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TACAN (AIR)
TEST GEAR—GENERAL

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

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Ministry of Defence

FOR USE IN THE
NAVAL SERVICE
ROYAL AIR FORCE

(Prepared by the Ministry of Aviation)

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	A.P. Code	*Old A.P.*
*ARI.*18107 *TACAN* (*AIR*)	116*B*–0304–1	2534*N*, *Vol.* 1
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Section 1

GENERAL

SECTION 1

GENERAL

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Chapter 1

TEST SET TYPES 7476A AND 7476B — GENERAL DESCRIPTION

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Introduction

1. Test set Types 7476A and 7476B are portable test instruments which provide facilities for the second and third line testing of coupling unit (indicator) Types 9546 and 11920 and indicator, electrical, Type 9547. Each test set weighs 46½ lb. and is contained in a metal case 9 in. × 12 in. × 16½ in. Attached to the sides of the case at the front are two hinged plates about 1¼ in. wide which are used to secure the test set to a 19 in. test rack when required. When the test set is used on a bench the flaps are pushed back so that they lie flat against the side of the case.

2. Test set 7476A has been modified to allow for the checking of coupling unit (indicator) Type 11920; when modified the test set is designated test set 7476B. The circuit changes are incorporated in fig. 1 of this appendix. The coupling unit (indicator) Type 11920 is of the same size and is similar in appearance to the coupling unit (indicator) Type 9546 and is interchangeable with it. The C.U. Type 11920, however, has two additional components which are shown in fig. 3 of Chapter 1. The modification is to allow for checking of these components.

3. When the C.U.11920 is being checked special interconnecting cables are required between the coupling unit and the test set 7476B; these cables are supplied as part of the modification kit to test set 7476A. The cable connections are shown in fig. 1 of Chapter 2.

4. Illustrated in fig. 1 are all the controls, indicators, plugs and sockets carried on the front panel. The preset control RV4 (fig. 2) is fitted within the unit on the right-hand side (from the front). Micro-switches S12 and S13 are also within the unit and fitted on a bracket behind the 115V A.C. entry plug PL1. The front panel is secured to the case by ten 2BA cheesehead screws. The test sets have the following sub-units:—

(1) Master torque transmitter (X1).

(2) Master torque indicator (X2).

Facilities

5. The test set provides the following facilities:—

(1) A master transmitter (X1) for checking the torque receivers in the indicator, electrical, Type 9547. A master indicator (X2) for checking the torque transmitters in coupling unit (indicator) Type 9546.

Facilities are provided for checking the master indicator against the master transmitter.

(2) Checking the '100 mile' indicator circuits in indicator, electrical, Type 9547 and coupling units (indicator) Type 9546 and 11920.

(3) Checking of motor generators and means of rotating the bearing and distance gear trains in the coupling units in either direction.

(4) Checking of bearing and distance resolvers in the coupling units.

(5) Checking of the sin/cos and linear potentiometers.

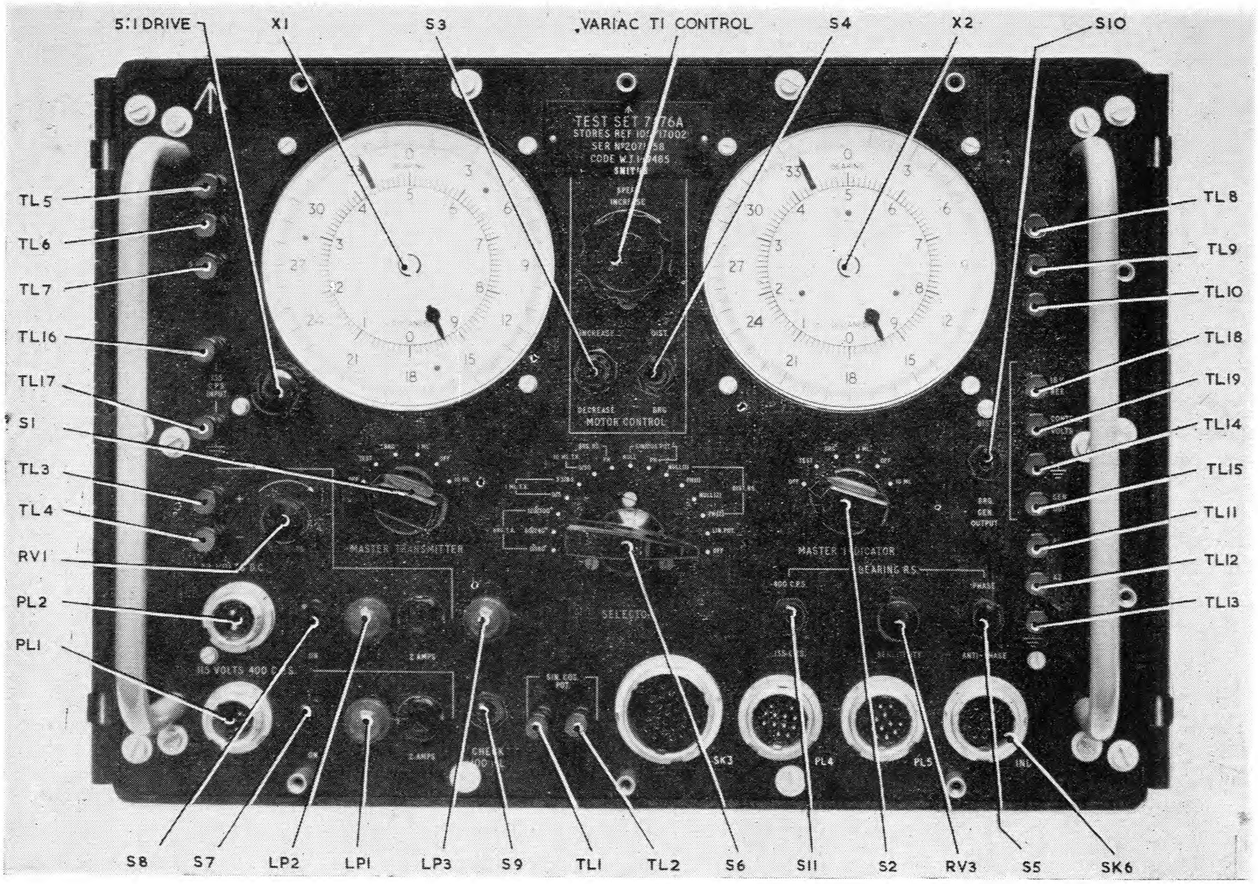

Fig. 1. Front panel

Connectors

6. There are four plugs and two sockets fitted on the front panel, namely:—

(1) PL1, a three-pin plug carrying 115V 400 c/s.

(2) PL2, a two-pin plug carrying 28V D.C.

(3) SK3, a 25-way socket connecting the test set to PL2 on the coupling unit.

(4) PL4, a 12-way plug connecting the test set to PL1 or PL3 on the coupling unit.

(5) PL5, a 12-way plug connecting the test set to PL4 on the coupling unit.

(6) SK6 (IND.), a 12-way socket connecting the test set to the indicator, electrical, Type 9547.

When SK3, PL4, PL5, and SK6 are connected to a coupling unit (indicator) and an indicator, electrical, the external connections shown in fig. 3 are made.

7. There are also 19 terminals on the front panel which provide connections for the injection of 135 c/s and external monitoring. The terminals are numbered on fig. 1 and annotated on the front panel as follows:—

(1) On the bottom of the front panel Terminals 1 and 2 marked SIN. COS. POT.

(2) On the left-hand side of the front panel:—

(a) Terminals 3 and 4 marked 28 VOLTS DC + and — respectively.

(b) Terminals 16 and 17 marked 135 CPS INPUT. TL17 is the earthy side of the input connection.

(c) Terminals 5, 6 and 7 marked S1, S2 and S3. These are the stator connections of the master transmitter synchro.

(3) On the right-hand side reading from top to bottom of the front panel:—

(a) Terminals 8, 9 and 10 marked S1, S2 and S3. These are the stator connections of the master indicator synchro.

(b) Terminal 18 marked 18V REF.

(c) Terminal 19 marked CONTROL VOLTS.

(d) Terminal 14 marked with an earth symbol.

(e) Terminal 15 marked GEN. OUT.

(f) Terminal 11 marked A1.

(g) Terminal 12 marked A2.

(h) Terminal 13 marked with an earth symbol.

Chapter 2

TEST RIG INSTALLATION TYPE 7477 AND TEST CRADLE TYPE 11106

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Introduction (*fig.* 1)

1. The test rig Type 7477 (*Ref. No.* 10*S*/16831) and test cradle Type 11106 (*Ref. No.* 10*S*/17006) together form the equipment required to perform bench testing of all the units comprising the TACAN airborne installation ARI.18107. The test rig is connected to the cradle by a 48-way cable and Fig. 1 shows the test rig connected to the cradle; the coupling unit Type 9546, indicator, electrical, Type 9547 and the control unit Type 7750 are shown in their respective positions on the test rig. The transmitter-receiver is not shown in position but it would normally be mounted on the rectangular frame on the cradle when being tested. It should be noted that the test rig and cradle are for bench testing the ARI.18107 installations, the individual units can be tested by the appropriate test gear detailed in other sections of this A.P.

TEST RIG TYPE 7477

2. The test rig has a pressed aluminium alloy case and is designed to be a compact unit to hold the ancillary units of the TACAN airborne equipment. The test rig is $17\frac{1}{4}$ in. high $\times$ 12 in. wide $\times$ 16 in. deep, the depth including 4 in. for the front cover assembly. The rig weighs about 28 lb. and is fitted with a leather carrying handle which is fitted in a recess on the top of the case. Fig. 2 shows the test rig front view with the component parts identified, also shown on this illustration are the extension leads and power connectors. The power leads are for the test rig and the extension leads allow the sub-units of the transmitter-receiver to be more accessible during servicing. Fig. 3 is a rear view of the test rig with the large lid assembly removed. Fig. 4 shows the internal wiring and connectors on the test rig. The circuit diagram of the test rig is shown on Fig. 5.

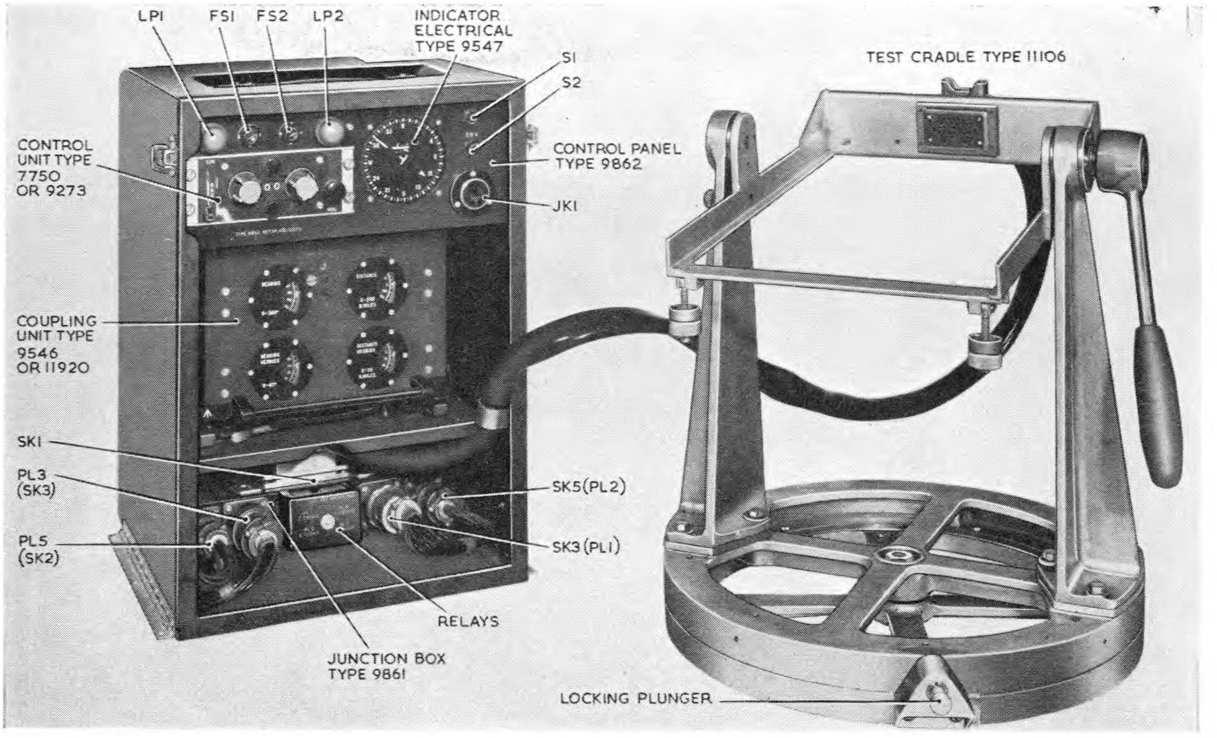

Fig. 1. Test rig and cradle

3. The test rig requires the following power supplies:—

(1) 115V $\pm$ 10% at 400 $\pm$ 20 c/s.

(2) 24–29V d.c. at about 1·0A.

Both power supplies are fed into the test rig via two 4-pole plugs which are mounted on a cut out situated on the top right-hand side at the rear (*Fig.* 3). The power connectors are shown on fig. 2, each is terminated at one end by a 4-pole socket, the other end of each connector being left free so that it can be terminated as circumstances require. The power connector terminations are 4-pole Mk. 4 sockets; to prevent the power supplies being connected to the wrong plug, the socket terminating the 28V d.c. connector (*Ref. No.* 10HS/113) is orientated to position 1 and the socket terminating the 115V a.c. connector (*Ref. No.* 10HS/112) is orientated to position 0.

4. The test rig is divided into three levels, at the top is the control panel Type 9862, in the middle is the mounting Type 9545 with backplate and at the bottom is the junction box Type 9861. There is also a front cover assembly which houses the connectors and blower assembly, the cover is secured to the case by four catches (some early models have only two catches).

5. The control panel Type 9862 (*Ref. No.* 10D/22591) carries the following items:—

(1) ILP1 the 115V a.c. "on" indicator.

(2) ILP2 the 28V d.c. "on" indicator.

(3) s1 the 115V off-on switch.

(4) s2 the 28V off-on switch.

(5) FS1 the 5A fuse for the 115V supply.

(6) FS2 the 2A fuse for the 28V supply.

(7) JK1 the IDENTITY TONE output jack.

The control panel has two holes cut in it, both can be seen on fig. 2. The circular hole on the right holds the indicator, electrical, Type 9547 (*A.P.* 2534*N*, *Vol.* 1, *Part* 2, *Sect.* 2, *Chap.* 10) which is shown in position on Fig. 1. The indicator is secured to the control panel by four 4 B.A. screws. The electrical connections to the indicator are made by PL4 which is connected to SK1 on the backplate via a 12-way cable (*Ref. No.* 10HS/18). The rectangular hole on the left holds control unit Type 7750 or 9273 (or American equivalent) (*A.P.* 2534*N*, *Vol.* 1, *Part* 2, *Sect.* 2, *Chap.* 1). Control unit Type 7750 is shown on fig. 1. Electrical connections to the control unit are made by PL6 whose connections are shown on the circuit (*fig.* 5).

6. The mounting Type 9545 (*Ref. No.* 10AJ/258) is fitted with a detachable backplate (*Ref. No.* 10AR/3026) which is secured to the mounting by 12 screws. The mounting is a standard type as used in an aircraft installation and is fitted with anti-vibration mountings, two Type 963 (2 lb) at the back and two Type 964 (3 lb) at the front. A quick release mechanism is fitted underneath the mounting; the mechanism can be seen on

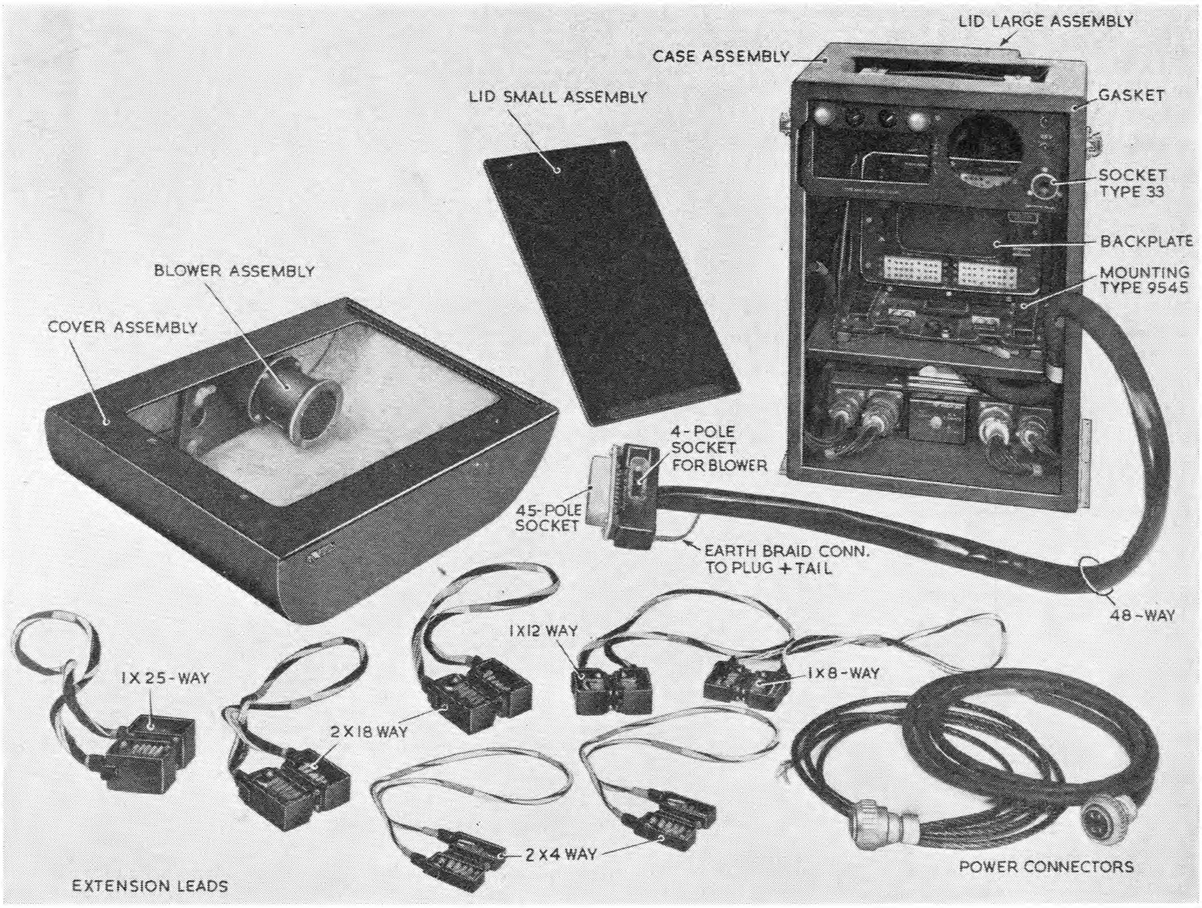

Fig. 2. Test rig Type 7477—front view and connectors

fig. 2 with the locking lever in the released position. When the lever is pushed to the left over the dead-centre position and then under the mounting (*fig.* 1), the coupling unit is locked in position by the tension of four heavy gauge springs which hold the coupling unit rigidly in the mounting. The backplate is fitted with three sockets which mate with plugs on the coupling unit. There are also two spigots fitted on the backplate to line up the coupling unit plugs with the backplate sockets.

7. The junction box Type 9861 (*fig.* 5) (*Ref. No.* 10D/22590) carries all the interconnections between the units fitted in the test rig and the transmitter-receiver. It also contains two filter units to protect the unit against radiations picked up in the power supply and control unit cables. The junction box has five connectors which mate with the following plugs and sockets:—

(1) SK1, a 45-pole socket mates with a 45-pole plug connected to a 48-way cable. The extra three leads in the cable carry the power supply to the blower assembly (*fig.* 4 and 5).

(2) SK2, a 10-pole socket mates with PL5.

(3) SK3, a 19-pole socket mates with PL3.

(4) PL1, a 19-pole plug mates with SK3.

(5) PL2, a 7-pole plug mates with SK5.

All connectors can be seen on fig. 4 except SK1 which is shown on fig. 1. Also shown on fig. 1 are the test rig connector numbers with the corresponding junction box connector numbers next to them in brackets.

Circuit description (*fig.* 5)

8. The 28V d.c. supply is fed to PL2 pins A and B on the test rig, pin A is the positive connector and pin B negative, pin C is an earth connection, pins B and C are connected together in the test rig. FS2, a 2A fuse, is connected between PL2/A and S2, the 28V off-on switch. When S2 is switched on the red 28V lamp ILP2 will light. ILP2 is in series with a 68-ohm resistor R2 across the 28V supply. The 115V 400 c/s supply is connected to pins A and B on PL1; pin A is the line connection and pin B the neutral which is earthed. FS1 a 5A fuse is connected between PL1/A and the 115V off-on switch S1. When S1 is depressed to the "on" position the red 115V lamp ILP1 will light.

ILP1 is in series with R1 a 1K-ohm resistor across the 115V supply. From S1 the 115V line is connected to terminal 3 on the terminal strip, it is then connected to the normally-open contact RL1/1.

WARNING

The 28V d.c. supply must be plugged in to PL2 and pin C of PL2 earthed prior to plugging in the 115V a.c. supply.

9. When S2 is closed, 28V is fed to terminal 2 on the terminal strip, from there it is fed to pins D and G on SK5 (*fig.* 5). SK5 mates with PL2 on the junction box Type 9861. The 28V fed to PL2/D on the junction box is fed to the following points:—

(1) To SK3/H via R1, this connection is not used at present.

(2) To the normally open contact RL3/1

(3) To SK2/D.

(4) Via the coils of relays 1, 2 and 3 and R2 to SK2/A.

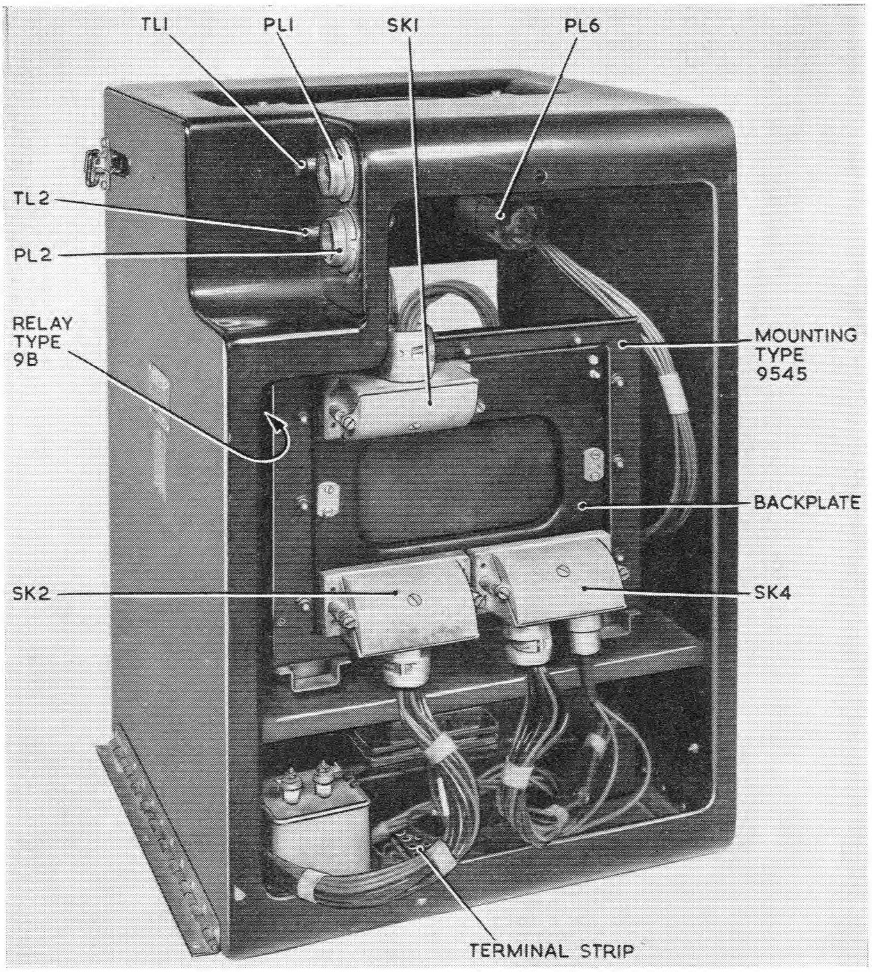

Fig. 3. Test rig Type 7477—rear view

10. SK2 on the junction box mates with PL5 which in turn is connected to PL6. PL6 feeds the control unit Type 7750 or 9273. When the switch on the control unit is operated, an earth is placed on SK2/A (*para.* 9(4)) causing relays 1, 2 and 3 to be energized and their contacts then connect the following points:—

(1) RL1/1 and RL1/2 in parallel connect PL2/C to SK1/1. This line carries 115V 400 c/s when available.

(2) RL2/1 and RL2/2 in parallel connect PL2/G to PL2/B. PL2/G has 28V on it (*para.* 9), thus 28V now appears on PL2/B.

(3) RL3/1 connects 28V to SK1/44 (*para.* 9(2)).

(4) RL3/2 connects PL2/E to SK1/3. This line carries 115V 400 c/s when available.

11. The 28V available on PL2/B in the junction box (*para.* 10(2)), is coupled via SK5/B and terminal 6 on the terminal strip to terminal 1 of RL1 and PL6/M. RL1 now energizes because it has 28V across its coil, consequently RL1/1 closes and 115V is connected to the following points when S1 is closed:—

(1) SK5 poles E and C.

(2) SK4 pole A.

(3) Terminals 4 and 5 on the terminal strip.

The 28V on PL6/M is fed to the control unit where it is used to light two dial illuminating lamps.

12. The 115V fed to SK5 poles E and C (*para.* 11(1)) is fed to PL2 pins E and C on the junction box Type 9861. There it is connected to SK1 in the junction box as detailed in para. 10(1) and (4). Thus it can be seen that the 115V supply cannot be connected to the TR9171 or the coupling unit until the 28V is available and the switch on the control unit is operated.

13. The 115V supply fed to SK4/A together with the earth on SK4/B provides the energizing supply for the bearing, one-mile and ten-mile transmitters in the coupling unit (*A.P.*2534N, *Vol.* 1, *Part* 2, *Sect.* 2, *Chap.* 10).

14. The 115V supply fed to terminal 4 of the terminal strip is the line supply for the blower assembly. From terminal 4 the 115V is fed to C1 a 1μF capacitor (*fig.* 3) and to pole 1 of the 4-pole socket for the blower assembly. The other side of C1 is connected to pole 2 of this socket to provide a quadrature supply for the blower motor; pole 3 of the socket is the earthed neutral line. The blower socket is mounted on top of bracket assembly Type 592 (*Ref. No.* 10*AR*/3074) which terminates the 48-way connector (connector *Type*

*A*521/20*A*/*R*1 *Ref. No.* 10HS/12). On the front of the bracket assembly Type 592 is a 45-pole socket which fits into the test cradle Type 11106.

15. The identity tone fed to the control unit from the transmitter-receiver is fed back to the test rig PL6/N from the slider of the identity tone volume control on the control unit. In the test rig, PL6/N is connected to the positive pin of the identity tone jack (JK1) and to terminal 1; the negative pin of JK1 and terminal 2 are earthed. All other connections between plugs and sockets in the test rig are through cableforms, details of which are given in fig. 5.

Cover assembly and lids

16. The extension leads are stowed in the cover assembly, access to which can be gained by releasing two Dzus fasteners at the top and removing the small lid assembly. Inside the small lid is an engraved plate giving details of the contents of the cover which should be nine connectors and the air blower; details of the contents are given in Table 1. The blower is secured to a bracket in the cover by two Dzus fasteners which are also used to secure the blower to bracket Type 592 on the test cradle. There is a gasket on the front edge of the test rig to prevent ingress of dust and moisture when the front cover is on the test rig. The large lid assembly on the rear of the test rig can be released by two Dzus fasteners at the top in order to obtain access to the terminal strip and the connectors mounted on the backplate.

TABLE 1

List of contents of the front cover assembly

Connector Type	Ref. No.	No. of cores	No. off	Remarks
E522/20C/R1	10HS/81	4	2	
E523/20C/R1	10HS/82	8	1	
E524/20C/R1	10HS/83	12	1	
E525/20C/R1	10HS/84	18	2	
E526/20C/R1	10HS/85	25	1	
B32/50E/R1	10HS/112	4	1	Power connector
B33/50E/R1	10HS/113	4	1	Power connector

The cover also contains Blower, air, Ref. No. 5UD/6464.

Special connectors

17. The extension leads contained in the front cover assembly are for use with a prototype transmitter-receiver. When the RT.220C or RT. 636 is being tested additional connectors are required; details of these are given in Table 2.

TABLE 2

Additional connectors required

Type	Ref. No.	Length	From	To	Connections
A661/20A/R1	10HS/202	18″	Chassis sockets J103/104/105/106	Sub-unit plugs P301/401/501/601	Pin to pin
A661/20A/R2	10HS/203	3″	Chassis socket J102	Video decoder unit P201	Pin to pin
A662/20A/R1	10HS/204	18″	Chassis socket J109	Power supply unit P901	Pin to pin
A660/20A/R1	10HS/205	18″	Chassis sockets J110/111	RF osc. IF amp P.1001/1101	Pin to pin

Note . . .

These connectors are not part of the test rig and will have to be demanded when required.

TEST CRADLE TYPE 11106

18. The test cradle, which is illustrated in fig. 1, has a cast aluminium alloy frame and a steel base. It is approximately 16½ in. high and the base is about 16 in. in diameter. The cradle weighs about 38 lb. It is connected to the test rig by a 48-way connector which is terminated at the cradle end by a special bracket (bracket assembly Type 952) and at the test rig end by a 45-pole plug which mates with socket SK1 on the junction box Type 9861; the three leads in the connector not connected to the 45-pole plug are taken to C1 and the terminal strip, these leads carry the air blower power supply. The bracket assembly carries two sockets, a 4-pole socket on the top carries the air blower

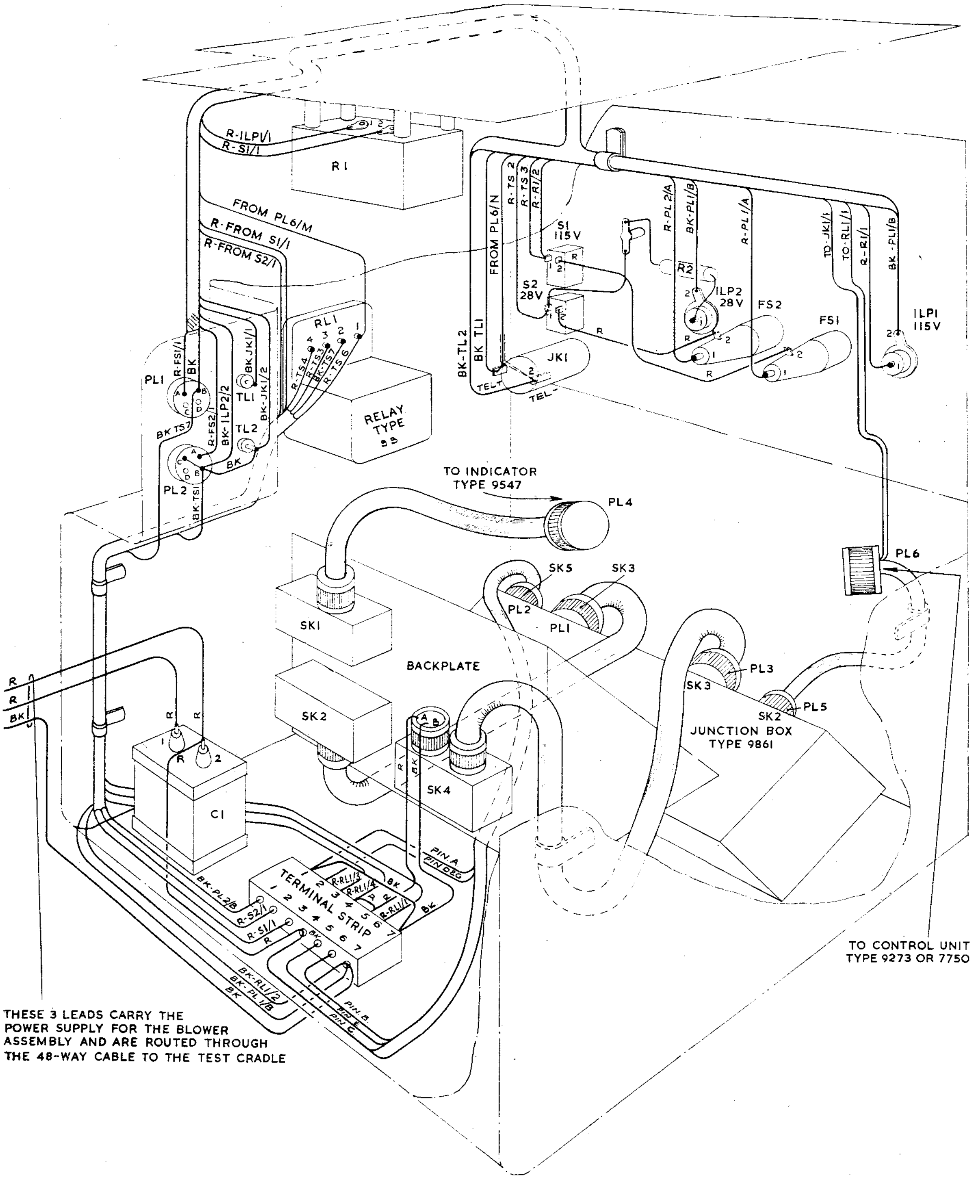

Fig. 4. Test rig Type 7477—wiring diagram

supply and a 45-pole socket on the front carries all the connections to the transmitter-receiver. The 45-pole socket fits into a rectangular hole in the back of the cradle frame, the socket is secured in place in the following manner. Undo the four 4 B.A. screws securing the 45-pole socket to the bracket, release the cable clamp at the rear of the bracket and slide the socket through the rectangular hole. Note that the socket must be pushed through the hole at an angle. Re-assemble the bracket leaving the socket on the transmitter side of the frame and the remainder of the bracket on the outside. Ensure that the 45-pole socket is the correct way up to mate with the plug on the transmitter-receiver and that the blower socket is on top of the bracket. Tighten the four B.A. screws at the front and the cable clamp at the rear. The 48-way connector also carries a strip of $\frac{1}{4}$ in.

braiding, this is secured to the socket and a tail of it is left hanging so that it can be attached to any particular unit on the transmitter-receiver and so enable a good earth bond to be made between the test rig and the transmitter-receiver.

WARNING

On no account should transmitter-receiver be placed in the cradle frame without the 45-pole socket in position. This precaution is necessary because the two spigots on the frame do not always get sufficient purchase on the transmitter-receiver to take its weight on their own should the frame be placed in a vertical position.

19. The rectangular frame which carries the transmitter-receiver should be locked in the horizontal position by the spring-loaded plunger at the top of the left-hand "leg"; this is to ensure that the frame does not tip up when the unit is first placed on it. The transmitter-receiver must always be secured to the frame by tightening two claw assemblies over two projections on the front of the unit. When the transmitter-receiver is secured to the frame the plunger can be withdrawn; the frame can then be set to any angle desired and locked by the handle on the right-hand side. The two spigots at the rear of the frame help to locate the unit's plug and the socket on the frame. It should be noted that the spigots only just enter the corresponding holes on the back of the transmitter-receiver and the main mechanical strength for holding the unit in the back of the frame comes from the mating of the 45-pole plug and socket (see Warning note at end of *para.* 18). The small hole at the rear of the test cradle frame is provided to accommodate the safety microswitch plunger fitted to the transmitter-receiver.

20. The base of the test cradle consists of two circular sections secured together in the centre by a fitting which allows the top section to rotate freely with respect to the bottom section. The bottom section is fitted with a spring-loaded plunger which fits into any one of a number of holes drilled in the periphery of the top section to hold the cradle in a set position. If required, the top section can be turned freely by pulling out the handle of the plunger and giving it a slight turn to lock it in the "out" position.

21. The top circular section carries the main framework of the test cradle which is secured to it by three bolts on either side. The framework consists of two "legs" which carry the rectangular frame. The rectangular frame is secured to the "legs" by two rotating joints and the frame is locked in the vertical plane by turning the handle on the right-hand side; when the handle is turned it tightens up a collet type chuck which clamps the spindle carrying the frame.

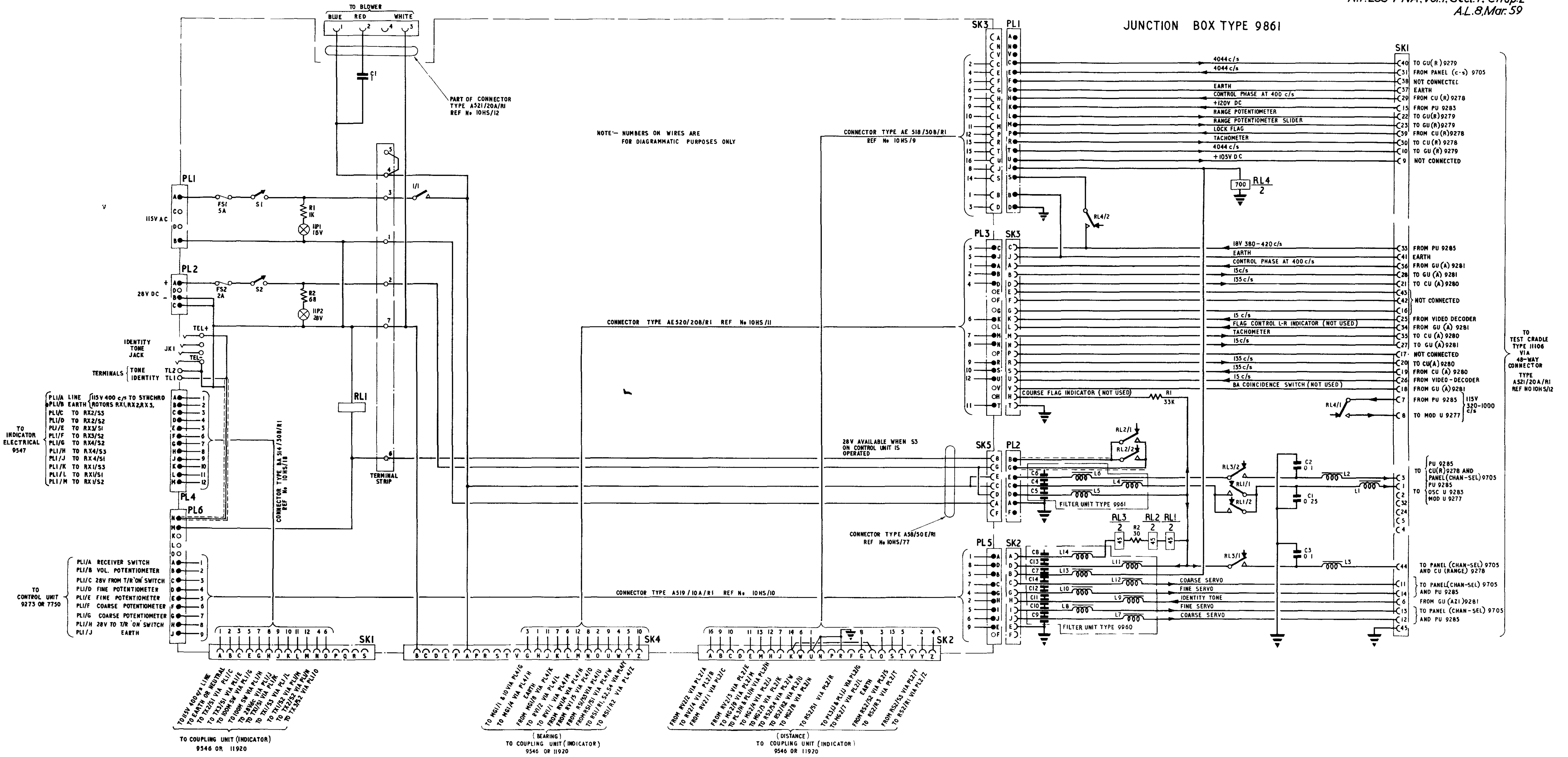

Fig. 5

Test rig 7477 — circuit

Fig. 5

924-6 6415 31531 HD & CO. LTD.

Chapter 3

TEST SET MOTOR CONTROL TYPE 9948

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Introduction

1. Motor control test set Type 9948 is provided as an item of TACAN (AIR) test equipment to check the operation and accuracy of reading on the dials of the coupling unit (indicator) Types 9546 and 11920 and indicator electrical Type 9547. In a normal equipment it is not possible to adjust the speed of the TACAN dials or to stop and reverse their movement. These operations can be done by inserting the test set between the mounting unit and the coupling unit on the A.R.I.

Connecting up (*fig.* 1)

2. To connect the motor control test set Type 9948, the connections to PL2 and PL4 of the couping unit are disconnected at the mounting tray and re-connected to PLA and PLC of the test set. Two connectors are provided which are connected between PLB and SKTA of the test set and PL2 and PL4 of the coupling unit at the mounting tray. The insertion of the test set does not affect the normal functions of the A.R.I. because it provides a straight through circuit when FUNCTION switch SA is set to OFF; in this position the DIRECTION switch SB is disconnected so the setting of this switch is immaterial.

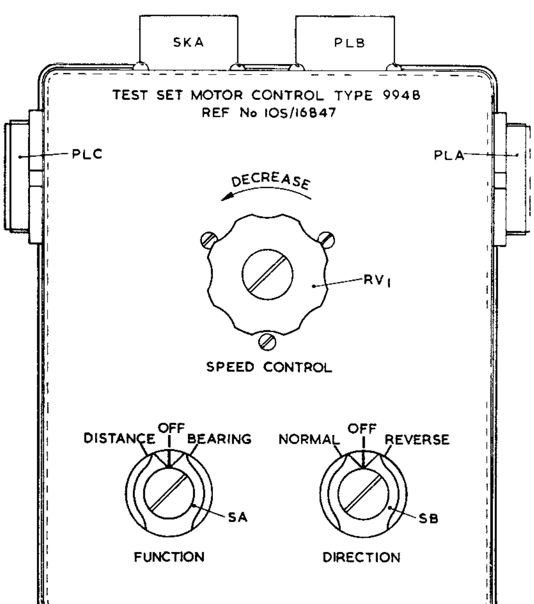

Fig. 1. Test set motor control Type 9948—front panel

Circuit description (*fig.* 2)

3. When FUNCTION switch SA is set to BEARING and DIRECTION switch SB to NORMAL, the distance motor MG2 in the coupling unit functions normally and the bearing motor MG1 standard control phase connections are disconnected at SA1Bb (terminals 5 and 8). Both control and fixed phases are then obtained from SA1Bc (terminals 9 and 12) in the following manner:—

(1) Control winding supply from pole Q of PLC via SA1Bc terminals 9 and 12, C1, SB terminals 10 and 9, SA2Bc terminals 12 and 9 to pole c of SKA.

(2) Fixed 18 V a.c. supply from pole A of PLC via SA1Bc terminals 9 and 12, RV1, SB terminals 6 and 5, SA2Bb terminals 8 and 5 to pole A of SKA.

Potentiometer RV1 is the motor SPEED CONTROL and it is connected to the fixed winding of MG1, terminals 3 and 1. C1 is connected to the control winding of MG1, terminals 4 and 2.

4. When SA is again set to BEARING and SB set to REVERSE the following circuits are provided:—

(1) Control winding supply from pole Q of PLC via SA1Bc terminals 9 and 12, C1, SB terminals 8 and 5, SA2Bc terminals 8 and 5 to pole A of SKA.

(2) Fixed winding supply from pole Q of PLC via SA1Bc terminals 9 and 12, RV1, SB terminals 12 and 9, SA2Bc terminals 12 and 9 to pole C of SKA.

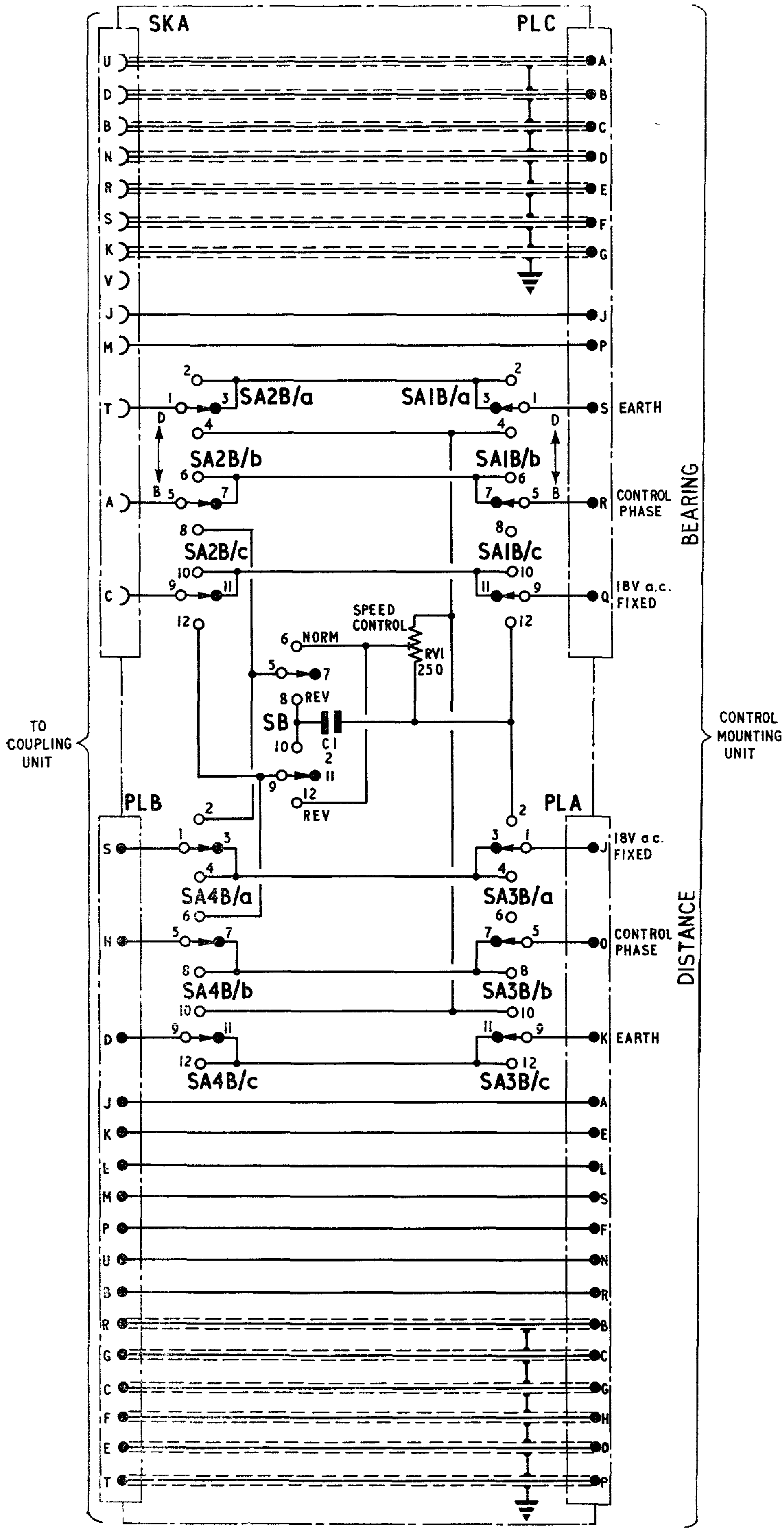

Fig. 2. Test set motor control Type 9948—circuit

This circuit arrangement is now the reverse of that described in para. 3. The control current, which must pass through C1, is now fed to MG1 terminals 3 and 1 and the fixed current, which passes through RV1 for speed control purposes, is fed to MG1 terminals 2 and 4.

5. A similar circuit arrangement exists when SA is set to DISTANCE. In this case the standard control circuit is disconnected at SA3Bb and both fixed and control currents are taken from SA3Ba according to the setting of SB; this determines which winding of MG2 should become the control winding via C1, and which should be the fixed winding through RV1.

SECTION 2

TESTER PERFORMANCE TYPE 10166 (10S/17501)

LIST OF CHAPTERS

Note:—A List of Contents appears at the beginning of each Chapter

1 **General description**

2 **Circuit description**

3 **Setting up and operating instructions**

4 **Servicing and fault diagnosis**

CORRIGENDA LEAFLET No.1/60

POWER SUPPLY. The performance tester Type 10166 is supplied from the manufacturers with power supply tapping set up for 115V, 400c/s (nominal) supply. To operate the tester on a 180V or 200V supply, the soldered connection on the mains input transformer must be moved to the correct tapping point.

Notes

(1) The information contained in this leaflet will be incorporated by normal amendment list action in due course.

(2) If, after receipt of this leaflet, an amendment list with a prior date and conflicting information is received, the leaflet must be taken as the overriding authority.

Section 2

PERFORMANCE TESTERS TYPE 10166 & 10166A

Chapter 1

GENERAL DESCRIPTION

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LEADING PARTICULARS

Ref. No. Type 10166	**10S/17501**
„ „ Type 10166A	**10S/17867**
Dimensions	$17\frac{1}{2}$ *in. by* 16 *in. by* 7 *in. with earlier lid.* *(depth increased by* 2 *in. with later lid.)*
Weight	35 *lb. approx.*
Power supply	115/180/200*V*, 320–1760 *c/s single phase.*
Power consumption	100*W at* 115*V*, 400 *c/s.*
Construction	*Main chassis framework carrying six miniaturized sub-units.*
Electronic valves	33
Semi-conductor diodes	22
Output level (receiver sensitivity) with facility switch set to DIR	*Variable* $\pm$6*dB from* ◀−110*dBW*▶ *with specially calibrated attenuator dial for accept/reject indication.* *Accuracy* $\pm$2*dB.*
Input level (transmitter power) with facility switch set to DIR	*Variable* $\pm$6*dB from* ◀+30*dBW*▶. *Accuracy of* $\pm$2*dB on channel* 39 *only.*
Output power, facility switch set to RAD *(Type* 10166*A only)*	−30*dBm (nominal).*
Range	*Choice of two,* 5 $\pm\frac{1}{4}$ *mile and* 105 $\pm$2 *miles.*
Bearing	*Choice of two,* 140° *and* 323° *both* $\pm$2°.
Identity tone	*Continuous,* 1350 *pulse groups per sec.*
R.F. output	1000 *Mc/s (channel* 39*) for receiver sensitivity checks.*
R.F. input	*All* 126 *frequency channels for transmitter power indication (accurate only on channel* 39*).*
Fuses	*Mains input fused on both line and neutral at* 2*A.*

Cables	*Two stowed in lid. 3-core mains input cable Ref. No.* 10*HS*/3121. *Coaxial connector, attenuator Type* 15017, *Ref. No.* 10*L*/16616.
Radiating antenna (*Type* 10166*A only*)	*Radiating antenna, stowed in lid, Ref. No.* ◀10*B*/20880▶.

Note . . .

Each performance tester Type 10166 *or Type* 10166*A should be used only with the coaxial connector, attenuator Type* 15017 (10*L*/16616) *bearing the same serial number as the performance tester. These instruments are calibrated with the particular connector they are issued with. When returned for calibration or repair, the correct connector must accompany the instrument.*

General

1. The performance testers Type 10166 (fig. 1) and 10166A (fig. 2) are portable test instruments designed to check the overall performance of the TACAN airborne installation ARI.18107 at first and second line servicing. The performance tester Type 10166A incorporates a radiating facility, otherwise both types are basically similar. The information in this Chapter applies generally to both types, but refers mainly to Type 10166A. The term 'performance tester' will therefore apply to both types and any differences will be made clear at the appropriate points.

2. The performance tester gives a clear accept/reject indication, of both receiver sensitivity and transmitter output power, on a scale (graduated in dB) which is coloured green and red. The scale is driven by a knob which also varies a piston attenuator. A cursor line is engraved down the centre of the perspex 'window' covering the scale.

3. The instrument has two distinct modes of operation which are selected by the METER SWITCH on the front panel. When the switch is in the RX SENS position the tester acts as a signal generator and generates an r.f. signal at 1000 Mc/s (channel 39) which is pulse coded and amplitude modulated to simulate the signal that the ARI.18107 installed in an aircraft would receive from a TACAN surface beacon (SRI.18118 or FGRI.18119). The tester can provide information signals equivalent to two

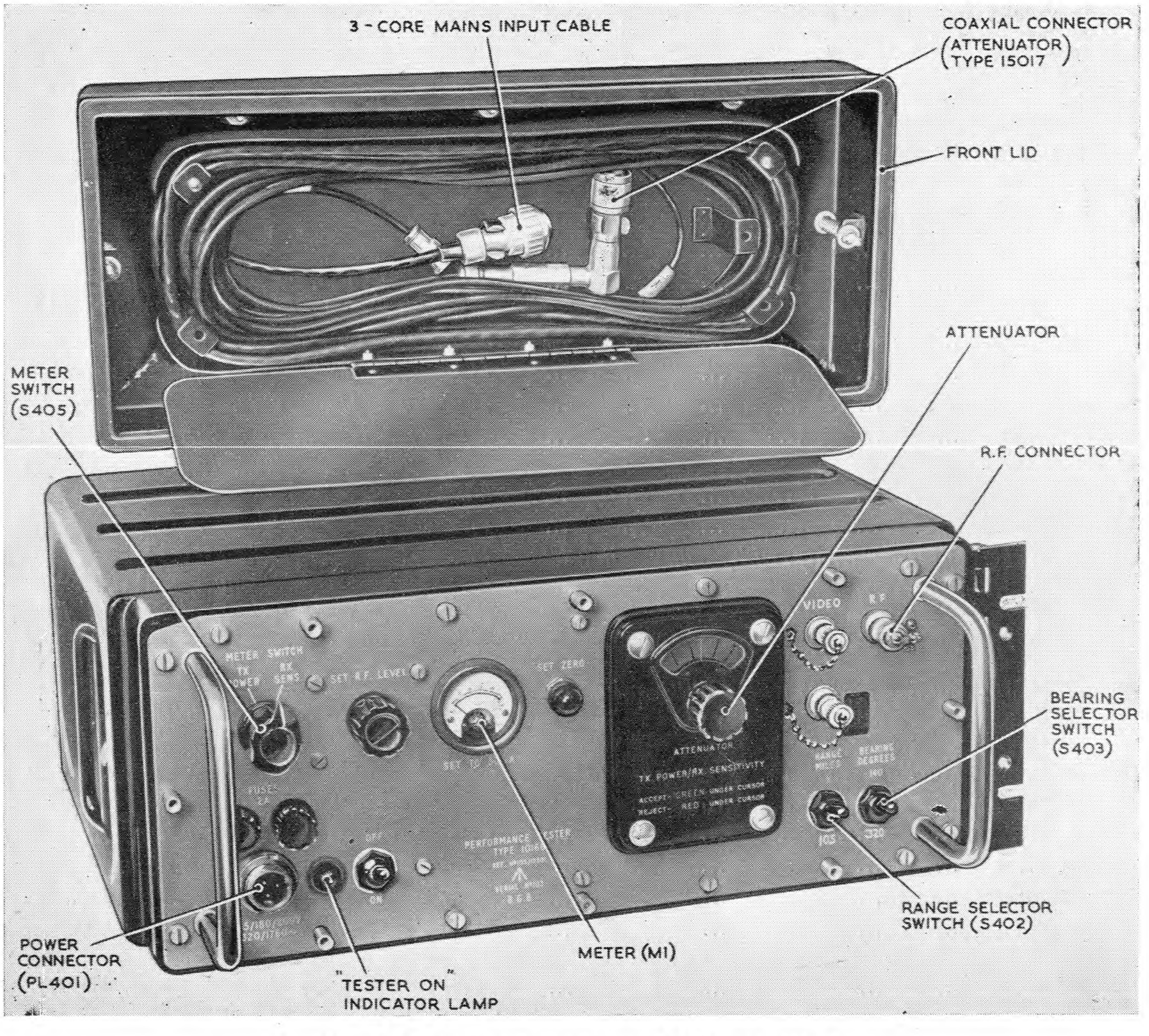


Fig. 1. Performance tester Type 10166: general view

fixed distances of 5 and 105 miles, and two fixed bearings of 140° and 323°, the required bearing or distance being selected by switches on the front panel. The identity tone, normally heard in a pilot's headset when interrogating a beacon, is generated continuously and is not coded as is the surface beacon signal.

4. The second mode of operation is selected when the METER SWITCH is in the TX POWER position, the instrument then operates as a power output indicator. This facility is available on all 126 channels. Thus it is possible to make a rapid check of the following functions of ARI.18107:

(1) Operation on one channel (channel 39, 1000 Mc/s).

(2) Sensitivity.

(3) Distance (5 and 105 miles).

(4) Bearing (140° and 323°).

(5) Identity tone (continuous).

(6) Output power (all channels), accurate only on channel 39. On all other channels only an indication is given.

(7) Coding and decoding.

5. When using the Type 10166, or the Type 10166A in the direct connection mode, measurements of airborne receiver sensitivity and transmitter peak power are made by manipulation of a colour-coded calibrated (1dB per division) r.f. attenuator. The colour code may be used to facilitate rapid GO/NO GO tests, the decibel calibration is used to make accurate quantitative tests. When using the Type 10166A in the radiating mode, the calibrated attenuator is by-passed by the DIR/RAD switch.

Power supplies

6. The performance tester requires only one primary power supply of 115/180/200V at 320–1760 c/s, and consumes 100W at 115V 400 c/s. The mains input lines are both fused at 2A. Normally 115V 400 c/s will be used as this is a standard aircraft supply, which is also required for ARI.18107. The secondary power supplies required by the tester are +105V, −150V and 6·3V a.c., these are derived from a power supply unit in the instrument.

External connections

7. Connection to the instrument is made by two cables which are stowed in the lid (fig. 1 and 2). The power connector is a 3-cored cable terminated at one end by a 3-pole socket which mates with the power input plug PL401 on the front panel of the tester; the other end of the cable is left free so that

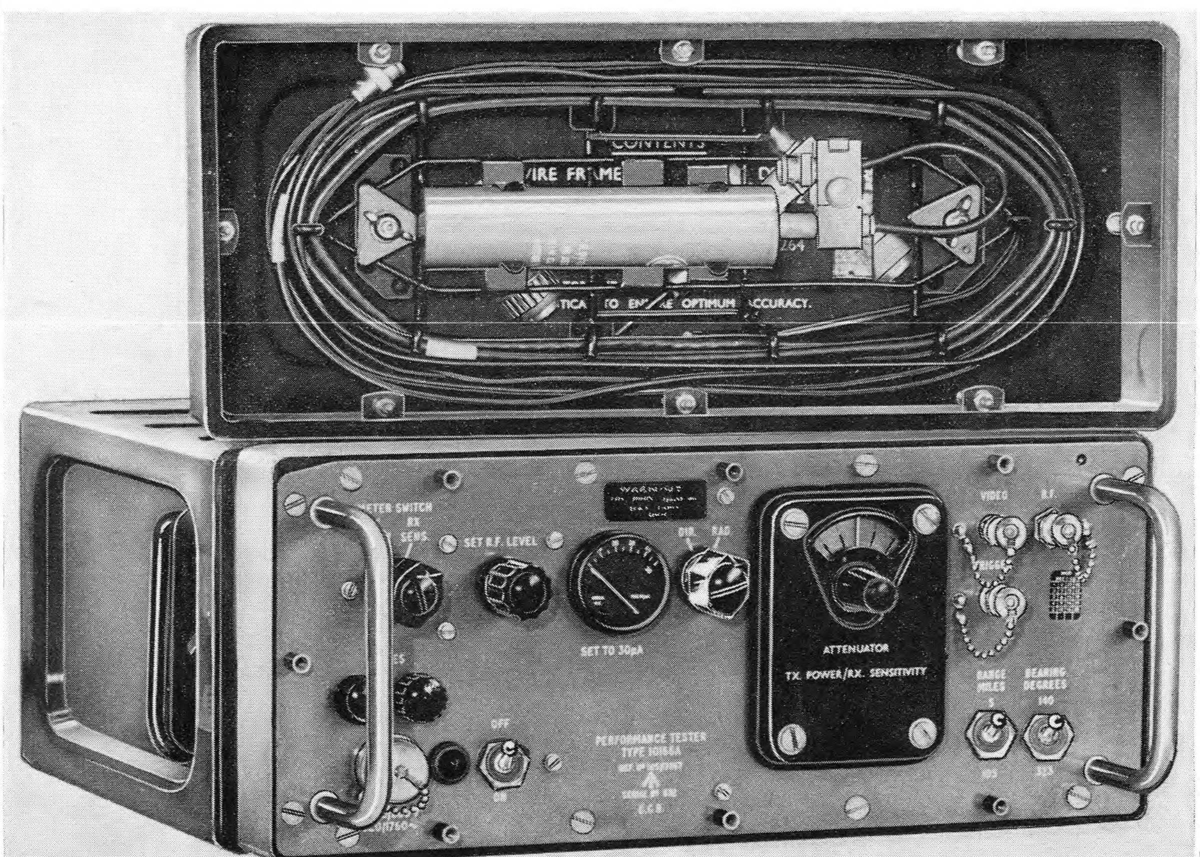


Fig. 2. Performance tester Type 10166A: general view

it can be terminated as circumstances require. The r.f. connection to the TACAN airborne equipment is made by a coaxial connector (attenuator Type 15017, Ref. No. 10L/16616,) which is shown on fig. 1.

Antenna

8. When the Type 10166A is used in the radiating mode, an antenna is required. This antenna (Ref. No. ◀10B/20880▶) is used in place of the coaxial connector and is also (in later models) stowed in the lid (fig. 2).

Mechanical characteristics of the performance tester

9. The instrument is contained in an aluminium-alloy case $17\frac{1}{2}$ in. wide by 7 in. high by 16 in. deep, the depth including 2 in. for the lid. It weighs approximately 35 lb and its external features, with the lid removed, are shown in fig. 1 and 2. The instrument is fitted with two hinged plates which lie level with the front panel: these plates enable it to be secured in a standard 19 in. test rack, if required. The lid is secured by eight captive screws which screw into threaded bushes on the front panel. In the earlier type lid (fig. 1) the two cables are stowed on fixed pegs and are protected by a hinged plate on which are printed the operating instructions; no provision is made for stowing the antenna in this lid. In the later type lid (which increases the depth of the instrument by 2 in.) both cables and the antenna are stowed on a removable plastic-coated wire drum (fig. 2). Around the edge of the lid where it meets the main cover is a rubber gasket which prevents the ingress of dust and moisture during storage and carriage.

10. The front panel of the instrument carries all the indicators, controls and connectors required to operate the performance tester. Also mounted on the front panel are two handles and eight bushes threaded to receive the captive screws on the front cover. All the components mounted on the front panel are sealed to make the instrument completely weather-proof. An air valve is fitted on the left-hand side of the case and must be opened when the tester is transported by air; this is to prevent the seals round the front panel components being broken by internal air pressure.

11. The chassis of the instrument can be removed from the case by unscrewing twelve 2 B.A. cheese-head screws which pass through the front panel into threaded holes in the outer case. When the chassis is withdrawn from the cover the main framework with the sub-units attached can be seen; top and bottom views of the instruments are shown in fig. 3, 4 and 5. Top and bottom views of the sub-units are shown with the relevant text in Chapter 2 of this Section.

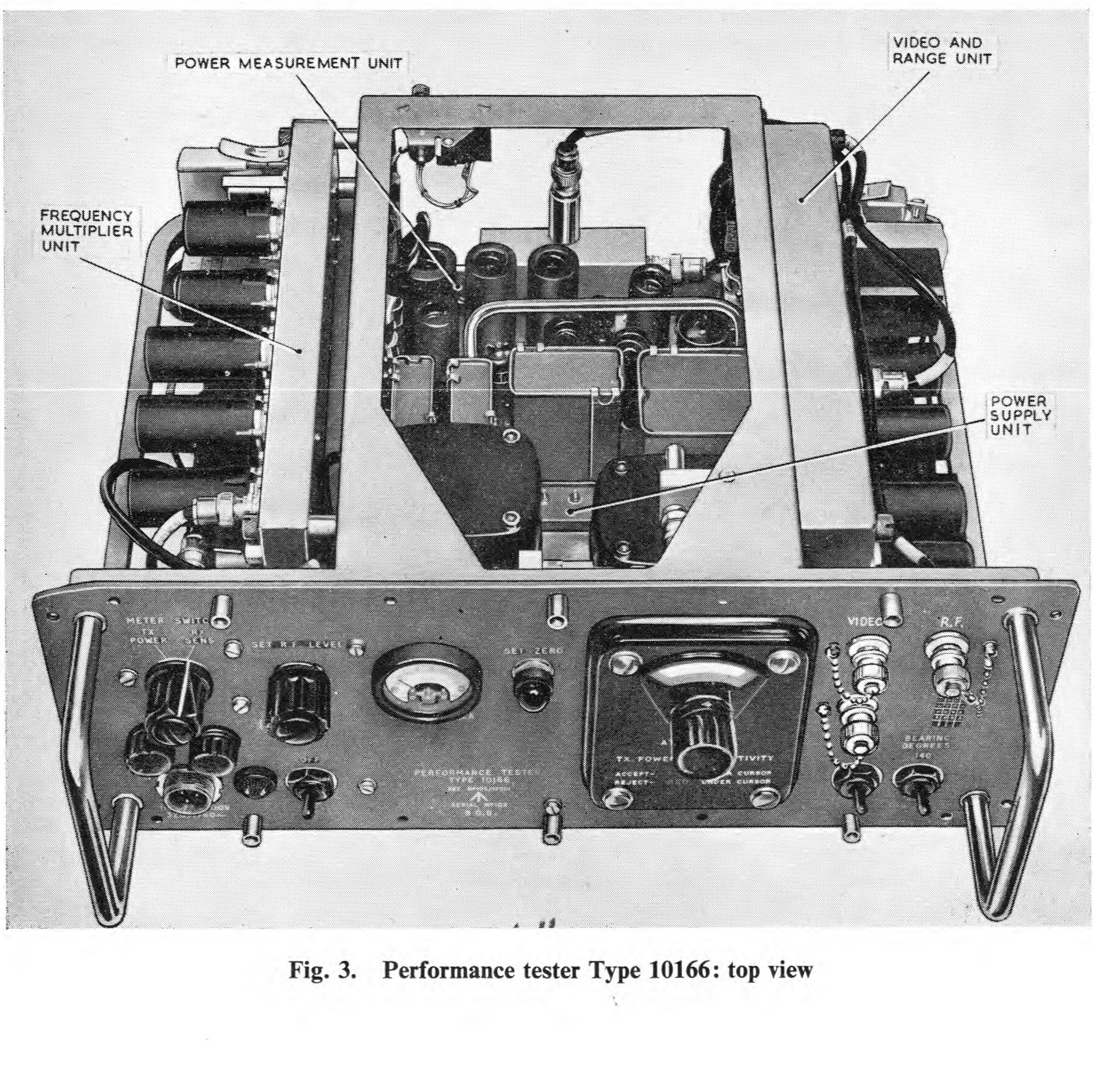


Fig. 3. Performance tester Type 10166: top view

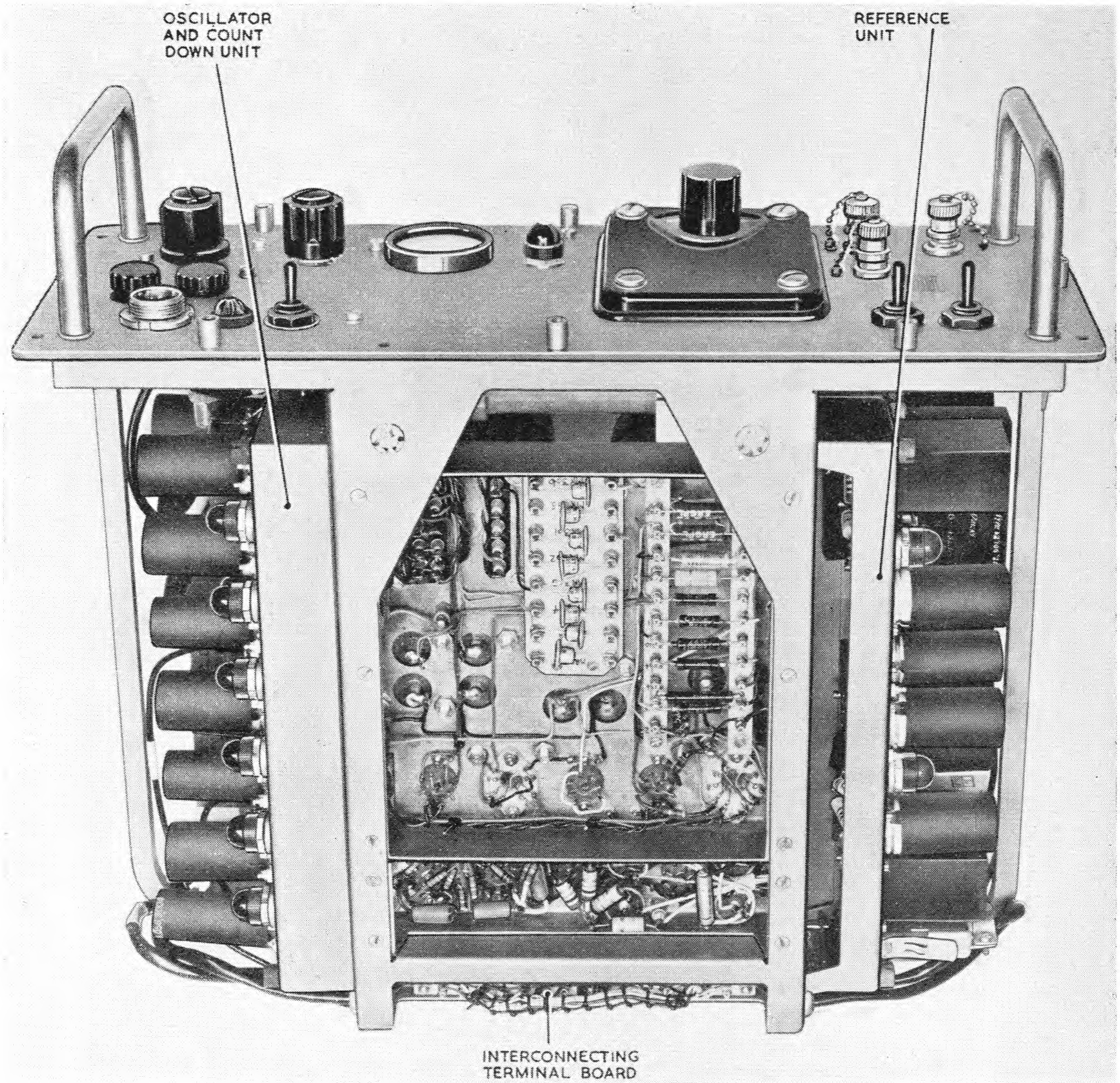


Fig. 4. Performance tester Type 10166: bottom view

12. The instrument comprises seven parts, as follows:

(1) Front panel and the framework which carries the coaxial system and the interconnecting terminal board.

(2) Oscillator and count-down unit.

(3) Reference unit.

(4) Video and range unit.

(5) Frequency multiplier unit.

(6) Power measurement unit.

(7) Power supply unit.

All connections to the sub-units named in items (2) to (7) above are made by miniaturized plugs and sockets. The complete instrument contains thirty-three electronic valves, fourteen crystal diodes and eight silicon junction rectifiers; details of the valve complement of the tester are given in Chapter 4 of this Section.

TACAN signals

13. The interrogation pulses transmitted by the TACAN airborne equipment consist of pulse pairs spaced at $12 \pm 0{\cdot}5 \mu S$ at a repetition rate of either 24–30 p.p.s. or 120–150 p.p.s. depending on whether the airborne equipment is on track or search. The signals will be at a frequency corresponding to one of the 126 channels, spaced at 1 Mc/s, in the band 1025–1150 Mc/s at a peak pulse power of 800W (min.). The signals from the airborne equipment trigger the DME reply circuits in the surface beacon, which is of the transponder type. The beacon is also transmitting the following information irrespective of whether it is being interrogated or not.

(1) Coded identity tone pulses—these consist of twin pulse pairs spaced at 100 μS at a repetition rate of 1350 c/s.

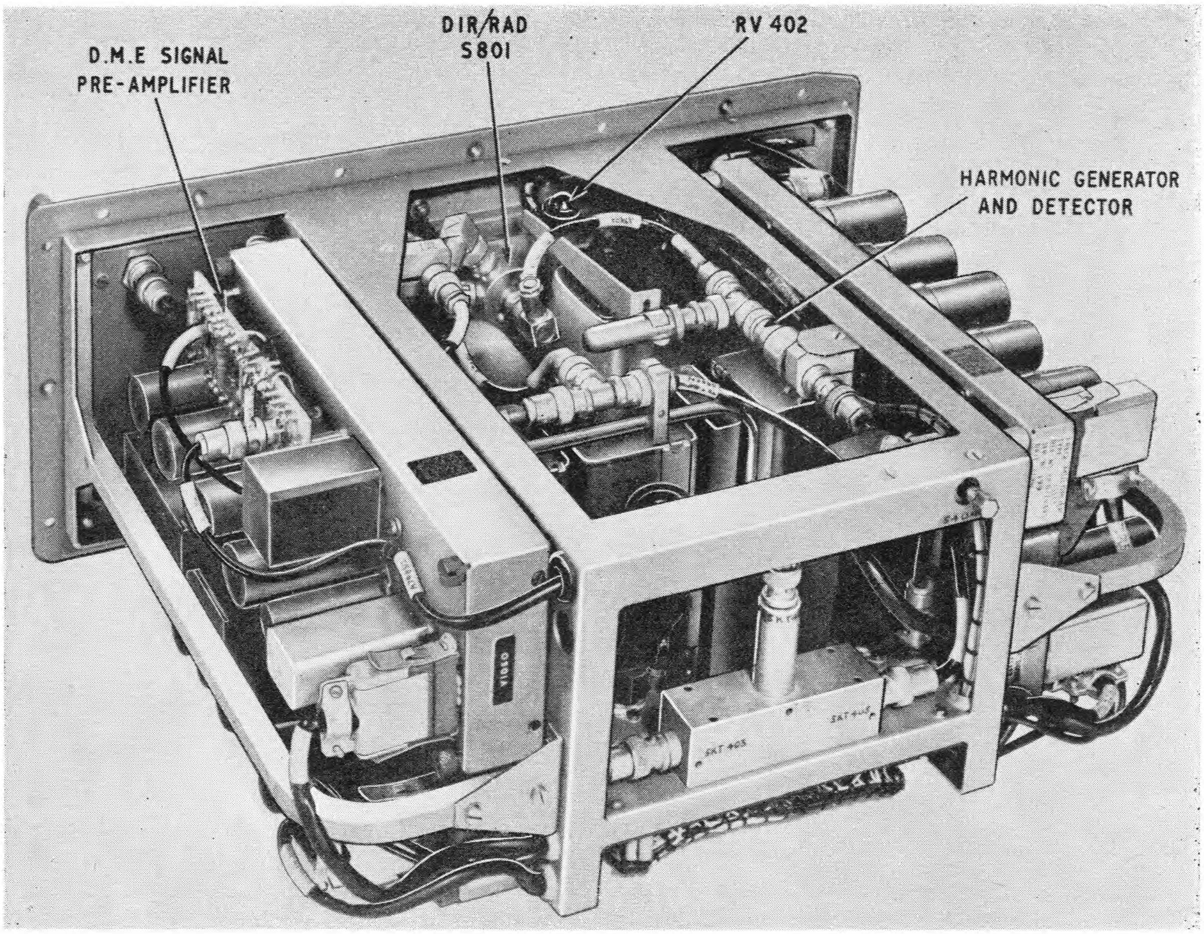


Fig. 5. Performance tester Type 10166A: internal view

(2) North marker bursts—these consist of a train of 12 pulse pairs spaced at 30μS occurring 15 times per second.

(3) Harmonic marker bursts—these consist of a train of 6 pulse pairs spaced at 24μS occurring at a rate of 135 times per second.

14. The north marker burst is generated once per revolution of the aerial and the harmonic marker burst eight times per revolution (i.e. every 40° of rotation except the space where the north marker occurs). The aerial rotates at 900 r.p.m. (15 rev/s), therefore the north and harmonic marker bursts are triggered at 15 and 135 c/s respectively. The three signals mentioned above, together with DME reply pulses, are mixed in their order of priority and every pulse is coded into a pulse pair spaced at $12 \pm 0{\cdot}5$ μS. The beacon transmits pulse pairs at an r.f. in the bands 962–1024 Mc/s and 1151–1213 Mc/s. The whole signal is then modulated by a 15 c/s and 135 c/s modulation pattern produced by parasitic elements round the aerial. The performance tester must simulate this signal in order to check the functions of the airborne equipment.

Production of TACAN signals by the tester (fig. 6)

15. The signal generated by the instrument is produced in the following manner. The transmitted pulse pairs are 'sampled' by a detector-sampler and fed to the video and range unit where each pair is decoded into a single pulse. The single pulse is then given a preset delay equivalent to either 5 or 105 miles on the TACAN indicator. The range reply pulse is then fed to the oscillator and count-down unit.

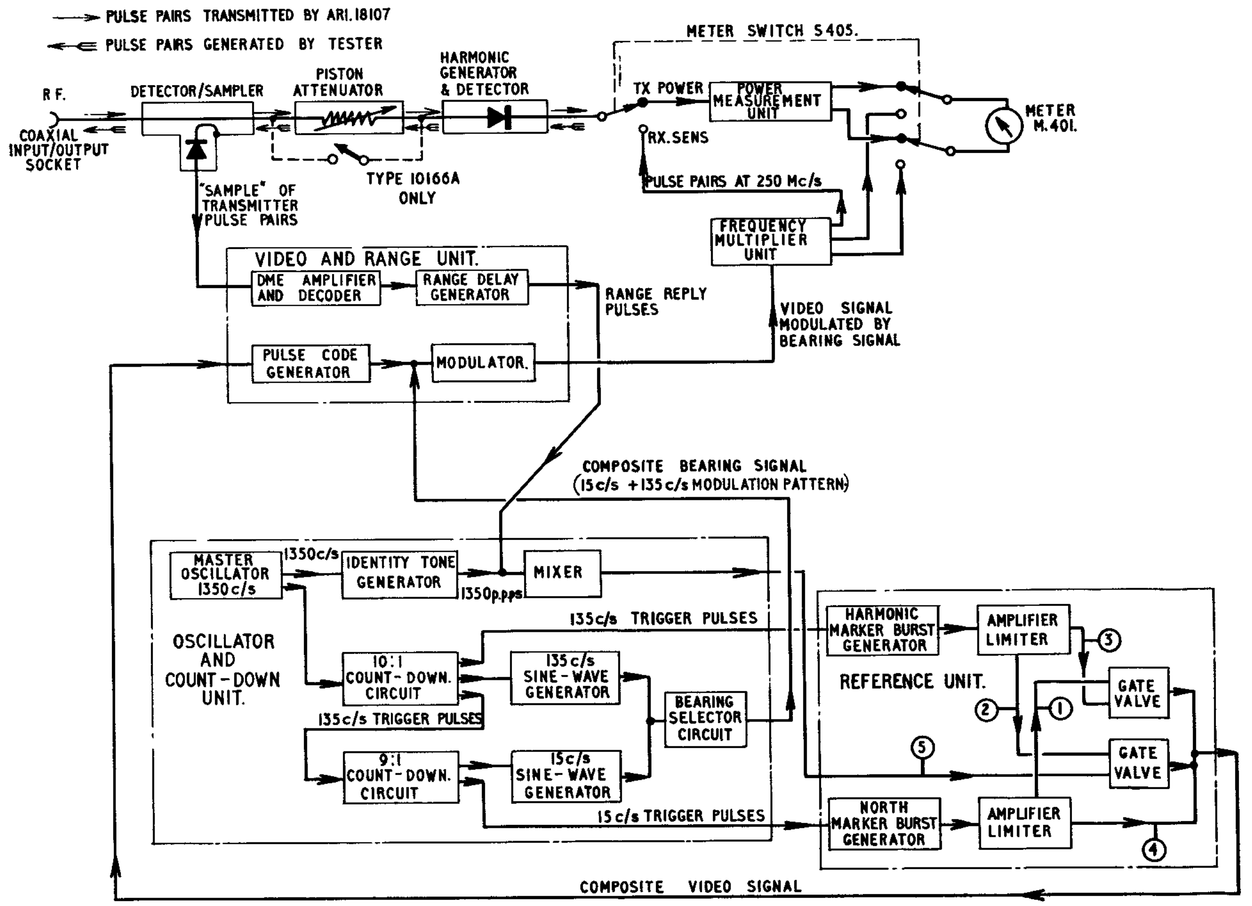
16. In the oscillator and count-down unit an oscillator generates a 1350 c/s signal from which pairs of pulses, spaced at 100μS, at a repetition rate of 1350 c/s, are produced to form the identity tone signal. It should be noted that the identity tone is generated continuously by the instrument and is not coded. The range reply and identity tone pulses are then mixed and fed to the reference unit for inclusion in the composite video signal.

