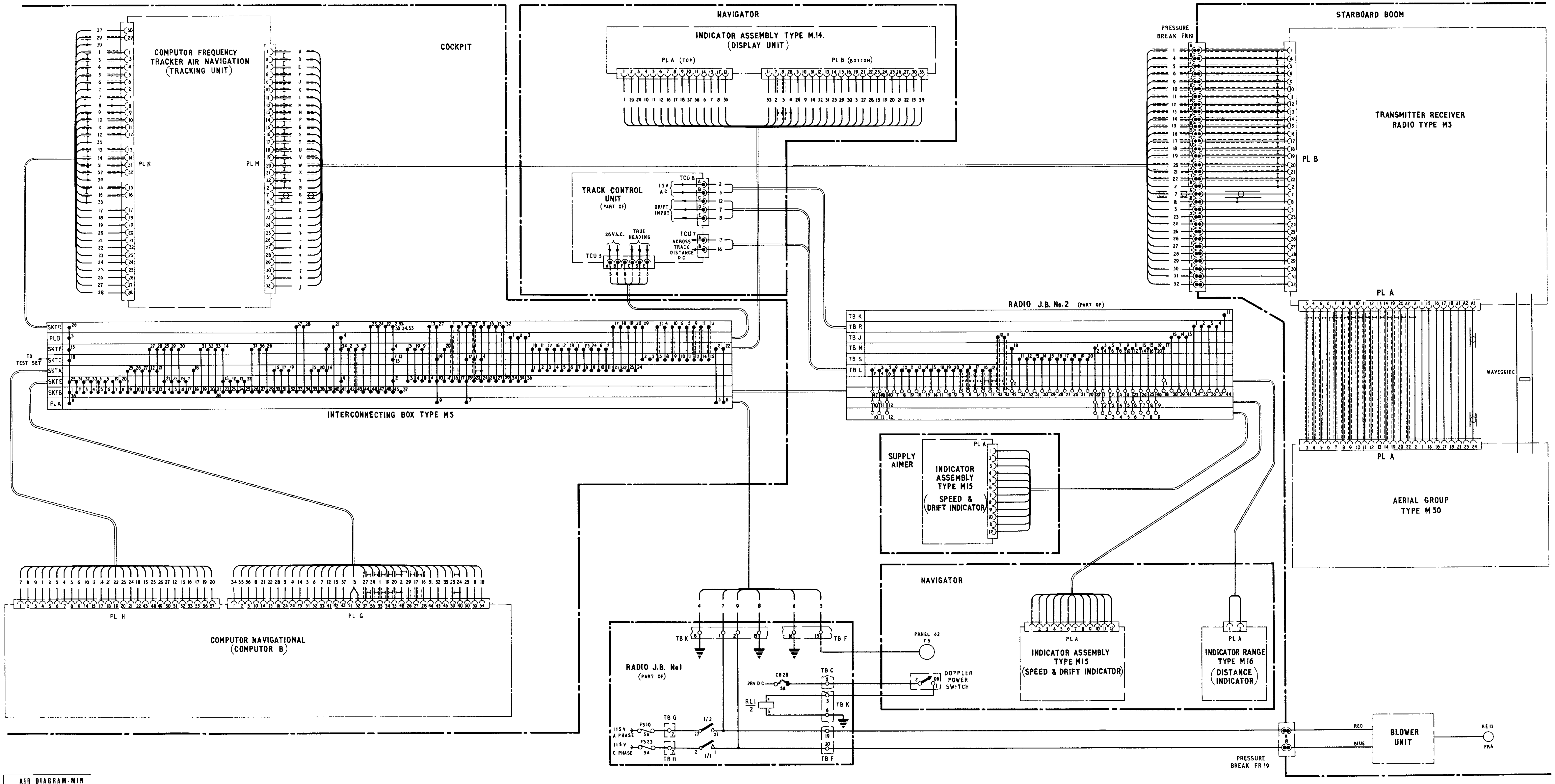
Interconnecting box Type M.5 : circuit

Fig.2

SECTION 2

DETAILS OF INSTALLATIONS



A.R.I. 23085 Marconi AD 2300 Doppler navigator equipment A.R.I. 23085 Argosy C Mk.1: interconnections

Fig.1

ARGOSY C Mk 1

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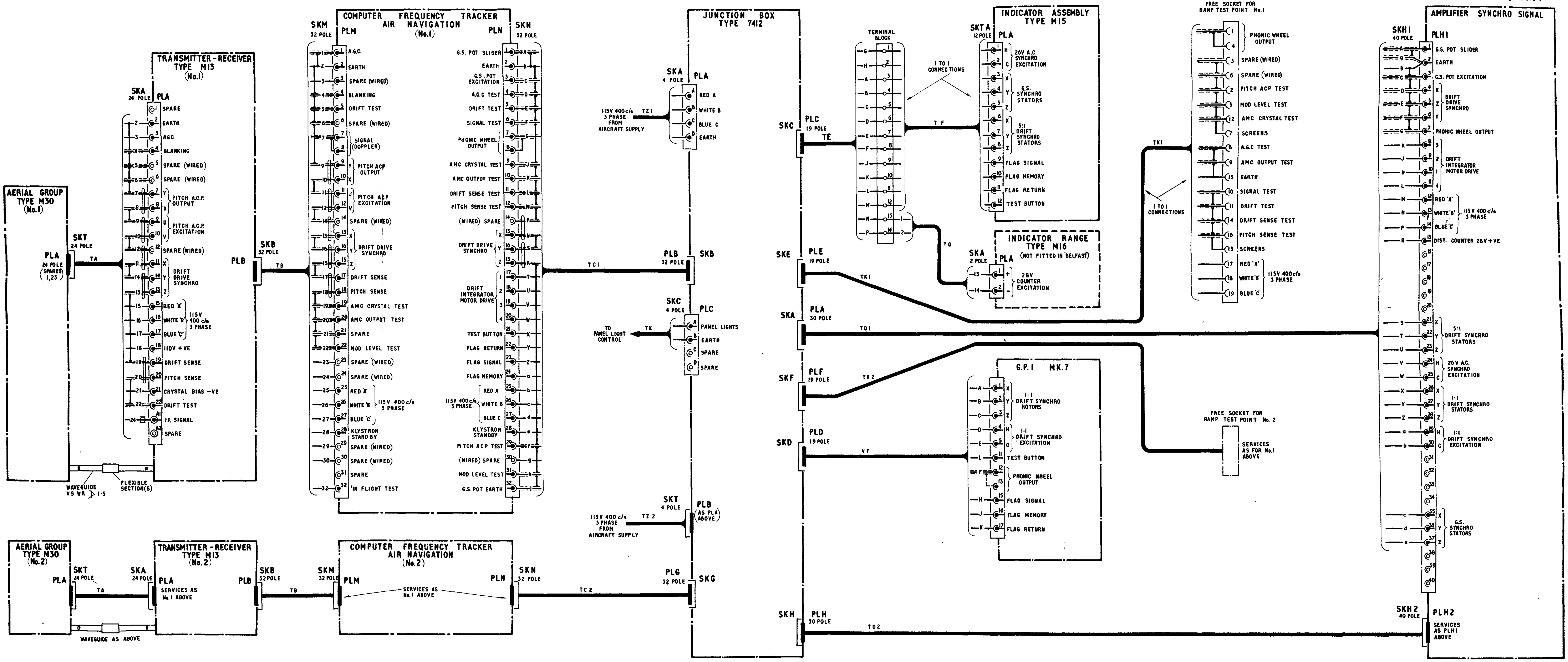

A.R.I. 23085/3 Marconi AD 2300 doppler navigation equipment: interconnections

Fig. 2

SECTION 3

DETAILS OF SPECIAL TEST EQUIPMENT

Chapter 1

TEST SET PERFORMANCE TYPE M.29

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LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Power supply required	115 *or* 200*V* ±5%, 400 *c/s 3-phase*
Power consumption	70 *watts*
Ambient temperature range	—40°*C to* +70°*C*
Altitude ceiling	20000 *feet*
Weight	23 *lb* (10·43 *kg*)
Dimensions	*Height* 10·9 *in.* (27·6 *cm*) *Width* 15·4 *in.* (39 *cm*) *Depth* 9 *in.* (22·7 *cm*)
Air cooling	*Not required*
Mounting	*None: portable unit*

Introduction

1. The test set is a portable unit designed to provide a convenient means of performing functional tests on the Doppler equipment. It is intended primarily for checking an installation in an aircraft, but is may also be used in the workshop. A special cable connects the test set with a socket, SKC, on the installation junction box (interconnecting box Type M.5). This cable conveys power supplies to the test set and provides access to a number of points in the installation for measurement purposes.

2. The unit is essentially a combined multi-range meter, monitoring oscilloscope, and signal generator. Arrangements for checking the drift, pitch, distance, and aerial switching circuits are also included. The tests which may be performed with the unit are as follows:—

(1) Check of the amplitude of the modulation applied to the transmitter klystron.

(2) Check of the a.m.c. crystal. This gives an indication of the power output sample detected for automatic mode centring of the klystron. It also gives an indication of transmitter power output.

(3) Check of the output level of the a.m.c. circuit. The presence of unwanted modulation can be observed.

(4) Check of the a.g.c. voltage. Any unwanted modulation or transient conditions can be observed.

(5) Check of the two types of crystal diode used in the equipment. Both forward and reverse currents are measured.

(6) Check of receiver noise and signal characteristics.

(7) Check of the amplitude of the phonic wheel tone from either the indicator drive unit or computor.

(8) Check of the search, follow, in-flight test, and distance-flown circuits, using the signal generator portion of the test set.

(9) Check of the action of the tracking unit in correcting drift and pitch errors.

(10) Check of the aerial waveguide switch for correct functioning and sequence of switching.

3. In addition to making functional tests, the test set can also be used to aid fault-finding. There is provision for using the oscilloscope to monitor waveforms other than those brought in by the test set connector.

Constructional details (fig. 1)

4. The basic structure of the unit consists of a horizontal chassis plate attached behind a rectangular front panel and supported at the rear by a pair of end-frames. Three vertical component boards are mounted above the chassis, one at the rear and one at each end. The complete assembly thus formed is referred to as the chassis assembly (component prefix No. 1). Three plug-in assemblies are fitted below the chassis plate; these are the velodyne amplifier (component prefix No. 2), the phonic wheel assembly (component prefix No. 5) and the power assembly (component prefix No. 8). The unit is housed in a metal container which, when the detachable front cover is properly fastened, is waterproof, both the container and the cover being fitted with rubber seals.

5. To allow air to flow through the unit for cooling purposes, the edges of the front panel are cut away. These vents are enclosed when the cover is fitted.

6. As far as practicable, the components are arranged in functionally-connected groups. All controls and components to which access is required when the test set is in use are mounted on the front panel. They are protected by a pair of guard frames. The left-hand vertical component board carries the components of the c.r.t. timebase circuit. Flying-lead based valves are employed. The right-hand vertical component board carries the components of the noise-shaping circuit. Again, flying-lead based valves are fitted, except for the noise valve 1V9, which has a B7G base. On the rear component board are the components of the Y amplifier, the tone amplifier, and the bridge mixer circuits, and the B9G base for the c.r.t.

7. Mounted beneath the chassis plate, in addition to the three plug-in assemblies, are the power transformer 1TR1 and the components forming the phase-sensitive rectifier circuit. On the top of the chassis plate are the e.h.t. smoothing capacitors, relays 1RLA and 1RLB, the e.h.t rectifier 1V5, and a small sub-chassis carrying the potential divider chain 1R94, 1R95, 1R96, 1RV14 and 1RV15.

8. The three plug-in assemblies are identical with those fitted in the indicator drive unit (Chap. 6). It should be noted that the velodyne amplifier assembly fitted in the computor is not identical with the equivalent assembly fitted in the test set and the indicator drive unit.

Functions of the controls (fig. 2)

9. The functions of the controls and other items mounted on the front panel are as follows:—

Oscilloscope controls

(1) Cathode ray tube (1V6). Displays waveform present in circuit selected by SCOPE SELECTOR switch.

(2) BRILL (1RV8). Controls brilliance of c.r.t. trace.

(3) FOCUS (1RV7). Controls focus of c.r.t. trace.

(4) VELOCITY (1RV9). Controls timbease speed within the limits set by the TIMEBASE switch.

(5) Y SHIFT (1RV5a/b). Shifts c.r.t. trace vertically.

(6) X SHIFT (1RV6a/b). Shifts c.r.t. trace horizontally.

(7) SYNC (1RV10). Controls level of signal fed to timebase for locking purposes.

(8) Y AMP GAIN (1SWD). Controls amplitude of signal applied to the input of the Y amplifier, in seven steps.

(9) TIMEBASE (1SWE). Sets timebase speed range.

Positions:
1 2·5 to 0·3 seconds
2 50 to 7·5 milliseconds
3 18 to 3 milliseconds
4 5 to 0·75 milliseconds
5 1·8 to 0·3 milliseconds.

(10) SCOPE SELECTOR (1SWC). Selects signal to be applied to the Y amplifier for display on the c.r.t. All signals reach the Y amplifier via the Y AMP GAIN control.

Positions:

SIG	Output of test set signal generator (cathode of 1V12).
AMC O/P	Output of a.m.c. assembly of transmitter-receiver (PLB20).
AGC	Output of a.g.c. circuit of tracking unit (PLN4) for observation of switching transients, etc.
P/W TONE	Output of photocell amplifier of computor (PLG39) or indicator drive unit (PLH7).
CAL	In this position, a 30mV peak-to-peak 400 c/s signal is applied to the Y amplifier for gain calibration.
EXT	Y AMP terminal connected to Y amplifier for monitoring external circuits.

(11) Y AMP and EARTH terminals. For the connection of any external circuit when the oscilloscope section of the unit is required for general waveform monitoring work.

Meter controls

(12) Meter engraved 10–0–10 (1M1). Indicates parameter of circuit selected by METER SELECTOR switch.

(13) METER SELECTOR (1SWA). See (12).

Positions:

MOD	Output of tone generator assembly of transmitter-receiver (PLB22) for check of modulation level applied to klystron.
AMC XTL	Output of a.m.c. crystal diode circuit of transmitter-receiver (PLB19) to provide indication of power output sample detected for a.m.c. circuit and indication of power output.
AMC O/P	Output of a.m.c. assembly of transmitter-receiver (PLB 20). This point can also be monitored by the c.r.t.
AGC	Output of a.g.c. circuit of tracking unit (PLN4). This point can also be monitored by the c.r.t.