17. The 1350 c/s signal is also fed to a 10:1 count-down circuit which generates a 135 c/s signal. This is used for three purposes as follows:

(1) It is fed to the reference unit to trigger the harmonic burst generator.

(2) It is used to drive a 135 c/s sine-wave generator whose output forms part of the modulation pattern.

(3) It is used to trigger a 9:1 count-down circuit.



REFERENCE UNIT

(1) BLANKING PULSES DURING GENERATION OF NORTH MARKER BURST.

(2) BLANKING PULSES DURING GENERATION OF HARMONIC MARKER BURST.

(3) HARMONIC MARKER BURST

(4) NORTH MARKER BURST

(5) RANGE REPLY + IDENTITY TONE PULSES

Fig. 6. Performance tester Type 10166 and Type 10166A: block diagram

18. The 135 c/s signal in para. 17 (3) triggers the 9:1 count-down circuit, the 15 c/s output being used for the following two purposes:

(1) It is fed to the reference unit to trigger the north marker burst generator.

(2) It is used to drive a 15 c/s sine-wave generator, the output of which forms part of the modulation pattern.

The two sine-waves mentioned in para. 17 (2) (135 c/s) and para. 18 (2) (15 c/s) are mixed to simulate the modulation pattern normally produced by the rotation of the beacon aerial.

The composite bearing signal is fed to a bearing selector circuit which produces a signal equivalent to either 140° or 323°. The selected bearing signal is then fed to the video and range unit.

19. The reference unit now has three inputs as follows:

(1) The mixed range reply and identity tone pulses (para. 16).

(2) The harmonic marker burst generator trigger (para. 17 (1)). This produces a train of 6 pulses spaced at 24μS.

(3) The north marker burst generator trigger (para. 18 (1)). This produces a train of 12 pulses spaced at 30μS.

20. The marker burst generators also produce blanking pulses which are fed to an electronic gate to cut off pulse trains of a lower order of priority than themselves during their passage. This results in the following order of priority at the gate output:

(1) North marker bursts.

(2) Harmonic marker bursts.

(3) Range reply and identity tone pulses.

These pulses form the composite video signal which is fed to the video and range unit. There, each pulse is coded into a pulse pair, spaced at 12 $\pm 0 \cdot 5 \mu S$, and shaped into a constant amplitude and width. The video signal is then modulated by the composite bearing waveform (para. 18) and fed to the frequency multiplier unit to produce pulses at an r.f. of 250 Mc/s in that unit. The 250 Mc/s signal is fed to a crystal multiplier, where the 4th harmonic is used and the complete TACAN signal at 1000 Mc/s (channel 39) is fed either directly to the airborne equipment or, with the Type 10166A set to the radiating mode, to the antenna.

21. In order to check the receiver sensitivity of the TACAN airborne equipment, the crystal multiplier current flowing through the secondary winding of the frequency multiplier output transformer is routed through a meter by two sections of the METER SWITCH. The meter is adjusted to read 30μA by varying the SET RF LEVEL potentiometer. ◀(DIR/RAD switch must be set to DIR).▶ This provides an output level of ◀-110dBW▶ variable $\pm$6dB by the built-in attenuator.

◀**Note . . .**

The RAD/DIR switch must NEVER be set to RAD with the connector/attenuator connected between the output terminal of the Test Set and the airborne equipment. This is because the transmitter output power is greater than the harmonic multiplier crystal can withstand.▶

22. When the performance tester is required to act as a power measuring instrument the signal is routed to the power measurement unit by setting the METER SWITCH to the TX POWER position. One section of the switch routes the incoming signal to the power measurement unit input while the other two switch sections connect the meter on the front panel to the power measurement unit output. The meter is then set to read zero by the SET ZERO control when the airborne equipment is switched off. Then, with the airborne equipment switched on, the ATTENUATOR dial is adjusted so that the junction of the red and green sectors of the dial is coincident with the cursor. The meter reading should be not less than 30μA for a serviceable equipment.

Chapter 2

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General

1. The description in this Chapter has been written basically for the Type 10166A. Where differences occur, details of the Type 10166 are also given.

2. The performance tester comprises a framework in which are mounted six sub-units. The framework also supports the front panel, the r.f. coaxial system and a number of components associated with the controls of the instrument. Components associated with the frame assembly are numbered 401–499. The six sub-units are as follows:

(1) Oscillator and count-down unit (components numbered 101–199).

(2) Reference unit (components numbered 201–299).

(3) Power supply unit (components numbered 301–399).

(4) Frequency multiplier unit (components numbered 501–599).

(5) Video and range unit (components numbered 601–699).

(6) Power measurement unit (components numbered 701–799).

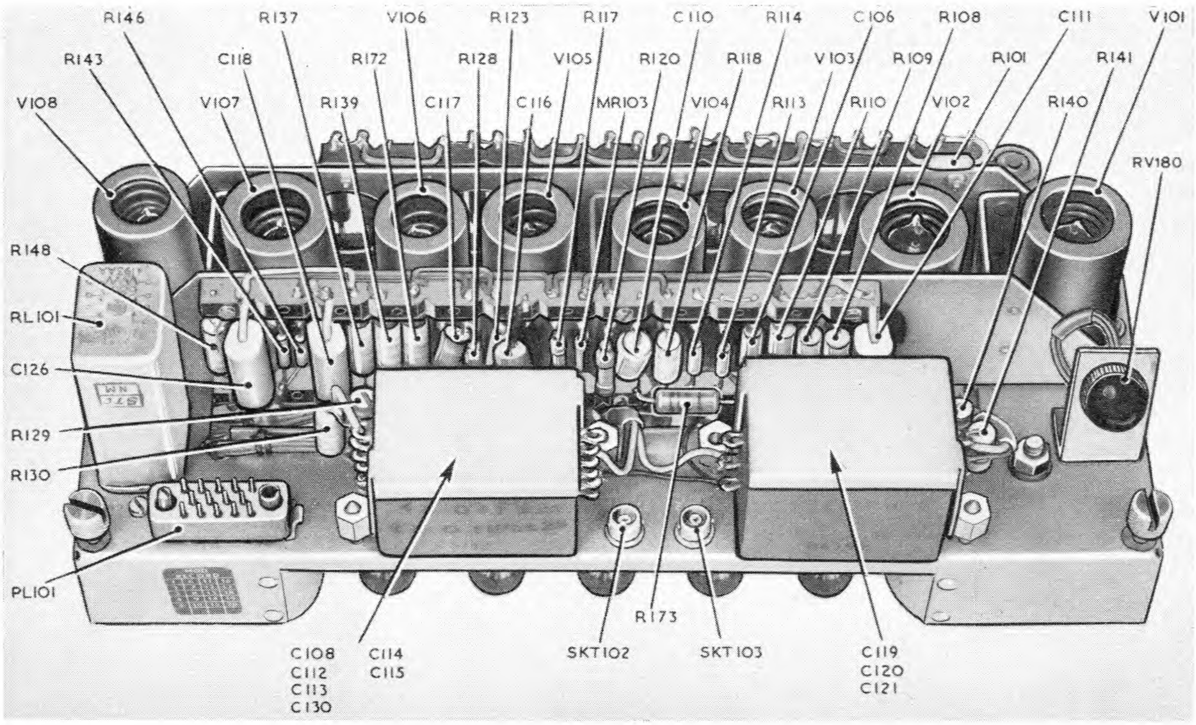


Fig. 1. Oscillator and count down unit: component location (top)

two units mounted on the left-hand side of the framework when viewed from the front. The sub-unit carries eight valves, all of which are mounted on the top of the chassis and are therefore accessible. The function of the sub-unit is to generate the 1350 c/s signal which produces the identity tone and from which is derived the pulses used to trigger the 15 c/s and 135 c/s marker burst generators. The DME reply pulses are also fed into the sub-unit, mixed with the identity tone, amplified, and then fed out again to the reference unit. The pulses fed out to trigger the marker burst generators are also used to drive sine-wave generators whose outputs are combined to form the modulating waveform. The outputs from the marker burst generators are taken from either the screen resistor or cathode resistor (as selected by the bearing selector switch) to obtain a 180° phase shift, required for two separate bearings. In some early models of the Type 10166, the two bearings are obtained by selecting either a direct output from the marker burst generators, or an output via a valve stage, which provides the 180° phase shift.

13. Connection is made to other units of the tester by the following connectors:

(1) PL101, a 14-pole plug, which carries the h.t. and l.t. supplies, the bearing switching and output lines (poles D and B), the DME reply pulse (pole F) and the mixed identity tone and DME reply pulses (pole C).

(2) SKT102, a coaxial socket, which carries the 135 c/s harmonic marker burst trigger pulses.

(3) SKT103, a coaxial socket, which carries the 15 c/s north marker burst trigger pulses.

1350 c/s oscillator and identity tone generator

14. V101a (half CV4013) is a triode Hartley oscillator generating a signal at a fixed frequency of 1350 c/s. The tuned circuit consists of L101, C101 and C127, the value of C127 being selected on test to give the exact frequency required. The oscillations are coupled from V101a anode to V102a grid by C103; the waveform at V102a grid can be observed on TP101. The values of the coupling capacitor C103 and V102a grid leak R111 are such that the 1350 c/s signal is differentiated.

15. V102 (CV4013) is a double-triode connected as a flip-flop circuit. The positive portion of the differentiated waveform appearing at V102a grid is used to trigger the circuit. Normally V102b is conducting and V102a is held cut off by bias developed across the common cathode load R112. When a positive trigger pulse appears at V102a grid, the valve conducts and the anode voltage falls, this fall being coupled to V102b grid by capacitor C195. Thus V102a comes into full conduction and V102b is cut off. C105 then commences to discharge towards h.t. potential at a rate determined by the setting of RV175. When C105 has discharged sufficiently to allow V102b to recommence conduction, V102a will once again be cut off. The pulses appearing at both anodes of V102 are differentiated and mixed in the network consisting of C106, C107, R113 and R114. The pulses from V102a anode are also fed to V103 via C104, MR102 and C128.

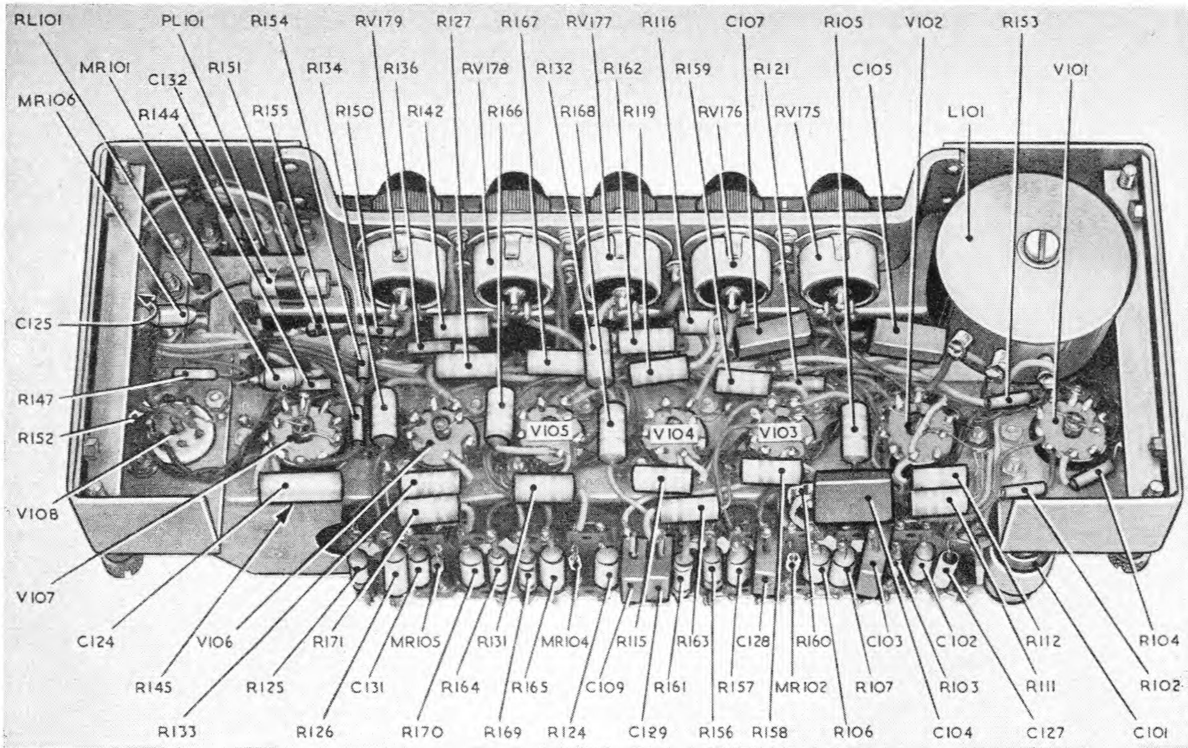


Fig. 2. Oscillator and count down unit: component location (bottom)

16. The pulses fed from the differentiating and mixing network form the identity tone signal which can be observed by an oscilloscope connected to TP102. The spacing of the tone pairs is controlled by RV175, the tone pulse separation control, which is adjusted to give 100μs spacing between the pulses in each pair at TP102.

17. The identity tone signal is fed to V107b grid via grid stopper R155. Also fed to V107b are the DME reply pulses from the video and range unit (para. 42); these pulses are fed into the unit on PL101/F and applied to the grid via R143 and R155. V107b (half CV4013) is a triode pulse amplifier whose bias potential is provided by R145 decoupled by C124; h.t. is fed to the anode from the reference unit (para. 30). V107b is normally conducting owing to a positive voltage from the h.t. line fed to its grid via R146. The grid is connected to earth by MR101 to limit the positive bias on the grid. All the pulses fed to V107b grid are negative-going, thus amplified positive-going pulses appear at the anode and are fed to the control grid of the gate valve (V204) in the reference unit (para. 38), via PL101/C and PL201/C. The output signal can be monitored on TP107.

10:1 count-down phanastron

18. The output from V102a anode is a negative-going pulse train at a p.r.f. of 1350. This pulse train triggers a two-stage 10:1 count-down circuit consisting of two pentodes V103 and V104, connected as phantastrons. Triggering pulses are fed via C104 and the clamping diode MR103 respectively. In the quiescent state of the circuit, the cathode potential of the first coupling diode MR102 is held at about +79V by the voltage divider R105 and R106 between +105V and earth. Consequently the anode potential of V103 is also limited to about +79V by the diode. The control grid of V103 is limited at the cathode potential by grid current flowing through R156 and the cathode is held at some potential above that of the suppressor by a combination of control grid and screen grid current through R158, with the result that the anode current is cut off by the suppressor grid bias. The potential on V103 suppressor is set by the potential divider R159 and R160, and on the suppressor of V104 by RV176. The two stages are coupled from V103 cathode via C129.

19. When a negative trigger pulse is applied to MR102 it is coupled to V103 control grid by C128 to start the 2:1 count-down cycle, the trailing edge of the pulse is fed from the cathode to V104 control grid via C129, MR103 and C108. These potentials on the grids cause the potential of the cathodes to be lowered instantaneously relative to that of the suppressor grids by an amount sufficient to allow anode current to flow. The fall in anode voltage is coupled to the grids by C128 and C108 and the cathode voltage falls further; this action is cumulative. Hence, even when the triggering pulse is removed, anode current continues to flow. Furthermore, when the circuit is in this condition any other triggering pulses applied to the grid will have no effect.

20. The cumulative action continues until the grid potential nearly reaches cut-off. The anode 'run-down' then commences and continues until the anode voltage bottoms. The voltages at grid and cathode then commence to rise, and this rise in cathode voltage with respect to that of the suppressor grid reduces anode current. This causes the anode voltage to rise and with it the grid and cathode voltages. A second cumulative action ensues, ceasing when the anode current is cut-off and the circuit reverts to its quiescent state.

21. The suppressor grid controls the division of valve current between the anode and screen grid, thus when the anode is cut-off the screen grid is drawing heavy current and its potential is at a minimum; when anode current flows, current is diverted from the screening grid whose voltage rises. Consequently, a positive-going voltage waveform is generated at the screening grid. The width of this waveform depends on the duration of flow of anode current, which in turn depends on the suppressor grid potential of V104 set by RV176. RV176 is adjusted to give a 10:1 count-down between the waveforms at TP101 and TP104. Similarly, when anode current is flowing, the voltage drop coupled to the control grid causes the cathode potential to fall and a negative-going rectangular waveform, whose duration is also determined by the duration of flow of anode current, is generated at the cathode. Outputs are taken from both the screening grid and cathode and fed to the fixed contacts of RL101/1, which is controlled by the bearing selector switch S403 on the front panel.

22. The positive pulses generated at V104 screen grid at 135 c/s are fed two ways:

(1) To SKT102 via C122. These are the harmonic marker burst pulses; C122 is part of a differentiating circuit.

(2) To V101b grid via the normally closed contact of RL101/1, C110, R173, R122 and R153.

23. V101b (half CV4013) is a triode sine-wave generator, its grid leak is R121, R153 is a grid stopper and R123 is its anode load. V101b anode is coupled back to the grid via two T-filters in parallel, the filters being connected to the grid circuit via blocking capacitor C111. The T-filter consisting of C113, C112, RV177 and R132 is a high-pass filter and the phase of the 135 c/s sine-wave is adjusted by the fine bearing control RV177 which is set to give the correct bearing as shown on the electrical indicator. The other filter, which consists of R130, R129 and C114, is a low-pass filter. The combined action of the two filters removes the harmonics and other unwanted frequencies from the square wave generated by the phantastron. The resulting sine-waves at 135 c/s are fed to a mixing circuit consisting of RV180, R137 and R139, and thence to V108, a triode amplifier, with the 15 c/s signal. RV180 is used to balance the 135 c/s and 15 c/s signals.

9:1 count-down phantastron

24. The negative 135 c/s pulses from V104 cathode are coupled to V105 anode via C109 and MR104, and subsequently to V106 anode via MR105. Diode MR104, and pentodes V105 and V106 (CV4011) form a two-stage 9:1 count-down circuit. The 135 c/s pulses trigger the circuit whose action is identical with that of the 10:1 count-down phantastron described in para. 18 to 23. In this instance the 9:1 count-down can be observed between the waveforms on an oscilloscope connected to TP104 and TP106. Outputs are taken from both the screen and cathode of V106 and connected via the fixed contacts of RL101/2. The positive-going 15 c/s waveform produced at V106 screen is fed two ways:

(1) To SKT103 via C123. These are the north marker burst trigger pulses. C123 is part of a differentiating circuit.

(2) To V107a grid via C132 and the normally-closed contact of RL101/2, C117, R138 and R154. V107a is a triode 15 c/s sine-wave generator.

25. The 15 c/s sine-wave generator is similar in circuit arrangement to the 135 c/s sine-wave generator. Once again there is the twin T-filter connected between anode and grid, the high-pass filter consisting of C120, C119, RV178 and R142, and the low-pass filter consisting of R141, R140 and C121. RV178 is the coarse bearing phasing control; it is set to give the correct 40° sector as shown on the electrical indicator on the airborne equipment. The 15 c/s sine-wave is then fed to the mixing network R139, RV180 and R137, where it is mixed with the 135 c/s signal (para. 23). The combined waveform of 135 c/s superimposed on a 15 c/s sine-wave is fed to V108 grid (triode amplifier) via C126, R151, RV179 and R150.

Bearing selector/modulation amplifier

26. V108 (CV4058) is a triode modulation amplifier which amplifies the combined waveform to a level suitable for feeding to the modulator stage in the video and range unit. The grid leak of V108 is the potentiometer RV179, which is adjusted to obtain the required modulation depth. R150 is an anti-parasitic resistor. Bias is provided by R152 and the anode load is R148. The composite modulation output waveform is fed via C125 and PL101/B to the video and range unit.

27. Relay RL101 is the bearing selector relay and its action is controlled by the bearing selector switch S403 on the front panel. The coil of RL101 is connected between the h.t. line, via R148, and PL101/D, which in turn is connected to the contact of S403 corresponding to the 140° bearing position. The relay RL101 has a diode MR106 across the coil to suppress the back e.m.f. which is generated as the coil is de-energized.

28. The switch contact of S403 corresponding to the 323° position is not connected. When the bearing selector switch S403 is in the 323° position the relay contacts are in the position shown on the circuit (fig. 16). When the bearing switch is in the 140° position, RL101 is energized and the outputs from the phantastrons are taken from the cathode loads to the filter/amplifiers, thus giving the required phase shift.

29. The composite bearing signal is fed from PL101/B to PL601/B on the video and range unit, where it is fed to the modulator valve V601. H.T. at +105V is fed into the oscillator and count-down unit from the power unit via PL101/P, and the valve heaters are all fed in parallel from a 6·3V a.c. supply via PL101/A and H.

REFERENCE UNIT

30. The reference unit (fig. 3, 4 and 17) is chassis mounted and is the lower of the two sub-units mounted on the right-hand side of the framework. The function of the sub-unit is to produce the north and harmonic marker bursts and to mix these marker bursts with the identity tone signal and DME reply pulses in the correct order of priority by using gating valves. The sub-unit carries five valves, all of which are mounted on the top of the chassis and are accessible. Connection is made to other units of the instrument by three connectors as follows:—

(1) PL201, a 14-pole plug, which accepts the h.t. and l.t. supplies, the identity tone and the DME reply pulses.

(2) SKT202, a coaxial socket, which accepts the 135 c/s pulses to trigger the harmonic burst generator.

(3) SKT203, a coaxial socket, which accepts the 15 c/s pulses to trigger the north marker burst generator.

(4) TP203, a test point, which accepts the composite video signal from TP603 in the video and range unit.

135 c/s (harmonic) marker burst generator

31. The 135 c/s signal generated by the oscillator and count-down unit is fed to the grid of V205a from SKT202. V205 (CV4013) is a double-triode connected as a flip-flop. This is used as a marker burst generator by having a parallel tuned circuit in V205b anode circuit. V205a grid leak is R221 and the grid is limited at earth potential by a negative limiter MR201; the anode load consists of R224 and RV231, bias is provided for both halves of the valve by the common cathode load R222. V205a anode is coupled to V205b grid by parallel capacitors C211 and C212. V205b anode load consists of R225 and the parallel-tuned circuit L202 and C214, whose resonant frequency is adjusted by L202 to 41·7 kc/s so that pulses spaced at 24μs are produced when it rings. V205b grid is held at about +9V by the voltage divider R226 and R227 which is connected between +105V and earth; hence, in the quiescent state, V205b conducts and V205a is cut off by bias developed across the common cathode load.

32. The 135 c/s trigger pulse is differentiated by C122 (in the oscillator and count-down unit) and R221; the positive portion of the waveform triggers

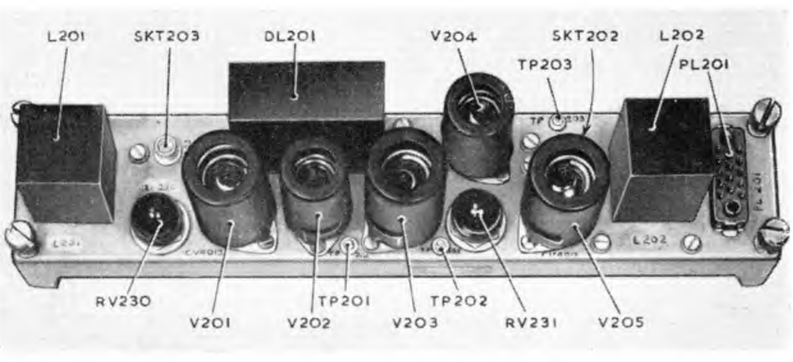


Fig. 3. Reference unit: component location (top)

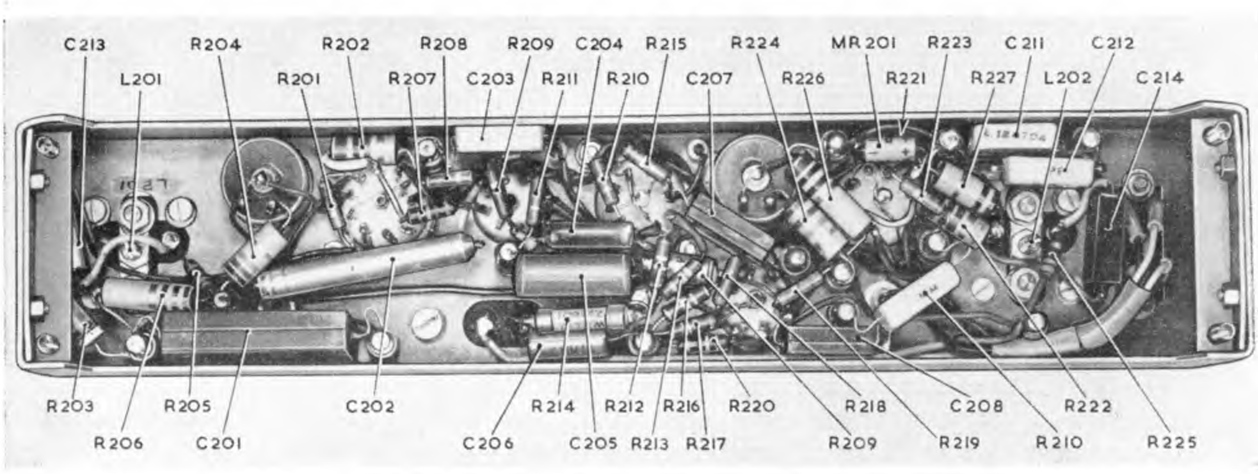


Fig. 4. Reference unit: component location (bottom)

V205a and normal cumulative action of a flip-flop occurs, resulting in V205a conducting and V205b being cut off. Capacitors C211 and C212 commence to discharge at a rate determined by RV231, which is adjusted for six positive pulses at TP202. V205a anode current is cut off sharply and the anode tuned circuit rings, producing a pulse train which is fed to V203b grid. The resumption of anode current damps out the ringing in the tuned circuit and the large fall in anode voltage, which occurs at the same time, is coupled to V203b grid by C207; V203b is cut off very sharply so that only six pulses will be amplified by V203b.

33. A negative pulse corresponding in width to the duration of the harmonic marker burst, i.e. about 130μs, is generated at the anode of V205a. This is coupled to the suppressor of gating valve V204 via R223 and C210, and is used as a blanking pulse. The pulse train generated by V205 is known as the harmonic marker burst and consists of six pulses spaced at 24μs intervals; it is generated for every trigger pulse applied to V205a.

34. The harmonic marker burst, which can be observed by connecting an oscilloscope to TP202, is fed to the grid of amplifier V203b (half CV4013) whose grid leak is R215 and anode load R213. The signal fed to the grid is actually a damped oscillation of six pulses superimposed on a positive square wave. The negative portion of the ring is amplified and the positive pulse train appearing at the anode is fed to the suppressor of gating valve V202 via a differentiating network C204 and R209 which sharpens the pulses.

15 c/s (north) marker burst generator

35. The 15 c/s positive pulses produced by the 9:1 count-down phantastron are fed to V201a grid from SKT203. These pulses are differentiated by C123 (in the oscillator and count-down unit) and V201a grid leak R201. V201 (CV4013) is a double-triode flip-flop. V201a anode load is R204 and RV230; the latter is the north marker burst duration control and is set for 12 negative pulses at TP201. V201b anode circuit comprises R205 and a tuned circuit consisting of L201 and C213 in parallel; the tuned circuit is tuned to 33·3 kc/s by adjusting L201. This frequency gives 30μs spacing to the pulses at TP201.

36. V201a anode is coupled to V201b grid by C201, and the V201b grid is maintained at about +9V by a voltage divider R206 and R203 connected between +105V and earth. The common cathode load is R202. V201b is normally conducting and when the positive trigger pulse reaches V201a grid, normal flip-flop action occurs and the sudden increase in V201b anode voltage causes the tuned circuit to ring at its resonant frequency. The resulting train of pulses is fed to V203a grid from V201b anode via C203.

37. V203a is a triode amplifier; its grid leak is R210 and its anode load is R212. The amplified positive-going pulse train is fed to the common anode connection of gating valves V202 and V204 via C205 and R211. A small amplitude negative pulse is fed from the north marker burst generator cathode (V201) to the gating valve grid (V202) via R207. The duration of the negative pulse (about 340μs) corresponds to the time taken for the north marker burst, i.e. 12 pulses spaced at 30μs.

The double gate (V202 and V204)

38. The gating valves V202 and V204 are both pentodes (CV4011); their anodes are connected and their common anode load is R219. V202 screen is fed direct from the h.t. line, and its cathode bias is provided by R208. Now V202 suppressor is fed with the harmonic marker burst (para. 34) and its grid is fed with a negative blanking pulse from the north marker burst generator (para. 37). Since the harmonic marker burst is generated continuously at 135 burst per second, every ninth burst will coincide with a north marker burst. Hence, whenever a north marker burst is generated, V202 is cut off by the blanking pulse from V201 cathode. Normally the valve is conducting and when the positive-going harmonic marker burst is applied to its suppressor grid, anode current is increased and a negative-going pulse train appears at the anode. Thus it can be seen that the north marker burst will suppress the harmonic marker burst and will take priority over it.

39. The second gating valve V204 has R219 as its anode load, cathode bias is provided by R218 and the screening grid is returned to the h.t. line. The suppressor grid is fed with negative blanking pulses 130μs wide from V205a anode (para. 33). The control grid is fed with range reply and identity tone pulses which were mixed in the oscillator and count-down unit (para. 17); this signal is fed to the grid via PL201/C, DL201 and C206. DL201 is a 2μs delay line whose purpose is to allow sufficient time for the negative blanking pulse to cut off V204 completely; if DL201 were not included, the rise time of the negative blanking pulse would be long enough to allow some of the identity tone and reply pulses to get through before the valve cut off. R214 is the anode load for V107b in the oscillator and count-down unit (para. 17) and C206 is the coupling capacitor. The signal fed to the grid of V204 is positive-going, hence negative-going pulses appear at the anode. Thus it can be seen that the harmonic marker burst will take priority over the identity tone and distance reply pulses.

40. It must be remembered that the trigger pulses for the identity tone, harmonic marker burst and north marker burst are all derived from the same source, therefore the initial pulse of each signal will be coincident with one or both of the others. The two marker burst generators produce blanking pulses to ensure the correct order of priority which is as follows:—

(1) North marker burst. This consists of 12 pulses spaced at 30μs at a repetition rate of 15 c/s.

(2) Harmonic marker burst. This consists of 6 pulses spaced at 24μs at a repetition rate of 135 c/s.

(3) Identity tone and distance reply pulses. The identity tone consists of pulse pairs spaced at 100μs at a repetition rate of 1350 c/s. The distance reply pulses are single pulses; their spacing is not fixed, as each airborne transmitter-receiver has its own slight variation in timing to prevent one equipment locking on to another aircraft's reply pulses. The airborne equipment also has two modes of operation, namely search and track. These give repetition rates of 120–150 and 24–30 pulses per second, respectively. It will be noticed that the identity tone and distance reply pulses are not cut off while the north marker burst is being generated; some of the different pulses are bound to coincide, but their relative repetition rates are such that the small number of pulses lost due to interaction are of no consequence.

41. To summarize the action of the double gate (V202 and V204) we have the following action. Positive identity tone and distance reply pulses are fed to V204 grid. They are amplified and appear as negative pulses at the common anode connection of the double gate, except when a blanking pulse is fed to V204 suppressor during a harmonic marker burst. Similarly, V202 has the harmonic marker burst fed to its suppressor which will produce negative pulses at the common anode connection, except when a blanking pulse is fed to its grid during a north marker burst. Also fed to the common anode connection of the double gate is the north marker burst via C205 and R211. The composite negative-going video signal is fed to TP203 via C208; from there it is fed to the video and range unit. The composite signal can be monitored on TP203.

VIDEO AND RANGE UNIT

42. The video and range unit (figs. 5, 6, 7, 18 and 19) is chassis mounted and is the sub-unit on the upper right-hand side of the chassis. The function of the sub-unit is two-fold, first it accepts the incoming interrogation pulse pairs from the TACAN airborne transmitter, decodes the interrogation into a single pulse and from that pulse produces, by means of a phantastron, the range reply. Secondly, the unit accepts the composite video signal from the reference unit and converts each pulse into a pair spaced at 12μs; a flip-flop ensures that all pulses have the same amplitude and width. The video signal is modulated by the composite bearing signal and amplified to a level suitable for modulating the output of the frequency multiplier unit. The unit carries six valves (five only with Type 10166), all of which are accessible. Connection is made to other units of the instrument by two connectors and a single wire as follows:

(1) PL601, a 14-pole plug, which accepts the h.t. and l.t. supplies, and the composite bearing waveform (pole B). It also carries the range reply and switching circuit (poles F and D) and the composite modulation signal (poles N and K).

(2) SKT803 (Type 10166A) or SKT602 (Type 10166), a coaxial socket, which accepts the 'sample' distance interrogation pulses transmitted by the TACAN airborne equipment.

(3) TP603 (test point) connected to TP203 on the reference unit. At this point the DME, identity and marker video pulses are fed into the video and range circuit.

DME signal pre-amplifier

43. The Type 10166A tester incorporates a pre-amplifier stage which boosts the level of the signal input received via the radiating antenna. This pre-amplifier remains in circuit regardless of the operating mode (radiate or direct connection) of the tester; its output, however, is limited and so remains constant for either mode. The interrogation pulses emitted by the airborne transmitter are detected by a crystal diode in the r.f. system and fed to SKT803 on the video and range unit. Variation of the video signal level by radiation from the test set antenna is prevented by two

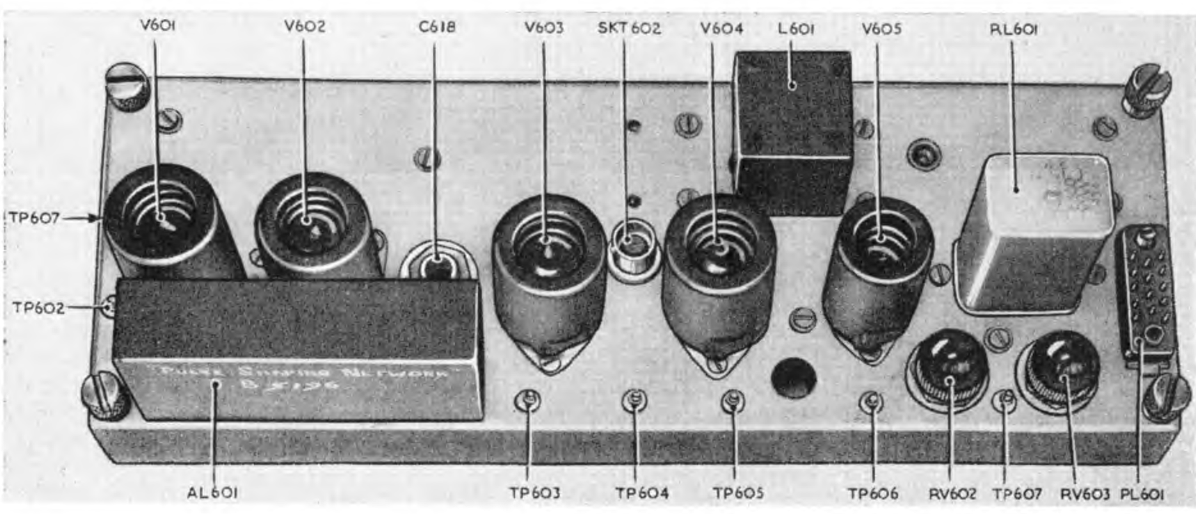


Fig. 5. Video and range unit (Type 10166): component location (top)

ferrite beads L801 and L802 on the lead linking SKT803 to the junction of R801 and the control grid of V801. This shielding effect also reduces the possibility of instability arising from unwanted feedback. V801 is connected as a conventional two-stage amplifier whose output is limited to about 1·4V by MR801 and MR802 to ensure that the positive-going signal input to V604 remains constant when using the tester in either mode of operation. With the Type 10166 tester, the input is via SKT602 and C607 and then direct to the input of V604b.

DECODING AND DISTANCE REPLY CIRCUITS

44. The interrogation pulses fed to the grid of V604b are in the form of positive pulse pairs spaced at 12μs $\pm$ 0·5μs, which can be observed on an oscilloscope connected to TP604. V604b is a triode limiter and its grid leak is R616. The cathode resistor R619 is decoupled by C608. The anode load is R621 and the negative output pulses are coupled to V604a grid by C609.

45. V604a is a triode amplifier-decoder whose grid is maintained at about +9V by a voltage divider consisting of R623 and R624 connected between +105V and earth. The anode of V604a is connected to a parallel tuned circuit L601 and C610 which is tuned to a resonant frequency of 83·3 kc/s; this corresponds to a pulse spacing of 12μs. The negative pulse pairs fed to the grid drive the valve to cut-off and the sudden voltage drop caused by the first pulse of the pair causes the anode circuit to ring. The second pulse of the pair, which appears 12μs later, is coincident with the second swing of the oscillatory ringing in the anode circuit, thus making the second pulse of the pair much stronger than the first.

46. The oscillations are fed to a clipping diode MR602, whose clipping level is approximately the h.t. voltage. Since only the second pulse of the pair can swing above that level, only that one will be passed by MR602. Thus it can be seen that this circuit performs two functions; firstly, it checks the pulse spacing, because it will only respond to pulse pairs with the correct spacing and, secondly, it decodes each correctly spaced pulse pair, producing one positive pulse for each pulse pair. The decoding pulse is coupled to V605 suppressor grid by C612 to trigger the phantastron cycle.

47. V605 (CV4011) is a pentode phantastron which introduces a fixed delay, equivalent to either 5 or 105 miles, into the range reply pulses. In the stable stage the circuit conditions are as follows: the suppressor grid is held at about +9V by the potential divider R626 and R628; the cathode is held at some potential above this by current through its load R629, the cathode current being the sum of the grid current through R627 and screen current through R631. Hence, as the cathode is positive with respect to the suppressor grid, anode current is cut off.

48. When the positive trigger pulse is fed to the suppressor grid, anode current flows and the anode voltage falls, causing grid voltage to fall almost to cut off. The anode potential then runs down

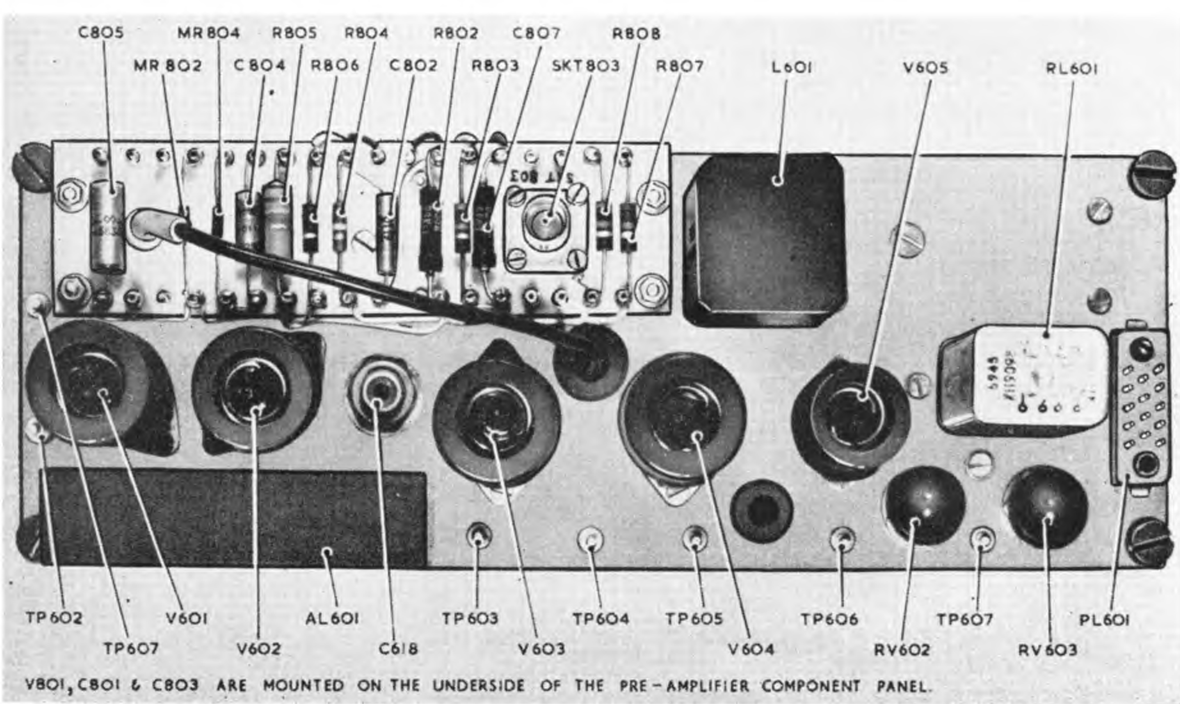


Fig. 6. Video and range unit (Type 10166A): component location (top)

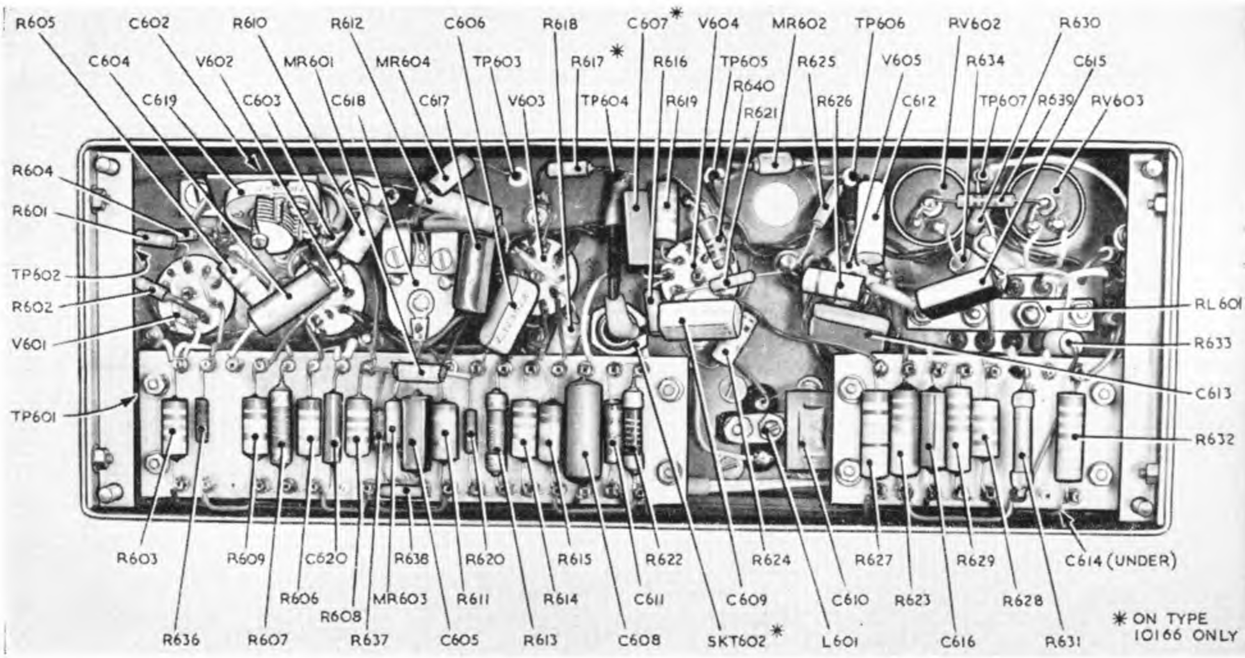


Fig. 7. Video and range unit: component location (bottom)

until the anode 'bottoms', the anode-grid capacitor then starts to charge at a rate determined by the variable resistor (RV652 or RV653) in the anode load and a further cumulative action occurs, which ceases when anode current is once again cut off. The duration of the positive rectangular waveform generated at the screen grid depends on the duration of the anode run-down, and this in turn depends on the potential to which the anode-grid capacitor charges after the anode voltage bottoms.

49. The anode-grid capacitor and its charging circuit is selected by RL601 contacts to give the time constant appropriate to the selected range. When switch S402 (RANGE MILES) on the front panel is in the 105 position, RL601 is not energized, as shown on the circuit (fig. 18), and the anode-grid capacitors C613 and C614 are connected in parallel by contacts 21 and 22 of RL601/2; at the same time, contacts 1 and 2 of RL601 connect R634, RV652, R639 and R632 in series as the anode load. RV652 is the 105-mile range adjustment and is set to give 1336μs $\pm$ 25μs between pulses monitored at TP607. When S402 is set to the 5-mile position, RL601 is energized; this re-arranges the circuit so that only C613 connects anode to grid and the anode load is RV653 and R632. RV653 is the 5-mile range adjustment and is set to give 100μs $\pm$ 6μs between pulses at TP607.

50. The positive rectangular waveform at V605 screening grid is fed to C615 which, together with R630, forms a differentiating circuit; thus the positive leading pulse of the differentiated waveform corresponds in time to the triggering pulse and the negative pulse to the time delay of the phantastron. It is the negative pulse which is used as the range reply pulse. The pulses are fed to PL101/F on the oscillator and count-down unit: from there they are fed to V107b grid. (para. 17).

Pulse pairing and shaping circuits

51. The composite video signal from TP203 in the reference unit (para. 41) is fed into the video and range unit at TP603. In this sub-unit each pulse is coded with a second pulse 12μs after the triggering pulse. The second pulses are generated in V603 which is the code generator. Each pulse in the pair is then fed to a shaping stage V602 where the pulses are given a uniform shape and width of 3·5μs, before being fed to the modulator valve V601, via a pulse shaping network.

52. The negative composite video pulses are fed to the grid of V603a (CV4013), which is normally conducting, via MR604 and C617/C618; MR604 ensures that only the negative half of the pulse reaches the grid. C618 is variable and is used to adjust the multivibrator cycle to produce the 12μs code interval. A negative pulse at the grid of V603a causes a positive pulse to form at the anode of V603a thus reducing the potential at the cathode of both V603a and b. The lowering of the potential at V603b cathode causes the valve to conduct and a further drop in potential is applied to V603a grid from V603b anode via C618 and C617, thus increasing the positive pulse at V603a anode. This is differentiated and fed to V602a via two diodes as follows :

(1) Positive pulses to the grid via C605, MR603 and C604.

(2) Negative pulses to the anode via C606 and MR601.

The 3·5μs pulses formed in V602 are fed through a pulse shaping network AL601 before reaching the modulator valve V601.

53. V602 (CV4013) is a double-triode flip-flop with a short time constant, whose function is to standardize the amplitude and width of each pulse.

Bias is provided by the common cathode load R605, the anode load for V602a is R608 and that for V602b is R607. V602a is coupled to V602b grid by C602 with C619 in parallel. C619 adjusts the period of the flip-flop to 3·5μs. V602a is normally held cut-off by bias developed across the common cathode load T605 by V602b current. V602a grid is connected to a bleeder network R609 and R610. The first positive pulse is fed to V602a grid from V603a anode (para. 52(1)) to trigger the flip-flop, and a narrow positive pulse is generated at V602b anode. The second negative pulse, about 10·5μs later, is fed to V602a anode and hence to V602b grid, thus lowering the conduction through V602b and again triggering the flip-flop and producing another narrow pulse at V602b anode. Thus every pulse appearing at V603a anode produces a pulse pair spaced at 12μs at V602b anode.

54. The pulse pairs are coupled by C603 and C620 to the grids of V601 via the pulse shaping network AL601 and anti-parasitic resistors R601 and R602. The R604 is the common grid leak for both halves of V601. Also fed to the junction of AL601 and R604 is the composite bearing signal of 135 c/s superimposed on 15 c/s, which is fed into the unit on PL601/B from PL101/B on the oscillator and count-down unit. The pulse pairs are therefore mixed with the bearing signal and fed to the grids of V601.

Modulator stage

55. V601 (CV4013) is a double-triode cathode follower, the two halves of the valve being connected in parallel. Modulation of the pulse pairs occurs because the bearing signal causes the working point on the Ia/Vg characteristic of the valve to oscillate. The anodes are joined together, and R636 prevents parasitic oscillations; the common cathode load is R603. Two outputs of the modulated video pulse train, which can be monitored at TP601, are taken from the cathode:

(1) Direct from the cathode to PL601/N. From there it is connected to PL501/N on the frequency multiplier unit to pulse modulate the anode of the output stage on that unit.

(2) Direct from the cathode to PL601K. This signal is fed to PL501/K on the frequency multiplier unit via the SET RF LEVEL potentiometer on the front panel. This signal is used to modulate the screen grids of the last three stages of the frequency multiplier.

FREQUENCY MULTIPLIER UNIT

56. The frequency multiplier unit (fig. 8, 9 and 20) is a chassis mounted sub-unit and is the upper of the two mounted on the left-hand side of the main framework. The function of the sub-unit is to generate an r.f. output of 250 Mc/s which is pulsed and modulated by the composite video and bearing waveforms from the video and range unit. The sub-unit carries five valves, all of which are accessible. Connection is made to other sub-units of the tester by two connectors as follows:

(1) PL501, a 14-pole plug, which accepts the h.t. and l.t. supplies and the modulated video signal (poles N and K); it also carries the d.c. to the meter mounted on the front so that the output level can be checked.

(2) SKT502, a coaxial socket, which carries the output signal.

Butler oscillator

57. V501 (CV4013) is a double-triode which is connected as a Butler oscillator, its frequency being determined by a quartz crystal connected between its cathodes. The anode tuned circuit is broad-band but, as the performance tester operates only on a fixed frequency of 1000 Mc/s (channel 39), it is adjusted for maximum output at the crystal frequency of 27·7777 Mc/s. V501a is a grounded-grid amplifier; the r.f. voltage developed across its anode inductor L502 is coupled to V501b grid by C501.

58. V501b is a cathode follower and the r.f. drive applied to its grid produces an r.f. potential in phase with it across its cathode resistor R503. The r.f. energy at V501b cathode is coupled to V501a cathode by a quartz crystal which provides a low impedance path at its marked frequency. The circuit operation relies on regenerative feedback, i.e. the two cathodes must be in phase and, since the crystal operation at exactly series resonance

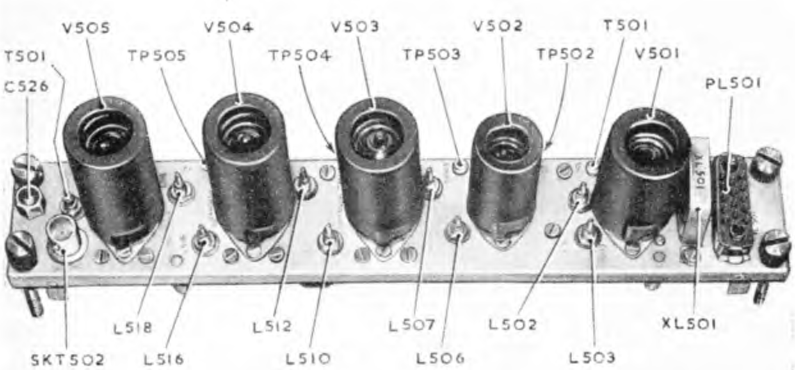


Fig. 8. Frequency multiplier unit: component location (top)

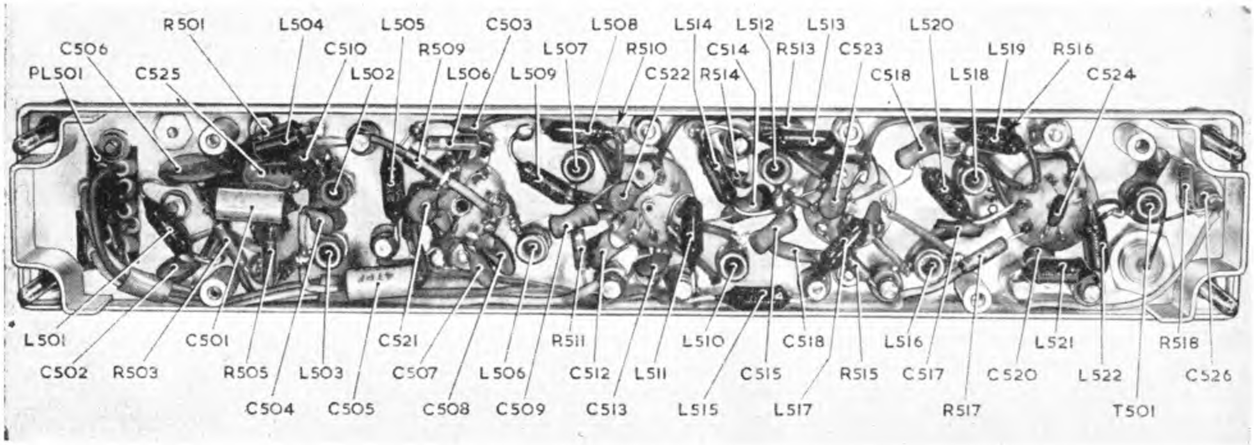


Fig. 9. Frequency multiplier unit: component location (bottom)

requires zero phase shift around the circuit loop, the various stray capacities must be compensated by the circuitry.

59. The cathode follower is almost free of phase shift due to extremely low grid-cathode capacitance and, at resonance, V501b cathode is virtually d.c. coupled to V501a cathode by the crystal. The anode-cathode capacitance of V501a is extremely small. Owing to the screening effect of the grid, the anode-cathode capacitance of V501a is extremely small. V501a anode circuit is tuned to the crystal frequency and coupled to V501b grid by C501. Hence the phase shift around the circuit loop is negligible and oscillation will occur at the marked frequency of the crystal.

60. The inductor L501 in V501 cathode circuit acts as a neutralizing filter, its value being chosen so as to resonate with the stray capacity of the crystal. C502 is a d.c. blocking capacitor. The feedback to V501a is developed across its cathode load resistor R505. V501b grid leak consists of two resistors R502 and R501 to provide for a test point (TP501) at their junction. The oscillations at 27·7777 Mc/s are coupled to V502 grid via capacitors C504 and C505.

Trebler-amplifier chain

61. V502 (CV4010) is a pentode trebler, its anode circuit being tuned to the third harmonic of the input frequency. A tuned inductor L503 in V502 grid circuit is in parallel with V501a anode coil (L502), as far as r.f. is concerned, and is coupled to it by C504, hence the oscillator is double tuned giving a sharply peaked response. V502 grid leak is made up of two resistors R507 and R506 to provide for a test point TP502, R506 being decoupled by C503. Bias is provided for this stage by R508. The signal at 83.333 Mc/s is coupled to V503 by C509.

62. V503 (CV2970) is a double-tetrode amplifier; it has a built-in decoupling capacitor connected between the screen grids and cathode. The coil L507 is effectively centre-tapped by coils L508 and L509 in the grid circuits to provide a push-pull input. The common connection of the grid coils is taken to grid leak R501; also connected to this point is TP503. The modulated video waveform fed to PL501/K from the video and range unit (para. 55) is fed, via the SET RF LEVEL potentiometer (RV401) on the front panel, to the common screen-grid connections of the last three valves in the trebler-amplifier chain V503, V504 and V505.

63. RV401 (on the front panel) sets the r.f. output level by adjusting the video drive to the screen-grids of the last three stages. The modulated video waveform is fed from PL501/K to V503 screen via a filter C513, R511 and C512. H.T. is shunt fed to the anodes via choke L511; this has the same effect as feeding h.t. to the centre of L510. Coils L510 and L512 are both adjusted for maximum output at TP504. The output is coupled to the next stage by C514 and C515, the inductor L512 being effectively centre-tapped by L514 and L513 to provide a push-pull input for V504.

64. V504 (CV2970) is a double-tetrode trebler. The grids are fed with a signal at 83·333 Mc/s, the junction of the grid coils being connected to TP504 and grid leak R513. The screen-grids are fed with the modulated video waveform via R515. The anode circuit is tuned to the third harmonic of the input frequency, resulting in an output signal at 250 Mc/s. V504 anode circuit is fed with h.t. via choke L517. Coils L516 and L518 are tuned for maximum output at TP505. V504 output is coupled to the next stage by C517 and C518.

65. V505 (CV2970) is a double-tetrode push-pull amplifier. Its circuit arrangement is similar to the preceding stage except for its anode circuit. L519 and L520 are the chokes providing a balanced input to the grids and R516 is the grid leak; TP 505 is connected to the junction of the two chokes. The modulated video waveform is fed to the screen via R517. The anode circuit is fed with modulated video taken direct from the cathode of the modulator valve (V601) in the video and range unit. This signal is fed into the unit on PL501/N and thence to the anode circuit via a filter L521, C520 and L522.

66. The anode circuit includes a transformer T501, which results in the valve having one output similar to a single valve amplifier. One end of the transformer is taken to PL501/C via smoothing network R518 and C525. From there it is connected to the meter (M401) on the front panel when the meter switch S405 on the front panel is set to the RX SENS position. T501 is adjusted for maximum deflection on M401. The other end of T501 is connected to SKT502 which carries the output signal of the frequency multiplier unit. This signal consists of oscillations at 250 Mc/s modulated by the composite video signal. The output is connected to the coaxial switch S405a/2.

67. H.T. at +105V is fed into the unit on PL501/P, filters being connected into the h.t. line between each stage to prevent unwanted frequencies being coupled through the h.t. line between stages. H.T. to V501 is filtered by L504 and C506, to V502 by L505 and C510 and to V504 by L515 and C528. For a similar reason the heaters are bypassed by capacitors C521, C522, C523 and C524 for V502, V503, V504 and V505 respectively.

COAXIAL SYSTEM

68. The coaxial system in the Type 10166A differs from that in the Type 10166; details are given in the diagram (fig. 14) and at the appropriate points in the text.

69. Much of the coaxial system is common to both the incoming and outgoing signals, the whole system being shown in fig. 14. The items not used by both the input and output signals are as follows:—

(2) The cable connecting SKT502 on the frequency multiplier unit to S405a/2. This carries the output from the multiplier unit.

(2) The cable connecting SKT702 on the power measurement to S405a/3. This carries the input pulses only.

(3) The cable connecting SKT602 on the video and range unit to SKT404 on the detector sampler. This carries the negative 'sampled' signals for triggering the range reply unit.

(4) The cable connecting SKT102 on the oscillator and count-down unit to SKT202 on the reference unit. This carries the 135 c/s pulses used to trigger the harmonic marker bursts.

(5) The cable connecting SKT103 on the oscillator and count-down unit to SKT203 on the reference unit. This carries the 15 c/s pulses used to trigger the north marker burst.

(6) With the tester in the radiating mode (Type 10166A only), the cable connecting S801/3 and the tee adapter.

70. The purpose for which the instrument is being used at any one time is determined by the METER SWITCH (S405) on the front panel. This is a three-section two-position switch, one position being marked TX POWER and the other RX SENS. The three sections are used as follows:

(1) S405a is a coaxial switch. When in the RX SENS position it connects the output of the frequency multiplier unit to the crystal. In the TX POWER position it feeds the incoming signals to the power measurement unit.

(2) S405b and S405c connect the meter M401 on the front panel to the appropriate circuit. Thus in the RX SENS position the meter is connected to the d.c. metering output (PL501/C) of the frequency multiplier unit, and in the TX POWER position to the output of the power measuring unit.

71. When the Type 10166A is used to check receiver performance (switch S405 in the RX SENS position) the instrument can be used in either the direct or the radiating mode. With the coaxial switch S801 (Type 10166A only) in the DIR position the operation of the coaxial system is similar to that of the Type 10166, the signals being fed via the piston attenuator. With S801 in the RAD position the piston attenuator is switched out of circuit and therefore the tests on the airborne equipment are only qualitative. The output from the frequency multiplier unit is taken ultimately to the antenna, from which power is radiated to the airborne equipment.

◀**Note . . .**

Do not select RAD *when using the connector/ attenuator.* ▶

72. When S405 is in the RS SENS position the instrument functions as a signal generator, and S405a connects the frequency multiplier output (SKT502) to the crystal multiplier (CV3923). The signal applied to the crystal is at 250 Mc/s, and the 4th harmonic of this frequency is used. This corresponds to the TACAN channel 39 (1000 Mc/s); any other harmonic will lie outside the frequency band used by TACAN (962–1213 Mc/s).

73. The 1000 Mc/s signal is then fed to the piston attenuator (Type 10166, or Type 10166A in the direct mode) via a stub which presents a short circuit to unwanted frequencies and an open circuit at the required frequency; it also acts as a d.c. return path for the crystal multiplier. The piston attenuator is adjusted by means of a knob marked ATTENUATOR on the front of a raised plate on the front panel. Above the knob is a perspex 'window' with a central vertical line. Through the window can be seen a plate, coloured red and green. This plate is calibrated in decibels from 0 to 9 on each colour, but the movement of the attenuator only allows a range of approximately ±6dB. The attenuator is calibrated to give an output of ◀110dBW▶ on the zero line which divides the red and green portions of the scale, thus the range of adjustment is ◀110dBW▶ ±6dB.

74. The attenuator is connected to the detector sampler and the signal passes through the sampler to the input-output socket (R.F.) on the front panel.

From there it is either connected to the TACAN equipment by a coaxial connector, or is connected to an antenna (Type 10166A only). The incoming signals are fed into the detector sampler, and a portion of the signal is coupled by means of a loop to a crystal diode positive detector, where it is rectified and fed to the video and range unit; there it is decoded and used to trigger the range reply pulses.

Note . . .

The abbreviation dBW is used to indicate power levels referred to 1 *watt.*

75. When the METER SWITCH is in the TX POWER position the tester is used for transmitter peak power measurement. This facility is available for all 126 frequency channels used by TACAN, but an accurate measurement can only be made on channel 39. The signal is fed via the coaxial system, that is, via the detector sampler, tee adapter (Type 10166A only), piston attenuator DIR/RAD switch in the DIR position (Type 10166A only), the short-circuit stub and multiplying crystal (used as a detector) to the coaxial switch S405. Switch contacts 1 and 3 route the input pulses to SKT702 on the power measurement unit.

POWER MEASUREMENT UNIT

76. The power measurement unit (fig. 10, 11 and 21) is chassis mounted and is situated at the rear of the central part of the framework. The function of the sub-unit is to amplify the input signals, by means of a four-stage amplifier, for application to a peak-reading meter circuit. The output of the power measurement unit is indicated on the meter on the front panel when the METER SWITCH is in the TX POWER position. The unit carries four valves all of which are accessible. Connection is made to other units of the equipment by two connectors as follows:—

(1) PL701, a 14-pole plug, accepts the h.t. and l.t. supplies; it also carries connections to the SET ZERO potentiometer RV402 (pins C and F), the output to the meter (pins K and N) and the receiver sensitivity signal, which passes through controls (RV724 and RV725) on the unit (pins D and L)

(2) SKT702, a coaxial socket, accepts the input signal.

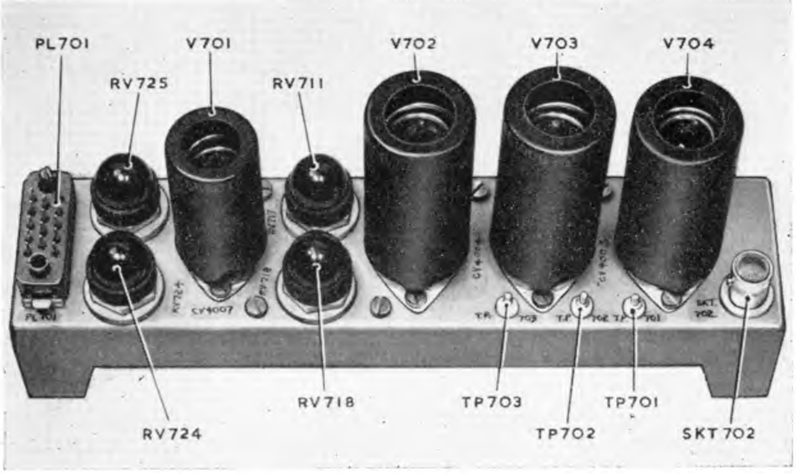


Fig. 10. Power measurement unit: component location (top)

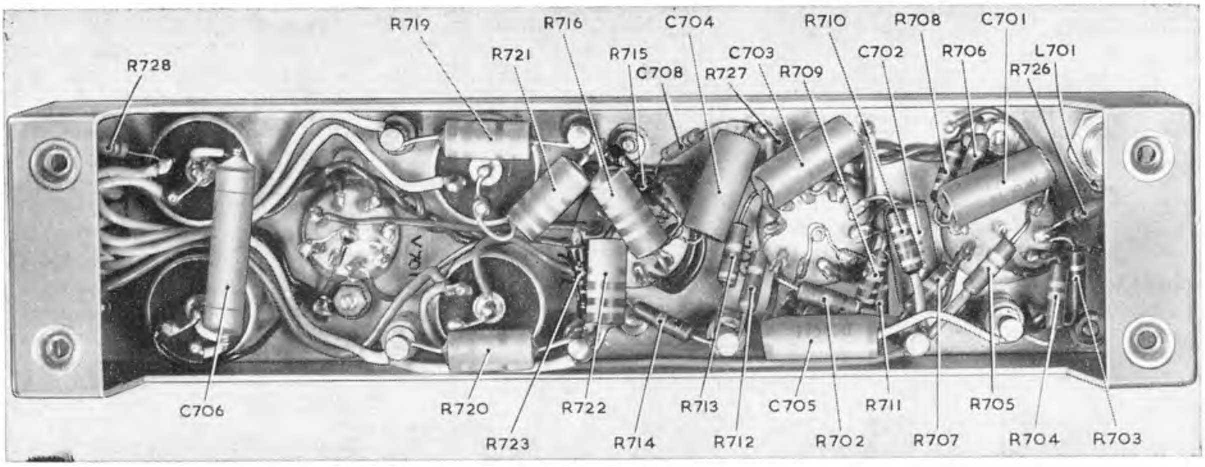


Fig. 11. Power measurement unit: component location (bottom)

Amplifier stages

77. The amplifying section of this sub-unit consists of three triode amplifiers in cascade followed by a paraphase amplifier; contained in two valves V704 and V703. A feedback loop is taken from the anode of the paraphase amplifier to the cathode of the first amplifier stage. The loop provides negative feedback which gives gain stability and ensures that valve changes do not upset the calibration.

78. The incoming signals are fed to SKT702 and from there they are fed through a filter choke L701 to the grid of V704b (half CV4004). The signal is then amplified and fed in turn to V704a (half CV4004) and V703b (half CV4003), which are both conventional triode amplifiers. The output of V703b is fed to V703a grid. V703a is a paraphase amplifier (half CV4003), its grid leak R712 is returned to the junction of cathode resistors R714 and R713 to reduce bias on the valve and to provide negative feedback, and bias is provided in the normal way by R713. V703a cathode circuit provides a low impedance source for charging C704. The output to the peak reading meter circuit is coupled to V702b grid from V703a cathode by C704.

79. V703 anode load is R702 and the output from the anode is coupled back to V704b cathode by C705 and R703. The input pulses at SKT702 are negative, therefore at V703a cathode the output is positive and at the anode negative, that is, in phase with the input, and consequently the feedback is negative.

Peak reading meter circuit

80. V702 and V701 together form a peak-reading meter circuit. V702 (CV4004) is a double triode and V701 (CV4007) a double diode. RV717 is the common anode load for the two halves of V702. R715, the grid leak of V702b, is returned to the junction of cathode resistors R716 and R719 bias being provided by R716. Similarly, R723, the grid leak for V702a, is returned to the junction of cathode resistors R722 and R720. The grid of each triode is limited to earth potential by a positive diode limiter, V701a on V702a grid and V701b on V702b grid. Cathode resistor R719 is connected to PL701/C and R720 to PL701F; these two pins are connected to the extremities of the SET ZERO potentiometer (RV402). The slider of the potentiometer is returned to −150V. The cathode ends of resistors R719 and R720 are connected to the meter (M401), R719 is connected to PL701/K via R721 and RV718, and R720 is connected directly to PL701/N. Thus the SET ZERO potentiometer is used to balance the voltage appearing at the cathodes of the two halves of V702.

81. The two variable resistors in V702 circuit are used to set up the sensitivity and calibration of the circuit. RV717 in the anode is termed the power sensitivity control and is adjusted in conjunction with RV718, which is the power set control. RV717 is set for discrimination of at least 4μA/dB on the meter, and RV718 for 30μA deflection, with the ATTENUATOR pass mark zero and with ◀1kW▶ peak power input from the TACAN airborne equipment in the search condition. Thus, with no input, the meter is set to read zero by RV402, then the METER SWITCH is put to TX POWER, the meter is adjusted to read 30μA by varying the piston attenuator, the reading on the attenuator giving the power levels in decibels with respect to the present level—in this case ◀110dBW▶.

82. The action of the peak reading meter circuit is as follows: The signal appearing at V703a cathode is coupled to V702b grid by ◀the high pass filter circuit C708 and R727 and▶ C704. This signal consists of positive pulse pairs with a spacing of 12μs at a p.r.f. of 120–150 p.p.s., because power measurement is always made with the airborne equipment in the 'search' condition. The diode V701b, which is connected between V702b grid and earth, and the input capacitor C704 together have a very short time constant, consequently the charge on C704 due to the positive leading edge of the pulse is immediately removed when the diode conducts. When the negative-going trailing edge of the input pulse reaches C704 the potential at V702b grid falls and V701b is cut off. With V701b cut off, a very large time constant is presented by the input capacitor and the grid circuit; thus a negative charge is held by C704.

83. When the second pulse of the pair (or the first pulse of the next pair), appears at C704 the positive leading edge discharges the capacitor and the trailing edge once again places a negative charge on the capacitor which is equal in amplitude to the peak value of the input pulse and of opposite polarity to it. Thus it can be seen that the signal applied to V702b grid will consist of large negative pulses whose peak amplitude is equal to the peak amplitude of the positive pulse pairs. Furthermore, it can be seen that the negative pulses will have a much higher energy level than the positive pulses producing them. ◀R727 and C708 form a high pass filter to eliminate audio frequency hum picked up from the test set's own circuits.▶

84. When the signal is fed to V702b the valve current is reduced, consequently the voltage across the cathode load resistors R719 and R720 becomes unbalanced and the resulting current flow to the meter is directly proportional to the degree of unbalance, i.e. the amplitude of the signal fed to V702b grid.

85. The diode V701a is connected between the grid of V702a and earth. Its function is to preserve the symmetry and balance of the meter circuit (which is essentially a bridge circuit) by offsetting the effects (such as contact potential) of the limiting diode V701b. Since V701a and V701b are the two halves of one valve, it can be assumed that any change in one will be accompanied by a similar change in the other, consequently any variation in these valves such as might result from loss of emission or reduced heater voltage, will not affect the balance of the circuit.

86. ◀Four other components RV724, R728, C706 and▶ RV725 are mounted on the chassis but do not form part of the power measurement circuit. They are used to adjust the SET LEVEL meter when the tester is being used as a signal generator, that is, with the METER SWITCH in the RX SENS position. The components are put on this chassis so that all the preset controls for the meter are in the same unit.

POWER SUPPLY UNIT

87. The power supply unit (fig. 12, 13 and 22) is chassis mounted and is situated in the front of the centre portion of main framework. The sub-unit produces three voltages as follows:

(1) +105V regulated at 50–120mA.
(2) −150V regulated at 0–4mA.
(3) 6·3 a.c. for heaters.

88. The sub-unit carries five valves, all of which are accessible, and eight silicon junction rectifiers which are mounted on the underside of the chassis. Connection is made to other units of the equipment by a 14-pole plug PL301.

Primary power requirements

89. Power is fed into the instrument on PL401, via a 3-pole plug mounted on the front panel. A 3-pole socket to mate with P401 terminates one end of a 3-core cable which is stowed in the lid of the instrument, the other end of the cable being left free so that it can be terminated as required. The instrument will operate on 115V, 180V or 200V at 320–1760 c/s; it requires 100 watts at 115V, 400 c/s. The power supply is fed from PL401 to S401, the ON-OFF switch, and then to fuses FS401 and FS402. The line connection from PL401/A also goes through a microswitch S404 which breaks the circuit when the instrument is removed from its case. The power leads are then connected to PL301 pins F and C (on the power supply unit) via the terminal board, pin F being the neutral (OV) connection and pin C the line connection.

Secondary power supplies

90. The primary power supply is fed to the appropriate tapping on the primary winding of the transformer T301. T301 has three secondary windings as follows:

(1) 240V between terminals 20 and 21.
(2) 300–0–300V from terminals 28, 29 and 30.
(3) 6·3V from terminals 17 and 18, and 26 and 27.

91. Terminals 17 and 26 are commoned, as are terminals 18 and 27. The 240V winding is connected to a full-wave bridge rectifier consisting of eight silicon-junction rectifiers, MR301–MR308 (BTH

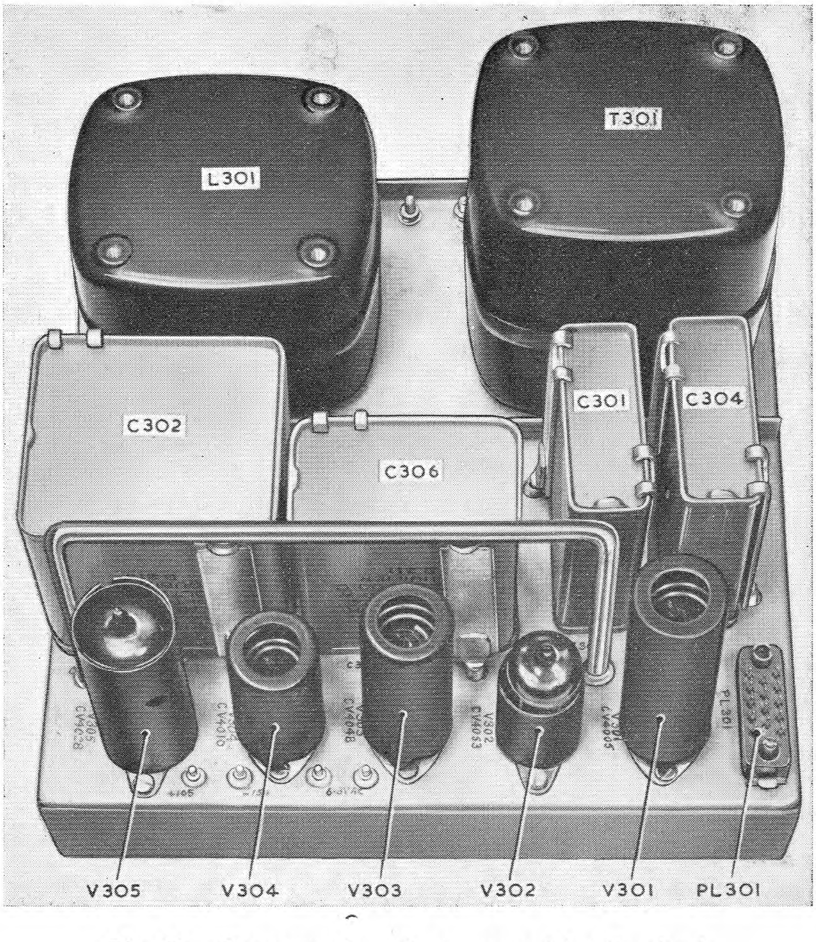


Fig. 12. Power supply unit: component location (top)

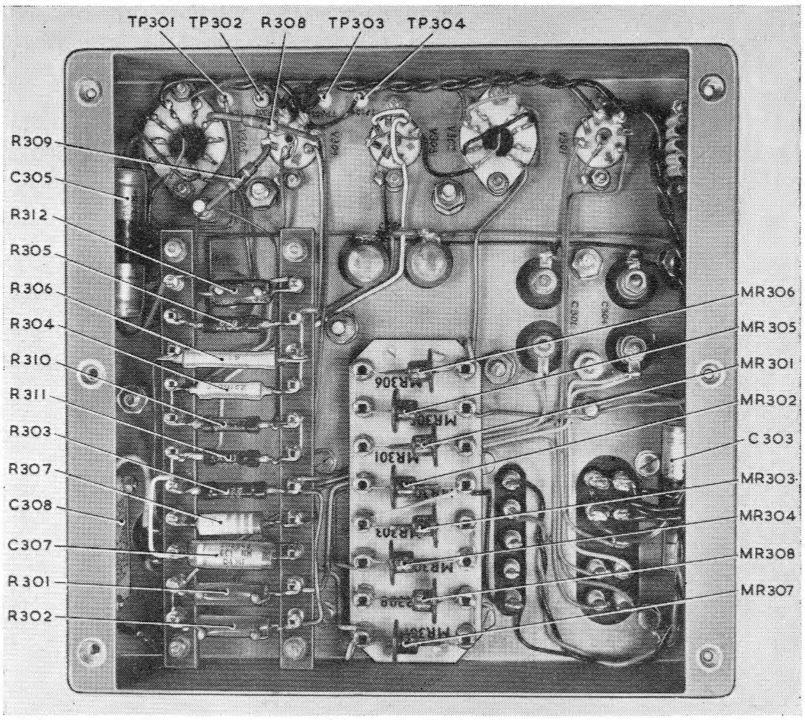


Fig. 13. Power supply unit: component location (bottom)

Type ◀CV7030▶, two rectifiers in series being used in each arm of the bridge. This type of rectifier is used to keep down the internal temperature of the tester and also to reduce size and weight. The output from the bridge is fed to the regulating circuit via the smoothing circuit which consists of L301, R312 and C302. C308 removes unwanted transients and other stray voltages.

92. Regulation of the +105V supply is provided by a hard valve, series stabilizer circuit consisting of V303 (CV4048), V304 (CV4010) and V305 (CV4038). V303 is a gas-filled voltage stabilizer valve which provides the reference potential of −84V for the grid of the difference amplifier V304, and V305 acts as a variable ballast resistance. Normal regulation action takes place in this circuit, that is, an increase in the output voltage will cause a corresponding increase in the potential at the grid of V304. The resulting increase in the current of V304 causes its anode potential to fall and consequently V305 grid falls causing the valve resistance to increase. An improvement in the regulation is effected by connecting the screen supply of V304 to the input side of V305 so that a rise in input voltage will increase valve current and have the same effect as a rise in output voltage. The regulator output is connected to PL301/P and can be monitored on TP301.

93. The 300–0–300V winding is connected to a full-wave rectifier V301 (CV4005) whose cathode is earthed. The centre-tap of the winding is connected to the smoothing network, thus providing a negative output. The smoothing network consists of C304, R301, C301, R302 and C303; its output is stabilized at −150V by a gas-filled voltage reference valve V302 (CV4053). The −150V is fed to PL301/R and can be monitored at TP302; it is also fed to V303 via R303 to provide the reference voltage of −84V for the regulator circuit (para 92).

94. The 6·3V winding provides the heater power for all the valves in the tester and the supply for the 'on' lamp ILP401 on the front panel. Each end of the winding is connected to three pins on PL301, one side of the winding being connected to pins H, L and N, and the other side to pins A, D and K. Pins H, L and N are on the earthy side of the winding. The 6·3V a.c. supply can be monitored on TP303 and TP304.

UNIT INTERCONNECTIONS AND FRONT PANEL ASSEMBLY

95. All interconnections between units except the coaxials shown on fig. 14 are made by 14-pole sockets. The socket cableforms are all taken to a 39-way terminal board for distribution. The 14-pole sockets are a miniaturized type with gold-plated contacts made from spring-tempered phosphor-bronze; this provides low contact resistance, prevents corrosion and facilitates soldering. The terminal board is only a jumper unit and all the interconnections are shown on fig. 23. Also shown on this figure are the circuit connections for most of the controls and indicators mounted on the front panel. The components mounted on the front panel are as follows:

(1) RV401, the SET RF LEVEL potentiometer. One end is connected to earth by R403.

(2) RV402, the SET ZERO potentiometer. This component is mounted on the front panel only

on the Type 10166 tester. With the Type 10166A tester this control is mounted inside the unit behind the front panel (fig. 23).

(3) S401, the main ON-OFF switch.

(4) S402, the RANGE MILES selector switch.

(5) S403, the BEARING DEGREES selector switch.

(6) S405, this is the METER SWITCH.

(7) S801, the DIR/RAD switch. This switch is on the Type 10166A tester only.