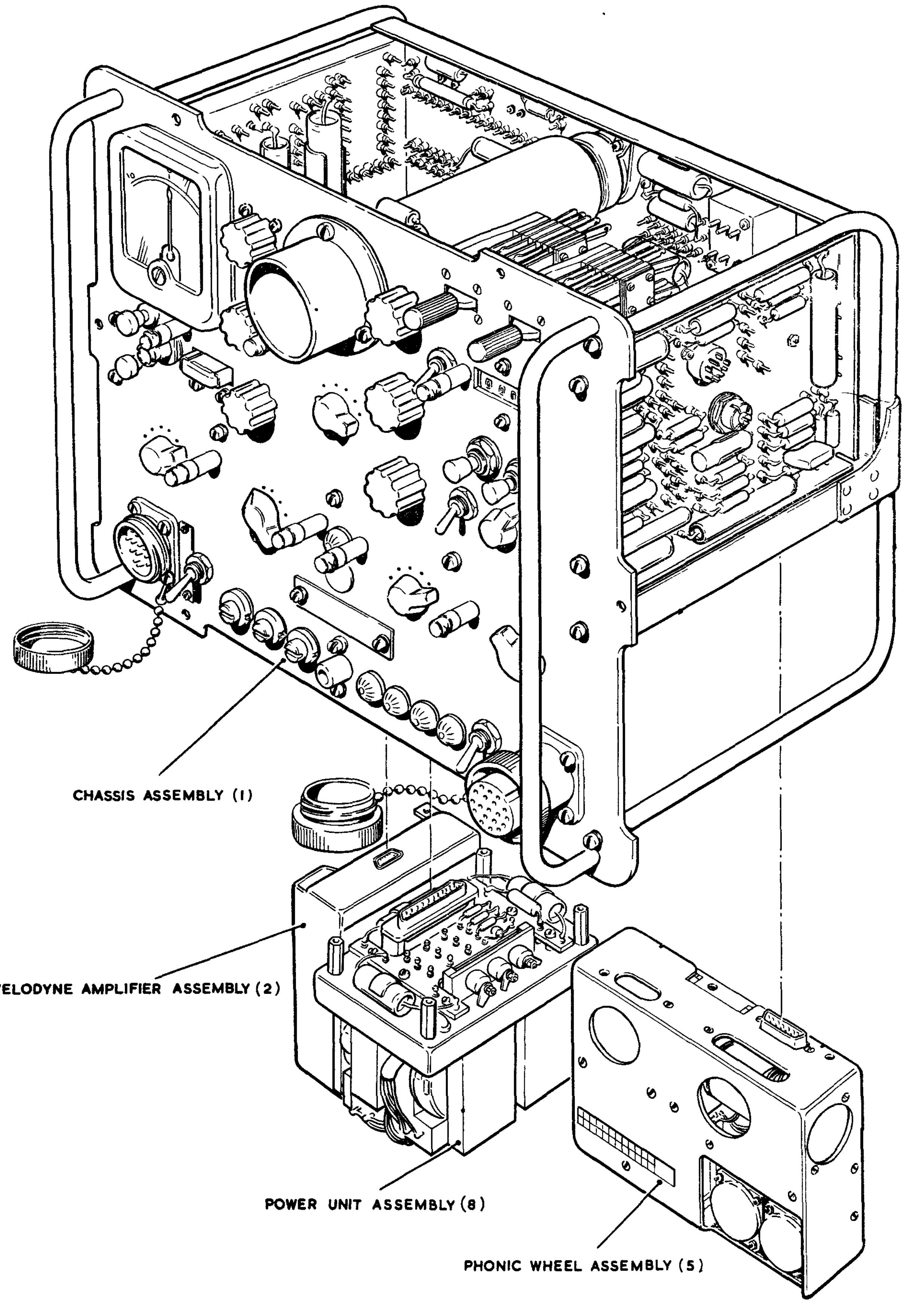


Fig. 1. General view of test set assemblies

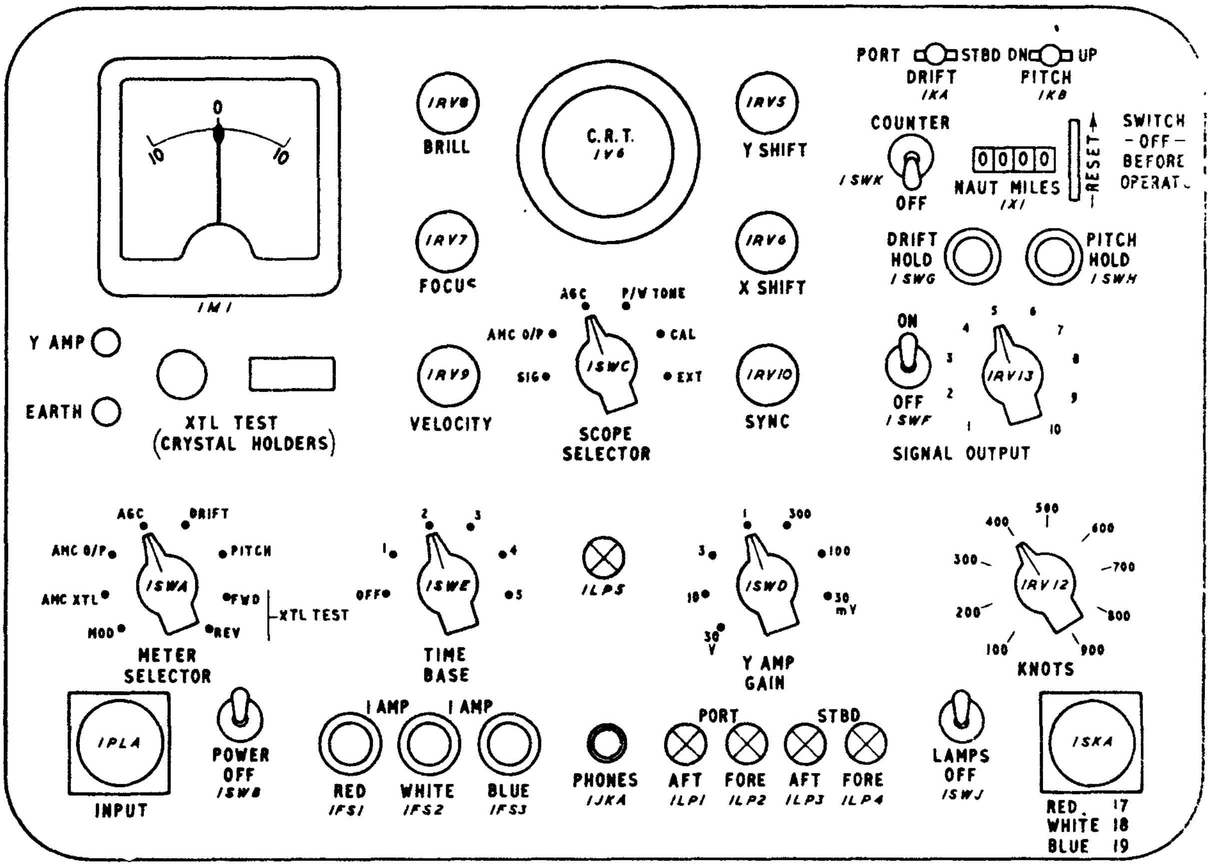


Fig. 2. Front panel controls

DRIFT — Output of drift servo amplifier 3V2 in aerial. Deflection of meter shows that the drift servo is responding to a drift error signal introduced by operation of the DRIFT key (17).

PITCH — Output of pitch a.c. pick-off 7X2 in tracking unit. Deflection of meter shows that the pitch servo is responding to a pitch error signal introduced by operation of the PITCH key (item 18).

FWD/REV XTAL TEST — For testing the two types of crystal used in the equipment in the forward and reverse directions of current.

Signal generator controls

(14) KNOTS (1RV12a and b). Controls frequency of simulated signal within a range equivalent to 100 to 900 knots.

(15) SIGNAL OUTPUT (1SWF and 1RV13). 1SWF is a toggle switch, labelled ON/OFF, which is wired in the signal path. It cuts off the signal when not required. 1RV13 controls the output level.

(16) PHONES (1JKA). Enables the output signal to be monitored with headphones. These must be of high impedance.

(17) DRIFT PORT, STBD (1KA). Causes the signal generator to simulate a drift error to check the operation of the drift servo system. Used in conjunction with the meter DRIFT circuit.

(18) PITCH DOWN, UP (1KB). Causes the signal generator to simulate a pitch error to check the operation of the pitch servo system. Used in conjunction with the meter PITCH circuit.

Miscellaneous

(19) DRIFT HOLD (1SWG). Stops the drift sense switching.

(20) PITCH HOLD (1SWH). Stops the pitch sense switching.

(21) PORT AFT, FORE and STBD AFT, FORE lights (1LP1 to 1LP4). Operated by the sense switching to show the direction of transmission.

(22) NAUT MILES (1X1). Calibrated in 0·1 mile steps to 999·9 nautical miles. It is driven from the signal generator portion of the test set.

(23) COUNTER/OFF (1SWK). Disconnects counter from the energizing pulses. Must be set to OFF before attempting to reset counter.

(24) XTL TEST crystal holders. For connecting the crystals undergoing test by the meter circuit. The two sockets are connected in parallel.

Supplies

(25) INPUT plug (1PLA). Input of test lines and power supply from installation junction box.

(26) POWER/OFF (1SWB). Switches the 115V (or 200V) 400 c/s power supply. Power "on" shown by amber indicator lamp 1LP5.

(27) RED, WHITE, BLUE fuses (1FS1, 1FS2, 1FS3). 1A power supply fuses. They are positioned to protect both the test set and any other equipment which may be connected to the socket 1SKA (item 29).

(28) LAMPS/OFF (1SWJ). Switches the 6·3V supply to the waveguide switch sequence lamps 1LP1 to 4 (item 21).

(29) RED 17, WHITE 18, BLUE 19 (1SKA). Makes available a power supply of 115V (or 200V) 400 c/s for other test equipment.

Brief description (fig. 3)

10. The SCOPE SELECTOR switch (1SWC) determines which signal is displayed on the c.r.t. The first four positions of the switch monitor various circuits in the installation, the fifth position brings in a calibrating voltage, and the final position connects the Y AMP terminals so that the unit can be used for general-purpose waveform monitoring. With the calibrating voltage selected, the gain of the Y amplifier can be adjusted with a preset resistor to give a trace of reference amplitude.

11. The chosen signal is passed to a potential divider network, and a fraction of the input, as decided by the position of the Y AMP GAIN switch (1SWD) is amplified by a three-stage amplifier 1V1 to 1V4 for application to the Y plates of the

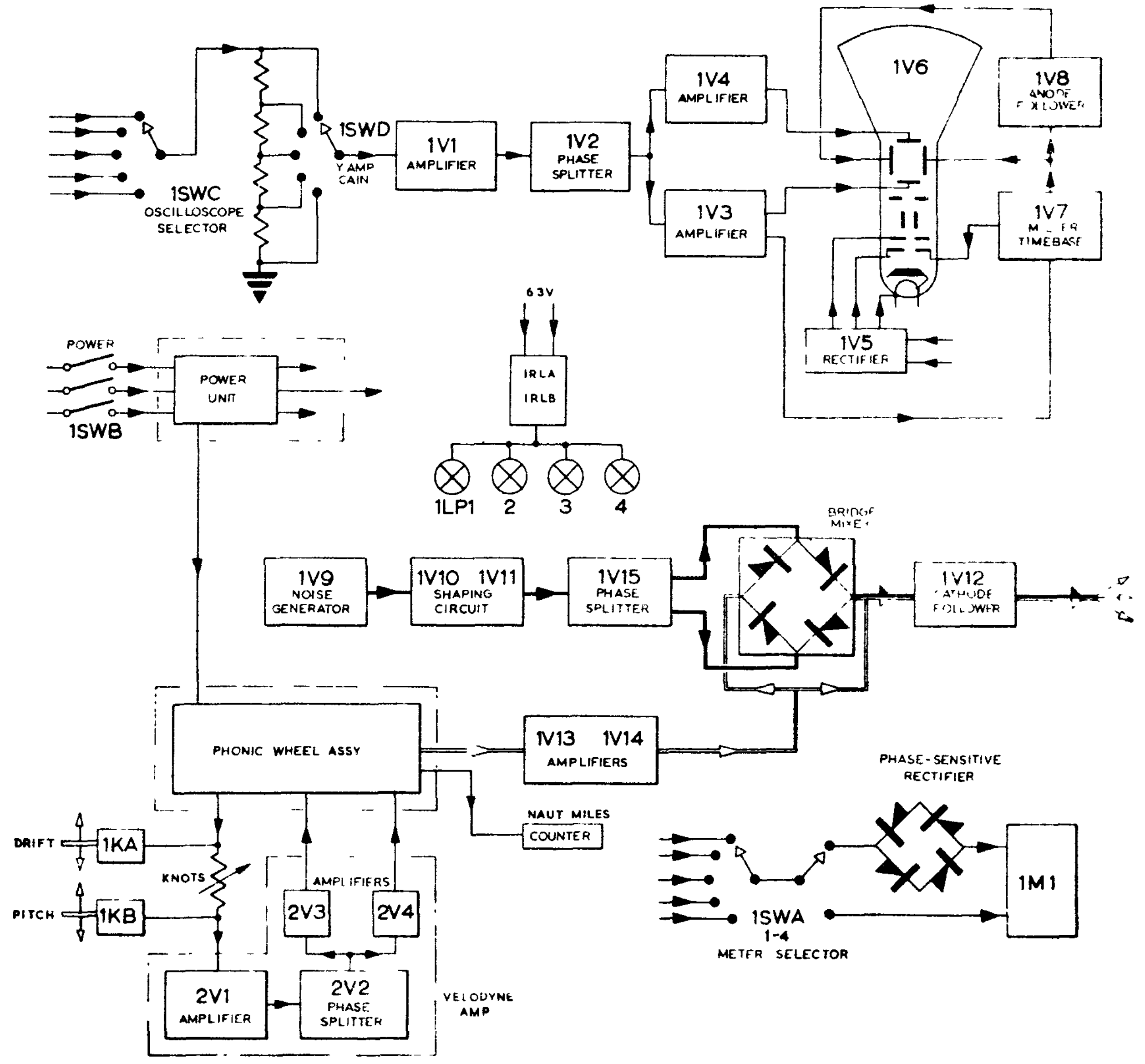


Fig. 3. Block diagram

c.r.t. The output stage 1V3, 1V4 is arranged in push-pull to give symmetrical deflection.

12. The timebase sweep waveform is generated by a Miller-transitron stage 1V7 and symmetrical deflection for the X plates is provided by a paraphase amplifier 1V8. A synchronizing signal for the timebase is fed from the Y amplifier, 1V3.

13. The simulated Doppler signal is produced by noise-modulating a variable-frequency tone. This tone is produced by the phonic wheel assembly at a frequency determined by the setting of the KNOTS control, while the noise is produced by a thyratron 1V9. Both the signal and the noise are amplified and passed to the mixer, which is of the double-balanced type and so produces an output consisting of sum and difference frequencies only. A cathode follower, 1V12, is interposed between the mixer and the output plug PLA pin 10. The SIGNAL OUTPUT level control is connected in the grid circuit of this stage.

14. The METER SELECTOR switch (1SWA) selects the required input signal for application to the meter circuit, which, for the drift and pitch tests, includes a phase-conscious detector arrangement. To carry out a pitch or drift servo test, key 1KA or 1KB is operated, as appropriate, and the signal generator simulates the corresponding error condition. Deflection of the meter needle then indicates that the servo system concerned is functioning.

15. The NAUT MILES counter 1X1 is operated by impulses from cam-operated contacts in the phonic wheel assembly. The impulses are fed to the counter via the COUNTER/OFF switch.

16. Two relays, 1RLA and 1RLB, are included in the test set. They are operated by the drift and pitch sense contacts in the aerial of the equipment under test in synchronism with the sense relays in the tracking unit. Their purpose is twofold:—

(1) to switch the PORT and STBD lamps 1LP1, 2, 3 and 4;

(2) to cause the signal generator to simulate a pitch or drift error signal when the appropriate key is operated.

17. Power supplies are derived from the 400 c/s input by the power assembly (component prefix No. 8) and by the circuit associated with transformer 1TR1 on the main chassis.

CIRCUIT DESCRIPTION

Oscilloscope circuits

18. Power supplies for the c.r.t. are derived from the power transformer 1TR1 (fig. 7) which is tapped to permit the use of a 115V or 200V input supply. The input supply from the installation is 3-phase, and this is conveyed from the input plug PLA pins 17, 18 and 19 to the fuses 1FS1, 2, and 3 via the POWER/OFF switch 1SWB (fig. 11). Transformer 1TR1 is fed from the white and blue phases and is protected by fuses 1FS2 and 3.

19. Secondary windings on 1TR1 provide an e.h.t. supply together with a 4V supply for the e.h.t. rectifier 1V5, and 6·3V supplies for the timebase valves, the c.r.t., and the panel lights. In addition, the transformer provides a 6·3V supply for the noise generator valves 1V9, 10, 11 and 12, and a 24V supply for the phase-sensitive rectifier circuit. The 140V h.t. supply is obtained from the power assembly.

20. The e.h.t. supply is smoothed by 1R54 and 1C13 and is then fed to a potential divider network consisting of 1RV8, 1R55, 1RV7, 1R53, which provides the various voltages required by the cathode, grid, and first anode of the c.r.t. The nominal cathode voltage is —700V. The grid voltage, negative with respect to the cathode, is adjusted by the BRILL control 1RV8, and the first anode voltage, positive relative to the cathode, is adjusted by the FOCUS control 1RV7. The second anode is fed from a further network 1R39, 1R40, which is connected to the +140V h.t. supply provided by the power assembly, as are also the ganged shift potentiometers 1RV5a and b and 1RV6a and b.

Timebase

21. The timebase generator consists of a Miller-transitron stage 1V7 and an anode follower paraphasing stage 1V8. Control of the sweep speed is obtained by varying the voltage to which the grid of 1V7 is returned with the VELOCITY potentiometer 1RV9. A number of speed ranges are made available by the TIMEBASE switch 1SWE. One wafer, 1SWE1, selects a combination of Miller capacitance and resistance from the components 1C20, 21, 22, 1R57, 58, while the other wafer, 1SWE2, selects a corresponding transitron capacitor. 1SWE2 also switches the h.t. supply to the timebase valves, and in the OFF position, the h.t. is cut off.

22. The sweep is synchronized by applying a small portion of the signal voltage from the Y amplifier output valve 1V3 to the suppressor grid of 1V7. The magnitude of this voltage is adjusted by the SYNC control 1RV10.

23. To prevent the flyback stroke from appearing on the screen of the c.r.t., a negative-going pulse developed in the screen-grid circuit of 1V7 during the transitron action is fed via 1C19 to the control grid of the c.r.t. The pulse is negatively d.c.—restored with respect to the bias voltage at the slider of 1RV8 by 1MR5. In addition, to ensure that the c.r.t. grid voltage is constant during the sweep period, the point from which the black-out pulse is taken is limited positively to the voltage at the junction 1R62, 1R63 by 1MR6. Thus the c.r.t. grid is held steady during the sweep, and is driven negative to black-out the trace during the flyback.

24 The sweep voltage appearing at the anode of 1V7 is applied to the paraphase amplifier 1V8. This valve produces an output substantially equal in amplitude but of opposite phase relative to the output of 1V7. The two outputs are applied to the

X plates of the c.r.t. via the blocking capacitors 1C16 and 1C17.

Y amplifier

25. The Y amplifier consists of three stages, 1V1, 1V2 and 1V3, 1V4 (fig. 8). Associated with the amplifier is a potential divider network 1R41—1R47. The signal to be displayed is chosen by the SCOPE SELECTOR switch 1SWC and passed via the blocking capacitor 1C2 to the top of the divider network. A fraction of this input is then passed by 1SWD to the first amplifier 1V1, and from thence via 1C5 to the phase splitter 1V2. The load resistor of 1V1 is in the form of a pre-set potentiometer which enables the signal level to be adjusted for gain calibration purposes. The phase splitter employs a triode-connected pentode, with half the load in the anode circuit and half in the cathode circuit. Voltages equal in magnitude but opposite in phase are developed at the anode and cathode respectively, and these are applied to the grids of the output valves 1V3, 1V4 in a push-pull arrangement. The outputs of 1V3, 1V4 are applied to the Y plates of the c.r.t. via the blocking capacitors 1C14, 1C15. In addition, a portion of the output of 1V3 is tapped off by 1RV10 to synchronize the timebase generator, as previously mentioned.

26. Gain calibration of the Y amplifier is effected by turning the SCOPE SELECTOR switch 1SWC to the CAL position, setting the GAIN switch 1SWD to 30mV, and adjusting 1RV4 to give a c.r.t. trace of reference amplitude. With 1SWC in the CAL position, a 30mV peak-to-peak 400 c/s test voltage is picked off at the junction 1R27, 1R26 from the 6·3V r.m.s. valve heater supply originating in the power assembly transformer 8TR2. As 1SWD is in the 30mV position, the full 30mV is applied to the amplifier 1V1. Adjustment of 1RV4 then varies the amplitude of signal passed on to the phase splitter and from thence through the output stage to the c.r.t. deflector plates. 1RV4 is set so that the peaks of the displayed waveform just touch the calibration lines on the screen graticule. The deflection resulting from the subsequent application of a test voltage is then proportional to 30mV, e.g. a trace of half the amplitude of the test signal indicates an input of 15mV and so on. To measure test voltages greater than 30mV the GAIN switch 1SWD is turned to a higher position. If, for example, the GAIN switch is set at 10V and the trace is half the calibration amplitude, the amplitude of the test voltage is 5V. It should be noted that the method of calibration gives results in terms of peak-to-peak voltages.

Signal generator circuits

27. The portions of the unit concerned in the generation of the simulated Doppler signal are the phonic wheel assembly (fig. 9), the velodyne amplifier (fig. 9), and the tone amplifier, noise generator and mixer circuits (fig. 10).

Tone

28. Dealing first with the tone generating sequence (fig. 9), a 24V, 400 c/s reference voltage is fed to transformer 5TR1 from 8TR1. Transformer 5TR1 supplies a resistive network which includes the speed control 1RV12b. From the wiper of this control a small 400 c/s voltage is fed to the input of the velodyne amplifier in series with the output of the tacho generator 5X1. The velodyne amplifier supplies the control winding of the phonic wheel motor 5MO1, while the reference winding is energized by a 115V supply from the power assembly. Motor 5MO1 rotates at a speed determined by the setting of the KNOTS control 1RV12b, velocity feedback being provided by the tacho generator 5X1. A filter, consisting of 5L1, 2, 3 and 5C1, 2 is included in the circuit of transformer 5TR1 to ensure that a pure waveform is applied to the energizing winding of 5X1 in phase quadrature with the reference supply to 5MO1. The velodyne amplifier and phonic wheel assemblies are similar to those used in the indicator drive unit.

29. Rotation of the phonic wheel causes a tone to be generated by the photocell 5V1 at a frequency determined by the setting of the KNOTS control 1RV12b, and this tone is passed to the amplifier 1V13 via 1TR2 (fig. 10).

30. The tone amplifier consists of two resistance-capacitance coupled stages 1V13 and 1V14. The tone input is fed to the primary winding of 1TR2, the secondary of which is damped by 1R117. As in the main equipment, a bias voltage is fed to the photocell from a potential divider network 1R97, 98, 99 connected between the h.t. line and earth. A preset gain control 1RV16 is interposed between the two stages. The output transformer 1TR3 is parallel-fed from the anode of 1V14 via 1C50.

Noise

31. The noise with which the simulated signal is generated originates in the thryatron 1V9. The circuit is arranged so that a small current flows into the grid of 1V9 from the h.t. line, and the noise output is tapped off at the junction 1R73, 74. This is fed via a preset level control 1RV11 to the grid of 1V10 which, with 1V11, forms a noise-shaping amplifier circuit. The higher-frequency components of the noise output of 1V9 are reduced by 1R75, 1C33.

32. The shaping amplifier incorporates a feedback capacitor 1C34 which is connected between the cathode circuit of 1V11 and the control grid of 1V10. As there is no phase reversal between the grid and cathode circuits of 1V11, this component is, in effect, a Miller capacitor connected between the anode and grid of 1V10. The resulting apparent capacitance between the grid of 1V10 and earth, together with the series resistor 1R76, gives the amplifier a falling amplitude/frequency response characteristic to simulate the shape of half the Doppler spectrum. In the air, however, the width of the received spectrum varies with the aircraft's speed, and to simulate this additional factor a variable component, 1RV12a, is included in the feedback circuit of the amplifier. This is ganged with the KNOTS control and changes the response shape of the amplifier simultaneously with changes of speed setting. The maximum output of the shaping amplifier occurs at approximately 20 c/s, falling to half-amplitude at about 700 c/s when the KNOTS control is set to the highest speed. At lower speed settings, the roll-off occurs at progressively lower frequencies, until at 100 knots the output is half the 20 c/s level at about 80 c/s.

Mixer

33. The noise output, now shaped to represent half the Doppler spectrum, is passed to the phase splitter 1V15 via 1C40. Anti-phase outputs from the cathode and anode of 1V15 are fed to the double-balanced mixer, the cathode output being adjustable by 1RV19 to equalize the two levels during setting-up operations. The mixer circuit causes the noise to modulate the phonic wheel tone introduced by 1TR3, and provides an output between the centre-tap of 1TR3 and earth which consists of the upper and lower sidebands only, the tone and original noise frequencies being suppressed. The two sidebands together simulate the Doppler spectrum which is derived by the equipment when the aircraft is in flight at a speed corresponding to the setting of the KNOTS control. Variable components 1RV17, 1RV18 and 1C52 are adjusted during setting-up operations to balance out the tone frequency.

34. From 1TR3, the signal is passed to the cathode follower output stage 1V12 via the SIGNAL OUTPUT level control 1RV13, and from thence to the SIGNAL input of the SCOPE SELECTOR switch 1SWC, the phone jack 1JKA, and to pin 10 of PLA. From this point the signal is fed, via the test set connector and the installation junction box, to the input transformer associated with 5V1 in the tracking unit search panel (fig. 6). An ON–OFF switch 1SWF is included in the output circuit.

Drift and pitch tests

35. Fig. 6 shows functionally the portions of the test set concerned with testing the operation of the drift servo system together with the appropriate parts of the Doppler installation.

36. As previously described, the control voltage for the phonic wheel velodyne is fed from transformer 5TR1 and is made variable by the KNOTS control 1RV12b. Besides the setting-up resistors 1RV14, 15, there are two fixed resistors 1R94 and 1R95. Associated with these two resistors are the PITCH and DRIFT keys 1KB and 1KA, and contacts of the pitch and drift sense relays, 1RLB3 and 1RLA2, respectively. With both keys normal, both relay contacts are disconnected, 1R94 is connected in series with the KNOTS control, and 1R95 is shorted out. The signal generator circuits then function as described, with the phonic wheel tone, at a frequency determined by the setting of the KNOTS control, being fed to the mixer together with the shaped noise spectrum from 1V9, 10, 11. At a level set by 1RV13, the simulated Doppler signal is passed to the equipment under test by a screened lead, where it is fed into the point in the tracking unit at which the real Doppler signal appears under operational conditions.

37. Within the equipment, the signal is tracked by the speed servo and the search, follow, and distance circuits can be checked. To simulate pitch and drift errors, use is made of the pitch and drift sense contacts in the aerial. These contacts operate the drift and pitch sense relays 1RLA and 1RLB in the tracking unit. When the test set is connected, the drift and pitch sense relays in the test set are placed in parallel with those in the tracking unit, and contacts 1RLA2 and 1RLB3 therefore operate in synchronism with the sense switching in the equipment.

38. If the PITCH key 1KB is thrown to either position, the short-circuit across 1R95 is broken, and the two resistors 1R94, 95 are together switched in and out of circuit by contacts 1RLB3. Similarly with the PITCH key normal and the DRIFT key 1KA thrown to either position, 1R94, 95 are switched in and out by contacts 1RLA2. Thus when either key is thrown, the value of resistance in series with the KNOTS control is alternately raised and lowered, the timing being determined by the switching of the corresponding sense relay, and the phasing by the position of the key UP or DOWN, PORT or STBD.

39. The switching of the series resistance when a key is thrown causes cyclic variations of the voltage applied to the velodyne, and this, in turn, produces corresponding variations in the frequency of the tone passed to the mixer. Thus the spectrum of the signal finally produced is shifted to and fro about the mean position in simulation of an error in the aerial drift or pitch plane, depending upon which key is operated.

40. Assuming that the DRIFT key is operated, the signal causes a 400 c/s error voltage to appear in the aerial drift servo control transformer 1X2 which is amplified and applied to the motor 1MO3. A portion of the error voltage is taken out through 3C5 to the test set where, when the METER SELECTOR switch 1SWA is set to DRIFT, it is passed to the phase-sensitive rectifier circuit 1MR1, 2, 3, 4. In this circuit the phase of the error sample is compared with that of a 400 c/s reference voltage from 1TR1. Unidirectional current is produced which passes through the meter 1M1, the direction of the current being dependent upon the relative phasing of the servo error voltage and the reference voltage from 1TR1. The sense of the connections is such that the meter needle moves to the right when the DRIFT key is thrown to STBD.

41. The general arrangement of the PITCH test circuit is similar to that described for the drift circuit except that, with the meter selector switch set to PITCH, the phase-sensitive rectifier is connected to the pitch pick-off 7X2 in the tracking unit. Deflection of the meter when the PITCH key is thrown indicates that a signal is reaching the pitch servo amplifier input (not the output, as in the drift circuit). The sense of the connections is such that the meter needle moves to the right when the PITCH key is thrown to UP.

42. For both drift and pitch tests the meter scaling is approximately 5–0–5 volts r.m.s. for full-scale deflection.

Meter circuits

43. The functions of the meter circuits in the pitch and drift tests are described in para. 40 above.

The remaining positions of the METER SELECTOR switch 1SWA are as follows.

MOD position

44. With the switch in the MOD position, the meter functions as an a.c. voltmeter to indicate the amplitude of the modulating tone produced by the tone generator assembly in the transmitter-receiver for application to the klystron (Sect. 1, Chap. 1). Connected across the output of the tone assembly is a rectifying circuit which feeds a unidirectional current through a series variable resistor 3RV2 to the test set PLA5. Within the test set the meter is switched in series with 1R20. Resistor 3RV2 in the tone generator is adjusted to give a reference deflection of the test set meter when the transmitter-receiver is set up (Sect. 2, Chap. 1).

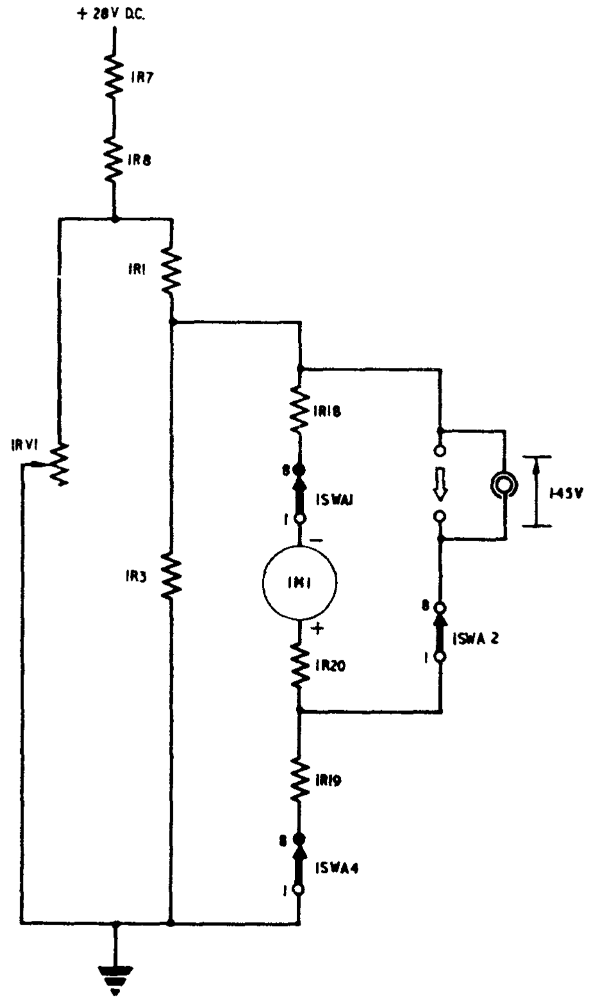


Fig. 4. Forward crystal test circuit

AMC XTL position

45. With the METER SELECTOR switch in the AMC XTAL position, the meter functions as a r.f. power meter to measure the power output of the transmitter. This is accomplished by connecting the meter as a d.c. voltmeter and causing it to indicate the d.c. component of the output of the a.m.c. crystal 1MR6 in the transmitter-receiver (Sect. 1, Chap. 1). The d.c. is fed from the transmitter-receiver PLB19 to the test set PLA12 and from thence to the meter in series with 1R6 and 1R20. Included in the transmitter-receiver is a series variable resistor 1RV4 which is adjusted during setting-up operations to calibrate the test set meter in terms of power output (Sect. 2, Chap. 1). The relationship between meter reading and power is not linear; readings of 4, 6, and 8, for example, represent powers of 450mW, 1W, and 1·8W respectively.

AMC O/P position

46. With the METER SELECTOR switch in the AMC O/P position, the meter functions as a d.c. voltmeter to measure the output of the a.m.c. assembly in the transmitter-receiver (Sect. 1, Chap. 1). This d.c. output is fed from the a.m.c. assembly to the grid of the e.h.t. control valve 1V14 and also to PLB20, from whence it is extended to the test set PLA9. Within the test set the meter is switched in series with 1R5 and 1R20. The meter scaling for the AMC O/P circuit is 2·5–0–2·5 volts d.c. for full-scale deflection.

AGC position

47. With the METER SELECTOR switch in the AGC position, the meter functions as a d.c. voltmeter to

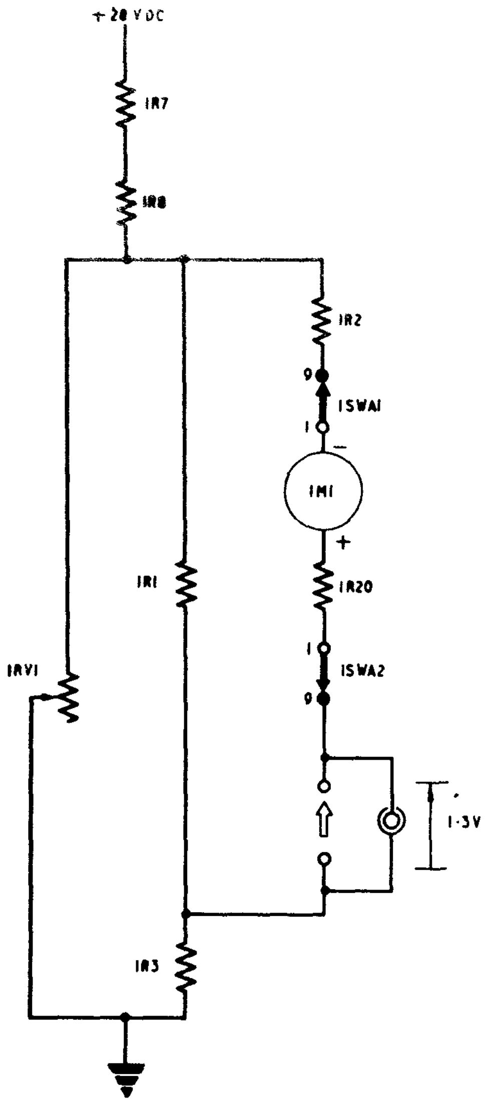


Fig. 5. Reverse crystal test circuit

measure the voltage on the a.g.c. line in the tracking unit (Sect. 1, Chap. 2). This voltage is fed from the a.g.c. and S/N assembly to the 1st i.f. amplifier in the aerial, and also to the test set PLA8. Within the test set the meter is switched in series with 1R9, 1R10 and 1R20. The meter scaling for the AGC circuit is 10–0–10 volts d.c. for full-scale deflection.

XTL TEST positions

48. With the METER SELECTOR switch in the XTL TEST positions, the circuit is as shown in fig. 4 for the forward current test, and as in fig. 5 for the reverse current test. In each instance, a known voltage, derived from the 28V d.c. supply, is applied to the crystal and the resulting current is measured by the meter. 1RV1 is adjusted during setting-up to give a known voltage across 1R3. For the forward test, the open-circuit voltage at the crystal holders is then 1·45V, and for the reverse test 1·3V.

SERVICING

General

49. The following paragraphs describe the tests and adjustments to preset components necessary to ensure that the test set is capable of assessing the performance of AD2300 equipments. The test set should not, however, be disturbed unnecessarily.

50. It is desirable that the correct supply voltage is maintained throughout the testing procedure. A warming-up period of 15 minutes should be allowed before making adjustments or taking measurements. Test apparatus should also be warmed up for the proper length of time.

Note . . .

Where electrolytic capacitors are used, these are of the tantalum type and do not require reforming.

51. Before commencing, the test set should be removed from its case, and, if the tests are to be followed through in sequence, the phonic wheel and power assemblies should be initially removed from the chassis assembly.

52. The three plug-in assemblies employed in the test set are identical with those of the same type in the indicator drive unit and would normally be interchangeable with them. If, however, it is necessary to interchange a phonic wheel assembly from a test set to an indicator drive unit, the assembly must be checked in accordance with the instructions for the indicator drive unit.

53. Where soldering action is called for during the tests, suitable thermal shunts should be employed.

Test equipment

54. (1) Multimeter, 20,000 ohms per volt.

(2) Signal generator, 20 c/s–50 kc/s.

(3) Valve voltmeter to measure voltages in the range of 9mV to 40V, 20 c/s–50 kc/s. For the noise tests, this should be of the mean reading type calibrated in terms of r.m.s. values on a sinusoidal input.

(4) Oscilloscope for the examination of waveforms and the measurement of time intervals in the range 300µS to 2·5 seconds.

(5) Stopwatch.

(6) High-impedance headphones.

(7) Power supply connector.

(8) Phonic wheel assembly extension connector.

(9) 1µF capacitor.

(10) 1K resistor.

(11) 100K resistor.

(12) 1·5V battery.

(13) 9V battery. For items (12) and (13) a 9V tapped grid bias battery is convenient.

PRELIMINARY ADJUSTMENTS AND TESTS

Chassis assembly: transformer tappings

55. The connections for the input voltage tappings on transformer 1TR1 are as follows:—

(1) 115 volts: blue phase to terminal 2
white phase to terminal 3

(2) 200 volts: blue phase to terminal 2
white phase to terminal 4.

Power assembly: transformer tappings

56. The input voltage links on transformer 8TR1 are as follows:—

(1) 115 volts; link terminals 1 to 4, 2 to 5, and 3 to 6.

(2) 200 volts: link terminals 4 to 7, 5 to 8, and 6 to 9.

Chassis assembly: setting KNOTS control

57. (1) Set multimeter on a range suitable for the measurement of 30 ohms resistance.

(2) Connect multimeter between slider and top end (clockwise direction) of 1RV12b (rear pot.) and set potentiometer to obtain 30 ohms resistance.

(3) Check that the control knob indicates 900 knots. If not, slacken the two knob-securing screws and re-position the knob on the spindle. Re-tighten the screws, at the same time ensuring that the required relationship of 30 ohms for an indicated 900 knots is maintained.

Chassis assembly: initial adjustment of 1RV2 and 1RV3

58. (1) Ensure that the METER SELECTOR switch is NOT in either PITCH or DRIFT position.

(2) Set 1RV2 and 1RV3 each to the centre of its travel.

Power supplies

59. It is essential that the power sources on the chassis assembly and power assembly are properly loaded when the following measurements are made. Ensure, therefore, that all three plug-in assemblies are in position.

60. The tests are made with the POWER, COUNTER, and LAMPS switches set ON. The TIMEBASE control can be set to any of the positions marked 1 to 5. The supply voltage should be 115V ±2% (or 200V ±2%).

(1) Direct voltages.

(a) H.T. (1RV6, X shift pot. to chassis): +140V ±5V.

(b) L.T. (1R7, in relay circuit, to chassis): +28V ± 1V.

(c) E.H.T. (1C18, c.r.t. cathode, to chassis): —700V ± 30V.

(d) Grid of 1V9 (pin 1, 1R73): +10V ±1V.

(e) Screen grid of 1V9 (pin 5, 1R115): —0·6V ±0·1V.

(2) Alternating voltages.

(a) Socket SKA, 17 (red), 18 (white), 19 (blue): 115V or 200V as appropriate.