(8) M401, the meter marked SET TO 30μA.

(9) The indicator for the ATTENUATOR.

(10) The input socket marked R.F.

(11) SKT408, the coaxial TRIGGER socket, to which a 15 c/s synchronising signal may be applied. (This socket is fitted to later models only).

(12) SKT409, the coaxial VIDEO socket, from which the detected video signals may be taken ◀via R405▶. (Fitted to later models only).

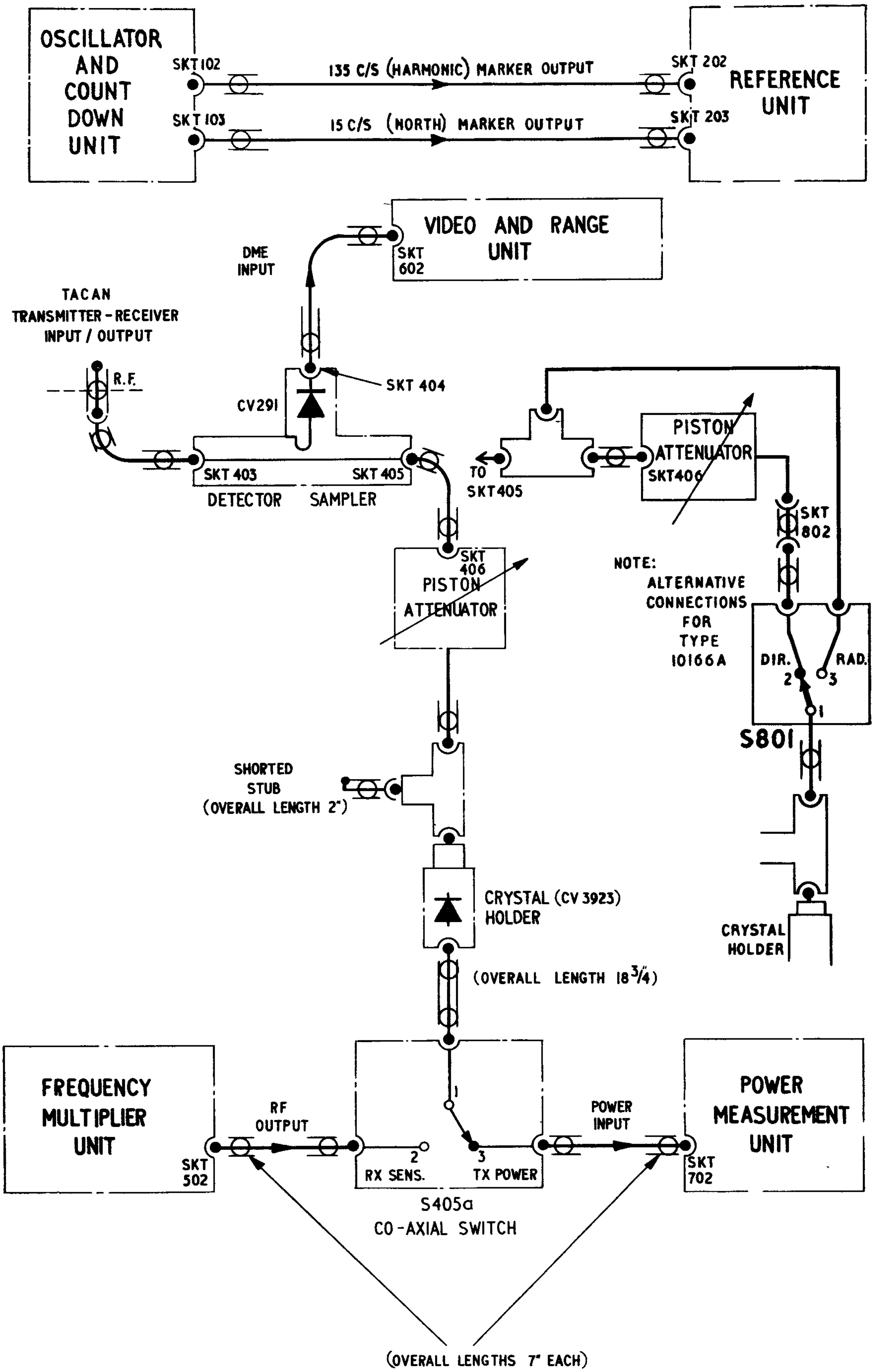


Fig. 14. Performance tester: co-axial system

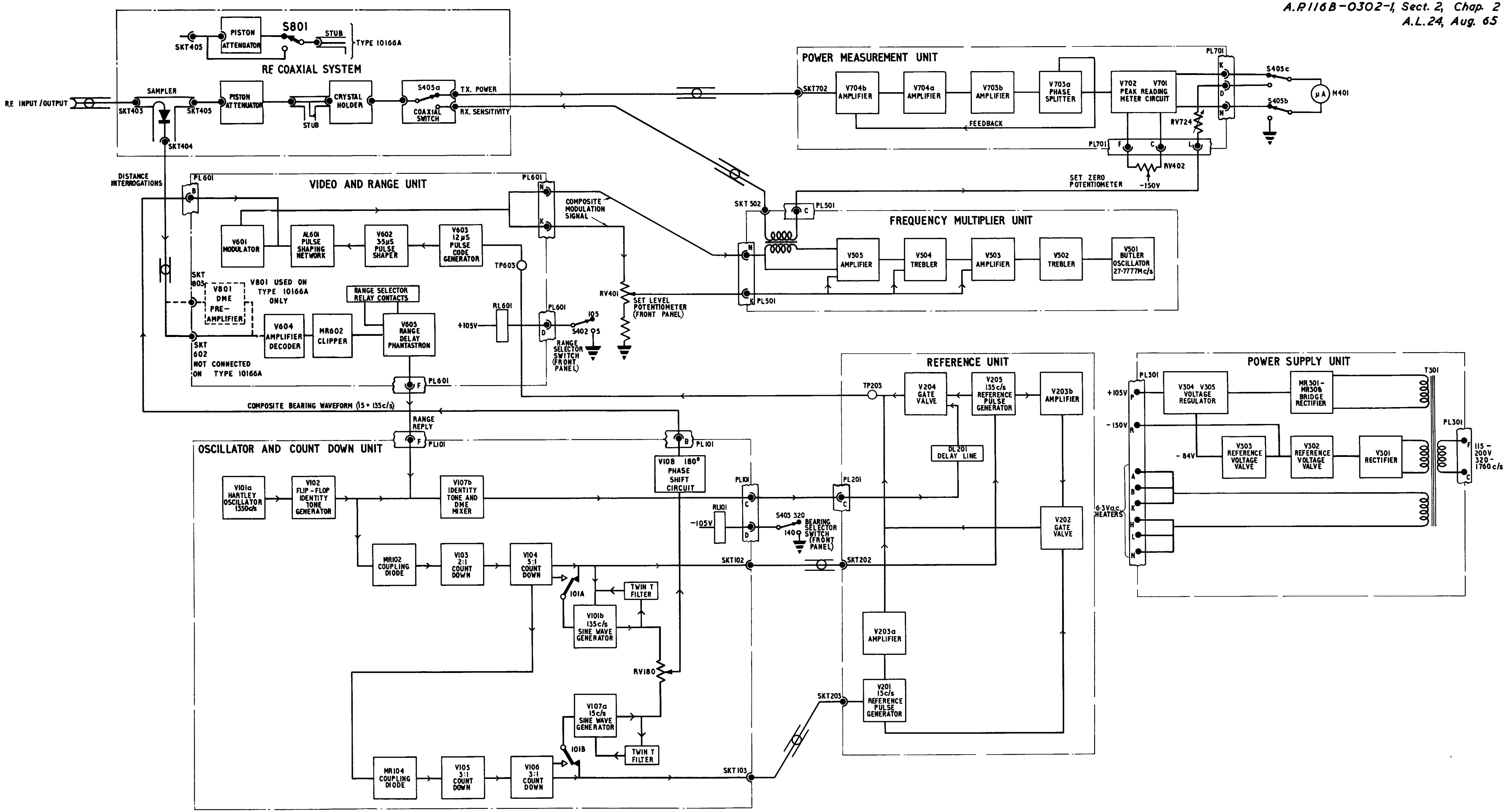
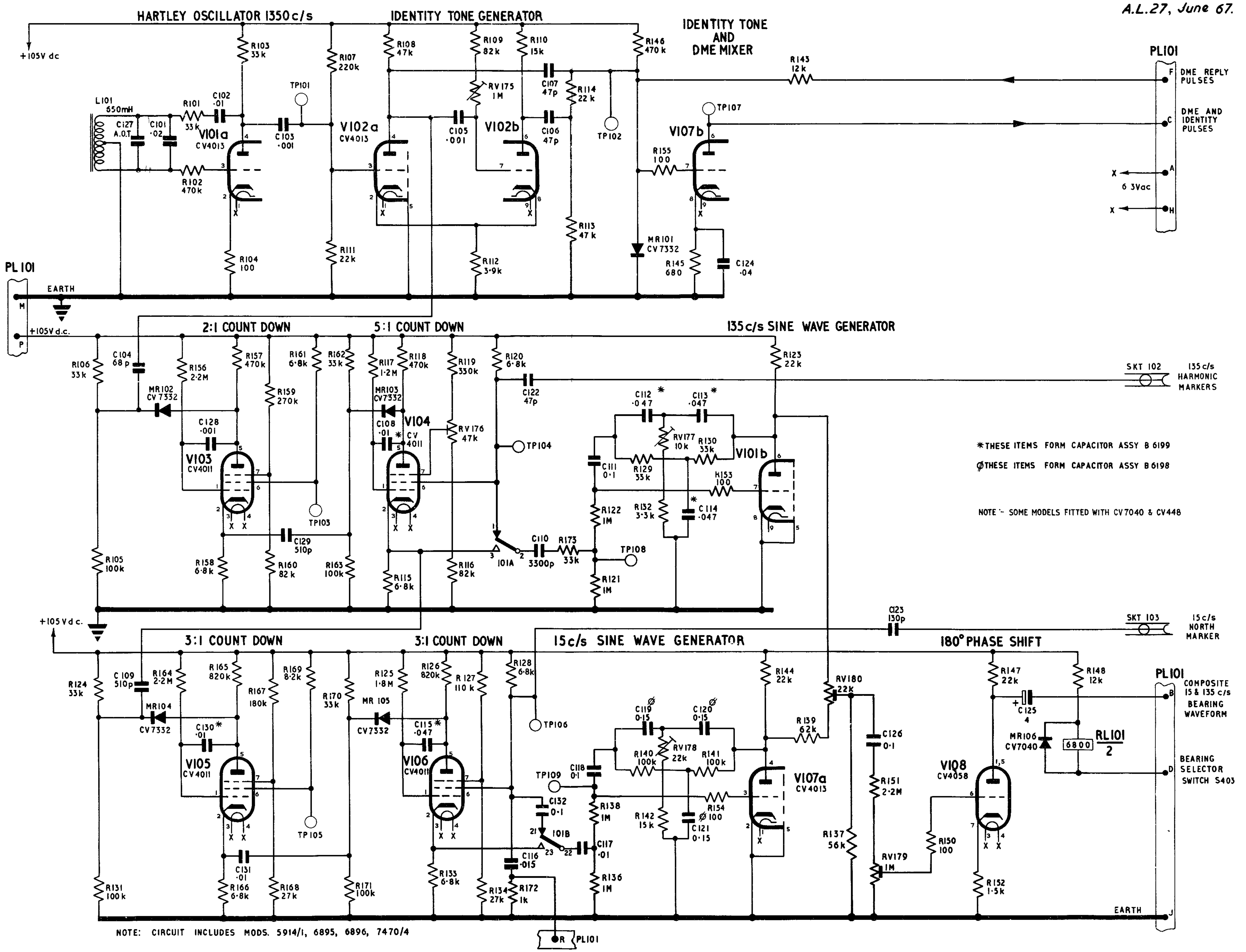


Fig. 15 Performance tester – block diagram Fig. 15



956/1 546927 271233 705 9.67

Fig. 16 Oscillator and count down unit: circuit Fig. 16

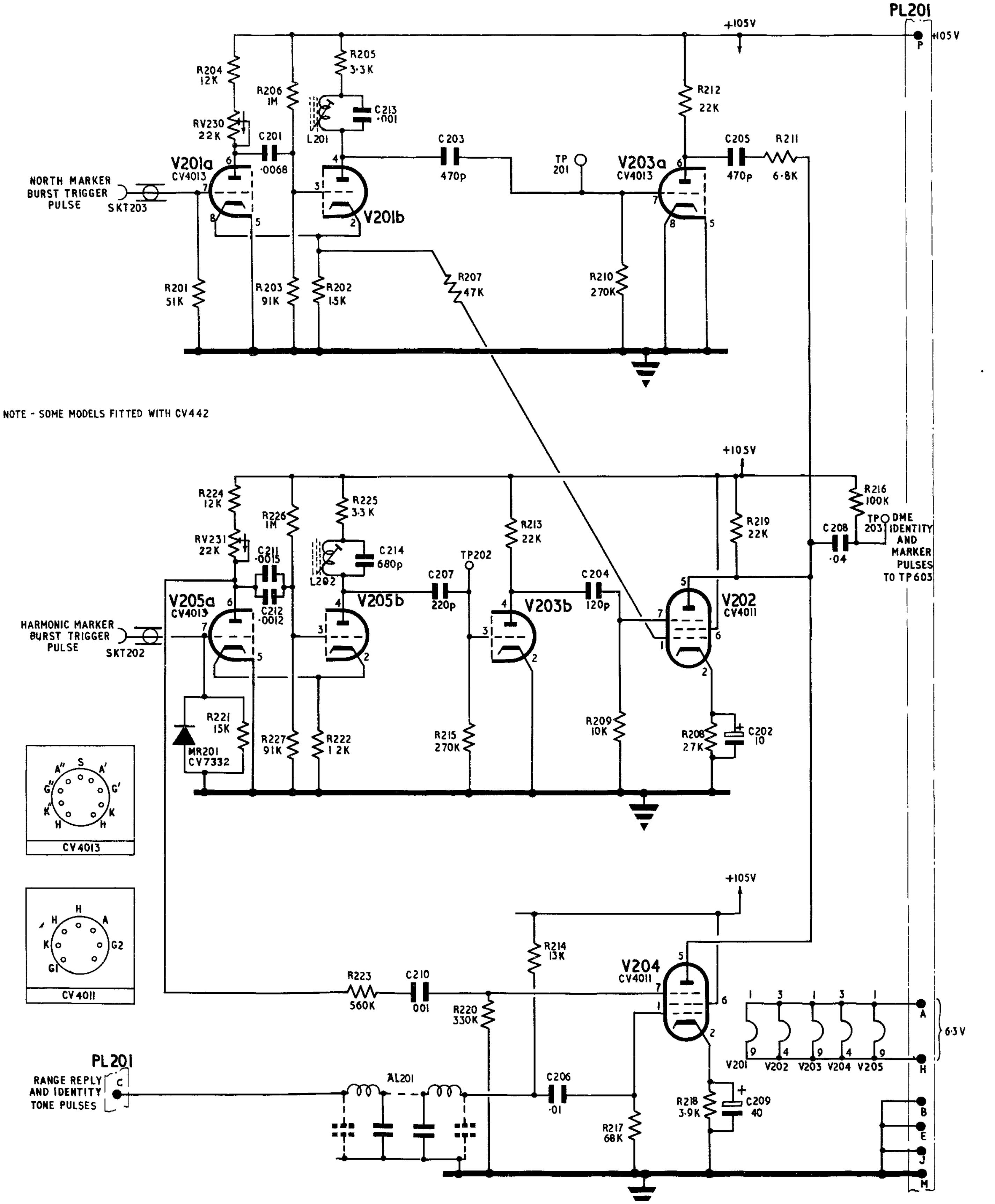


Fig.17 Reference unit-circuit Fig.17

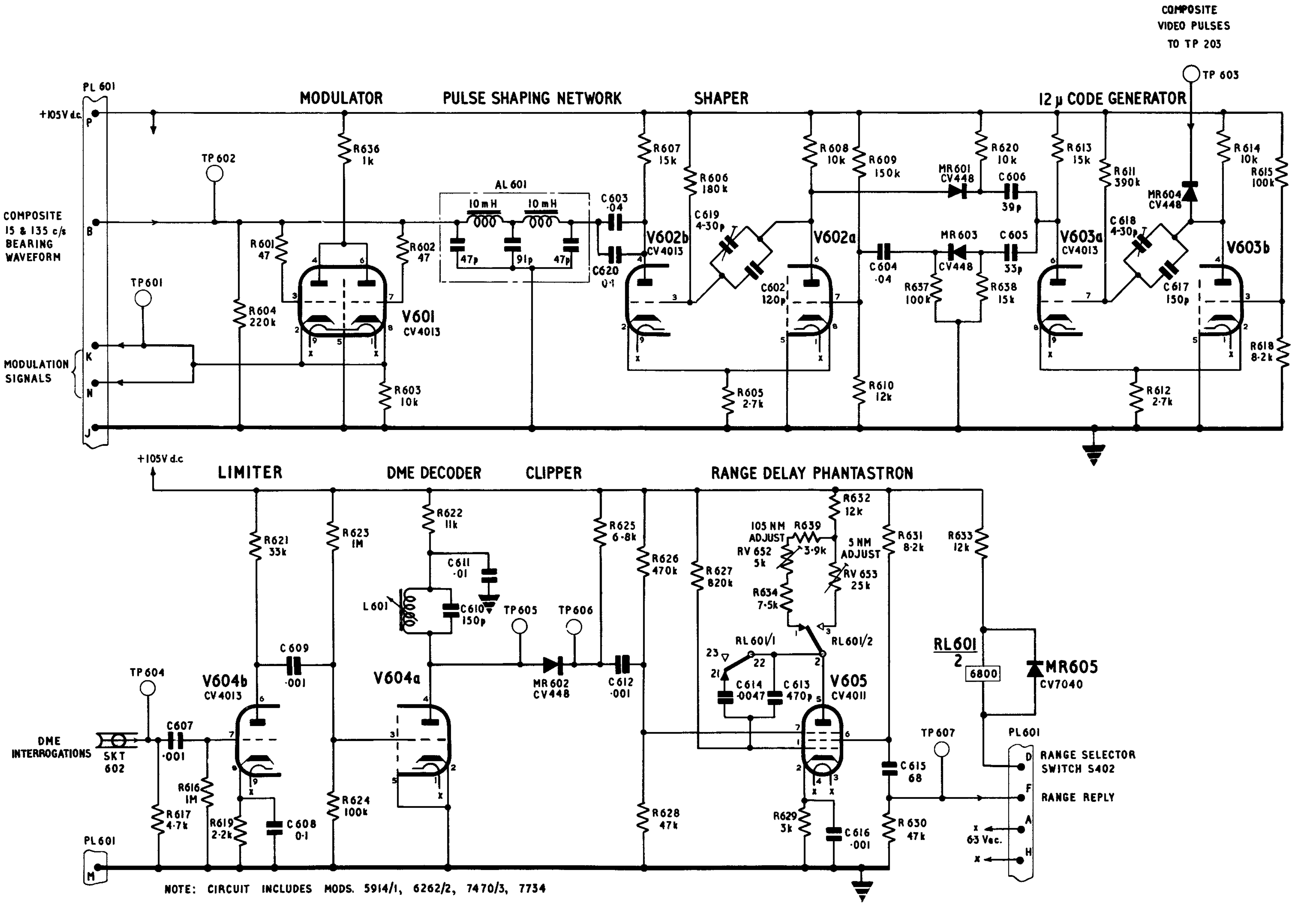


Fig.18 Video and range unit (Type 10166): circuit Fig.18

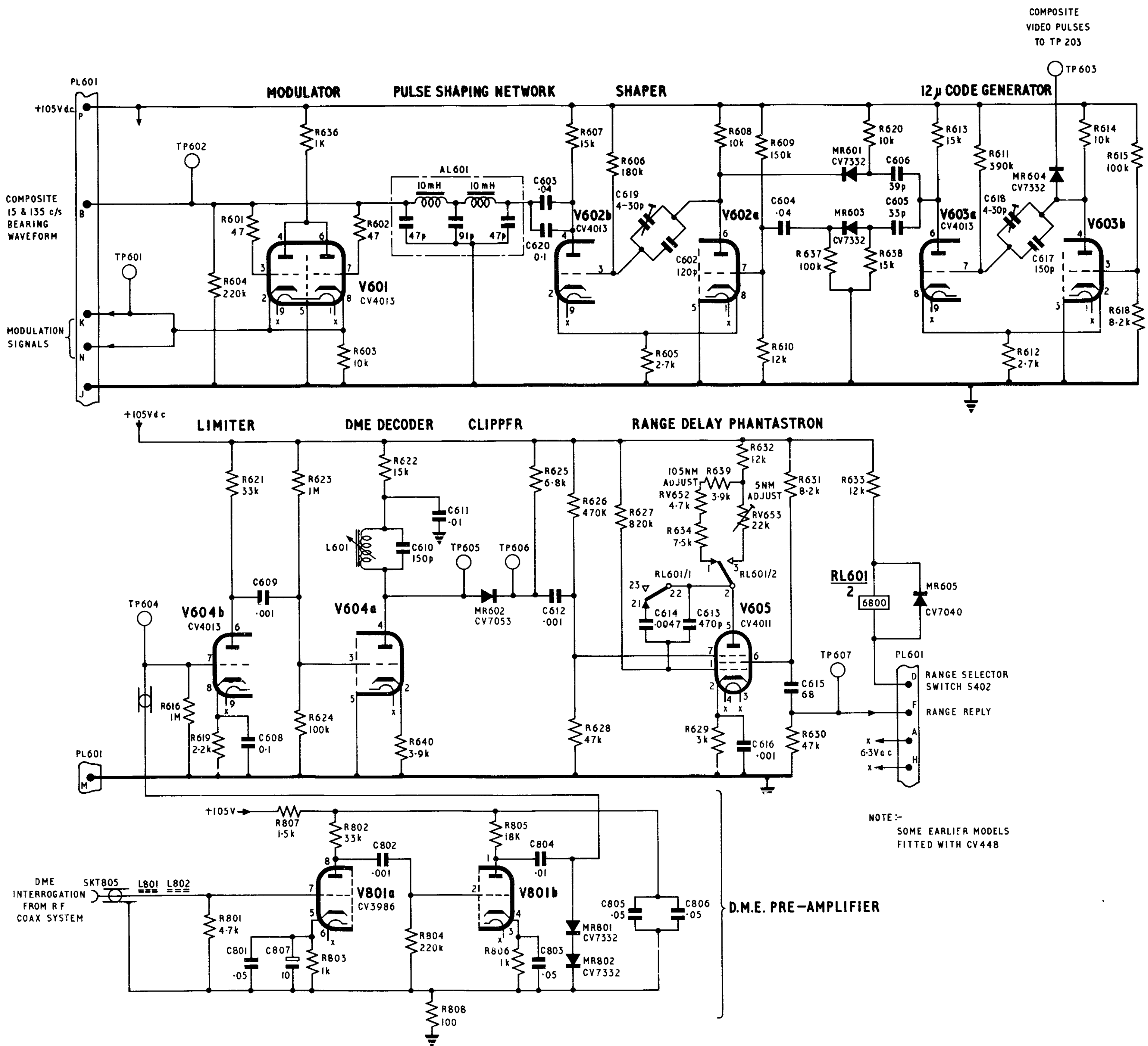


Fig. 19 Video and range unit (Type 10166A): circuit Fig. 19

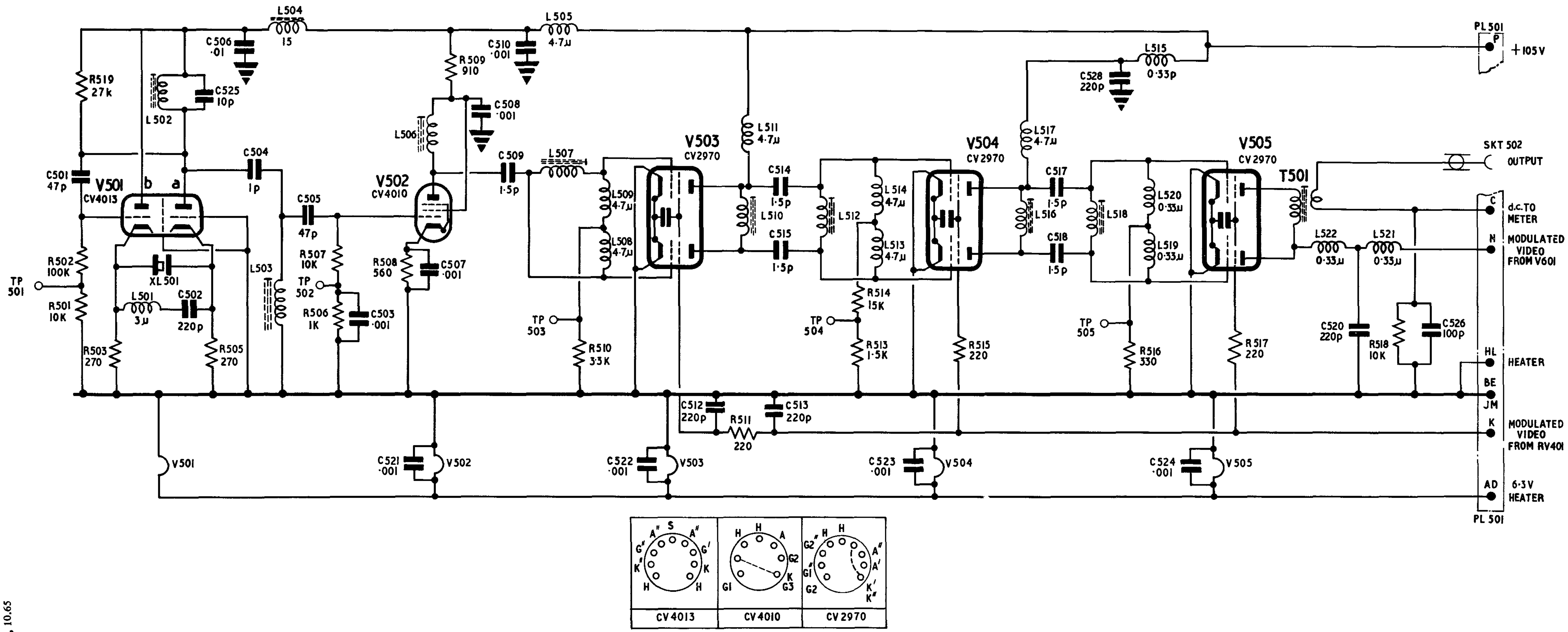


Fig. 20 Frequency multiplier unit-circuit Fig. 20

956/4, 87057, 571504, 705, 10.65

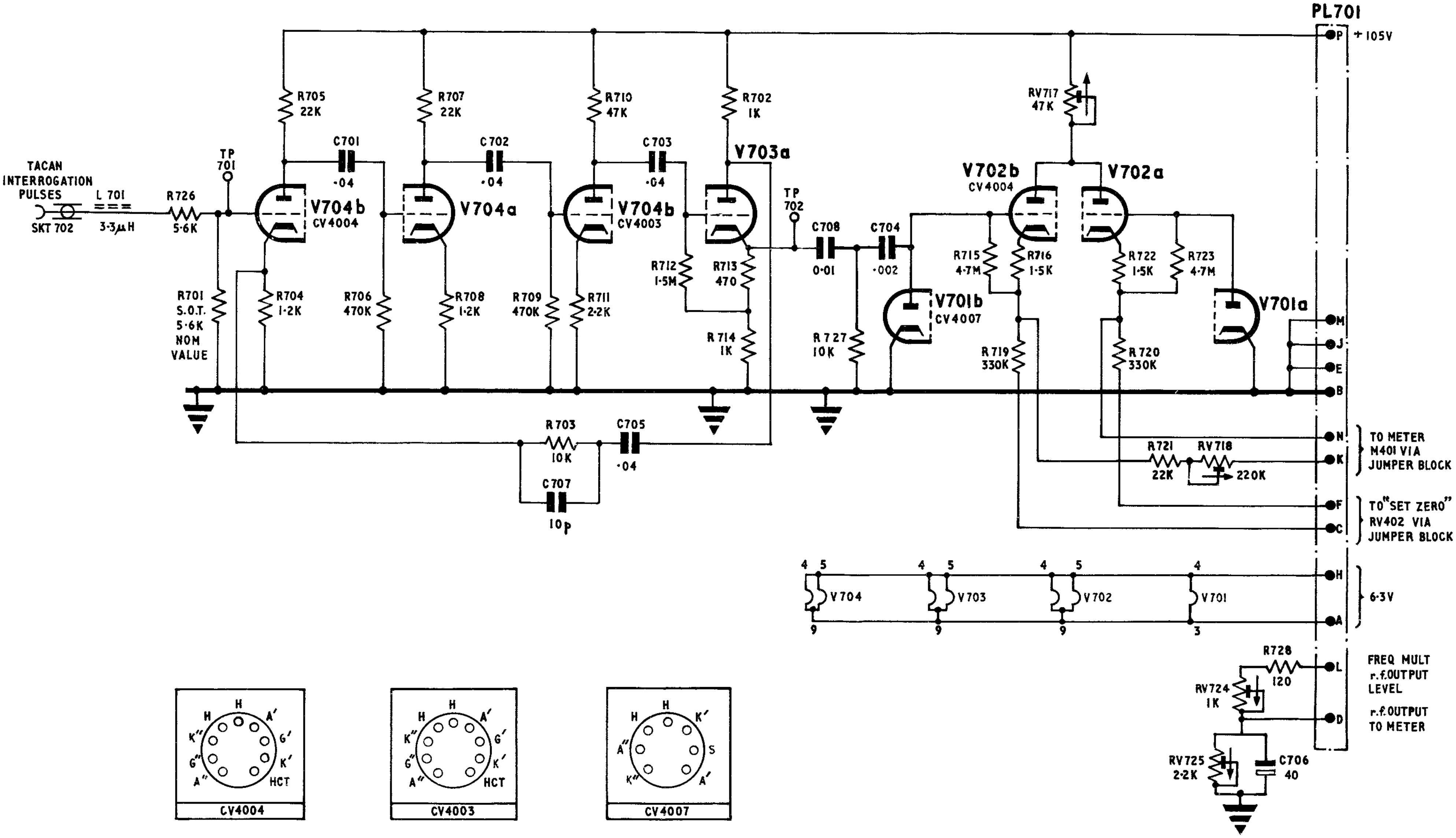


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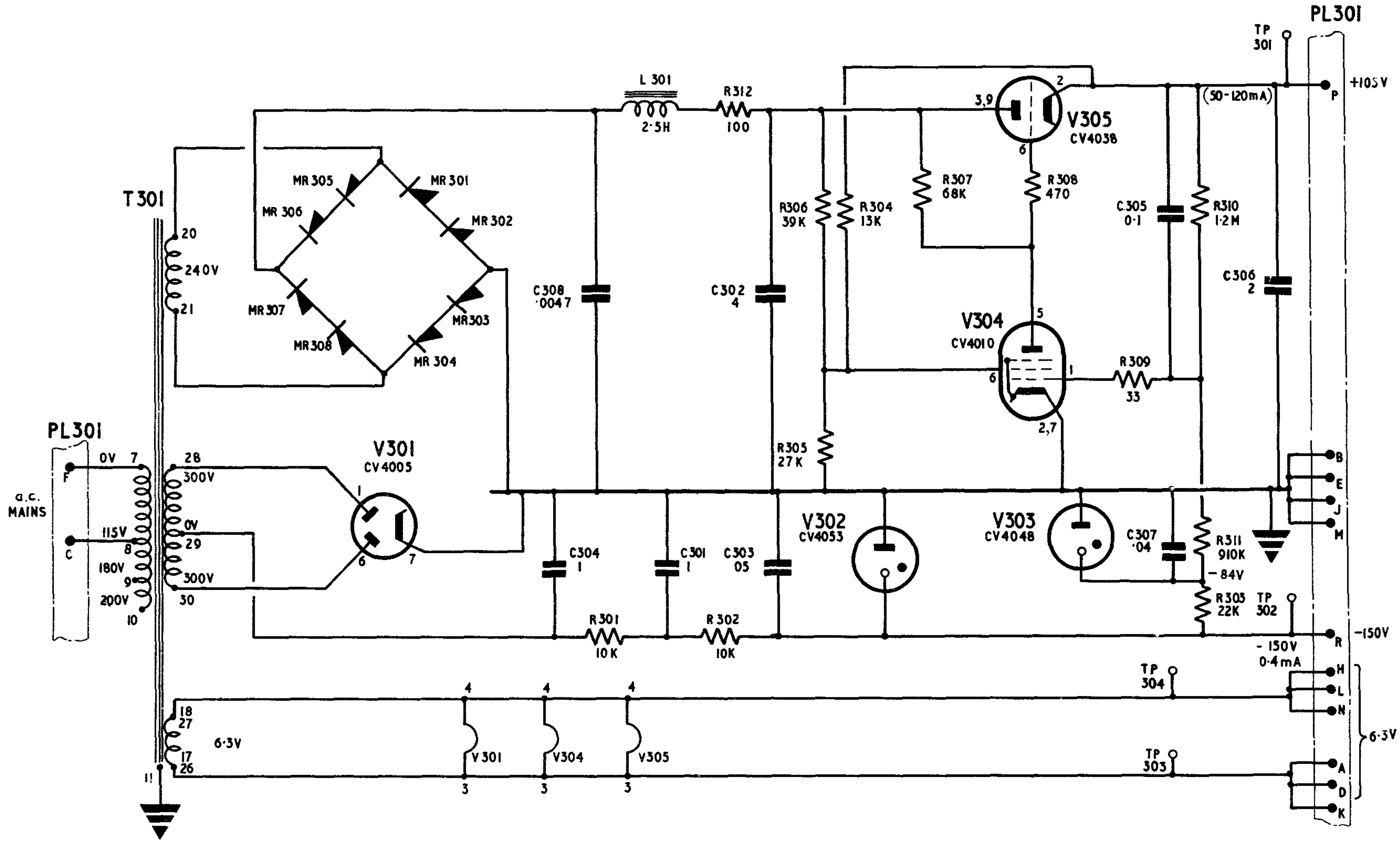
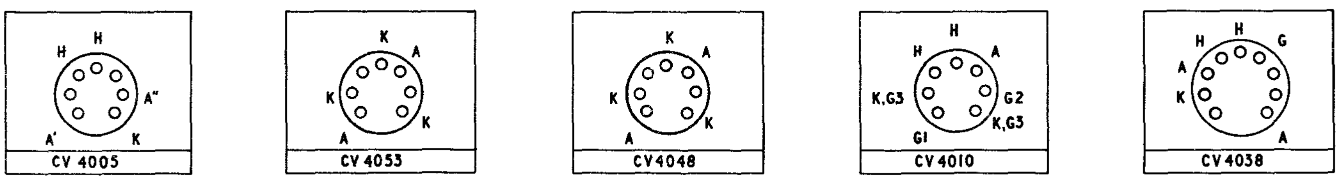
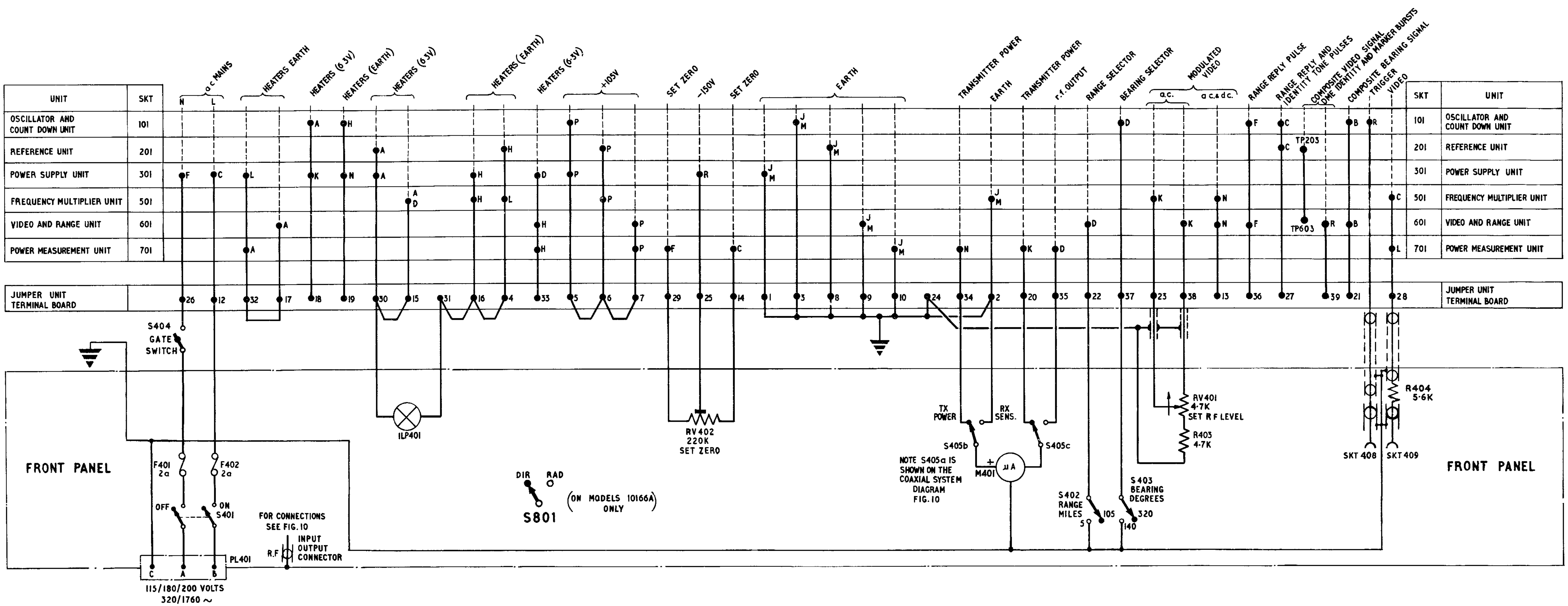
Fig. 21 Power measurement unit—circuit Fig. 21





956/4, 87057, 571504, 705, 10.65

Fig.22 Power supply unit – circuit Fig.22



956/1 546927 271233 705 9.67

Fig. 23 Tester performance Types 10166 and 10166A: interconnections Fig. 23

Chapter 3

OPERATING INSTRUCTIONS

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Introduction

1. This chapter gives the operating instructions for the performance testers Type 10166 and Type 10166A. These instructions assume that the setting up procedure (chapter 4 of this Section) has been properly carried out. The front panels, with the controls, are given in fig. 1 and 2.

Connections

2. To operate a performance tester the following connections must first be made:

(1) Performance tester to the appropriate power supply.

(2) R.F. connector on instrument to aerial socket on TR unit.

◀**Note . . .**

NEVER set the DIR/RAD *switch to* RAD *when using the connector/attenuator.*▶

With the Type 10166A set to the radiating mode, this connection, of course, must not be made. The R.F. connector is then replaced by the antenna (para. 9).

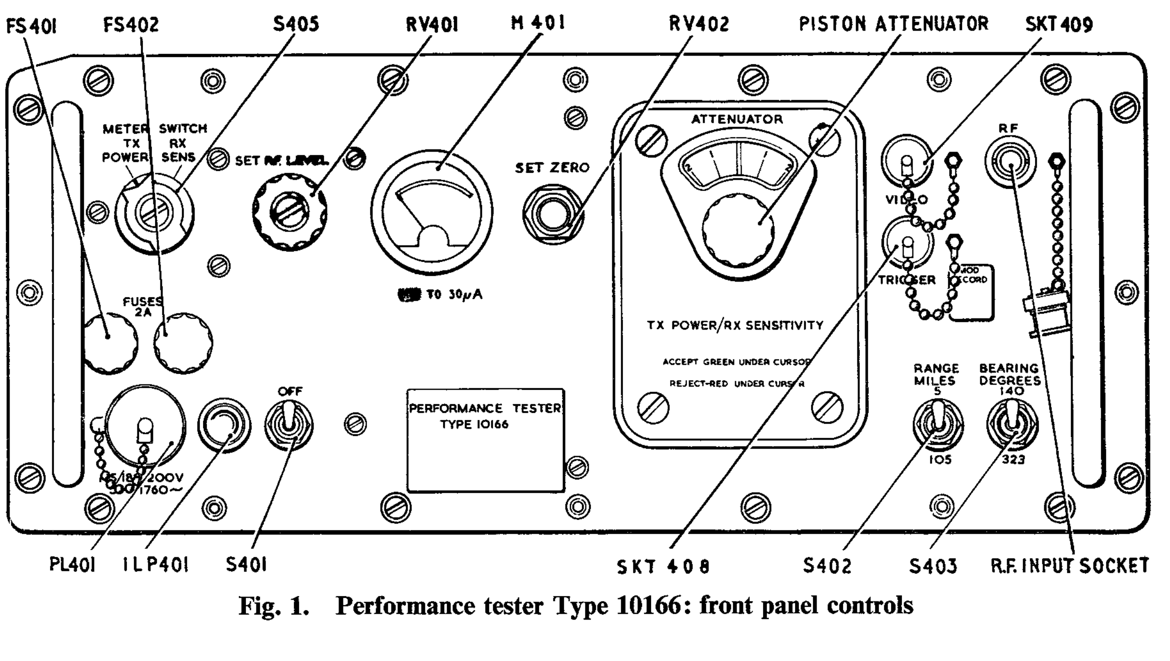

Fig. 1. Performance tester Type 10166: front panel controls

Direct connection mode

3. Set up the performance tester as follows:

(1) Set the ON-OFF switch (S401) to the ON position and allow a 5 minute warming-up period.

(2) Set the DIR/RAD switch (S801) to the DIR position (Type 10166A only).

(3) Set the METER SWITCH (S405) to the TX POWER position.

(4) Set the ATTENUATOR dial to the junction of the green and red sections of the dial.

(5) Adjust the SET ZERO control (RV402) (if necessary) for a meter indication of zero.

(6) Set the METER SWITCH (S405) to the RX SENS position.

(7) Adjust the SET RF LEVEL (RV401) for a meter indication of 30μA.

Note . . .

Throughout testing procedure, ensure that the indication of 30μ*A is maintained.*

(8) Set the RANGE MILES switch (S402) to 5.

(9) Set the BEARING DEGREES switch (S403) to 140.

4. Make the following receiver tests in this order. Identity tone, bearing 140° and 323°, distances 5 and 105 nautical miles and power output.

Identity

5. To check the identity tone proceed as follows:

(1) Switch the airborne TACAN equipment to ON and to either REC or BRG.

(2) Select channel 39.

(3) Check that the control unit dial lamp lights and allow 5 minutes for the equipment to warm up.

(4) Plug in the headset and adjust VOL control to a suitable level.

(5) Check that the identity tone is audible.

(6) Remove headset.

Bearing

6. To check the bearing receiver sensitivity proceed as follows:

(1) Ensure that the SET RF LEVEL on the performance tester has remained at 30μA. Adjust as necessary.

(2) Observe that the indicator needle and coupling unit bearing dials on the TACAN equipment indicate between 135° and 145°.

(3) Set the BEARING DEGREES switch (S403) to 323.

(4) Check that:

(*a*) After a short delay lock is lost.

(*b*) The indicator needle and coupling bearing dials rotate.

(*c*) Lock re-occurs first time round when the needle appears between 318° and 328°.

Distance

7. To check distance receiver sensitivity proceed as follows:

(1) Set control unit to the distance mode.

(2) Set the ATTENUATOR to green 4.

(3) Check that the indicator and coupling unit distance dials indicate between 4·5 and 5·5 nautical miles, and that the bar disappears.

(4) Set the RANGE MILES switch (S402) to 105.

(5) Check that after a delay of between 8 to 10 seconds:

(*a*) Lock is lost, i.e. the bar appears.

(*b*) The indicator behind the bar and the coupling unit distance dials rotate.

(*c*) Lock re-occurs, i.e. the bar disappears, the first time round, when indicating between 102 and 108 nautical miles.

Power output

8. To check the power output proceed as follows:

(1) Set the METER SWITCH (S405) to TX POWER. Ensure that the transmitter-receiver

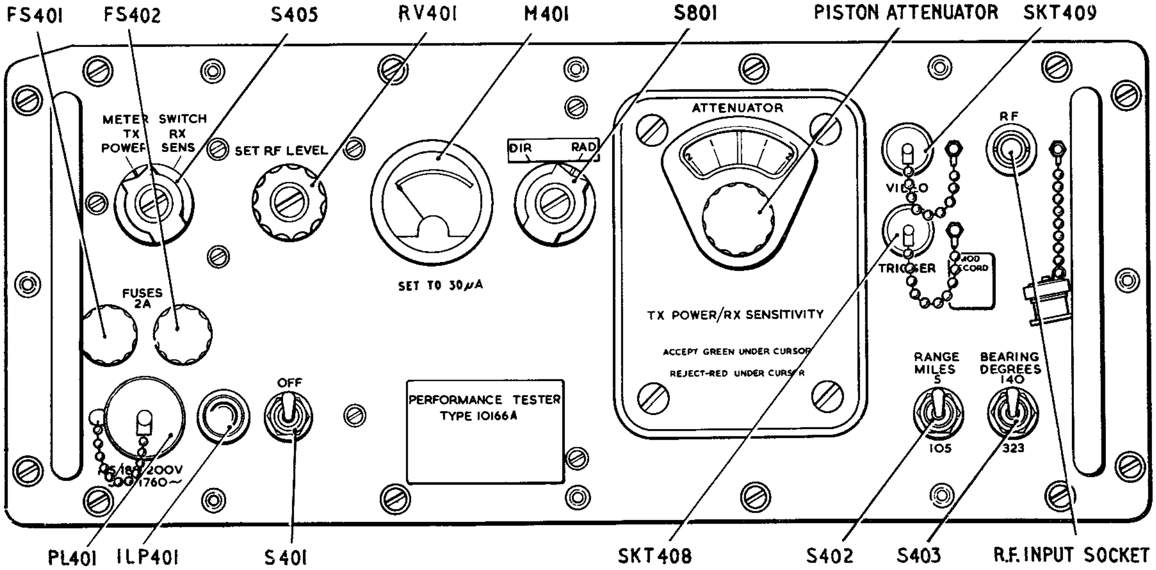

Fig. 2. Performance tester Type 10166A: front panel controls

is in the search mode, i.e. the distance indicator warning flag is showing and the range counters are rotating rapidly.

(2) Adjust the ATTENUATOR until the meter indicates 30μA.

(3) Check that the ATTENUATOR indicates green under the cursor.

(4) Check that the bar is visible and that both bearing and distance indications are rotating smoothly.

(5) Switch TACAN to OFF. Disconnect performance tester and reconnect the aerial system.

Radiating mode (Type 10166A only)

9. Set up the performance tester Type 10166A as follows:

(1) If the radiating test was preceded by direct connection tests, ensure that the airborne TACAN equipment r.f. connection is replaced when the tester r.f. connector is removed.

(2) Set the tester approximately 30 ft. from the TACAN installation and in an attitude such that the antenna, when connected, will be vertical.

(3) Clamp the antenna to the instrument handle and connect the coaxial lead to the R.F. output socket (fig. 3). Certain early versions of the antenna plug directly into the R.F. socket and a clip is engaged on the handle of the tester to maintain the antenna in a vertical position. Alternatively, the antenna may be mounted in a vertical position, preferably on a wooden pole, and connected to the tester R.F. socket via a 50-ohm coaxial cable. This cable may have a maximum length of 25 ft. but, in these circumstances, it is recommended that the antenna be not more than 25 ft. from the TACAN installation antenna.

Note . . .

The antenna, however mounted, should not be placed within 10 ft. of any large metal object as this may have a considerable effect on its performance. The tester antenna should also not be placed within 10 ft. of the TACAN installation, as this may cause damage to the crystal in the tester. Maximum antenna separation for satisfactory operation is dependent on individual site and installation characteristics.

Checking installation performance

10. To check the TACAN installation performance, using the radiating facility, proceed as follows:

(1) Set the DIR/RAD switch (S801) to RAD.

(2) Set the METER SWITCH (S405) to RX SENS.

(3) Adjust the SET RF LEVEL control for a meter indication of 30μA.

(4) Set the RANGE MILES switch (S402) to 5.

(5) Check that the TACAN range indicator 'locks on' and indicates between 4·5 and 5·5 nautical miles.

(6) Set the RANGE MILES switch (S402) to 105.

(7) Check that the TACAN range indicator 'locks on' and indicates between 102 and 108 nautical miles.

(8) Set the BEARING DEGREES switch (S403) to 140.

(9) Check that the TACAN bearing indicator 'locks on' and indicates between 135° and 145°.

(10) Set the BEARING DEGREES switch (S403) to 323.

(11) Check that the TACAN bearing indicator 'locks on' and indicates between 318° and 328°.

(12) Check that the identity tone can be heard in the headset.

Note . . .

(1) *The airborne TACAN bearing indication is determined by the pulse pattern generated within the tester and is quite independent of the relative positions of the TACAN equipment and the tester. TACAN installations giving indication outside the limits stated above are unserviceable.*

(2) *When testing the AN/ARN-501 airborne equipment the range indicator will not unlock when the tester range is altered. The channel should be momentarily changed to enable the indicator to unlock and go into the search mode.*

Caution . . .

If the test set is to be used in a workshop for long periods of continuous operation, it should stand in a free space to allow adequate dissipation of heat from the case. ◀*Always return the* DIR/RAD *switch to* DIR *after radiating tests. This prevents accidental damage to the test set's circuits when using the connector/attenuator.*▶

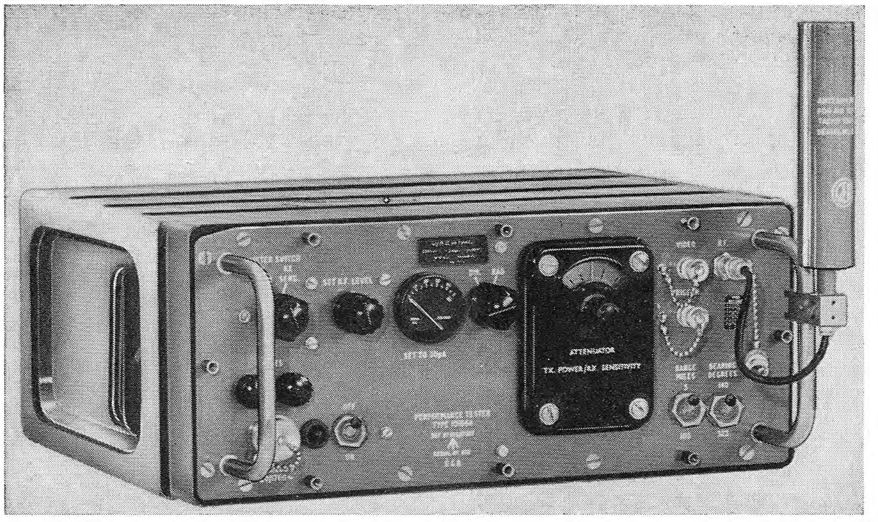

Fig. 3. Performance tester Type 10166A: method of mounting antenna

Chapter 4

SERVICING AND FAULT DIAGNOSIS

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Mechanical servicing	2	*Resistance tests*	6
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General

1. This chapter contains information of use when diagnosing faults in the test sets Type 10166 and 10166A. After any repairs have been carried out, and at intervals specified in D.C.I.'s, the test set should be sent to a Calibration Centre where the rather complex array of standard test equipment required for the purpose is available. User units are warned against the adjustment of internal preset controls.

Mechanical servicing

2. The frequency multiplier unit, the oscillator and count down unit, and the video and range unit may be removed from the chassis after removing the interconnecting plugs and sockets and attachment screws, four in each sub-unit. The remainder of the test set should be dismantled using the following procedure, reference should be made to fig. 1. To reassemble the procedure should be reversed.

(1) Remove the Power Measurement Unit A by removal of four countersunk screws from beneath unit.

(2) Remove six countersunk screws from beneath Power Unit B.

(3) Slide Power Unit B back as indicated by arrow.

(4) Remove attenuator knob C.

(5) Remove attenuator front cover D by releasing four captive screws.

(6) Remove rubber gasket E.

(7) Remove two right-hand attenuator fixing screws, nuts and washers F.

(8) Remove four front panel retaining screws and washers G.

(9) Remove four handle retaining nuts and washers, and two handles H.

(10) Release SKT 406 J.

(11) Remove plug K from Tee adaptor (non-radiating versions), or SKT 802 (radiating versions).

(12) Ease front panel forward and remove two left-hand attenuator fixing screws, nuts and washers L.

(13) The attenuator can now be removed if required.

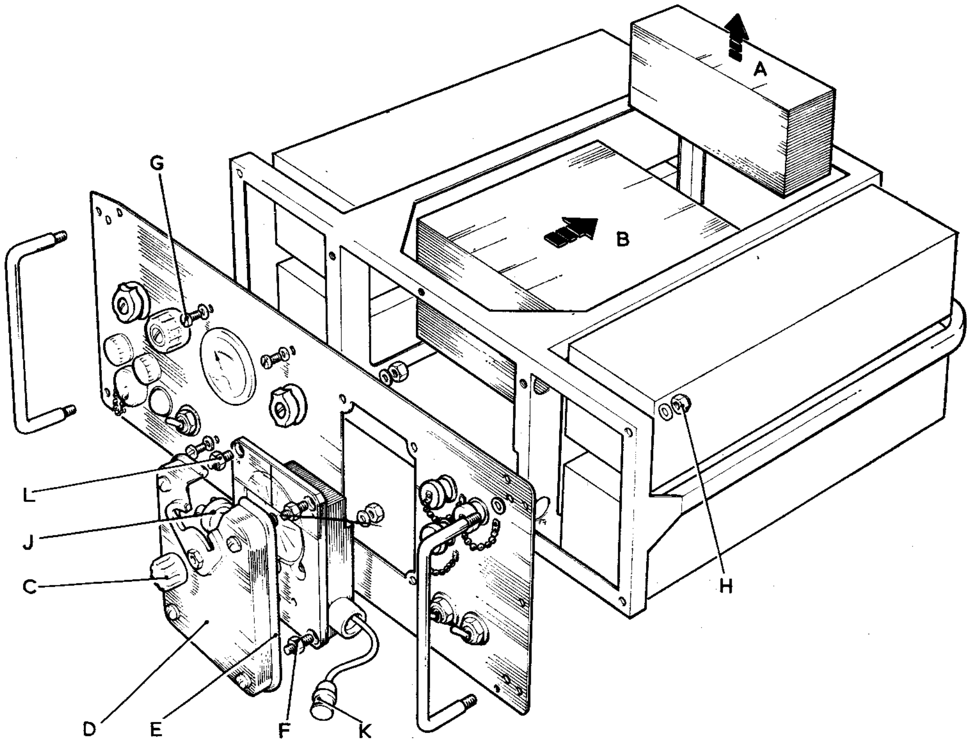


Fig. 1. Dismantling methods

3. Certain bearings in the attenuator drive mechanism require occasional lubrication, details can be seen by reference to fig. 2. Details of the construction of the attenuator can be seen in fig. 3. It is not recommended that the attenuator be dismantled unnecessarily. A key to the annotations of figs. 2 and 3 are given in Table 1.

TABLE 1

Component parts of the variable attenuator

Key to fig. 2	Key to fig. 3
A—LIMIT CAM	H—TUNING ADJUSTMENT SCREW
B—CAM ADJUSTMENT SCREW	J—RESISTOR
C—QUADRANT ADJUSTMENT SCREW	K—LOCATING SLOT
D—ATTENUATOR BARREL	M—PLUG SCREW
E—CURSOR DATUM LINE	N—LOOP ASSEMBLY
F—ATTENUATOR LOCKING SCREW	Q—LOOP ASSEMBLY FIXING SCREW
P—QUADRANT FIXING SCREW	
R—QUADRANT ASSEMBLY	

Power supplies

4. All voltage measurements and waveform tests are dependent on the supply voltages, it is therefore recommended that the output of the power unit be tested before other tests, typical results are listed in Table 2. It is important that the input a.c. supply be adjusted correctly before testing.

TABLE 2

Power unit outputs

Supply	Test Point	Typical Voltage	Output Load
+105V	TP301	+105V	50—120 mA
−150V	TP302	−160V	4 mA
6·3V a.c.	TP303 TP304	6·3V a.c.	—

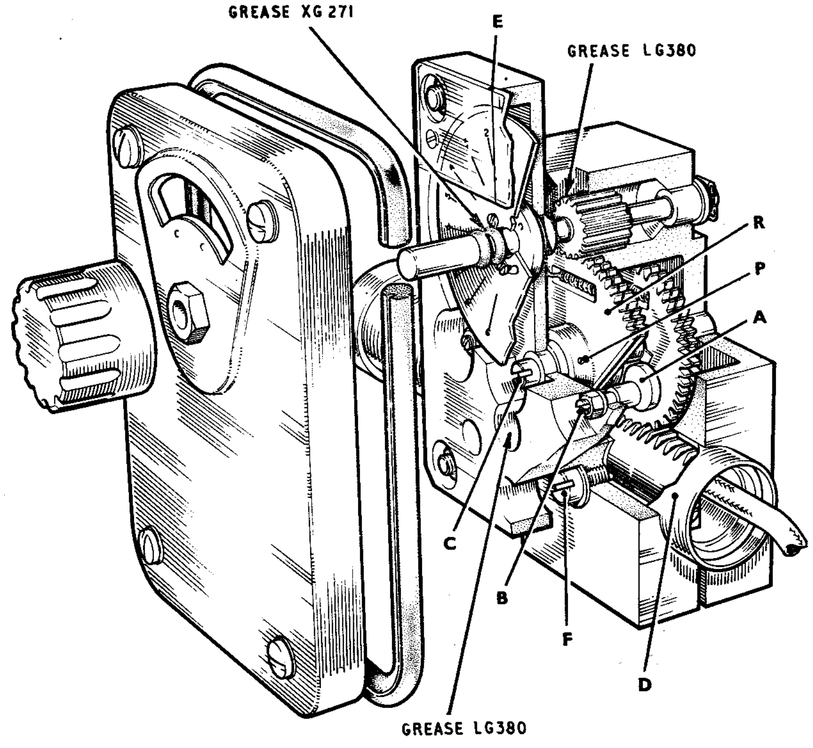


Fig. 2. Attenuator drive unit mechanism

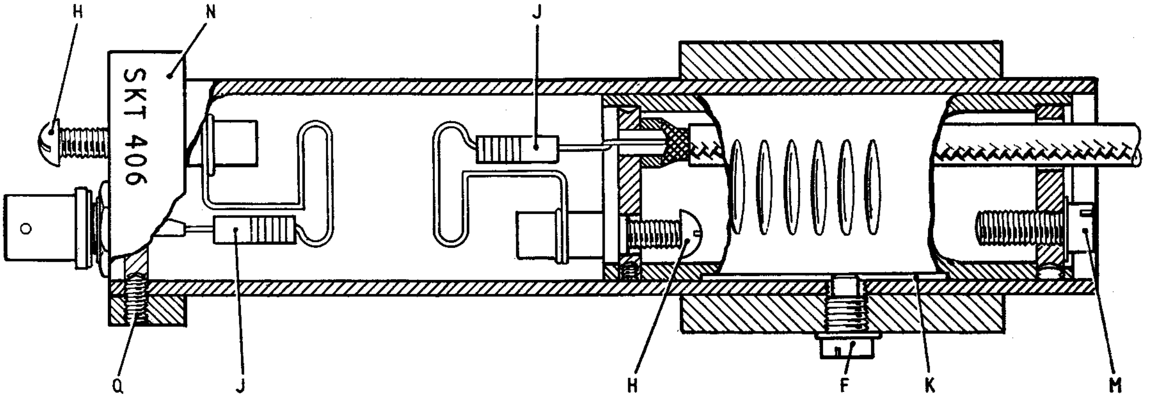
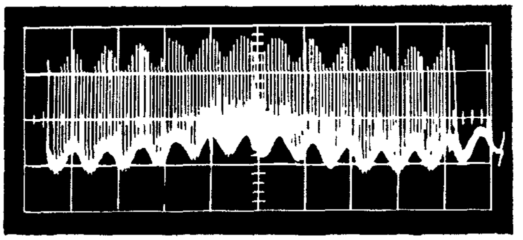
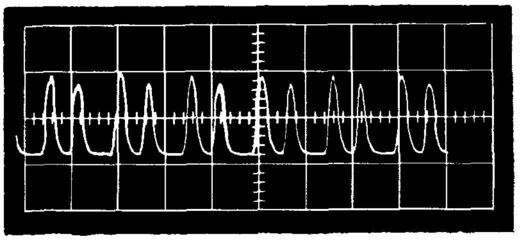


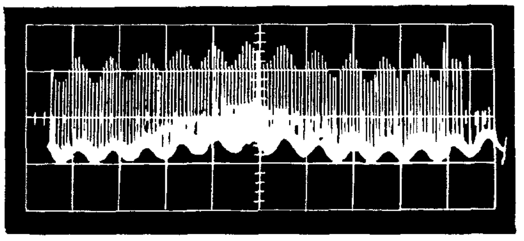
Fig. 3. Construction of variable attenuator



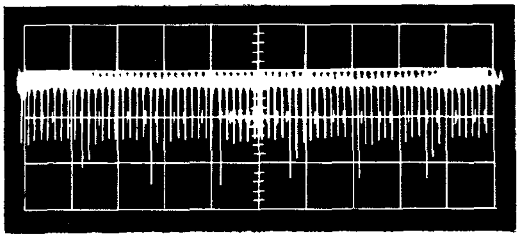
Test point 601
Main sweep calibration 10 ms/cm
Amplitude calibration 10 v/cm



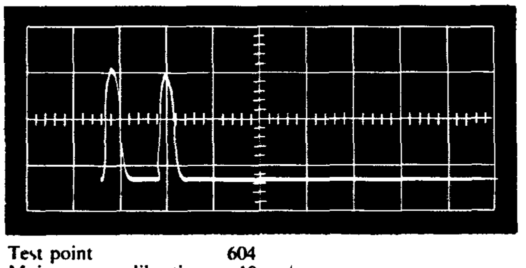
Test point 601
Main sweep calibration 20 μs/cm
Amplitude calibration 10 v/cm (Part of main burst expanded)



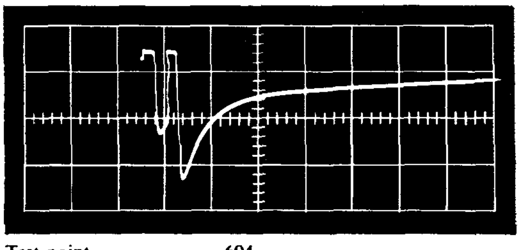
Test point 602
Main sweep calibration 10 ms/cm
Amplitude calibration 10 v/cm



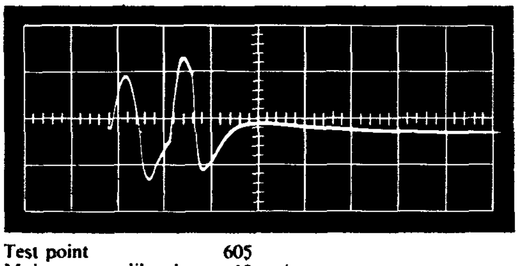
Test point 603
Main sweep calibration 5 ms/cm
Amplitude calibration 10 v/cm



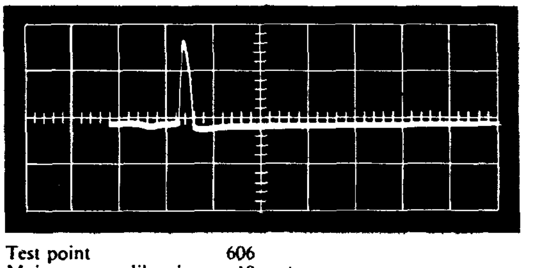
Test point 604
Main sweep calibration 10 μs/cm
Amplitude calibration 1 v/cm (NON RAD)



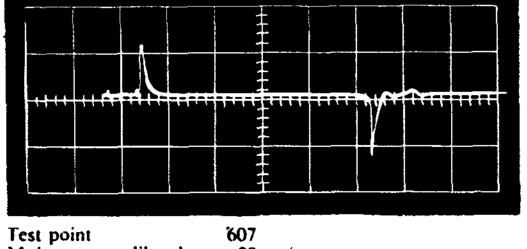
Test point 604
Main sweep calibration 20 μs/cm
Amplitude calibration 10 v/cm (RAD)



Test point 605
Main sweep calibration 10 μs/cm
Amplitude calibration 50 v/cm

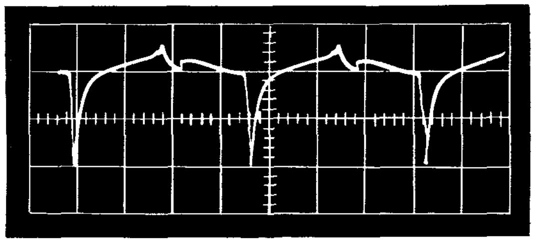


Test point 606
Main sweep calibration 10 μs/cm
Amplitude calibration 10 v/cm

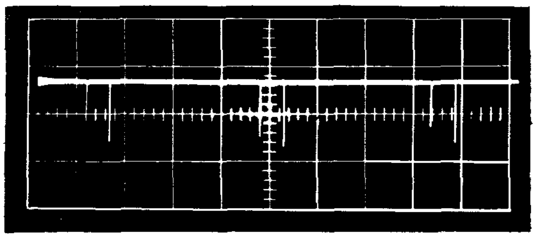


Test point 607
Main sweep calibration 20 μs/cm
Amplitude calibration 10 v/cm

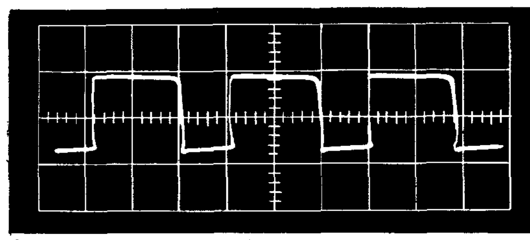
Fig. 4. Oscilloscope waveforms A (Video and range unit)



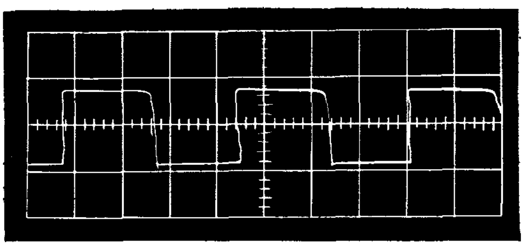
Test Point 101
Main sweep calibration 0·2 ms/cm
Amplitude calibration 10 v/cm



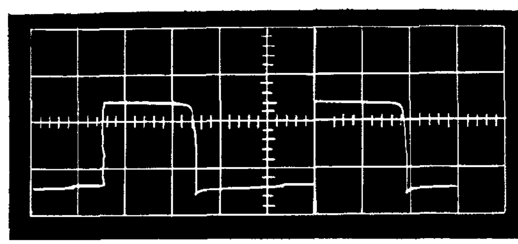
Test point 102
Main sweep calibration 0·2 ms/cm
Amplitude calibration 2 v/cm



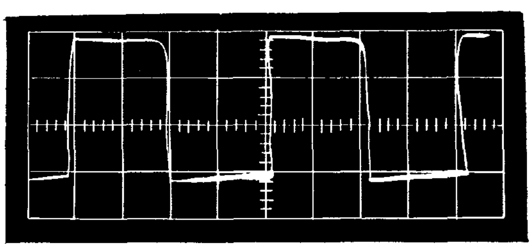
Test point 103
Main sweep calibration 0·5 ms/cm
Amplitude calibration 20 v/cm



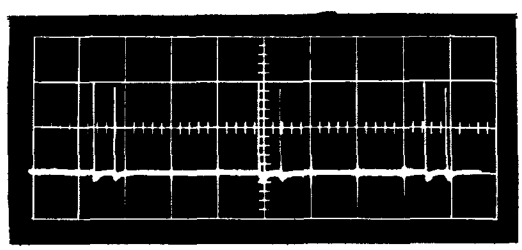
Test point 104
Main sweep calibration 2 ms/cm
Amplitude calibration 20 v/cm



Test point 105
Main sweep calibration 5 ms/cm
Amplitude calibration 20 v/cm



Test Point 106
Main sweep calibration 15 ms/cm
Amplitude calibration 10 v/cm



Test point 107
Main sweep calibration 0·2 ms/cm
Amplitude calibration 10 v/cm

Fig. 5. Oscilloscope waveforms B (Oscillator and count down unit)

Voltage tests

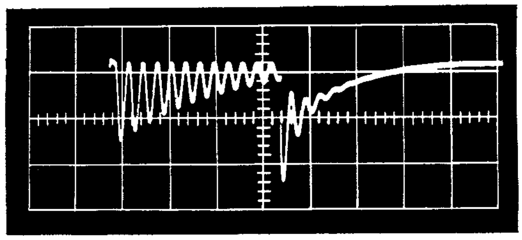
5. Typical voltages at the various valve pins are listed in Table 3. These are all d.c. and with respect to chassis except for the valve heater supplies and except where specifically stated; reference should be made to the circuit diagrams of Chap. 2 when taking measurements.

Resistance tests

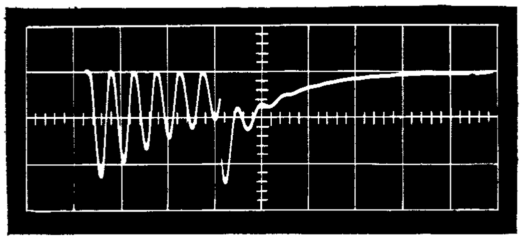
6. Typical d.c. resistance measurement tests, with respect to chassis, are given in Table 4. The equipment should be switched off and disconnected from the supply before resistance measurements are taken.

Oscilloscope waveforms

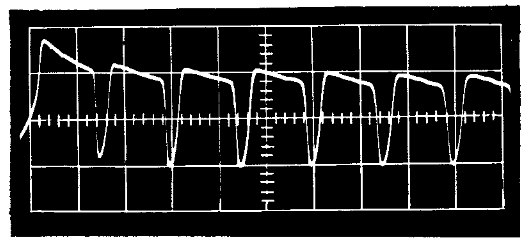
7. Various waveforms which can be observed on an oscilloscope connected to the various test points are given in figs. 4, 5 and 6.



Test point 201
Main sweep calibration 0·1 ms/cm
Amplitude calibration 20 v/cm

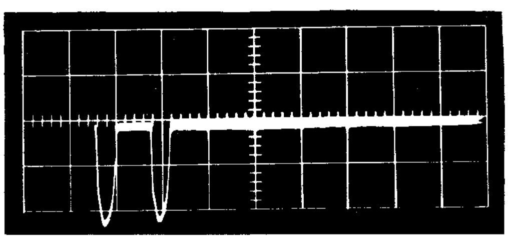


Test point 202
Main sweep calibration 50 μs/cm
Amplitude calibration 20 v/cm

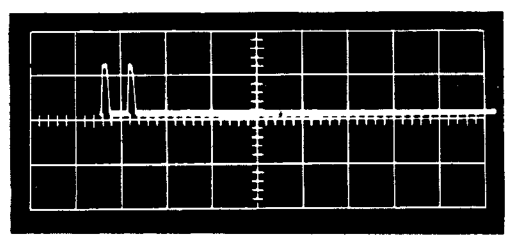


Test point 203
Main sweep calibration 20 μs/cm
Amplitude calibration 20 v/cm

Reference Pulse Unit—Waveforms

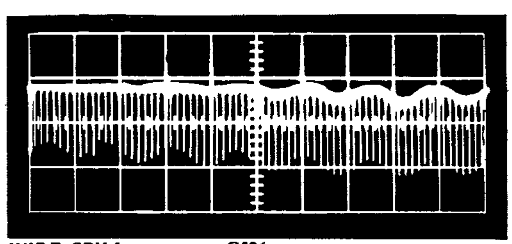


Test point 701
Main sweep calibration 10 μs/cm
Amplitude calibration 0·5 v/cm



Test point 702
Main sweep calibration 20 μs/cm
Amplitude calibration 10 v/cm

Power Measuring Unit—Waveforms



WIRE SPILL C526
Main sweep calibration 5 ms/cm
Amplitude calibration 0·5 v/cm (amplitude varies with setting of RF LEVEL)

Frequency Multiplier Unit—Waveform

Fig. 6. Oscilloscope waveforms C (Reference pulse unit, power measurement and frequency multiplier unit)

TABLE 3

Typical voltages at valve pins

Valve	1	2	3	4	5	6	7	8	9
V101	6·3	0·1	0	72	0	65	−0·4	0	6·3
V102	6·3	18	9	90	0	52	15	18	6·3
V103	14	15	6·3	6·3	40	92	20	—	—
V104	17	18	6·3	6·3	42	90	20	—	—
V105	15	19	6·3	6·3	75	84	13	—	—
V106	16	18	6·3	6·3	46	90	20	—	—
V107	6·3	0	0	75	0	80	0·2	1·3	6·3
V108	71	0	6·3	6·3	71	0	2·5	—	—
V201	6·3	9·4	6·3	87	0	106	0	9·4	6·3
V202	76	11·5	6·3	6·3	100	107	0	—	—
V203	6·3	0	−0·5	50	0	44	−0·5	0	6·3
V204	0	3·8	6·3	6·3	102	106	0	—	—
V205	6·3	9	8	82	0	106	0	9	6·3
V301	300 a.c.	—	6·3	6·3	—	300 a.c.	0	—	—
V302	0	−160	—	−160	0	—	−160	—	—
V303	0	−80	—	−80	0	—	−80	—	—
V304	−2·2	0	6·3	6·3	—	—	0	—	—
V305	—	105	200	6·3	6·3	96	—	—	200
V501	6·3	1·3	0	106	0	106	0	1·4	6·3
V502	0	4·2	6·3	6·3	100	100	4·5	—	—
V503	1·4	−1·3	−2·4	6·3	6·3	0	106	106	0
V504	1·4	−1·2	−1·2	6·3	6·3	0	106	106	0
V505	1·5	−0·05	−0·05	6·3	6·3	0	3·3	3·3	0
V601	6·3	3·3	0	105	0	105	0	3·5	6·3
V602	6·3	13·5	14·5	44	0	105	8	13·5	6·3
V603	6·3	11·5	8	105	0	50	12	11·5	6·3
V604	6·3	0	0·8	45	0	80	0	1·7	6·3
V605	17	17	6·3	6·3	105	65	9·2	—	—
V801 (Type 10166A)	66·5	0·25	6·3	1·35	1·65	6·3	0·05	85	—
V701	0	−0·3	6·3	6·3	0	0	−0·3	—	—
V702	100	−0·3	0·3	6·3	6·3	100	−0·3	0·3	6·3
V703	100	0·14	8·3	6·3	6·3	55·5	0	2·5	6·3
V704	90	0	0·64	6·3	6·3	94	0	0·65	6·3

TABLE 4

Typical resistances to chassis at valve pins

Valve	1	2	3	4	5	6	7	8	9
V101	0	100	500	35K	0	20K	0	0	0
V102	0	2·9K	20K	50K	0	20K	—	3·9K	0
V103	200K	6·3K	0	0	460K	10·6K	50K	—	—
V104	1·2M	6·6K	0	0	460K	10·4K	850K	—	—
V105	2M	6·6K	0	0	800K	10·6K	20K	—	—
V106	1·6M	6·5K	0	0	800K	10·5K	20K	—	—
V107	0	0	2M	20·4K	0	20K	20·5K	700	0
V108	20K	0	0	0	30K	560K		—	—
V201	0	1·5K	80K	12K	0		50K	1·5K	0
V202	45K	2·5K	0	0	30K	26K	10K	—	—
V203	0	0	270K	26K	0	40K	300K	0	0
V204		3·8K	0	0	30K	9K	340K	—	—
V205	0	1·1K		12K	0	20·5K	350K	1·1K	0

TABLE 4 (Contd.)

Typical resistances to chassis at valve pins

Valve	1	2	3	4	5	6	7	8	9
V301	200K	—	0	0	—	200K	0	—	—
V302	0	200K	—	200K	0	—	200K	—	—
V303	0	200K	—	200K	0	—	200K	—	—
V304	100K	0	0	0			0	—	—
V305	—		20K	0	0	100K	—	—	20K
V501	0	300	10·4K	9K	0	9K	0	400	0
V502	10K	550	0	0	9·5K	9·5K	500	—	—
V503	4·2K	2·9K	2·9K	0	0	0	8·6K	8·6K	0
V504	4·2K	15K	15K	0	0	0	8·5K	8·6K	0
V505	4·2K	340	340	0	0	0	4·6K	4·6K	0
V601	0	4·8K	200K	10K	0	10K	200K	4·8K	0
V602	0	2·7K	180K	18K	0	40K	10K	2·7K	0
V603	0	2·7K	7·5K	18K	0	20K	360K	2·7K	0
V604	0	0	85K	20K	0	40K	600K	2·2K	0
V605	3K	3K	0	0	30K	15K	40K	—	—
V801 (Type 10166A)	40K	4·6K	0	1·1K	1·1K	0	200K	20K	—
V701	0	500K	0	0	0	0	500K	—	—
V702	25K	500K	200K	0	0	25K	500K	200K	0
V703	9·5K	140K	1·5K	0	0	55K	500K	2·3K	0
V704	30K	500K	1·2K	0	0	30K	1·7K	1·7K	0

Section 3

TEST SET RADIO 6625–99–970–5393

Chapter 1
GENERAL DESCRIPTION

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LEADING PARTICULARS

Ref. No.	**6625–99–970–5393**
Dimensions	$17\frac{1}{2}$ *in. by* 17 *in. by* 7 *in.*
Weight	43 *lb.*
Power supply	115/180/200*V*, 320–1760 *Hz, single phase.*
Power consumption	120*W at* 115*V* 400 *Hz.*
Construction	*Main chassis framework carrying five miniaturized sub-units.*
Electronic valves	27.
Semi-conductor diodes	26.
Operating channel	*Air-to-air channel* 39 (1126 *MHz test set transmit,* 1063 *MHz test set receive*).
Simulated ranges	0 ± ¼ *nautical mile and* 100 ± 2 *nautical miles.*
Output level (direct)	*−84dBm ± 2dB, this is the r.f. level at the fixed attenuator with the* SET R.F. LEVEL *set to* 30.
Output level (radiate)	*Not less than* −32*dBm.*
Input level (direct)	800*W peak, input to the r.f. coaxial connector/attenuator at the end remote from the test set.*
Input level (radiate)	−5*dBm, this is the level at the* RADIATE *socket which ensures satisfactory triggering of the reply circuits.*
Antenna separation (radiating mode)	*Maximum* 40–50 *ft, minimum* 10 *ft.*
Fuses	*Mains input fused on both line and neutral at 2A,* 240*V winding on transformer in power supply unit fused at* 250*mA.*
Cables	*Two stowed in lid. 3-core mains input cable Ref. No.* *Coaxial connector/attenuator Type Ref. No.*
Antenna	◄ *Ref. No. 5820-99-428-0361* ►

Note . . .

Each test set, radio should be used only with the coaxial connector/attenuator Type Ref. No. bearing the same serial number as the test set. The test sets are calibrated with the particular connector they are issued with. When returned for calibration or repair, the correct connector must accompany the test set.

General

1. The test set, radio 6625–99–970–5393 is complementary to the performance tester Type 10166A in that it provides for testing only the air-to-air ranging function of the TACAN airborne equipment. The performance tester Type 10166A, described in Section 2 of this publication, should be used for testing the navigational functions and transmitter output power of the airborne equipment.

2. The test set is used either with a coaxial cable connector between it and the airborne installation (the direct method), or with the antenna connected to the r.f. output of the test set (the radiating method). With either method the test set has the following three modes of operation:

(1) INTERROGATE; in which the test set transmits an interrogating signal to the airborne equipment and receives a reply after a predetermined delay.

(2) TRANSPOND; in which the test set is interrogated by the airborne equipment and replies with information representing one of two fixed ranges.

(3) SYSTEM TEST; in which the test set combines both the interrogate and transpond functions.

3. If two aircraft interrogate each other as, for instance, during flight refuelling, both aircraft would expect to receive the same range information. However, if different ranges are indicated, the fault could be in either aircraft installation and, in the absence of other information, neither pilot would know which range figure was correct. An important feature of the test set is that, in the SYSTEM TEST mode, observation of the aircraft's instruments alone (during pre-flight testing) is sufficient to establish whether the equipment in the aircraft is operating correctly.