WARNING . . .

Take care when making the following check. The heater is at e.h.t. voltage with respect to the chassis.

(b) E.H.T. rectifier heater (1V5, pins 3 and 4): 4V ±0·2V.

(c) All other valve heaters: 6·3V ±0·3V.

(d) P.W. tacho filter supply (8TR1, U and V): 40V ±2V.

Velodyne amplifier: direct voltages

61. Earth the control grid of 2V1 (pin 1, 2R4). Check the following voltages with respect to chassis.

(1) 2V3, 2V4 cathodes (pins 2, 2R15): +15V ±3V.

(2) 2V2 cathode (pin 2, 2R10): +77V ±7V.

(3) 2V1 cathode (pin 2, 2R7): +1V ± 0·3V.

62. Remove earth from 2V1 grid.

Velodyne amplifier: gain measurement

63. (1) Switch the test set OFF.

(2) On the phonic wheel assembly, disconnect the motor (5MO1) leads which terminate on terminals 1 and 3 respectively on the tag strip which is secured to transformer 5TR1. Access to the terminal strip is gained by releasing and opening the left-hand side hinged panel.

Note . . .

The colour coding of the leads on motor 5MO1 differs on early and later models, as indicated in the following table. The numbers are those on the tag strip on which the leads terminate.

Early version	*Later version*	*Tag*
Blue	Yellow	1
Green	Red	2
Yellow	White	3
Brown	Black	4
Red	Red/black	5
Black	Green	6

(3) On the velodyne amplifier assembly, disconnect the control grid (green lead) of 2V1 and connect a 1K resistor from this lead to chassis.

(4) Connect the output of the signal generator to 2V1 grid (green lead) via the 1μF capacitor and the 100K resistor.

(5) Switch the test set ON, and, after a suitable warming-up period, inject a signal of 10mV (measured at 2V1 grid) at a frequency of 400 c/s.

(6) With the valve voltmeter, check the output at the anodes of 2V3 and 2V4 (with motor 5MO1 stationary). The output should be between 20V and 40V r.m.s. with respect to chassis.

(7) Switch the test set OFF. Disconnect the oscillator, the 1K and 100K resistors and the 1μF capacitor.

(8) Re-connect the control grid of 2V1.

(9) On the phonic wheel assembly, re-connect the leads removed at (2) above.

Phonic wheel assembly: adjustment of photocell lamp 5LP1

64. The phonic wheel assembly should be connected to the chassis assembly with the appropriate extension connector.

(1) With the test set switched OFF, release the hinged panel which in turn permits the photocell assembly access door to be opened.

(2) Locate resistors 1R97 and 1R98 (on rear panel near c.r.t. base) and disconnect the inner of the screened lead which terminates at the junction of these two resistors.

(3) Connect the multimeter, on the 1mA d.c. range, between the disconnected lead and the junction of the resistors, positive of the meter to the tag (i.e. in series with the output of the photocell).

(4) Check the alignment of the filament of lamp 5LP1 in relation to the lens. Initially the filament should be positioned parallel to, and in line with, the centre of the lens. Parallel adjustment of the lamp in relation to the lens is accomplished by rotating the lamp within the housing. Vertical adjustment of the lamp in relation to the lens is obtained firstly by varying its position within the housing, and secondly by releasing the two screws securing the lamp housing to the access door and moving the housing up or down as required.

(5) Switch the test set ON.

(6) Adjust the position of the lamp, turning it within its holder if necessary, to obtain the highest current reading on the multimeter, reducing the range from 1mA to 50μA until photocell current is observed.

(7) If it has been necessary to adjust the position of the lamp housing, the securing screws should be tightened and locking varnish applied.

(8) Switch the test set to OFF.

(9) Disconnect the multimeter, and re-connect the screened lead to the junction 1R97, 1R98 unless the tone amplifier gain is to be checked, in which instance the lead should be left disconnected in readiness (para. 87).

(10) Remove the extension connector and refit the phonic wheel assembly to the chassis assembly.

Phonic wheel assembly: tacho excitation voltage

65. (1) Ensure that all three plug-in assemblies are in position. Switch the test set ON.

(2) Check the tachometer generator excitation voltage appearing across terminals 1 and 3 of transformer 5TR1 on the phonic wheel assembly. This should be 24V ±2V a.c.

(3) Check the speed potentiometer excitation voltage at terminals 1 and 2 of transformer 5TR1. This should be 4·75V ±0·4V a.c.

SETTING UP

66. It is assumed that all the tests previously described have been satisfactorily completed. The test set should be out of its case, and, with power applied, have been switched on for at least 15 minutes since the conclusion of the last test.

Meter circuits

Caution . . .

Before commencing the following tests, ensure that 1RV2 and 1RV3 are each set to the centre of travel (para. 58). This is essential to avoid the possibility of damage to the meter.

67. The meter 1M1 should first be adjusted for central reading. Set the METER SELECTOR switch to AGC, place the test set on its back, and adjust the mechanical control for exact zero.

MOD position

68. (1) With the test in normal attitude, set the METER SELECTOR to MOD.

(2) Connect the negative terminal of the 1·5V battery to chassis. Switch the 20,000 ohms/volt multimeter to the 2·5 volts d.c. range. Connect the positive terminal of the multimeter to the positive terminal of the battery, and the negative terminal of the multimeter to pin 5 of plug PLA.

(3) The percentage of full-scale deflection of the test set meter 1M1 should be equal to that of the multimeter ±5% and should be to the right.

(4) Remove the connection to pin 5 of PLA.

AMC XTL position

69. (1) Set the METER SELECTOR to AMC XTL.

(2) Connect the positive terminal of the multimeter to the battery as in (2) above, range 2·5V d.c., and connect the negative terminal to pin 12 of PLA.

(3) As for (3) above.

AMC O/P position

70. (1) Set the METER SELECTOR to AMC O/P.

(2) Connect the negative terminal of the 1·5V battery to chassis, and the positive terminal to pin 9 of PLA.

(3) Using the 2·5V d.c. range, connect the multimeter across the battery so that it registers the battery voltage.

(4) The reading obtained on the meter 1M1 should agree with the multimeter within ±5%. Meter 1M1 should be deflecting to the right.

AGC position

71. (1) Set the METER SELECTOR to AGC.

(2) Connect the negative terminal of the 9V battery to chassis, and the positive terminal to pin 8 of PLA.

(3) Using the 10V d.c. range, connect the multimeter across the battery so that it registers the battery voltage.

(4) The reading obtained on the meter 1M1 should agree with the multimeter within ±5%. Meter 1M1 should be deflecting to the right.

Crystal test voltage: adjustment of 1RV1

72. (1) Set the multimeter to the 2·5V d.c. range. Connect the negative terminal to chassis and the positive terminal to the outer pole of the coaxial crystal holder.

(2) Adjust 1RV1 for a reading of 1·8 volts.

Note . . .

The following two tests, FWD XTL *position and* REV XTL *position, will cause the meter 1M1 to exceed full-scale deflection to the left, but will not cause damage.*

FWD XTL position

73. (1) Set the METER SELECTOR to FWD XTL.

(2) With the multimeter, check the voltage across each crystal holder. These voltages should be equal, and should be between 1·4V and 1·5V d.c. The outer pole of the coaxial holder and the arrow 'tail' contact on the tray should both be positive.

(3) Switch the multimeter to the 1mA range and again connect it to one of the crystal holders. The current should be between 0·6mA and 0·7mA.

REV XTL position

74. (1) Set the METER SELECTOR to REV XTL.

(2) With the multimeter, check the voltage across each crystal holder. This should be between 1·15V and 1·45V d.c. The inner pole of the coaxial holder and the arrow 'head' contact on the tray should both be positive.

(3) Switch the multimeter to the 250μA range and again connect it to one of the holders. The current should be between 105μA and 145μA.

PITCH and DRIFT positions

75. (1) Set the METER SELECTOR to PITCH.

(2) Switch the multimeter to the 50μA range and connect it between pin 2 and pin 7 (chassis) of PLA.

(3) Adjust 1RV3 to produce minimum deflection on the multimeter, and 1RV2 to produce minimum deflection on meter 1M1.

(4) Repeat the above adjustments until both meters read zero.

Oscilloscope circuits

SHIFT controls

76. Check the action of the X and Y shift controls; clockwise for 'right' and 'up' movement respectively.

BRILL control

77. Check the action of the brilliance control; clockwise for increase. It should be possible to extinguish the trace by turning the control counter-clockwise.

FOCUS control

78. Check that satisfactory focusing is obtained.

TIMEBASE and VELOCITY controls

79. (1) Check that the timebase collapses when the TIMEBASE switch is turned to OFF.

(2) Check the length of the timebase trace on each range. This should exceed 1 inch at all positions of the VELOCITY control.

(3) Check that the brilliance does not vary unduly over the trace length.

(4) Connect the Y input of the test oscilloscope to the anode of 1V7 (pin 4, 1R60). Check that the timebase appears to be linear at each end of the range.

(5) Measure the time of sweep at each end of each range. These times should be within 30% of the following:—

1	2·5 to 0·3 seconds
2	50 to 7·5 milliseconds
3	18 to 3·0 milliseconds
4	5 to 0·75 milliseconds
5	1·8 to 0·3 milliseconds.

Y amplifier calibration voltage

80. (1) Connect the valve voltmeter between the junction 1R26, 1R27 and chassis.

(2) The 400 c/s voltage at this point should be 10·6mV r.m.s. (30mV peak to peak) ±10%.

Y amplifier calibration

81. (1) Set the SCOPE SELECTOR to CAL.

(2) Set the Y AMP GAIN switch to 30mV.

(3) Adjust 1RV4 so that the peaks of the trace observed on the c.r.t. extended to the upper and lower calibration lines of the graticule.

SCOPE SELECTOR switch and SYNC control

82. (1) Set the SCOPE SELECTOR to EXT.

(2) Connect the output of the signal generator, set to a frequency of 1 kc/s, between the Y AMP and EARTH terminals.

(3) Check the action of the SYNC control.

(4) By increasing the output level from the signal generator, check that a deflection of full tube diameter can be obtained without clipping or visible distortion.

(5) Disconnect the signal generator lead from the Y AMP terminal (leaving the other connected to the EARTH terminal) and connect it in turn to pins 10, 9, 8, and 1 of plug PLA, simultaneously turning the SCOPE SELECTOR to SIG, AMC O/P, AGC and P/W TONE respectively. A trace of the same amplitude should be obtained at each switch position.

(6) Reconnect the generator lead to the Y AMP terminal in readiness for the next test.

Y amplifier gain

83. (1) Continuing from the previous test, and with the signal generator still set to 1 kc/s, set the SCOPE SELECTOR to EXT.

(2) Set the Y AMP GAIN switch to 30mV.

(3) Adjust the output of the signal generator so that the peaks of the trace observed on the c.r.t. extend to the upper and lower calibration lines on the graticule.

(4) Using the valve voltmeter or the oscilloscope, measure the input at the Y AMP terminal.

(5) Repeat the procedure with the Y AMP GAIN switch set to each of its other positions in turn.

(6) The input required in each instance should agree with the Y AMP GAIN switch setting within ±15%. Note that this switch is calibrated in peak-to-peak values. Table 1 shows the limits of the voltages to be obtained in both peak-to-peak and r.m.s. values.

TABLE 1

Y AMP GAIN switch positions and input levels at ±15% limits

Switch position	*R.M.S. values*	*Peak-to-peak values*
30mV	9·0 to 12·2mV	25·5 to 34·5mV
100mV	30 to 41mV	85 to 115mV
300mV	90 to 122mV	255 to 345mV
1V	0·3 to 0·41V	0·85 to 1·15V
3V	0·9 to 1·22V	2·55 to 3·45V
10V	3·0 to 4·1V	8·5 to 11·5V
30V	9·0 to 12·2V	25·5 to 34·5V

Y amplifier frequency response

84. (1) Continuing from the previous tests, with the signal generator connected to the Y AMP terminal, frequency 1 kc/s, SCOPE SELECTOR to EXT, set the Y AMP GAIN switch to 100mV.

(2) Adjust the output of the signal generator so that the peaks of the c.r.t. trace extend to the upper and lower calibration lines on the graticule. Measure the input level.

(3) Repeat the procedure at frequencies of 20 c/s and 50 kc/s.

(4) The Y amplifier should not be more than 0·5dB down at 20 c/s, nor more than 6dB down at 50 kc/s, i.e. the input voltage measured at 20 c/s should not be more than 1·06 times the input at 1 kc/s and the input measured at 50 kc/s should not be more than twice the input at 1 kc/s.

Speed potentiometer: setting-up with counter check

Caution . . .

It is essential to ensure that the setting of the KNOTS control knob has been checked as detailed in para. 57 before proceeding. Also, the equipment must be at optimum working temperature; the COUNTER *switch should have been* ON *during the warm-up period.*

Adjustment of 1*RV*14 *and* 1*RV*15

85. (1) Set KNOTS control to 800 knots.

(2) Using the stopwatch, adjust 1RV14 to produce 100 counts in 45 seconds ±0·5 second. (Each count represents 1/10 n. mile.)

(3) Set the KNOTS control to 200 knots.

(4) Using the stopwatch, adjust 1RV15 to produce 25 counts in 45 seconds ±0·5 second

(5) Repeat (1) to (4) above until the correct number of counts is obtained in the given time at both speed settings.

(6) Finally, check that at:

(a) 900 knots, 100 counts are obtained in 40 seconds ±0·5 second; and at

(b) 100 knots, 25 counts are obtained in 90 seconds ±2 seconds.

(7) Switch the counter OFF. Check that it can be reset to zero.

Sense checks

86. The following checks cover the operation of relays 1RLA, 1RLB and the associated circuits, operation of the DRIFT and PITCH keys, the DRIFT HOLD and PITCH HOLD buttons, the indicator lamps, and the PHONES jack.

(1) Set LAMPS switch to ON. The PORT AFT lamp should light.

(2) Press the DRIFT HOLD button. The STBD AFT lamp should light. Release the button and short PLA pin 14 to pin 15 (chassis). The same lamp should light.

(3) Press the PITCH HOLD button. The STBD FORE lamp should light. Release the button and short PLA pin 16 to pin 13 (chassis). The same lamp should light.

(4) Press the DRIFT HOLD and PITCH HOLD buttons at the same time. The PORT FORE lamp should light.

(5) Plug high impedance headphones into the PHONES position. A signal should be heard.

(6) Set the KNOTS control to 900 knots.

(7) Set either DRIFT or PITCH key to the right, i.e. STBD and UP positions respectively. Using the headphones, a slight increase in frequency should be heard.

(8) Setting either DRIFT or PITCH key to the left, i.e. PORT and DOWN respectively, should result in a slight decrease in frequency being heard.

(9) Press the DRIFT HOLD button and set the DRIFT key to STBD. The frequency should decrease slightly.

(10) Press the PITCH HOLD button and set the PITCH key to UP. The frequency should decrease slightly.

(11) Press the DRIFT HOLD button and set the DRIFT key to PORT. The frequency should increase slightly.

(12) Press the PITCH HOLD button and set the PITCH key to DOWN. The frequency should increase slightly.

Signal generator circuits

Tone amplifier

87. (1) Connect the test oscilloscope and valve voltmeter to the top of 1C50.

(2) Set 1RV16 fully clockwise and note the maximum residual hum and noise level. This should be less than 1·75V r.m.s.

(3) Set the valve voltmeter to its highest voltage range for safety.

Note . . .

If the inner conductor of the screened lead wired to the junctions 1*R*97, 1*R*98 *was not disconnected for adjustment of the photo-cell excitation lamp (para.* 64), *it should be disconnected now, before proceeding to the following gain tests.*

(4) Connect the output of the signal generator to the junction 1R97, 1R98 via the 1μF capacitor and 100k resistor.

(5) Set the signal generator frequency to 5 kc/s and increase the level of the input to the amplifier until clipping is observed on the oscilloscope. The output level, just before clipping occurs, should be greater than 10V r.m.s.

(6) Switch the test set OFF.

(7) Connect the valve voltmeter between the junction 1R97, 1R98 and chassis. Set the signal generator to 10 kc/s and adjust its output to produce a level of 12·5mV at this point.

(8) Disconnect the valve voltmeter from the junction 1R97, 1R98 and connect it to the output of the signal generator. Note the reading obtained.

(9) With the signal generator set to 1 kc/s, repeat (7) and (8) above.

(10) With the valve voltmeter still connected to the output of the signal generator, reduce the output level of the generator until the reading has fallen to one-tenth of its previous value. Disconnect the valve voltmeter. The object of this procedure is to set the input to the amplifier at 1·25mV, 1 kc/s. The reading obtained at 10 kc/s will be used later.

(11) Switch the test set ON.

(12) After a suitable warming-up period, connect the valve voltmeter to the top end of 1C50. The output should be greater than 6·0V r.m.s. Disconnect the valve voltmeter.

(13) Set the oscillator to 10 kc/s. Connect the valve voltmeter across the output of the signal generator, and adjust the output level to one-tenth of the value obtained at (8) above. This is to set the input to the amplifier at 1·25mV, 10 kc/s. Disconnect the valve voltmeter.

(14) Connect the valve voltmeter to the top end of 1C50. The output should be greater than that obtained at (12) above.

(15) Switch the test set OFF.

(16) Disconnect the signal generator, the 1μF capacitor and the 100k resistor, and reconnect the inner of the screened lead to the junction 1R97, 1R98.

(17) Switch the test set ON.

(18) Set the KNOTS control to 100 knots and 900 knots in turn. The outputs obtained at 1C50 at these speeds, relative to 1 kc/s and 10 kc/s respectively, should not be less than those obtained at (12) and (14) above.

(19) Set the KNOTS control to 600 knots.

(20) Adjust 1RV16 to obtain 7·0V r.m.s. (20V peak-to-peak) output at 1C50.

(21) Check that the waveform obtained is reasonably sinusoidal and that when the speed is varied from 100 to 900 knots the output does not fall below 5·0V r.m.s. (14V peak-to-peak).

(22) Disconnect the test oscilloscope and valve voltmeter.

Noise shaper

88. (1) Set the KNOTS; control to 600 knots.

(2) Connect the test oscilloscope and valve voltmeter to the top end of 1R112 (cathode 1V15).

(3) Adjust 1RV11 to obtain 3·5V as measured on the valve voltmeter. The oscilloscope should show 20V peak-to-peak. The waveform should be random noise and should not contain any tone component, nor should it be clipped at top or bottom.

(4) Set the KNOTS control to 900 knots and 200 knots in turn. The amplitude at 900 knots should increase slightly on that obtained at (3) above, and at 200 knots fall to less than one-half that level.

(5) Switch the test set OFF.

(6) Disconnect that end of 1R75 which joins the junction 1R73, 1R74 (rear end).

(7) Connect the free end of 1R75 to earth via the 1K resistor.

(8) From the junction of 1R75 and the 1K resistor, connect the 100K resistor to the output of the signal generator via the 1μF capacitor.

(9) Switch the test set ON and allow a suitable warm-up period.

(10) Set the signal generator to 20 c/s and increase the output of the generator so as to obtain the maximum output from the circuit under test without overloading, as observed on the test oscilloscope. This maximum should be greater than 9·0V r.m.s. (25V peak-to-peak).

(11) Set the KNOTS control to 200 knots. Adjust the input to give an output of approximately 5V r.m.s. (14V peak-to-peak). Then adjust the frequency of the signal generator for maximum output.

Note . . .

At 200 knots, the maximum output will generally appear in the region of 20 c/s. Should the maximum output appear to be below the minimum frequency available from the generator, it may be taken that the maximum output occurs at 20 c/s.

(12) Adjust the input to given an output of 5·0V r.m.s. (14V peak-to-peak).

(13) Slowly increase the frequency of the signal generator up to 200 c/s. The output should fall to 2·5V r.m.s. (7V peak-to-peak) at a frequency between 125 and 200 c/s.

(14) Set the KNOTS control to 800 knots. Repeat (12) and (13) above, but take the signal generator up to 800 c/s. The output should fall by one-half at a frequency between 500 and 800 c/s.

(15) Disconnect the signal generator. Check the hum level. This should be less than 150mV r.m.s. (0·5V peak-to-peak).

(16) Switch the test set OFF. Disconnect the 1K and 100K resistors and the 1μF capacitor, and reconnect 1R75 to the junction 1R73, 1R74.

(17) Switch the test set ON, and after a suitable warming-up period set the KNOTS control to 600 knots. Check the output. It should be the same as set at (3) above.

(18) Disconnect the test oscilloscope and valve voltmeter.

Mixer tone balance

89. (1) Set the KNOTS control to 600 knots.

(2) Set the SCOPE SELECTOR to SIG.

(3) Set the SIGNAL OUTPUT switch to ON and the SIGNAL OUTPUT control to maximum. Observe the signal on the test set c.r.t.

(4) Connect the test oscilloscope to the rear end of 1C42 and obtain a synchronizing voltage from the top end of 1C50.

(5) Short 1V11 grid to earth.

(6) Adjust 1RV17, 1RV18 and 1C52 for minimum output as observed on the test oscilloscope.

Mixer noise balance

90. (1) Remove short from 1V11 grid.

(2) Remove the test oscilloscope synchronizing connection from 1C50.

(3) Synchronize the test oscilloscope from a heater line. (Note that one side of the heater supply is earthed.)

(4) Short the top end of 1C50 to chassis.

(5) Adjust 1RV19 for minimum noise on the test oscilloscope.

(6) Remove short from the top end of 1C50. Connect the valve voltmeter to the rear end of 1C42.

(7) The voltage indicated should be greater than 1·5V r.m.s. (8·5V peak-to-peak), falling when the knots control is set to speeds below 600 knots.

(8) Connecting either the control grid of 1V11 or the top end of 1C50 to chassis should cause the output, observed as at (7) above, to drop by more than 30dB at any speed in the range 100–900 knots.

(9) Remove the test oscilloscope, valve voltmeter, and test connections.

TABLE 2

Fault location

Fault	*Possible cause*	*Remedial action*
Power ON lamp fails to light, but panel illumination lamps light when POWER switch is set to ON.	Defective lamp 1LP5	Replace 1LP5.
Power ON lamp and all panel illumination lamps fail to light when POWER switch set to ON.	(a) Open-circuit fuse	Check 1FS2, 1FS3. If defective: ascertain if overload conditions present thus causing rupture of fuse. Clear fault, replace fuse(s).
	(b) Transformer 1TR1 defective	Check transformer and associated circuits. **WARNING: HIGH VOLTAGE**
Counter (1X1) not functioning when COUNTER/OFF switch set to COUNTER and POWER switch set to ON, but PORT/STBD, FORE/AFT lamps operating correctly.	(a) Mechanical damage to counter (1X1)	Inspect 1X1, replace if damaged.
	(b) Contacts 5SWA defective	Inspect contacts, replace if defective.
	(c) Low or no 28V d.c. supply to contacts 5SWA	Check supply voltage.
	(d) Rectifier 1MR11 defective	Check, replace if defective.
Counter (1X1) not functioning PORT/STBD, FORE/AFT lamps not operating, and meter (1M1) not functioning when METER SELECTOR switch set to XTL TEST position.	No 28V d.c. supply from power assembly	Check rectifiers 8MR5, 8MR6, 8MR7 and transformer 8TR1 winding PLMN. Replace defective items. Check 1MR11 for short circuit; replace if defective.
Counter (1X1) operating but not producing correct number of counts for a given setting of KNOTS control.	(a) Mechanical damage to counter (1X1)	Inspect 1X1, replace if damaged.
	(b) Incorrect d.c. supply to contacts 5SWA	Check voltage.
	(c) Rectifier 1MR11 defective	Check 1MR11, replace if defective.
	(d) Incorrect on/off ratio of contacts 5SWA	Change assembly.
	(e) Frequency/speed relationship of simulated signal incorrect	See below.

TABLE 2—(contd.)

Fault location

Fault	*Possible cause*	*Remedial action*
Frequency/speed relationship of simulated signal incorrect.	(a) Incorrect positioning of KNOTS control on spindle of 1RV12	Check position as detailed in para. 57.
	(b) Maladjustment of 1RV14	See para. 85.
	(c) Maladjustment of 1RV15	See para. 85.
	(d) Tone amplifier gain incorrect	Check adjustment of 1RV16. See para. 87.
	(e) Noise shaper gain incorrect	Check adjustment of 1RV11. See para. 88.
	(f) Bridge balance incorrect	Check adjustment of 1RV17, 1RV18, 1C52. See para. 89.
	(g) Velodyne amplifier assembly gain incorrect	Check gain as detailed in para. 63.
	(h) Phonic wheel assembly defective—excessive stiction	Change assembly.
	(i) Tachogenerator (5X1) excitation voltage incorrect	Check that 24V ±2V a.c. are present across terminals 1 and 3 of 5TR1. If incorrect: check 5TR1, 5C1, 5C2, 5C3, and supply from 8R2, 8TR1 (40V ±2V a.c. across terminals U, V).
	(j) Speed potentiometer (1R94, 1R95, 1RV14, 1RV12b, 1RV15) excitation voltage incorrect	Check voltage across terminals 1 and 2 of 9TR1. This should be 4·75V ±0·4V a.c. If incorrect, check as in (i).
Low output from photo-electric cell 5V1 in phonic wheel assembly.	(a) Incorrect positioning of lamp 5LP1	Check adjustment as detailed in para. 64. If adjustment of lamp does not affect required results, replace 5LP1, check 5R2.
	(b) 5V1 unserviceable	Replace 5V1.
Low simulated signal output level.	(a) Noise shaper gain incorrect	Check adjustment of 1RV11. See para. 88.
	(b) Tone amplifier gain incorrect	Check adjustment of 1RV16. See para. 87.
	(c) Bridge balance incorrect	Check adjustment of 1RV17, 1RV18, 1C52. See para. 89.
	(d) Cathode-follower 1V12 defective	Check 1V12, and associated components. H.T. at anode 1V12 is 140V ±5V d.c. with respect to chassis.
	(e) Low output from 5V1 in phonic wheel assembly	See previous fault.
Excessive noise on simulated signal.	Incorrect adjustment of 1RV19	Check adjustment. See para. 90.
Incorrect crystal current readings on meter 1M1 when METER SELECTOR switch set to either XTL TEST position.	(a) Maladjustment of 1RV1	Check adjustment. See para. 72.
	(b) Incorrect d.c. supply to 1RV1	Check that 28V ±1V d.c. are present at 1R7 with respect to chassis.
X and Y SHIFT controls not effective.	Low d.c. supply to 1RV5, 1RV6 (shift controls)	Check 140V ±5V d.c. supply to 1RV5, 1RV6. If incorrect, check h.t. circuit.
Excessive brilliance of c.r.t. trace.	Decrease in ohmic value of 1R54, 1RV8, 1R56	Check resistors, replace if defective.

TABLE 2—(contd.)

Fault location

Fault	*Possible cause*	*Remedial action*
Insufficient brilliance of c.r.t. trace.	(a) Increase in ohmic value of 1R54, 1RV8, 1R56	Check resistors, replace if defective.
	(b) Low e.h.t. supply	Check e.h.t. supply (—700 ±30V) at 1C18 with respect to chassis. **WARNING: OBSERVE SAFETY PRECAUTIONS.** If low, check 1C12, 1C13, 1C11, 1C18, 1V5.
When SCOPE SELECTOR switch is set to CAL position with Y AMP GAIN switch set to 30mV position, peaks of trace on c.r.t. do not extend to upper and lower calibration lines of the graticule.	Maladjustment of 1RV4	Set up 1RV4 as detailed in para. 81.

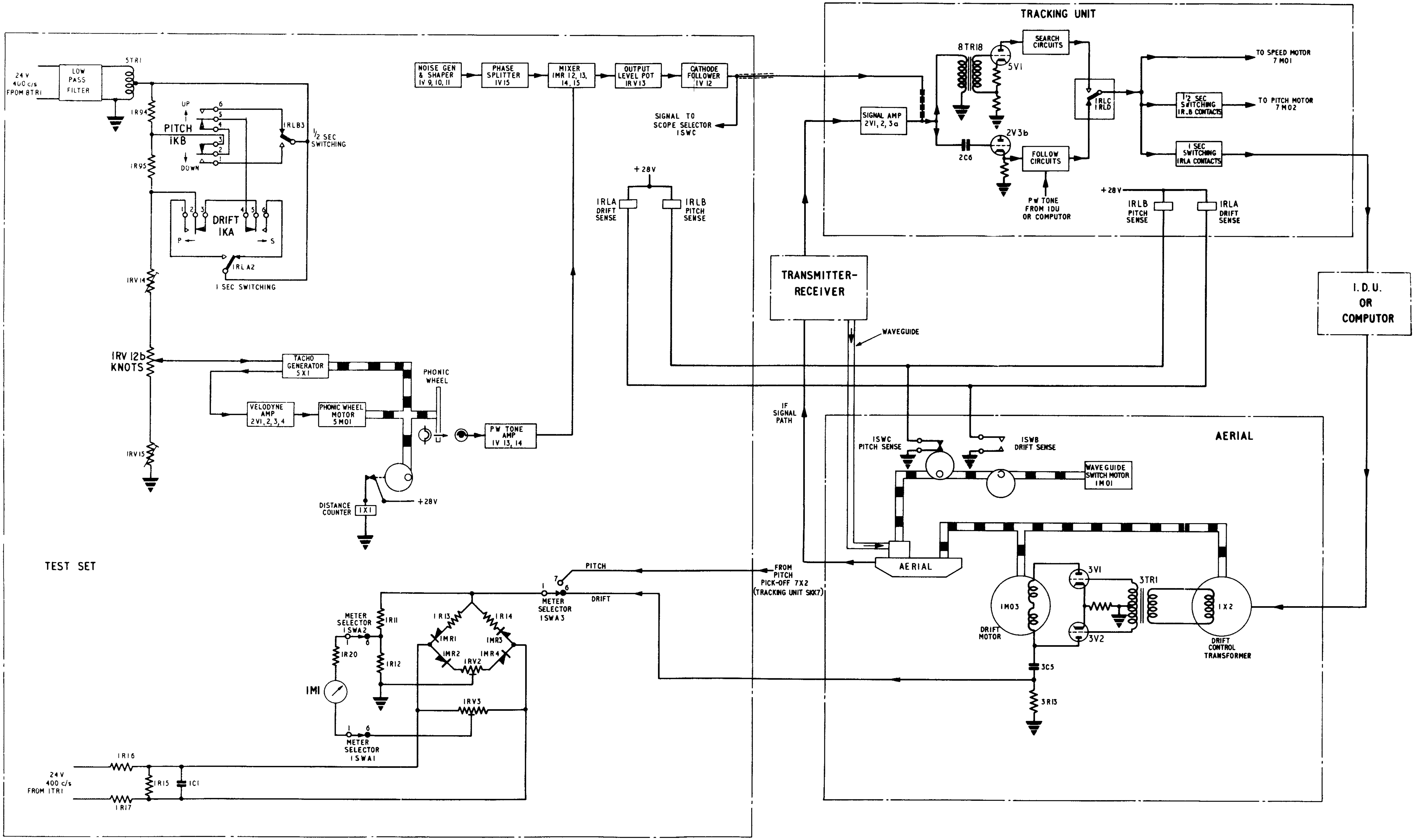
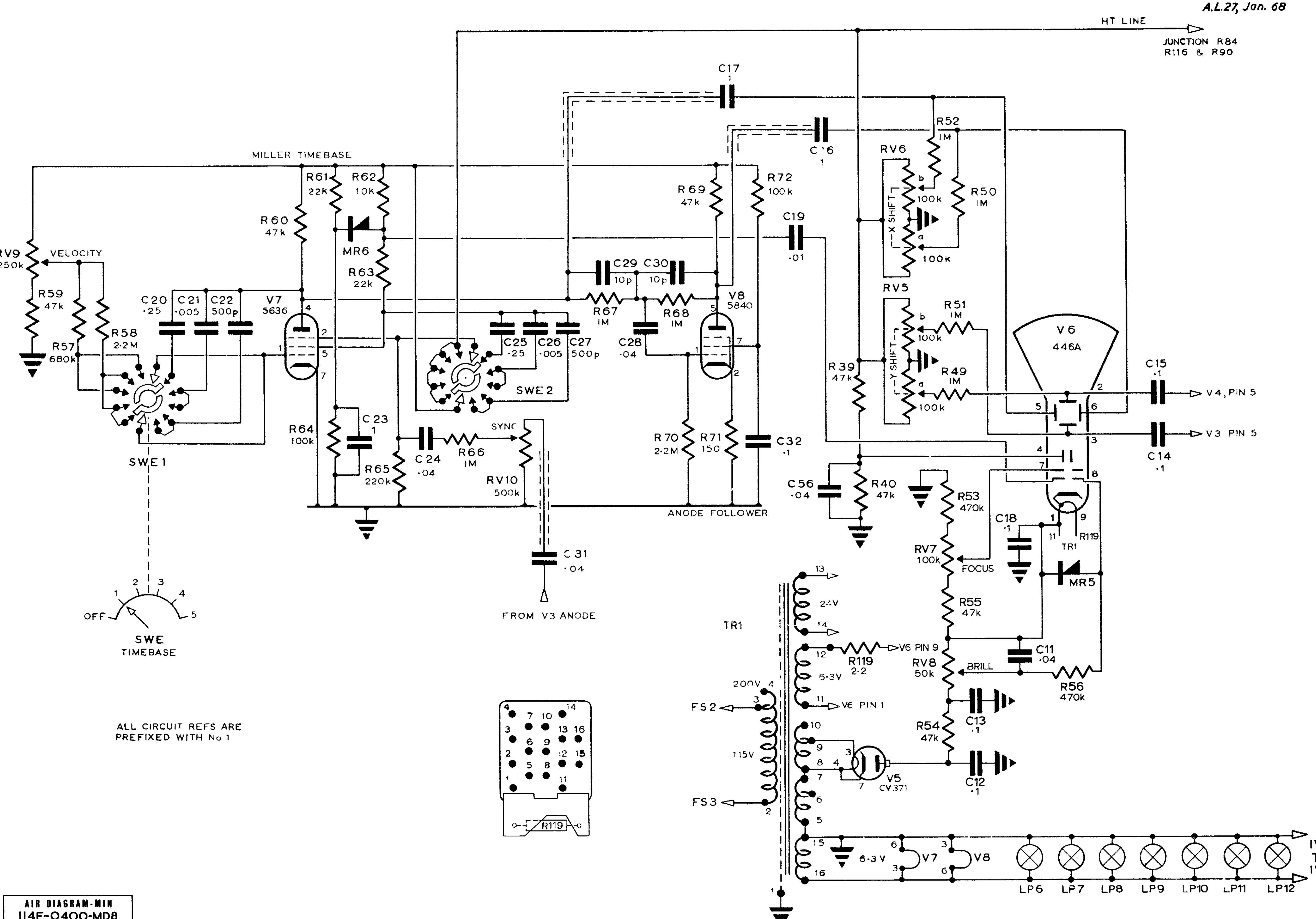