4. In the INTERROGATE mode correct operation of the airborne equipment is shown on the test set by coloured 'accept' or 'reject' indicator lights. In the TRANSPOND mode correct operation is shown by the display of the appropriate range figure on the aircraft's instruments. Note that the test set TRANSPOND function tests the airborne equipment's 'interrogate' function, and the test set INTERROGATE function tests the airborne 'transpond' function.

5. In using the test set it is pre-supposed that the navigational functions of the airborne installation have been tested and found satisfactory. When the test set is used in the 'direct connection' method its signals are preset to a threshold level so that quantitative indications of airborne receiver sensitivity and the air-to-air ranging function can be made. The radiating facility is provided so that a functional check of the air-to-air ranging system can be made without direct connection to the aircraft; this method does not check airborne receiver sensitivity. An operational range of approximately thirty feet is obtainable with the antenna directly connected to the test set. However, the antenna—possiby mounted on a mast—may be connected to the test set via a 50-ohm coaxial cable, but with this method, separation between the antenna and aircraft is reduced to approximately twenty-five feet for reliable operation.

Power supplies

6. The test set requires only one primary power supply of 115/180/200V at 320–1760 Hz and consumes 120W at 115V 400 Hz. The mains input lines are both fused at 2A. Normally 115V 400 Hz will be used because this is a standard aircraft supply which is also required for the ARI.18107. The secondary power supplies required by the units of the test set are +150V, +200V, −150V and 6·3V a.c.; these supplies are derived from a power supply unit in the test set.

External connections

7. Connections to the test set are made by two cables which are stowed in the lid (fig. 1). The power connector is a 3-core cable terminated at one end by a 3-pole socket which mates with the power input plug PL401 on the front panel of the test set; the other end of the cable is left free so that it can be terminated as circumstances require. The r.f. connection to the TACAN airborne equipment is made by a coaxial connector/attenuator Type   , Ref. No.   .

Mechanical characteristics of the test set

8. The test set is contained in an aluminium alloy case $17\frac{1}{2}$ in. wide by 7 in. high by 17 in. deep, the depth including 4 in. for the lid. The test set weighs approximately 43 lb. and its external features, with the lid removed, are shown in fig. 1. The instrument may be fitted with two hinged plates which lie level with the front panel; these plates are to secure the test set to a standard 19 in. test rack if required. The lid is secured by eight captive screws which screw into threaded bushes on the front panel. The two cables and the antenna are stowed in the lid. Around the edge of the lid where it meets the main case is a rubber gasket which prevents the ingress of dust and moisture during storage and carriage.

9. The front panel of the instrument carries all the indicators, controls and connectors required to operate the tester. Also mounted on the front panel are two handles and eight pillars threaded to receive the captive screws on the case lid. All the components mounted on the front panel are sealed to make the test set completely weather-proof. An air valve is fitted on the left-hand side of the case and must be opened when the instrument is being transported by air; this is to prevent internal air pressure breaking the seals round the front panel components.

10. The chassis of the test set can be removed from the case by unscrewing twelve 2 B.A. cheese-head screws which pass through the front panel into threaded holes in the outer case. When the chassis is withdrawn from the case the main framework with the sub-units attached can be seen, a general view of the chassis is shown in fig. 2. Views of the sub-units are shown with the relevant text in Chapter 2 of this section.

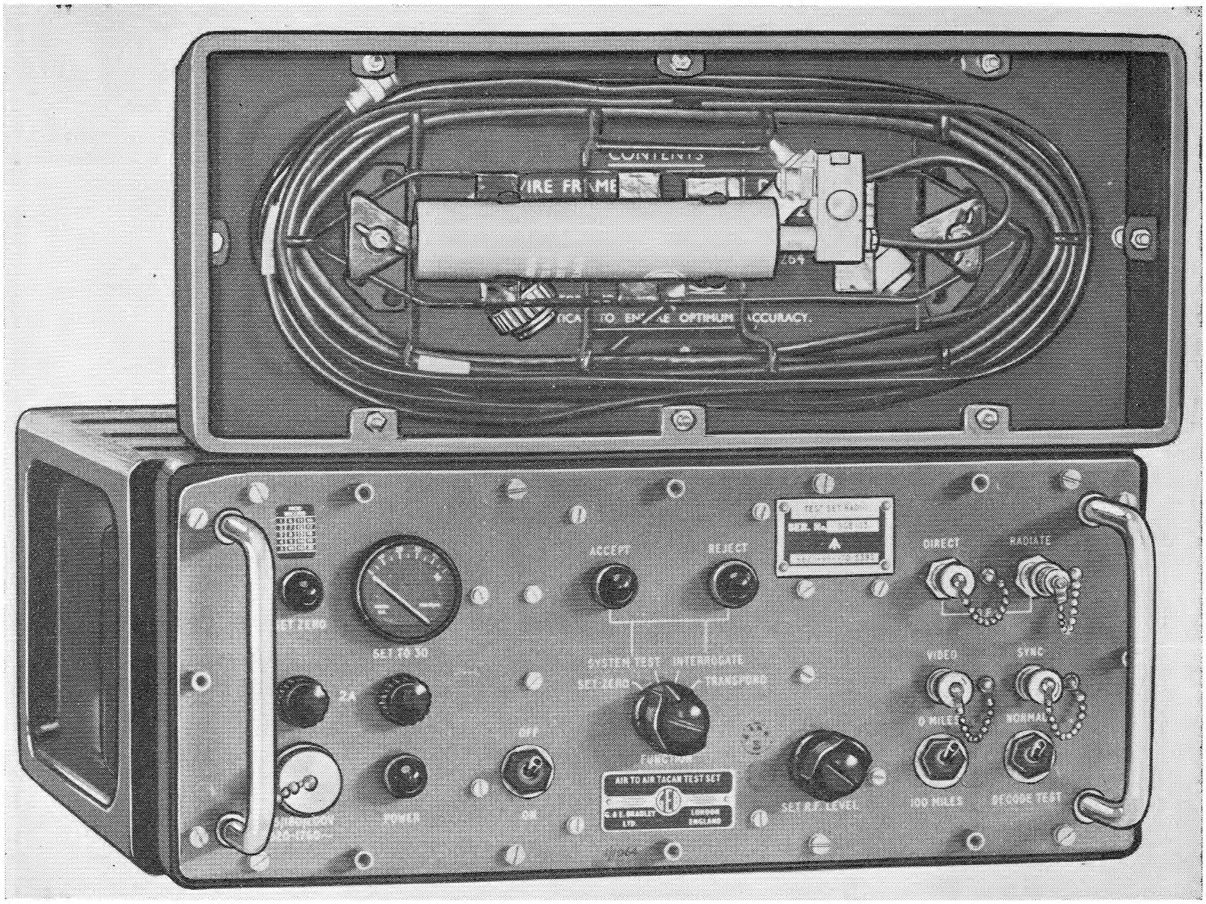

Fig. 1. General view of test set

11. The chassis is composed of six parts, as follows:—

(1) Front panel and the framework which carries the coaxial system and the inter-connecting terminal board.

(2) Transponder unit.

(3) Frequency multiplier unit.

(4) Power measurement unit.

(5) Interrogator unit.

(6) Power supply unit.

All connections to the sub-units named in sub-para. (2) to (6) above are made by miniaturized plugs and sockets. The whole test set contains twenty-seven electronic valves and twenty-six diodes; details of the valve complement of the test set are given in Chapter 4 of this section.

FUNCTIONAL DESCRIPTION

12. The test set has three modes of operation controlled by the FUNCTION switch. When the FUNCTION switch is set to INTERROGATE, the test set generates an r.f. signal modulated with interrogating pulse pairs. This signal is transmitted to the airborne equipment; the received reply signal is modulated with single pulses which, if delayed for the correct interval, cause an ACCEPT lamp to light.

13. When the FUNCTION switch is set to TRANSPOND, the test set is interrogated by pulse pairs from the airborne equipment and generates a single-reply pulse for each interrogating pulse pair received. A range switch selects one of two fixed delays to give a simulated range of either 0 or 100 miles.

14. When the FUNCTION switch is set to SYSTEM TEST, the interrogate and transpond functions operate simultaneously. An interlock circuit ensures that the test set will transpond only when a correct reply to its own interrogation signal is received. A fourth position of the FUNCTION switch, SET ZERO, is included so that the output power level metering circuit can be set up with no signal present at its input.

FUNCTION **switch set to** INTERROGATE (fig. 4)

15. When the FUNCTION switch is set to INTERROGATE, a generator in the interrogator unit produces pulses at a rate of approximately 125 per second. These pulses trigger an encoder circuit in the transponder unit and a delayed gate pulse generator in the interrogator unit. The encoder circuit gives two output pulses, separated by 12μs for every input pulse. When the NORMAL/DECODE TEST switch is set to DECODE TEST, the encoder produces only a single pulse for each input pulse; this test checks that the airborne equipment is not spuriously transponding to single interrogation pulses.

16. The encoder output is applied to a 4μs waveform generator circuit which gives an output pulse of known amplitude and duration for each input pulse. The waveform generator output is applied, via a driver amplifier and cathode follower, across the SET RF LEVEL potentiometer; the signal at the slider of this potentiometer is fed through a shaping network to modulate the three final stages of the frequency multiplier unit. The SET RF LEVEL potentiometer is adjusted so that the output power of the test set signal is at a threshold level, thus checking the sensitivity of the airborne receiver (DIRECT output only).

17. The frequency multiplier unit comprises a crystal controlled Butler oscillator operating at 31·277 Mc/s, two frequency tripler stages and two amplifier stages. The modulated r.f. output signal (281·5 Mc/s) from the frequency multiplier unit is applied to the harmonic multiplier and power divider circuit in the r.f. coaxial system. The harmonic multiplier output has a d.c. component and components at all harmonics of the input frequency. The fourth harmonic, i.e. 1126 Mc/s, is selected and applied via an isolating network to the RADIATE socket. Another signal path from the isolating network passes through an attenuator to the DIRECT socket.

18. The d.c. component of the harmonic multiplier output (uni-directional pulses) is applied to the power measurement unit. This comprises an amplifier, a cathode follower, and a peak-reading voltmeter circuit which feeds the meter (SET TO 30) on the front panel. The meter indication is related to the power output at 1126 Mc/s.

19. If the airborne equipment is operating correctly a single reply pulse will be generated for each pulse pair received from the test set. These reply pulses have a fixed time delay with respect to the interrogating pulses. The reply pulses are received either at the DIRECT socket, via the cable, or at the RADIATE socket, via the dipole aerial. The reply signal is demodulated by a detector diode in the coaxial system, which is common to both inputs. Owing to the alternative methods of using the test set (DIRECT or RADIATE), the voltage level of the reply pulses may vary by ten to one. In general, the pulses received via the antenna have the

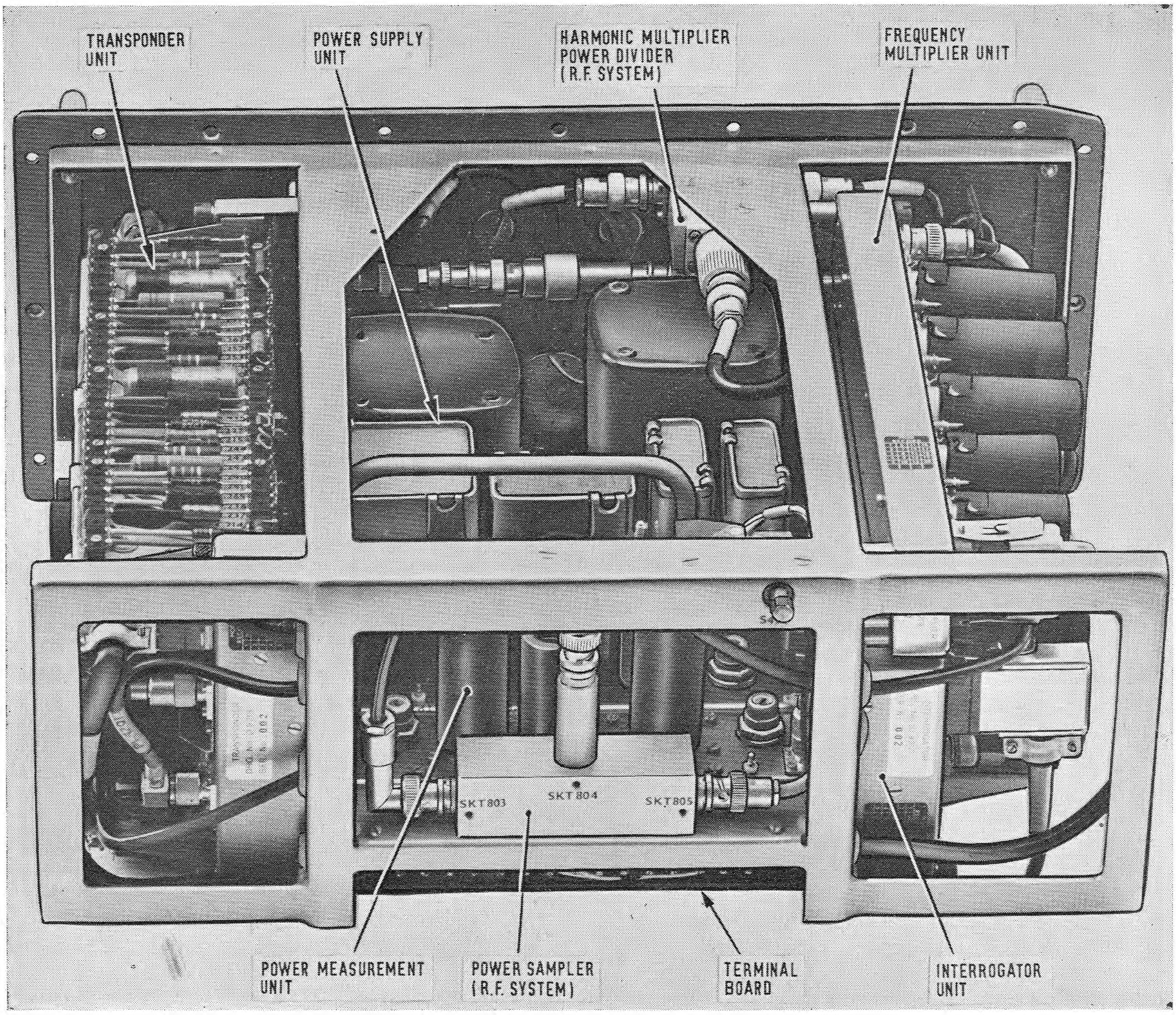

Fig. 2. Internal view of test set

greatest range of amplitude, the pulses received by direct connection being reasonably constant in amplitude. The first three stages of the transponder unit amplify and limit the incoming pulses so that the following circuits (coincidence gate in the INTERROGATE mode or decoder in the TRANSPOND mode) always receive pulses of constant amplitude, regardless of their source.

20. The output from the limiter is applied to a coincidence ('AND') gate in the interrogator unit. Pulses from the p.r.f. generator are also applied (via the 62μs delay and gate pulse generator) to the gate, which produces an output only when both inputs are coincident, i.e. when the reply pulses from the airborne equipment are coincident with the delayed pulses from the test set.

21. The output from the coincidence gate is applied to a reply rate voltage converter circuit whose output is proportional to the rate at which input pulses are received. The converter output is common to the bias circuit of the relay control valve, in whose anode circuit is the 'accept reject' relay RLB. The bias circuit is connected so that the voltage due to the converter output acts in opposition to that derived from the negative supply. The relay control valve is normally cut off, but when the rate of converter input pulses exceeds a predetermined value, the relay valve bias is backed off and the valve conducts, thus energizing the relay. The relay is physically located in the transponder unit because one of its contacts is used to inhibit the transpond function in certain circumstances. The relay control valve bias is adjusted so that the 'accept reject' relay operates when the number of received pulses that are coincident with the gate pulse exceeds 70% of the transmitted pulse pairs. The operation of the relay switches the REJECT lamp off, and the ACCEPT lamp on.

FUNCTION **switch set to** TRANSPOND (fig. 5)

22. When the FUNCTION switch is set to TRANSPOND, interrogating pulse pairs are received at one of the two input sockets and detected in the r.f. coaxial system, as described in para. 19.

23. The detected pulses are applied to the transponder unit where they are amplified and limited as described in para. 19. The limited output is then taken to a pulse pair decoder circuit, which gives a single output pulse for each pulse pair received, but only if the received pair is correctly spaced. The output from the decoder circuit is applied to a delay-pulse generator, which is switched on when the FUNCTION switch is set to TRANSPOND. The output pulses from the delay generator have a duration which simulates a distance of either 0 or 100 miles (depending upon the setting of the range switch) between the test set and the airborne equipment. The delay generator output modulates the r.f. output of the frequency multiplier unit, via the pulse generator, driver and cathode follower circuits, as described in para. 17. The modulated r.f. signal is then applied to the r.f. coaxial system and transmitted to the airborne equipment via the DIRECT or RADIATE output socket.

FUNCTION **switch set to** SYSTEM TEST

24. When the FUNCTION switch is set to SYSTEM TEST, both the interrogate and transpond functions, as described in the foregoing paragraphs, are performed simultaneously. The interrogation pulses are generated as described in para. 15 to 21 and the 'accept reject' relay RLB in the transponder unit is energized only if sufficient correct reply pulses are received. Contacts of relay RLB apply the output from the delay generator in the transponder unit to the subsequent stage (pulse generator) when the relay is energized. Thus the relay acts as an interlock device which prevents the test set from transponding until it has received correct replies to its own interrogations.

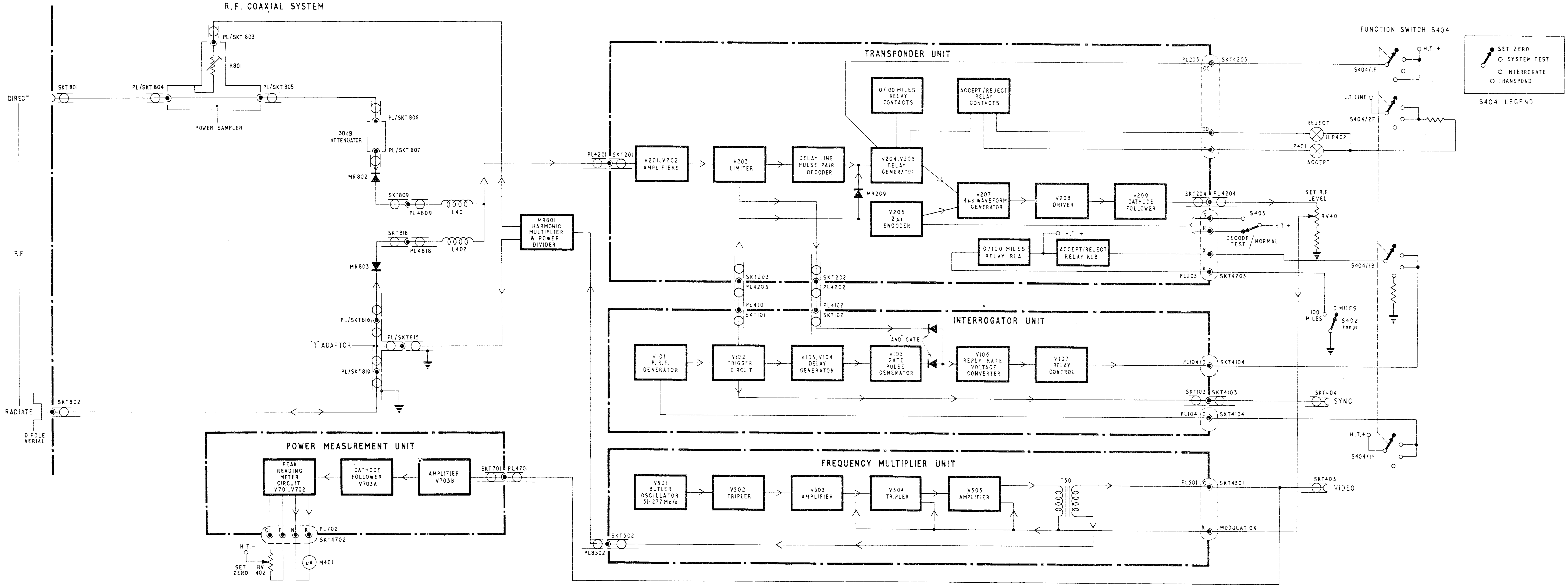

Fig. 3

Test set radio 6625-99-970-5393: block diagram

Fig. 3

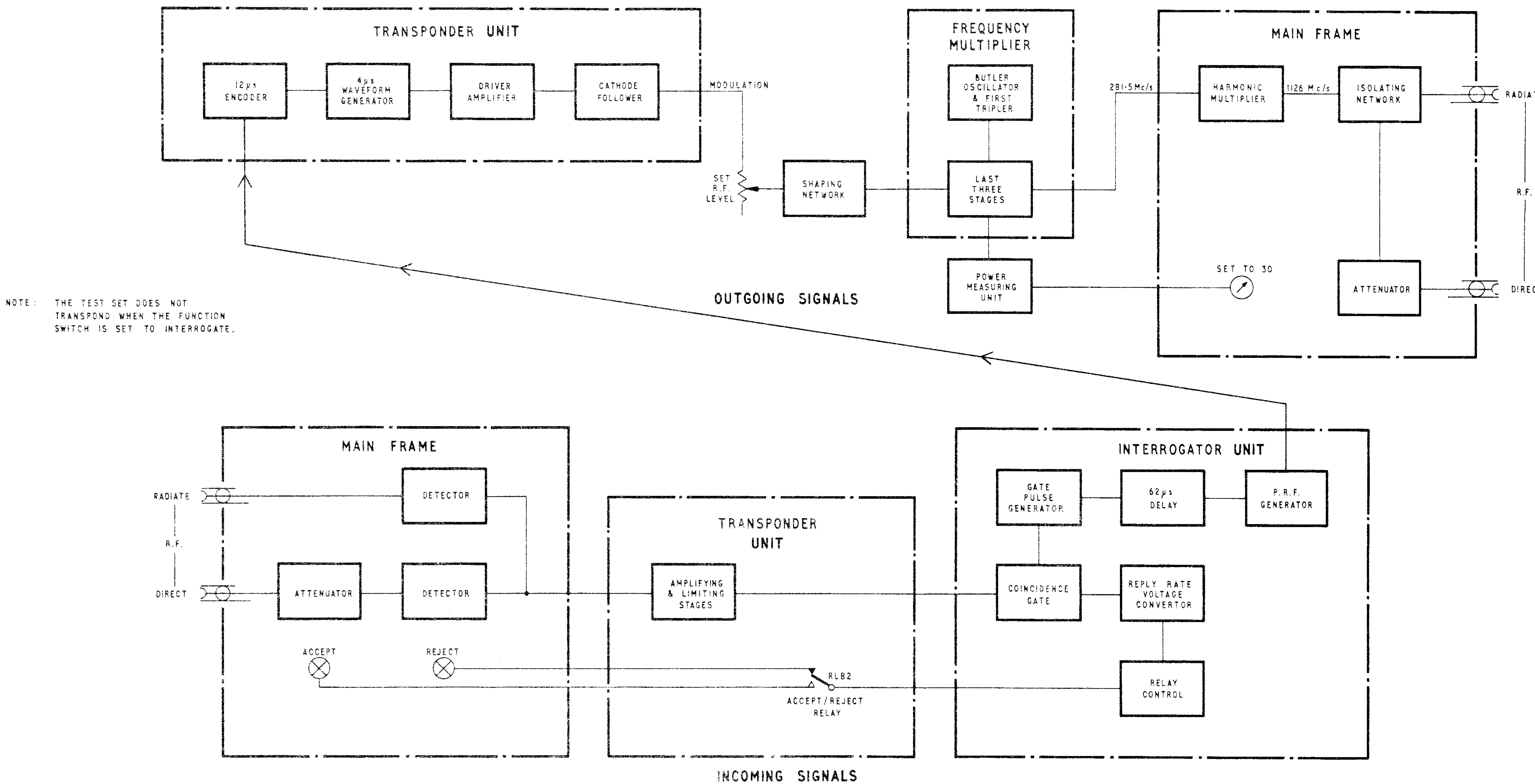

Fig. 4 Test set radio 6625-99-970-5393: function switch at INTERROGATE Fig. 4

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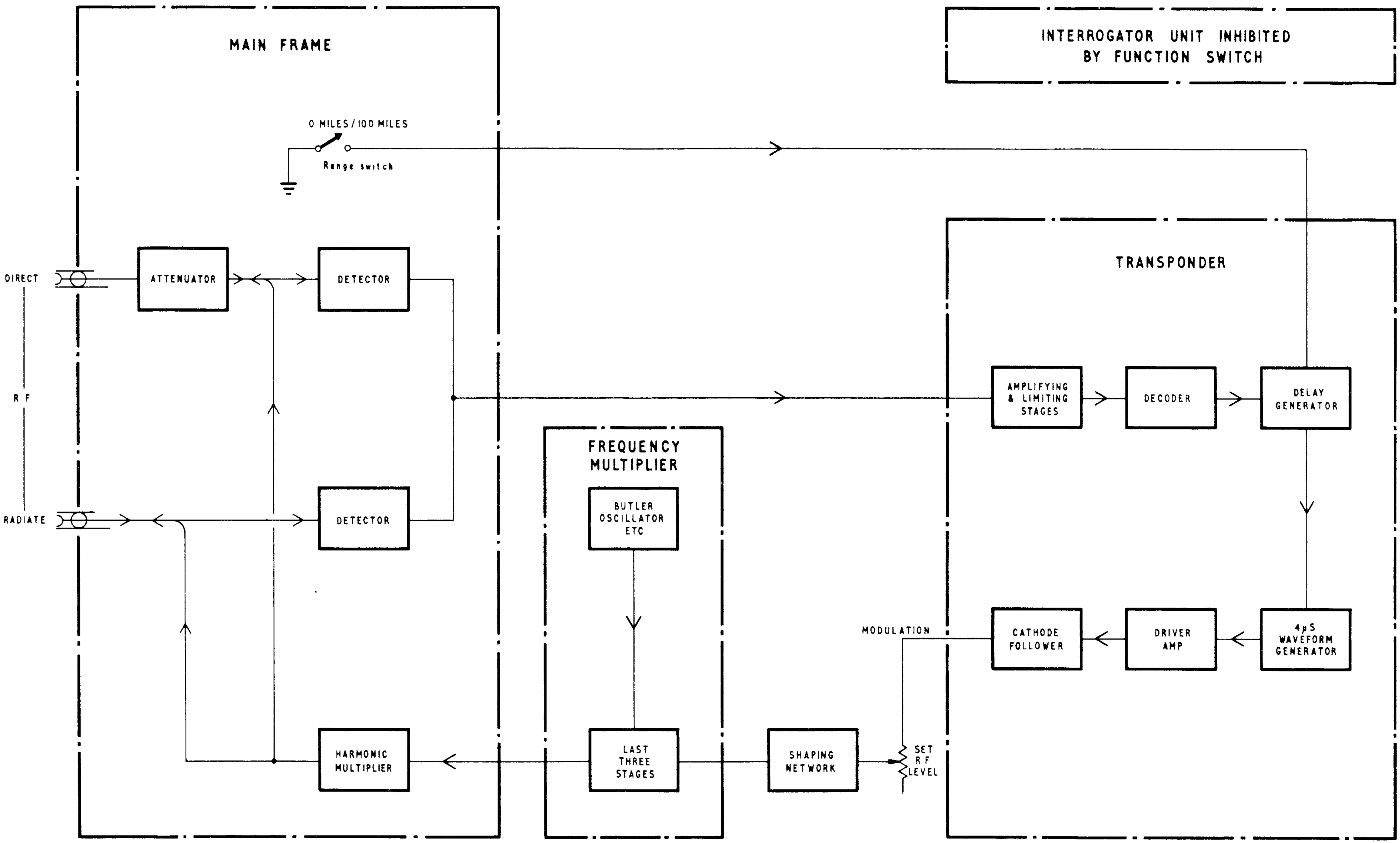

Fig. 5 Test set radio 6625-99-970-5393: function switch at TRANSPOND Fig. 5

86617 579843 865-P P LTD 9502

Chapter 2

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Power supply unit: circuit	20
Chassis assembly: circuit	21

General

1. The circuit of the test set, radio 6625-99-970-5393 comprises seven sub-units. The main chassis forms one unit, which includes the front panel; the components are numbered from 401–499. The components of the r.f. system are numbered from 801–899. The other five units are mounted on sub-chassis, and are referred to as follows:—

(1) Interrogator unit (components numbered 101–199)

(2) Transponder unit (components numbered 201–299)

(3) Power supply unit (components numbered 301–399)

(4) Frequency multiplier unit (components numbered 501–599)

(5) Power measurement unit (components numbered 701–799)

A functional description of the test set together with block diagrams fig. 3, 4 and 5, are given in Chap. 1 of this section.

R.F. COAXIAL SYSTEM

2. The r.f. coaxial system (fig. 1) performs the following functions:—

(1) It accepts the 281·5 MHz modulated r.f. output from the frequency multiplier unit, selects the fourth harmonic of this signal (harmonic multiplier) and transmits at 1126 MHz from either the DIRECT socket, at an accurately controlled level, or from the RADIATE socket, via the antenna.

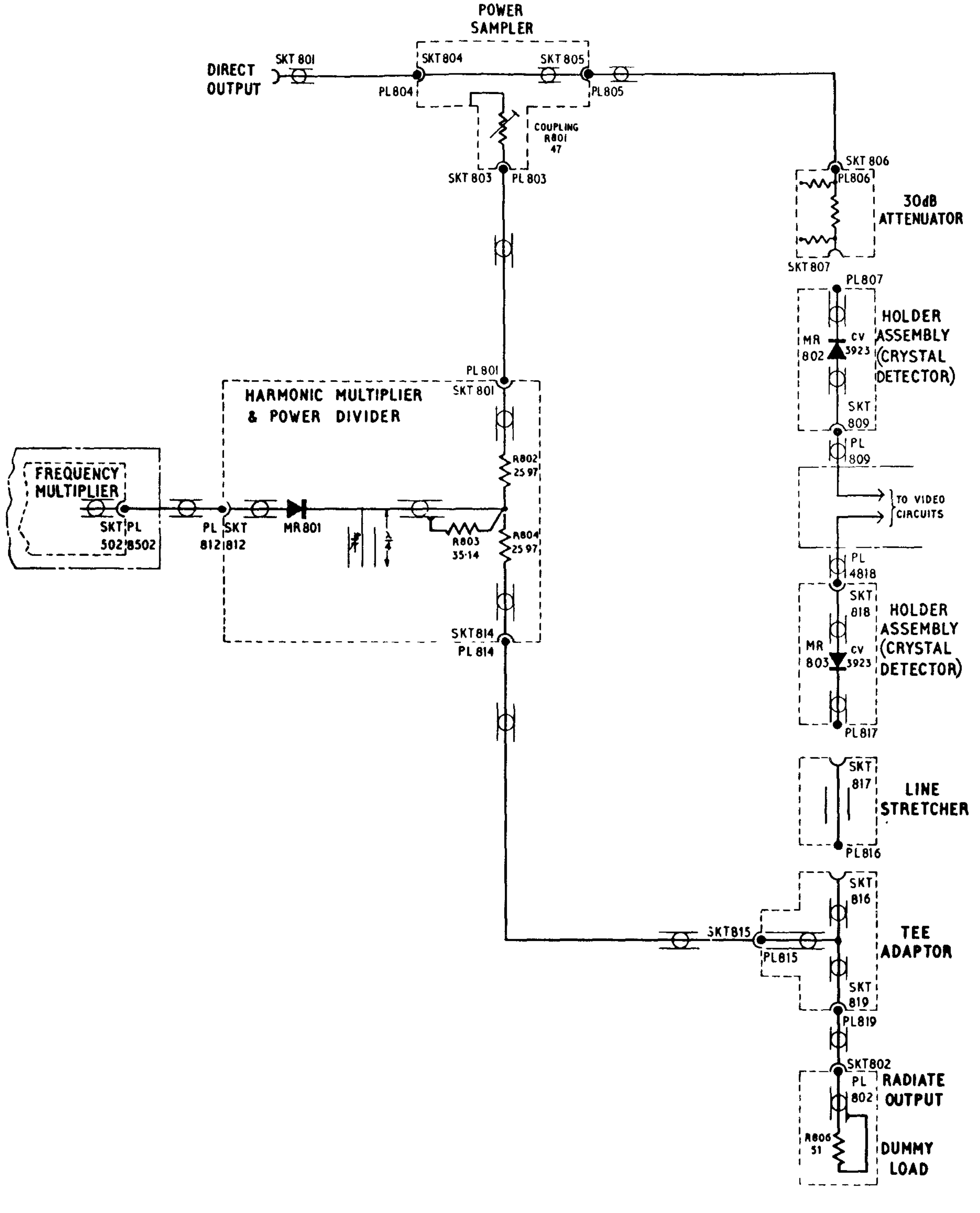

Fig. 1. R.F. co-axial system

(2) It accepts an input from the airborne equipment, at either the DIRECT or the RADIATE socket, detects the incoming signal and applies the detected pulses to the transponder unit.

Outgoing signals

3. The output from the frequency multiplier unit at SKT502 consists of pulse-modulated r.f. signals at 281·5 MHz. This output is applied via socket SKT812 to the harmonic multiplier and power divider network. Since MR801 is non-linear its output is rich in harmonics. The main line is tapped into an open-circuit quarter-wave stub; the stub is approximately a quarter-wavelength long at 1126 MHz (four times the input frequency applied to the diode) and is exactly tuned to this frequency by a capacitive trimmer at the open-circuit end. The stub forms part of the harmonic multiplier assembly. The line is resonant at 1126 MHz and presents a near short-circuit at other frequencies so that outputs are obtained only at 1126 MHz. R802, R803 and R804 form an isolating pad from which two outputs are taken, each at a power level of approximately 25dBm.

4. The output from the isolator pad at SKT814 is applied to the RADIATE output socket SKT802 via a T-adaptor. The radiating antenna is normally connected to the RADIATE socket; however, when using the direct connection method the socket must be terminated with the dummy load R806 to maintain the low level (DIRECT) output power accuracy The other connection from the T-adaptor is taken to a diode detector via a length of coaxial line, the length of which is adjusted to minimize the v.s.w.r. on the main line.

5. ◄ The output from the isolator pad at SKT811 is taken to the variable arm of the power sampler (used here as a form of adjustable, directive, attenuator). The variable arm has a built-in polyiron attenuator, which in conjunction with R801 (the launching loop) provide a reasonable match to the output of the Harmonic multiplier. Altering the angular position of the launch loop (R801), varies the coupling into the main arm, thus providing a means of pre-setting the absolute r.f. output level. The output of the main arm at SKT804 is fed to the front panel DIRECT OUTPUT (SKT801). During calibration of the equipment, the r.f. level is adjusted to -59dBm nominal at SKT801.►

6. ◄The cable used to connect the DIRECT socket to the airborne equipment has a known attenuation of approximately 25dB and the position of R801 is adjusted to give a signal level at the input to the airborne equipment of --84dBm 2dB, this being the necessary level to test the threshold sensitivity of the airborne equipment ►

7. ◄ The power sampler is a reciprocal device, hence incoming signals are fed to the harmonic multiplier power divider. However, since the harmonic multiplier is tuned to a frequency 63MHz removed from the incoming signal, these are not detected by the multiplier crystal and hence do not interfere with the normal operation of the outgoing signal level monitoring circuits.►

Incoming signals

8. Incoming signals may arrive at the test set either via the antenna and the RADIATE socket SKT802 or via the cable/attenuator and the DIRECT socket SKT801. The input is a modulated r.f. signal at 1063 MHz, and having a power level of not less than + 5dBm if it is a radiated signal, or approximately + 35dBm if it is a direct-connection signal.

9. Signals from the RADIATE socket pass through a coaxial line to a T-adaptor. A portion of the signal is detected by the diode MR803 and applied to the transponder unit via SKT818 and two ferrite filter beads (L402 shown on fig. 21)

10. ◄Signals from the DIRECT socket are coupled to the DIRECT crystal detector with a loss of 30dB. The signals are detected by diode MR802 and applied to the transponder unit via SKT809 and the ferrite filter beads L401. The ferrite beads L401 and L402 remove the residual r.f. signal from the detector output.►

TRANSPONDER UNIT

11. The transponder unit is chassis mounted and is situated at the upper right-hand side of the main framework. Component location is given in fig. 2, 3, 4, and 5 and the circuit in fig. 16. All detected incoming signals from the r.f. coaxial system are applied to SKT201 on the transponder unit. Incoming pulses at this point may be either interrogation pulse pairs, generated in the airborne equipment, or single pulse replies to test set interrogations, generated by the transponder in the airborne equipment. This incoming signal may be inspected at test point TP201.

12. The operation of the transponder unit is controlled by the FUNCTION switch S404 on the front panel. When the FUNCTION switch is set to TRANSPOND, detected interrogation signals from the r.f. coaxial system are applied to the transponder unit at SKT201. After amplification and limiting, the pulses are applied to a decoder which produces an output pulse only if the incoming pair is correctly spaced. The decoder output triggers a delay generator whose output occurs after a time (set by the range switch) which represents either 0 or 100 nautical miles. The delay output is further processed and then fed as modulation to the frequency multiplier unit.

13. When the FUNCTION switch is set to INTERROGATE, the 12μs encoder generates a pulse pair for each trigger pulse (at SKT203) from the p.r.f generator in the interrogator unit. Operation of the DECODE TEST switch S403 causes the circuit to generate a single pulse instead of a pulse pair and thus checks that the airborne equipment is not spuriously transponding to single interrogation pulses. The p.r.f. generator signal at SKT203 is also used as a blanking pulse to prevent the inadvertent decoding of outgoing interrogation signals

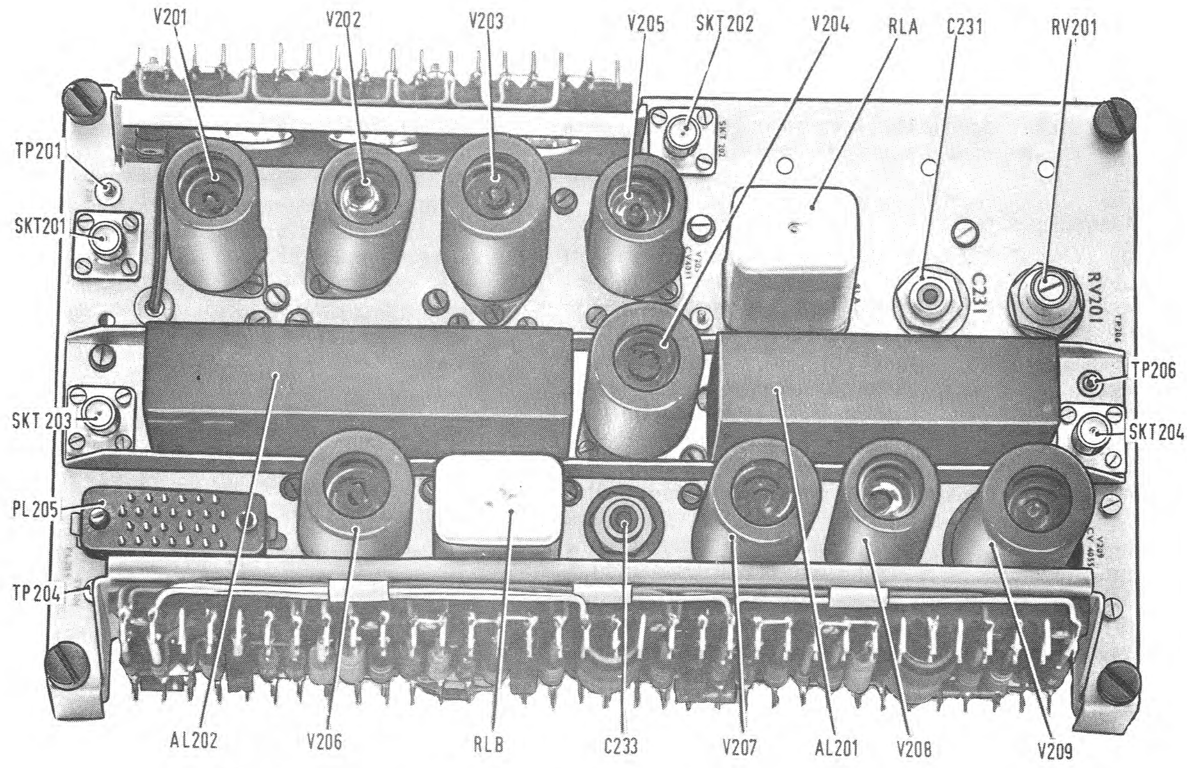

Fig. 2 Transponder unit : component location (top)

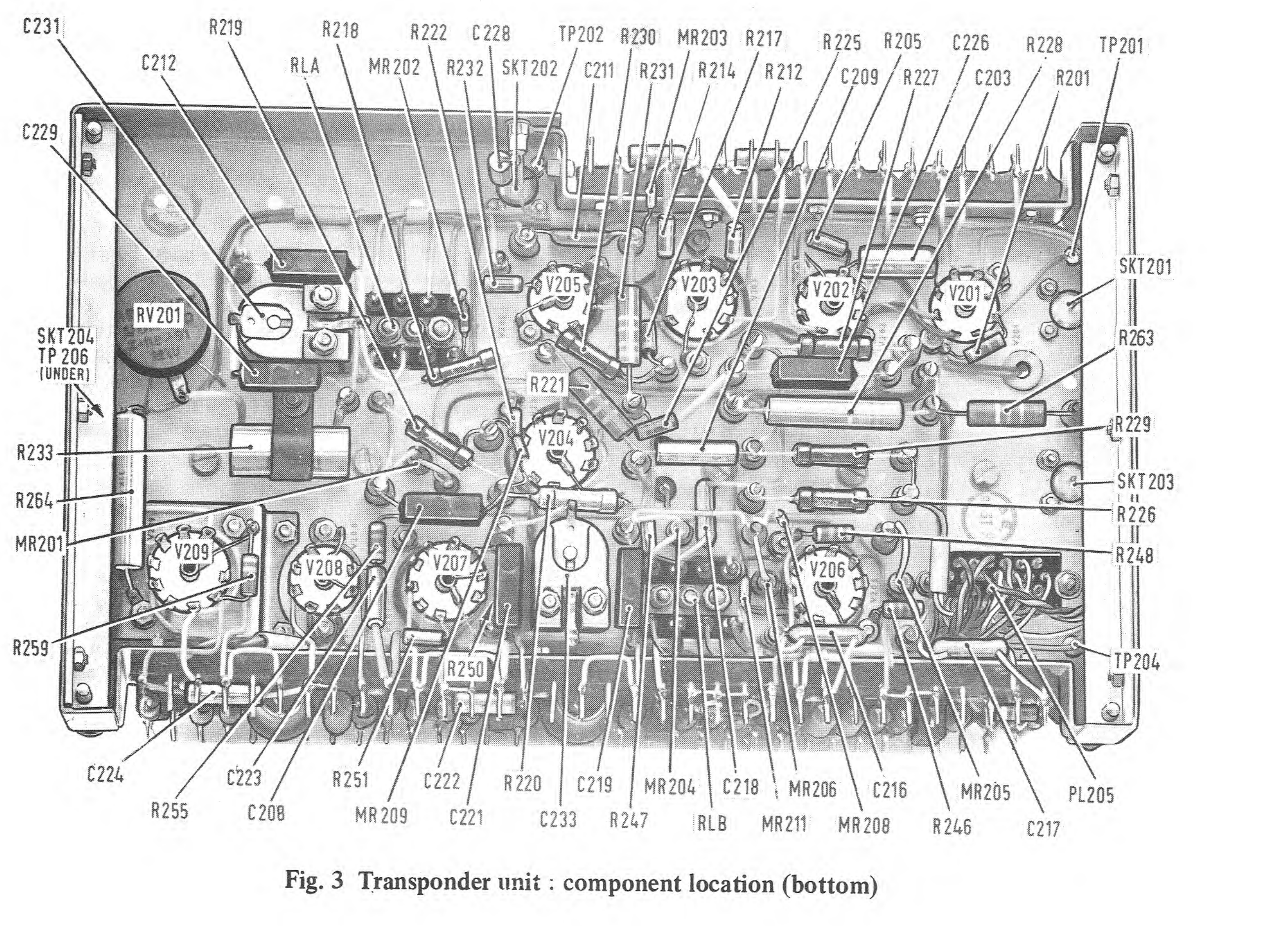

Fig. 3 Transponder unit : component location (bottom)

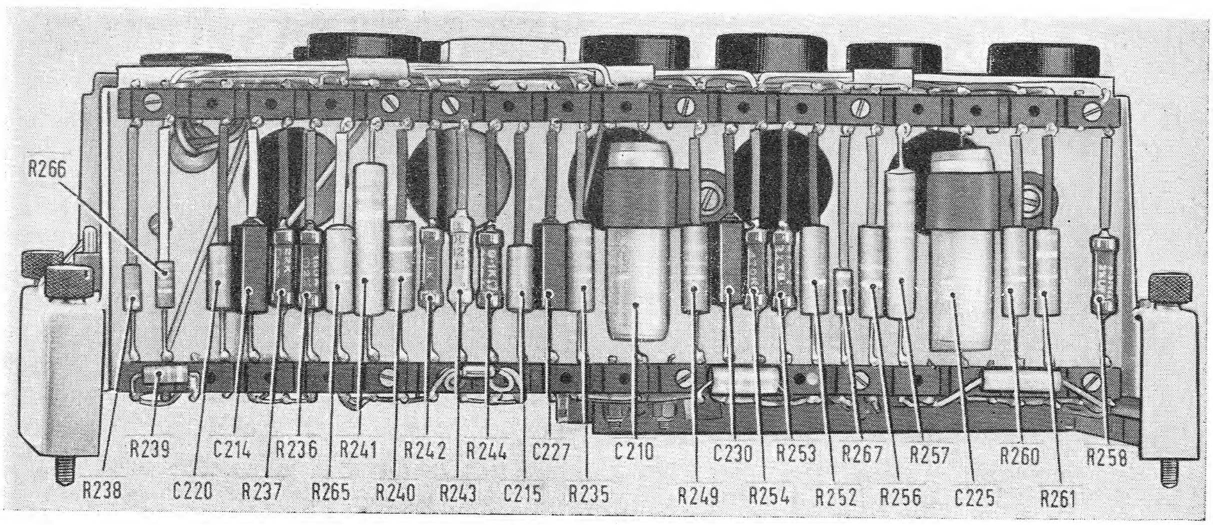

Fig. 4. Transponder unit: component location (left hand side)

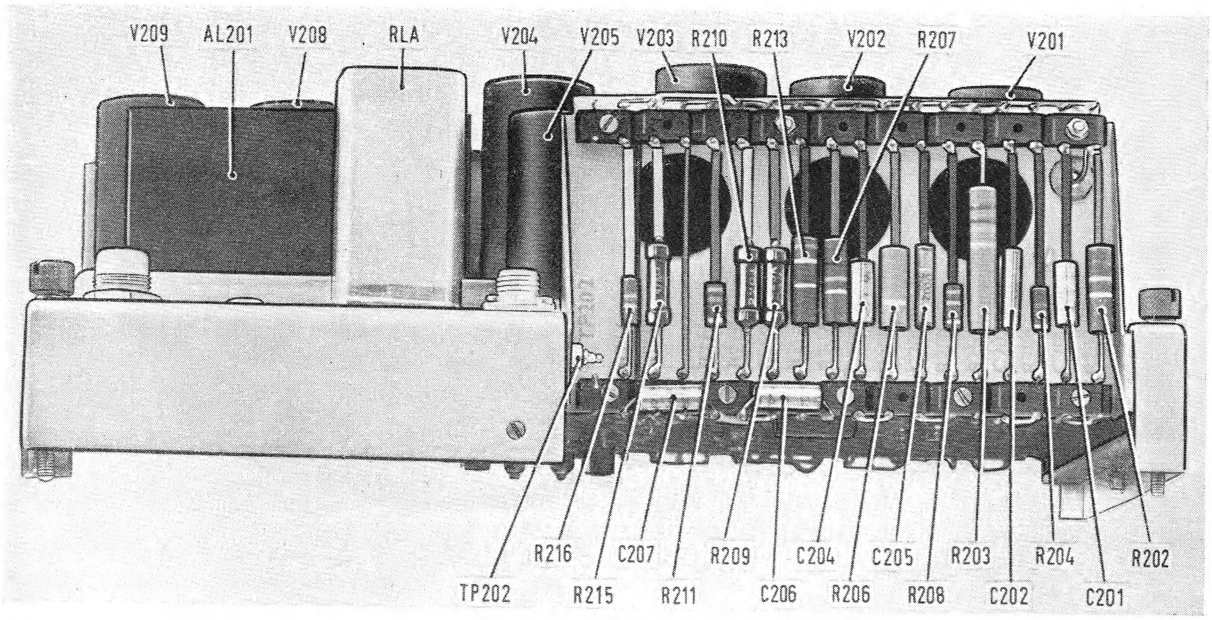

Fig. 5. Transponder unit: component location (right hand side)

14. In the SYSTEM TEST position of the FUNCTION switch, the test set transponds and interrogates the airborne equipment simultaneously. An interlock relay in the transponder unit prevents the generation of reply pulses until correct replies to the test set interrogations are received.

Amplifier and limiter stages

15. The negative-going pulses at SKT201 are applied to the first of two amplifier stages V201 and V202. The output at the anode of V202 is applied, via C206, to a limiter stage V203. V203A is normally conducting, but the gain of V201 and V202 is sufficient to drive it beyond cut-off when an incoming pulse is present. When a pulse is applied to the grid of V203A, the resulting positive-going pulse is applied to the grid of V203B via C207. V203B is normally cut off, but the positive-going pulse, together with the fall in cathode potential due to the cutting-off of V203A, ensures that V203B is driven to saturation. The two amplifier stages and the limiter ensure that the output pulses from the limiter are constant in amplitude.

16. Two outputs are taken from the limiter circuit; one from the anode of V203A is taken via C228 to SKT202; the other output, from the anode of V203B, is applied via an open-circuited delay line AL201 to the pulse pair decoder.

Pulse pair decoder

17. The function of the pulse pair decoder is to ensure that only correctly spaced incoming pulse pairs will pass to the next stage, i.e. single pulses or incorrectly spaced pairs will not trigger the next stage (delay generator).

18. The output from the anode of V203B is applied, via R217, to the open-circuited delay line AL201. The first pulse of a correctly spaced pair ($12\mu s$) to reach the delay line travels along it and, since the line is open-circuited, is reflected back. The reflected pulse arrives at the delay line input terminals at the same time as the second pulse of the pair and forms a pedestal on which the second pulse is based. The amplitude of the combined pulse is sufficient to overcome the bias on MR201 and a single pulse is passed on to the delay generator circuit. The bias voltage on MR201 is present only when the FUNCTION switch is set to TRANSPOND or SYSTEM TEST. In the other positions of this switch, no output is obtained from the decoder as wafer S404/1F (fig. 21) disconnects the h.t. from R218 via PL205/CC.

Delay generator

19. The delay generator comprises V204, V205 and the associated circuit. The circuit operates only when the FUNCTION switch is set to TRANSPOND or SYSTEM TEST. In these positions S404/1F applies h.t. via PL205/CC to the anode of V204B.

20. With the h.t. applied but with no input to V204B, the initial conditions are as follows. V204B is conducting owing to the grid potential set by the divider chain R218, R219 and R220. V204 cathode potential is approximately 5V above earth potential and slightly more positive than the grid of V204B. The anode of V205 is cut off because its suppressor is biased negatively from R229/R230. V205 screen is conducting, the screen potential being approximately +20V. The grid voltage of V204A is approximately −10V owing to the potential divider R227/R226; V204A is therefore cut off.

21. The delay generator is normally triggered by the decoded interrogation pulses from the airborne equipment. The delay generator might also be triggered (in the SYSTEM TEST mode) by stray pick-up of the test set's interrogation pulses. This is prevented by taking the positive-going p.r.f. generator pulses from SKT203, integrating them in R266/C227 and applying them through the diode MR209 to V204B. Thus, spurious pulses from the decoder are cancelled by the p.r.f. generator pulses from which they were derived. MR209 is reverse-biased and isolates C227 from V204B while genuine trigger pulses are present.

22. When a negative-going pulse from the decoder is applied via C208 to the grid of V204B, its anode potential rises. The rise in potential is fed through C209 to the suppressor of V205, resulting in the flow of anode current in V205. This causes V205 anode potential to fall and the fall is coupled back to its control grid; screen current is reduced and therefore the screen potential rises. The rise is fed back to the grid of V204A. V204A commences to conduct, thus cutting off V204B through the common cathode resistor R222. The anode potential of V205 runs down until it 'bottoms', forcing the screen current to rise. The rising screen current causes a fall in screen potential and the fall is coupled back to the grid of V204A. This reduces V204 cathode potential and enables V204B to conduct again. V204B anode potential falls, thereby cutting off V205 suppressor and, hence, V205 anode current.

23. With the range switch S402 set to 100 MILES the earth line to relay RLA is completed and contact RLA2 makes. The time taken by the linear run-down of V205 anode is then determined by the constant discharge current of C211 through R233, and is adjusted by RV201. When the range switch is set to 0 MILES relay RLA is not energized as the earth line is interrupted by S402. Contact RLA2 is then in the open position, thus C231, C212 and C229 in parallel are in series with C211, and the discharge time is therefore decreased. V204B is held cut off during run-down so that any further trigger pulses at V204B grid have no effect.

24. At the end of the action, the timing capacitors recharge through R231 to the 200V h.t. line. However, the diode MR203 prevents V205 anode from rising above 105V. This arrangement improves the recovery time of the circuit.

25. The screen voltage of V205 rises during the switch-on action when the valve is triggered, remains high during the run-down and falls during the switch-off action at the end of the run-down. This voltage waveform is differentiated by C218 and R247 and taken as an output. It consists of a positive-going pulse coincident with the trigger pulse followed, after a delay of either 50μs (0 MILES) or 1286μs (100 MILES), by a negative-going pulse.

26. The delay generator output is used when RLB is energized, and earthed by contact RLB1 when RLB is de-energized. The relay is controlled by the relay control valve in the interrogator unit (para. 63). Briefly, RLB is:—

(1) Not energized when the FUNCTION switch is set to SET ZERO

(2) Energized when the FUNCTION switch is set to TRANSPOND.

(3) Subject to the reply rate voltage converter in the interrogator unit (para. 62) when the FUNCTION switch is set to INTERROGATE or SYSTEM TEST.

Correct functioning of the delay generator can be verified by examining the waveform at test point TP203. Contact RLB2 switches on either the REJECT or ACCEPT indicator lamp.

12μs encoder

27. The 12μs encoder V206 is a cathode-coupled monostable circuit with delay line coupling. Its function is to provide two output pulses, having the correct time spacing, for each single pulse applied to it from the p.r.f. generator in the interrogator unit. The p.r.f. generator output frequency is 125 p.p.s. and the pulse width is approximately 20μs; the pulses are applied to the encoder circuit via SKT203, and may be examined at test point TP204.

28. In the stable state V206A is cut off and V206B is conducting; the current being determined by the voltage at V206B grid and the cathode resistor. Positive-going incoming pulses at SKT203 are differentiated by C214/R237 and applied to the grid of V206A. The leading edge causes V206A to conduct and the resulting fall at the anode of V206A is fed to V206B by the 12μs delay line AL202. This reduces the current flow through V206B which, because of the cathode coupling, increases the current flow through V206A. The cumulative actions continues until V206A is fully conducting and V205B is cut off. This state exists until, after 12μs, the delay line coupling is effectively removed and V206B again conducts.

29. The waveform at V206A consists of a negative step, followed at 12μs intervals by a series of positive steps as the delay line recharges. The waveform at V206B is a rectangular positive-going pulse having a duration of 12μs. Output pulses from both anodes are differentiated by C216/R245 or C217/R246. The diodes MR205 and MR206 pass only the negative-going pulses, so the input to the next stage (pulse generator) consists of a negative-going pulse from MR205 followed, after an interval of 12μs, by a similar negative-going pulse from MR206.

30. The anode of V206B is connected to the 105V line via the load resistor R241, PL205/R and the DECODE TEST/NORMAL switch S403 when it is in the NORMAL position (fig. 21). When S403 is set to DECODE TEST the h.t. is applied via PL205/S to R265, thus V206B is switched off. As V206A is biased as an inverter only a single pulse is obtained from the encoder. This gives a quick check ensuring that the airborne equipment is not transponding to single interrogation pulses.

4μs waveform generator

31. The 4μs waveform generator V207 accepts input pulses from either of two sources, the 12μs encoder or the delay generator. Diodes MR204, MR205 and MR206 form an 'or' gate for negative-going pulses such that any one input will trigger the pulse generator, which gives an output pulse for each input pulse received.

32. The 4μs waveform generator is a monostable circuit. In the stable state, V207A is conducting and V207B is held cut off by the potential divider R253/R254 connected to the −150V line via R254.

33. When a negative-going input pulse is applied, via C219, to the grid of V207A, the valve changes over so that V207A is cut off and V207B is conducting. In this state, a positive potential exists at the cathode of V207B, and C233 (in parallel with C221) discharges through R250 until, after approximately 4μs, the cut-off point is reached and V207 reverts to its stable state.

34. The positive potential at the cathode of V207B is approximately equal to the negative drop at the grid of V207A, and this equivalence is substantially independent of valve characteristics and h.t. potential. Thus the 'on' time of V207B is not appreciably affected by h.t. variations and valve ageing or replacement; however, small adjustments may be made by use of the trimmer capacitor C233.

Driver amplifier and cathode follower

35. The negative-going pulses from the 4μs waveform generator are applied through C223 to an amplifier stage V208. This is followed by a cathode-follower stage V209 whose output is connected to SKT204 (MODULATION). The cathode follower is negatively biased to reduce the standing current and also the residual r.f. c.w. output.

36. The outgoing pulses at SKT204 are used to modulate the frequency multiplier unit. The 4μs pulses are arranged either:—

(1) In pairs, spaced 12μs apart, derived from the p.r.f. generator (interrogation pulses), or

(2) as single pulses derived from the decoder and delay generator (reply pulses).

FREQUENCY MULTIPLIER UNIT

37. The frequency multiplier is a chassis mounted unit and is the upper unit of the two mounted on the left-hand side of the main framework. The function of the unit is to generate an r.f. output of 281·5 Mc/s which is pulsed and modulated by the video signal from the transponder unit. The unit carries five valves all of which are accessible. Connection is made to other units of the tester by two connectors as follows:—

(1) PL501, a 14-pole plug, which accepts the h.t. and l.t. supplies and the modulated video signal (poles N and K); it also carries the d.c. to the meter mounted on the front panel so that the output level can be checked.

(2) SKT502, a coaxial socket, which carries the output signal.

Component location is shown on fig. 6 and 7, and the circuit diagram on fig. 17.

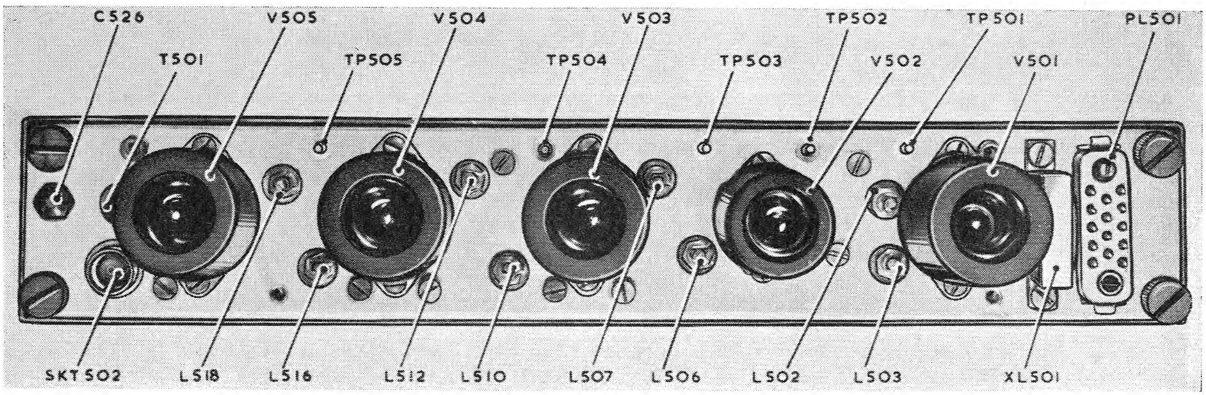

Fig. 6. Frequency multiplier unit: component location (top)

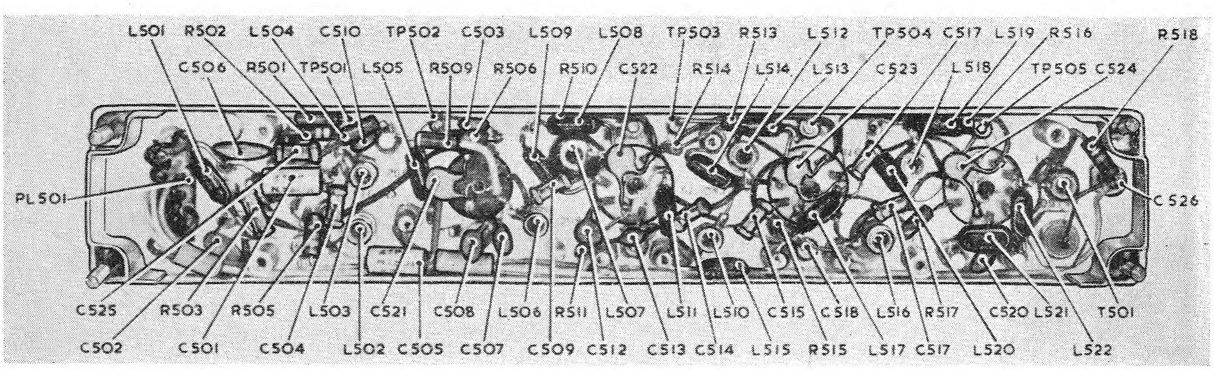

Fig. 7. Frequency multiplier unit: component location (bottom)

Butler oscillator

38. V501 (CV4013) is a double-triode oscillator connected as a Butler oscillator; its frequency is determined by a quartz crystal connected between the two cathodes. The anode tuned circuit is broadband but, as the test set only operates on a fixed frequency of 1126 Mc/s (channel 39), it is adjusted for maximum output at the crystal frequency of 31·277 Mc/s. V501A is a grounded-grid amplifier; the r.f. voltage developed across its anode inductor L502 is coupled to V501B grid by C501. V501B is a cathode follower and the r.f. drive applied to its grid produces an r.f. potential in phase with it across its cathode resistor R503. The r.f. energy at V501B cathode is coupled to V501A cathode by a quartz crystal XL501 which provides a low impedance path at its marked frequency. The circuit operation relies on regenerative feedback i.e. the two cathodes must be in phase and, since the crystal operation at exactly series resonance requires zero phase shift around the circuit loop, the various stray capacities must be compensated by the circuitry. The cathode follower is almost free of phase shift due to extremely low grid-cathode capacitance and, at resonance, V501B cathode is virtually d.c. coupled to V501A cathode by the crystal. Due to the screening effect of the grid, the anode-cathode capacitance of V501A is extremely small. V501A anode circuit is resonated at the crystal frequency and coupled to V501B grid. Hence the phase shift around the circuit loop is negligible and oscillation will occur at the marked frequency of the crystal.

39. The inductor L501 in V501 cathode circuit resonates with the stray capacities of the crystal and acts as a neutralizing filter. The feedback to V501A is developed across its cathode load resistor R505. V501B grid leak consists of two resistors R502 and R501 to provide for a test point (TP501) at their junction. The oscillations at 31·277 Mc/s are coupled to V502 grid via capacitors C504 and C505.

Trebler-amplifier chain

40. V502 (CV4010) is a pentode trebler, its anode circuit being tuned to the third harmonic of the input frequency. A tuned inductor L503 in V502 grid circuit is in parallel with V501A anode coil (L502), as far as r.f. is concerned, and is coupled to it by C504, hence the oscillator is double tuned giving a sharply peaked response. V502 grid leak is made up of two resistors R507 and R506 to provide for a test point TP502, R506 being decoupled by C503. Bias is provided for this stage by C507 and R508. The signal at 93·833 Mc/s is coupled to V503 by C509.

41. V503 (CV2970) is a double-tetrode amplifier; it has a built-in decoupling capacitor connected between the screen grids and cathode. The coil L507 is effectively centre-tapped by coils L508 and L509 in the grid circuits to provide a push-pull input. The common connection of the grid coils is taken to grid leak R510; also connected to this point is TP503. The modulated video waveform fed to PL501/K from the video and range unit is fed, via the SET RF LEVEL potentiometer (RV401) on the front panel, to the common screen-grid connections of the last three valves in the trebler-amplifier chain V503, V504 and V505. RV401 (on the front panel) sets the r.f. output level by adjusting the video drive to the screen-grids of the last three stages. The modulated video waveform is fed from PL501/K to V503 screen via a filter C513, R511 and C512. H.T. is shunt fed to the anodes via choke L511; this has the same effect as feeding h.t. to the centre of L510. Coils L510 and L512 are both adjusted for maximum output at TP504. The output is coupled to the next stage by C514 and C515, the inductor L512 being effectively centre-tapped by L514 and L513 to provide a push-pull input for V504.

42. V504 (CV2970) is a double-tetrode trebler. The grids are fed with a signal at 93·833 Mc/s, the junction of the grid coils being connected to TP504 and grid leak R513. The screen-grids are fed with the modulated video waveform via R515. The anode circuit is tuned to the third harmonic of the input frequency, resulting in an output signal at 281·5 Mc/s. V504 anode circuit is fed with h.t. via choke L517. Coils L516 and L518 are tuned for maximum output at TP505. V504 output is coupled to the next stage by C517 and C518.

43. V505 (CV2970) is a double-tetrode push-pull amplifier. Its circuit arrangement is similar to the preceding stage except for its anode circuit. L519 and L520 are the chokes providing a balanced input to the grids and R516 is the grid leak; TP505 is connected to the junction of the two chokes. The modulated video waveform is fed to the screens via R517 and also to the anode circuit via PL501/M and a filter L521, C520 and L522. The anode circuit includes a transformer T501, which results in the valve having one output similar to a single valve amplifier. One end of the transformer is taken to PL501/C via smoothing network R518 and C525. From there it is connected to the meter (M401) on the front panel. T501 is adjusted for maximum deflection on M401. The other end of T501 is connected to SKT501 which carries the output signal of the frequency multiplier unit. This signal consists of oscillations at 281·5 Mc/s modulated by the composite video signal.

44. H.T. at +105V is fed into the unit on PL501/P, filters being connected into the h.t. line between each stage to prevent unwanted frequencies being coupled through the h.t. line between stages. H.T. to V501 is filtered by L504 and C506, to V502 by L505 and C510 and to V504 by L515 and C528. For a similar reason the heaters are bypassed by capacitors C521, C522, C523 and C524 for V502, V503, V504 and V505 respectively.

POWER MEASUREMENT UNIT

45. The power measurement unit is chassis mounted and is situated at the rear of the central part of the framework. The function of the unit is to amplify the input signals, by means of a two-stage amplifier, for application to a peak-reading meter circuit. The unit carries three valves all of which are accessible. Connection is made to other units of the equipment by two connectors as follows:—

(1) PL702, a 14-pole plug, which accepts the h.t. and l.t. supplies; it also carries connections to the SET ZERO potentiometer RV402 on the front panel (pins C and F), and the output to the meter (pins K and N).

(2) SKT701, a coaxial socket, which accepts the input signal.

Component location is given in fig. 8 and 9, the circuit is given in fig. 18.

Amplifier and cathode follower

46. Potentiometer RV701 is connected across the input at SKT701 so that the measurement sensitivity can be preset. V703B and V703A are, respectively, a feedback amplifier and a cathode follower. Negative feedback is provided by undecoupled bias resistors in V703A to ensure stability and to minimize the effects of valve aging or replacement on the operation of the unit. Test points are provided at the slider of RV701 (TP701) and at the cathode of VT703A (TP702).

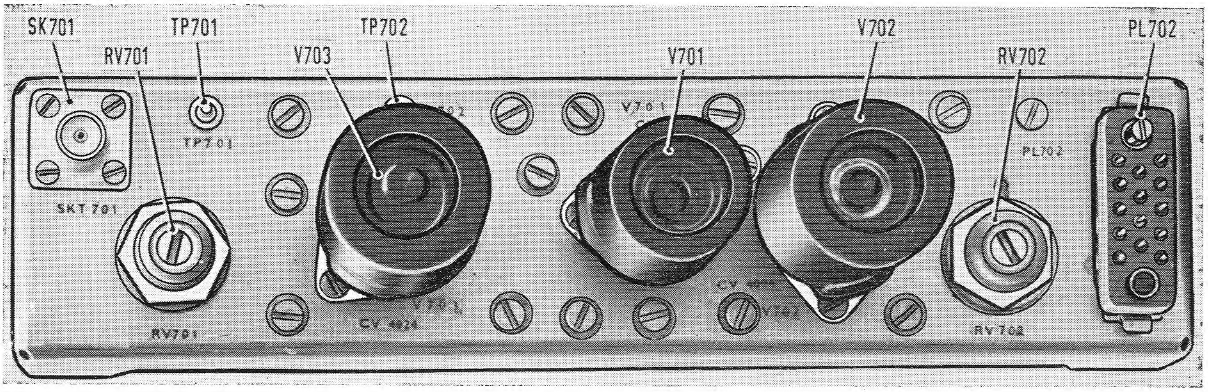

Fig. 8. Power measurement unit: component location (top)

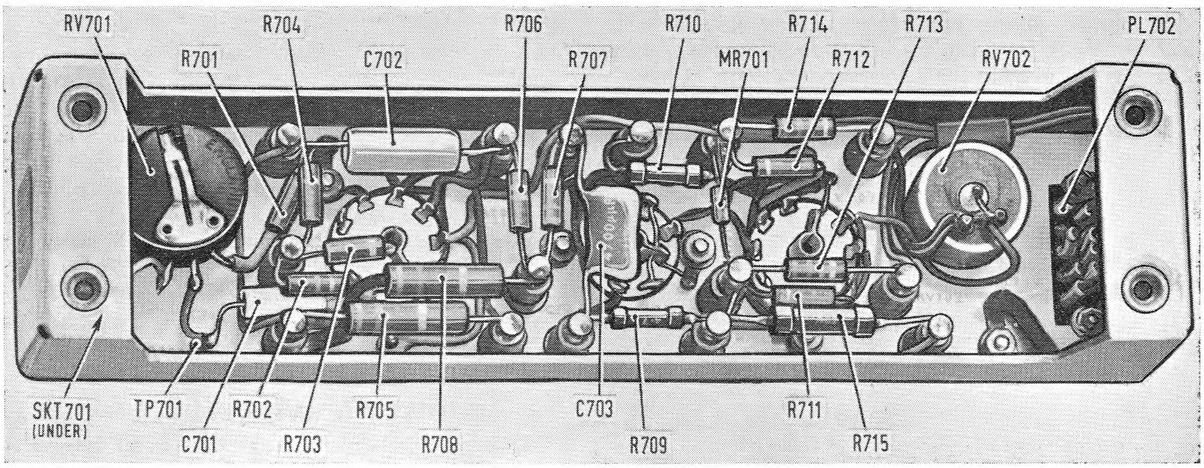

Fig. 9. Power measurement unit: component location (bottom)

Peak-reading meter circuit

47. V701 and its associated circuit forms a peak-reading valve voltmeter circuit. The output from the cathode follower V703A, consisting of positive-going pulse pairs, charges C703 through V701A. At the end of a pulse, the right-hand side of C703 is left negatively charged with respect to chassis because the voltage across a capacitor cannot change instantaneously. This negative potential unbalances the current flow in the cathodes of V702, the difference current flowing through the meter M401. The input conductance of V702 is not sufficiently high to discharge C703 appreciably during the inter-pulse period when operating with single or double pulses at a p.r.f. of 125 p.p.s. RV702 is included to obtain maximum meter indication when operating with longer pulse intervals, i.e. on TRANSPOND at 30 p.p.s. Zener diode ◀MR701▶ prevents damage to the meter if the circuit is overloaded.

48. V701B is connected between the grid of V702A and earth to preserve the symmetry of the meter circuit and to minimize the effect of supply fluctuations. In the absence of an input signal, the meter indication can be adjusted to zero by means of the SET ZERO potentiometer RV402.

INTERROGATOR UNIT

49. The interrogator unit is chassis mounted and is situated at the lower rear of the left-hand side of the main frame. The interrogator unit contains the p.r.f. generator whose output pulses are the timing control for the test set system in the INTERROGATE or SYSTEM TEST modes. The p.r.f. generator output pulses are applied, firstly, to the 12μs encoder (in the transponder unit) whose output ultimately becomes the outgoing interrogation signal, and secondly, to a delay generator and coincidence gate whose function is to check the correctness of the incoming reply pulses. This unit also contains the 'accept/reject' relay control valve (the actual relay being in the transponder unit). Component location is given in fig. 10, 11 and 12, the circuit is given in fig. 19.

P.R.F. generator

50. The p.r.f. generator V101 is a multivibrator which generates pulses at a repetition rate of 125 p.p.s. and feeds them to the trigger circuit.

51. Consider that, owing to noise, a small negative-going change in potential occurs at the grid of V101B. The anode current falls and the anode potential rises. This increase is coupled to

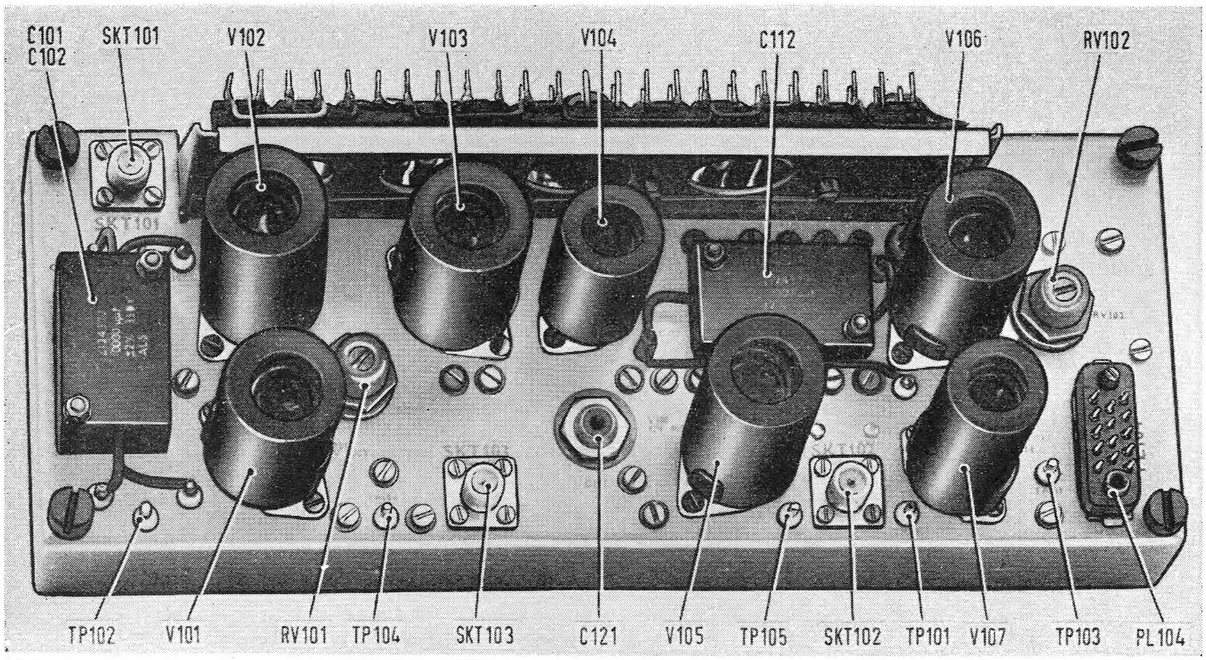

Fig. 10. Interrogator unit: component location (top)

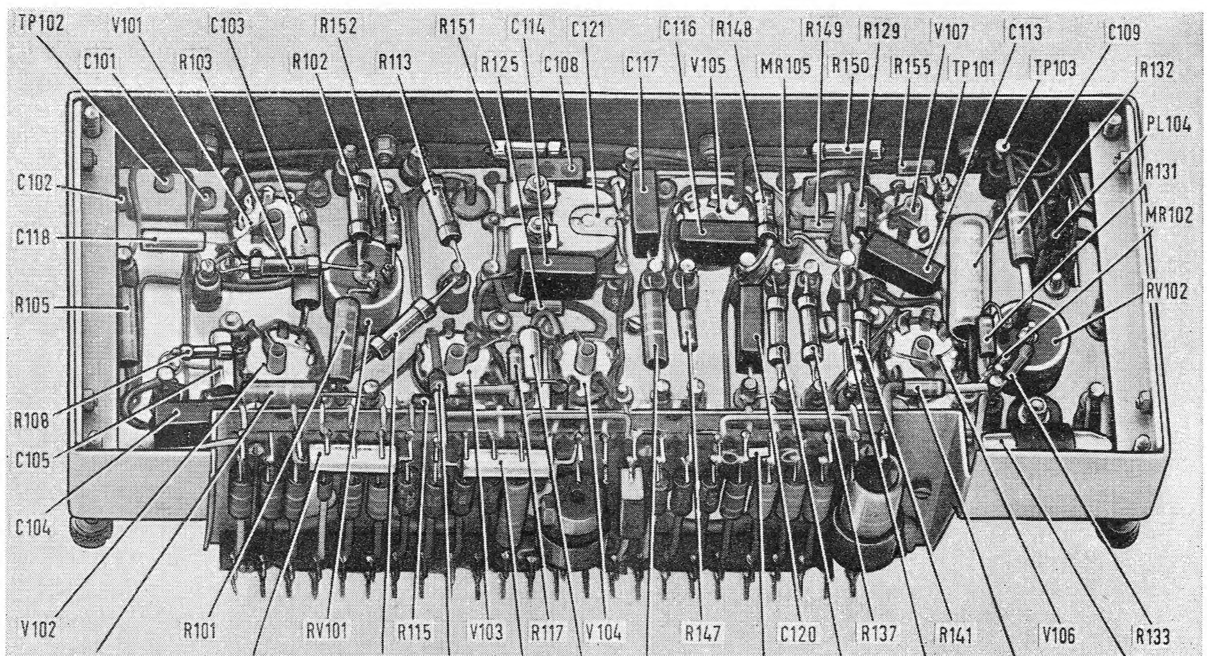

Fig. 11. Interrogator unit: component location (bottom)

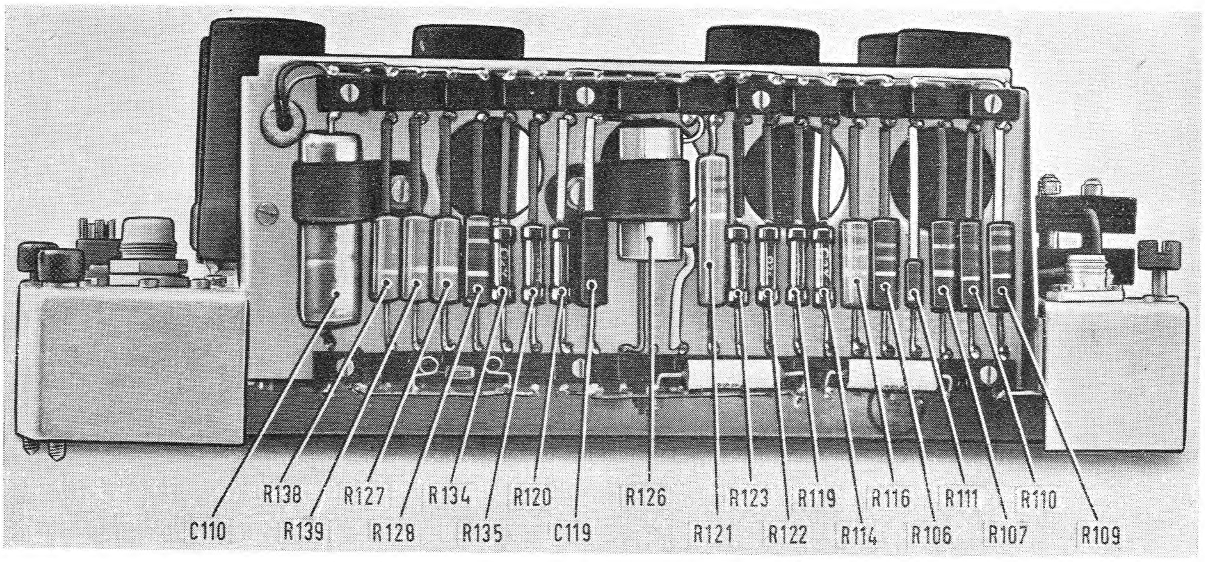

Fig. 12. Interrogator unit: component location (side panel)

the grid of V101A by C101, so that the current through V101A increases and its anode potential falls. This fall in potential is coupled to the grid of V101B and increases the original negative-going change. A cumulative action thus takes place until V101B is cut off and V101A is fully conducting. The circuit remains in this state until the negative potential at the grid of V101B leaks away, the time taken depending on the time constant of C102, R102 and the aiming potential set by RV101. As soon as the grid potential of V101B reaches the point at which anode current begins to flow, the anode potential of the valve falls. This fall is coupled to the grid of V101B so that a cumulative action again takes place until V101B is fully conducting and V101A is cut off.