Fig. 6 Functional diagram of drift test Fig. 6



ALL CIRCUIT REFS ARE PREFIXED WITH No 1

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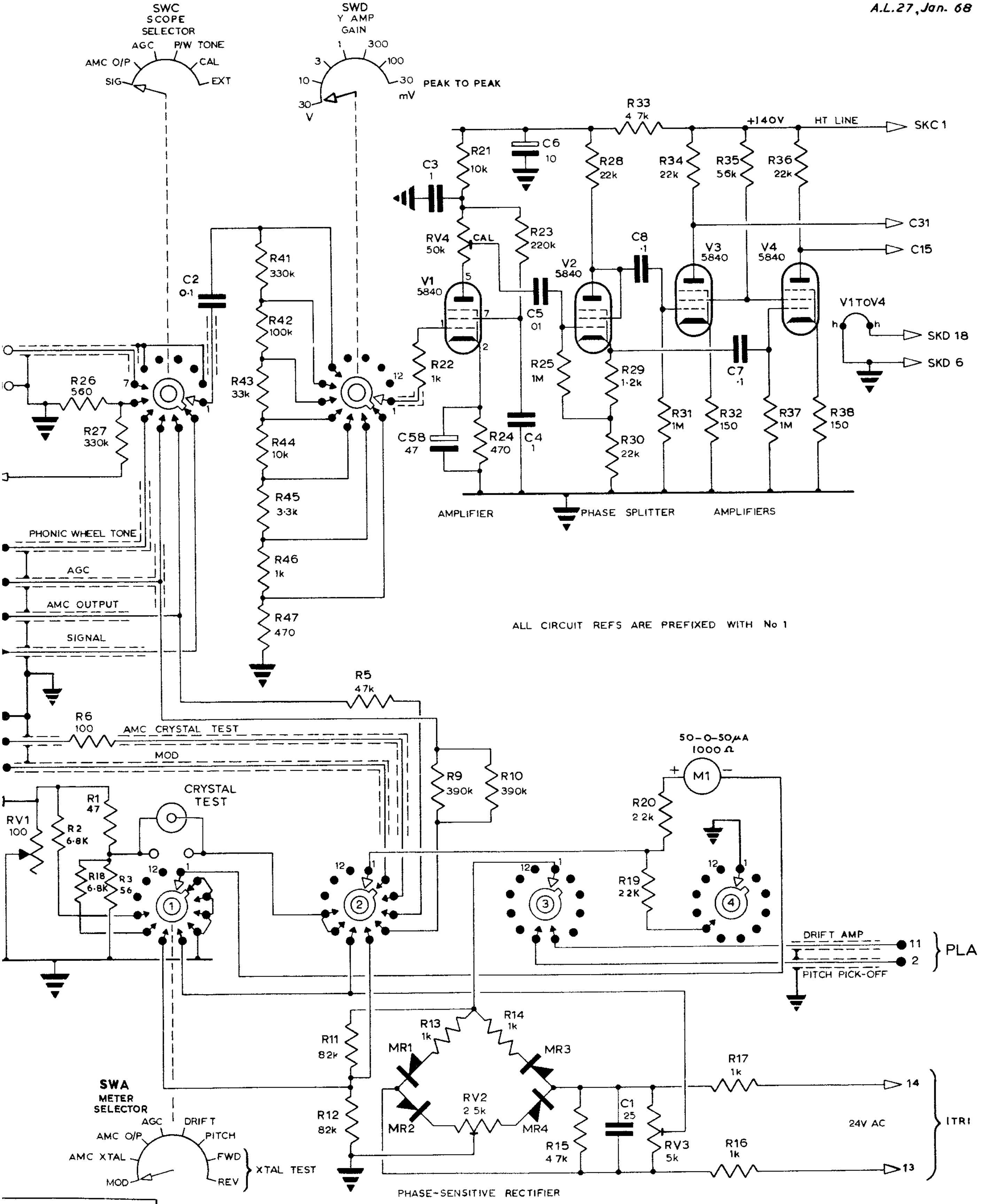
CRT timebase and power supply circuit

Fig. 7



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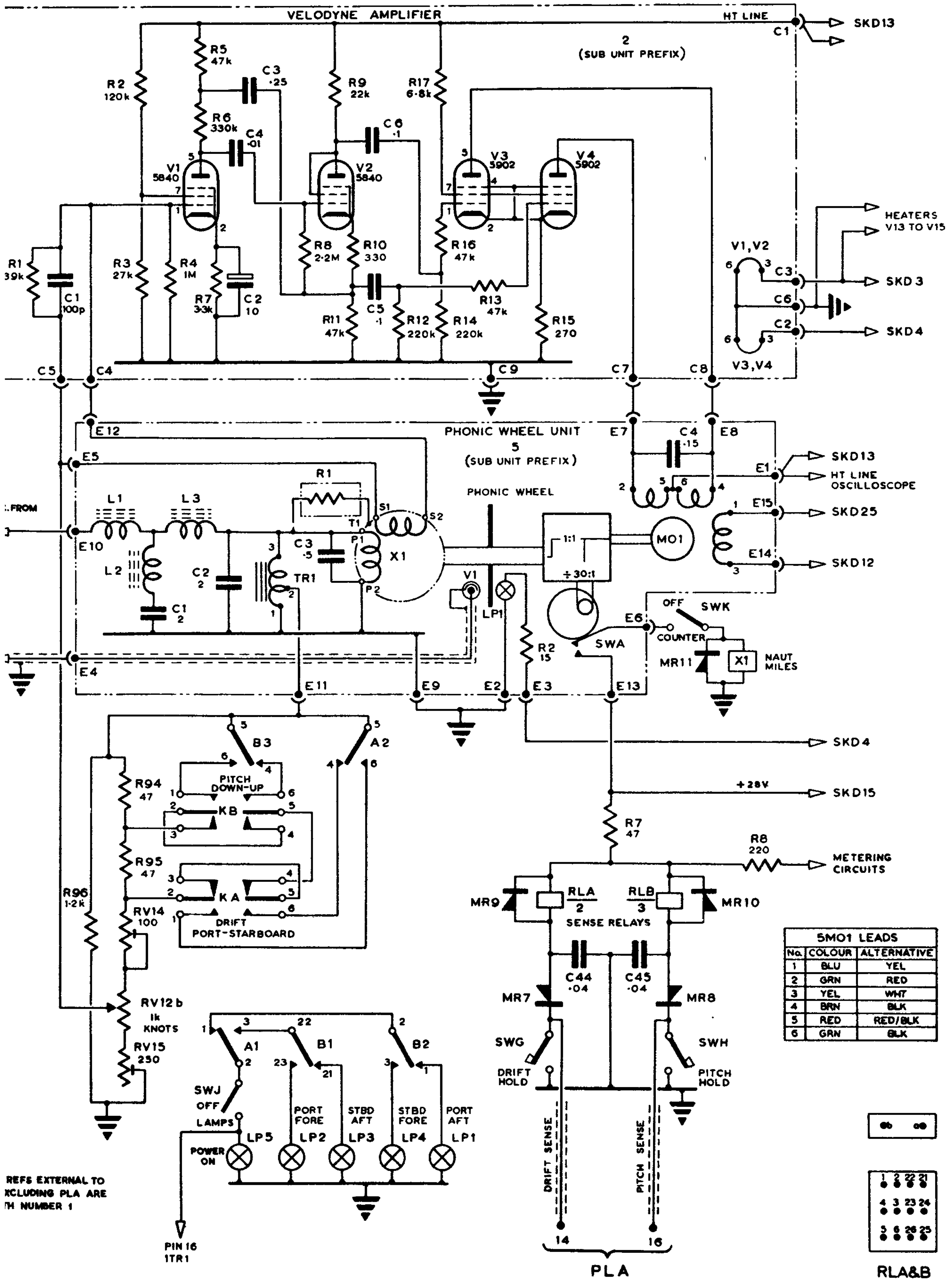
Y amplifier and meter circuits

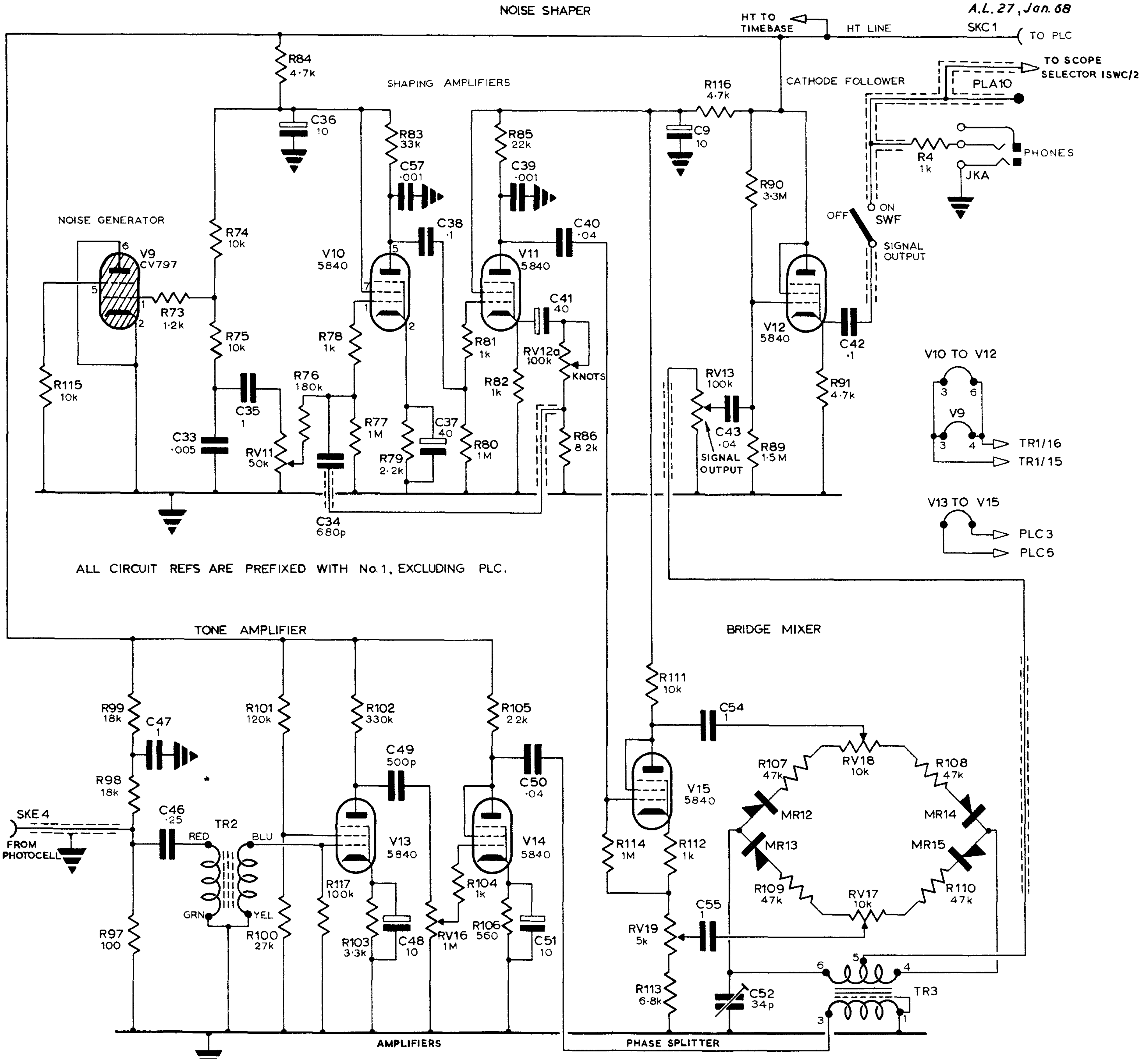
Fig. 8

TEST SET PERFORMANCE TYPE M29



5MO1 LEADS		
No.	COLOUR	ALTERNATIVE
1	BLU	YEL
2	GRN	RED
3	YEL	WHT
4	BRN	BLK
5	RED	RED/BLK
6	GRN	BLK

Velodyne amplifier, phonic wheel assembly and miscellaneous circuits Fig.9



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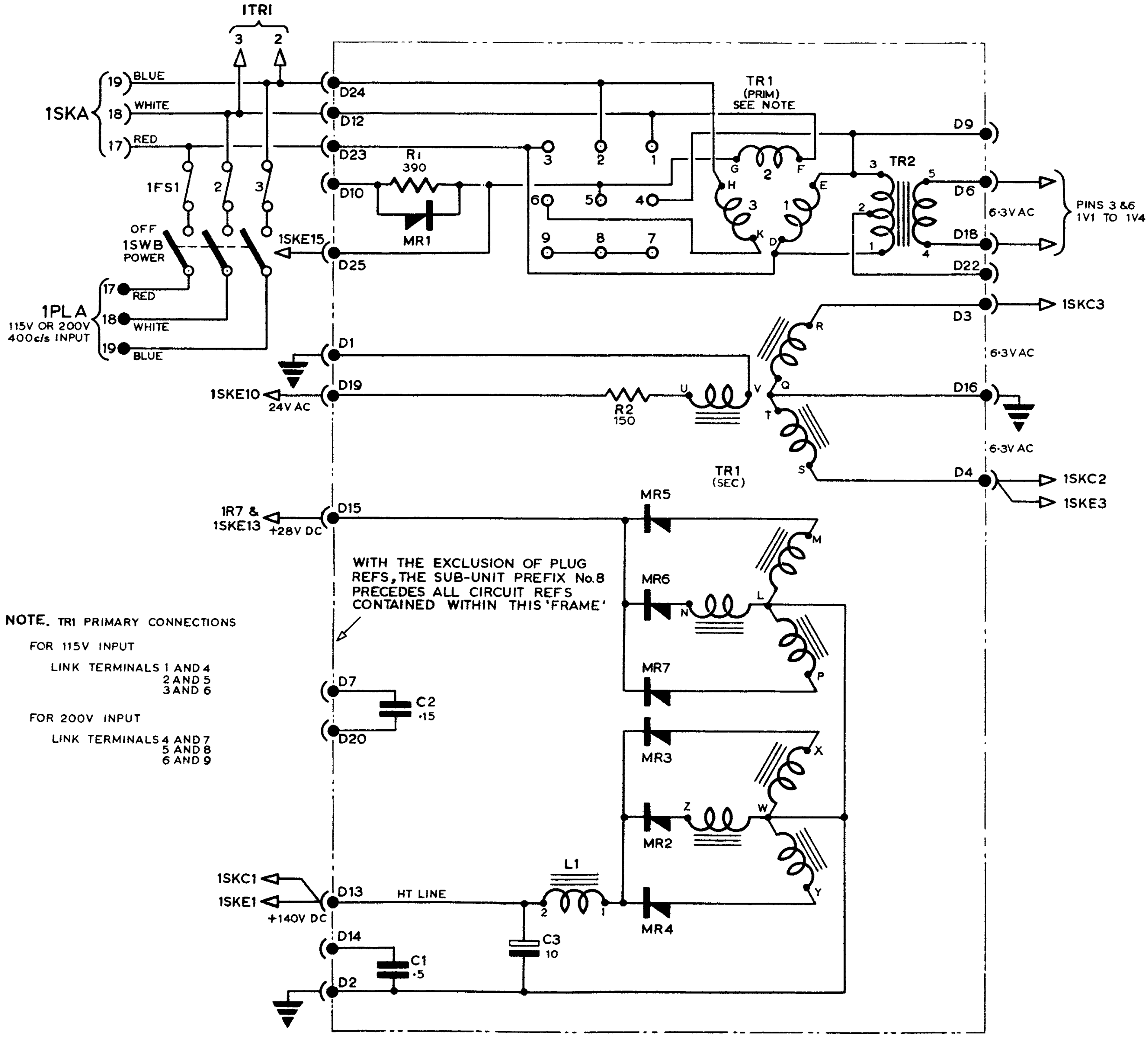
Noise, tone amplifier and mixing circuits

Fig.10

TEST SET PERFORMANCE TYPE M29



NOTE. TR1 PRIMARY CONNECTIONS

FOR 115V INPUT

LINK TERMINALS 1 AND 4
2 AND 5
3 AND 6

FOR 200V INPUT

LINK TERMINALS 4 AND 7
5 AND 8
6 AND 9

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C.B.H. 8007

Power assembly : circuit

Fig. 11

TEST SET PERFORMANCE TYPE M29

Chapter 2

TEST SET, FLIGHT CONTROL SYSTEM TYPE M.14

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Test set, flight control system, Type M.14 is a portable test set designed to perform a series of functional tests on computor navigational (computor B) in the AD2300 Doppler installation at second and third lines. It affords the following facilities:—

(1) An output voltage representing drift angle and simulating the drift signal from the tracking unit. Provision is made to vary the drift angle in 10° steps from 0-30° to port or starboard.

(2) An output voltage representing the heading reference signal normally derived from the aircraft gyro-compass system. The required heading can be set up by reference to a counter-type indicator on the panel.

(3) A resistive network to complete the speed circuit in the computor in the absence of the tracking unit and so provide an input to the computor speed amplifier. A control on the test set gives equivalent speeds of 0, 80, 500 and 900 knots.

(4) Provision for examining the output of the reference signal generator (phonic wheel) in the computor.

2. The test set is primarily a go/no go device. Its purpose is to check that the appropriate circuits in the computor are functioning correctly, but it is not intended to perform measurements or prove the accuracy of the computor.

General description

3. The test set (fig. 1 and 2) is similar in appearance to test set Type M.29. All components are mounted on a panel and frame assembly housed in a case measuring approximately 11 in. high × 15½ in. wide × 9 in. deep. The panel is protected by a cover retained in position by clip fasteners. Inside this cover, and held by a spring clip, is a correction chart giving heading counter readings against true headings.

4. All connections into and out of the test set are made through sockets on the panel with the exception of the power supply input. This is a flying lead brought out through the bottom right-hand corner of the panel and unterminated so that the appropriate plug can be fitted according to the user's requirements.

5. The complete assembly is identified as test kit, radio (6625–99–970–8510) consisting of test set Type M.14 and a set of thirteen connectors housed in a transit case.

Fig. 1. Test set Type M.14: general view

Circuit

General

6. A circuit diagram of test set Type M.14 is given in fig. 5. It should be noted that the test set also functions as a junction box, all connections between this unit and the computor and indicating units being routed through the 82-pole socket SKA. A schedule of connections for the main cableform is given in fig. 4, which should be studied in conjunction with the circuit diagram.

Drift angle

7. Referring to fig. 5, the desired drift angle is set up by operation of the SET DRIFT control which moves the rotor of synchro MS3 in 10° steps. The stator windings are coupled, via SKA/67, 68 and 69, to the stator of the aerial drift feedback synchro 6X3 in the computor. Excitation for 6X3 is provided by the computor 26V supply.

8. The voltage induced in the rotor of MS3 as the result of changing its position with respect to the stator windings is applied to the grids of V1, a double-triode valve with the two sections connected in parallel. V1 output is applied to the grid of V2A and a fraction of V2A output, approximately equal to the grid input, is fed to the grid of V2B. The outputs from V2 anodes, equal in amplitude but of opposite phase, are applied to the grids of the push-pull amplifier stage formed by V3 and V4. To prevent phase shift and overloading, the voltage excursions at the grids of V1 and V2A are limited by the diodes MR1, MR2, MR3 and MR4. H.t. for the amplifier valves is derived from the 145V d.c. supply in the computor and fed in via SKA/7.

9. The anode load of the push-pull stage is formed by the primary winding of a transformer TR1 and the secondary output is taken, via SKA/35 and 63, to one winding of the drift drive motor 6MO1 in the computor. Normally, this motor derives inputs from two identical amplifiers in the tracking unit, but for test purposes this is unnecessary and the other winding on 6MO1 is supplied with an excitation voltage from TR2 in the test set, fed out via SKA/54 and 71.

10. Since the servo loop amplifier in the test set is a high gain circuit, a damping network is included to prevent instability. This consists of R23, R24, R25 and MR5 connected across the excitation supply from TR2 and hence across the winding of 6MO1. The degree of damping can be selected by SWD (DRIFT SERVO DAMPING). When the desired drift angle has been selected, SWD should be set to give the minimum damping consistent with complete stability.

11. Movement of the SET DRIFT control causes the amplifier to produce a drive voltage so that 6MO1 in the computor rotates. In so doing it drives the associated synchros until 6X3 in the computor is in alignment with MS3 in the test set, whereupon there is no input to the amplifier and the system comes to rest. If the computor is functioning correctly, an output will be produced by 6X1 and the drift angle set up on the test set will be displayed on a speed and drift indicator coupled to SKD.

Heading reference

12. In normal operation the drift angle evaluated by the computor is related to the aircraft heading and for this purpose a heading reference signal is fed to the computor from the aircraft gyro-compass. Under test, this input is simulated by a synchro MS1 in the test set. Movement of the synchro rotor is controlled through reduction gearing by a knob on the panel and the rotor position is shown on a counter-type indicator. To allow for mechanical tolerances, each test set is individually calibrated and has, in the lid, a correction chart showing counter readings against true headings.

13. The stator windings of MS1 are connected, via switch SWA and SKA/10, 11 and 12, to the differential synchro 6X2 in the computor. MS1 rotor is connected across the excitation supply

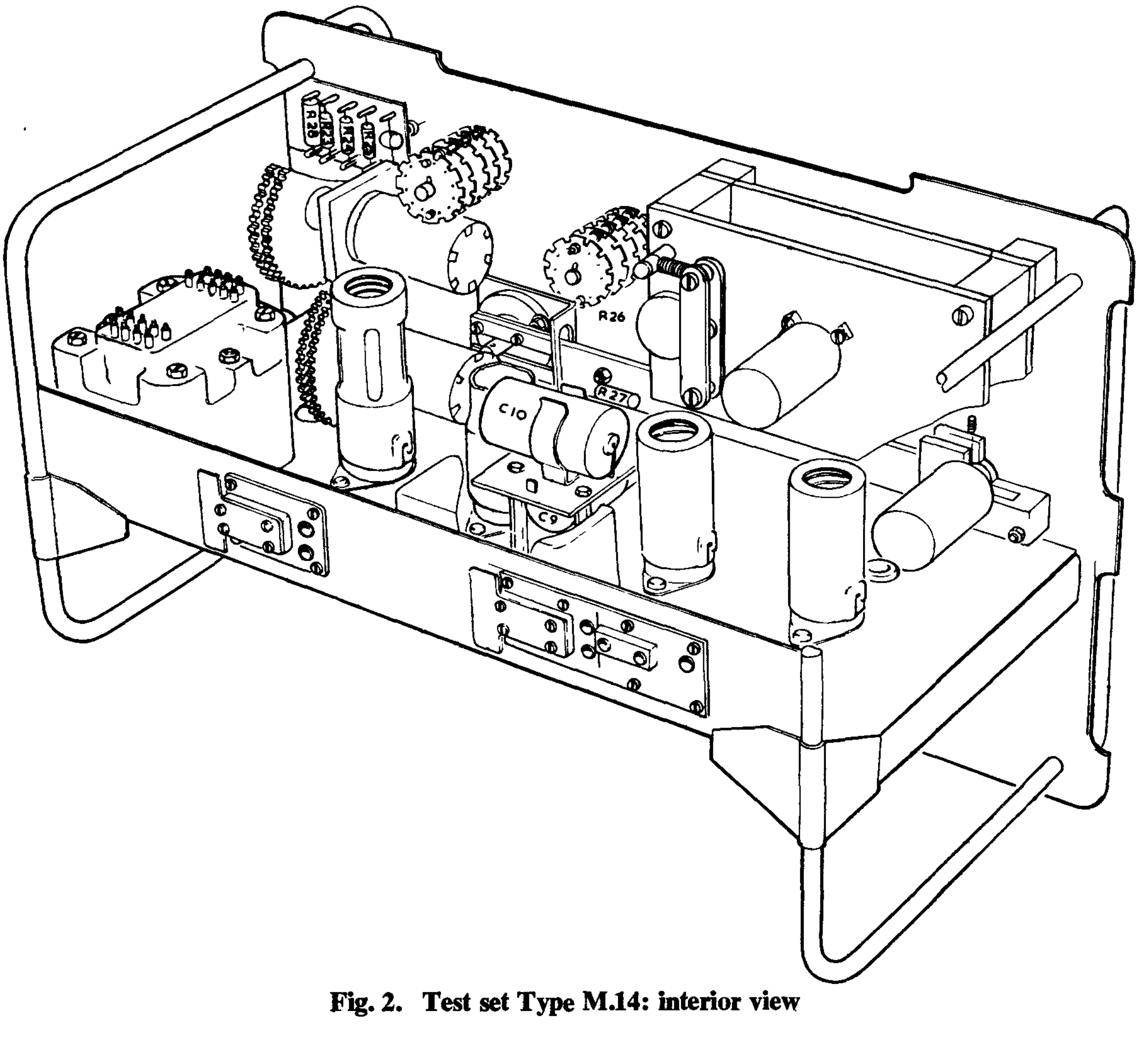

Fig. 2. Test set Type M.14: interior view

from TR2. With SWA in the HEADING position, the computor receives a normal heading reference signal.

Stiction test

14. An effective stiction test requires a very small degree of movement of the rotor of the synchro providing the input signal. Accordingly, when SWA is set to ERROR ANGLE STICTION TEST, MS1 is disconnected and the stator windings of MS2 are connected to SKA/10, 11 and 12. A shaft, terminated in a ball knob, protrudes through the panel of the test set and is coupled to the rotor of MS2. Associated with this shaft is the two-position control marked 1/5° and 1/10°. Thus, depending upon the setting of the angle control, MS2 rotor can be moved through 1/5° or 1/10° and the stiction of the computor system checked.

Ground speed

15. To check the operation of the computor speed circuits the test set contains a potential divider network consisting of R18-R21 and this network is connected, via SKA/62 and 70, across potentiometer 6X7 in the computor. The rotor of switch SWB, which enables various tapping points on the network to be selected, is taken to transformer TR2 in the computor speed amplifier. Thus, movement of SWB varies the speed amplifier input and, if the computor circuits are functioning correctly, the output from the speed synchro will cause a speed and drift indicator connected to SKD to show a ground speed which should agree substantially with that indicated by the test set switch.

Reference signal

16. The reference signal, generated by the phonic wheel in the computor, is fed to the tracking unit for comparison with the Doppler signal so that even its complete absence would not invalidate any of the tests for which test set Type M.14 is designed. Accordingly, the output of the photo-electric cell amplifier in the computor is fed into the test set via SKA/46 and 37 and brought out to two terminals TP1 and TP2 on the panel. By connecting a suitable indicator (e.g. test set Type M.29) to these terminals, the operation of the generator can be checked and the frequency measured.

Across track limit warning

17. The across track gearbox in indicator assembly Type M.14 contains a cam-operated switch controlling a d.c. supply to an external indicator. When the across track limit is reached the switch breaks the supply to give a visual warning. To check the operation of this circuit, test set Type M.14 includes a relay RLA, the contacts of which are in series with an indicator lamp LP2 connected across the 26V winding on TR2. The coil of relay A is connected between earth and (via R22) SKB/N. When a computor is under test, relay A is energized and the contacts make, connecting LP2 across the 26V supply so that the lamp lights. If across track limit conditions are produced, the relay supply should be interrupted and LP2 will then be extinguished.

Additional facilities

18. Test set Type M.14 includes certain additional facilities which are not related to the tests it is designed to perform on the computor. One of these is a third synchro in the heading circuit designated ADDITIONAL HEADING. Although the rotor of this synchro is linked to the heading control on the panel so that its position is indicated by the counter, the stator connections are brought out to socket SKH. Normally, excitation is derived from the internal 26V a.c. supply, but, by changing over two links within the unit, the rotor connections can be transferred to SKH/4 and 5 to permit excitation from an external source.

19. The remaining extra facilities are associated with sockets SKC (MISC.), SKF (1 : 1 DRIFT) and SKG (ACROSS TRACK). Details of the outputs provided at these sockets are given in the following list:

Socket	Pin No.	Service
SKC	1	Track error output X
	2	Track error output Y
	3	Track error output Z
	4	Actual track X
	5	Actual track Y
	6	Actual track Z
	7	Auto-pilot track error signal H′
	12	Auto-pilot track error signal C′
	9	Along track distance output X
	8	Along track distance output Y
	13	Along track distance output Z
	14	Across track output X
	15	Across track output Y
	11	Across track output Z
	17, 18	26V a.c.
SKF	1	6X4 energizing
	3	Drift synchro stator X
	4	Drift synchro stator Y
	5	Drift synchro stator Z
SKG	1	Across distance a.c. H′
	2	Across distance a.c. C′
	3	Across track deviation +ve
	4	Across track deviation −ve

Connectors

20. Thirteen connectors are provided with each test set. They are illustrated in fig. 3 and details are as follows:—

Item No.	Ref. No.	Terminations End A	Terminations End B	Length ft.	Length in.	Function
1	6625–99–971–1320	Dual 57-pole sockets	82-pole plug	4	0	Computor to test set (SKA)
2	6625–99–971–1321	2 sockets 10H/20998	37-pole plug	4	0	Indicator Type M.14 to test set (SKB)
3	6625–99–971–1316	2-pole socket	2-pole plug	4	0	Indicator Type M.16 to test set (SKE)
4	6625–99–971–1315	12-pole socket	9-pole plug	4	0	Indicator Type M.15 to test set (SKD)
5	6625–99–971–1314	19-pole plug	19-way term. block	4	0	Miscellaneous output terminal block
6	6625–99–971–1317	6-pole plug	6-way term. block	4	0	1 : 1 drift terminal block
7	6625–99–971–1318	4-pole plug	4-way term. block	4	0	Across track terminal block
8	6625–99–971–1319	5-pole plug	5-way term. block	4	0	Additional heading output terminal block
9	10HS/3250	9-pole plug	9-pole socket	1	$6\frac{1}{2}$	9-way patch connector
10	10HS/3251	Plug 10H/20999	Socket 10H/21000	1	$7\frac{3}{4}$	15-way patch connector
11 12	10HS/3252	Plug 10H/21801	Socket 10H/21802	1	9	25-way patch connectors
13	10HS/3253	Plug 10H/21822	Socket 10H/20998	1	3	37-way patch connector

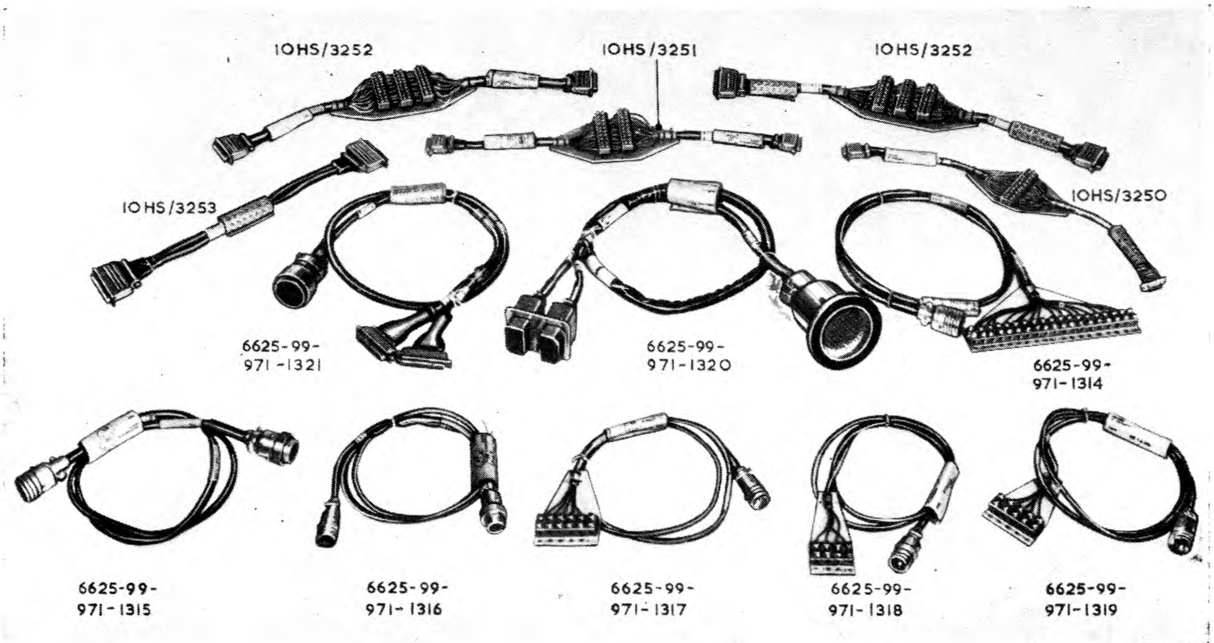

Fig. 3. Connectors

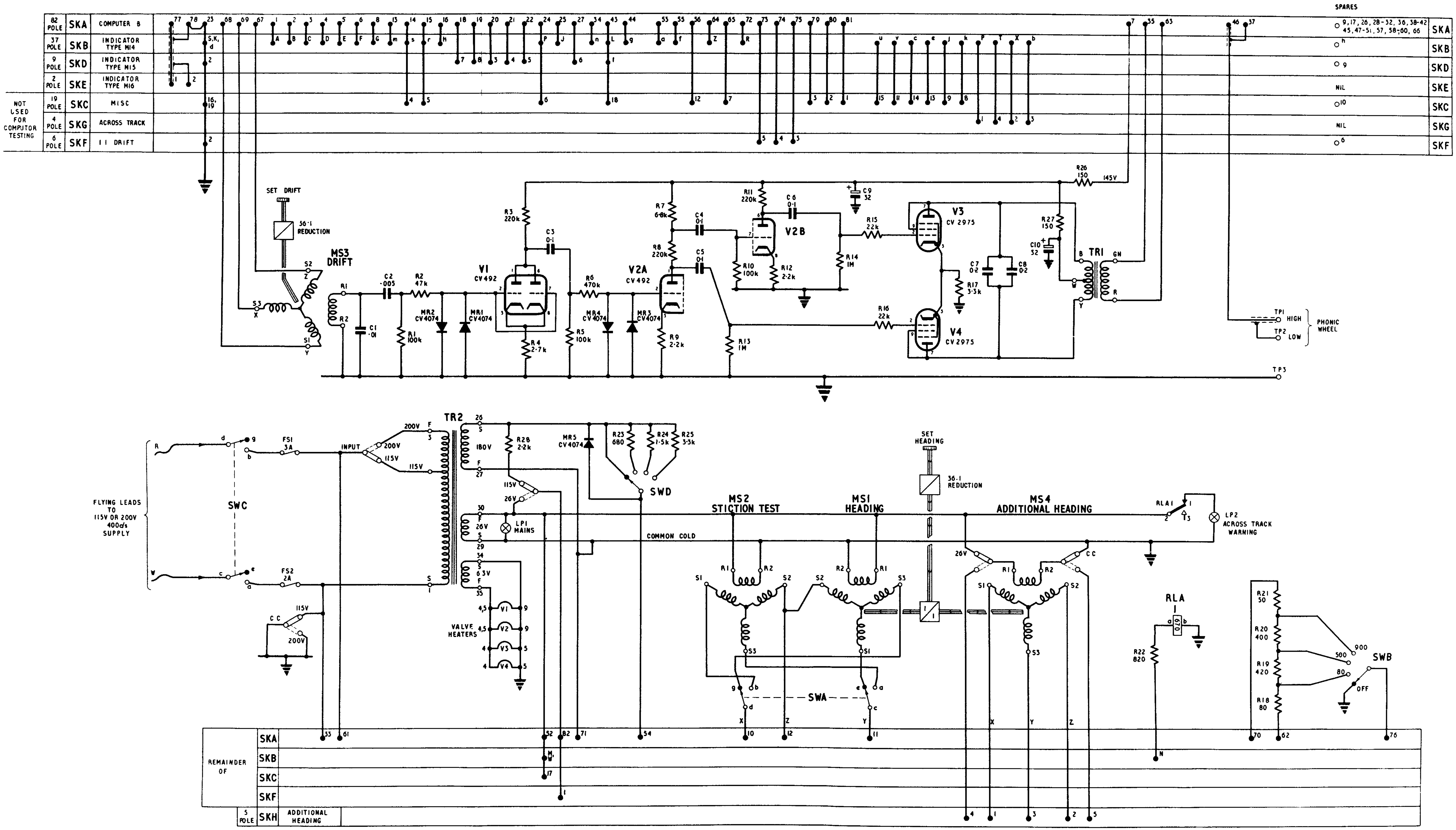

Fig. 5 Test set, flight control system Type M.14 : circuit Fig. 5

Chapter 3

CHAMBER, CABLE TERMINAL (10AD/4004)

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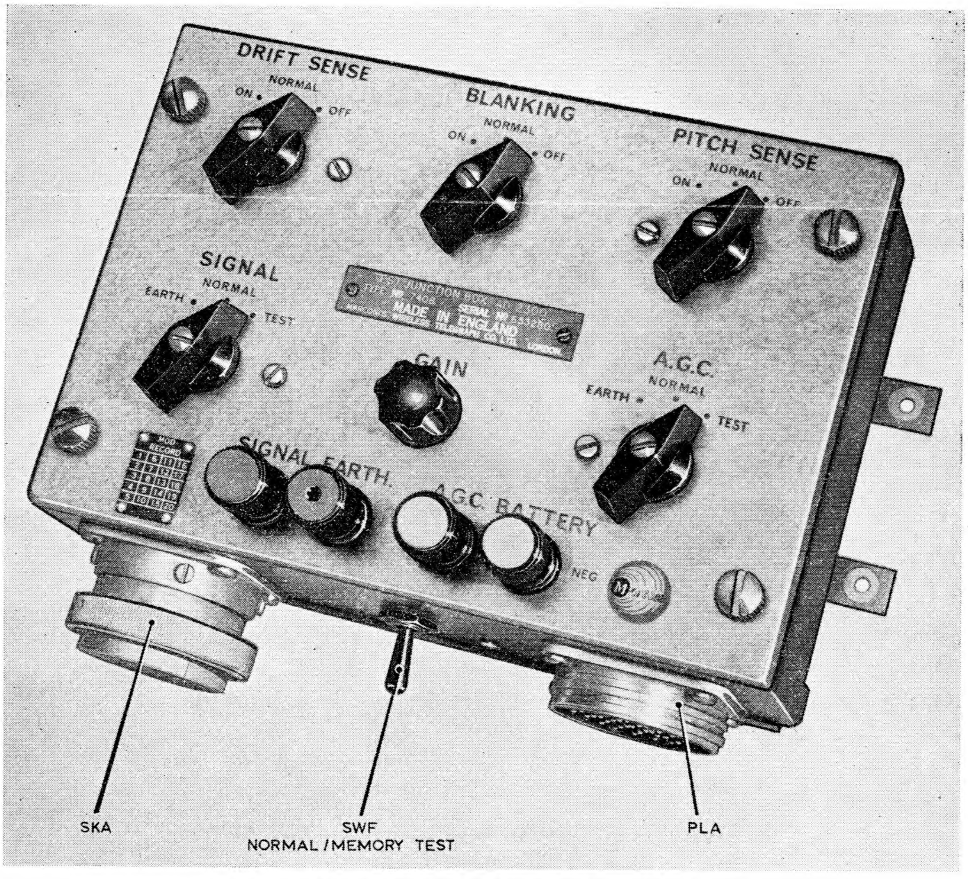


Fig. 1. Chamber, cable terminal: general view

Introduction

1. Chamber, cable terminal (10AD/4004) is a test junction box employed in second line bay servicing of ARI23085. It functions by interrupting circuit paths between transmitter-receiver and tracking unit thereby allowing functional tests to be made on the installation. Vol. 4 of this publication covers fully the use of chamber, cable terminal for 2nd line servicing.