52. The anode of V101A is connected to the 105V line via R105, PL104/C, SKT104/C and the FUNCTION switch on the SYSTEM TEST and INTERROGATE positions only. The p.r.f. generator is switched off when the switch is set to SET ZERO or TRANSPOND, since no output is required from it in these modes of operation.

Trigger circuit

53. The trigger circuit is a monostable flip-flop which generates a trigger pulse of known amplitude and duration for each input pulse applied to it from the p.r.f. generator. These pulses are used in three ways:—

(1) From the anode of V102A to trigger the delay generator.

(2) From the cathode of V102A, via SKT101, to the 12μs encoder in the transponder unit.

(3) From a cathode tap on V102A, via SKT103 to the external SYNC. socket.

54. In the stable state, V102B is conducting and V102A is cut off. Negative-going pulses from the p.r.f. generator are applied to the grid of V102B through C103 and the circuit changes over with V102B cut off. C104 then discharges through R108 until, after approximately 20μs, the circuit returns to its stable state.

55. The circuit is similar to that of the 4μs waveform generator in the transponder unit (para. 31 to 34) in that it is substantially independent of valve characteristics and h.t. potential. Resistor R111 in series with the SYNC output (SKT103) prevents damage to the circuit if the SYNC terminal is accidentally short-circuited to chassis.

Delay generator

56. The delay generator triggers the gate pulse generator after a time equal to that required for interrogation of the airborne equipment and the reception of the delayed reply, a total of approximately 62μs from the initiating p.r.f. generator pulse.

57. The delay generator comprises V103 and V104; its operation is similar to that described in para. 19 to 26. Correct operation of the circuit can be verified by examining the waveform at test point TP104.

Gate pulse generator

58. The gate pulse generator V105 is a monostable flip-flop and is triggered by the negative-going output pulse from the delay generator. The gate pulse at the cathode of V105A has an amplitude of 25V and a duration of 3μs.

59. The operation of the circuit is the same as that described in para. 31 to 34. The test point for the circuit is TP105.

Coincidence gate

60. The coincidence gate comprises the two diodes MR104 and MR105; its purpose is to prevent the triggering of the reply rate voltage converter until limited incoming pulses at SKT102 are coincident with gate pulses from V105.

61. In the absence of pulses both diodes conduct, MR104 via R140 and R153, and MR105 via R149. Positive-going pulses from the gate pulse generator and SKT102 cut the diodes off, but unless these pulses are coincident C113 always has a path to earth. When both diodes are cut off simultaneously (coincident pulses) C113 commences to charge to 105V, through R140 and the grid-cathode path of V106A but is arrested at 20V, the amplitude of the incoming pulse. When either pulse terminates the period of coincidence, the resulting negative-going step is coupled to the grid of V106A.

Reply rate voltage converter

62. The reply rate voltage converter comprises a monostable multi-vibrator (V106) and a diode (MR103); it provides a direct voltage control signal for operating the relay control valve. The control signal is dependent on the rate at which coincident pulses are received. Ideally, this would be at regular 8ms intervals (i.e. 125 p.p.s.) but, in practice, some pulses are lost either in airborne receiver noise or by coinciding with airborne interrogation pulses, both losses being of a random nature. The output at V106A anode consists of positive-going pulses having a duration of 2ms at intervals of 8ms (or a multiple thereof when pulses are missing). The amplitude of the pulses is determined by the bias diode MR103; the bias level is fixed partly by the potential divider R134/R135 and partly by the charge acquired by C111. The d.c. level of the pulses is restored to a new level, which is negative with respect to chassis, by means of the diode MR102 and the potential divider including RV102. The waveform is smoothed by R130/C110 to obtain a control signal which is a direct voltage with superimposed ripple. This control signal is negative with respect to chassis when there are no reply pulses but becomes progressively less negative as the reply efficiency increases towards 100%.

Relay control valve

63. The relay control valve (V107) is operated by the output from the reply rate voltage converter. When the FUNCTION switch is set to SYSTEM TEST or INTERROGATE, relay RLB in the transponder unit is connected (via SKT205/X, S404/lb and SKT104/d) between the anode of V107 and the 105V line. This is the 'accept/reject' relay that operates the indicator lamps and connects the transponder delay generator output to the 4μs waveform generator. RV102 is set so that V107 conducts (and the 'accept/reject' relay energizes) when the coincidence rate between received pulses and test set pulses is greater than 70%.

POWER SUPPLY UNIT

64. The power supply unit is chassis mounted and is situated in the front of the centre portion of the main framework. The unit produces four voltages as follows:—

(1) +200V d.c. unregulated at 0–5mA.

(2) +105V d.c. regulated at 50–120mA.

(3) −150V d.c. regulated at 0–4mA.

(4) 6·3V a.c. for heaters.

65. The unit carries four valves, all of which are accessible, and eight silicon junction rectifiers which are mounted on the underside of the chassis. Connection is made to other units of the equipment by a 14-pole plug PL301. The component location is given in fig. 13 and 14, the circuit is given in fig. 20.

Secondary power supplies

66. T301 has three secondary windings as follows:—

(1) 240 volts between terminals 20 and 21.

(2) 300–0–300 volts from terminals 28, 29 and 30.

(3) 6·3 volts between terminals 17 and 18, and 26 and 27.

The two 6·3V secondaries are wired in parallel, terminal 17 being connected to 26, and 18 to 27. The 240V winding is connected via fuse FS301 across a full-wave bridge rectifier comprising four silicon junction rectifiers MR301–MR304. The d.c. output from the bridge is filtered by C308, L301, R312 and C302; it is then connected to PL301/B, the +200V output and also to a regulating circuit from which is derived the +105V output.

67. Regulation is effected by means of a series stabilizer circuit comprising V303, V304 and V305. V303 is a gas-filled voltage stabilizer which provides the reference potential of −84V for the grid of the control amplifier V304, V305 acting as a variable ballast resistor. An increase in output voltage at the cathode of V305 causes an increase in voltage at the moving contact of RV301 and at the grid of V304.

68. The anode current of this valve thus increases causing a greater voltage drop across R307 and therefore a lower voltage at the valve anode. The grid voltage of V305 therefore decreases causing its resistance to increase and the voltage at its cathode to decrease in opposition to the original change in output. Regulation of the circuit is improved by deriving the screen supply for V304 from the unregulated 200V source so that a rise in input voltage will increase the screen voltage, and therefore the anode current, of V304 and have the same regulating effect as a voltage rise at the cathode of V305. The regulated 105V output from the circuit is applied to PL301/P and can be measured at TP301.

69. A full-wave rectifier circuit comprising two pairs of diodes in series (MR305–MR308) is connected across the 300–0–300V secondary winding on T301. The junction of MR306 and MR307 is connected to earth and the unsmoothed negative voltage at the centre-tap of the winding is applied to the capacitor input filter comprising C304, R301, C301, R302 and C303. The output from the filter is stabilized at −150V by the gas-filled stabilizing valve V302 before being applied to PL301/R. The voltage can be measured at TP302.

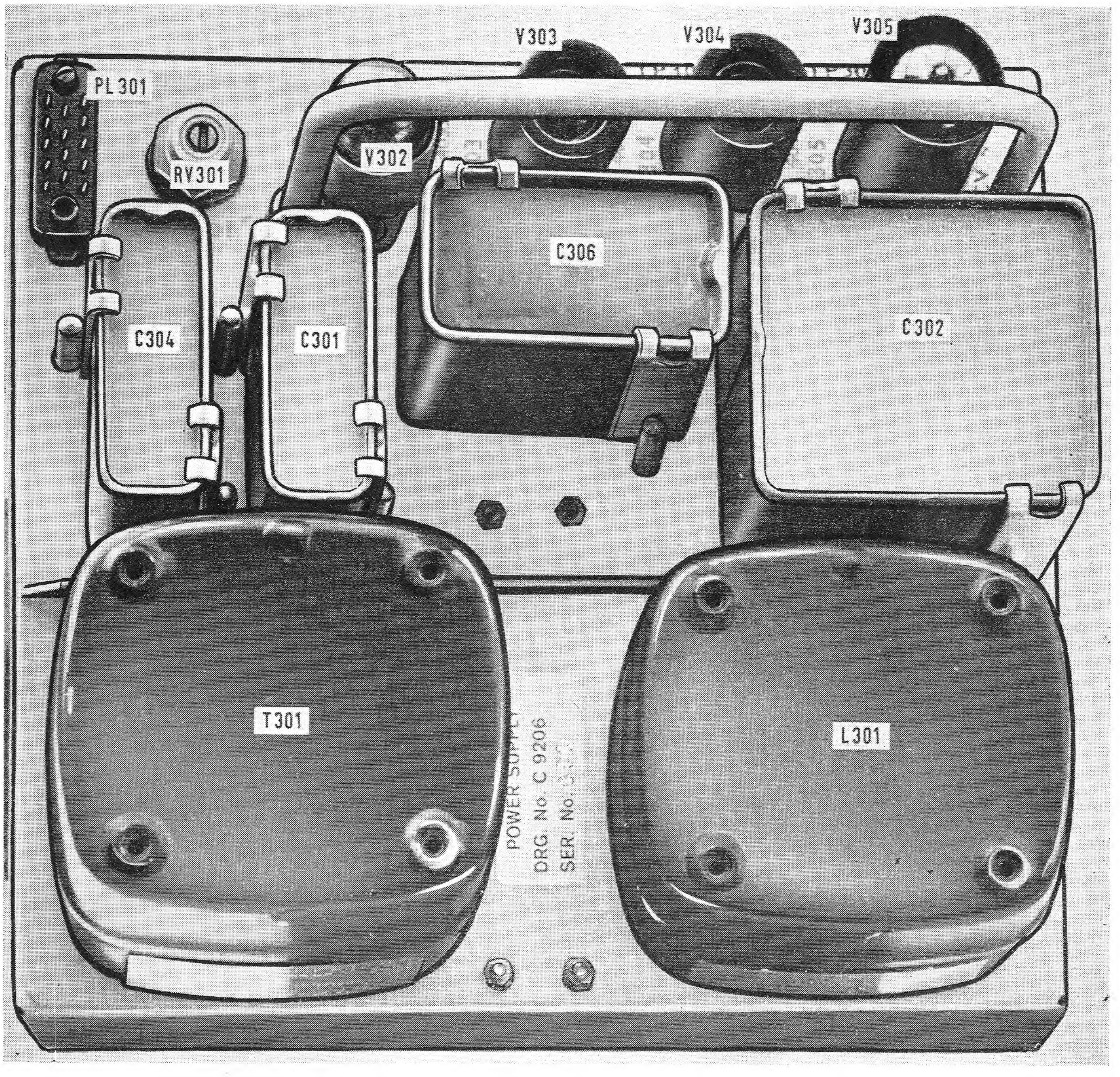

Fig. 13. Power supply unit: component location (top)

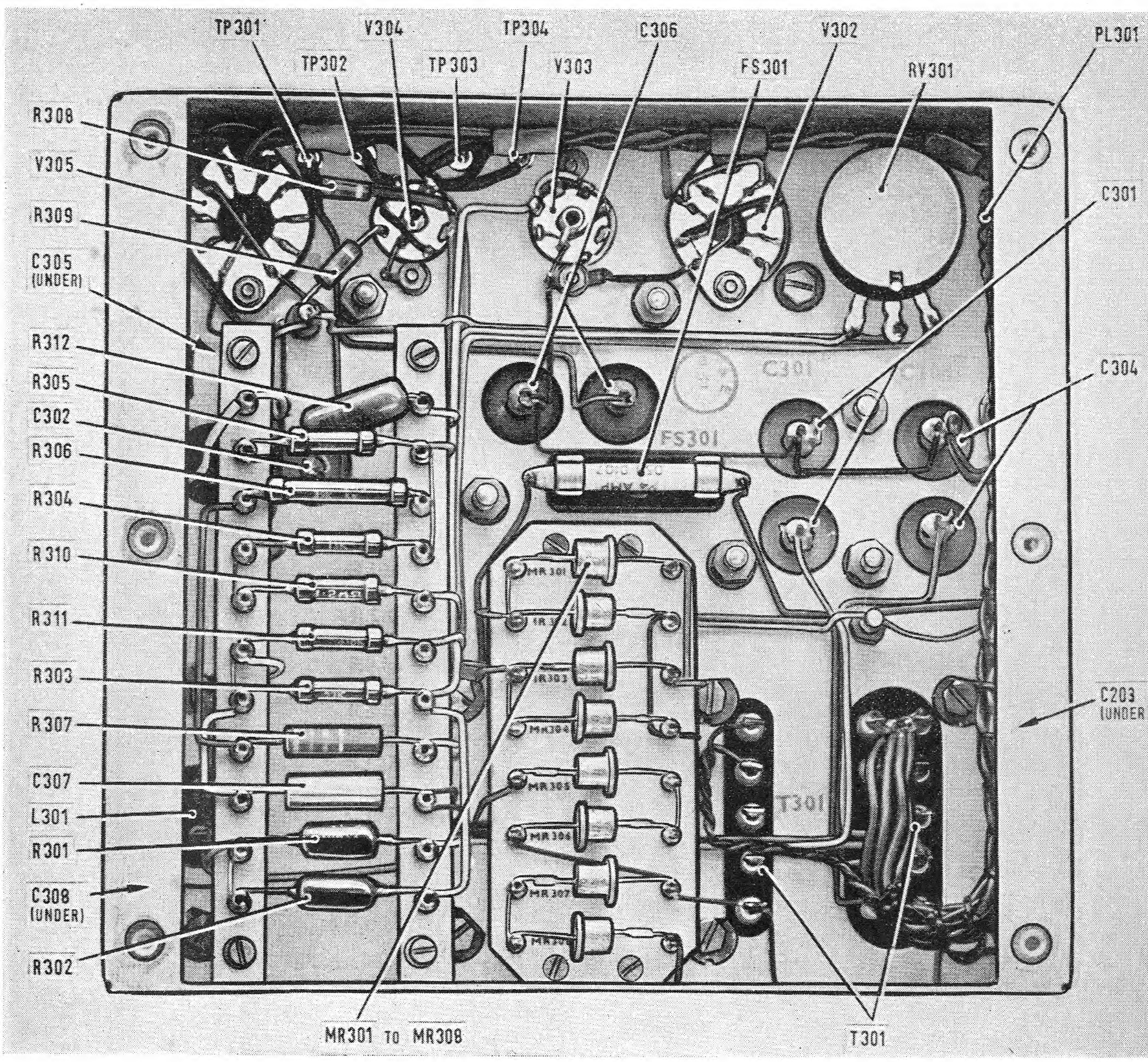

Fig. 14. Power supply unit: component location (bottom)

70. The 6·3V heater supply from the transformer is connected directly to pins H, L, N and K, A, D of PL301, thus providing three 6·3V output circuits. The heater supply voltage can be measured by connecting either an oscilloscope or a meter between TP303 and TP304.

Note . . .

TP304 is connected to chassis via a link on the 39-way terminal board.

Input power supplies

71. Power is fed into the test set via PL401, a three-pole plug mounted on the front panel. A three-pole socket to mate with PL401 terminates a three-core cable which is stowed in the front cover, the other end of the cable being left free for termination as required.

72. The test set will operate on 115V, 180V or 200V at 320–1760 c/s and consumes about 120W at 115V, 400 c/s. The input supply is fed via PL401 to S401, the ON/OFF switch, and then to fuses FS401 and FS402. The line connection from PL401/A is fed via a microswitch, S405, which breaks the input supply connection when the outer cover of the test set is removed. The neutral connection of the mains input is then fed to PL301/F and is connected to the primary tapping on T301.

CHASSIS ASSEMBLY

73. The chassis assembly comprises the main frame and front panel. The general construction is shown in fig. 15. The circuit (fig. 21) shows the connections from the 39-way terminal board to the miniature sockets that connect the sub-units. The majority of the front panel components have been described elsewhere in conjunction with the sub-units associated with them.

74. The video pulse output from SKT204 on the transponder unit is connected via PL4204 to the SET RF LEVEL potentiometer RV401. The slider of RV401 feeds the video signal through a filter network comprising C401–C403, L403, L404, R401 and R402. This network gives the video pulses the required shape before they are fed to the frequency multiplier unit where they are used to modulate the output signal.

75. Detected incoming signals from the r.f. coaxial system are connected through PL4809 (DIRECT) or PL4818 (RADIATE) and ferrite filter beads L401, L402 to PL4201; from there they are fed to SKT201 on the transponder unit. Filter beads L401 and L402 remove the r.f. component from the detected signal.

76. The components mounted on the front panel are as follows:—

(1) RV401, the SET RF LEVEL potentiometer.
(2) RV402, the SET ZERO potentiometer.
(3) S401, the mains ON–OFF switch.
(4) S402, the range miles selector switch.
(5) S403, the NORMAL/DECODE TEST switch.
(6) S404, the FUNCTION switch.
(7) M401, the meter marked SET TO 30.
(8) ILP401, the ACCEPT indicator lamp.
(9) ILP402, the REJECT indicator lamp.
(10) ILP403, the POWER indicator lamp.
(11) SKT801, the DIRECT r.f. output socket.
(12) SKT802, the RADIATE r.f. output socket.
(13) SKT404, the SYNC. output socket.
(14) SKT405, the VIDEO output socket.
(15) PL401, the 3-pole mains input socket, marked 115/180/200V 320–1760~.
(16) FS401 and FS402, the 2A mains fuses.

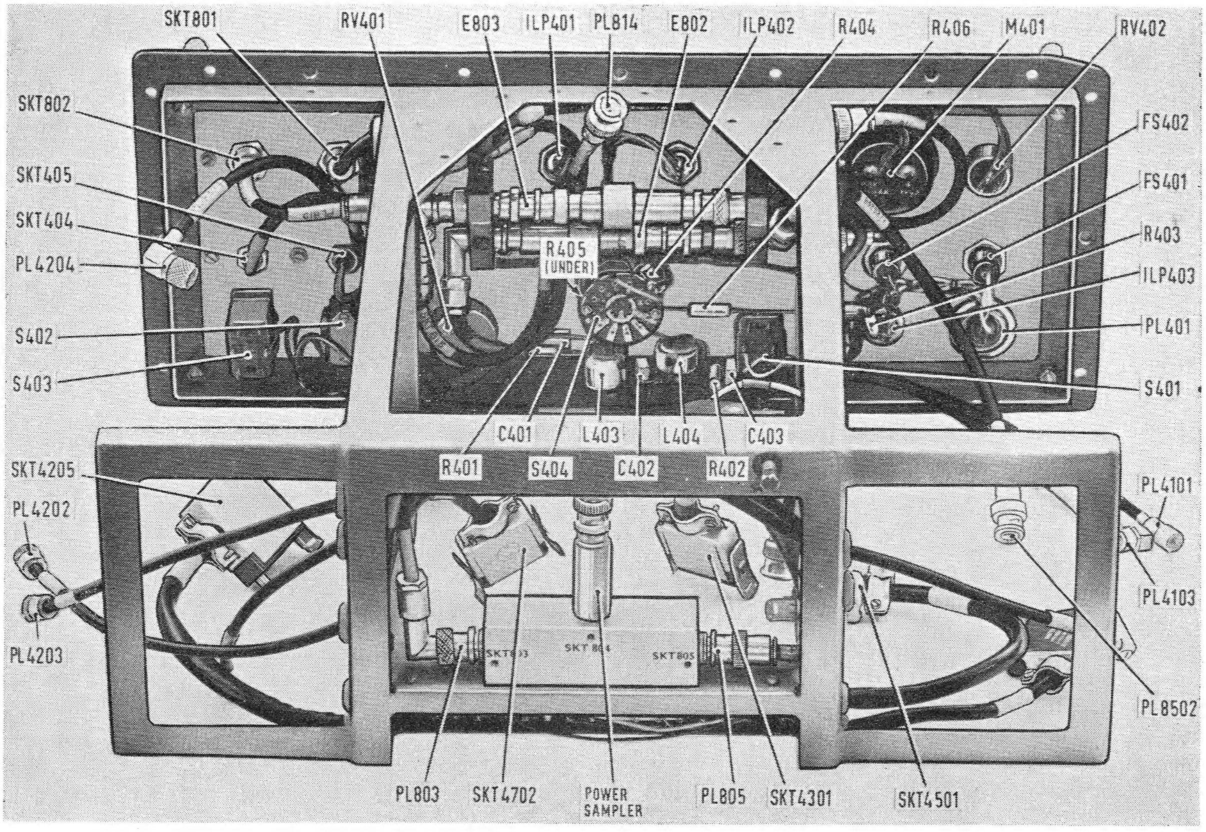

Fig. 15. Chassis assembly with sub-units removed: component location

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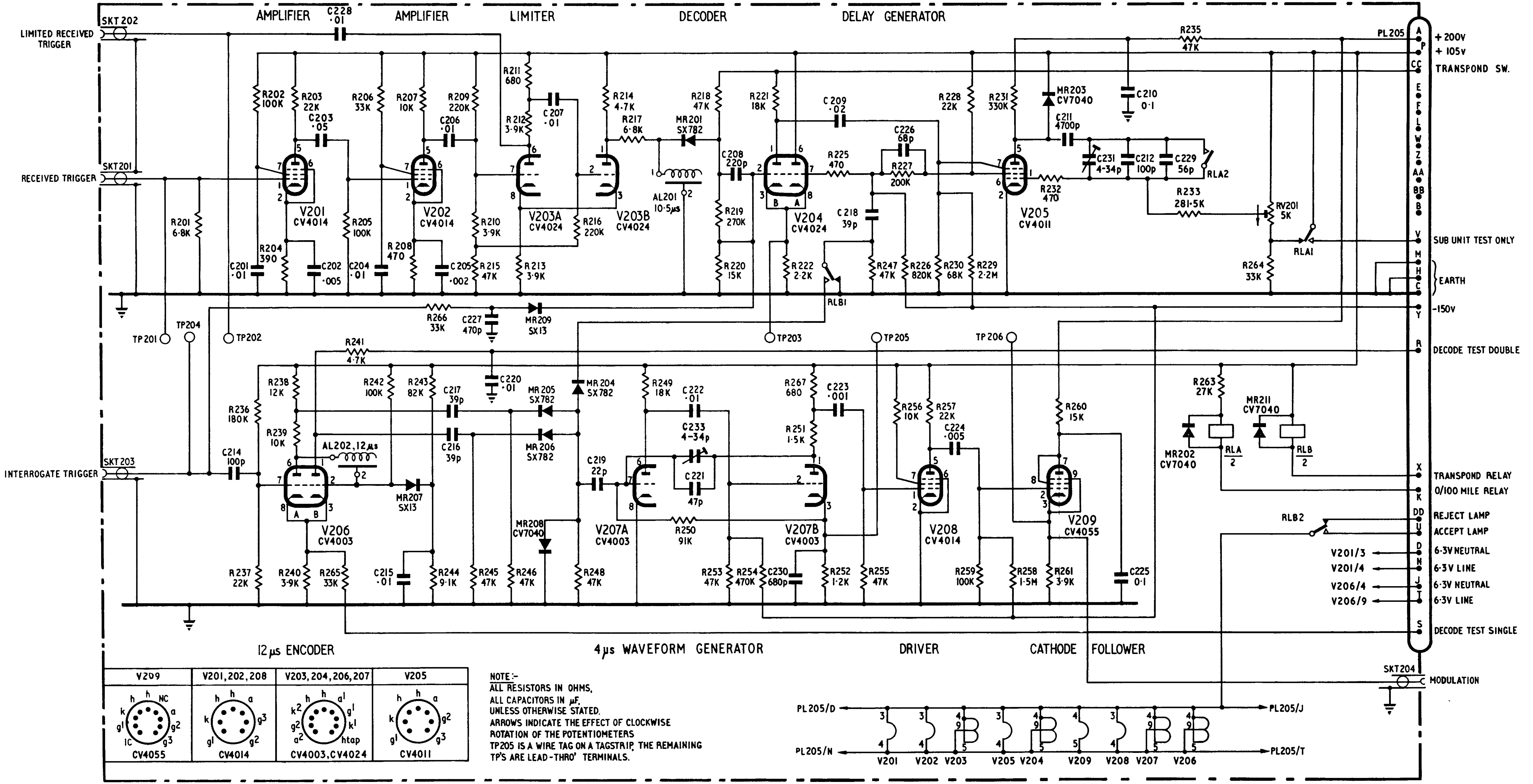

Fig. 16 Transponder unit: circuit Fig. 16

956/4, 86938, 571266, 705, 9.65

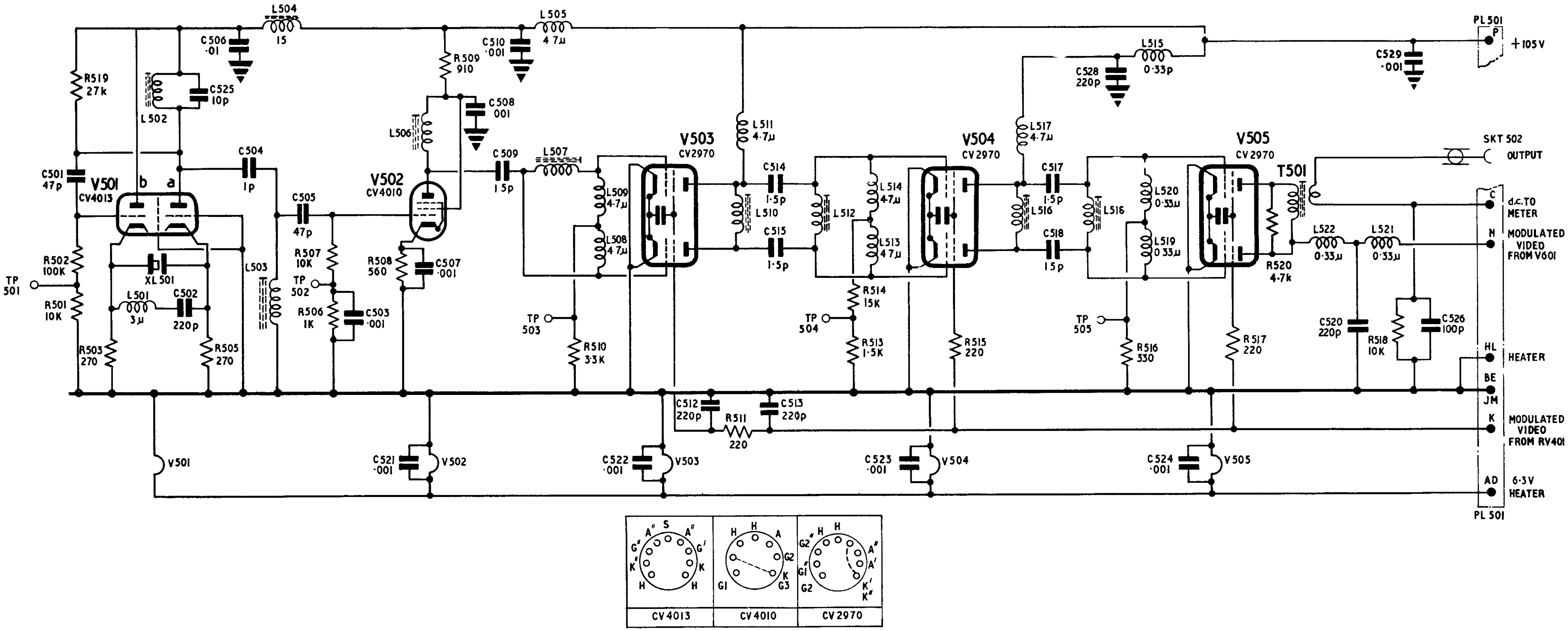

Fig. 17 Frequency multiplier unit-circuit Fig. 17

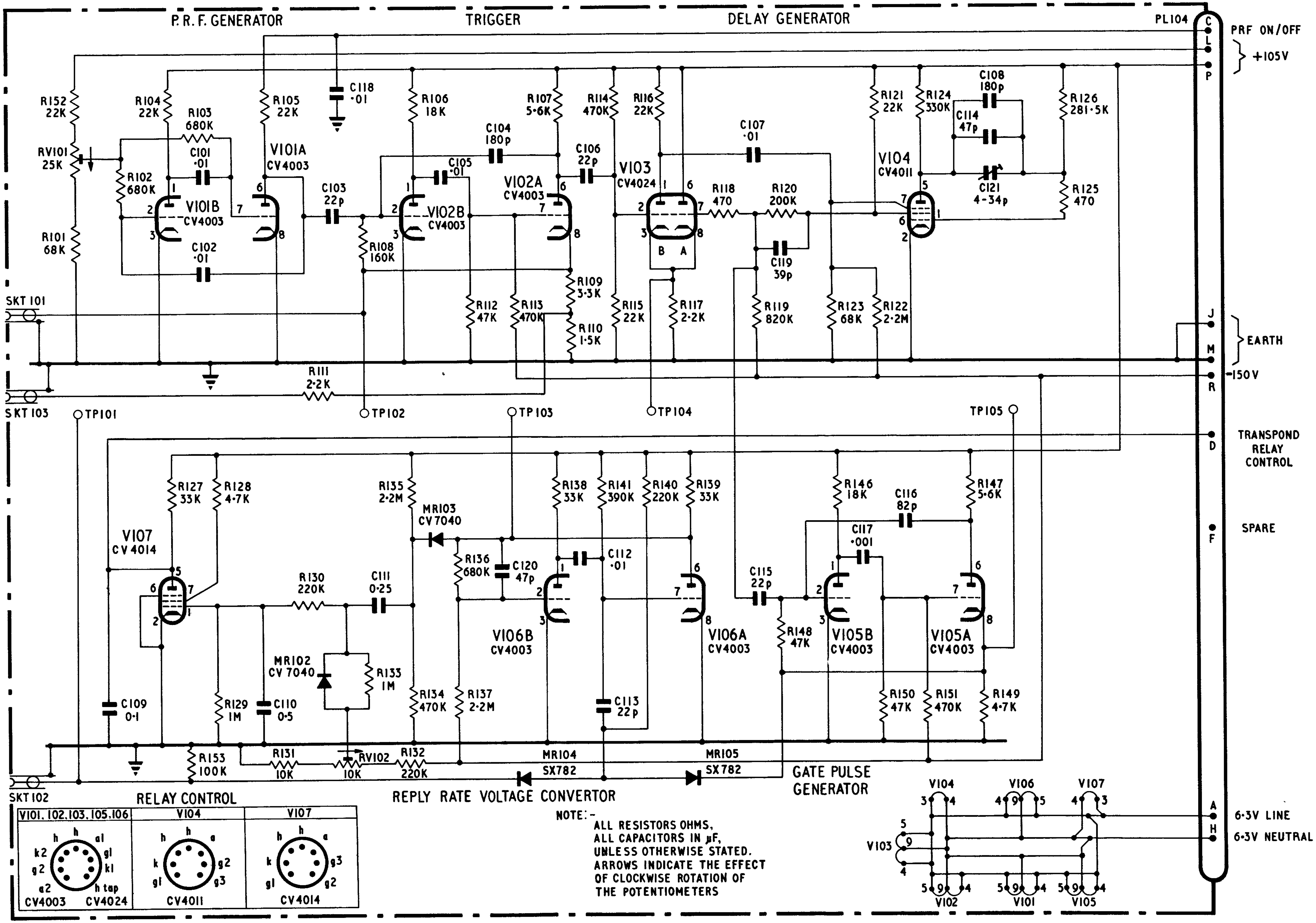

Fig.19 Interrogator unit: circuit Fig. 19

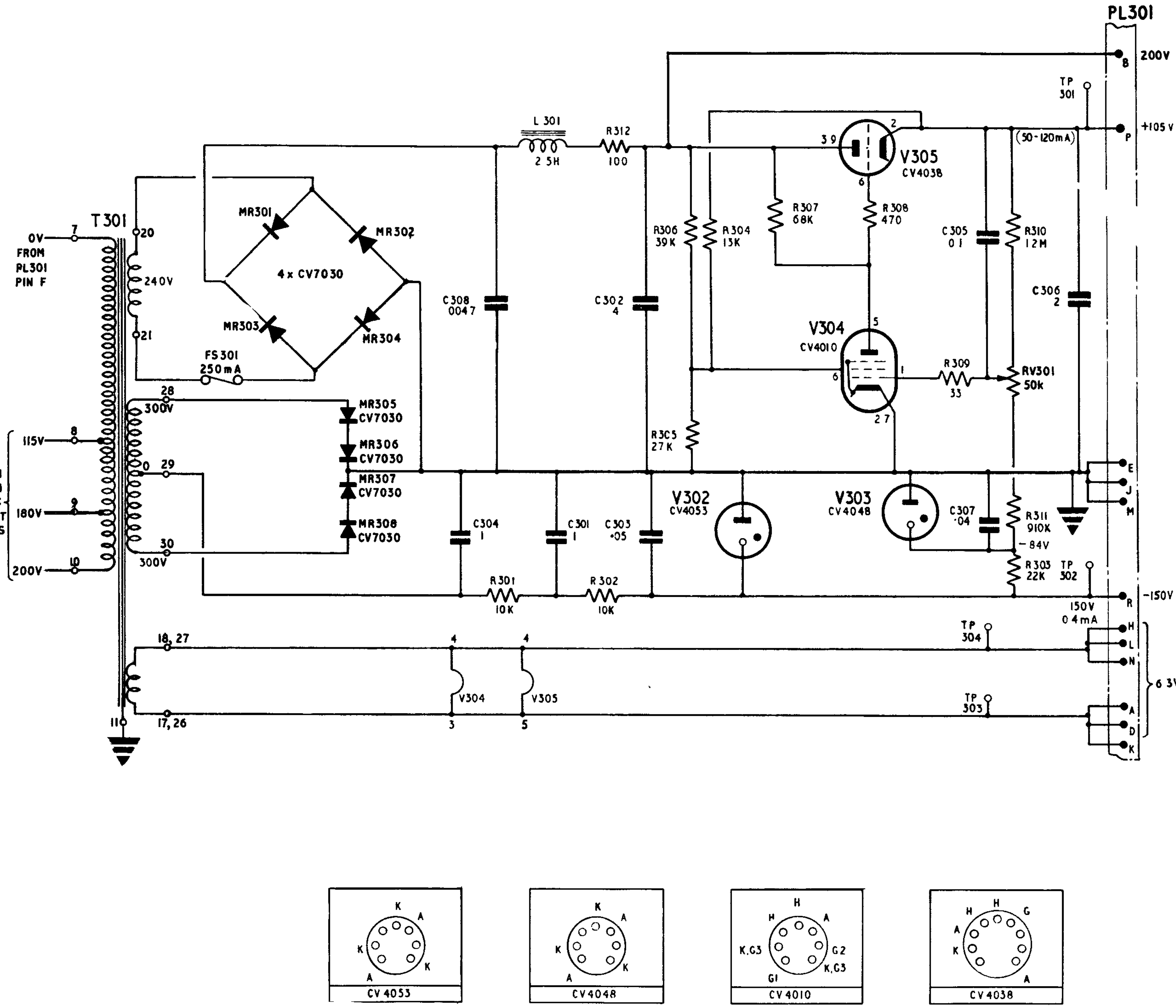

Fig.20 Power supply unit - circuit Fig.20

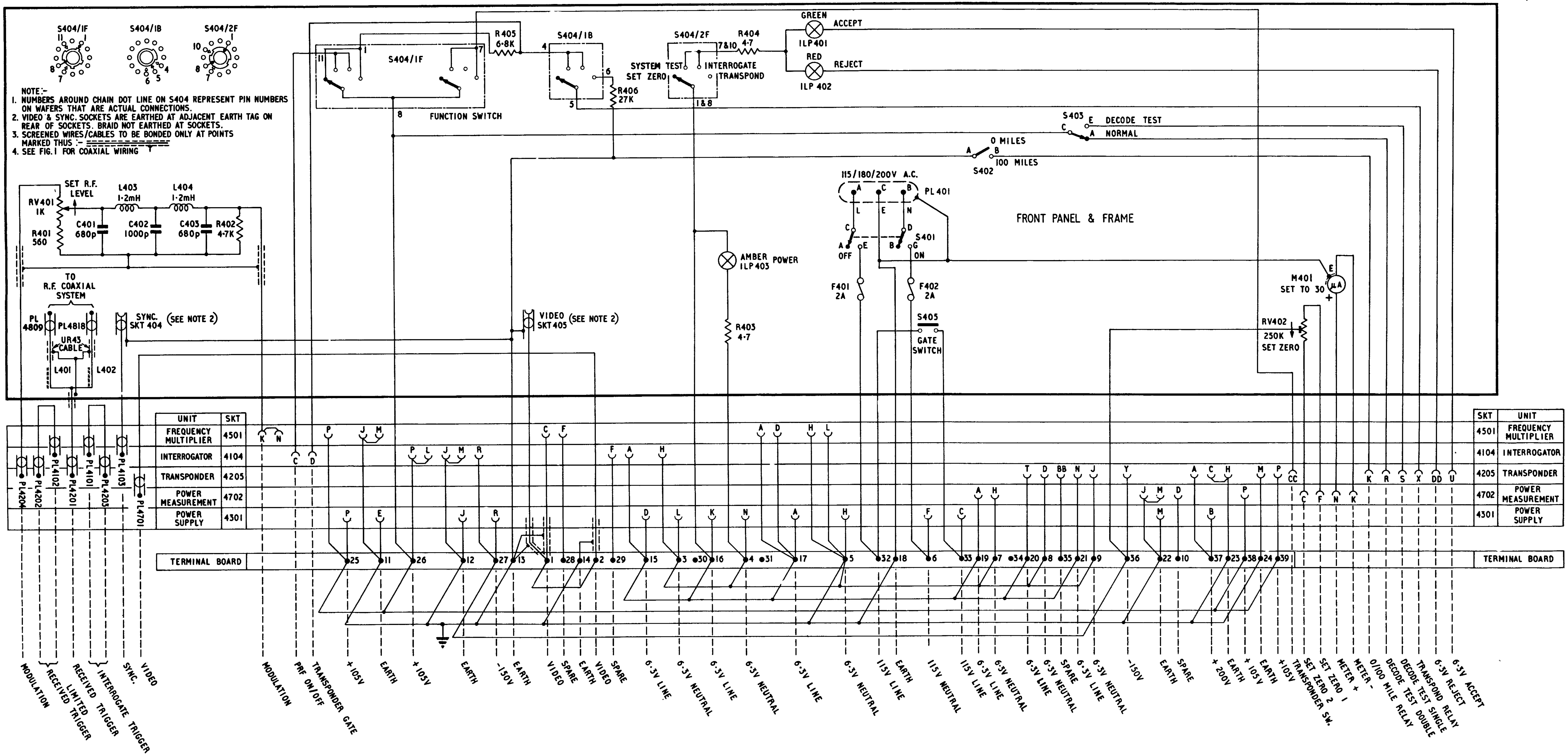

Fig. 21 Chassis assembly: circuit Fig. 21

Chapter 3
OPERATING INSTRUCTIONS

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Front panel controls of test set	1

Introduction

1. This chapter gives the operating instructions for the test set, radio 6625–99–970–5393. These instructions assume that the equipment has been correctly set up and is in serviceable condition. The front panel, with the controls, is given in fig. 1.

Connections

2. To operate the test set, it must first be connected to the appropriate power supply. If the unit is to be operated in the DIRECT mode, then the DIRECT R.F. socket on the unit must be connected to the aerial socket of the airborne equipment, using the connector/attenuator Type

Caution . . .

Do not connect the connector/attenuator to the radiate socket. This will cause internal damage to the test set circuits.

Direct connection mode

3. The procedure for using the test set in the direct connection mode is as follows:—

(1) ◄Connect the DIRECT R.F. socket on the test set to the corresponding r.f. socket on the TACAN airborne equipment, via the r.f. connector/attenuator stowed in the cover. Ensure that the dummy load cap is in position over the R.F. RADIATE socket. An additional 6dB attenuator is supplied. This enables the test to be carried out at -90 dBm, for special applications.►

(2) Switch the test set ON and allow a minimum period of five minutes before making any tests. Meanwhile, set the airborne equipment to CHANNEL 39.

Note . . .

The FUNCTION *switch on the airborne equipment control unit has various designations according to the type of unit. Operation* (3) *requires that the airborne transmitter shall be off, whereas operation* (5) *requires the transmitter on and selection of the air-to-air mode.*

(3) Set the test set FUNCTION switch to SET ZERO and adjust the SET ZERO control until the meter reads zero.

(4) Set the FUNCTION switch to SYSTEM TEST and note that the red REJECT lamp is alight. Adjust the SET RF LEVEL control until the meter reads 30.

(5) Set the airborne equipment to 'transmit air-to-air mode' and note that the red REJECT lamp goes out and the green ACCEPT lamp comes on.

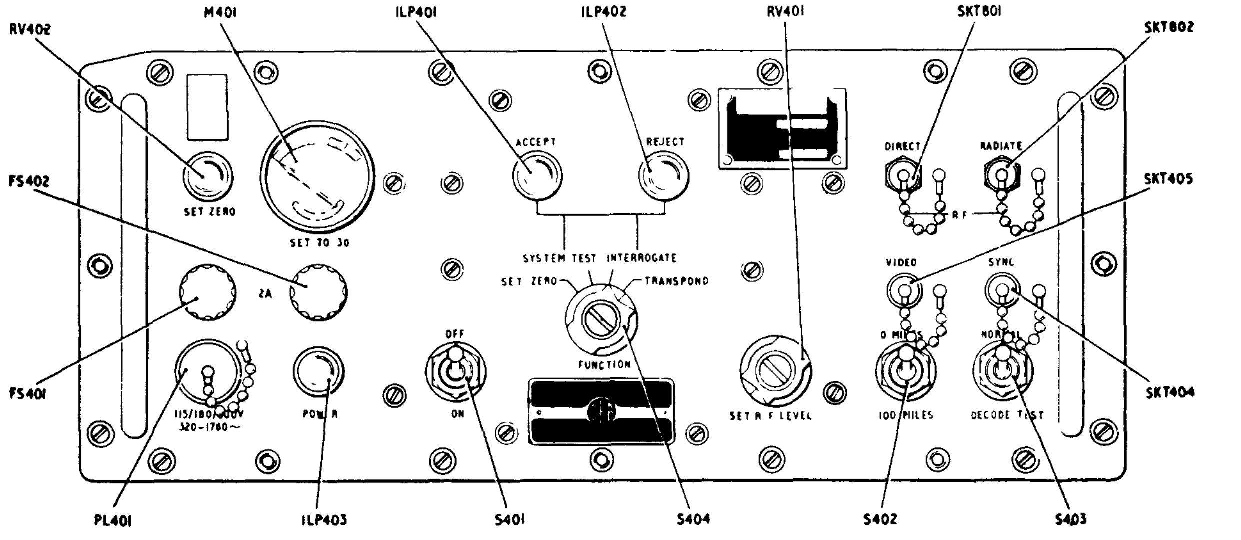

Fig. 1. Front panel controls of test set

(6) Examine the airborne range indicator and note that it indicates the range set by the test set 'range' switch.

(7) Set the 'range' switch to its alternative position and repeat (6). The permissible error in the airborne range indication is the sum of its own and the test set tolerances as follows:—

Range switch position	Test set tolerance	Airborne equipment tolerance
0 MILES	±¼ mile	±1/10 mile
100 MILES	±2 miles	±3/10 mile

(8) Depress the NORMAL/DECODE TEST switch (it is spring biased to NORMAL) and note that, after a few moments, the ACCEPT light goes out and the REJECT light comes on.

Note . . .

On SYSTEM TEST *an electrical interlock prevents the test set from replying to interrogations from the airborne installation until correctly timed replies to the test set interrogations are received. Thus, observation of the airborne range indicator alone is sufficient to confirm correct operation of the airborne installation.*

(9) If the SYSTEM TEST indicates a failure the defect may be localized by selecting INTERROGATE on the test set FUNCTION switch. If the green ACCEPT light comes on after not more than five seconds the transpond circuits of the airborne installation can be assumed serviceable.

(10) Set the FUNCTION switch to TRANSPOND and note that both lights go out. If the airborne range indicator shows the range set by the test set 'range' switch (sub-para. (7)), the interrogate circuits of the airborne installation can be assumed serviceable.

Note . . .

Certain defects in the airborne equipment can cause a 'reject' indication on SYSTEM TEST *but an 'accept' indication on* TRANSPOND *and* INTERROGATE *when each is tested as a separate function.*

Radiating mode

4. The procedure for using the test set in the radiating mode is as follows:—

(1) If the radiating test was preceded by direct connection tests, ensure that the TACAN equipment r.f. connection was replaced when the test set connector/attenuator was removed.

(2) Set the instrument approximately 30 feet from the TACAN installation under test.

(3) Clamp the test set antenna to the instrument handle and connect the coaxial lead to the R.F. RADIATE output socket. Some early versions of the antenna plug directly into the R.F. RADIATE socket and have a fixed clip which engages on the handle of the instrument. Alternatively, the aerial may be remotely mounted in a vertical position, preferably on a wooden pole, and connected to the test set R.F. RADIATE output socket via a 50 ohm coaxial cable. This cable may have a maximum length of 25 feet but, in this case, it is recommended that the test set antenna be not more than 25 feet from the TACAN airborne antenna.

Note . . .

The test set antenna, however mounted, should not be placed within ten feet of any large metallic object as this may have a considerable effect on its performance; neither should it be within ten feet of the TACAN airborne installation under test as this may damage components in the test set. Maximum antenna separation for satisfactory operation is dependent on individual site and installation characteristics.

(4) Operate the test set as detailed in para. 3, operations (2) to (10) inclusive. Note that the airborne receiver sensitivity is not checked in the radiating method. When the test set is used at marginal ranges (greater than 30 ft) the range indication on the airborne set may vary slightly from that obtained with a direct connection between test set and airborne equipment.

Use of test set in bay servicing

5. If the test set is used as an aid to bay servicing the airborne equipment, oscilloscope synchronization should be taken from the coaxial SYNC socket on the test set while examining the transpond functions of the airborne set, and from the SUPP PULSE socket on the airborne set while examining the interrogate function.

Note . . .

The test set TRANSPOND *mode checks the airborne 'interrogate' function and the* INTERROGATE *mode checks the airborne 'transpond' function.*

6. A signal derived from all outgoing r.f. pulses is present at the VIDEO socket on the test set. That is, for each pulse transmitted by the test set a monitoring pulse is present at the VIDEO socket. This can be used as a rapid check on the functioning of the test set.

Caution . . .

If the test set is to be used in a workshop for long periods of continuous operation, it should stand in a free space to allow adequate dissipation of heat from the case.

Chapter 4

SERVICING AND FAULT DIAGNOSIS

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Oscilloscope waveforms B (interrogator unit)	3
Oscilloscope waveforms C (power measurement unit)	4

General

1. This chapter contains information of use when diagnosing faults in the test set radio. After any repairs have been carried out, and at intervals specified in D.C.I.'s, the test set should be sent to a Calibration Centre where the rather complex array of standard test equipment required for the purpose is available. User units are warned against the adjustment of internal preset controls.

Mechanical servicing

2. Dismantling of the test set radio is similar to that of the test set Type 10166 described in Sect. 2, Chap. 4. The general arrangement of the sub units can be seen in fig. 1.

Power supplies

3. All voltage measurements and waveform tests are dependent on the supply voltages, it is therefore recommended that the output of the power unit be tested before other tests, typical results are listed in Table 1. It is important that the input a.c. supply be adjusted correctly before testing.

TABLE 1

Power unit outputs

Supply	Test Point	Typical Voltage	Output Load
H.T.+	PL 301 Pin B	180—210	0—5 mA
H.T.+	TP 301	104—106	50—120 mA
H.T.−	TP 302	145—155	0—5 mA
L.T. (a.c.)	TP 303 / TP 304	6·15—6·45	11 A

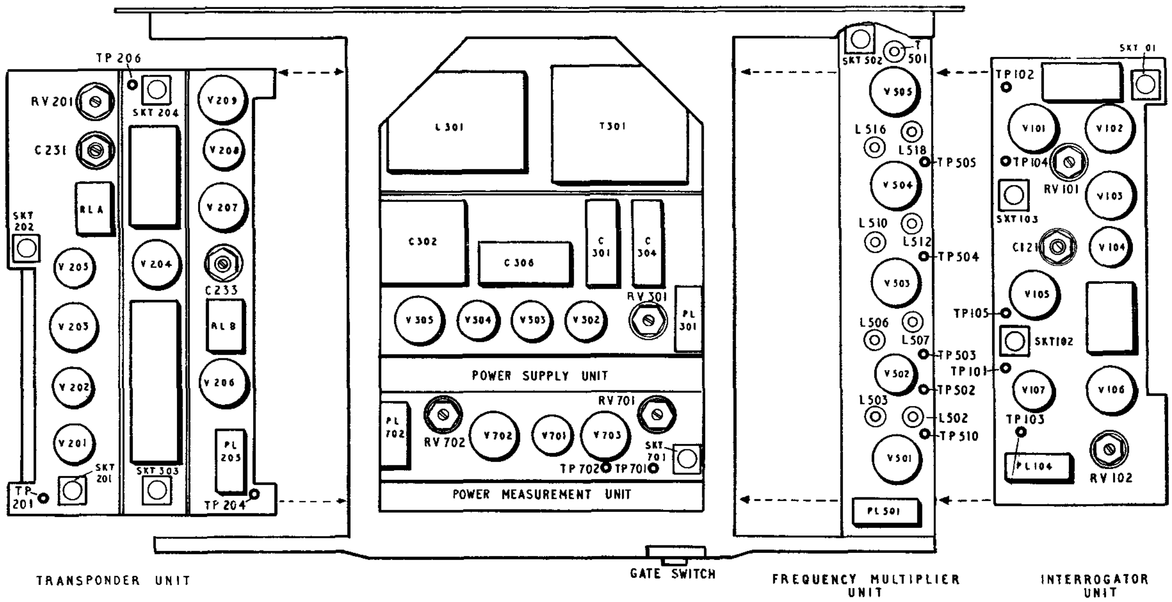

Fig. 1. General arrangement of sub-units

4. The amount of ripple and noise on either of the H.T.+ lines should not exceed 15 mV peak-to-peak.

Voltage tests

5. Typical voltages at the various valve pins are listed in Table 2. These are all d.c. and with respect to chassis except for the valve heater supplies and except where specifically stated; reference should be made to the circuit diagrams of Chap. 2 when taking measurements. All the voltages in the transponder unit (V201 to V209 inclusive) should be taken with the FUNCTION switch at TRANSPOND, for all other voltages the FUNCTION switch should be at SET ZERO.

Resistance tests

6. Typical d.c. resistance measurement tests, with respect to chassis, are given in Table 3. The equipment should be switched off and disconnected from the supply before resistance measurements are taken. The function switch should be set to SYSTEM TEST.

Oscilloscope waveforms

7. Various waveforms which can be observed on an oscilloscope connected to the various test points of the transponder unit, interrogator unit and power measurement unit are given in figs. 2 and 3. Waveforms at other units are similar to those obtained in the test set Type 10166 (Sect. 2, Chap. 4).

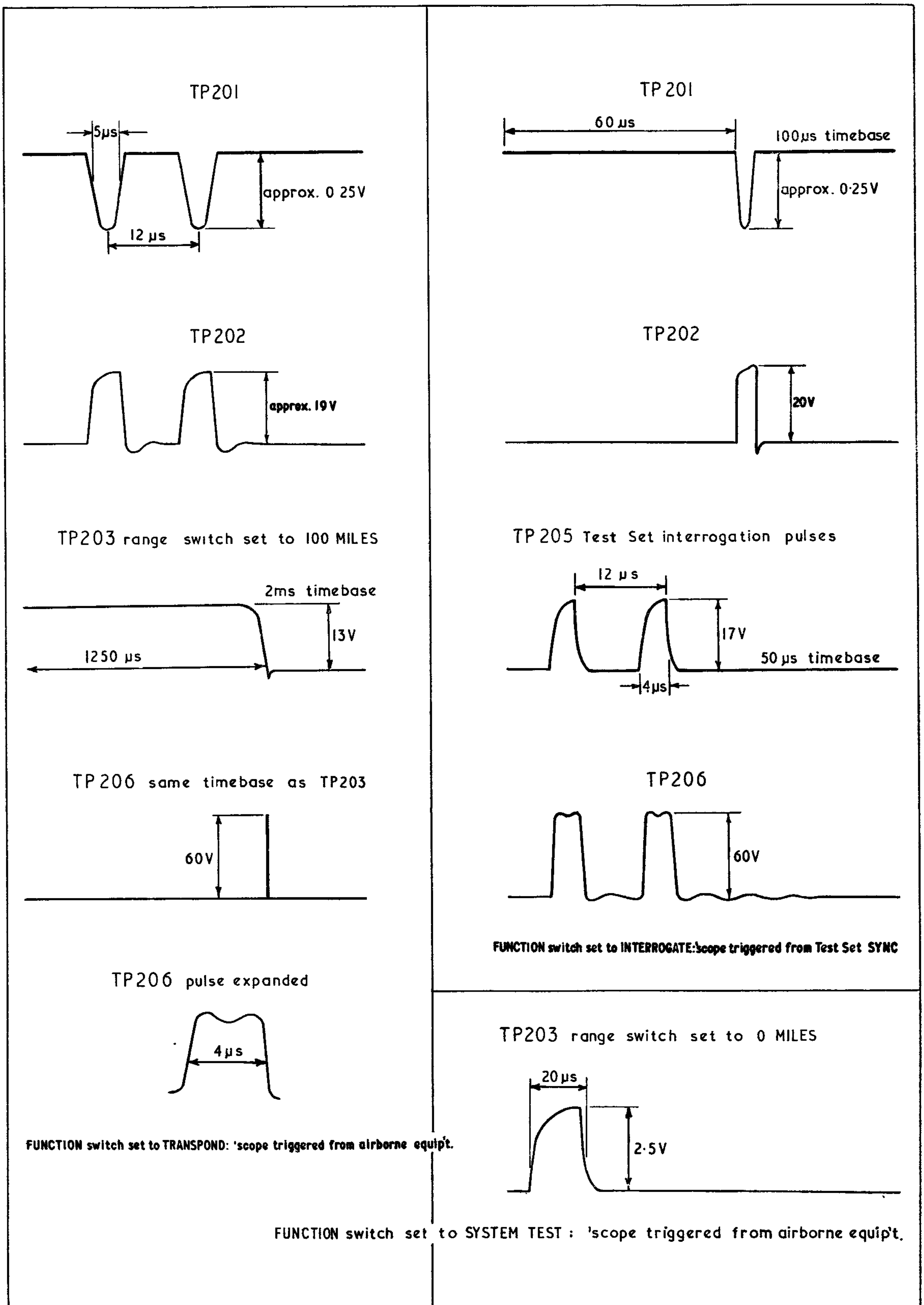

Fig. 2. Oscilloscope waveforms A (transponder unit)

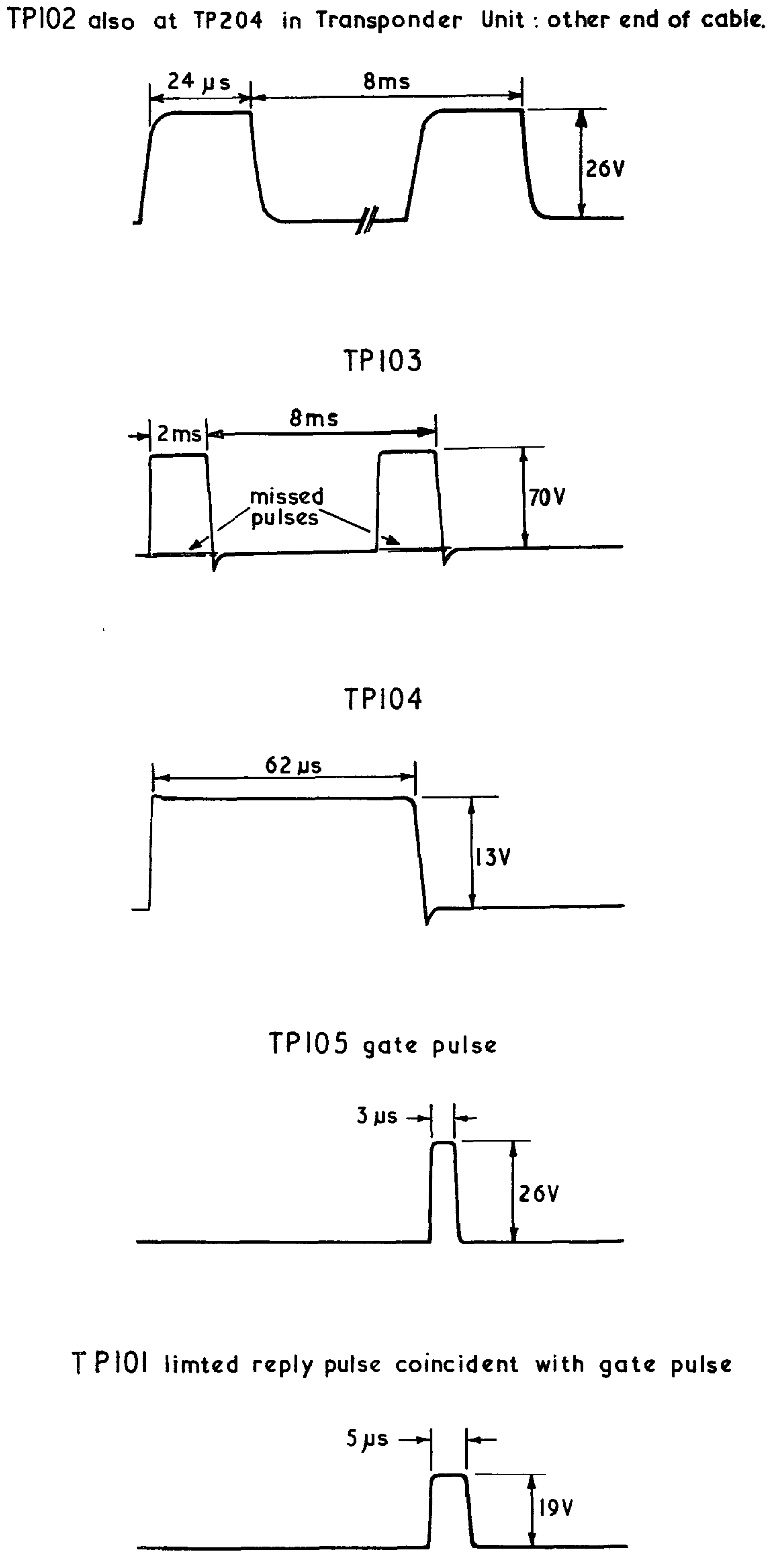

Fig. 3. Oscilloscope waveforms B (interrogator unit)

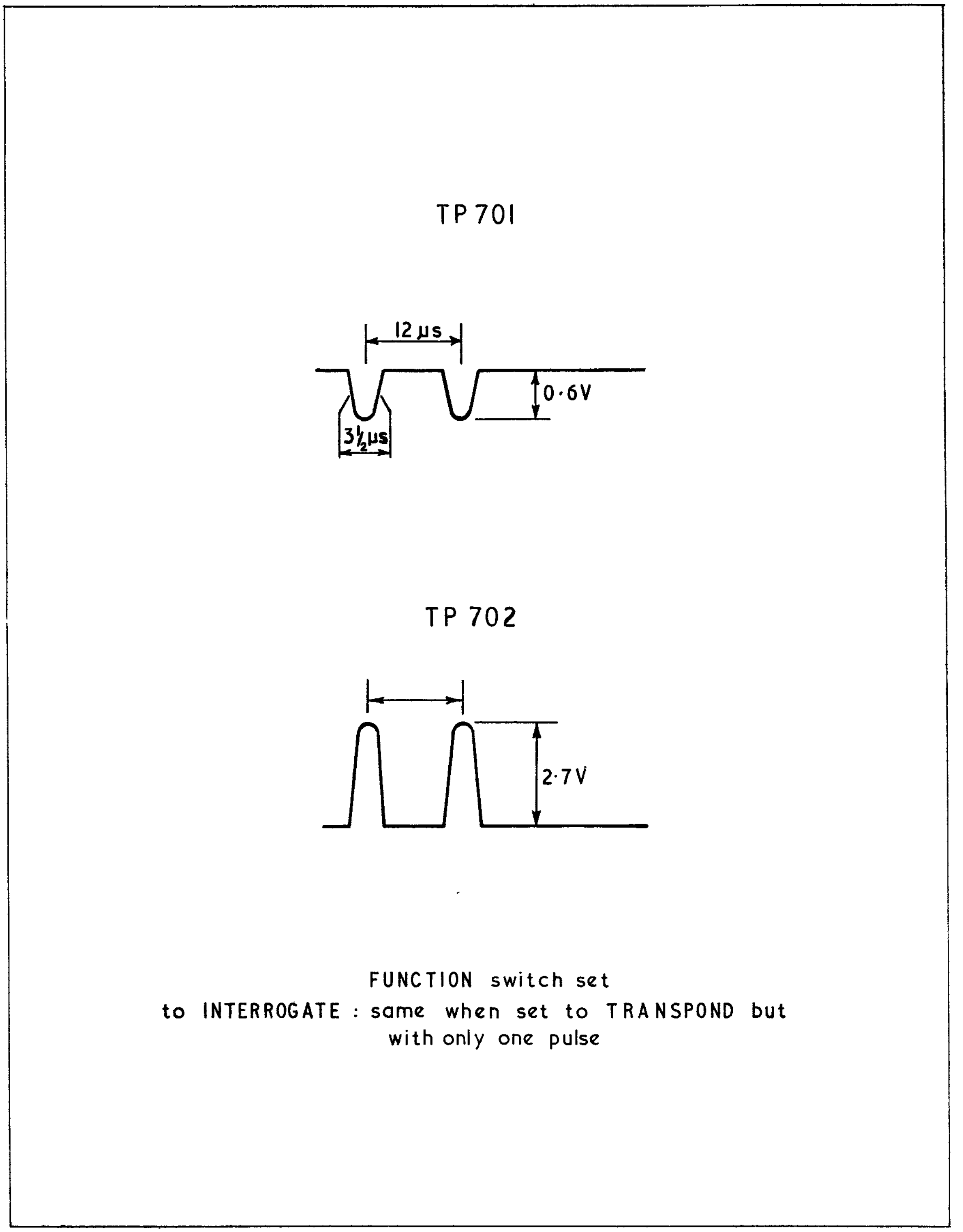

Fig. 4. Oscilloscope waveforms C (power measurement unit)

TABLE 2

Typical voltages at valve pins

Valve No.	1	2	3	4	5	6	7	8	9
V201	0	0·73	0	6·5	70	0·73	60	—	—
V202	0	1·07	0	6·5	86	1·07	89	—	—
V203	102	15	19	0	0	85	19	19	6·5
V204	60	4·4	5	0	0	104	−9·5	5	6·5
V205	0·9	0	0	6·5	105	23	−4	—	—
V206	84	18	19	0	0	103	11	19	6·5
V207	104	−13	0	0	0	41	−0·2	0	6·5
V208	−0·4	0	0	6·5	15·5	0	80	—	—
V209	0	−9	0·45	4	6·5	0	200	200	0·45
V101	30	0·22	0	6·5	6·5	−0·6	−0·14	0	0
V102	42	−0·2	0	6·5	6·5	104	−13	0	0
V103	53	4	4·7	6·5	6·5	104	−10	4·7	0
V104	0·93	0	6·5	0	88	22·5	−4	—	—
V105	38	0·05	0	0	6·5	103	−13	1·8	0
V106	103	−20	0	6·5	6·5	16	0·55	0	0
V107	−3	0	6·5	0	104	0	104	—	—
V302	0	−146	—	−146	0	—	−146	—	—
V303	0	−84	—	−84	0	—	−84	—	—
V304	−26	0	6·5	0	92	92	0	—	—
V305	—	103	208	0	6·5	90	—	—	208
V701	0	−0·4	0	6·5	0	0	−0·4	—	—
V702	82	−0·4	0·2	6·5	6·5	82	−0·4	0·17	0
V703	81	3	4·2	6·5	6·5	103	10	14·4	0

TABLE 3

Typical resistance to chassis from valve pins

Valve No.	1	2	3	4	5	6	7	8	9
V101 (CV4003)	30K	720K	0	H	H	32K	720K	0	H
V102 (CV4003)	27K	165K	0	H	H	14·5K	47K	5·1K	H
V103 (CV4024)	33K	23K	202K	H	H	8·5K	180K	2·2K	H
V104 (CV4011)	280K	0	H	H	330K	30K	68K	—	—
V105 (CV4003)	27K	51K	0	H	H	14·5K	43K	5K	H
V106 (CV4003)	43K	560K	0	H	H	43K	390K	0	H
V107 (CV4014)	220K	0	H	H	14·5K	0	13·8K	—	—
V201 (CV4014)	900	390	H	H	30K	390	105K	—	—
V202 (CV4014)	100K	470	H	H	19K	370	42K	—	—
V203 (CV4024)	12K	270K	3·9K	H	H	12·5K	41K	3·9K	H
V204 (CV4024)	27K	11K	2·2K	H	H	8K	190K	2·2K	H
V205 (CV4011)	280K	0	H	H	420K	30K	65K	—	—

TABLE 3 (Contd.)

Typical resistance to chassis from valve pins

Valve No.	1	2	3	4	5	6	7	8	9
V206 (CV4003)	12K	100K	3·9K	H	H	31K	18K	3·9K	H
V207 (CV4003)	10K	42K	1·2K	H	H	27K	90K	0	H
V208 (CV4014)	47K	0	H	H	31K	0	18K	—	—
V209 (CV4055)	4K	100K	3·9K	H	H		27K	27K	3·9K
V301				NOT FITTED					
V302 (CV4053)	0	70K	—	70K	0	—	70K	—	—
V303 (CV4048)	0	92K	—	92K	0	—	92K	—	—
V304 (CV4010)	550K	0	H	H	82K	10K	0	—	—
V305 (CV4038)	—	8K	3K	H	H	82K	—	—	3K
V501 (CV4013)	H	270	110K	8K	0	8K	0	270	H
V502 (CV4010)	11K	560	H	H	9K	9K	560K	—	—
V503 (CV2970)	1·2K	3·3K	3·3K	H	H	0	8K	8K	0
V504 (CV2970)	1·2K	16·5K	16·5K	H	H	0	8K	8K	0
V505 (CV2970)	1·2K	330	330	H	H	0	1·2K	1·2K	0
V701 (CV4007)	0	5M	H	H	0	0	5M	—	—
V702 (CV4004)	42K	5M	320K	H	H	42K	5M	320K	H
V703 (CV4024)	14K	100K	1·2K	H	H	8K	108K	7K	H

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Section 4

TEST SET TYPE 7739

SECTION 4

TEST SET TYPE 7739 (10S/17011)

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Note.—A List of Contents appears at the beginning of each Chapter.

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3 Servicing and alignment instructions

Chapter 1

GENERAL DESCRIPTION AND OPERATING INSTRUCTIONS

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LEADING PARTICULARS

Marker frequencies
- 750 *kc/s marker oscillator* ± 2%
- 40·25 *Mc/s marker oscillator* ±0·02%
- 63 *Mc/s marker oscillator* ± 0·02%

Booster amplifier (40·25 *Mc/s*)
- *Bandwidth* ± 5 *Mc/s at less than* — 6 *dB output level* (*with* 100 *mV input*)
- ± 0·75 *Mc/s at less than* — 0·5 *dB output level* (*with* 100 *mV input*)

Booster amplifier (*output*)
- *Minimum output* 7*V RMS with* 100 *mV RMS input at* 40·25 *Mc/s.*
- 63 *Mc/s marker oscillator output not less than* 50 *mV RMS.*
- *Valve heaters should be* 6·3 *V RMS* ± 5%.
- *Bias supply calibrated scale. Tolerance* ± 0·1*V of setting voltage* — 3*V bias line to be* ± 5%.

Power Supply ... 100*V to* 115*V or* 200 *to* 250*V ac* (45 *c/s to* 530 *c/s*)

Dimensions ... 17½ *in. by* 10½ *in. by* 13½ *in. high.*

Weight ... 39 *lb.*

General description

1. Test set 7739 (*fig.* 1) is part of the test equipment required for 2nd line (RN) and 3rd line (RAF) servicing of the amplifying unit (IF) of the airborne transmitter-receiver. It is used in conjunction with the frequency swept oscillator CT202 and a suitable oscilloscope, e.g. oscilloscope Type 13A, as a crystal controlled marker generator for use in the alignment of the amplifying units (i.f.).

2. For the alignment of the r.f. unit (multiplier), the booster amplifier varies the output of the CT202. The terminated output voltage of the booster amplifier is 7V r.m.s. for less than 100mV input from the CT202. The crystal controlled marker generator provides a marker at 40·25 Mc/s with optional subsidiary markers at 750 kc/s intervals in relation to the centre frequency marker.

3. For the alignment of the amplifying unit (i.f.), the crystal controlled marker generator provides a marker at 63 Mc/s with optional subsidiary markers at 750 kc/s intervals. Variable negative bias supplies are provided for use during the alignment of this unit.

4. The test set circuit diagram, the connecting diagrams, and a list of contents are etched on the hinged lid covering the storage space in the front cover.

Note . . .
The circuit diagram etched on the hinged lid may not incorporate the latest modifications and amendments. Always check by referring to the circuit diagram in this publication.

The storage space contains all relevant connectors and adaptors, etc., which are needed for the alignment of both units. These are listed below:

1 mains connector	(10HS/86)
1 booster amplifier input connector	(10HS/87)
1 63 Mc/s marker output connector	(10HS/89)
1 40·25 Mc/s marker output connector	(10HS/91)
2 bias output connectors	(10HS/90)
1 impedance matching unit input connector...	(10HS/88)
1 impedance matching unit Type 11448	(10B/16901)
1 test prod Type 11449	(10S/17026)
1 adaptor test	(6625-99-943-2327)
1 63 Mc/s adaptor test ...	(6625-99-943-1805)
1 lead Type 233	(10HS/80)

5. The test set is housed in an instrument case Reference No. 10S/17025. It has facilities for mounting in a 19 in. rack.

Operating instructions

6. After the test set Type 7739 has been unpacked, remove all packing material, inspect the instrument, set the voltage selector plugs to suit the mains voltage in use, and insert the correct fuses.

Mains Fuses

7. For use on 200V to 250V supplies, use two 1-amp. fuses Ref. (Z590109), and for use on 110V supplies use two 2-amp. fuses Ref. (Z590110). All fuses are accessible from the front panel and holders are supplied for those not in use.

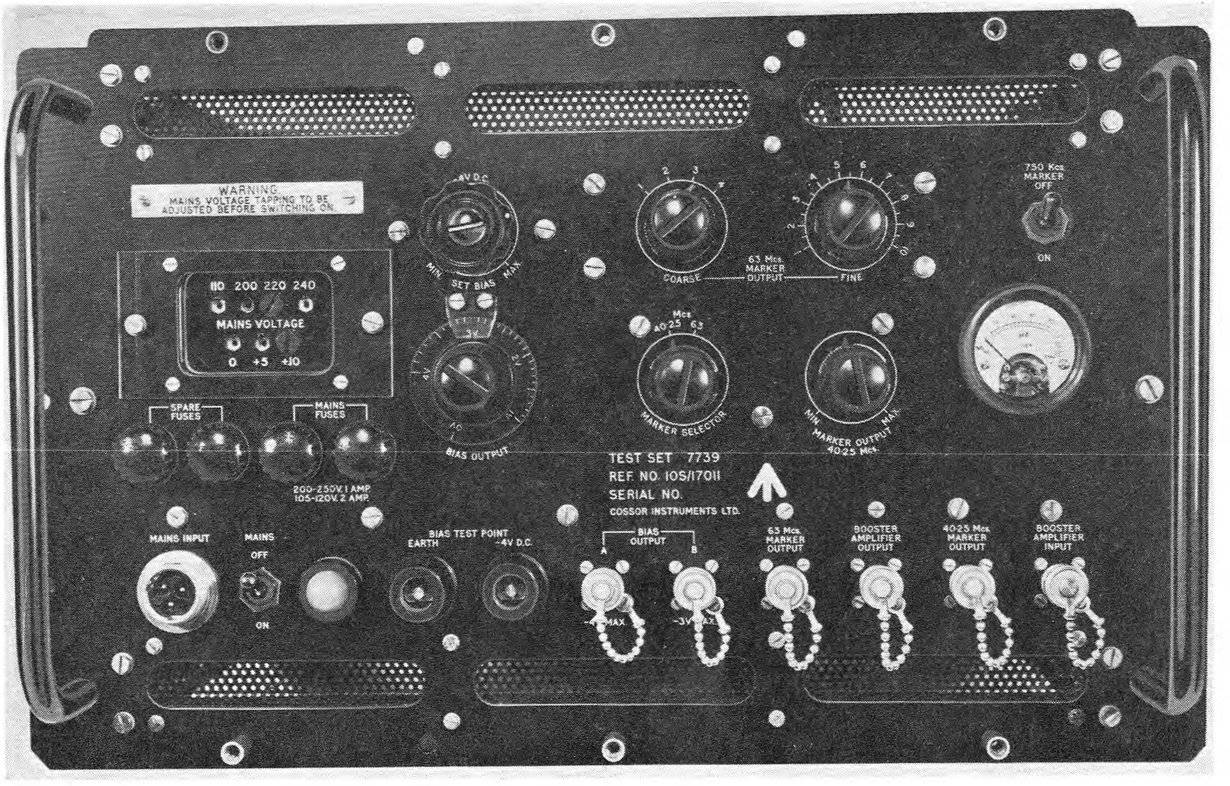

Fig. 1. Front panel controls

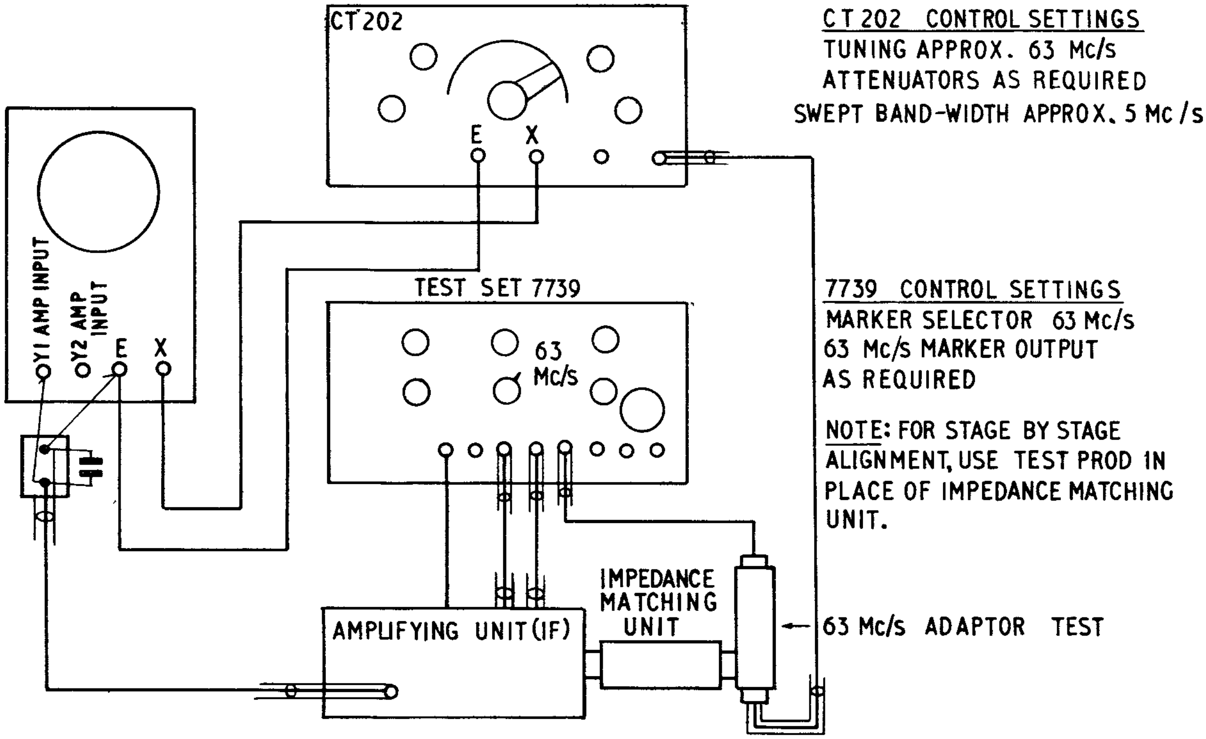

Fig. 2. Testing for alignment of amplifying unit (i.f.)

Mains connector (10*HS*/86)

8. Remove the three-core mains connector with its 3-pole Mk. 4 socket from the front cover, where it is stored, and fit it with a suitable three-pin plug. The colour coding is as follows:

Line	Red
Neutral	Blue
Earth	Green

Warning

The instrument must not be operated with the case off, except when servicing it, and even then the greatest caution must be observed. As an extra precaution, a microswitch has been fitted which disconnects the mains supply when the chassis is removed from the case.

Testing for alignment of amplifying units (IF)

9. Connect the amplifying units (i.f.), the test set 7739, the CT202, and the oscilloscope Type 13A as in fig. 2, namely:—

(1) Connect the output of the CT202 to the 63 Mc/s adaptor test (6625-99-943-1805) with the impedance matching unit input connector (10HS/88);

(2) Connect the 63 Mc/s adaptor test to the test set 7739 63 Mc/s MARKER OUTPUT socket via the 63 Mc/s marker output connector (10HS/89);

(3) Connect the impedance matching unit Type 11448 (10B/16901) between the 63 Mc/s adaptor test and the input socket of the amplifying units (i.f.);

(4) Connect the bias supplies from the 7739 to the i.f. amplifier with the bias output connectors (10HS/90);

(5) Connect the earth terminal on the 7739 to the i.f. amplifier chassis;

(6) Connect the i.f. output and chassis of the i.f. amplifier to the Y INPUT and EARTH terminal of the oscilloscope with the connector provided, i.e. lead Type 233 (10HS/80);

(7) Connect the X and EARTH terminals on the CT202 to the X and EARTH terminals on the oscilloscope respectively;

(8) Connect h.t. and heater supplies to the i.f. amplifier.

10. Set up the equipment in the following manner:

(1) Set the CT202 CARRIER TUNING control 63 Mc/s, the SWEPT BANDWIDTH to approximately 4 Mc/s and the RF OUTPUT to a convenient working level, i.e. a level at which no overloading occurs.

(2) Switch the 7739 MARKER SELECTOR switch to 63 Mc/s and set the 63 Mc/s MARKER OUTPUT controls to minimum.

(3) Switch on all supplies to the test gear, allowing a warming-up period of at least ten minutes before use.

(4) With no input to the oscilloscope, align the traces to coincide. Monitor the output response of the i.f. amplifier on the A1 amplifier of the oscilloscope.

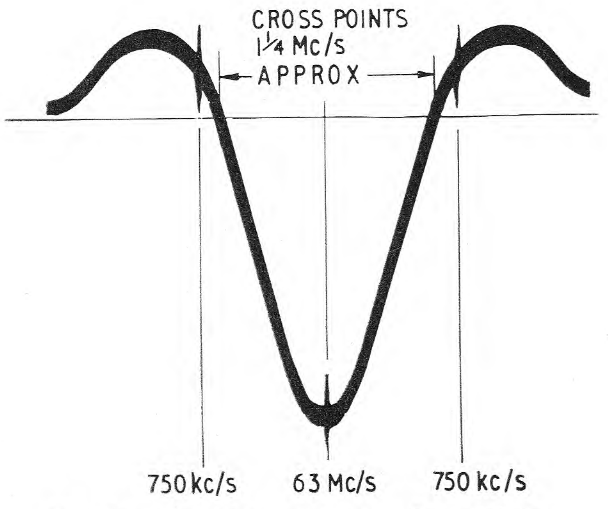

Fig. 3. Final response curve of amplifying unit (i.f.)