General description

2. The chamber is constructed as shown in fig. 1 and measures 8 in. long × $5\frac{1}{2}$ in. wide × $2\frac{7}{8}$ in. deep, excluding switch and socket projections. Attached to the case are flanges having $\frac{1}{8}$ in. diam. fixing holes on centres $8\frac{3}{8}$ in. × 2 in. Connections to the chamber are made via special cables at the 37-pole plug PLA (to the tracking unit) and 37-pole socket SKA (to the transmitter-receiver). When the chamber is removed from the circuit the free ends of the two connecting cables (fitted with mating plug and socket) are joined to complete the circuit between transmitter-receiver and tracking unit.

Circuit

General

3. Five, three-position switches, SWA–SWE, are contained in the chamber and the installation circuit functions affected by these are, DRIFT SENSE, BLANKING, PITCH SENSE, SIGNAL, A.G.C. A toggle switch, SWF, is incorporated and has positions NORMAL and MEMORY TEST; the latter position disables the in-flight memory test function of the installation and allows a setting-up procedure in the signal comparator to be carried out. The GAIN control, RV1, is used in conjunction with the A.G.C. switch (set to TEST) and provides a variable d.c. voltage at SKA1 (derived from an external or internal battery supply) to control the gain of the i.f. amplifier in the aerial assembly.

Front panel terminals

4. Front panel terminals and their functions are as follows:—

(1) BATTERY/EARTH. These allow connection of an external battery to the chamber, should this be desirable, or permit the p.d. of the internal battery to be measured. Either battery should have a p.d. of approximately 9V.

(2) A.G.C./EARTH. Connecting a multimeter across the terminals permits measurement of the potential on the a.g.c. line to the transmitter-receiver.

(3) SIGNAL/EARTH. Used for two purposes depending on the position of the SIGNAL switch, and allows an external doppler signal to be injected into tracking unit or permits measurement of the transmitter-receiver output.

Switch functions

5. Fig. 2 shows that each switch controls a circuit path between PLB of transmitter-receiver and PLM of tracking unit. When each switch is set to its NORMAL position, all connections necessary for complete functioning of the installation are made between PLB and PLM (via respective switches in the chamber). The switches and their functions are as follows:—

(1) BLANKING (SWB):	NORMAL	Contacts 1SWA in the aerial waveguide assembly make an earth connection each ½-second, switching relay 2RLA in the tracking unit, disabling the pulse modifier and blanking the doppler signal at the a.f. amplifier (PLA18).
	ON	2RLA remains energized. Doppler signal is blanked via 2RLA1 and pulse modifier is disabled.
	OFF	2RLA is de-energized. Doppler signal passes to 8TR18 (via PLL17).
(2) DRIFT SENSE (SWA) and PITCH SENSE (SWC):	NORMAL	Drift sense contacts 1SWB in the aerial waveguide assembly make contact each second, earthing relay coil 1RLA in the tracking unit (PLM17). Pitch sense contacts 1SWC operate each half-second and earth coil 1RLB (PLM18). Contacts of 1RLA and 1RLB switch a.g.c. capacitors 1C4–1C7 and phase windings of 7MO2 and drift integrator motor 6MO1.
	ON	Relays 1RLA, 1RLB energized.
	OFF	Relays 1RLA, 1RLB de-energized.
(3) SIGNAL (SWD):	NORMAL	Doppler signal from cathode of 2V2 (PLC24) in the i.f. amplifier of transmitter-receiver is fed via chamber (SKA7, PLA7) to input transformer 1TR2 in the tracking unit (PLM7).
	EARTH	Output of 2V2 is fed to SIGNAL/EARTH terminals of chamber. Signal voltage is monitored via filter network connected across terminals. No signal is fed to tracking unit.
	TEST	Simulated doppler signal from signal generator may be applied to SIGNAL/EARTH terminals (i.e. when testing tracker performance). No signal is fed from transmitter-receiver to tracking unit.
(4) A.G.C. (SWE):	NORMAL	A.g.c. voltage derived from cathode circuit of 5V2 (PLD10) in the signal comparator of the tracking unit is fed via chamber

(PLA1, SKA1) and transmitter-receiver to i.f. amplifiers 2V3, 2V4 in the aerial assembly (PLB5).

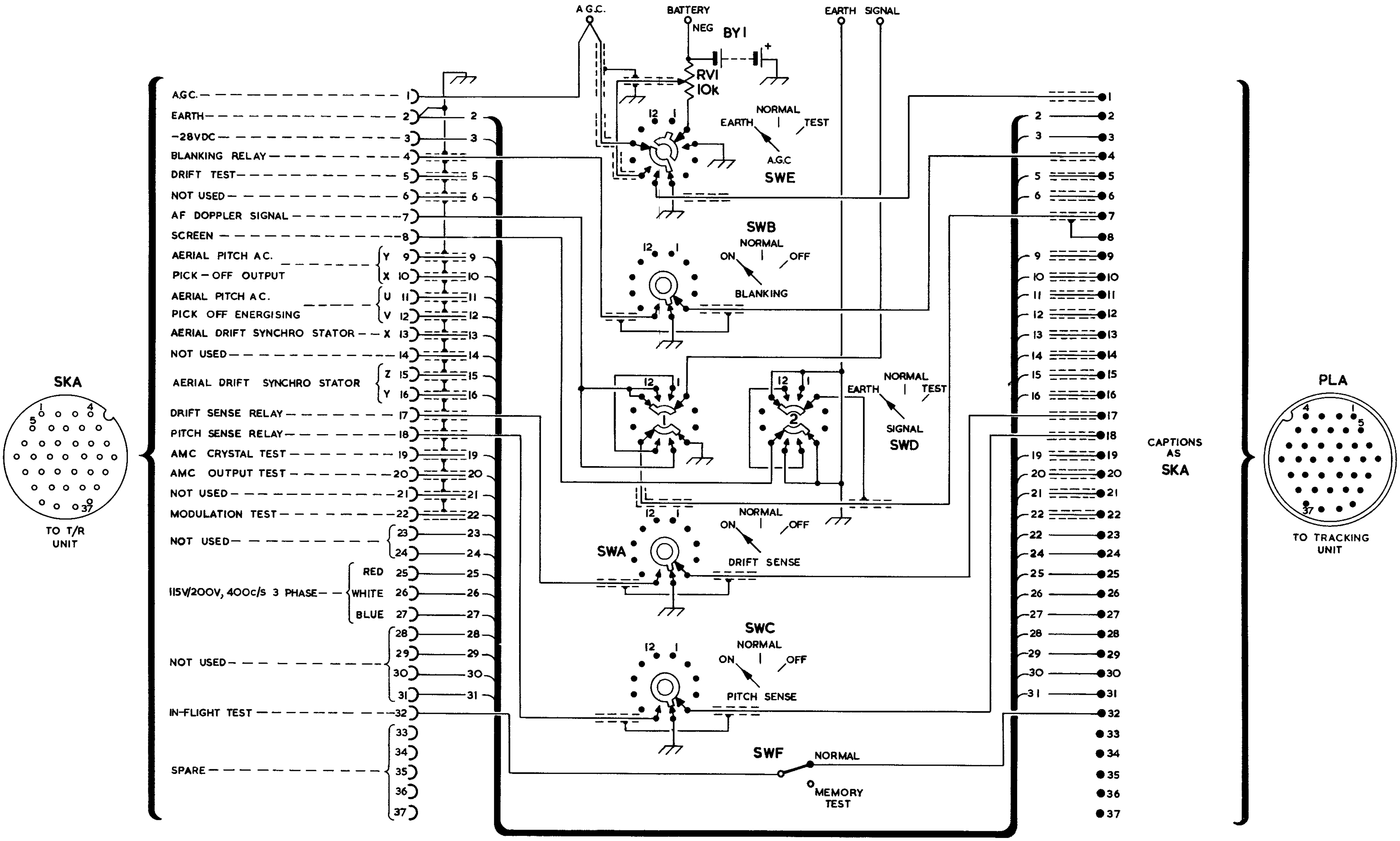
EARTH — A.g.c. line to transmitter-receiver is earthed. I.f. gain is at maximum.

TEST — Chamber battery is connected across GAIN control RV1 and earth. Control voltage is fed to i.f. amplifiers in the aerial assembly (para. 3).

(5) MEMORY TEST/NORMAL switch (SWF):

NORMAL — Depressing TEST button on indicator M.15 with installation working under memory conditions, produces the normal in-flight memory test function.

MEMORY TEST — Earth line from 1RLG4 in tracking unit to coil of 1RLB in transmitter-receiver brought about by depressing TEST button on indicator M.15, is broken. No 800 c/s modulation applied to the transmitter klystron and tracking unit receives no doppler signal. With A.G.C. switch set to TEST, gain of system is raised to a level where the corresponding increase in noise output of transmitter-receiver should drive tracking unit to signal conditions. 5RV3 sets up the operating point of 5V3, the signal comparator in the transmitter-receiver, determining at what signal level the tracking unit changes from memory to signal conditions.



AIR DIAGRAM-MIN
114E-0400-MD1
BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE ROYAL AIR FORCE
ISSUE 1 Prepared by the Ministry of Aviation

Chamber, cable terminal (10AD/4004): circuit

Fig. 2

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Chapter 4

TEST SET, SYNCHRO UNIT TYPE 7427

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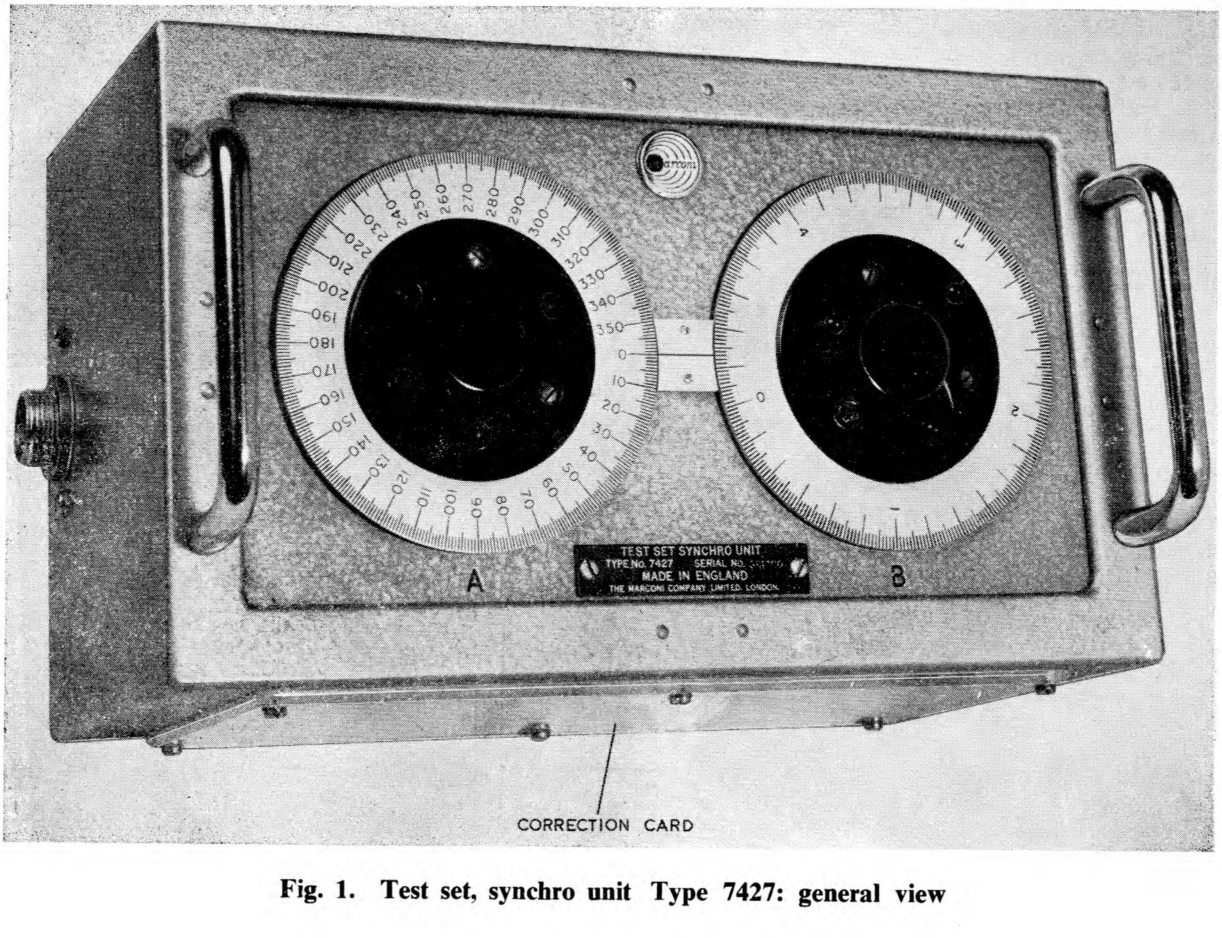

Fig. 1. Test set, synchro unit Type 7427: general view

Introduction

1. Test set, synchro unit, Type 7427 is a test set used in conjunction with ARI.23085 to check the drift accuracy of the aerial sub-unit. To check the aerial drift movement it is necessary to know:—

(1) the aerial position in relation to the fore and after axis of the aircraft

(2) the input information.

The aerial position can be determined by using the scale and vernier of the Aerial test jig, Type 7424. A synchro output of known accuracy is required to supply the input information and this synchro must be calibrated so that an angular change of 0·5 minute can be determined. The test set, synchro unit, Type 7427, fulfils this requirement.

General description

2. The test set is shown in fig. 1 and measures approximately $10\frac{13}{16}$ inches long by $5\frac{5}{16}$ inches wide by $6\frac{9}{16}$ inches high, excluding plug, dial rotating knobs and stand projections. Connections to the synchro unit within the sealed container are via a 6-pole plug PLA on the left-hand side of the container. On the front of the instrument are two dials, A and B. Dial A is engraved every degree for 360 degrees and is attached to the synchro shaft within the container. It is driven through a 60:1 ratio reduction gear train by dial B. Each 360 degree rotation of dial B gives an incremental movement of 5 degrees rotation on the synchro. The complete test set is calibrated against a master synchro and combined synchro and backlash errors are plotted for both clockwise and counter-clockwise synchro rotation. A correction card, specific to the particular instrument, is attached to one side of the case beneath a clear Perspex cover.

WARNING . . .

> **The accuracy of this instrument can be affected if subjected to mechanical shock.**

Circuit description

3. Refer to the circuit diagram fig. 2. The a.c. power supply for the rotor of the synchro is 26V, 400 c/s and is applied to terminals R1 and R2 via plug PLA/D and PLA/E respectively. When the test set is in use the stator connections S1, S2 and S3 are connected via plug PLA/A, PLA/B and PLA/C to the stator connections S1, S2 and S3 respectively of the drift synchro 1X2 in the aerial.

Setting-up procedure

4. The following setting-up procedure for the Test set, synchro unit Type 7427 must be carried out in the event of the synchro in the test set being changed.

(1) Refer to circuit diagram, fig. 2.

(2) Connect a valve voltmeter between terminals S1 and S2.

(3) Connect a 26V, 400 c/s, a.c. power supply between terminals R1 and R2 and switch on the supply.

(4) Set the two scales of the test set to read 0 degrees 0 minutes. Slacken the synchro body clamps.

(5) Rotate the body for a null indication on the valve voltmeter.

(6) Connect together terminals R2 and S3 of the synchro.

(7) Using a multimeter check that the voltage between terminals R1 and S2 is approximately 36V a.c.

(8) If the voltage is approximately 16V a.c. remove the link from terminals R2 and S3 and repeat (5) for the alternative null. Repeat (6) and then recheck (7).

(9) Remove the link from terminals R2 and S3.

(10) Using the valve voltmeter, determine and maintain the null and tighten the synchro body clamps, checking that the scales are still at 0 degrees 0 minutes.

(11) Switch off the a.c. power supply.

(12) Disconnect the power supply and the valve voltmeter.

(13) Replace the back cover of the test set.

Note . . .

> *The test set must now be recalibrated for synchro and backlash errors against a master synchro and the correction card completed before the instrument is used.*

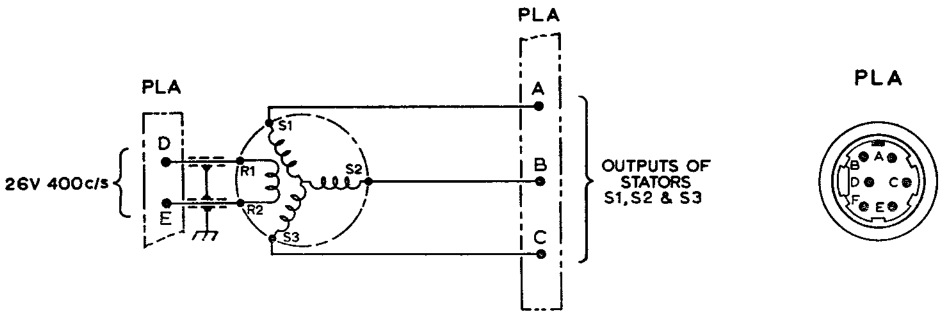

Fig. 2. Test set, synchro unit Type 7427: circuit