(5) Increase the 63 Mc/s marker output level until a marker appears on the response curve. Adjust the CT202 carrier tuning control to bring the marker into the centre of the trace. Switch on the 750 kc/s markers.

(6) Using the A2 amplifier, and with the Y PLATE SELECTOR switch set to A1/A2, align the i.f. amplifier to obtain a response curve as in fig. 3 according to the alignment instructions in AP116B–0304–6 or NAVAL Vol. 4, Part 6.

Note 1 . . .
Physical spacing between the centre marker and the 750 kc/s markers can be changed by an adjustment of the CT202 SWEPT BANDWIDTH control. Small spurious markers may appear between the centre marker and the 750 kc/s markers during alignment. These should be ignored.

Note 2 . . .
The marker output should always be reduced to a minimum during the final stages of alignment.

Note 3 . . .
If complete re-alignment is necessary, the test prod Type 11449 (10*S*/17026) *may be used in place of the impedance matching unit for stage to stage alignment. The r.f. level will have to be increased as necessary.*

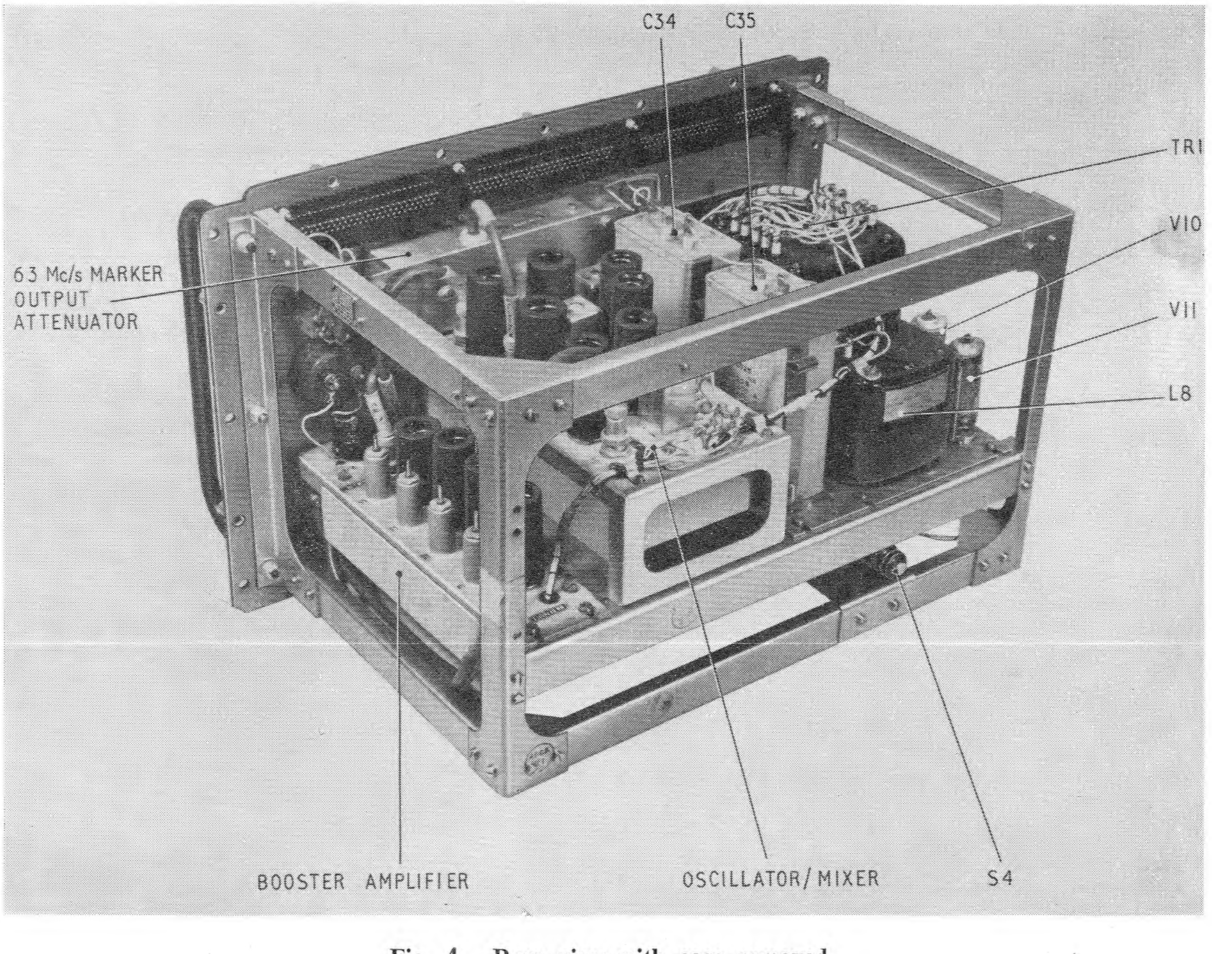

Fig. 4. Rear view with case removed

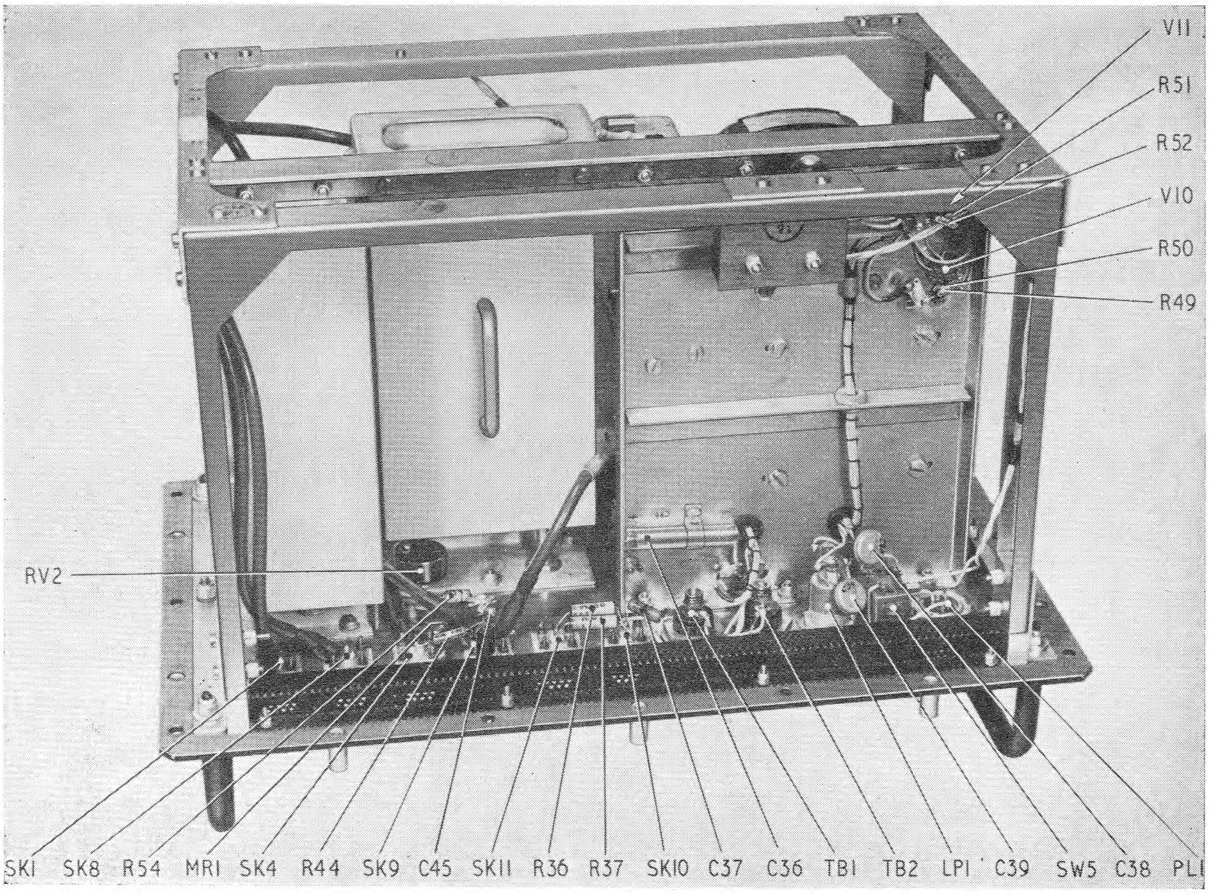

Fig. 5. View from below with case removed

Chapter 2

CIRCUIT DESCRIPTION

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General

1. The complete circuit diagram of the test set 7739 is shown in fig. 2. It consists physically of three parts ; the power unit and main chassis, the booster amplifier, and the oscillator/mixer assembly, the latter two each have their own separate chassis. Electronically, the oscillator/mixer unit is in three sections : the 750 kc/s marker oscillator, the oscillator quadrupler, and the mixer and marker amplifier. All controls and sockets, etc. are mounted on the front panel.

Mains supply

2. The mains input is via a connector provided, to a 3-pin plug, PL1, on the front of the instrument. Mains switch, S5, fuses, FS1 FS2, and voltage selector, LK1, are also inserted in the mains supply. A miscroswitch, S4, on the rear of the chassis disconnects the mains supply when the chassis is removed.

3. The voltage selector panel is situated on the front of the instrument, two small plugs select different tappings on the transformer T1. The tappings are at 110V, 200V, 230V and 240V and are adjustable by + 5V or + 10V.

4. The transformer TR1 supplies HT and heater voltages and a pilot lamp 1LP1 in the heater circuit indicates when power is applied to the instrument.

HT and bias supplies

5. The HT circuit uses a full-wave rectifiers system V10 and V11 and an inductance-capacitance filter, L8, C34 and C35.

6. External bias supplies are derived from the HT supply and are available at the front panel. A maximum bias of –4V and –3V are obtainable and a bias test terminal TB2 is provided for continuous monitoring of the –4V level.

7. A front panel pre-set control (RV4) allows the –4V level to be adjusted. RV5 is a calibrated control which may be set over a range of –1V to –4V.

Booster amplifier

8. The booster amplifier is a 4-stage wide-band amplifier centred on 40·25 Mc/s. There are three single-tuned stages feeding a wide-band output stage matched and terminated with a 51-ohm impedance when connected to adaptor test (6625–99–943–1805). The first stage of the amplifier is V1. An 82-ohm resistor R1 in the grid circuit provides a termination for the signal input coaxial cable. The anode circuit of V1 is capacity coupled to the inductor L1 which should be tuned to 37 Mc/s. Circuit damping is provided by a 2·2K resistor R2 and negative feedback developed across a 560-ohm resistor R4 common to the first two stages of the amplifier. The second stage of the amplifier is V2, the grid of which is directly connected to the inductor L1. The anode circuit is capacity coupled to the inductor L2 which should be tuned to 41·5 Mc/s. Circuit damping is provided by a 2·2K resistor R6 and negative feedback developed across the 560-ohm resistor R4.

9. The third stage of the amplifier is V3, the grid being directly connected to the inductor L2. The anode circuit is capacity coupled to the inductor L3 which should be tuned to 38·5 Mc/s. Circuit damping is provided by a 510-ohm resistor R10, in the anode circuit of V3. The output stage of the amplifier is V4. The grid is directly connected to the inductor L3. The output circuit is transformer coupled to a 51-ohm terminated coaxial cable. A 560-ohm resistor R56 provides a load for the secondary if the adaptor test (6625–99–943–2327) is not connected. This prevents excessive meter deflection of M1 the output monitor. The tuned circuit L3 is tuned to 44 Mc/s.

10. The terminated output voltage is at least 7V RMS with less than 100 mV RMS input. The overall frequency response is 39·5 Mc/s to 41 Mc/s with variation in output of less than 0·5 dB : and 35·5 Mc/s to 45·5 Mc/s with variation in output of less than 6 dB, at maximum output.

11. The output is monitored with a 0–100 µA DC meter M1, via a half-wave germanium rectifier MR1, and pre-set control RV6.

Crystal calibrator

12. The calibrator consists of a crystal-controlled oscillator V5A working in a Pierce circuit at a fundamental frequency of 15·75 Mc/s or 10·0625 Mc/s ± 0·02%. The fourth harmonic of either frequency is selected in the grid circuit of V5B via switch S1c and applied via RC coupling in the anode circuit to the grid of a detector V7A. These are the centre frequency markers at 40·25 Mc/s or 63 Mc/s selected by switch S1a.

15. A portion of the frequency modulated booster amplifier output, centred on 40·25 Mc/s is applied to V7B grid via R44 and SK6 and, together with the markers applied to V7A grid via Sia and V5B, it produces a beat frequency in the anode circuit of V7A when the applied signal frequencies coincide.

16. This rectified signal is amplified by V8 and V9 and applied to the display oscilloscope via SK7 to appear as a marker or markers on the trace. The gain of the amplifier is controlled by RV2 in the grid circuit of V9.

Impedance matching unit Type 11448

17. The impedance matching unit is connected between the input of the amplifying unit (IF) and the 63 Mc/s adaptor test during final stages of alignment. The input impedance is approximately 70ohms and the output is arranged to be resonant at 63 Mc/s with the stray capacities of the connectors and input conditions of the 63 Mc/s amplifying unit (IF).

Test prod Type 11449

18. The test prod is for stage-by-stage signal

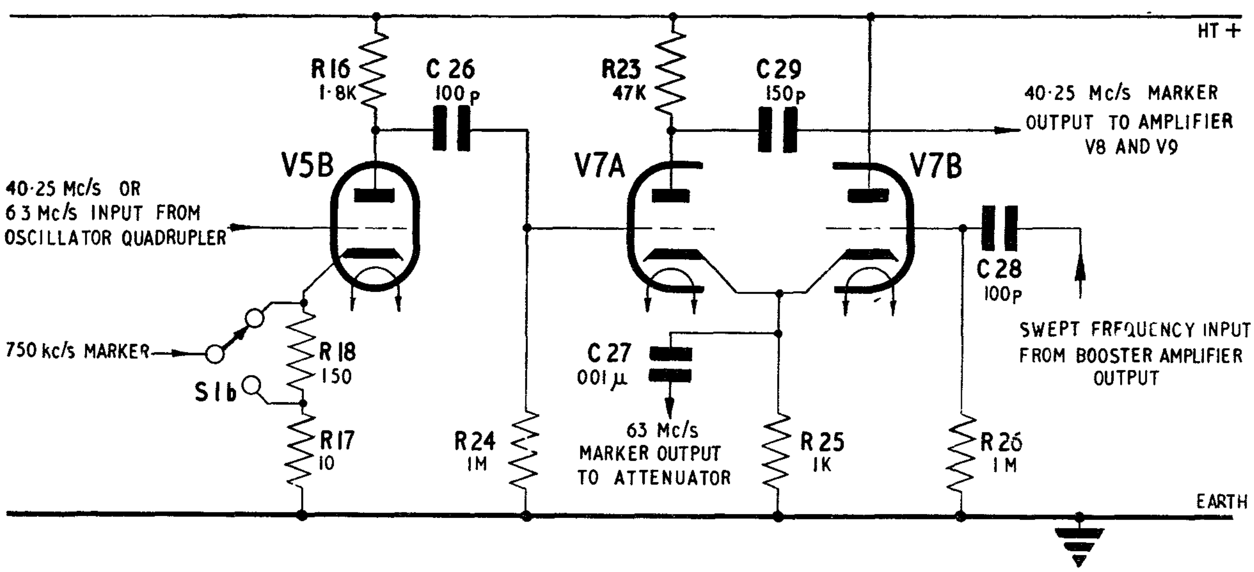


Fig. 1. Simplified mixer circuit

13. The output of the subsidiary 750 kc/s marker oscillator V6 is applied to the cathode circuit of V5B via a pre-set control RV1 ; it modulates the centre frequency markers producing sum and difference frequencies resulting in 750 kc/s interval side markers. These markers are optional and may be selected by switch S2. Frequency tolerance of the 750 kc/s marker is ± 15 kc/s.

14. Cathode follower valves V7A and V7B have a common cathode load, R25, and provide an output source for the 63 Mc/s marker or markers, via a variable attenuator RV3 and a switched attenuator (S3), at a maximum output level of 50 mV RMS across an 82-ohm connector terminated at SK9.

application of the CT202 output to the 63 Mc/s amplifying unit (IF) via the appropriate valve-holder. It is used in place of the impedance matching unit in the initial stages of alignment of the amplifying unit (IF). The input impedance is approximately 80ohms.

63 Mc/s adaptor test

19. The 63 Mc/s adaptor test is for 63 Mc/s marker injection into the test prod or impedance matching pad together with CT202 output and is for use during alignment of the amplifying unit (IF). This unit contains a 63 Mc/s tuned circuit for reducing the amplitude ratio between the centre marker and the 750 kc/s markers. Trimmer C44 is adjusted to give minimum output at 63 Mc/s.

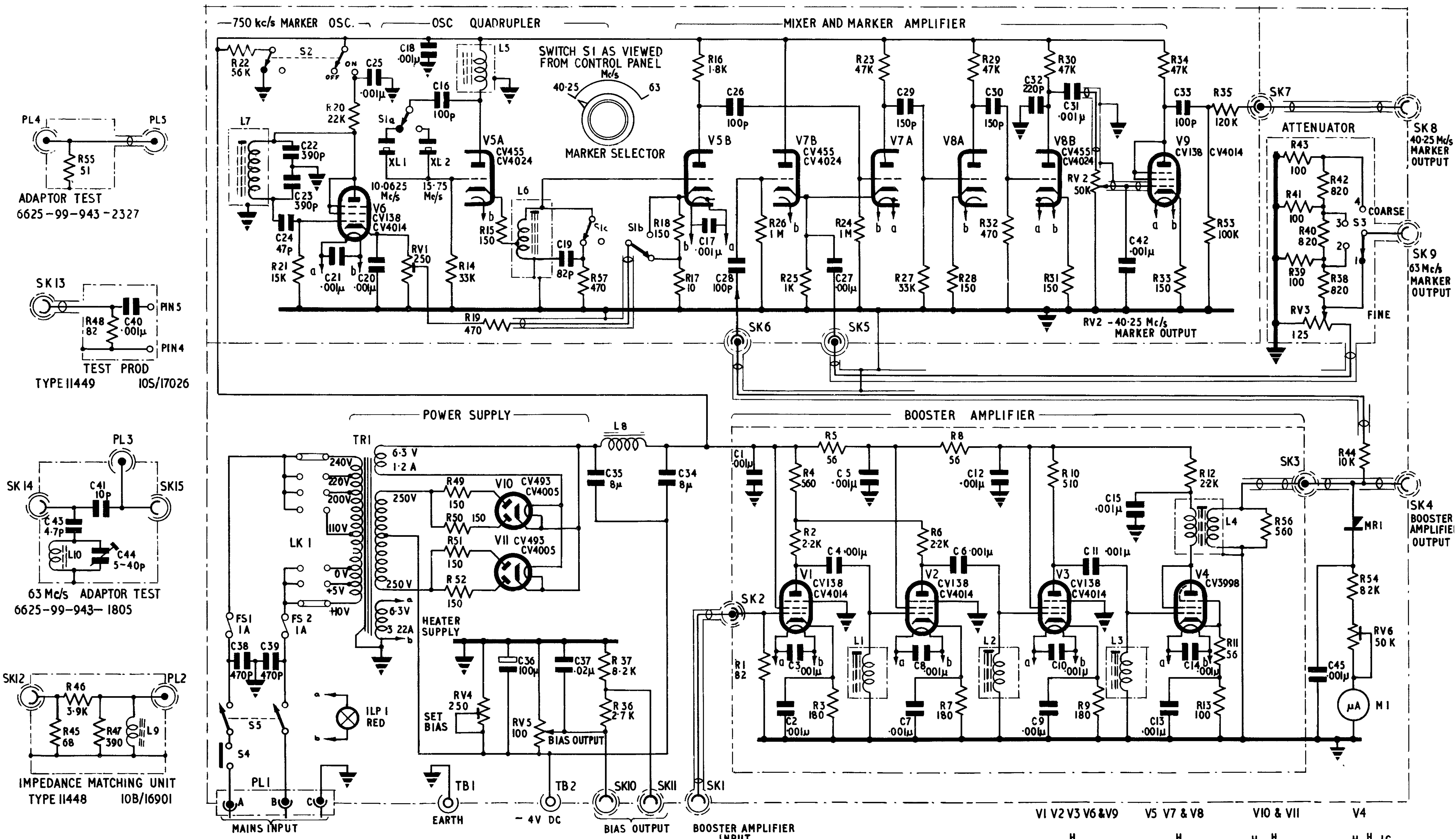
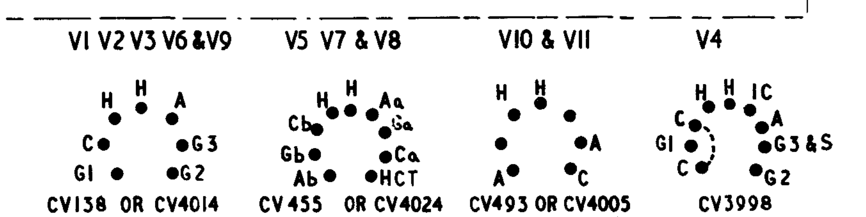


FIG. 2 TEST SET 7739 TYPE 10S/17011 CIRCUIT DIAGRAM



Chapter 3

SERVICING AND ALIGNMENT INSTRUCTIONS

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Introduction

1. The test set 7739 (10S/17011) is an item of special test gear required for use with the airborne radio installations 18107 series. Major servicing is not carried out by units, maintenance action is confined to minor servicing, including replacement of valves and those components which do not affect the alignment of any part of the circuit.

2. Servicing of the parts affecting alignment is to be carried out only at the appropriate alignment or calibration centre. RN 2nd line workshops may carry out the alignment procedures specified, provided all the test equipment listed is available.

Warning

This instrument uses voltages which may be dangerous. Do not operate the test set with its case removed except when servicing makes this necessary. Exercise extreme caution and always use well insulated tools for testing the circuits.

Dismantling and reassembly

3. To remove the front cover, slacken off the ten large screws on the outside of the case, and lift off. To remove the instrument from its case, unscrew completely the ten 4B.A. cheese-head screws around the outer edge of the front panel and lift out the chassis by the two handles. Remove the covers of the marker oscillator/mixer and the booster amplifier by unscrewing the four red screws on the top of the two chassis.

Note . . .

Further dismantling should not be necessary for normal routine servicing.

4. When repair work has been completed, re-assemble the test set in the reverse order of that given for dismantling but, before putting back the case, shake out any loose pieces of wire or solder.

Minor repairs—Precaution when changing components

5. Some of the resistors used in this instrument have very short leads. Consequently, when soldering a new resistor into position, care must be taken not to overheat it or its value will alter. It is advisable to attach a crocodile clip near the end of the resistor to absorb some of the heat from the soldering iron.

6. When changing any of the larger capacitors use a hot, well-tinned iron to solder the connecting lead to the capacitor terminal. Make the joint quickly and cool it by blowing. Do not overheat the terminal or the internal connection may become unsoldered and the capacitor will be open-circuited.

Cleaning switch contacts

7. Do not use abrasive materials to clean the contacts and rotor blades on the wafer switches or damage will result to the silver plating. For cleaning use carbon tetrachloride to which a few drops of light oil have been added.

Fault finding—general

8. Most faults likely to arise on the test set may be diagnosed from the examination of the outputs on an oscilloscope and the action produced by operating the different controls. When starting to localize a fault, refer to the circuit description and diagram in Chapter 2 and proceed by careful deduction to narrow down the fault to one stage of the circuit. Then make a detailed check of voltages and component values in order to find the defective items.

9. Fig. 1 and 2 are component layout diagrams which will help to locate particular components. Tables 1 to 3 give details of the valves used in the test set and the valve base connections are shown on the circuit diagram.

10. The tables give approximate values of voltages to be expected at certain points in the circuit. In addition, the following paragraphs give some general advice on tracing faults.

No mains input

11. If the pilot light on the front panel does not light when the set is connected to the mains and switched on, check the fuses and that the micro-switch is working.

No HT voltage

12. If there is no h.t. voltage when the mains power is applied, check that the resistance between TR1 h.t. secondary centre-tap and chassis is between 0 and 70 ohms depending on the setting of RV4; if this is not so, check individually all wiring and components associated with this circuit and the h.t. rail for short-circuit conditions. With the 750 kc/s MARKER switch to OFF, check that the resistance between the h.t. rail and chassis is 56K.

Faulty booster amplifier

13. If the output voltage monitor reads high or full scale with no or little output across the adaptor test (6625–99–943–2327), check that the adaptor test mates correctly with the BOOSTER AMPLIFIER OUTPUT socket on the front panel.

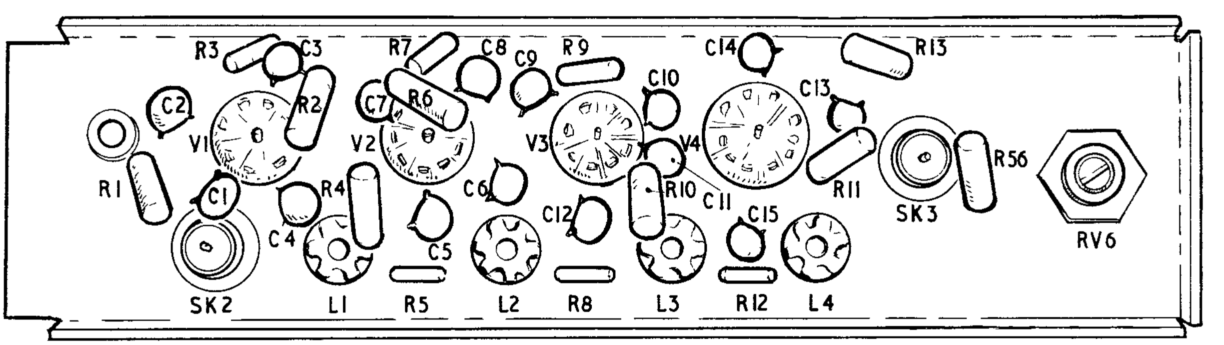


Fig. 1. Test set 7739—Components in booster amplifier

TABLE 1 (*see para.* 20 *to* 22)

Voltages in Booster Amplifier

Valve	Electrode	Pin number	Voltage (Volts)
V1	Anode	5	195
CV138	G3	6	0
or	G2	7	222
CV4014	G1	1	0
	Cathode	2	2
	Heater	3 and 4	6·3 RMS

Valve	Electrode	Pin number	Voltage (Volts)
V2	Anode	5	193
CV138	G3	6	0
or	G2	7	220
CV4014	G1	1	0
	Cathode	2	2
	Heater		6·3 RMS
V3	Anode	5	212
CV138	G3	6	0
or	G2	7	217
CV4014	G1	1	0
	Cathode	2	2
	Heater	3 and 4	6·3 RMS
V4	Anode	7	188
CV3998	G3	8	2·2
	G2	9	188
	G1	2	0
	Cathode	1 and 3	2·2
	Heater	4 and 5	6·3 RMS

14. If the output voltage monitor fails to indicate when the normal 100 mV input is applied at 40·25 Mc/s, check that SK3 on the booster amplifier is mating correctly. If, however, the output is normal across the adaptor test (6625–99–943–2327), check the meter M1 and the meter rectifier MR1 by applying approximately 6V RMS from a separate source, e.g. from the 6V heater line. This should give a reading of 60 μA.

15. If the output is low or the bandwidth characteristic is out of the specification limits, as quoted in Chapter 2, para. 10, RAF should return the test set to the appropriate calibration or alignment centre. At the appropriate calibration centre change any suspect valves and re-align using the following test equipment. RN should either re-align using the following test equipment, or return the test set to the calibration centre.

Signal generator either signal generator Type 68 (10S/16370), or Avo test oscillator CT378.

Multimeter valve CT429 or

Valve millivoltmeter Type 8426 (10S/16727).

Video oscillator (signal generator 65B) (10S/16499)

(1) Mate the adaptor test (6625–99–943–2327) with the booster amplifier output socket on the front panel ;

(2) Connect a multimeter valve CT429 or millivoltmeter Type 8426 (10S/16727) input probe to the terminated adaptor test 6625–99–942–2327 with a BNC 50-ohm receptacle using short leads;

(3) Apply the output of a signal generator 68 (10S/16370) terminated in 82ohm resistor to the junction of V4 pin 1 and C11. Set the generator to 44 Mc/s. Adjust the slug in L4 for maximum output, and lock the slug ;

Note . . .
Input approximately 50 *mV for* 0·1*V output.*

(4) Transfer the signal generator output to the junction of V3 pin 1 and C6. Set the generator to 38·5 Mc/s, adjust the slug in L3 for maximum output, and lock the slug ;

Note . . .
Input approximately 160 *mV for* 1*V output* (38·5 *Mc/s*).

(5) Transfer the signal generator input to the junction of V2 pin 1 and C4, and reduce the output of the generator approximately 20 dB. Set the generator to 41·5 Mc/s, adjust the slug in L2 for maximum output, and lock the slug ;

Note . . .
Input approximately 14 *mV* (41·5 *Mc/s*).

(6) Transfer the signal generator to the BOOSTER AMPLIFIER INPUT socket on the front panel having removed the 82ohm termination. Set the signal generator to 37 Mc/s, adjust the slug in L1 for maximum output, and lock the slug ;

Note . . .

Input approximately 2 *mV for* 1*V output.*

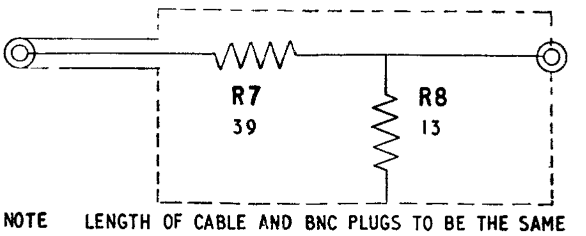
(7) Connect a test adaptor similar to the adaptor test (6625–99–943–2327) but having an attenuation of 4 : 1 ;

Note . . .
This should comprise resistances of 13 *ohms and* 39 *ohms in series as a cable termination, the output being taken from across the* 13 *ohm resistance. RF cable should be the same length and have similar connectors to the adaptor test* (6625–99–943–2327) (fig. 2).

(8) Set the generator to 40·25 Mc/s and increase the input to obtain a millivoltmeter reading

of 1·5V. Check the frequency response of the amplifier ; with 100 mV input and the generator set to 35·25 Mc/s and 45·25 Mc/s, the output must not be less than 0·75V. With the generator set 39·5 Mc/s and 41 Mc/s, the output must not be less than 1·34V ;

(9) Check that an output level of 7V ÷ 4 can be obtained at 40·25 Mc/s using the millivoltmeter and 4 : 1 output attenuation (*fig.* 2) ;



NOTE LENGTH OF CABLE AND BNC PLUGS TO BE THE SAME AS ADAPTOR TEST 6625-99-943-2327.

Fig 2. Booster amplifier output 4 : 1 attenuator for test purposes

Table 2 (*see para.* 20 *to* 22)

Voltages in Oscillator/Mixer

Valve	Electrode	Pin number	Voltage (Volts)
V5	Anode A	6	205
CV455	Grid A	7	0
or	Cathode A	8	2
CV4024	Anode B	1	222
	Grid B	2	0
	Cathode B	3	1·8
	Heater	4 and 5 to 9	6·3 RMS
V6	Anode	5	105
CV138	G3	6	105
or	G2	7	105
CV4014	G1	1	0
with 750 kc/s	Cathode	2	1·2
MARKER switch ON	Heater	3 and 4	6·3 RMS
V7	Anode A	6	140
CV455	Grid A	7	0
or	Cathode A	8	3·6
CV4024	Anode B	1	222
	Grid B	2	0
	Cathode B	3	3·6
	Heater	4 and 5 to 9	6·3 RMS
V8	Anode A	6	112
CV455	Grid A	7	0
or	Cathode A	8	0·45
CV4024	Anode B	1	100
	Grid B	2	0
	Cathode B	3	0·45
	Heater	4 and 5 to 9	6·3 RMS
V9	Anode	5	60
CV138	G3	6	60
or	G2	7	60
CV4014	G1	1	0
	Cathode	2	0·55
	Heater	3 and 4	6·3 RMS

(10) With the output set to a meter reading of 1·5V (on the millivoltmeter using the 4 : 1 attenuator), set RV6 until the panel meter reads 60 µA.

Faulty oscillator/mixer

16. If there is no 40·25 Mc/s centre marker output;

(1) Check that XL1 is oscillating at the fundamental frequency of 10·0625 Mc/s by coupling a wavemeter into the cathode circuit of V5A and checking that maximum signal pick-up is obtained at approximately 10 Mc/s. This is not intended to be an accurate frequency check. Marker selector should be in 40·25 Mc/s position.

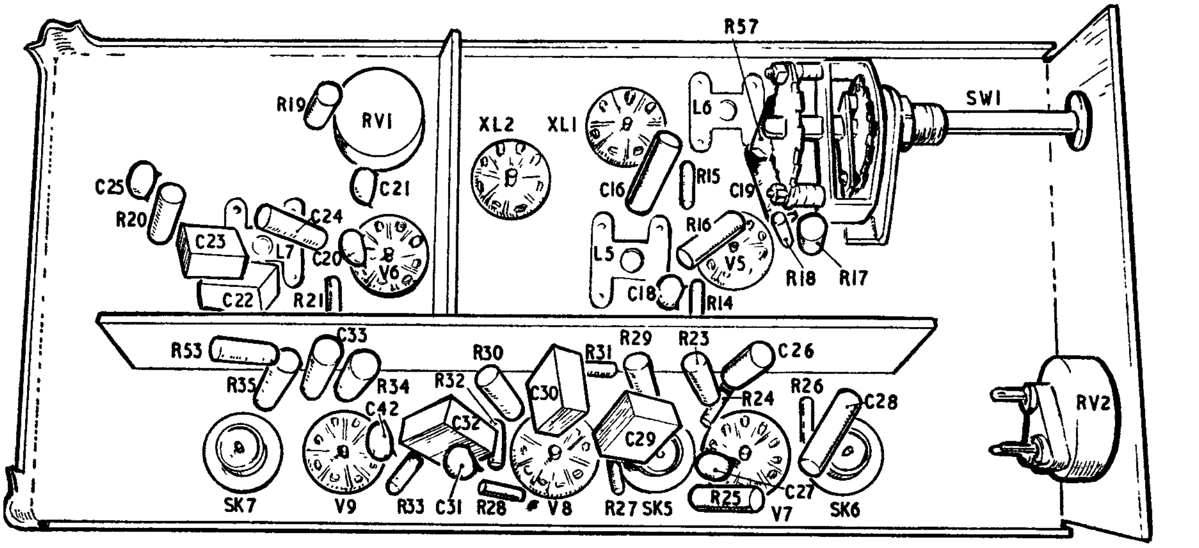


Fig. 3. Test set 7739—Components in oscillator/mixer

(2) Check that the resistance to earth from the junction of C28 and SKT6 is approximately 10K.

(3) Check the marker amplifier V7A, V 8 and V9 as follows : with the 750 kc/s marker switched off and the MARKER SELECTOR to 40·25 Mc/s, connect a video oscillator via a 0·1 μF capacitor to the junction of R23 and C29. Mate the 40·25 Mc/s marker output connector (10HS/91) with the 40·25 Mc/s MARKER OUTPUT socket on the front panel, and connect the other end to an oscilloscope Y amplifier and chassis. Set the oscilloscope Y amplifier gain to maximum and switch off the time-base. Set the video oscillator to 20 kc/s and set the 40·25 Mc/s marker output control (RV2) to maximum. Set the video oscillator output to give a Y deflection on the oscilloscope of 4 cm (approximate) reducing the Y amplifier gain if necessary. Remove the 40·25 Mc/s marker connector from the Y amplifier input, and replace it by the video oscillator output connector. Reset the video oscillator output for the same Y deflection ; the difference in the video oscillator settings to be at least 40 dB.

17. If there is no 750 kc/s marker ;

(1) Check that V6 circuit oscillates when the 750 kc/s MARKER switch is on and check RV1 for continuity ;

(2) Check S1b switch contacts.

18. If there is no 63 Mc/s centre marker output ;

(1) Check that XL2 is oscillating at the fundamental frequency of 15·75 Mc/s by coupling a wavemeter into the cathode circuit of V5A and checking that maximum signal pick-up is obtained at 15·75 Mc/s. This is not intended to be an accurate frequency check. Marker selection should be in 63 Mc/s position.

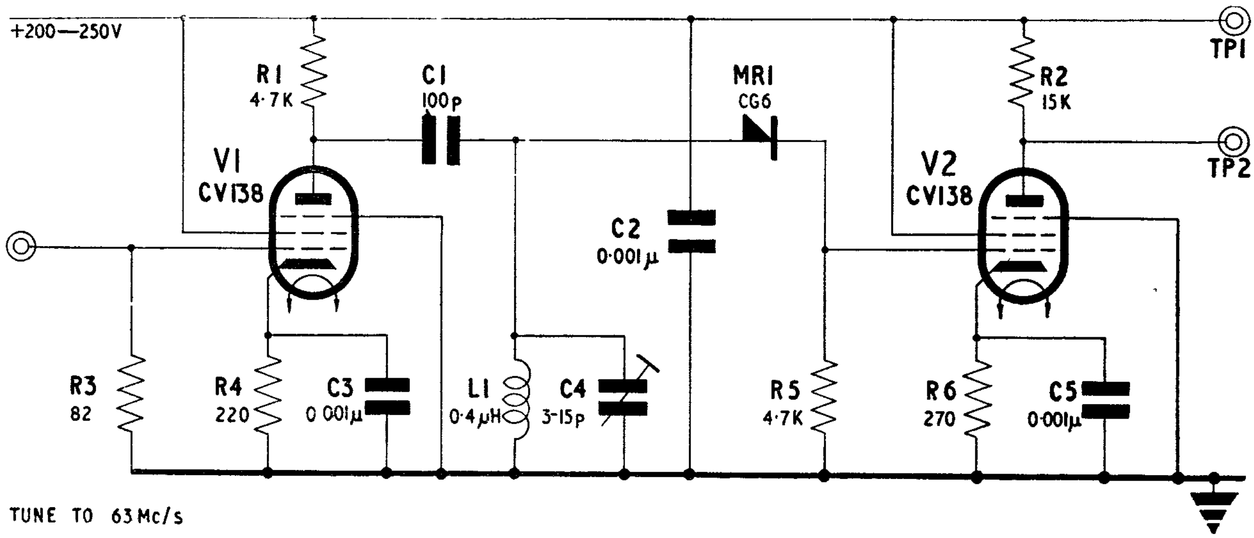


Fig. 4. Circuit for 63 Mc/s single tuned test amplifier

(2) If the alignment of the oscillator/quadrupler circuit is suspected, return the test set to the appropriate calibration centre. Check the alignment of the 63 Mc/s adaptor test (6625–99–943–1805) as follows ; connect the adaptor test 63 Mc/s marker socket to the output of a signal generator tuned to 63 Mc/s and, with the output controls set to maximum, connect the signal output plug of the adaptor test to a millivoltmeter, Type 8426 (10S/16727), set to the 150 mV range. Adjust the trimmer C44 in the adaptor test for the minimum output reading on the millivoltmeter.

(3) If the alignment of the oscillator/quadrupler circuit is suspected :

(a) Set the 750 kc/s MARKER switch to OFF and the MARKER SELECTOR switch to 63 Mc/s ;

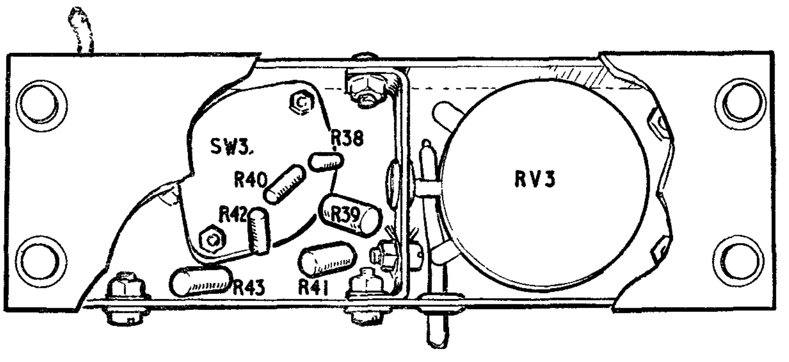


Fig. 5 Components in 63 Mc/s. marker output attenuator

(b) Mate the 63 Mc/s connector with the 63 Mc/s MARKER OUTPUT socket on the front panel and connect the other end to a 63 Mc/s RF strip with 80ohm input impedance (*fig.* 4) ;

(c) Connect a voltmeter (multimeter Type 1) set to the 100V range, between TP1 and TP2 of the test amplifier ;

(d) Adjust the slug in L6 for maximum meter deflection. The marker output must not be less than 50 mV RMS as compared with the signal generator applied to the RF strip in place of the 63 Mc/s marker signal.

(4) Check the alignment of the 63 Mc/s adaptor test (6625–99–943–1805) as follows. Connect the adaptor test 63 Mc/s marker socket to the output of a signal generator tuned to 63 Mc/s and, with the output controls set to a maximum, connect the signal output plug of the adaptor test to a millivoltmeter, set to the 150 mV range. Adjust the trimmer in the adaptor test for the minimum output reading on the millivoltmeter.

Faulty bias supply

19. If there is excessive ripple on the amplifying unit (IF) bias supply, check that the ripple across the test set 7739 BIAS TEST terminals is less than 15 mV peak-to-peak. If the ripple is greater than this figure, change C36.

Voltages

20. The tables of voltages given should be useful for the diagnosis of most faults. Slight divergencies from these figures will not necessarily indicate abnormal operating conditions, the voltage readings given in the Table being for guidance only. Hence discretion should be used in allowing for valve and component tolerances and supply variations.

21. Except where indicated otherwise, measurements are to be taken with controls in the following positions :

MARKER SELECTOR	40·25 Mc/s
750 kc/s MARKER	OFF
63 Mc/s MARKER OUTPUT 40·25 Mc/s MARKER OUTPUT	Minimum (fully counter-clockwise)

22. All measurements are taken with multimeter Type 1, the 10V ranges used for low readings, the 250V range for HT. All readings are made with respect to chassis and all voltages are dc except where indicated otherwise. The mains voltage supply should be 230V, 50 c/s with the voltage selector set to the 230V position.

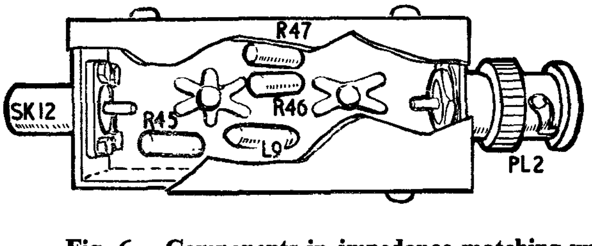


Fig. 6. Components in impedance matching unit Type 11448

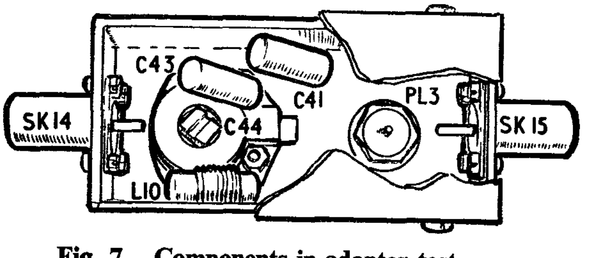


Fig. 7. Components in adaptor test 6625-99-943-1805

Table 3 (*see para.* 20 *to* 22)

Voltages in power supply

Valve	Electrode	Pin number	Voltage (Volts)
V10 and V11	Anodes	1 and 6	250 RMS
CV493 or	Cathode	7	255
CV4005	Heater	3 and 4	6·3 RMS (strapped to cathode)

HT current with no signal applied to booster amplifier approximately 70 mA. TR1 primary current 0·24 amps. with secondary normally loaded.

375/6. Wt. No. 24279. D. No.

Section 5

VIDEO SIMULATOR TYPE 7478 AND WATTMETER TYPE 324

Chapter 6

WATTMETER CT324

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Introduction

1. Wattmeter CT324 (10S/17027) is a piece of test equipment designed to measure the peak power output and the pulse repetition frequency (p.r.f.) of the TACAN airborne transmitter. When used in conjunction with signal generator Type 7760 (10S/17045) and video simulator test set 7478 (10S/17004) the wattmeter provides a means of checking the overall performance of the TACAN airborne equipment as follows :—

(1) A video pulse output of 40V peak at low impedance for feeding into the video simulator Type 7478.

(2) When the signal generator Type 7760 is modulated by the video simulator equipment, the output can be fed back to the airborne equipment via the directional coupler and the attenuator in the wattmeter.

2. The wattmeter is built into a chassis with a front panel upon which are mounted the controls, indicators and connectors shown in fig. 1. It weighs 33 lb. and is 16·5 inches wide, 12 inches deep and 7 inches high. The top and underside of the chassis mount the various components shown in fig. 2 and 3. The chassis is enclosed in a dust cover which carries two hinges which can be used to mount the equipment in a standard 19-inch rack. A cover is provided to protect the front panel controls when the wattmeter is in store, transit etc. The cover provides stowage space for the following connectors :—

(1) Connector Type

A 60-inch UR 67 connecting TX INPUT to the airborne set, this connector incorporates a low-pass filter.

(2) Connector Type

Connects PULSE OUTPUT to oscilloscope Type 81, and has a plug at one end and a crocodile clip at the other.

(3) Connector Type 3429 (10HA/8240). A 9-foot mains lead connecting mains input plug to the supplies.

(4) Dummy load Type

A 52-ohms load in a B.N.C. male plug.

3. The electrical data of the equipment is as follows —

(1) Mains input. A mains tap is located on the front panel, from which may be selected the appropriate voltages 115, 200, 210, 220, 230, 240 and 250 volts. A supply of 45–65 c/s at 25 watts is required.

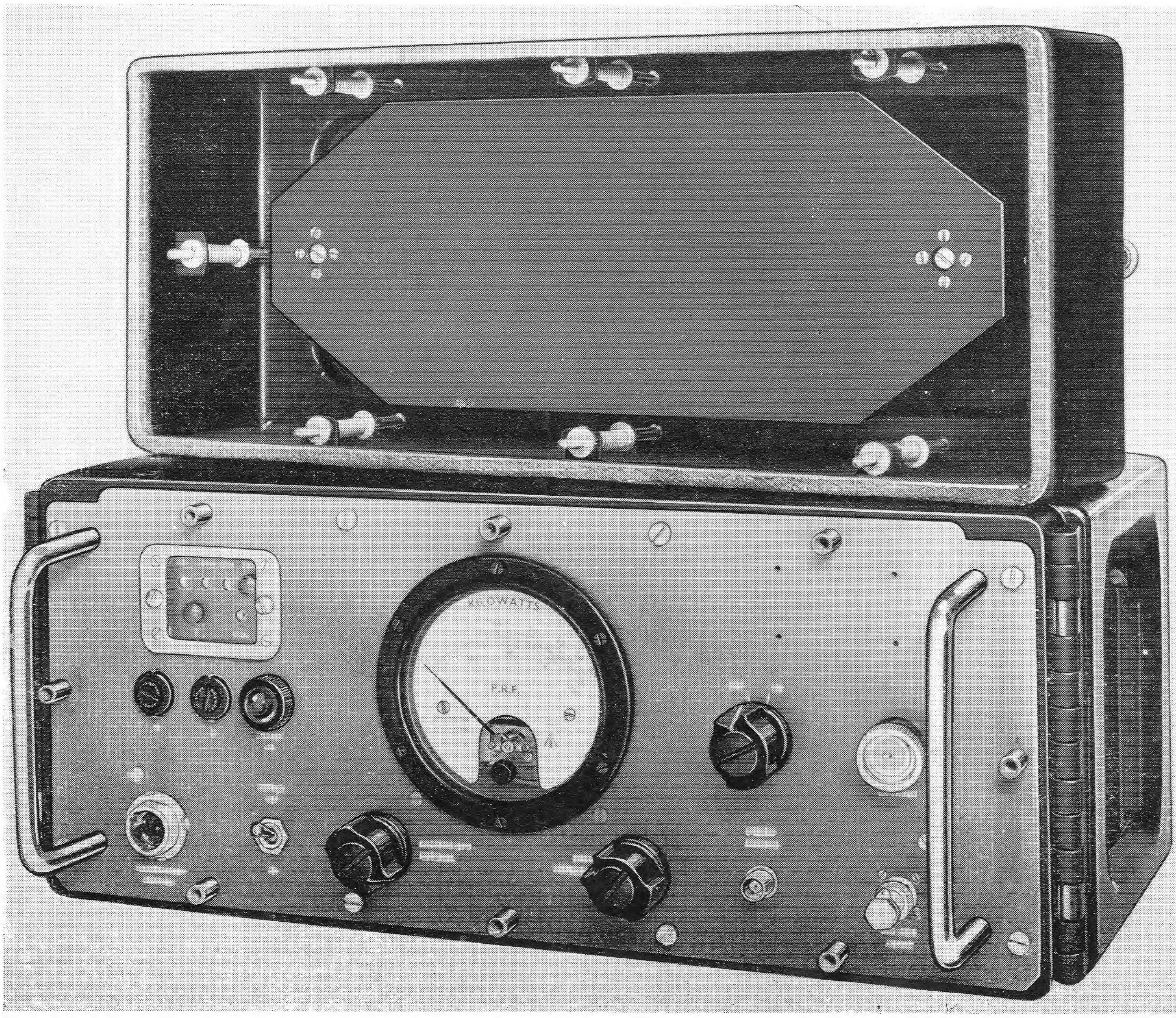


Fig. 1. Wattmeter CT324 Front view.

(2) Peak power measurement. A meter indication shows the peak power at the aerial plug of the TACAN airborne equipment. The range of power measurement is 0 to 2·5 kW and the lowest calibration mark is at 300 watts. The low-pass filter incorporated in the r.f. connector is provided to filter out harmonic power from the transmitter signal and so permits accurate power readings. The input impedance is 52 ohms.

(3) Feed-through facilities. The signal from the airborne equipment is detected and amplified in the wattmeter and then fed to the video simulator. This pulse voltage can be set to greater than 40V peak for any input between 250 watts and 2·5 kW. The video signal from the video simulator is used to modulate the signal generator Type 7760 ; the output is fed via the wattmeter directional coupler, which has an input impedance of 52 ohms, back to the airborne equipment aerial plug.

(4) Pulse repetition frequency measurement. The p.r.f. of the interrogating pulses from the airborne equipment is measured between 0 to 200 pulse pairs per second $\pm$ 5 per cent.

CIRCUIT DESCRIPTION

4. Pulses of r.f. power from the airborne transmitter are fed to plug PL2, they are then passed through a 17·2dB attenuator and a directional coupler to a 52-ohm load resistor R7. V1 (CV5140) a u.h.f. diode, detects the voltage across R7. The pulse envelope, as detected by V1, is used to operate all the circuits in the wattmeter. With the BACKING OFF CONTROL (RV3) set with its slider at the grounded end of its track (fully clockwise), there will be no positive bias on the cathode of V1. The pulses of r.f. power dissipated in R7 will then be fully detected by V1 and the resultant positive-going video pulses will be applied via C3 and R14 to the grid of V3 ; they will also be applied via PULSE AMPLITUDE control (RV1) to the grid of V2A.

5. V2A, one half of CV4024, is a straightforward pulse amplifier passing the output via transformer coupling TR2 to V2B, a cathode-follower output stage. The transformer TR2 is so connected that a positive pulse appears at the output socket SK2. Diode MR3 is fitted to bypass any negative overshoot. The output from SK2 supplies distance trigger pulses to test set 7478. V3 (CV4014) ampli-

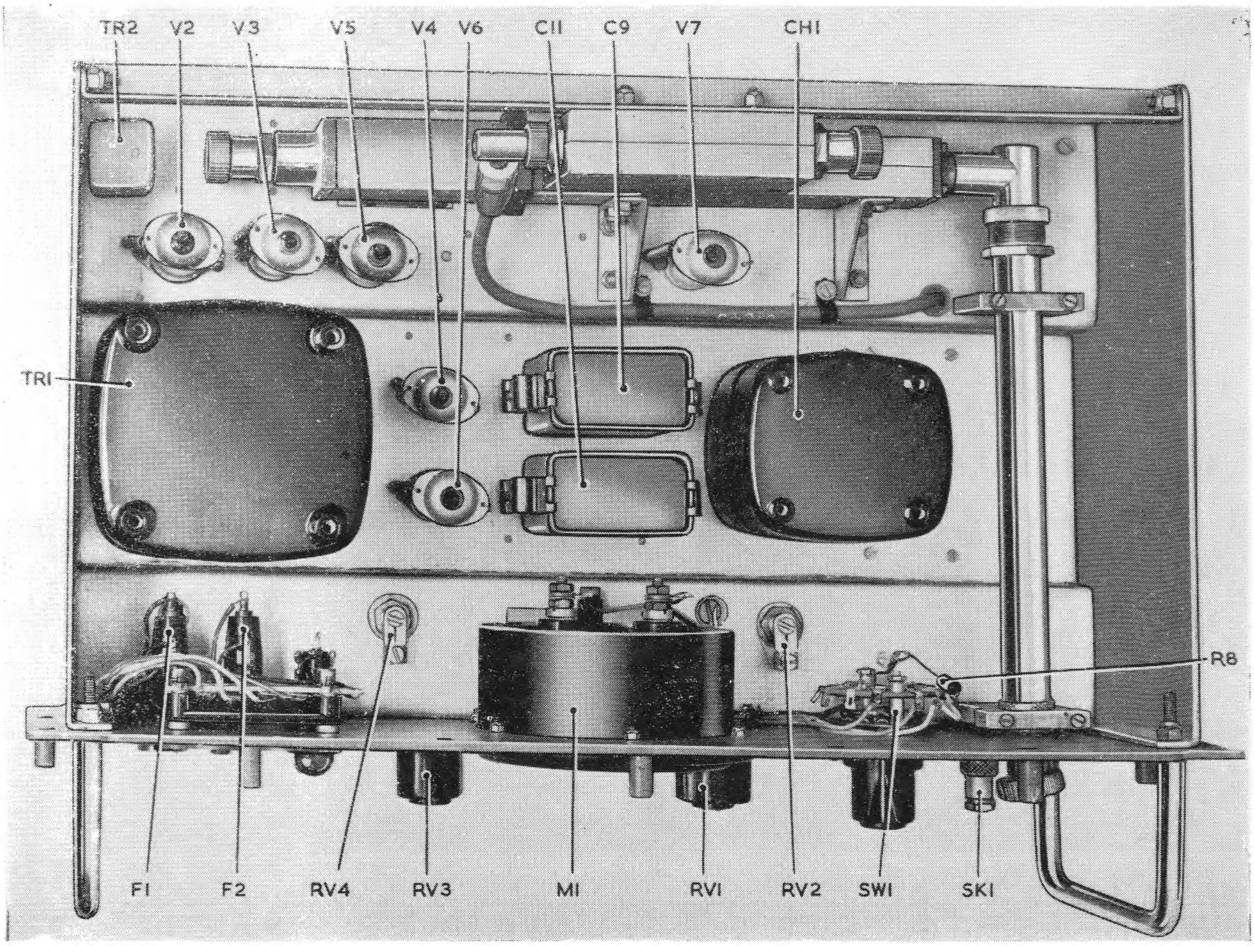


Fig. 2. Wattmeter CT324 Top view

fies and inverts the pulses received from V1, they are then passed via C5 to the cathode of V4A. V4A, one half of CV4025, is a gating diode. When V4A conducts a negative pulse is applied to the grid of V5B via C7. V5 (CV4024) is a double-triode monostable multivibrator ; in the absence of a trigger signal V5B is fully conducting and V5A is cut off by the positive bias developed across the common cathode resistor R21.

6. The negative trigger pulses from V4A via C7 to V5B will be in the form of 4μS pulse pairs spaced by 12μS. The p.r.f. of these pulse pairs will be about 130 or about 30 depending upon whether the TACAN transmitter is in the search or the track mode. The first pulse of a pair causes the anode current of V5B to decrease sharply and hence to reduce the voltage drop across R21. V5A then conducts with a resultant fall in anode voltage which is applied by C7 to V5B grid. The current through V5B again decreases, with a further fall in voltage across R21. Thus, the trigger pulses arriving through V4A is reinforced by cumulative action and the anode current of V5B is cut off while V5A passes heavy current. V4A then ceases to conduct due to the voltage drop across R19, thereby isolating V5B from further input triggering until the cumulative action is complete. The voltage on V5A anode falls to a low value and stays there while C7 begins to acquire a charge, so allowing the grid of V5B to become less negative. Sufficient charge on C7 allows the second triode to begin conducting again and the cycle is repeated when the next effective trigger pulse arrives.

7. The grid of V5B is clamped to a low positive potential by V4B (about 1V less positive than the cathode in the quiescent state) so that the charge on C7 is stabilized via V4B when the circuit returns to its quiescent state ; the whole cycle takes about 3 mS to complete. The valve V5 is therefore triggered by the first pulse in each pulse pair emitted by the airborne transmitter, while the second pulse is ignored because V4A is cut off when it arrives. By clamping the grid of V5B, diode V4B stabilizes the quiescent current through V5B and hence the pulse amplitude, it also serves to increase the triggering sensitivity of the multivibrator. The resultant multivibrator type waveform produced at the anode of V5B is applied to diodes MR1 and MR2 (CV448) via C8 which partially differentiates this waveform.

8. Pulses of current pass through MR1 and MR2 whenever V5B switches from off to on and vice versa. When the anode of V5B swings negative, diode MR2 passes the resultant pulse directly to

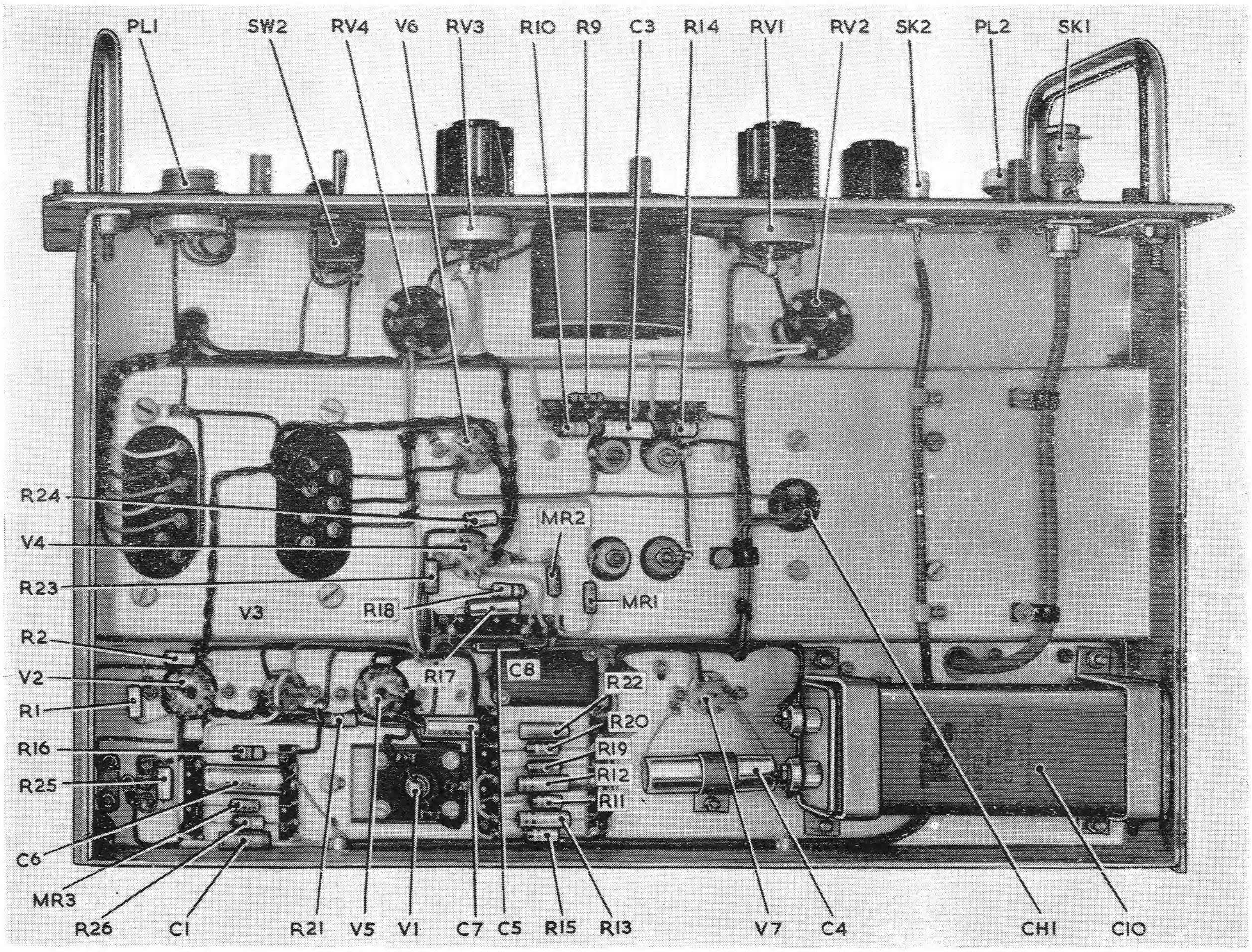


Fig. 3. Wattmeter CT324 Under view

ground, but with a positive swing the pulse passes through the circuit connected in series with MR1, charging C9. Thus, a continuous train of pulse pairs arriving from the airborne transmitter under test causes a steady potential to appear across C9 ; this gives a meter indication (with the front panel switch SW1 in PRF position) corresponding to the number of pulse pairs per second arriving from the airborne equipment. Since C9 is charged by differentiated pulses, variations in the multivibrator output pulse width will have very little effect. The slider of RV4 is given an initial calibration adjustment which provides a discharge path for C9 when p.r.f. is not being indicated on the meter M1.

9. Power measurement is achieved by applying a " backing-off " voltage to the cathode of the diode detector V1 until the diode ceases to conduct. At this point the backing off voltage is equal to the peak detected voltage and is proportional to the peak power output from the airborne transmitter. By switching SW1 to the " KW " position, the d.c. backing-off voltage is measured on the meter, which in this position is read by using the " Kilowatts " scale. The d.c. voltage required to back off the peak voltage due to a given power input is calculated in the next paragraph to be 49·2V for a 2·5kW input. During calibration RV3 is set to 49·2V and RV2 is adjusted so that the meter on the front panel reads 2·5 kW. The backing off voltage is obtained from the conventional full-wave rectifier V6 (CV4005) power supply circuit. A 150V neon stabilizer tube V7 supplies a constant voltage source for backing off the diode V1. The screen of V3 is also connected to this 150V supply, together with the clamping diode V4B cathode potential divider.

10. The d.c. voltage required to back off the peak voltage due to a given power input is calculated as follows :—

Let peak power input from Tacan airborne transmitter be	... = 2·5 kW.
Attenuation due to attenuator	... = 18·5 dB
Attenuation due to directional coupler between PL3 and PL4 (with 52 ohms dummy load fitted to "SIG. GEN. INPUT" socket on front panel, or the signal generator connected)	... = 1·4 dB.
Attenuation due to 5 ft. of coaxial connecting cable	... = 0·4 dB
Total attenuation up to load resistor R7.	... = 20·3 dB

Peak r.f. power in load is 20·3 dB down on 2·5 kW

20·3 dB represents a ratio of 107·2

$\therefore$ Power dissipated at R7 during the pulse ... ... $= \dfrac{2500}{107 \cdot 2}$ watts

$= 23 \cdot 3$ watts

As distinct from instantaneous peak power, the peak power in the pulse is

$$\frac{(V\ max)^2}{2} \times \frac{1}{R}$$

where R = the load resistance

$\therefore$ Peak power in load $= \dfrac{(V\ max)^2}{104}$

$\therefore$ V Max $= \sqrt{23 \cdot 3 \times 104} = 49 \cdot 2$ volts

OPERATING INSTRUCTIONS

11. The mains tap on the front panel must first be checked to ensure that it is correctly set for the supply available. The instructions are set out under the following functional headings :—

(1) Measurement of peak power output.

(2) Using video output for lining up the airborne transmitter.

(3) To operate the airborne equipment with delayed pulses.

Measurement of peak power output

12. Connect the airborne equipment aerial plug to TX INPUT plug on the front panel using connector Type supplied with the wattmeter, switch on both equipments and proceed as follows:–

Note . . .

The switch on the airborne remote control unit must not be in the TRANSMIT position when the aerial plug is not connected to a load.

(1) Turn the BACKING OFF CONTROL (RV3) fully clockwise and turn the PRF/KW switch (SW1) to PRF.

(2) When the airborne set begins to transmit, the wattmeter reads the pulse repetition frequency.

(3) Adjust the BACKING OFF CONTROL so that the meter just reads zero.

(4) Turn the PRF/KW switch to KW and read peak power output on the front panel meter.

Using video output for lining up the airborne transmitter.

13. Connect an oscilloscope CT316 across the PULSE OUTPUT socket of the wattmeter and turn the BACKING OFF CONTROL fully clockwise. With the airborne set transmitting, adjust the PULSE AMPLITUDE control (RV1) to some convenient setting which shows a pulse on the oscilloscope of less than 40V peak. The ganged tuning of the airborne transmitter can be aligned, using the amplitude of the waveform shown on the oscilloscope as a monitor. The PULSE AMPLITUDE control can, of course, be adjusted to maintain a convenient amplitude in the oscilloscope when the output of the transmitter appears larger as the alignment is improved.

14. An alternative method for lining up the airborne transmitter is as follows :—

(1) Turn the PRF/KW switch to PRF.

(2) With the airborne set transmitting, adjust the BACKING OFF CONTROL until the diode V1 is just conducting i.e. meter just reading.

(3) The ganged tuning of the airborne transmitter can than be aligned, using the meter indication as a monitor. Any increase in power output will cause diode V1 to conduct further with a resultant increase in meter reading. By further adjustment of the BACKING OFF CONTROL, a more accurate indication of the tuning peak of the airborne transmitter can be obtained.

To operate the airborne equipment with delayed pulses.

15. With the airborne equipment connected to the wattmeter (PL2), connect the PULSE OUTPUT socket (SK2) to the WATTMETER socket on the video simulator using the connector supplied with the latter equipment. Measure the video pulse amplitude using the oscilloscope CT316 at the MODULATOR socket of the video simulator. For accurate work set this amplitude to 25V peak. The video simulator will operate with larger inputs but this may result in an error of up to $\frac{1}{4}$ nautical mile due to the rise time of the pulse.

16. Now connect the r.f. output of the signal generator 7760 to SIG. GEN. INPUT socket (SK1) on the wattmeter. The delayed reply pulse from the video simulator is used to modulate the signal generator and the output from the signal generator is fed via the SIG. GEN. INPUT socket and PL2 on the wattmeter back to the airborne set to simulate a reply from the ground beacon and so operate the distance measuring circuits. The total attenuation appearing between the signal generator and the aerial plug of the airborne set (18·5 dB attenuator plug, 8·5 dB for the directional coupler) equals 27·0 dB and this figure must be added to the attenuation shown in decibels on the signal generator attenuator dial, when sensitivity of the receiving circuits of the airborne equipment is being checked.

Note . . .

When the signal generator 7760 is not being used the SIG. GEN. INPUT *socket is terminated with a 52-ohm dummy load in a BNC male plug, this is done to preserve the voltage standing wave ratio (VSWR) of the r.f. system in the wattmeter.*

FAULT FINDING

17. A step by step procedure has been adopted for the following instructions as this is most likely to locate the fault quickly. It is assumed that the equipment concerned is known to be faulty but no information on the nature of the fault is available. Before switching on, check that the mains voltage panel is correctly adjusted for the supply available and that the valve complement is both correct and complete. The circuit description and operating instructions should be used in conjunction with this procedure :—

(1) *Panel lamp fails to glow when power is switched on.* Examine other valves in the unit to see if all filaments are glowing. If not, check the two front panel fuses connected in series with the power transformer primary. If these are not blown, check mains switch and wiring.

(2) *Panel lamp and valve filaments glow but wattmeter otherwise inoperative.* Check h.t. voltage on C10 to chassis (300V $\pm$ 30 volts). Check voltage between pin 5 and ground on V7 (150V $\pm$ 5 volts). Inspect the u.h.f. diode valve V1, in the diode head assembly, to see that the filament is glowing; it is visible from the underside of the chassis. The wattmeter should next be tested using an airborne set which is known to be working properly. With the airborne set transmitting and the front panel switch in the PRF position turn the BACKING OFF CONTROL fully clockwise.

No reading on p.r.f. meter

18. Check potentials on V3 electrodes and compare with those shown in Table 1. Also check the potentials on V4 and V5. If all are correct, use CT316 oscilloscope (triggered from the cathode of V1) and check that the pulse signal is arriving at the grid of V3 and that it is inverted and amplified at the anode of V3. The oscilloscope will trigger from the first pulse in every pulse pair arriving from the airborne transmitter, so the square waveform generated in V5 stage will begin coincident with the first pulse and will last for 2 to 4·5 msecs, ignoring the second pulse spaced 12 microseconds after the first. Check connections to C8 and the germanium diodes MR1 and MR2. Check the meter circuit by switching PRF/KW switch to KW and move the BACKING OFF CONTROL, with which it should be possible to deflect the meter point from no reading to full scale deflection.

Wattmeter and p.r.f. readings correct, but no pulse output from front panel socket.

19. As the wattmeter works then the signal at C3 must be correct. Check electrode voltages on V2 and compare with the figures given in Table 1. Using the CT316 oscilloscope, triggered in the same way as in the previous test, check the pulse amplitude on the grid of V2A (pin 2) adjusting the PULSE AMPLITUDE control suitably. It should be possible. to obtain an amplitude of 40V negative pulse at pin 1 (anode) of V2A. Check the input to the cathode-follower stage (positive-going pulse) and the components in the cathode output circuit.

TABLE 1

Typical test point figures (with no signal input).

Test point	Range	Reading
V2B cathode pin 8	(testmeter Type F) 10v d.c.	6·8
V2A cathode pin 3	(testmeter Type F) 10v d.c.	4·3
V2A anode pin 1	(testmeter Type F) 400V d.c.	307
V3 cathode pin 2	(testmeter Type F) 10V d.c.	1·5
V3 anode pin 5	(multimeter Type 1) 250V d.c.	145
V4A cathode pin 5	(multimeter Type 1) 1000V d.c.	302
V4B cathode pin 1	(multimeter Type 1) 25 d.c.	9·7
V5A cathode pin 3	(multimeter Type 1) 25 d.c.	10·8
V5B cathode pin 8	(multimeter Type 1) 25 d.c.	10·8
V5B anode pin 6	(multimeter Type 1) 1000 d.c.	125

Re-calibration of meter scales

20. Re-calibration of meter scales can be carried out if suitable equipment is available :—

kW scale. A d.c. voltmeter is required for this check, accuracy $\pm$ 1 per cent at f.s.d. and sensitivity of 50000 ohms per volt or better. Connect the meter from the junction of R10, R9 and RV3, negative lead to chassis and adjust RV3 until the meter reads 49·2 volts. Switch SW1 to KW and adjust RV2 for f.s.d. on the wattmeter (i.e. 2·5 kW). Re-adjust RV3 so that the meter reads 15·6 volts and note that M1 reads 0·25kW $\pm$ 10 per cent.

21. *Diode trimming adjustment.* This is a pre-set screw set on the diode block and is the final factory adjustment on diode performance. On no account is this screw to be re-adjusted unless the following procedure is carried out, using a 1000 Mc/s slotted line :—

(1) In order to carry out the alignment procedure it is necessary to remove the diode block from the wattmeter. This entails unscrewing the diode block from the chassis and then releasing it from the directional coupler. The whole operation is far easier if the complete r.f. assembly is removed from the wattmeter (i.e. attenuator, directional coupler and diode head.).

(2) The diode head is connected to the slotted line by means of a special adaptor which will have to be of local manufacture as it is a non-standard component and will depend on the type of connection on the slotted line. The characteristic impedance of the system must be maintained at 52 ohms.

(3) Set up the slotted line on 1075 Mc/s., loosen the locking nut on the pre-set screw and adjust the screw until the best VSWR is obtained. This VSWR should be about 1·08. Lock the screw in this position and obtain a series of readings of VSWR——frequency within the range 1025 Mc/s to 1150 Mc/s. All readings of VSWR obtained should be less than 1·15. A typical curve is shown in fig. 4.

(4) In the event of a diode being changed, the wattmeter may be checked against another wattmeter CT324 as a temporary measure. If there is a large discrepancy between the wattmeters then the slotted line procedure described above must be adopted before reliable measurements of power can be obtained.

22. *PRF scale.* An airborne set and a pulse counter are required for this check. The airborne set should be connected in the normal fashion for measurement of power output from the transmitter. The BACKING OFF CONTROL is adjusted so that the p.r.f. reading on the wattmeter is at the maximum obtainable. With a pulse counter connected to the pin 6 of V5, (h.t. on this point) the readings of p.r.f. should agree (pulse count over 1 second). The accuracy of the scale reading should be ± 5 per cent ; if not so, adjust RV4. Alternatively, an airborne set whose p.r.f. is known accurately may be connected to the wattmeter and RV4 adjusted to give the correct reading.

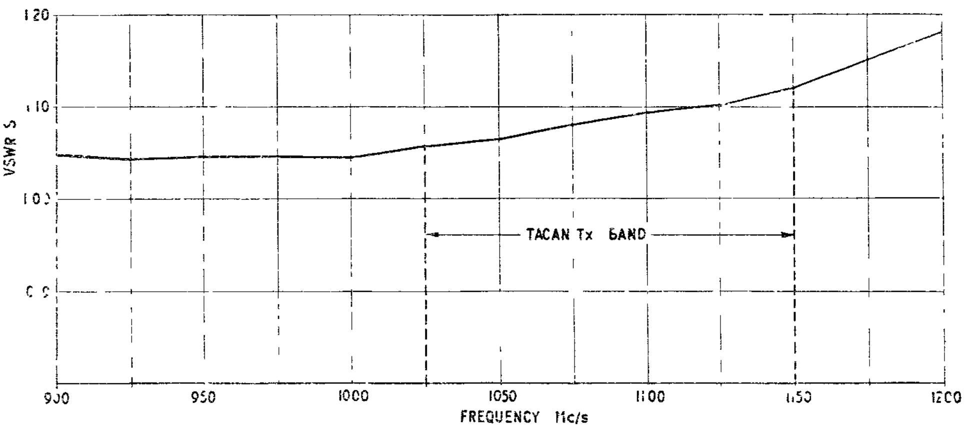
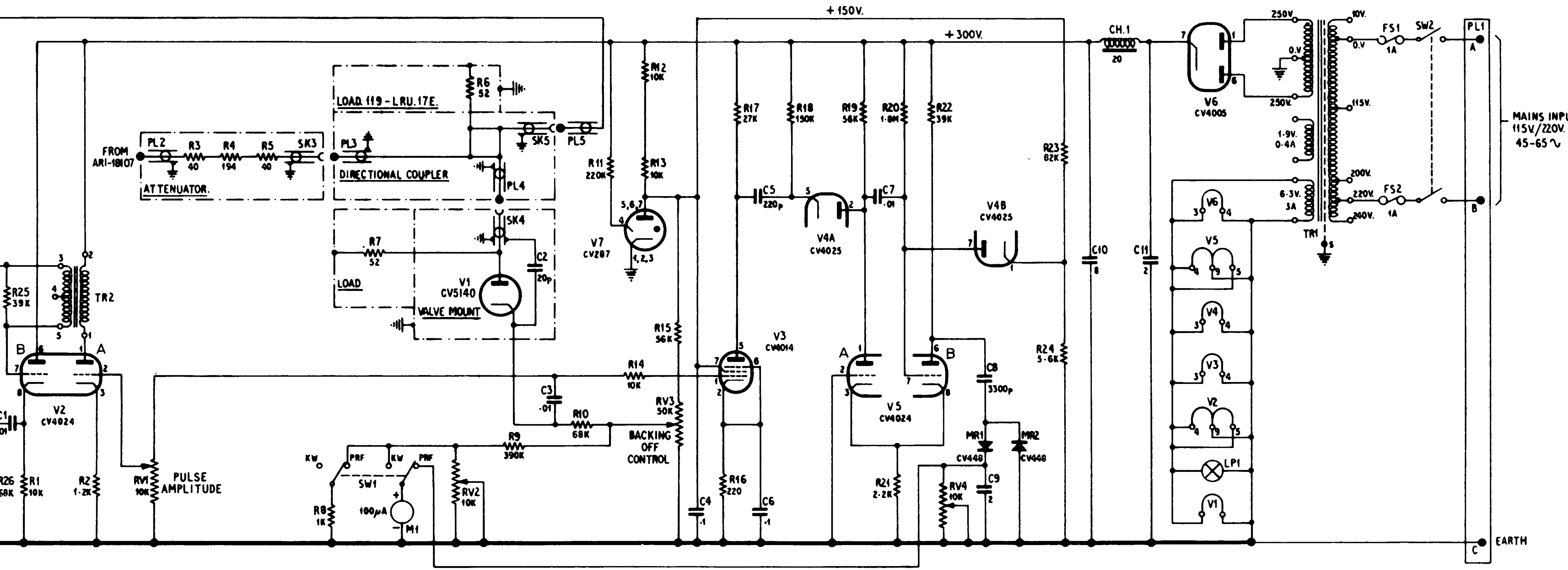


Fig. 4. Diode head—Variations of VSWR to frequency

375/6 Wt. 36132 D. No. 8263



Wattmeter CT324 – circuit

Fig. 5

Section 6

TEST SET TYPE 7476A, 7476B and 11964

Chapter 1

(Revised)

TEST SET TYPES 7476A and 7476B

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LEADING PARTICULARS

Test set	Type 7476A
Ref.No.	105/17002
Manufacturers Pt.No. ...	WTD 149485(Smiths Industries)
Weight	46½ lbs
Length	19in
Width	9in
Height	12in

Test set	Type 7476B
Ref.No.	105/17048
Manufacturers Pt.No. ...	WTD 153462(Smiths Industries)
Weight	46½ lb
Length	19in
Width	9in
Height	12in

Modifications

1. The information contained in this chapter describes equipment incorporating the modifications listed in Table 1.

Introduction

2. Test set 7476A and 7476B are portable test instruments which provide facilities for the second and third line testing of coupling unit (indicator) Types 9546 and 11920 and indicator, electrical, Type 9547. Attached to the sides of the case at the front are two hinged plates which are used to secure the test set to a 19in. test rack when required.

When the test set is used on a bench the flaps are pushed back so that they lie flat against the side of the case. Test sets incorporating mod. 1 have different cases to pre-mod test sets and the front panels are modified to suit the cases.

3. Test sets 7476A and 7476B are basically similar except that test set 7476B has additional facilities for testing coupling unit (indicator) Type 11920. The coupling unit (Indicator) Type 11920 is of the same size and is similar in appearance to the coupling unit (indicator) Type 9546 and is interchangeable with it. The C.U. 11920, however, has two additional components which are shown on fig.3. When the C.U. 11920 is being checked special interconnecting cables, supplied with test set 7476A, are required between the coupling unit and the test set. The cable connections are shown in fig.1 of Chapter 2.

4. Illustrated in fig.1 are all the controls, indicators, plugs and sockets carried on the front panel. The preset control RV4 (fig.2) is fitted within the unit on the right-hand side (from the front). Micro-switches S12 and S13 are also within the unit and fitted on a bracket behind the 115V A.C. entry plug PL1. The front panel is secured to the case by ten 2BA Cheesehead screws. The test sets have the following sub-units:-

(1) Master torque transmitter (X1).

(2) Master torque indicator (X2).

DESCRIPTION

Facilities

5. The test set provides the following facilities:-

(1) A master transmitter (X1) for checking the torque receivers in the indicator, electrical, Type 9547. A master indicator (X2) for checking the torque transmitters in coupling (indicator) Type 9546. Facilities are provided for checking the master indicator against the master transmitter.

(2) Means for checking the '100 mile' indicator circuits in indicator, electrical, Type 9547 and coupling units (indicator) Type 9546 and 11920.

(3) Facilities for checking the motor generators and means of rotating the bearing and distance gear trains in the coupling units in either direction.

(4) Facilities for checking the bearing and distance resolvers in the coupling units.

(5) Facilities for checking the sin/cos and linear potentiometers.

Connectors

6. There are four plugs and two sockets fitted on the front panel, namely:-

(1) PL1, a three-pin plug carrying 115V 400Hz.

(2) PL2, a two-pin plug carrying 28V D.C.

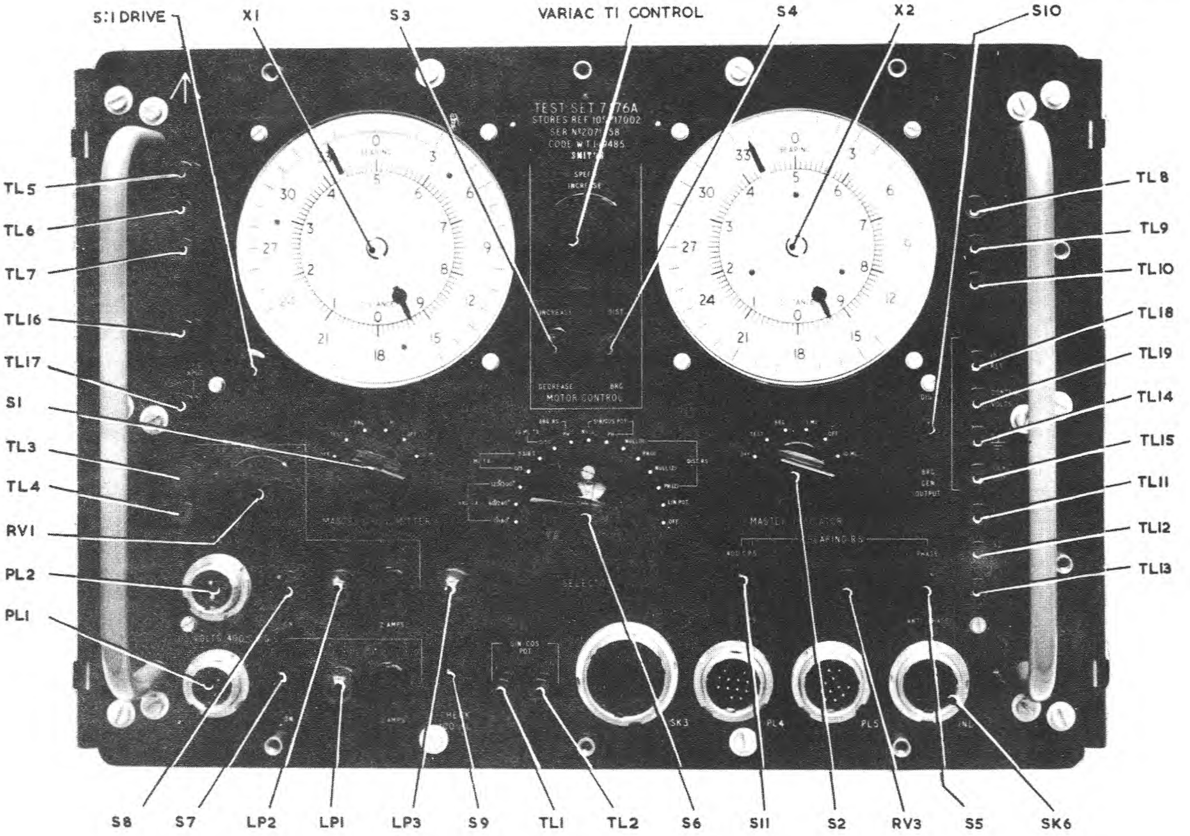

Fig.1 Front Panel

(3) SK3, a 25-way socket connecting the test set to PL2 on the coupling unit.

(4) PL4, a 12-way plug connecting the test set to PL1 or PL3 on the coupling unit.

(5) PL5, a 12-way plug connecting the test set to PL4 on the coupling unit.

(6) SK6 (IND), a 12-way socket connecting the test set to the indicator, electrical, Type 9547.

When SK3, PL4, PL5, and SK6 are connected to a coupling unit (indicator) and an indicator, electrical, the external connections shown in fig.3 are made.

7. There are also 19 terminals on the front panel which provide connections for the injection of 135Hz and external monitoring. The terminals are numbered on fig.1 and annotated on the front panel as follows:-

(1) On the bottom of the front panel Terminals 1 and 2 marked SIN. COS. POT.

(2) On the left-hand side of the front panel:-

(a) Terminals 3 and 4 marked 28 VOLTS DC + and - respectively.

(b) Terminals 16 and 17 marked 135 CPS INPUT. TL17 is the earthy side of the input connections.

(c) Terminals 5,6 and 7 marked S1, S2 and S3. These are the stator connections of the master transmitter synchro.

(3) On the right-hand side reading from top to bottom of the front panel:-

(a) Terminals 8,9 and 10 marked S1,S2 and S3. These are the stator connections of the master indicator synchro.

(b) Terminal 18 marked 18V REF.

(c) Terminal 19 marked CONTROL VOLTS.

(d) Terminal 14 marked with an earth symbol.

(e) Terminal 15 marked GEN. OUT.

(f) Terminal 11 marked A1.

(g) Terminal 12 marked A2.

(h) Terminal 13 marked with an earth symbol.

Power supplies (figs.4 and 5)

8. The following power supplies are required to operate the test set.

(1) 28V DC ± 1.5 volts.

(2) 115V ± 5 volts 400Hz ± 20Hz.

The 115V AC is applied to the test set via PL1 then through microswitches S12 and S13 to a double-pole, on-off switch S7. The 2-amp fuse FS1 is connected in the line from PL1/A which is the line connection, PL1/B being earth. An AC 'on' indicator lamp LP1 (red) is connected across the supply. The lamp is in series with two capacitors in parallel (C5, C7). The 28V DC is applied via PL2 to a double-pole on-off switch S8. A 2-amp fuse FS2 is connected in the line from PL2/A. A DC "on" indicator lamp LP2 (red) is connected across the supply. A 500-ohm variable resistor (RV1) marked DC VOLTS is included to vary the DC input volts for indicator tests. Another indicator LP3 (red) lights up when the CHECK 100ML switch (S9) is pressed and the 100-mile contacts in the coupling unit are closed.

Ancilliary equipment

9. The ancilliary equipment required for use with the test set is as follows:-

(1) A frequency selective valve voltmeter for monitoring synchro outputs and measuring motor-generator parameters.

(2) A 400Hz phase sensitive null detector for checking phase of generator output and synchro phase shifts and nulls.

(3) A 135Hz supply with a source impedance of approximately 500 ohms at 5V RMS.

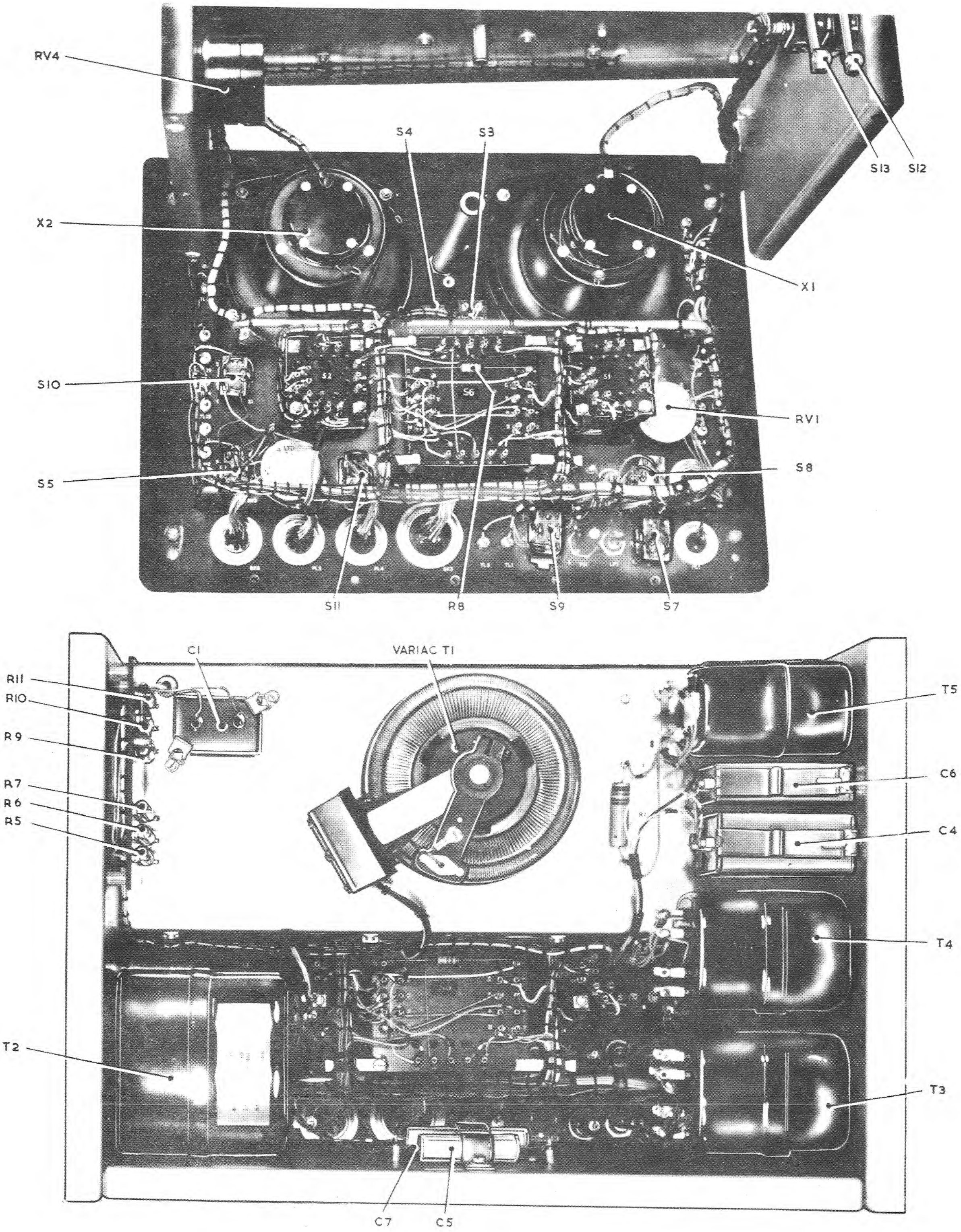

Fig.2 Component location

(4) A coupling unit, Type 9546 or Type 11920, complete with mounting Type 9545 and backplate.

(5) An indicator electrical, Type 9547.

Motor speed control

10. To test the motor generators MG1 and MG2 in the coupling units (AP 116B-0304-1,Pt.2, Sect.2 Chap.10 and 11) a voltage variable from 0 to 20 volts, is available from the test set. The 115V 400Hz is fed across variac T1 (transformer Type 4234); the variac control marked SPEED INCREASE is brought out to the front panel and is rotated in a clockwise direction to increase speed. The voltage output from the variac slider is applied to the primary of T2 (transformer Type 4721). T2 has two secondary windings, only one is used, and it supplies 50V centre - tapped from terminals 3,4 and 5 when 115V is applied to the primary. As the primary voltage is continuously variable by T1, the secondary voltage varies between 0 and 25 volts in each half of the winding. Connected to terminal 3 are three 33-ohm resistors R9, R10, R11 and a 25-ohm variable resistor RV4, all in series. Connected between terminal 5 and RV4 are two capacitors in parallel, C4 and C6. Thus, depending on the position of switch S3, the phase of the control voltage to the motor generators will be changed.

11. There are three controls in the motor control circuit, namely:-

(1) T1, the SPEED INCREASE Control.

(2) Switch S3; this is a 3-position centre-biased switch marked INCREASE-DECREASE. The switch controls the direction of rotation of the motor generators by changing the phase of the control voltage.

(3) Switch S4, a double-pole, changeover switch marked DIST-BRG. One pole routes the motor control voltage to either the distance or bearing motor generators in the coupling unit via SK3/G or PL5/L respectively.
The second pole routes the 18V 400Hz reference voltage from terminal 8 of T3 to the distance or bearing motor generators via SK3/H or PL5/K respectively. The 18V reference supply is bought out to terminal 18 marked 18V REF.; this enables the 18V to be monitored by an external valve voltmeter. The motor control voltage may be monitored at terminal 19 marked CONTROL VOLTS. Terminals 19 and 18, together with terminal 14 (earth), also enable individual motor generators to be tested with the same control facilities.

12. Switch S10 marked GEN. OUTPUT DIST-BRG is used in conjunction with the motor control circuit; it is a double-pole changeover switch which routes either the bearing or distance generator output to terminal 15 (GEN.OUT). The bearing generator output is routed into the test set via PL5/M and the distance generator output via SK3/L.

Bearing resolver checking circuit

13. Transformer T5 and its associated network are provided for checking the bearing resolver (RS1) in the coupling unit. The associated network consists of R1 (560-ohms), RV3 (100K-ohms) marked SENSITIVITY, a double-pole, changeover switch S5, marked PHASE-ANTIPHASE, and a quadrature network consisting of C1 (.01μF) and three resistors in series R5, R6, R7 (each 39K-ohm). Also used in this check are a double-pole, changeover switch S11 marked 400 CPS - 135 CPS and switch S6 marked SELECTOR.

14. A 135Hz supply is injected via terminals 16 and 17 (135 CPS INPUT) and one pole of switch S11 to the primary of T5. The circuit is completed when switch S11 is in the 135 CPS position. Variable resistor RV3 is connected across T5 secondary winding and, together with switch S5, provides means of obtaining accurate null positions 180 deg. apart on the bearing resolver. To monitor the null positions a phase angle voltmeter is connected to TL11 (A1) and TL13 (earth) and SELECTOR switch S6 turned to position 7 (BRG.RS.PH).

15. The 135Hz supply is fed to PL5/D via switch S11 and R1. R1 is a 560-ohm resistor which simulates the normal source impedance of the circuit driving the resolver. When a 135Hz supply is not available a very rough null may be obtained by using a 400Hz supply. The 400Hz supply is derived from T3 terminal 10 and is fed via switch S11 in the 400 CPS position.

Selector switch (S6)

16. S6 is the SELECTOR switch. It is a 15-position, 4-bank switch. Switch wipers S6/1, S6/2 and S6/3 connected to terminals 13 (earth), 11 (A1) and 12 (A2) respectively, make the necessary connections between the test set and the equipment under test. Switch wiper S6/4 routes 5V 400Hz from T4 terminal 11 to the component under test.

Master indicator and master transmitter

17. Switches S1 and S2 are 4-pole, 6-way switches. S1 is marked MASTER TRANSMITTER and MASTER INDICATOR. The switches are used in conjunction with the two Synchros X1 and X2. When both switches are in position 2 marked TEST one synchro is checked against the other for accuracy, i.e., the MASTER TRANSMITTER can be turned by a knob in the bottom left-hand corner of the dial and the MASTER INDICATOR should follow with an accuracy of ± 1½ deg.

18. Master torque transmitter unit X1 is a panel-mounted instrument comprising a synchro transmitter in a standard 3¼ in. case with a 5in. diameter dial. The dial is graduated 0-360 deg. bearing and 0-10 distance. The synchro shaft is directly coupled to the pointer and is actuated by a knob in the bottom left-hand corner giving a drive to the shaft at a reduction ration of 5 : 1.

19. The master torque indicator X2 is similar to transmitter X1 except for the type of synchro fitted i.e. synchro receiver Type 1.

TABLE 1

Modifications

Mod.No.	Strike off No.	Brief details
6162/NA	1	New case and panel introduced. Profile of panel changed to suit new case; pre-mod panel cannot therefore be used with post mod case, and vice versa.

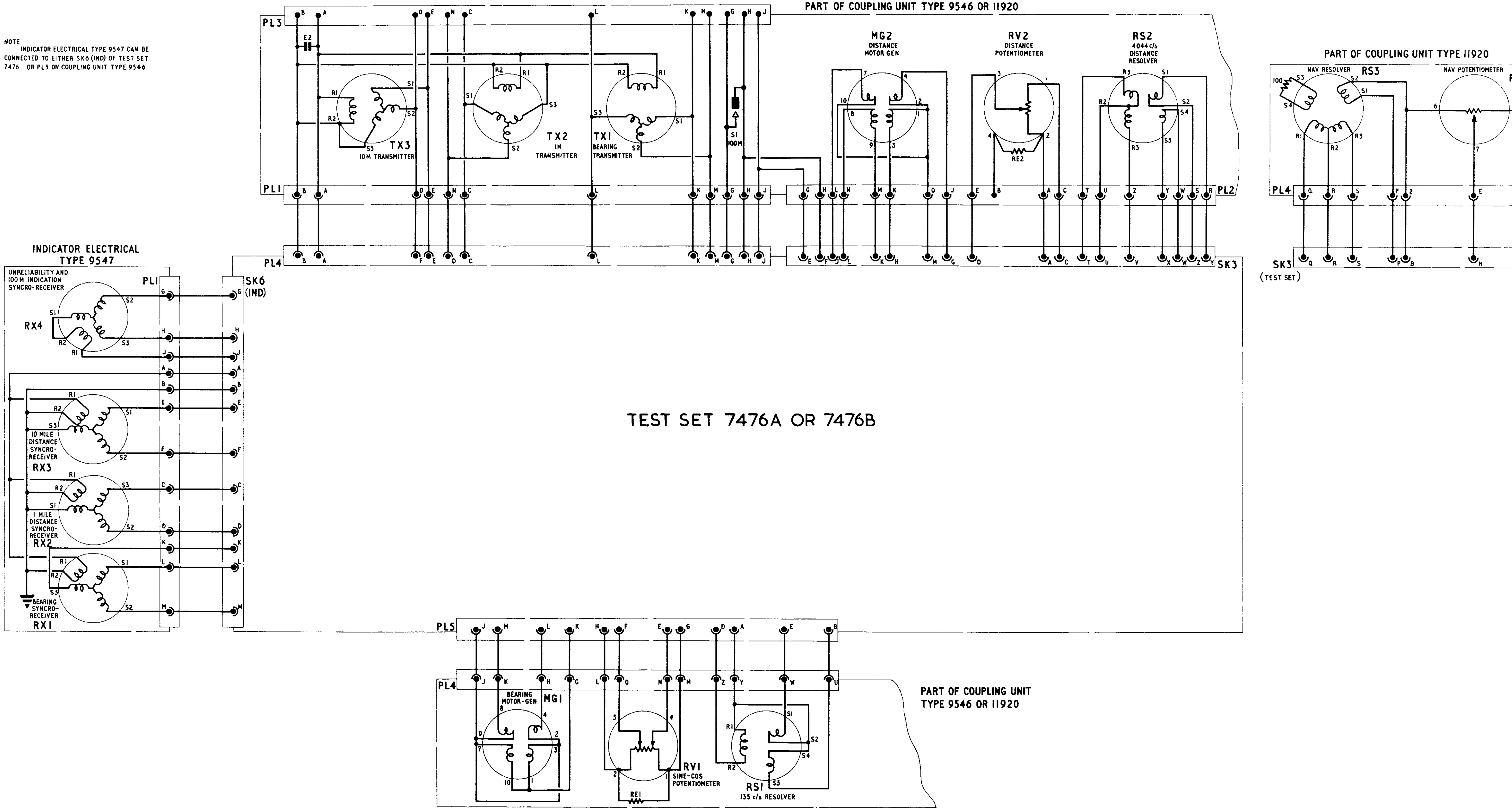

Fig.3 Test set 7476: external connections

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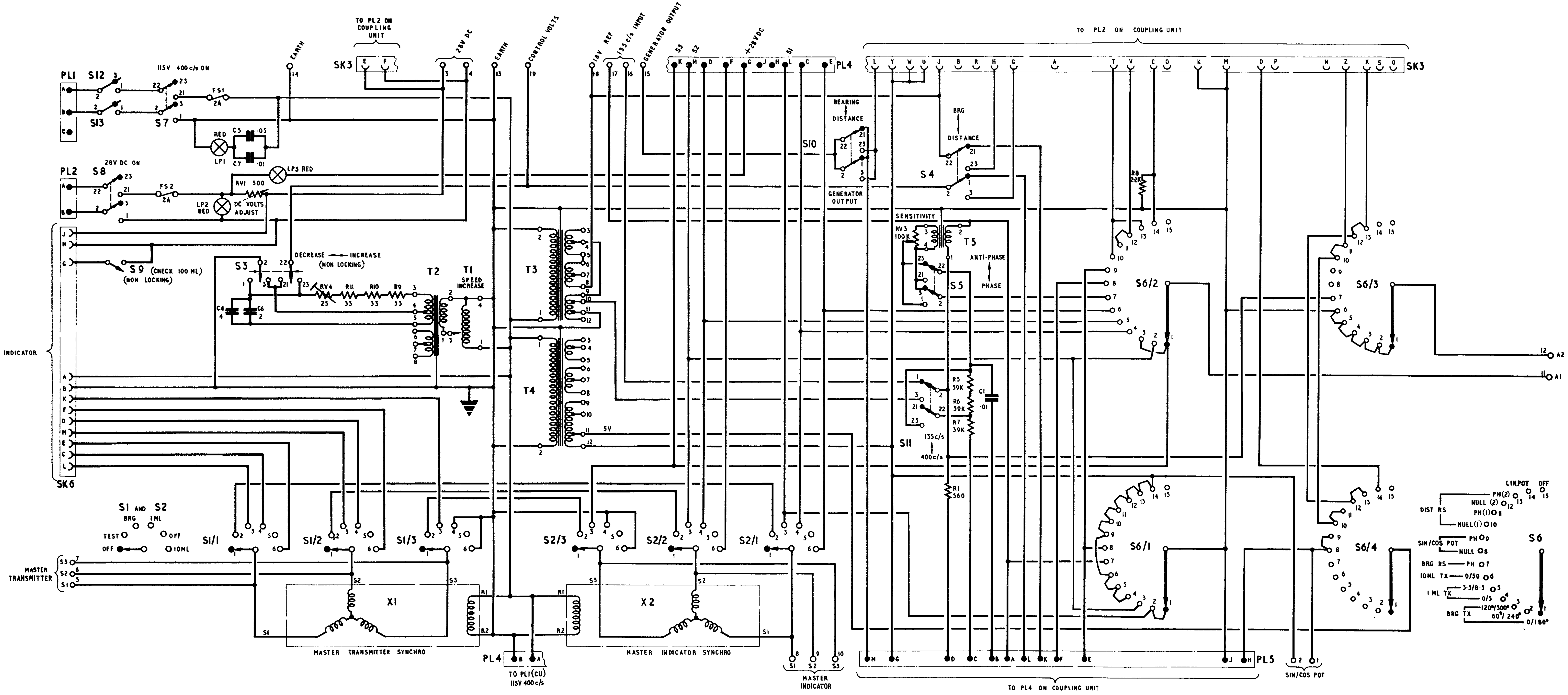

Fig.4 Test set 7476 A – circuit Fig.4

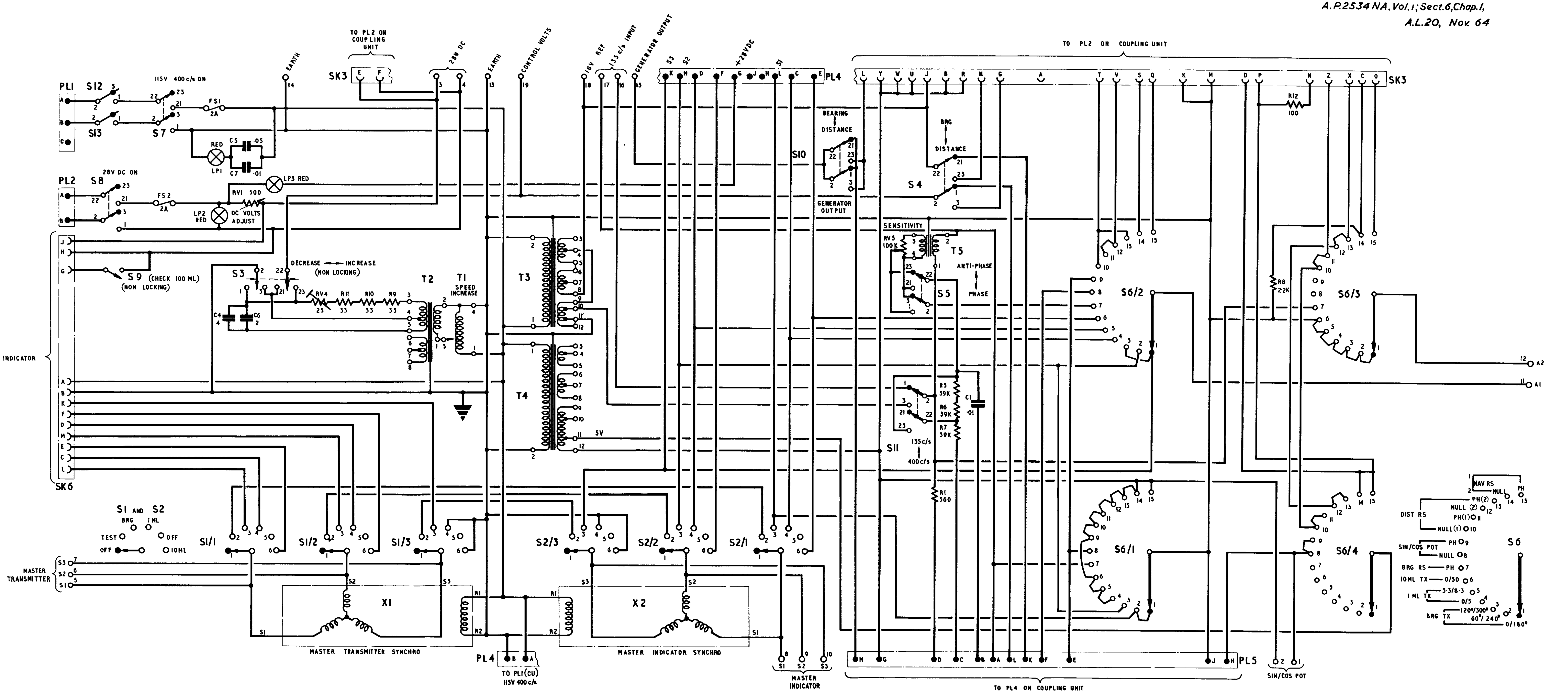

Fig. 5 Test set 7476B - circuit Fig. 5

Chapter 2

TEST SETS TYPE 7476A AND 7476B—FUNCTIONAL TESTS AND CHECKS

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Power supply checks	10
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ILLUSTRATION

	Fig.
Cable connections between the test sets and coupling units	1

Introduction

1. Test set Type 7476A and 7476B (*Chap.* 1, *App.* A) are designed to perform functional tests on coupling units (indicator) Type 9546 and 11920 and indicator, electrical, Type 9547. There are a number of tests and checks applied to the test set itself which may be divided into the following sections:—

(1) Functional tests to confirm that power supplies are properly connected and that indicators and switches are functioning normally.

(2) Further checks to locate faults should the test set go out of action.

Functional checks

2. Connect the 28V d.c. supply to the 2-pin plug PL2 with the earthy side to pin B; note that pin B is not earthed in the test set. Switch S8 down to ON position. The red indicator lamp LP2 should light.

3. Connect the 115V 400 c/s supply to the 3-pin plug PL1 with the line connection to pin A and the neutral, which is earthed, to pin B. Pin C is not connected. Switch S7 down to the ON position. The red indicator lamp LP1 should light.

Warning

During manufacture the sleeves on the cores of the 115V a.c. power cable were marked Phase A, Phase B and Phase C. The core marked Phase A is connected to pin A of PL1 and must be connected to the line side of the supply. The core marked Phase B is connected to pin B of PL1 and must be connected to the neutral (or earth) side of the supply. Failure to connect these leads the right way round can cause the earth line in the test set to be burnt out.

4. With S7 still switched to ON position, the following functional tests should be carried out to check the master transmitter and master indicator.

(1) Switch both S1 (MASTER TRANSMITTER) and S2 (MASTER INDICATOR) to position 2, marked TEST.

(2) Rotate master transmitter by the knob in the bottom left hand corner of the dial; the master indicator should follow movements within $\pm 1\frac{1}{2}$ deg.

Cable connections to the test set (other than power) (*fig.* 1)

5. When the coupling units Type 9546 or 11920 are connected to the test set, the coupling unit will be mounted in a mounting Type 9545 (*para.* 7(9) *Chap.* 1) complete with a backplate (*para.* 7(10) *Chap.* 1). There are a number of variations possible in the interconnections between the test set, the coupling unit and the electrical indicator, two of which are shown for the test set 7476A and C.U.9546 in fig. 1(a) and 1(b) and one for the test set 7476B and the C.U.11920 in fig. 1(c).

6. On the coupling units, plugs PL1 and PL3 are of the same pattern and are wired in parallel, it is therefore immaterial whether PL1 or PL3 is connected to PL4 on the test set. Similarly if the electrical indicator is being fed from the coupling unit it can be connected to either PL1 or PL3. If the indicator is fed direct from the test set it is connected to SK6 (IND).

7. When C.U.9546 is coupled to test set 7476A, the following connections are always made:—

(1) PL2 (coupling unit) to SK3 (test set).

(2) PL4 (coupling unit) to PL5 (test set).

8. When C.U.11920 is coupled to test set 7476B the cables are connected as follows:—

(1) SK3 (test set) is connected to PL2 (coupling unit) and to part of PL4 (coupling unit). The cable is split into two (*fig.* 1(c)) and the cable entry into PL4 (coupling unit) is also split to take two separate cables.

(2) PL5 (test set) to part of PL4 (coupling unit).

Further checks for fault location

9. There are a number of checks and tests which may be applied to the test set in conjunction with the coupling units (indicator) Type 9546 and 11920 and the indicator, electrical, Type 9547 in order to locate any fault. These checks may be divided into the following sections:—

(1) Power supply checks.

(2) Motor generator supply checks.

(3) Bearing resolver test circuit checks.

(4) Voltage output checks.

(5) Master transmitter and master indicator checks.

(6) Continuity checks.

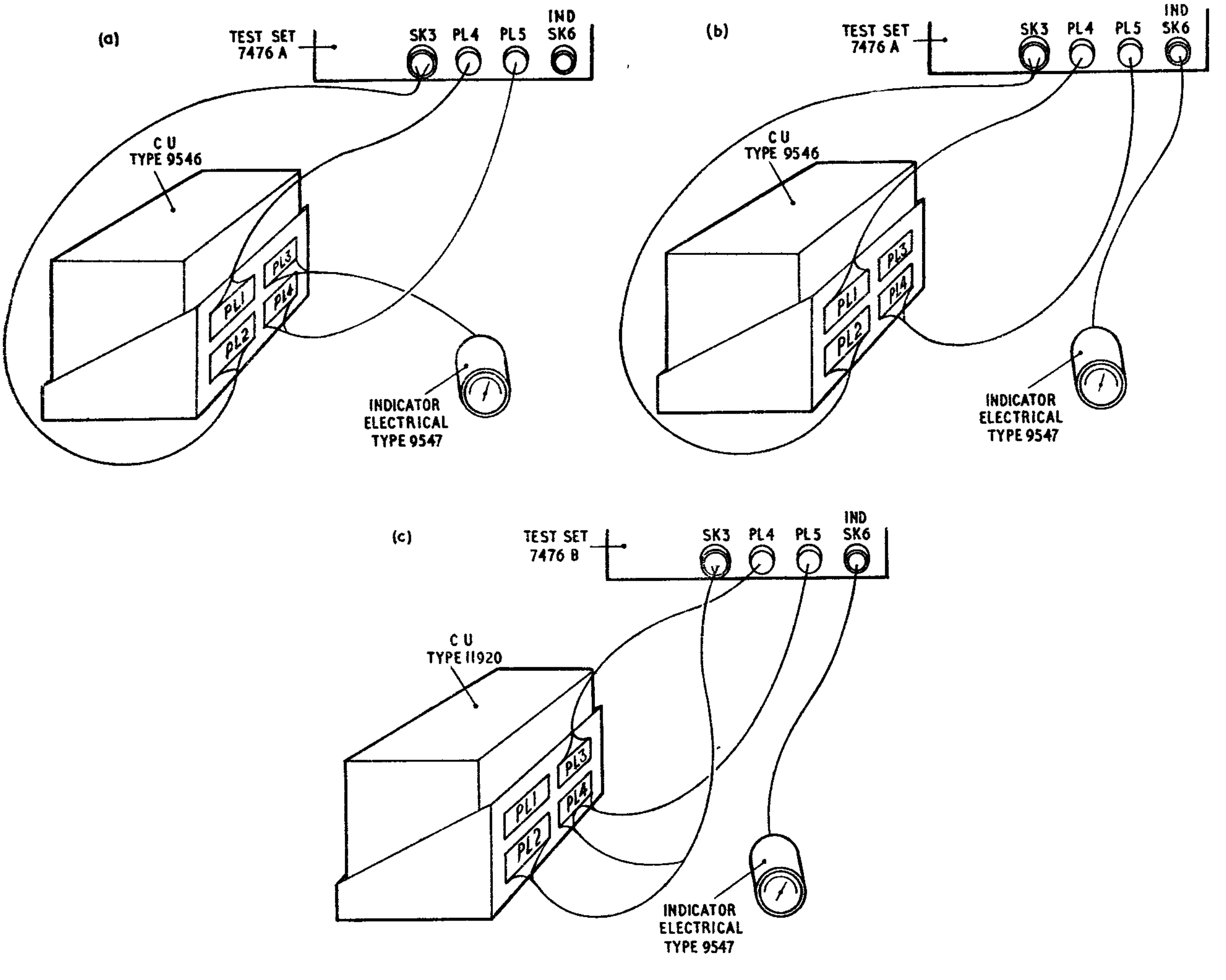

Fig. 1. Cable connections between the test sets and coupling units

Power supply checks

10. If the 28V "on" lamp LP2 does not light when S8 is depressed (*para.* 2) the 2A fuse FS2 and lamp LP2 should be checked. If a fault is suspected in the wiring, the following procedure should be adopted:—

(1) Connect a 100-ohm 4W resistor between terminals 3 and 4. Switch the multimeter Type 1 to 100V d.c. range and connect it between SK6/J and SK6/H. Rotate RV1 DC VOLTS in a clockwise direction from minimum to maximum, the multimeter reading should vary from about 5V to that of the primary supply (28V nominal). Remove the multimeter and resistor.

(2) Connect PL4/G to SK6/G, depress S9 100ML switch. The red indicator lamp LP3 should light. With S9 still depressed remove the link between PL4/G and SK6/G, LP3 should go out.

11. If the 115V "on" lamp LP1 does not light when S7 is depressed (*para.* 3) the 2A fuse FS1, lamp LP1 , and microswitches S12 and S13 should be checked. If LP1 lights but faulty wiring is suspected, the following points should be checked:–

(1) Switch the multimeter Type 1 to the 250V a.c. range and connect it between PL4/A and PL4/B; check that 115 $\pm$5V is indicated.

(2) Repeat this check with the multimeter between SK6/A and SK6/B. Disconnect the multimeter.

Motor generator supply checks

12. Make the appropriate connections between the test set and the mounting unit backplate as detailed in para. 5 and 8. Insert a coupling unit into the mounting tray and switch on the test set. Check that the indicators on the coupling unit rotate at varying speeds when T1 SPEED INCREASE control on the test set is varied; also that the indicators rotate smoothly for all combinations of MOTOR CONTROL switches S3 (INCREASE-DECREASE) and S4 (DIST-BRG.)

13. If a fault is suspected in the motor generator supply circuit, no attempt must be made to adjust RV4; this must only be done with specialised equipment at a calibration centre. The specialised equipment consists of a dummy load of 115 ohms $+ j100$ ohms and a phase-sensitive valve-voltmeter giving indication of the in-phase and quadrature components of an alternating voltage. The dummy load should be capable of accepting 120mA, 400 c/s; it consists of a 115 ohm $\pm$ 1 per cent (100 ohm + 15 ohm) wire-wound resistor and an inductance of 0·04 Henries $\pm$ 5 per cent measured at 120mA, 400 c/s.

Bearing resolver test circuit checks

14. The bearing resolver test circuit should be checked as follows:—

(1) Connect the 135c/s output socket on the test set Type 7478 (video simulator) to terminals 16 and 17 135 CPS INPUT on the test set. TL17 is the earthy side of the input. Switch S11 BEARING RS 135CPS – 400 CPS to 135 CPS position.

(2) Connect a valve-voltmeter (*Chap.* 1, *para.* 7(2)) between PL5 pins A and D (A being earth with respect to D) and check that the output is the same as the 135c/s output of the test set Type 7478. Disconnect valve-voltmeter.

(3) Connect the valve-voltmeter between TL11 (A1) and PL5/B. Switch S6 SELECTOR to position 7 marked BRG.RS.PH and check that when BEARING RS SENSITIVITY control RV3 is rotated from end to end, the voltage varies smoothly with BEARING RS switch S5 in both PHASE and ANTI-PHASE position. Disconnect the valve-voltmeter.

Voltage output checks

15. The test set produces three output voltages. Connect a valve-voltmeter between the points detailed below and check that the correct voltage is indicated.

(1) Between TL14 (earth) and TL18 18V REF. The meter should read 18 $\pm$ 0·9V.

(2) Between PL5/J and PL5/H, with S6 SELECTOR switched to position 9 marked SIN/COS POT PH. The meter should read 5 $\pm$ 0·5V.

(3) Between TL14 (earth) and TL12 (A2) with S11 in 400 CPS position and S6 SELECTOR in position 7 marked BRG RS PH. The meter should read 10 $\pm$ 1·0V.

Master transmitter and master indicator checks

16. The following checks should be carried out to check the wiring of the master transmitter (X1) and master indicator (X2).

(1) Switch S1 and S2 to position 1, marked OFF.

(2) Connect the following terminals together:— TL5(S1) and TL8(S1), TL6(S2) and TL9(S2), TL7(S3) and TL10(S3). Rotate the master transmitter by the knob and check that the master indicator follows within $\pm 1\frac{1}{2}$ deg. Remove interconnection between terminals.

(3) Connect the following points together:— SK6/L to PL4/L, SK6/K to PL4/K and SK6/M to PL4/M. Switch S1 and S2 to position 3, marked BRG. Rotate the master transmitter, the master indicator should follow within $1\frac{1}{2}$ deg. Remove connections between SK6 and PL4.

(4) Connect SK6/C to PL4/C and SK6/D to PL4/D. Switch S1 and S2 to position 4, marked 1 ML. Rotate the master transmitter, the master indicator should follow within $\pm 1\frac{1}{2}$ deg. Remove the connections between PL4 and SK6.

(5) Connect SK6/E to PL4/E and SK6/F to PL4/F. Switch S1 and S2 to position 6, marked

10ML. Rotate the master transmitter, the master indicator should follow within $\pm 1\frac{1}{2}$ deg. Remove the connections between SK6 and PL4.

Should any of the checks detailed above give an error in excess of $\pm 1\frac{1}{2}$ deg., then X1 or X2 must be changed.

Continuity checks

17. Should any part of the test set fail to function correctly, the point-to-point connections listed in Table 1 may help to locate wiring or switch faults. An ohmeter (multimeter Type 1 or similar) should be connected between any two points on one line in the table under the conditions specified in the right-hand column. The resistance between any two points should not be greater than 0·5 ohm. The insulation resistance between all parts not intended to be connected electrically, measured with a 500V megger, should be not less than 40 megohms.

Table 1

Continuity Check Points

	PL1	PL2	SK3	PL4	PL5	SK6	TL	*Test conditions*
(1)	B		M, K		J		14, 13	S7 in ON position, S12 and S13 closed
(2)			M				12	S6 to positions 1, 2, 3, 4, 5 and 6
(3)			F			H	4	
(4)			E			J	3	
(5)			J				18	
(6)					K		18	S4 to BRG.
(7)			H				18	S4 to DIST.
(8)					L		19	S4 to BRG.
(9)			G				19	S4 to DIST.
(10)					M		15	S10 to BRG.
(11)			L				15	S10 to DIST.
(12)				L			13	S6 to positions 1 and 2
(13)				L			12	S6 to positions 1 and 2
(14)							12, 13	S6 to positions 1, 2, 3, 4, 5 and 6
(15)				E			11	S6 to position 6
(16)				D			11	S6 to position 5
(17)				C			11	S6 to position 4
(18)				K			11	S6 to positions 1 and 3
(19)				M			11	S6 to position 2
(20)				M			13	S6 to position 3
(21)			W, U		G			
			Y					
			B, R					On test set 7476B only
(22)					G		13	S6 to positions 4, 5, 6, 9, 10, 11, 12, 13 and 14 (And 15 on 7476B only)
(23)					F		11	S6 to position 8
(24)					E		11	S6 to position 9
(25)					E		13	S6 to position 8
(26)					A		13	S6 to position 7
(27)							17, 13	S6 to position 7
(28)			Z				12	S6 to positions 10 and 11
(29)			X				12	S6 to positions 12 and 13
(30)			T				11	S6 to positions 10 and 13
(31)			V				11	S6 to positions 11 and 12
(32)			C				11	S6 to position 14
(33)					H		1	
(34)					G		2	

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Appendix A

TEST SET TYPE 11964—FUNCTIONAL TESTS AND CHECKS

LIST OF CONTENTS

	Para.
Introduction	1
Additional equipment	2
Setting up procedure	4
Performance check	14

Introduction

1. Test set Type 11964 is designed to perform functional tests on coupler indicator Type 11963 and 13555. There are a number of tests and checks applied to the test set itself which may be divided into the following sections:—

(1) Setting up procedure to be adopted on a repaired test set.

(2) Performance check to be used to check the serviceability of a test set. This does not involve removing the test set from its case.

Additional equipment

2. The following additional equipment is required for both setting up procedure and performance check:—

(1) A phase sensitive valve voltmeter.

(2) An a.c. valve voltmeter.

(3) A variac with a voltmeter connected across its output to enable the 400 c/s supply to be accurately set and monitored.

(4) Resistor 47 ohm 10 watt.

(5) Resistor 150 ohm 6 watt.

(6) Resistor 120 ohm $\frac{1}{2}$ watt.

(7) Dummy motor load 115+j100 ohm (*para.* 3).

(8) Resistor 1 ohm $\pm$ 1%.

(9) Resistor 1·5 ohm $\pm$ 1%.

3. The dummy motor load should be capable of accepting 120 mA at 400 c/s. It consists of a 115 ohm $\pm$ 1% (100 ohm + 15 ohm) wire-wound resistor and an inductance of 0·04 Henries $\pm$ 5% measured at 120 mA, 400 c/s.

Setting up procedure

4. Remove the test set from its case. Temporarily short circuit microswitch S3, or temporarily fix in the 'ON' position. Ensure S4 is switched off. Connect the test set to the AB phase of the 400 c/s supply via the variac and voltmeter. Adjust the voltage to 115V exactly. Set S2 and S10 to OFF and S1 to position 6 (marked O). Connect the 47 ohm 10 watt resistor between TL5 and TL6. Connect the a.c. valve voltmeter, on transformer input, between TL5 and TL6 (earth.) Switch on S4 and note the reading on the a.c. valve voltmeter, which should be 18V approximately.

5. Disconnect the wire from transformer T1 tag 12, 13 or 14 and reconnect to tag 12, 13 or 14 to give the most accurate 18V output, which must be better than $\pm$ 5%. Operate S1 and check that for clockwise movement, the output voltage increases by approximately 5% and for anticlockwise movement, the output voltage decreases by approximately 5%. Set S1 so that the output is 18V $\pm$ 1%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

6. Connect the 150 ohm 6 watt resistor and the a.c. valve voltmeter to transformer input between SK1/P and SK1/N (earth). Switch on S4 and set S2 to position 3 (NAV. RES. 1). The meter should read 26V $\pm$ 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

7. Connect the 120 ohm $\frac{1}{2}$ watt resistor and the a.c. valve voltmeter to transformer input, between SK1/L and SK1/M (earthy). Switch on S4 and set S2 to position 7 (SIN/COS POT PHASE). The meter should read 5V $\pm$ 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

8. Connect the dummy motor load in parallel with the phase sensitive valve voltmeter, to transformer input at TL4 and TL6 (earth). Rotate variac T2 to give 18V quadrature leading, with S7 set to INCREASE, and lagging with S7 set to DECREASE.

9. Set T2 and S7 to give 18V quadrature leading. Adjust RV3 to bring reference phase reading to zero. Check that with S7 set to DECREASE and T2 set to give 20V quadrature lagging, the reference phase reading is not greater than 2V.

10. Check that the range of the variac T2 is from less than 1V to at least 22V quadrature phase. Switch off S4 and disconnect the phase sensitive valve voltmeter and dummy motor load.

11. Set S2 to position 2 (BEARING RES.) Connect the phase sensitive valve voltmeter, to transformer input, at TL1 and SK1/U (earthy). Set S5 to 400 C/S and S4 to ON. Rotate bearing resolver SENSITIVITY control (RV1). Check that the voltage indicated on the meter varies from 0V to 5V $\pm$ 0·5V reference reverse phase, when S8 is set to 0° and reference in phase when S8 is set to 180°. Switch off S4, return S2 to OFF position and disconnect the phase sensitive valve voltmeter.

12. Connect the external cables to the test set. In the following para. 12 and 13, the connectors on the ends of the cables will be referred to by the plug or socket number of the coupling unit to which they connect. Connect the 1 ohm ± 1% resistor between SK3/A and PL2/G and the 1·5 ohm ± 1% resistor between SK3/A and SK1/A. Switch on S4 and set S10 to TEST 1. Adjust RV2 (CAL.) to make LP2 (red) extinguish and LP3 (green) light. Set S10 to TEST 2. LP3 (green) should now extinguish and LP2 (red) light. If this does not occur, readjust RV2 and repeat this procedure until the conditions are met. Switch off S4 and remove the resistors.

13. Connect a short circuit between the following pairs of points in turn. Switch on S4 and with S10 in the position indicated, check that LP2 (red) extinguishes and LP3 (green) lights.

S/C between		*S10 set to*
SK3/A	PL2/G	1
SK3/A	SK1/A	2
SK3/A	PL4/T	3
SK3/B	PL2/H	4
SK3/B	SK1/B	5
SK3/B	PL4/3	6
SK3/G	SK1/G	7
SK3/G	PL4/E	8
SK3/C	SK1/C	9
SK3/C	PL4/2	10
SK1/K	PL4/S	11
SK1/J	PL4/R	12
SK1/H	PL4/Q	13
SK1/L	PL4/P	14
SK1/E	PL4/C	15

Performance check

14. Ensure S4 is switched off. Connect the test set to the AB phase of the 400 c/s supply via the variac and voltmeter. Adjust the voltage to 115V exactly. Set S2 and S10 to OFF and S1 to position 6 (marked o). Connect the 47 ohm 10 watt resistor between TL5 and TL6. Connect the a.c. valve voltmeter, on transformer input, between TL5 and TL6 (earth). Switch on S4 and note the reading on the meter, which should be 18V ± 5%. Set S1 so that the output is 18V ± 1%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

15. Connect the 150 ohm 6 watt resistor and the a.c. valve voltmeter, to transformer input between SK1/P and SK1/N (earth). Switch on S4 and set S2 to position 3 (NAV. RES. 1). The meter should read 26V ± 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

16. Connect the 120 ohm $\frac{1}{2}$ watt resistor and the a.c. valve voltmeter, to transformer input between SK1/L and SK1/M (earthy). Switch on S4 and set to position 7 (SIN/COS POT PHASE). The meter should read 5V ± 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

17. Connect the dummy motor load in parallel with the phase sensitive valve voltmeter, to transformer input, at TL4 and TL6 (earth). Check that the range of the variac T2 is from less than 1V to at least 22V quadrature phase. Switch off S4 and disconnect the phase sensitive valve voltmeter and dummy motor load.

18. Connect the external cables to the test set. In this para. the connectors on the ends of the cables will be referred to by the plug or socket number of the coupling unit to which they are connected. Connect the 1 ohm ± 1% resistor between SK3/A and PL2/G and the 1·5 ohm ± 1% resistor between SK3/A and SK1/A. Switch on S4 and set S10 to test 1. Adjust RV2 (CAL.) to make LP2 (red) extinguish and LP3 (green) light. Set S10 to TEST 2. LP3 (green) should now extinguish and LP2 (red) light. If this does not occur, readjust RV2 and repeat this procedure until the conditions are met. Switch off S4 and remove the resistors.

Chapter 3

(Revised)

TEST SET TYPE 11964

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LEADING PARTICULARS

Test set	Type 11964
Nato No.	6625-99-915-0063
Manufacturers Pt.No.	647TE (Smiths Industries)
Length	19in
Width	10½in
Height	18in

Modifications

1. The information contained in this chapter describes equipment incorporating the modifications listed in Table 1.

Introduction

2. Test set Type 11964 is designed to perform functional tests on coupling units (indicator) Type 11963 and 13555. Attached to the sides of the case at the front are two hinged plates which are used to secure the test set to a 19in test rack when required. The cables are stored beneath a cover which is attached to the front panel by means of knurled-headed screws. Special connectors are required for use with each type of coupler indicator.

3. Illustrated in fig.1 are all the controls, indicators, plugs and sockets carried on the front panel. The preset control RV3 (fig.2) is fitted within the unit on the left-hand side (from the front). The microswitch S3 is also within the unit and fitted behind the 115V. a.c. entry plug PL2. The front panel is secured to the case by ten 2 BA cheesehead screws.

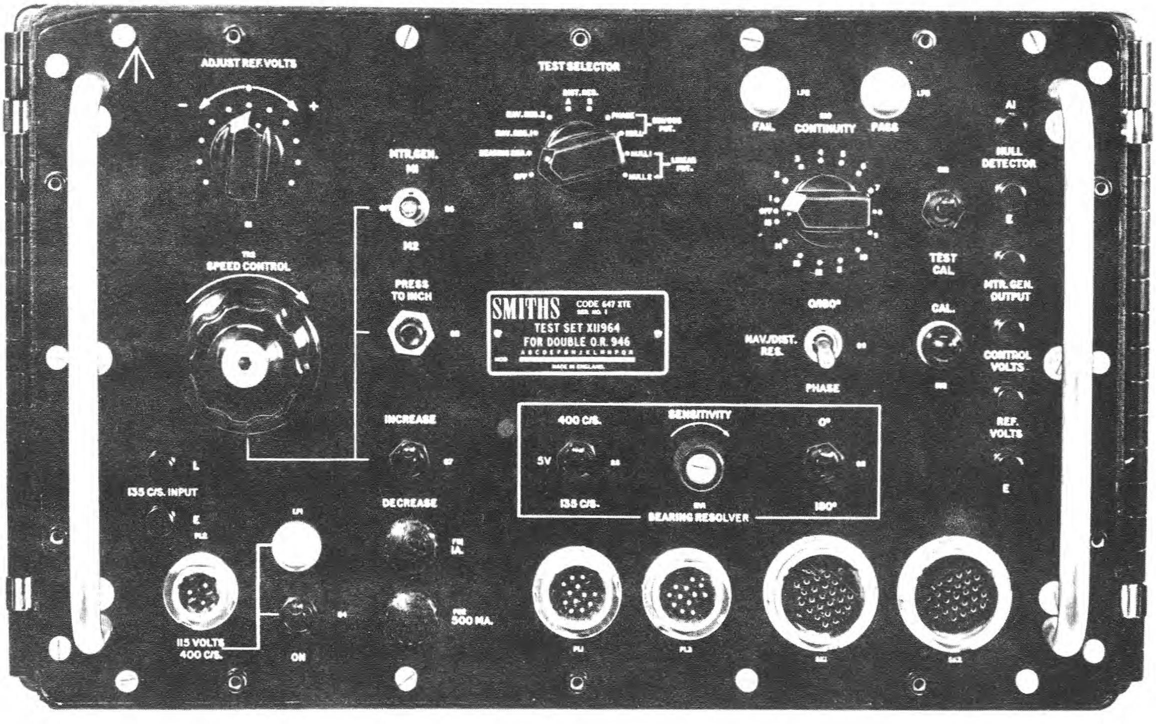


Fig.1 Test set Type 11964 - front panel

DESCRIPTION

Facilities

4. The test set provides the following facilities:-

(1) The necessary switching, phasing and voltage control of the 400Hz supply to check the motor generators and provide a means of rotating the bearing and distance gear trains in the coupling unit in either direction.

(2) The necessary switching for checking the bearing and distance resolvers.

(3) The necessary switching for checking the potentiometers.

(4) Means for checking the continuity of certain through connections in the coupling unit.

Connectors

5. There are three plugs and two sockets fitted on the front panel, namely:-

(1) PL1, a 12-pole plug to connect the continuity tester to SK1 on coupling unit Type 11963. This plug is not used with coupler indicator Type 13555.

(2) PL2, a 3-pole plug to connect the 115V 400Hz supply to the test set.

(3) PL3, a 12-pole plug connect to SK3 on coupling unit Type 11963. This makes connections for further continuity checks and for checks on the second navigational resolver. This plug is not used with coupler indicator Type 13555.

(4) SK1, a 25-pole socket to connect general facilities to PL4 on coupling unit Type 11963 or PL2 and part of PL1 on coupler indicator Type 13555.

(5) SK2, a 25-pole socket to connect general facilities to PL2 on coupling unit Type 11963 or to the remaining part of PL1 on coupler indicator Type 13555.

6. When PL3, SK1, PL1 and SK2 are connected to coupling unit Type 11963 by means of cables 10 HS 6625-99-945-3853 to 3856 respectively, the external connections shown in fig.3(a) are made. When SK1 and SK2 are connected to coupler indicator Type 13555 by means of cable TE 19398 the external connections shown in fig.3(b) are made.

7. There are also 8 terminals of the front panel which provide connections for the injection of 135Hz and for external monitoring. The terminals are numbered on fig.1 and annotated on the front panel as follows:-

(1) On the left-hand side of the front panel terminals 7 and 8 marked 135 c/s INPUT L and E respectively. TL8 is the earthy side of the input connection.

(2) On the right-hand side of the front panel reading from top to bottom:-

(a) Terminals 1 and 2 are marked NULL DETECTOR A1 and E respectively.

(b) Terminal 3 marked MTR. GEN. OUTPUT.

(c) Terminal 4 marked CONTROL VOLTS.

(d) Terminal 5 marked REF. VOLTS.

(e) Terminal 6 marked E.

Power supplies (fig.6)

8. The power supply required to operate the test set is 115 ± 5V 400 ± 20Hz single phase. The supply is applied to the test set via PL2 then through microswitch S3 to a double-pole on-off switch S4. The microswitch S3 ensures that the line side of the power input is broken when the panel is withdrawn from the case. From the other side of S4 two seeds are taken, one via a 500 mA fuse FS2 to the continuity checking circuit and the other via a 1A fuse FS1 to the main power supply circuits. An indicator lamp LP1 (red) in series with capacitor C1, is connected across the supply. From FS1, the supply is routed via bank 3 of S10 (CONTINUITY switch), which forms an interlock so that no power is supplied to the coupling unit when continuity checks are being carried out. Switch S1 selects one of eleven taps on the line end of T1 primary winding, to enable the effect of mains voltage variation to be offset up to ± 5% of 115V. Three taps are provided at the "earthy" end of T1 primary so that, with an input of 115V and with S1 in the centre position, the output voltages may be accurately set. The voltages available from the

main power supply circuits are as follows:-

(1) 5V ± 5% in phase 400Hz for checking potentiometers and bearing resolver.

(2) 26V ± 5% in phase 400Hz for checking range and navigational resolvers.

(3) 18V ± 5% in phase 400Hz for energizing the motor-generators.

(4) A quadrature 400Hz supply, variable from 0-20V leading or lagging, to control the speed of the motor generators.

Ancilliary test equipment

9. The ancilliary test equipment required for use with the test set is as follows:-

(1) A frequency selective valve voltmeter for monitoring synchro outputs and measuring motor-generator parameters.

(2) A 400Hz phase sensitive null detector for checking phase of generator output and synchrophase shifts and nulls.

(3) A 135Hz supply with a source impedance of approximately 500 ohms at 5V r.m.s.

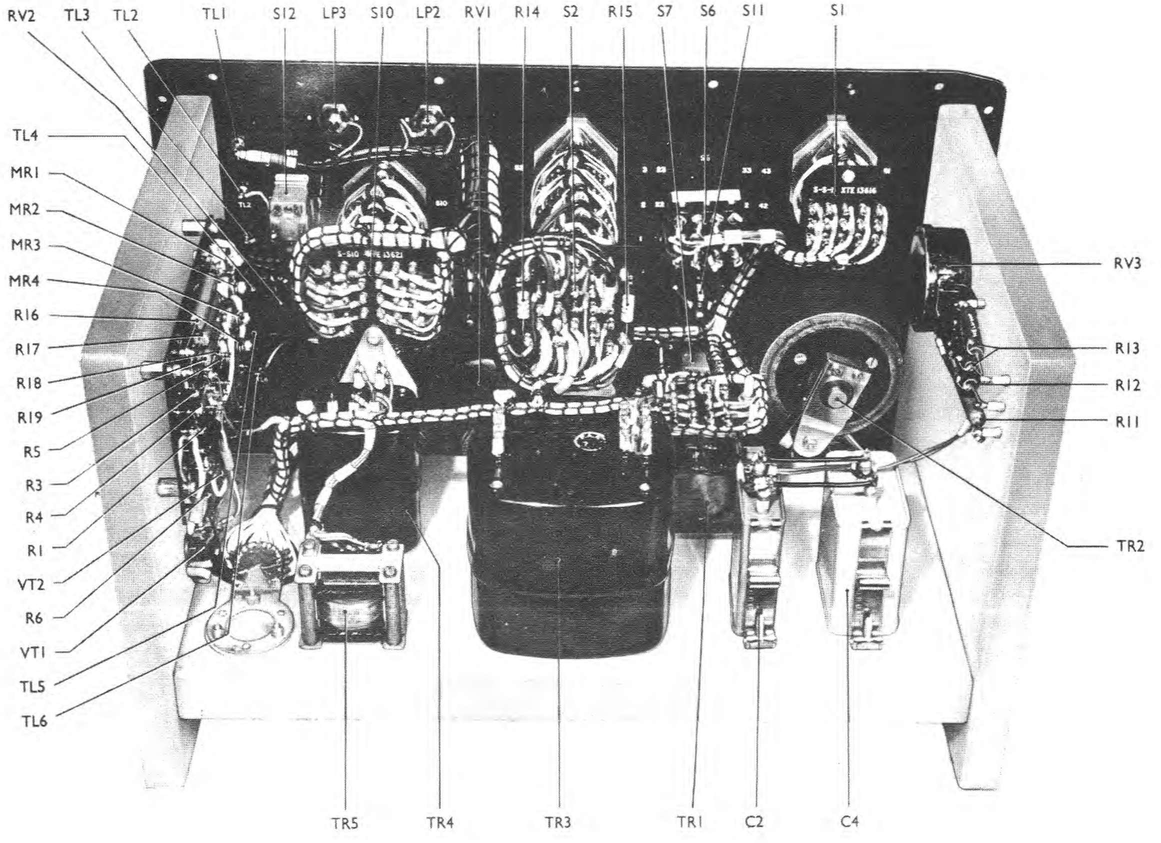


Fig.2 Test set Type 11964 - rear view (top)

Motor speed control

10. To test the motor generators MG1 and MG2 in the coupling unit a quadrature voltage, variable from 0 to 20 volts is available from the test set. The 115V 400Hz supply is fed to variac T2. The variac control marked SPEED CONTROL is brought out of the front panel and is rotated in a clockwise direction to increase speed. The voltage output from the variac slider is applied to the primary winding of transformer T3. This transformer has two secondary windings, only one being used, and it supplies 50V centre-tapped from tags 3,4 and 5 when 115V is applied to the primary. As the primary voltage is continuously variable by T2, the secondary voltage varies between 0 and 25 volts in each half of the winding. Connected to tag 3 are three 33 ohm resistors R11, R12 and R13 and a 25 ohm variable resistor RV3, all in series. Connected between tag 5 and RV3 are two capacitors in parallel, C2 and C4. The component values are so adjusted that the voltage appearing between tag 4 and the junction of RV3, C2 and C4 is always phase shifted by 90° from the supply voltage. Thus a variable quadrature voltage is available whose sense may be reversed by means of the switch S7.

11. There are four controls in the motor control circuit namely:-

(1) T2, the SPEED CONTROL.

(2) Switch S7; this is a double-pole changeover switch marked INCREASE-DECREASE. The switch controls the direction of rotation of the motor-generators by reversing the phase of the control voltage.

(3) Switch S11; this is a press-button switch marked PRESS TO INCH. The switch provides means of applying the control voltage to the motor-generators for very brief periods so that the bearing and distance dials may be set or nulls determined with considerable accuracy.

(4) Switch S6; this is a three-pole three-position toggle switch marked MTR. GEN - M1 - OFF - M2. One pole routes the 18V 400Hz reference voltage from tag 20 of T1 to the bearing or distance motor-generators via SK1/G or SK2/L and SK2/F respectively. This reference supply is also brought out to TL5 marked REF. VOLTS. This enables the 18V to be monitored by an external valve voltmeter. The second pole of S6 routes the motor control voltage to the bearing or distance motor-generators via SK1/H or SK2/J respectively. The control voltage may also be monitored at TL4 marked CONTROL VOLTS. The third pole of S6 routes either the bearing or distance generator output to TL3, marked MTR.GEN.OUTPUT. The bearing and distance generator outputs are routed into the test set via SK1/K and SK2/N respectively. Terminals TL4 and TL5 together with TL6 (earth), also enable individual motor-generators to be tested with the test set control facilities.

Bearing resolver checking circuit

12. Transformer T4 and its associated network are provided for checking the bearing resolver (RS1) in the coupling unit. The associated network consists of R10 (560 ohm), RV1 (100 Kilohm) marked SENSITIVITY, a double-pole changeover switch S8 marked 0^{o}-190^{o} and a quadrature network consisting of C3 (0.01μF) and three resistors R7, R8 and R9 (each 39 kΩ) in series. Also used in this check are a double-pole changeover switch S5 marked 400 c/s and rotary switch S2 marked TEST SELECTOR.

13. A supply of 5V, 135Hz (para.9(3)) is injected via terminals TL7 and TL8 (135 c/s INPUT) and one pole of switch S5 to the primary of T4. The circuit is completed when switch S5 is in the 135 c/s position. Variable resistor RV1 is connected across T4 secondary winding, and together with switch S8, provides means of obtaining accurate null positions 180 deg. apart on the bearing resolver. To monitor the null positions, the a.c. valve voltmeter is connected to TL1 (A1) and TL2 (E) and the TEST SELECTOR switch S2 is set to position 2 (BEARING RES)

14. The 135Hz supply is fed to SK1/Z via switch S5 and R10. R10 is a 560 ohm resistor which simulates the normal source impedance of the circuit driving the resolver. When S5 is set

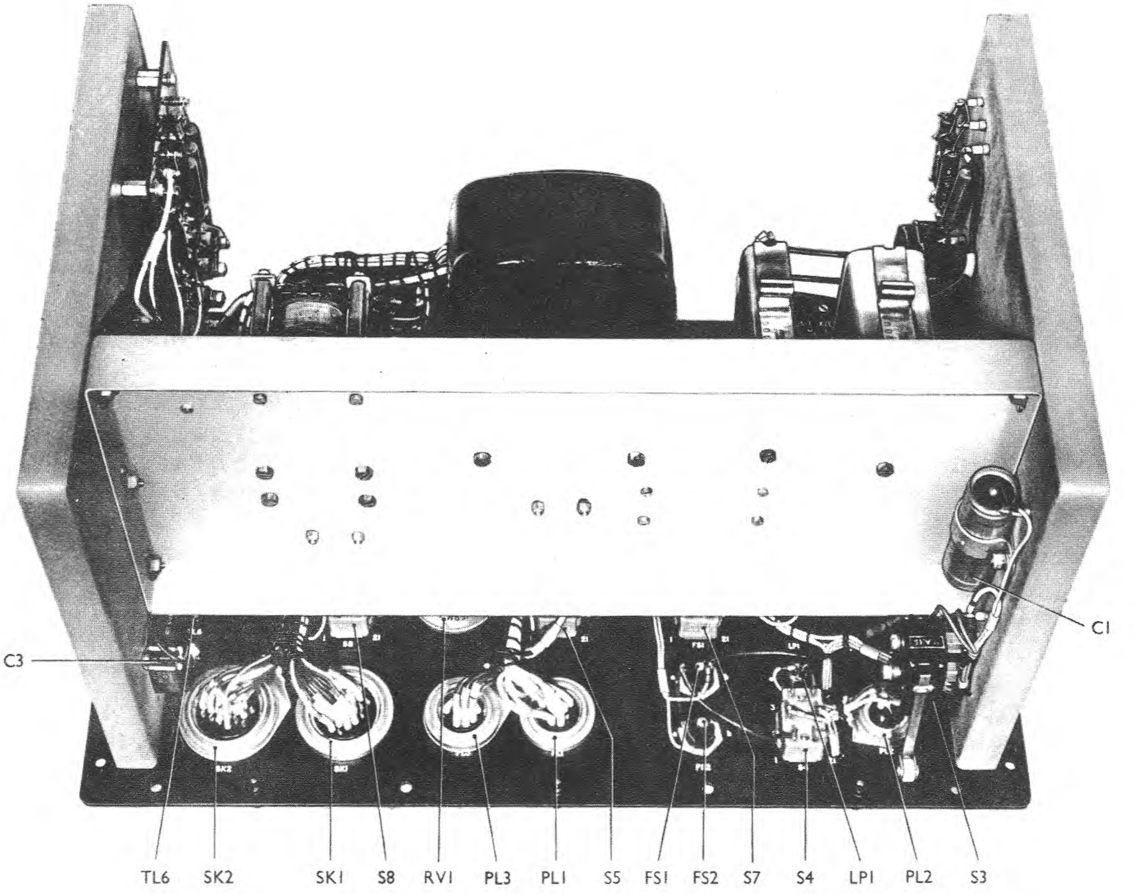


Fig.3 Test set Type 11964 - rear view (bottom)

to 400 c/s, the same tests may be carried out at 400Hz, the supply being obtained from T1, tag 16.

Selector switch S2

15. S2 is the TEST SELECTOR switch, which is a 10 position, 5-bank rotary type. Switch wipers S6/1, S6/2, S6/3 and S6/4 connected to T1 tags 15 and 16 (5V 400Hz), T1 tag 18 (26V 400Hz) and terminal TL1 (A1) respectively, make the necessary connections between the test set and the equipment under test. Switch wiper S2/5 routes the 115V 400Hz supply to the primary winding of T5, ensuring that there is no supply to the continuity tester unless the TEST SELECTOR switch is set to OFF. This switch wiper together with S10/3 (para.10) forms an interlock between the continuity tester and the rest of the test set.

16. When testing the distance and navigational resolvers, S2 is used in conjunction with S9. Switch S9 is a 4-pole changeover switch marked NAV./DIST. RES - 0/180° - PHASE.

Continuity tester

17. The continuity tester consists of a selector switch S10 marked CONTINUITY and a transistor switching circuit containing two lamps LP2 (red), marked FAIL, and LP3 (green) marked PASS. The switching circuit consists of an emitter coupled pair of transistors VT1 and VT2 with the lamps LP2 and LP3 in their collectors. The input to the circuit is between the base of VT1 and the common line via a preset input resistance combination R18 and RV2. When the input is open circuit, the switching circuit is in the condition where VT1 is conducting and VT2 is cut off, so that the FAIL lamp lights. This condition will also hold when the input is shunted by a resistance of 1.5 ohms or more. When a resistance of 1 ohm or less is shunted across the input, the base bias of VT1 is so reduced that the circuit switches over to the state where VT1 is cut off and VT2 is conducting, so that the FAIL lamp extinguishes and the PASS lamp lights. Power for the circuit is provided by transformer T5 and four diodes MR1, MR2,MR3 and MR4 connected as a full-wave bridge rectifier. The CONTINUITY switch S10 is a 3-pole, 3-position rotary switch, even contacts only being used, except for contact 1 which is used as an OFF position. Wipers S10/1 and S10/2 connect the input of the switching circuit to the circuit under test. Wiper S10/3 forms an interlock (para.10).

TABLE 1

Modifications

Mod.No.	Strike off Mod.No.	Brief details
A4668/1	1	Transistor types changed due to non-availability of original components. Resistors R3 and R18 change from S.I.T. components to fixed values and resistance values of R4 & R5 changed to accomodate new resistor types.R6 deleted.

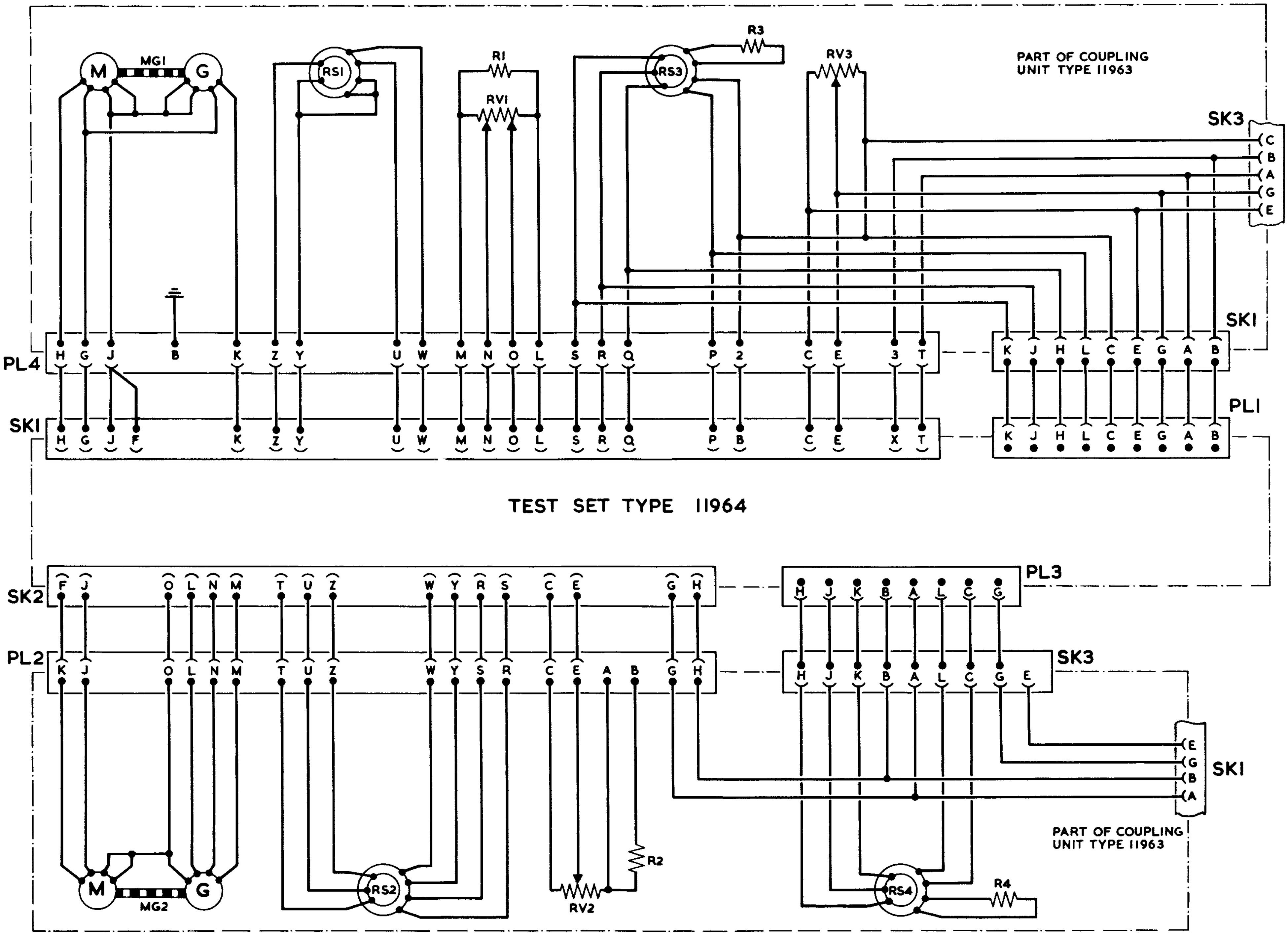


Fig. 4 External connections for coupling unit Fig. 4

GCM.570113 27-4-65

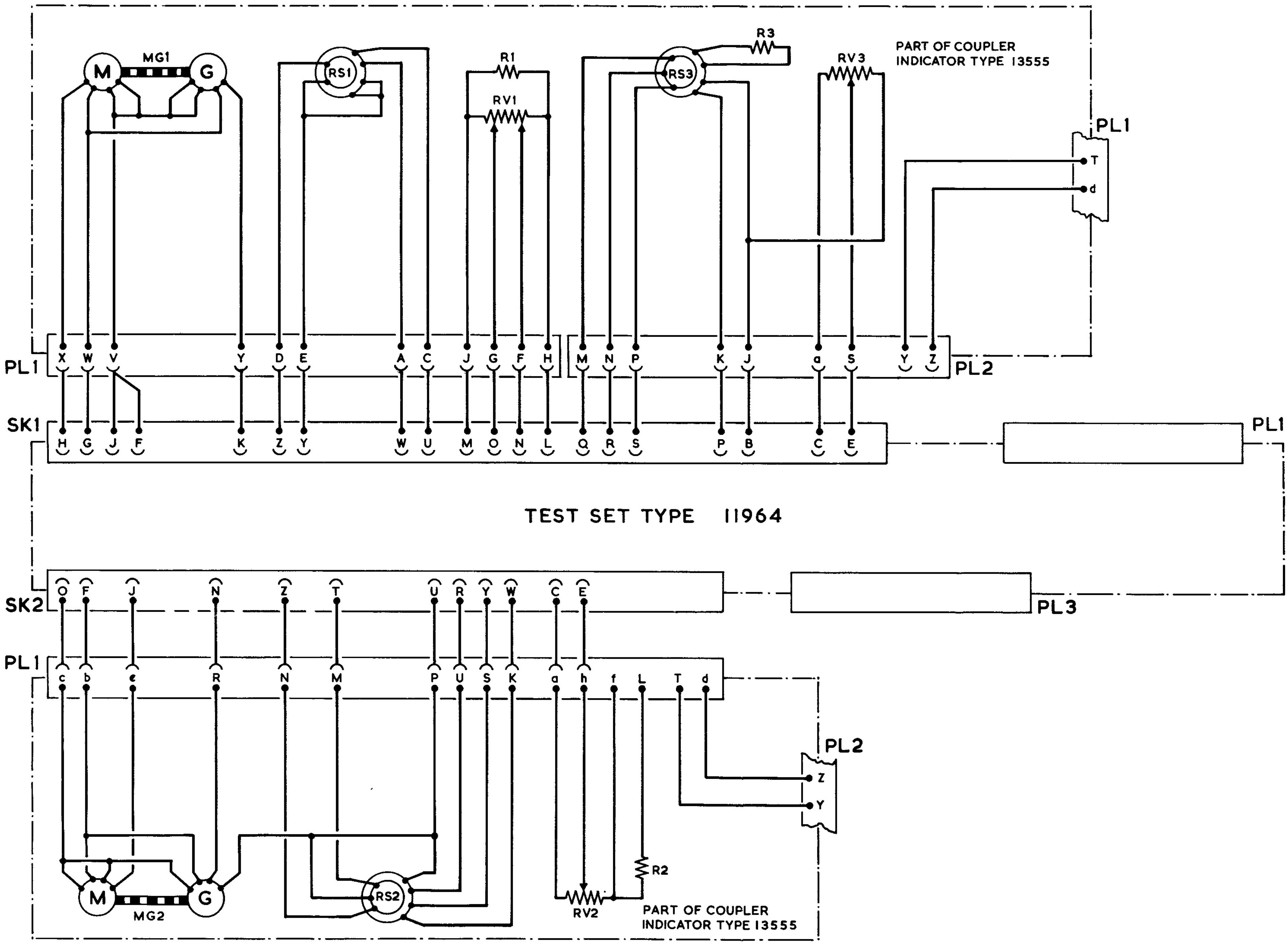
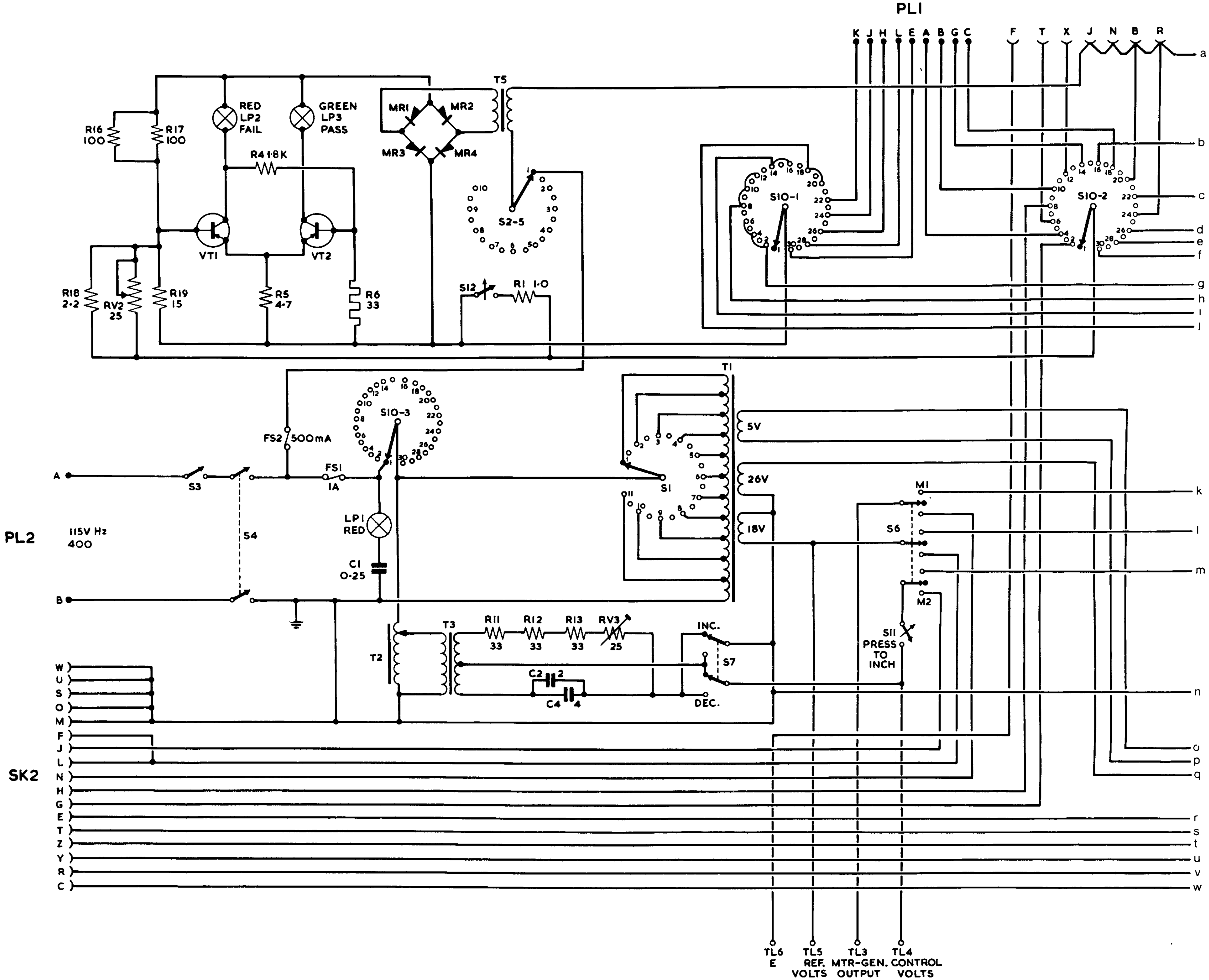


Fig. 5 External connections for coupling indicator Fig. 5



Test set Type 11964 – circuit (sheet 1)

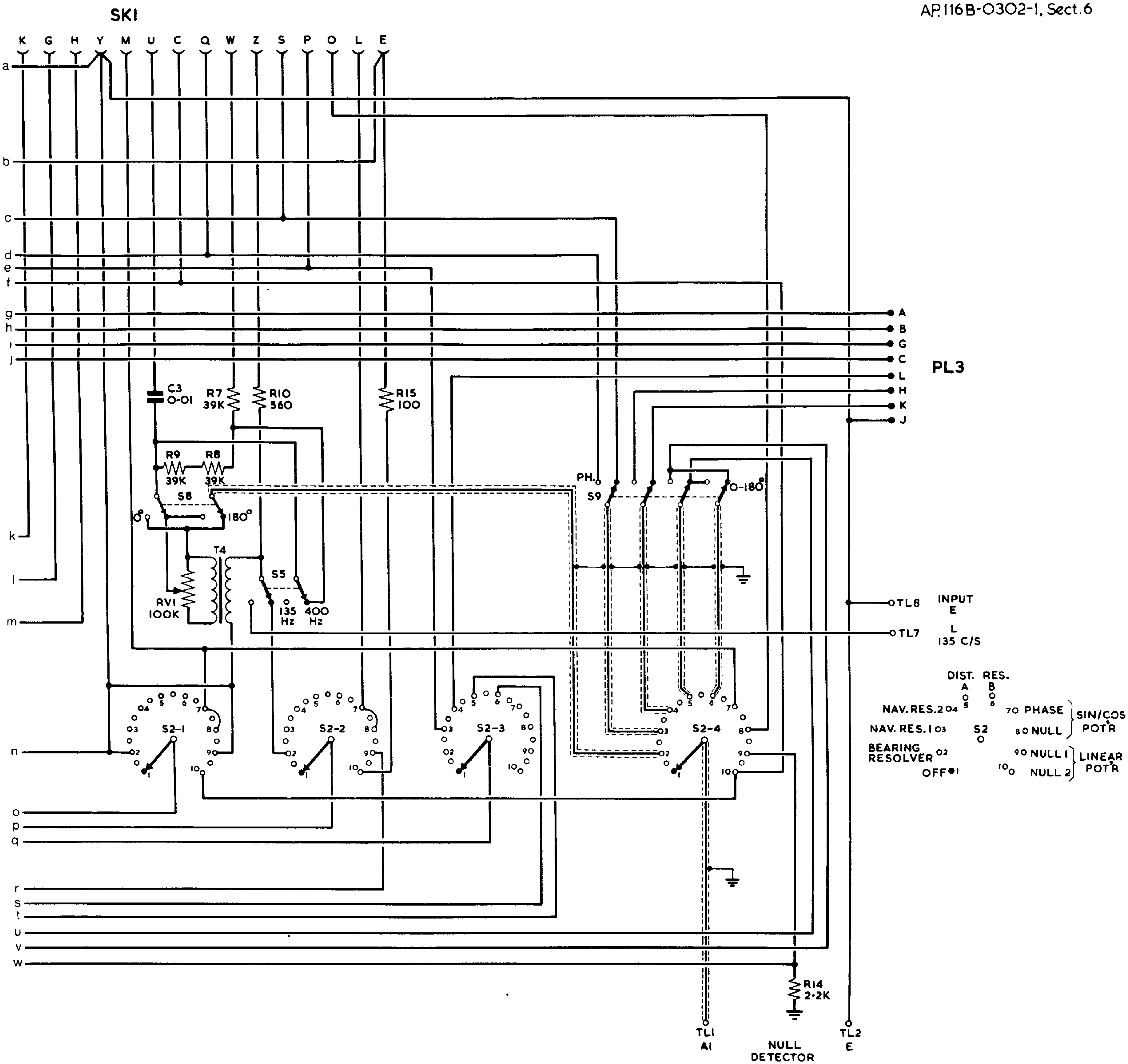


Fig. 6

Test set Type 11964 — circuit (sheet 2)

Chapter 4

TEST SET TYPE 11964—FUNCTIONAL TESTS AND CHECKS

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Introduction

1. Test set Type 11964 is designed to perform functional tests on coupler indicator Type 11963 and 13555. There are a number ot tests and checks applied to the test set itself which may be divided into the following sections:—

(1) Setting up procedure to be adopted on a repaired test set.

(2) Performance check to be used to check the serviceability of a test set. This does not involve removing the test set from its case.

Additional epuipment

2. The following additional equipment is required for both setting up procedure and performance check:—

(1) A phase sensitive valve voltmeter.

(2) An a.c. valve voltmeter.

(3) A variac with a voltmeter connected across its output to enable the 400 c/s suuply to be accurately set and monitored.

(4) Resistor 47 ohm 10 watt.

(5) Resistor 150 ohm 6 watt.

(6) Resistor 120 ohm ½ watt.

(7) Dummy motor load 115+j100 ohm (*para.* 3).

(8) Resistor 1 ohm ± 1%.

(9) Resistor 1·5 ohm ± 1%.

3. The dummy motor load should be capable of accepting 120 mA at 400 c/s. It consists of a 115 ohm ± 1% (100 ohm % 15 ohm) wire-wound resistor and an inductance of 0·04 Henries ± 5% measured at 120 mA, 400 c/s.

Setting up procedure

4. Remove the test set from its case. Temporarily short circuit microswitch S3, or temporarily fix in the 'ON' position. Ensure S4 is switched off. Connect the test set to the AB phase of the 400 c/s supply via the variac and voltmeter. Adjust the voltage to 115V exactly. Set S2 and S10 to OFF and S1 to position 6 (marked O). Connect the 47 ohm 10 watt resistor between TL5 and TL6. Connect the a.c. valve voltmeter, on transformer input, between TL5 and TL6 (earth.) Switch on S4 and note the reading on the a.c. valve voltmeter, which should be 18V approximately.

5. Disconnect the wire from transformer T1 tag 12, 13 or 14 and reconnect to tag 12, 13 or 14 to give the most accuıate 18V output, which must be better than ± 5%. Operate S1 and check that for clockwise movement, the output voltage increases by approximately 5% and for anticlockwise movement, the output voltage decreases by approximately 5%. Set S1 so that the output is 18V± 1%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

6. Connect the 150 ohm 6 watt resistor and the a.c. valve voltmeter to transformer input between SK1/P and SK1/N (earth). Switch on S4 and set S2 to position 3 (NAV. RES. 1). The meter should read 26V ± 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

7. Connect the 120 ohm ½ watt resistor and the a.c. valve voltmeter to transformer input, between SK1/L abd SK1/M (earthy). Switch on S4 and set S2 to position 7 (SIN/COS POT PHASE). The meter should read 5V ± 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

8. Connect the dummy motor load in parallel with the phase sensitive valve voltmeter, to transformer input at TL4 and TL6 (earth). Rotate variac T2 to give 18V quadrature leading with S7 set to INCREASE, and lagging with S7 set to DECREASE.

9. Set T2 and S7 to give 18V quadrature leading. Adjust RV3 to bring reference phase reading to zero. Check that with S7 set to DECREASE and T2 set to give 20V quadrature lagging, the reference phase reading is not greater than 2V.

10. Check that the range of the variac T2 is from less than 1V to at least 22V quadrature phase. Switch off S4 and disconnect the phase sensitive valve voltmeter and dummy motor load.

11. Set S2 to position 2 (BEARING RES.). Connect the phase sensitive valve voltmeter, to transformer input, at TL1 and SK1/U (earthy). Set S5 to 400 c/s and S4 to ON. Rotate bearing resolver SENSITIVITY control (RV1). Check that the voltage indicated on the meter varies from 0V to 5V ± 0·5V reference reverse phase, when S8 is set to 0° and reference in phase when S8 is set to 180°. Switch off S4, return S2 to OFF position and disconnect the phase sensitive valve voltmeter.

12. Connect the external cables, to the test set. In the following para. 12 and 13, the connectors on the ends of the cables will be referred to by the plug or socket number of the coupling unit to which they connect. Connect the 1 ohm $\pm$ 1% resistor between SK3/A and PL2/G and the 1·5 ohm $\pm$ 1% resistor between SK3/A and SK1/A. Switch on S4 and set S10 to TEST 1. Adjust RV2 (CAL.) to make LP2 (red) extinguish and LP3 (green) light. Set S10 to TEST 2. LP3 (green) should now extinguish and LP2 (red) light. If this does not occur, readjust RV2 and repeat this procedure until the conditions are met. Switch off S4 and remove the resistors.

13. Connect a short circuit between the following pairs of points in turn. Switch on S4 and with S10 in the position indicated, check that LP2 (red) extinguishes and LP3 (green) lights.

S/C between		*S10 set to*
SK3/A	PL2/G	1
SK3/A	SK1/A	2
SK3/A	PL4/T	3
SK3/B	PL2/H	4
SK3/B	SK1/B	5
SK3/B	PL4/3	6
SK3/G	SK1/G	7
SK3/G	PL4/E	8
SK3/C	SK1/C	9
SK3/C	PL4/2	10
SK1/K	PL4/S	11
SK1/J	PL4/R	2
SK1/H	PL4/Q	13
SK1/L	PL4/P	14
SK1/E	PL4/C	15

Performance check

14. Ensure S4 is switched off. Connect the test set to the AB phase of the 400 c/s supply via the variac and voltmeter. Adjust the voltage to 115V exactly. Set S2 and S10 to OFF and S1 to position 6 (marked o). Connect the 47 ohm 10 watt resistor between TL5 and TL6. Connect the a.c. valve voltmeter, on transformer input, between TL5 and TL6 (earth). Switch on S4 and note the reading on the meter, which should be 18V$\pm$ 5%. Set S1 so that the output is 18V$\pm$1%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

15. Connect the 150 ohm 6 watt resistor and the a.c. valve voltmeter, to transformer input between SK1/P and SK1/N (earth.) Switch on S4 and set S2 to position 3 (NAV. RES. 1). The meter should read 26V$\pm$5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

16. Connect the 120 ohm $\frac{1}{2}$ watt resistor and the a.c. valve voltmeter, to transformer input between SK1/L and SK1/M(earthy.) Switch on S4 and set to position 7 (SIN/COS POT PHASE). The meter should read 5V $\pm$ 5%. Switch off S4 and disconnect the a.c. valve voltmeter and load resistance.

17. Connect the dummy motor load in parallel with the phase sensitive valve voltmeter, to transformer input, at TL4 and TL6 (earth). Check that the range of the variac T2 is from less than 1V to at least 22V quadrature phase. Switch off S4 and disconnect the phase sensitive valve voltmeter and dummy motor load.

18. Connect the external cables to the test set. In this para. the connectors on the ends of the cables will be referred to by the plug or socket number of the coupling unit to which they are connected. Connect the 1 ohm $\pm$ 1% resistor between SK3/A and PL2/G and the 1·5 ohm $\pm$1% resistor between SK3/A and SK1/A. Switch on S4 and set S10 to test 1. Adjust RV2 (CAL.) to make LP2 (red) extinguish and LP3 (green) light. Set S10 to TEST 2. LP3 (green) should now extinguish and LP2 (red) light. If this does not occur, readjust RV2 and repeat this procedure until the conditions are met. Switch off S4 and remove the resistors.

Chapter 5

TEST SET TYPE 11964 ADAPTOR (1098/1 TE)—GENERAL DESCRIPTION

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Introduction

1. Test set Type 11964 (Stores Ref. 6625-99-915-0063) was designed to perform functional tests on coupler indicators Type 11963 and 13555, but is also used to carry out functional tests on those parts of coupler indicator Type 13893 (Stores Ref. 5826-99-952-2312) which are similar. Functional tests on the remaining parts of coupler indicator Type 13893 are carried out by test set Type 11964 adaptor (1098/1 TE), this unit also being used to perform a complete functional test on distance indicator Type 13894 (Stores Ref. 5826-99-952-2313). The 1098/1 TE is contained in a metal case $17\frac{1}{2}$ in. $\times$ $6\frac{7}{8}$ in. $\times$ $6\frac{1}{2}$ in. deep. Two hinged metal plates secured to the side of the case enable the unit to be fitted in a 19 in. rack when required. The cables supplied with the unit are stored in a cover which is secured to the front panel by eight knurled-headed screws: the overall size of the unit complete with cover being $17\frac{1}{2}$ in. $\times$ $6\frac{7}{8}$ in. $\times$ 12 in. deep.

Fig. 1. Front panel

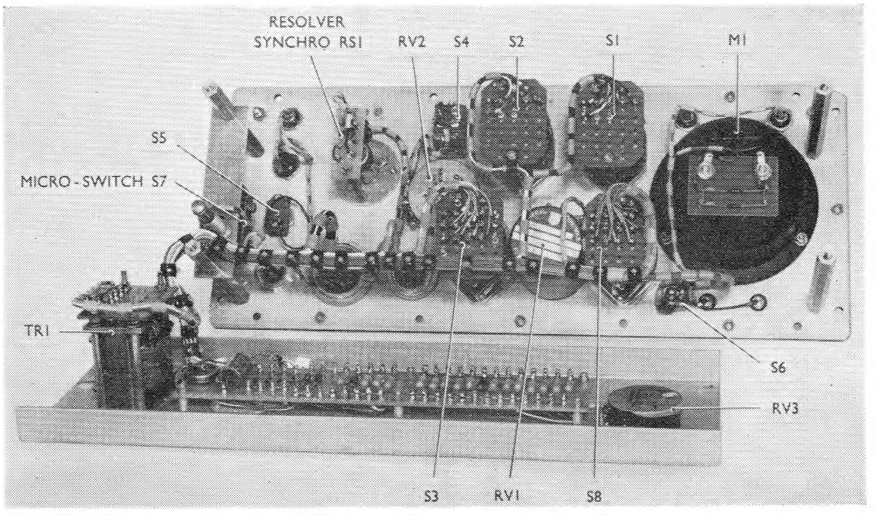

Fig. 2. Internal view

2. The front panel, shown in fig. 1, is secured to the case by twelve 2 BA cheesehead screws. The controls and electrical connectors, with the exception of RV3 and S7, are carried on the front panel. The preset control RV3 is fitted on the unit chassis whilst microswitch S7 is fitted behind power supply plug PL1.

Facilities

3. The test set provides the following facilities:

(1) The necessary switching for checking the bearing differential synchro, bearing transmission synchro and radial selection resolver in the coupler indicator.

(2) The necessary switching for checking the distance potentiometers RV3 and RV4, and for measuring the To/From and Left/Right signals in the coupler indicator.

(3) A means of checking the operation of the distance indicator warning flag and relay RC in the coupler indicator.

(4) A potentiometer to provide a comparison signal for the distance indicator amplifier.

(5) A means of checking the distance indicator and coupler indicator as a system.

(6) Power supplies for the distance and coupler indicators.

Connectors

4. Three connectors, one plug (PL1) and two sockets (SK1 and SK2), are secured to the front panel. The 115V power supply is fed to the unit via cable TE 20097 (Stores Ref. 10HA/8359) connected to 3 pole plug PL1. Distance indicator Type 13894 is connected to 12 pole socket SK2 by cable TE25994 (Stores Ref.). Coupler indicator type 13893 is connected to 25 pole socket SK1, and also to test set Type 11964, by cable TE 25995 (Stores Ref.). The external connections made when testing the coupler indicator and distance indicator are shown in figs. 3 and 4 respectively.

5. Terminals TL1 and TL2 on the front panel enable a null detector to be connected to the unit. In order to use the null detector, switch S8 must be set to INDICATOR DISTANCE (position 3).

Ancillary test equipment

6. A 400 c/s phase sensitive null detector is required for use with the 1098/1 TE. A 330TE (Stores Ref. 6C/2056), is suitable.

Power supplies

7. A 115V $\pm$ 5V, 400 c/s $\pm$ 20 c/s power supply is required to operate the 1098/1 TE. The supply is applied, via single pole on-off switch S5, microswitch S7 and 1A fuse FS1, to TR1 primary. Microswitch S7 breaks the A phase line of the supply when the test set is removed from its case. A red indicator lamp (LP3) is connected in series with voltage limiting capacitor C2 across TR1 primary. The three secondary windings of TR1 are used to provide the following power supplies:—

(1) A 26V centre-tapped supply for the distance measuring potentiometer in the distance indicator and for the test set DRIVE DISTANCE COUNTER potentiometer (RV1).

(2) A 26V power supply for the coupler and distance indicators and for the test set relay checking lamps and RADIAL SELECTION RESOLVER synchro (RS1).

(3) A 10·2V supply for the coupler indicator CDX synchro.

(4) A variable 0-30V d.c. supply in conjunction with full wave rectifier MR1 to MR4, capacitor C1 and potentiometer RV2. This supply is used for checking the distance indicator warning flag and coupler indicator relay.

Coupler indicator CDX and CX null checks

8. Four-bank rotary switches S1 and S2 enable the null positions of the coupler indicator relative bearing CDX and bearing transmission CX to be checked, using a null detector connected to terminals TL1 and TL2.

9. Selector S1 provides the switching necessary to check the rough and fine nulls of the coupler indicator CDX. A 10·2V supply is fed to two of the CDX stator windings via pins SK1/C and SK1/D, the third stator winding, connected to pin SK1/B is not used for this check. Position 2 of S1 enables a rough null check to be carried out. When S1 is set to position 2, the 10·2V supply is also connected to one rotor winding, the two remaining rotor windings are connected together and the null detector is connected between the commoned rotor windings and the earth line of the 10·2V supply. Positions 3, 4 and 5 of S1 enable the fine null positions of the CDX to be checked. In position 3 the null detector is connected between pins SK1/E and SK1/V, in position 4 between pins SK1/E and SK1/W and in position 5 between pins SK1/V and SK1/W.

10. Selector S2 is used, in a similar manner to selector S1, to carry out rough and fine null checks on the coupler indicator bearing transmission CX. The CX rotor is energised from the 26V coupler indicator supply on pins SK1/A and R. The null detector is connected to selector S2 via switch wafer S1/4 when selector S1 is set to OFF (position 1). The rough null check is carried out with selector S2 set to position 2. In this position two of the CX stator windings are commoned and the earth line of the 26V rotor supply is connected to the third stator winding. The null detector is connected between the commoned stator windings and the live side of the 26V supply. Fine null checks are carried out on positions 3, 4 and 5 of selector S2. In position 3 the null detector is connected between pins SK1/U and SK1/F, in position 4 between pins SK1/F and SK1/X and in position 5 between pins SK1/U and SK1/X.

Coupler indicator radial selection resolver (RS3)

11. Signals for the coupler indicator radial selection resolver are obtained from resolver synchro RS1 in the 1098/1 TE. Resolver RS1 is energized from the test set 26V supply obtained from the secondary winding of transformer TR1 and may be set to various positions by means of the RADIAL SELECTION RESOLVFR control on the front of the test set. This control may be set in 30 degree steps from 0 to 360 degrees.

Coupler indicator distance potentiometer

12. Signals from the coupler indicator distance potentiometers RV3 and RV4 can be measured on a null detector connected to terminals TL1 and TL2 on the 1098/1 TE. When selectors S1 and S2 are set to OFF (position 1) terminal TL1 is connected to one common side of the distance potentiometers (pin SK1/Y) via switch wafers S1/4 and S2/4. When single-pole three position switch S4 is set to LIN. POT. 3, terminal TL2 is connected to the wiper of RV3 (pin SK1/S). When S4 is set to LIN. POT. 4, terminal TL2 is connected to the wiper of RV4 (pin SK1/H).

Metering facilities

13. The test set d.c. meter M1 can be used to measure either current or voltage, selection being achieved by double pole, three position switch S6. Diodes MR5 and MR6 are connected across M1 to prevent damage to the meter movement if it is inadvertently overloaded. When switch S6 is set to CURRENT the meter can be used to measure the To/From and Left/Right signals from the coupler indicator. When switch S6 is set to VOLTAGE, meter M1 is used to measure the voltage across test set potentiometer RV2. Variable resistor RV3 and resistor R17 limit the meter current, RV3 is pre-set during assembly to obtain the correct meter range.

To/From and Left/Right signal measurement

14. Five-bank rotary switch S3 selects the various loads (resistors R1 to R14) required when the coupler indicator To/From and Left/Right current outputs are measured on meter M1 (switch S6 set to CURRENT). The To/From output is taken to the test set via pins SK1/P and SK1/R, which is connected to the test set common line, and is measured when selector S3 is set to position 2. The Left/Right output is taken to the test set via pins SK1/M and SK1/N, and is measured when selector S3 is set to positions 3 or 4. Resistors R1, R2, R5, R6, R11 and R12 from the To/From output load in position 2 of S3, meter M1 having a range of 1mA-0-1mA when this output is measured. Two meter ranges are available for measuring the Left/Right output; a 250μA-0-250μA range in position 3 of S3, when resistors R3, R4, R7, R8, R11 and R12 form the output load or a 1mA-0-1mA range in position 4 of S3 when resistors R3, R4, R9, R10, R13 and R14 form the output load.

Relay RC (Coupler indicator)

15. Test set control RV2 and lamps LP1 and LP2 are used to check the operation of coupler indicator relay RC. Control RV2 provides a variable 0-30V d.c. supply for the relay coil on pins SK1/0 and SK1/Q, variation of RV2 thus enables the relay to be energized or de-energized as required. Lamp LP1 (red) is connected in series with current limiting resistor R19 between the test set 26V supply and pin SK1/Z. Lamp LP2 (green) is connected in series with current limiting resistor R18 between the test set 26V supply and pin SK1/L. When relay RC is de-energized lamp LP1 will light via relay contact RC1 whereas when relay RC is energized lamp LP2 lights.

Warning flag (Distance indicator)

16. The d.c. supply for the distance indicator warning flag is obtained from potentiometer RV2 on the 1098/1 TE and is variable from 0 to 30V. The supply is fed to the indicator via pins SK2/E and SK2/D.

Distance indicator servo amplifier

17. When seven-bank, rotary switch S8 is set to INDICATOR DISTANCE (position 3,) potentiometer RV1 on the 1098/1 TE may be used to check the operation of the distance indicator servo amplifier. The servo amplifier compares the wiper voltage of RV1 and the wiper voltage of the distance measuring potentiometer in the distance indicator; and drives the distance counters accordingly. Thus adjustment of RF1 varies the servo amplifier input and the distance counter reading may be related to the setting of RV1.

18. Both RV1 and the distance measuring potentiometer are supplied from a test set a.c. supply. The supply for the distance measuring potentiometer is obtained from switch wafers S8/3 and S8/5, when switch S8 is in position 3, and appears on pins SK2/F and SK2/G. The wiper of RV1 is connected to position 3 of switch wafer S8/4 and is taken to the distance indicator via pin SK2/H. Switch wafers S8/1 and S8/2, when in position 3, connect 10k ohm dummy loads R20 and R21 to the coupler indicator distance potentiometers.

19. Position 3 of switch water S8/6 connects the distance indicator earth to the centre-tap of the secondary winding of TR1 which supplies both RV1 and the distance measuring potentiometer. Thus the servo amplifier, the distance measuring potentiometer and RV1 all have the same earth reference potential.

System check

20. Both test set Type 11964 and the 1098/1 TE are required to carry out a system check on the coupler and distance indicators. In order to carry out this check, the 1098/1 TE switches should be set as follows: S8 to SYSTEM, S4 to LIN. POT. 4 and all other switches (except S5) to OFF. The null detector should not be connected.

21. When switch S8 is set to SYSTEM (position 1), switch wafers S8/3, S8/4 and S8/5 make the necessary connections between the coupler indicator distance potentiometer RV4 and the distance indicator. Switch Wafer S8/6 connects the distance indicator earth to the centre-tap of the potentiometer supply transformer TR2 in the coupler indicator. The distance measuring potentiometer and servo amplifier in the distance indicator, and the distance potentiometer in the coupler indicator thus all have the same earth reference potential.

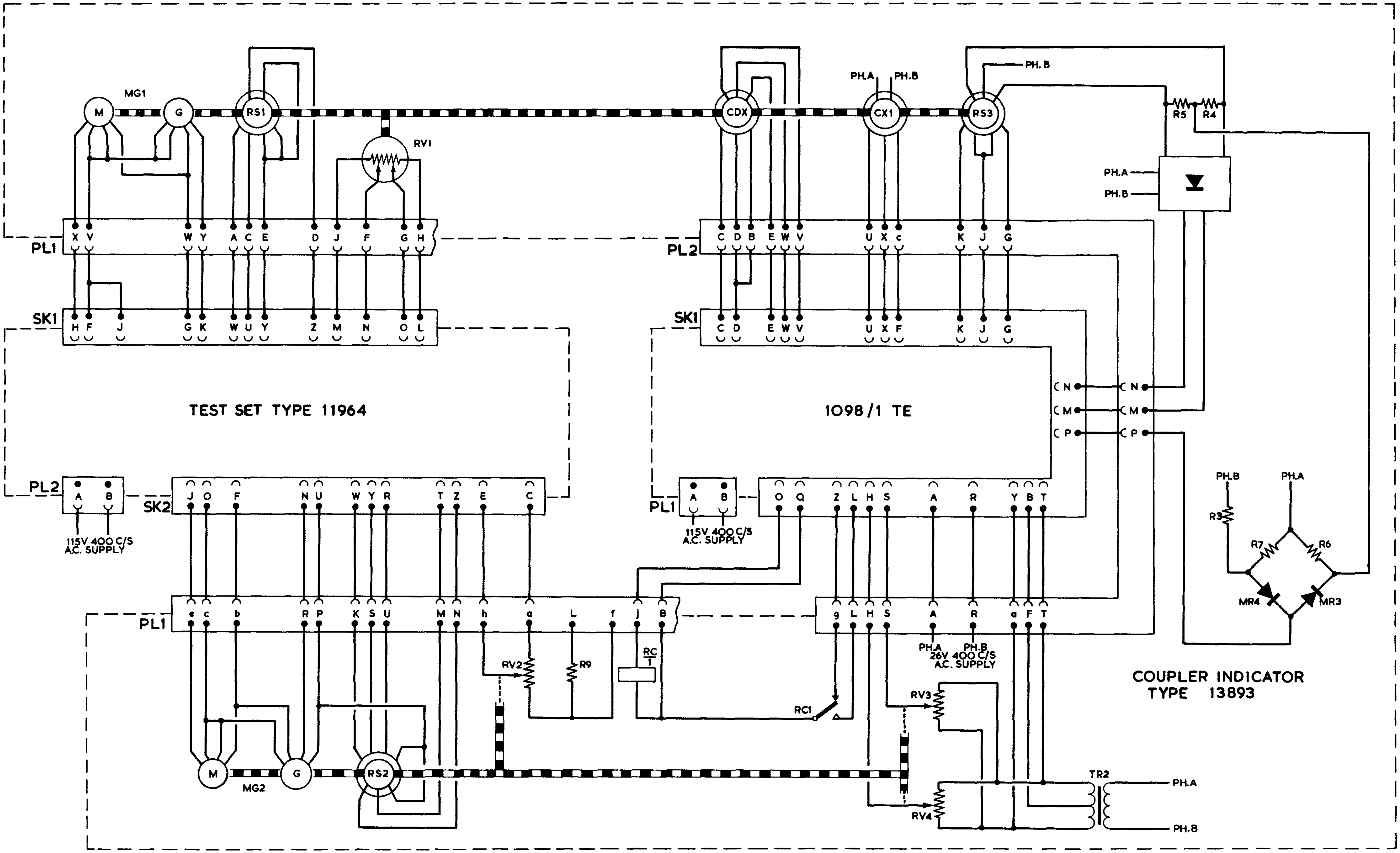

Fig.3 External connections—coupler indicator Fig.3

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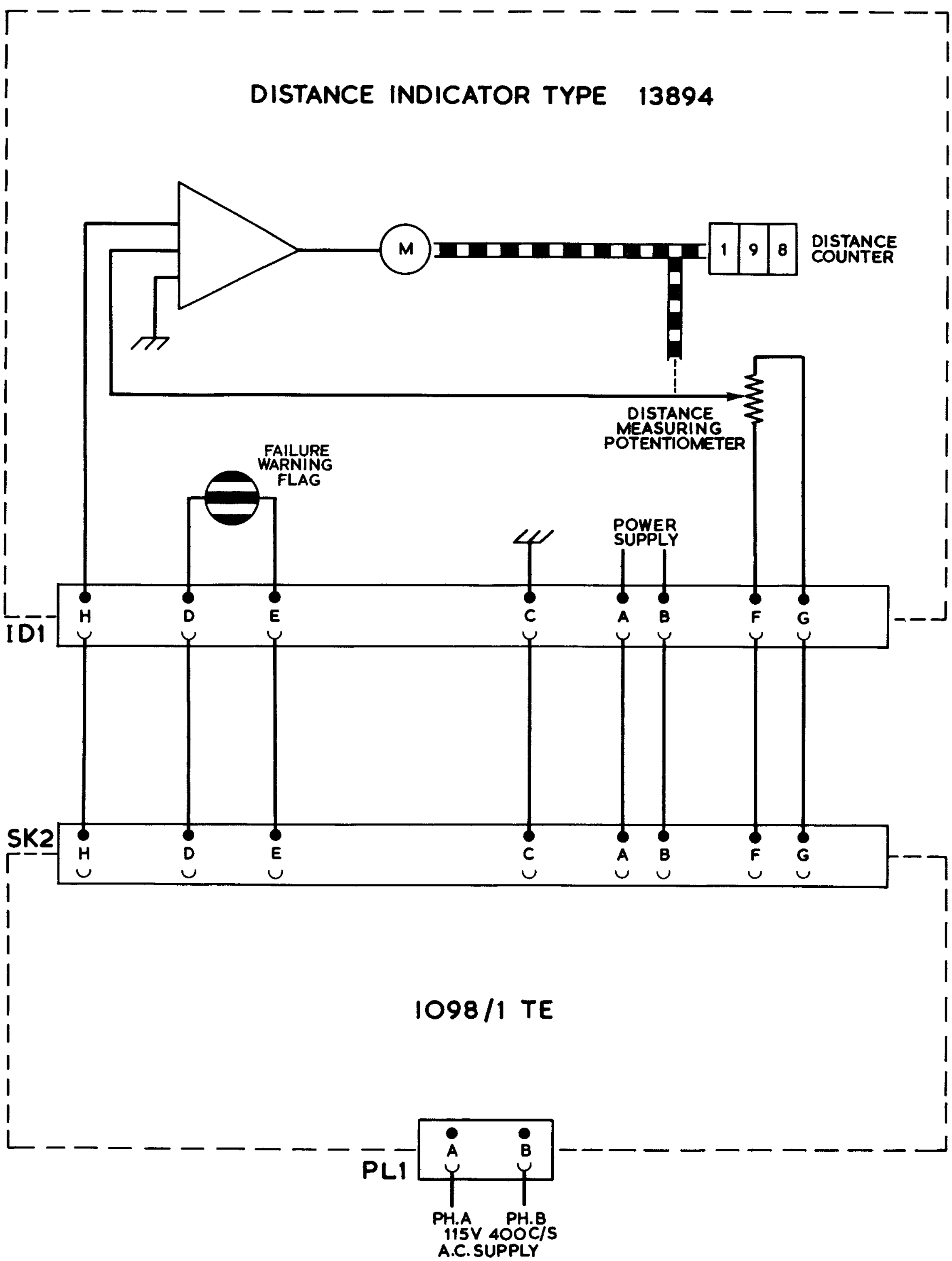

External connections—distance indicator Fig.4

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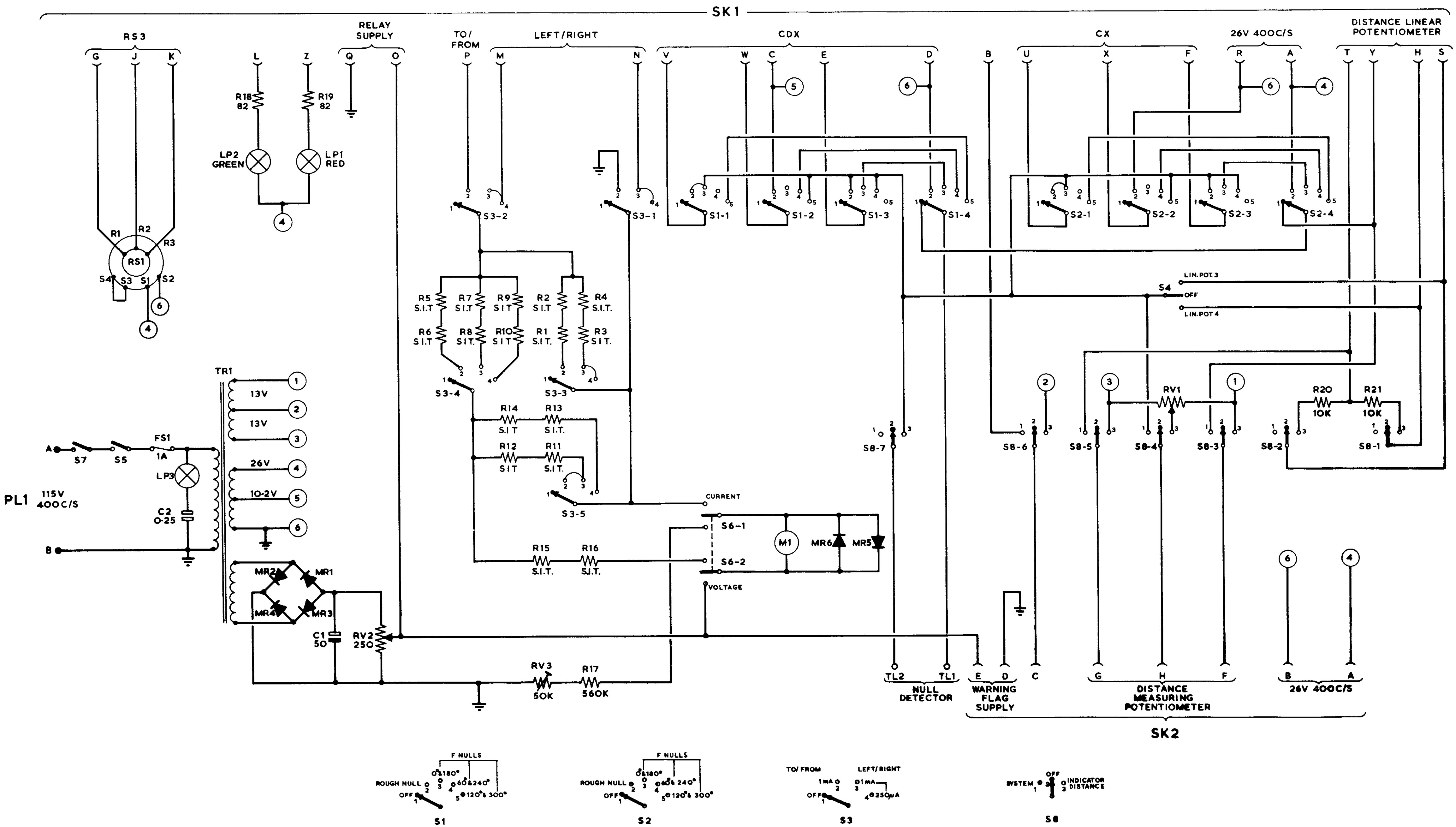

Fig.5

Test set 1098/1TE—circuit

Fig.5

Chapter 6

TEST SET TYPE 11964 ADAPTOR (1098/1 TE)—FUNCTIONAL TESTS AND CHECKS

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Introduction

1. The 1098/1 TE is designed to perform functional tests on distance indicator Type 13894 (Stores Ref. 5826-99-952-2313) and, in conjunction with test set type 11964, on coupler indicator Type 13893 (Stores Ref. 5826-99-952-2312). The functional tests and checks applied to the 1098/1 TE may be divided into the following sections:

(1) A performance check to test the serviceability of the 1098/1 TE.

(2) A system check using a serviceable distance indicator and coupler indicator.

Additional equipment

2. The following additional equipment is required:

(1) A 400 c/s phase sensitive voltmeter. A 330 TE (Stores Ref. 6C/2056) is suitable.

(2) Avometeı model 8.

(3) Resistance bridge.

(4) Test set type 11964 (Stores Ref. 6625-99-915-0063).

Performance Check

3. (1) Set all switches on the 1098/1 TE to OFF.

(2) Connect the 1098/1 TE to the AB phase of a 115V 400 c/s supply using cable TE 20097 (Stores Ref. 10HA/8359). Switch on the supply.

(3) On the 1098/1 TE, set S5 to ON, S2 to position 2 and S8 to position 3. Check that lamp LP3 is lit.

(4) Using the phase sensitive voltmeter, measure the voltage between each of the following points, in turn:

Pins SK1/A and SK1/D
Pin SK1/D and terminal TL1
Pins SK2/F and SK2/G
Pins SK2/A and SK2/B

In each instance the phase sensitive voltmeter reading should be between 25V and 27V reference.

(5) Using the phase sensitive voltmeter, measure the voltage between pins SK1/C and SK1/D and between pins SK1/C and SK1/Q. In each instance the voltmeter reading should be between 10V and 10·5V reference.

(6) Using the phase sensitive voltmeter, measure the voltage between pins SK2/C and SK2/G and betwwen pins SK2/F and SK2/C. In each instance the phase sensitive voltmeter reading should be between 12·5V and 13·5V reference.

(7) Set control RV2 to 500 divisions and, using the phase sensitive voltmeteı, check that the voltage between pins SK2/F and SK2/H is between 12·5V and 13·5V reference.

(8) On the 1098/1 TE, set S5 to OFF and S8 to OFF, and turn control RV2 fully counter-clockwise. Connect the Avometer model 8 between pins SK2/E and SK2/D (negative).

(9) On the 1098/1 TE, set S6 to VOLTAGE and S5 to ON.

(10) Adjust control RV2 on the 1098/1 TE to obtain each reading listed below, in turn, on the Avometer. Check that in each instance the reading of meter M1 on the 1098/1 TE is within the specified limits.

Avometer reading	*Reading of Meter M1*
(V)	(V)
5	4—6
10	9—11
15	14—16
20	19—21
25	24—26
29	28—30

(11) On the 1098/1 TE, set S5 to OFF and turn control RV2 fully counter-clockwise.

(12) Disconnect the Avometer from pins SK2/E and SK2/D. Re-connect the Avometer between pins SK1/O and SK1/Q (negative),

(13) Repeat sub-para. (10) and (11) above.

(14) Disconnect the Avometer from pins SK1/O and SK1/Q.

(15) On the 1098/1 TE, connect pin SK1/Z to pin SK1/R, set S5 to ON and check that lamp LP1 lights. Set S5 to OFF and disconnect pin SK1/Z from pin SK1/R.

(16) On the 1098/1 TE, connect pin SK1/L to pin SK1/R, set S5 to ON and check that lamp LP2 lights. Set S5 to OFF and disconnect pin SK1/L from pin SK1/R.

(17) On the 1098/1 TE, set S3 to position 2 and S6 to CURRENT.

(18) Using the resistance bridge, measure the resistance between pins SK1/R and SK1/P. The resistance should be between 342 and 368 ohms.

(19) Set S3 to position 3 and, using the resistance bridge, measure the resistance between pins SK1/N, and SK1/M. The resistance should again be between 342 and 368 ohms.

(20) Set S3 to position 4 and check that the resistance between pins SK1/N and SK1/M is now between 190 and 210 ohms.

(21) On the 1098/1 TE, set the RADIAL SELECTION RESOLVER control to 0 degrees. Disconnect the resistance bridge from the test set.

(22) Connect together pins SK1/J and SK1/K on the 1098/1 TE. Connect the phase sensitive voltmeter between pins SK1/J and SK1/G.

(23) Set switch S5 on the 1098/1 TE to ON and check that the phase sensitive voltmeter reading is 0 ± 72 mV.

(24) Set the RADIAL SELECTION RESOLVER control to 180 degrees and again check that the phase sensitive voltmeter reading is 0 ± 72 mV.

(25) Set switch S5 on the 1098/1 TE to OFF. Disconnect the phase sensitive voltmeter from the test set.

(26) Remove the connecting link from between pins SK1/J and SK1/K and link together pins SK1/J and SK1/G. Connect the phase sensitive voltmeter between pins SK1/J and SK1/K.

(27) Set switch S5 on the 1098/1 TE to ON and check that the phase sensitive voltmeter reading is approximately 26V.

(28) Set switch S5 to OFF, disconnect the phase sensitive voltmeter and remove the connecting link from between pins SK1/J and SK1/G.

(29) Switch off the power supply to the test set.

(30) Using the Avometer model 8 set to the 'OHMS' range, measure the resistance between each of the following points listed below, in turn. Where necessary, set the test set controls to the positions specified. In every instance the resistance must be not more than 1 ohm.

Measure resistance between	*Set controls as follows*
Pin SK1/V and terminal TL2	S1-position 2; S8-position 3
Pins SK1/V and SK1/U	S1-position 2; S2-position 2
Pins SK1/V and SK1/U	S1-position 3; S2-position 3
Pins SK1/V and SK1/S	S1-position 2; S4-LIN. POT 3
Pins SK1/V and SK1/H	S1-position 2; S4-LIN. POT 4
Pins SK1/W and SK1/C	S1-position 2
Pin SK1/W and terminal TL1	S1-position 4
Pins SK1/W and terminal TL2	S1-position 5; S8-position 3
Pin SK1/E and SK1/S	S1-position 2; S4-LIN. POT 3
Pin SK1/E and terminal TL1	S1-position 3
Pin SK1/D and terminal TL1	S1-position 2
Pins SK1/D and SK1/Q	—
Pin SK1/U and terminal TL1	S2-position 2; S-8 position 3
Pins SK1/X and SK1/D	S2-position 2
Pin SK1/X and terminal TL1	S2-position 4; S1-position 1
Pin SK1/X and terminal TL2	S2-position 5; S8-position 3
Pin SK1/F and terminal TL2	S2-position 2; S8-position 3
Pin SK1/F and terminal TL1	S2-position 3; S1-position 1
Pins SK1/B and SK2/C	S8-position 1
Pins SK1/Y and SK2/F	S8-position 1
Pins SK1/S and SK2/H	S8-position 1; S4-LIN. POT 3
Pins SK1/T and SK2/G	S8-position 1
Pins SK1/O and SK2/E	—
Pins SK1/Q and SK2/B	—
Pins SK1/Q and SK1/R	—
Pins SK1/A and SK2/A	—
Pins SK2/D and SK2/B	—

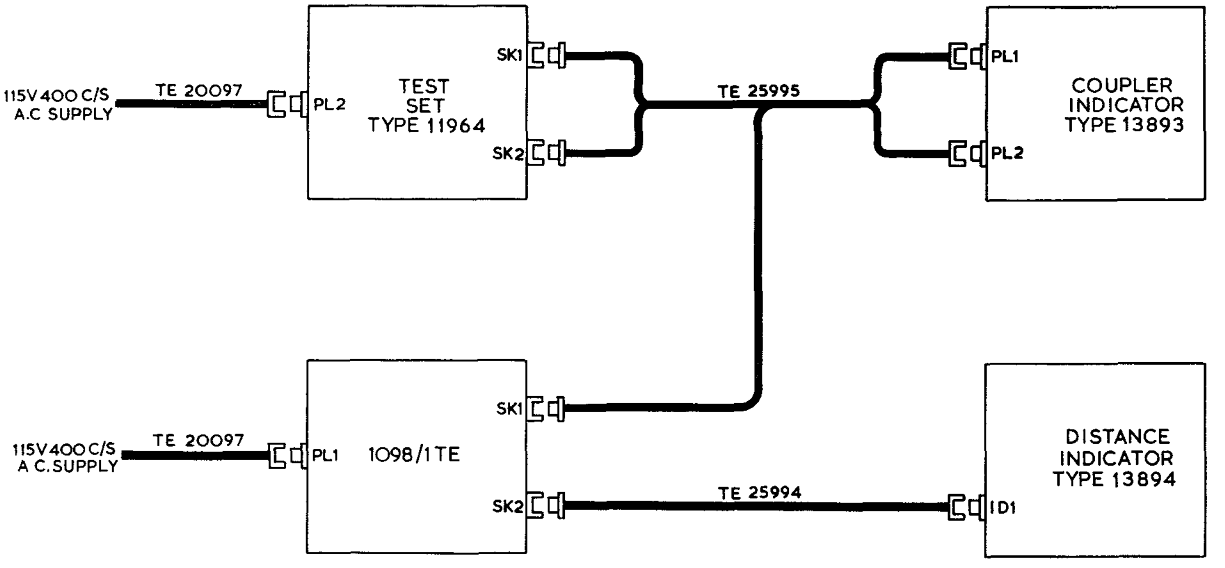

Fig. 1. System test connections

System check

4. (1) Connect a coupler indicator type 13893 (Stores Ref. 5826-99-952-2312) and a distance indicator Type 13894 (Stores Ref. 5826-99-952-2313) to the 1089/1 TE and to test set Type 11964 (Stores Ref. 6625-99-915-0063) as shown in fig. 1.

(2) Set all switches and controls on the 1098/1 TE and on test set Type 11964 to the 'off' or fully counter-clockwise position, as appropriate.

(3) Switch on the power supplies to the 1098/1 TE and to test set Type 11964 and set switches S5 and S4, respectively, to ON. Allow the equipment to warm up.

(4) On test set Type 11964, set S6 to M2. On the 1098/1 TE set S8 to SYSTEM and S4 to LIN. POT.4

(5) On test set Type 11964, depress S11 and rotate control TR2 clockwise until the coupler indicator distance dials run smoothly. Release S11.

(6) Adjust control RV2 on the 1098/1 TE until the coupler indicator warning flag disappears from view.

(7) Using controls S7 and S11 on test set Type 11964 as necessary, adjust the coupler indicator distance dials to obtain each setting listed below, in turn. For each setting, check that the reading of the distance counter (distance indicator) is within the specified limits.

Distance dials setting (miles)	*Distance counter reading (miles)*
50	49— 51
100	99—101
150	149—151
199	198—200

(8) Switch off the power supplies to the 1098/1 TE and to test set Type 11964 by means of switches S5 and S4 respectively. Disconnect the test circuit.

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Section 7

TESTER PERFORMANCE TYPE 7288

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2 **Circuit description**

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Chapter 1

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Introduction

1. Tester performance 7288 is used to test the overall functions of the ARI.18107 series equipments at first and second line servicing. The equipment is energized from a battery supply of 26 to 30 V. d.c. (negative ground). The h.t. supply is obtained from a rotary transformer.

2. The tester performance generates an r.f. signal which simulates the normal signal received by the ARI from a surface beacon or transponder aircraft. It also provides information signals equivalent to two fixed bearings and distances, both switched as required, and the beacon identity code response which is manually keyed. Facilities exist for testing relative sensitivity, peak pulse power output and aerial circuits of the airborne equipment under test.

3. The electrical circuits may be considered as being composed of four main groups namely:—

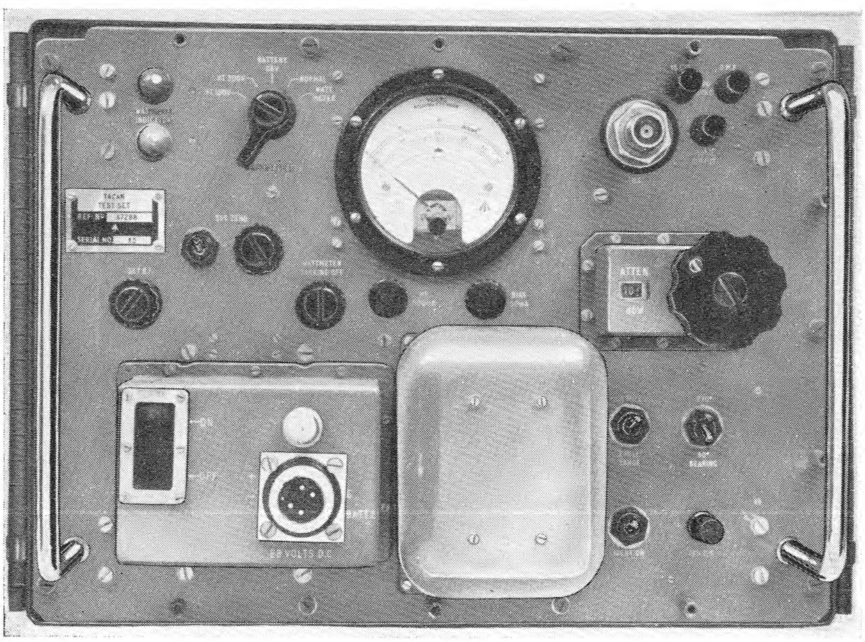

Fig. 1. Tester performance 7288—front view

(1) The circuits in which the pulse trains are generated and correctly timed for insertion into the composite pulse signal. A l.f. waveform is used to amplitude modulate the composite pulse signal.

(2) The coder and modulator circuits in which

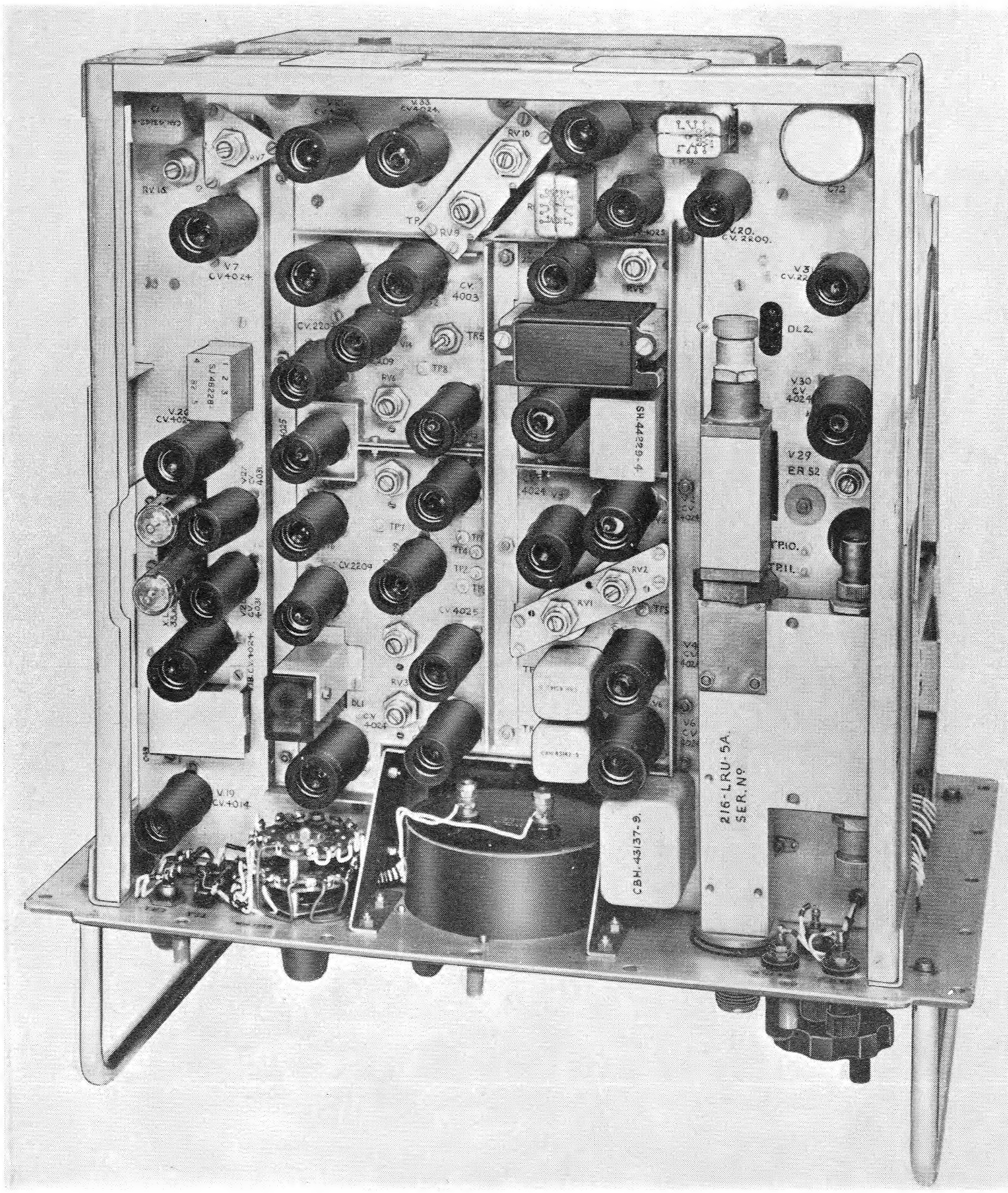

Fig. 2. Tester performance 7288—top view

the signal is correctly coded by the addition of pulses in accordance with the TACAN system. The resultant complete pulse train is amplitude modulated and increased in power to drive the r.f. unit or signal generator.

(3) The r.f. circuits comprise the r.f. unit and its variable output attenuator and the directional coupler with termination resistance loads. The r.f. unit supplies the complete signal, exactly as the ARI receives it from the beacon, on channel 39, i.e. at 1000 Mc/s. The directional coupler is installed to protect the r.f. attenuator from the power of the interrogating pulses from the airborne equipment.

(4) The power and distance measuring circuits in which the output of the ARI is delivered to a diode detector. These are used as a "backed off" valve voltmeter when power measurement is being carried out or as a straightforward diode detector when range circuits are being tested. The power measuring circuits comprise the balance detector with its front panel balance indicator of two lamps and the necessary circuits to operate them. The range measuring circuits include the required accurate pulse delays to simulate the beacon delayed replies for the distances indicated on the front panel of the test set.

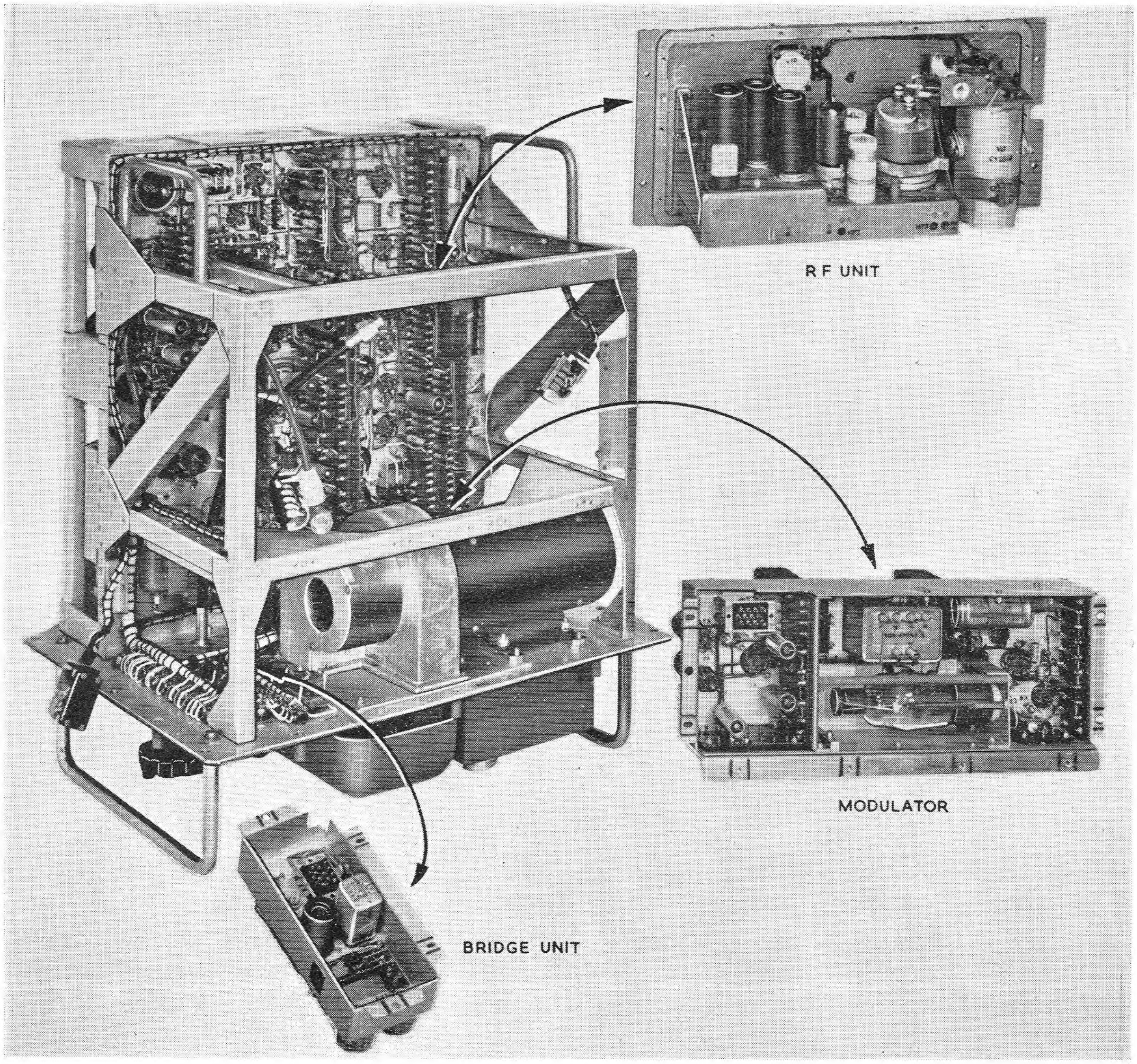

Fig. 3. Tester performance 7288—chassis sub-units removed

4. The tester performance 7288 is contained in a

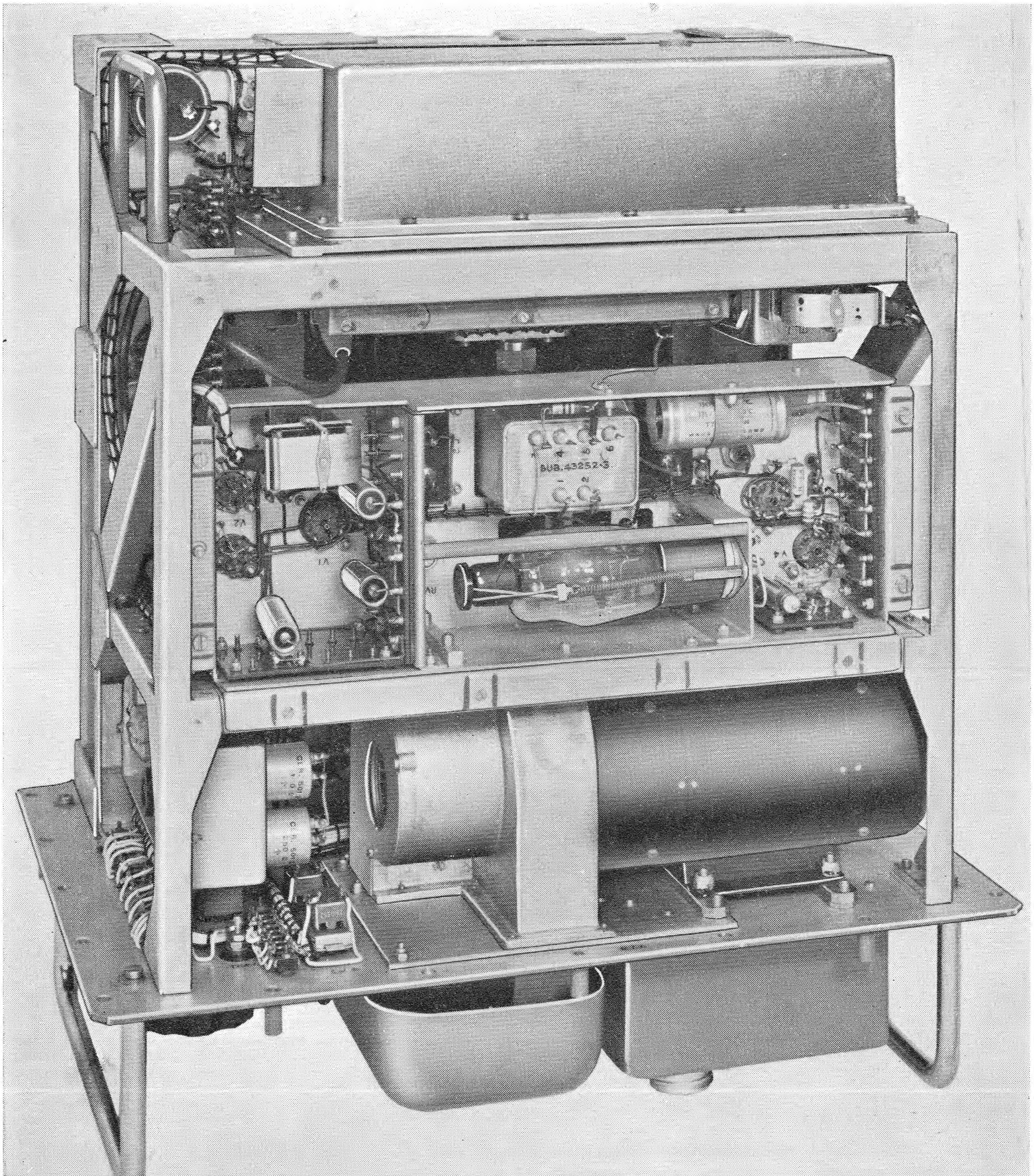

Fig. 4. Tester performance 7288—chassis sub-units assembled

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single unit case of standard design which is intended for mounting in a 19–inch rack, or on a suitable trolley or on the bench as required. The equipment is made up of the following:—

(1) The mounting unit; this comprises the main chassis and front panel; it contains 33 valves for the video circuit functions.

(2) The modulator, which contains six valves.

(3) The RF unit, containing six valves.

(4) The bridge unit.

Items (2) to (4) are detachable sub-units which are mounted in unit (1).

5. The rotary transformer which supplies the HT voltages is mounted on the front panel. It incorporates a blower which draws air in through filters in each side of the case and expels it through a cowled vent in the front panel. The equipment is designed to operate in wet weather. All controls are splash proof and the weight of the tester in its case is 65 lb. including the cover.

6. The equipment is intended for use with the Plessey IFF test set (test kit aerial Type 6996) cable box; this includes a 25 foot RF cable and aerial tester known as a test hat. An adaptor is provided to connect this cable to the test set; this adaptor is stored in the cover together with a fixed attenuator for use as a direct connector to the aircraft set when the test hat is not used.

Performance data

7. Typical performance figures for the tester performance 7288 are as follows:—

(1) RF OUTPUT. Adjustable over the range –70dB to –130dB referred 1W of power applied to the aerial terminal when the fixed attenuator is connected in series with the RF cable (52 ohms) accuracy is ±5dB.

(2) BATTERY SUPPLY. Input voltage 26 to 30 V DC (neg. ground)

Input current 11 amp at 28v.

Input power at 28v, DC 308w.

(3) SIGNAL COMPONENTS

(a) *Radio frequency* adjusted to 1000 Mc/s ±0·005% (channel 39).

Level adjustment as in (1).

(b) *Random pulse rate* at 2 400 pulse pairs per second.

(c) *Identity pulse rate at* 1 350 pulse pairs per second.

(d) 15 *c/s reference marker pulse train:*— 12 pulse pairs at rate of one pair every 30 μs occurring 15 times per second, synchronised with the 15 c/s modulation.

(e) 135 *c/s reference marker pulse train:*—

6 pulse pairs at the rate of one pair every 24 μS occurring 120 times per second, synchronised with the 135 c/s modulation.

(f) *Coding*:—All pulse pairs have 12 μS spacing ± 1 μS.

(g) *Pulse shape*:—Width 3·5 ± 1 μS rise and fall time not more than 3 μS.

(h) *Pulse height modulation*:—The composite RF output from the equipment is amplitude modulated by signals of 15 and 135 c/s. The resultant modulation pattern is correctly phased in relation to the 15 and 135 c/s reference marker pulse trains. Modulation amplitude is 20 to 35 per cent.

(i) *Distance measuring signals:*—Reply pulses to the interrogating pulses from the airborne set are inserted in the RF output signal to simulate ranges of one mile or 101 miles. Accuracy is ± 0·25 miles plus one per cent.

(j) *Bearing measuring signals*:—Synchronism between the amplitude modulation and the 15 and 135 c/s reference marker pulse trains is arranged to simulate bearings of 90 or 270 degs. Accuracy is ± two degrees.

(4) *Power measuring circuits.* Output peak pulse power from ARI can be checked over the range of 400 to 3 000 W by using the fixed attenuator and 200 to 1 500 W aerial tester Type 6996. Accuracy with the fixed attenuator is better than ±3dB.

(5) *Beacon identity.* The identity tone circuits in the ARI can be tested by manual keying of the biased switch on the front panel.

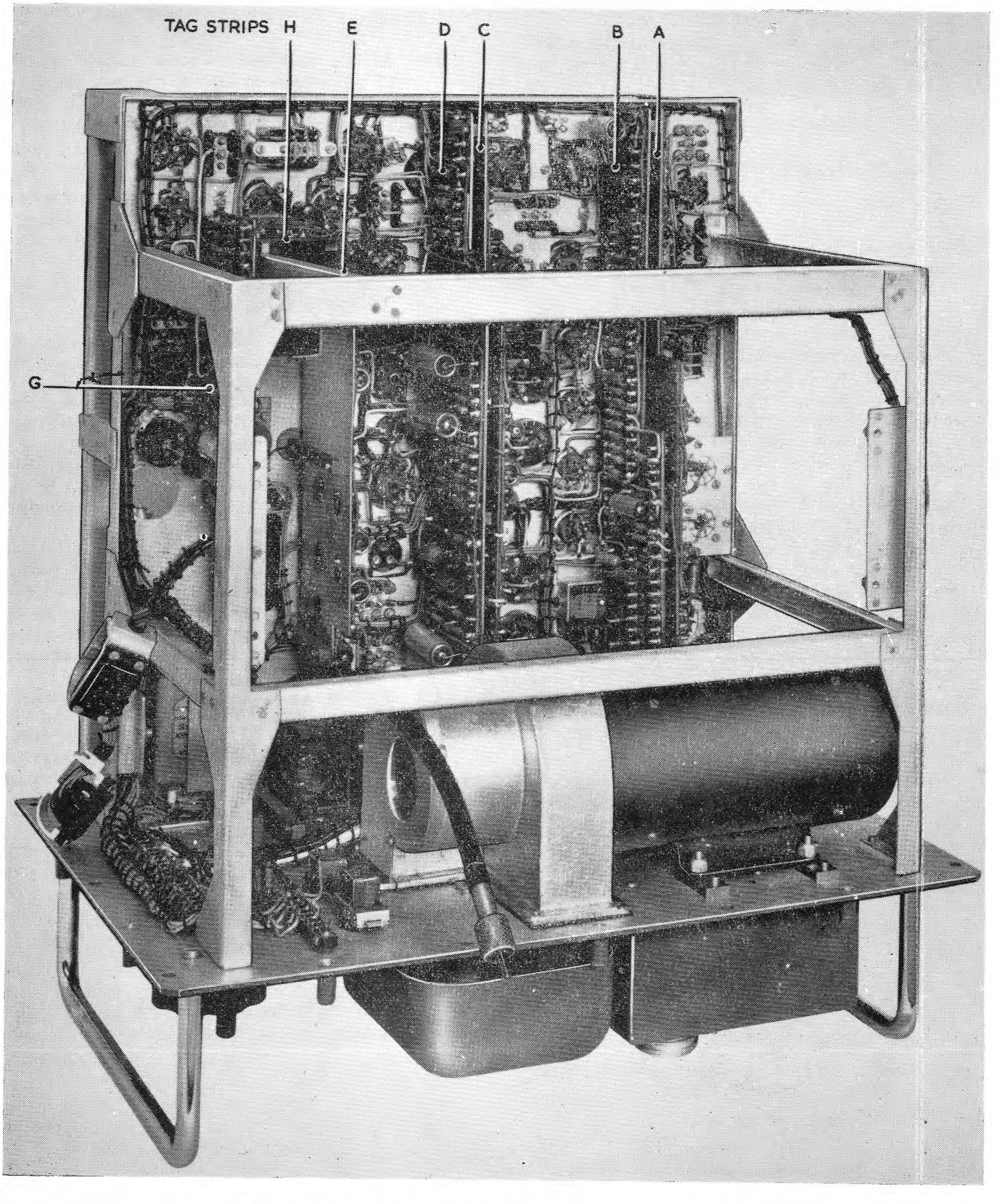

Fig. 5. Tester performance 7288—location of tag strips

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MOUNTING UNIT AND FRONT PANEL (*fig.* 1)

1. The main chassis circuitry of the mounting unit and front panel can be divided into two parts.

(1) The azimuth circuits which generate the necessary bursts of marker pulses, the noise pulses and the sine waves which modulate all these pulses.

(2) The range circuits which respond to the interrogating pulses from the airborne set and give a reply for a range reading : alternatively the circuits can be switched to give an indication of airborne set output power.

2. Consider the azimuth circuits first. All these circuits are synchronized to the 135 c/s oscillator. The output from this circuit has its frequency divided by nine and thus gives a 15 c/s waveform which is filtered to give a pure sine wave. The 135 c/s and 15 c/s sine waves are suitably phase shifted and then added together in the mixer. The added sine waves are then connected to the modulator, either directly, or via a 180 deg. phase shifting valve, depending upon the position of the bearing switch.

3. The markers are generated by crystal oscillators and gated into the required bursts by circuits synchronized to 135 c/s for harmonic markers and to 15 c/s for the North markers. A harmonic marker gate is blanked out every time a North marker gate occurs. These bursts of pulses are then mixed with the "noise" or identity pulses in the priority mixers which do not allow "noise" or identity pulses into the marker bursts. The "noise" pulses, which are synthesized by a constant 2·4 kc/s pulse train or the identity pulses, a 1·35 kc/s pulse train, are generated by a Hartley oscillator and the required p.r.f. is obtained by the position of a key. The output from the mixers is then taken to the modulator via a coding circuit where the 1000 Mc/s multiplier circuit is modulated before being fed to the output terminal.

4. Now to consider the range circuits. When the interrogating signal is received from the airborne set, it is demodulated by the diode in the diode head and then passed through an amplifier and a decoder. From this point the resulting pulse is switched to take one of three routes, as follows :—

(1) To a circuit which delays the pulse sufficiently to give a 1 mile reading on the airborne set.

(2) To a circuit which delays the pulse to the equivalent of 101 miles. To obtain stability of this relatively large delay, an oscillator is pulsed and a cycle is gated at the required time delay.

Note . . .

The pulses from either condition (1) *or* (2) *are mixed with the azimuth pulses in the priority mixers.*

(3) To a circuit which gives an indication of A.R.I. output power by illumination of coloured lamps on the front panel.

135 c/s oscillator V1b, cathode follower V1a and phase shifter (*fig.* 2).

5. The oscillator valve is V1b and together with L1 the circuit is a conventional Hartley oscillator. An output is taken from the anode to the limiter circuits and a pure sine wave output from the coil to a cathode follower V1a. The output of the cathode follower is connected to terminal 1 on the front panel, marked 135 c/s, which gives approximately 10V peak-to-peak for checking the coupling unit of the airborne installation. Another output is taken to transformer TR4 which has a centre tapped secondary winding. This winding is part of a bridge network for shifting the phase of the 135 c/s, the operation of which is described in the following para.

6. Consider fig. 4 which is the vector diagram of fig. 3 taking the secondary voltage (*Ein*) as reference. Since the transformer is fed from a resistive source and presents a relatively low impedance output, *Ein* may be considered constant. The current *I* presents a capacitive load and therefore leads *Ein*. Therefore, voltage *IR* leads *Ein* as shown and voltage *IXc* lags *IR* by 90 deg. The latter is important since it means that the resultant must fall within the circle shown. One output connection is taken from a centre tap on TR4, therefore the resultant *Eout* is drawn from a point half way along vector *Ein* to the junction of the vectors *IR* and *IXc* and, as can be seen, by variation of RV15 over a suitable range *Eout* can be moved in phase about the centre tap by nearly 180 deg. and is of constant amplitude. Since in fact the centre tap is earthed the circuit produces the variable 135 c/s balanced about earth which is convenient for feeding into the sinewave mixing amplifier.

135 c/s limiter V2b and multivibrator V2a and V3b (*fig.* 2).

7. The squared 135 c/s is DC coupled via limiting resistance R7 to limiter V2b. Due to grid current in the positive excursion and cut off in the negative, the output at the anode of V2b is a square wave. Some negative DC bias is built up across C2 due to the rectifying action of grid current which tends to give limiting action about the centre of the waveform.

8. The output of V2b is coupled to a cathode coupled multivibrator, V2a and V3b, the latter valve giving a 135 c/s square wave with relatively fast edges. For a better description of this type of multivibrator see the North and harmonic oscillator description para. 23 to 25. These edges are passed on by differentiating, to blocking oscilltator trigger valve V3a.

Blocking oscillator dividers and trigger circuits V3a, V4 and V5a (*fig.* 2 & 9 (*a*)).

9. The function of these circuits is to divide the 135 c/s by nine to give 15 c/s. This is done in two stages of division-by-three in two blocking oscillators. The first one consisted of valves V4b and V5a, parallel triggered by V3a which has a certain amount of negative feedback applied to its cathode by R16 and C10 to control the trigger amplitude.

10. When a positive pip from the differentiating circuit reaches the grid of V3a, it overcomes the negative bias and makes the valve conduct. This causes the anode of this valve and the anode of V4b to fall. Due to the transformer TR1, a positive pulse appears on the grid of V5a and triggers the first blocking oscillator in the following manner.

The circuit is a conventional blocking oscillator with a cathode follower added to present the low impedance required to charge the relatively large condenser (C11) necessary at the low frequencies used.

11. Consider fig. 9 (a) which is the waveform at the grid of the blocking oscillator valve V4b. Assume the condenser C11 is discharging through R19 as shown. Because V4b is cut off by the charge across C11, the loop gain is zero and the circuit is stable. But when one of the trigger pulses overcomes the charge, V4b conducts and the circuit becomes regenerative in the following manner :— The voltage at the anode of V4b travels negatively and due to transformer connections the grid of V5a and therefore its cathode travel positively. Due to coupling by C11 to the grid of V4b, this grid is taken more positive and the circuit is regenerative. Also, grid current is taken which charges C11.

12. When the drive to the grid of V5a ceases, the circuit becomes regenerative in the opposite direction and V4b is rapidly cut off and is kept that way by the charge which C11 has assumed, the circuit having then completed one cycle. By choosing the correct values for R19 and C11 the circuit can be made to trigger every third pulse, the fine adjustment being made by variation of RV1 which varies the potential to which R19 and C11 are discharging.

13. The second blocking oscillator V4a works in an identical manner to the first one except that the effective time constant is three times as large. As with the first one, it is triggered by a negative pulse at the anode of V4a, the pulse in this case coming from a winding on TR1. Terminal 2 (15 c/s) which is mounted on the front panel provides a negative pulse suitable for synchronizing an oscilloscope.

15 c/s filters V6b (*fig.* 2 *and* 9 (*a*)).

14. The signal on pin 2 V4a is similar to that shown in fig. 9 (a) except that it has a frequency of 15 c/s. This signal is passed through an RC filter and appears at low level and lacking many of the upper harmonics, at the slider of RV4. This potentiometer then passes the signal at a pre-set level to amplifier V6b which has tuned transformer TR3 in its anode. The secondary of TR3 is connected in a phase shifting network which is functionally the same as the 135 c/s phase shifter described in para. 6. The pure and suitably phased 15 c/s sinewave is then passed on to the grid of the mixing amplifier.

Sinewave mixer V7b, phase inverter V7a and cathode follower V6a (*fig.* 2).

15. The 135 c/s and 15 c/s sinewaves are mixed in V7b, the 135 c/s is added at the cathode and the 15 c/s at the grid. The output from the anode of V7b is fed to V7a, an amplifier which has a gain of exactly one by virtue of the negative feedback applied to it and has a phase inversion of 180 deg. Switch SW3, which is a front panel control and marked 270 deg. or 90 deg. can select 180 deg. phase change if needed. After the switch the sinewaves are taken via a cathode follower V6a to the modulator. RV13B is coupled to the "Set RF" control on the front panel and compensates for changes in modulation depth with RF level.

North gate generator V8 and V9 (*fig.* 2 & 9(*c*)).

16. The North gates are generated by V8 and V9, in a phantastron circuit and are pulses 360 μS long. They are triggered from the second blocking oscillator, coupled by a winding on TR2. For details of phantastron circuit see para. 48 and 49. Positive gates obtained from the screen of V8 are fed to the North mixer V17 and negative gates from the cathode are fed to the 9th harmonic blank V10 and via a mixing diode V11 to the tone mixer V15.

9th harmonic blank circuit (*fig.* 2).

17. This circuit is built round V10 and its purpose is to allow the negative North gates to cut off the valve at the suppressor so that the harmonic triggers at the grid are not amplified when a North gate occurs. Since the negative gate from V8 is triggered from the end of the divide-by-nine chain, there is some delay with respect to the 135 c/s trigger pulse which originates it. Also the edge of the negative gate is fairly slow and as a result about 35 μS delay is required on the 135 c/s harmonic triggers in order that they may be blanked successfully.

18. To do this, harmonic triggers are taken from the anode of V3b in the form of 135 c/s square waves and the edges of the waveform are slowed down by R14 and C8. The grid of V10 is negatively biased so that the valve does not conduct until some way towards the top of the waveform which gives the required delay of about 45 μS. The remaining negative pulses at the anode of V10 are then passed on to trigger the harmonic gate circuits in V13 and V12.

Harmonic gate generator V12 and V13 (*fig.* 2 & 9 (*b*))

19. The harmonic gates are generated by a phantastron similar to the North gate generator circuit V8 and V9. The valves concerned are V12 and V13 and the length of the gates is 144 μS. Positive gates obtained from the screen of V12 are fed to the harmonic mixer V16 and negative gates from the cathode are fed via a mixing diode V11 to the tone mixer V15.

Negative gate mixing diode V11 (*fig.* 2)

20. The purpose of the diode V11 is to isolate the two phantastron gate generators and at the same time mix the negative gates from each and pass them on to the tone mixer V15.

Tone oscillator and limiter V26b (*fig.* 2)

21. The oscillator is built round V26b and is a conventional Hartley circuit. The limited output from the anode is passed to the limiter V26a which produces a square wave output with fairly sharp edges at its anode. The square waves are then differentiated and passed to the tone mixer V15.

22. The oscillator V26b normally runs at 2·4 kc/s, which produces the equivalent to noise pulses necessary in the TACAN signal, but when SW4 is closed C49 is placed in the tuned circuit and the frequency is then 1·35 kc/s which operates the identity tone circuits in the airborne set. SW4 is mounted on the front panel marked IDENT ON and is a toggle switch mechanically biased in the off position.

North V28 and harmonic V27 oscillators (*fig.* 2 & 5)

23. The North oscillator has a frequency of 33·333 kc/s and comprises V28 and XL2 ; the harmonic oscillator has a frequency of 41·666 kc/s and consists of V27 and XL1. The two circuits are identical except for the crystals and the following description applies to both. First consider fig. 5 the basic circuit of a cathode coupled multivibrator. The circuit can rest in one of two states depending upon the value of *VG*. One state is with VA conducting and *VB* cut off by the resulting cathode voltage and the other state is where *VB* is conducting and *VA* is cut off.

24. Assume that *VG* is below *VK*, then *VA* will be cut off and *VB* will be conducting. If *VG* is slowly taken more positive then a point will be reached when *VA* will begin to conduct, this will cause its anode to drop which will be transferred by the capacitor C to the grid of *VB*. This voltage drop at VB grid will cause a drop in value of *VK*, thus causing VA to switch on more rapidly and so the circuit will flip over to the condition where VA is conducting and VB is cut off. Similarly, the circuit will flop back to the original state if *VG* is again reduced.

25. From the above description it will be obvious that if *VG* is held positive enough to make the circuit readily swing one way or the other, then excitation at almost any point will make the circuit oscillate ; so it is in the oscillator circuits where a high Q tuned circuit, namely the crystal is placed in series with C. Excitation from the circuit causes the crystal to resonate and therefore, in turn, reexcite the circuit to oscillate at the crystal frequency. To produce the marker pulses, the limited outputs are taken from the anodes, differentiated and then passed on to the appropriate mixer grids of V16 or V17.

Priority mixers V14 to V17 (*fig.* 2 & 9 (*d*))

26. The circuit consists of four pentodes with short suppressor bases namely V14, V15, V16 and V17 and associated components. In each case the gates are applied to the suppressor and the pulses to the grid. The grid in each case is cut off by the common negative 15 volts line as are the suppressors of V16 and V17. The anodes are strapped together and the common load is part of the coding circuit. The distance mixer V14 gates the required range pulse into the pulse train as described later in range circuit descriptions. The tone mixer V15 mixes pulses from the tone oscillator V26b into the pulse train, but stops them when marker bursts occur by virtue of the negative gates applied to the suppressor.

27. The harmonic mixer V16 is normally cut off at the suppressor and therefore the pulses from the harmonic oscillator V27 at the grid are not passed to the anode. When a positive harmonic gate arrives at the suppressor a harmonic burst of six pulses is generated at the anode and thus fills the gap in the tone pulses produced by the tone mixer V15. The North mixer V17 is the same as the harmonic mixer except that it is gated by North gates, pulsed by the North oscillator V28 and twelve pulses are thus generated at the anode.

Coding circuits V18 and V19 (*fig.* 2, 6 & 9 (*e*))

28. The anodes of the priority mixers are strapped together and connected to a 12 µS delay line DL 1 which is terminated by R78. The fact that R78 is taken to HT potential gives a DC path for the anodes and since all mixers are normally cut off there is no DC current to trouble the delay line. Thus, by coupling the direct pulse by C32 and the delay line output by C34, a negative pulse pair with 12 µS spacing is available to trigger the multivibrator V18, for every single pulse at the mixer anodes. A certain amount of DC restoration is provided by MR2 and isolation of the trigger circuits from the multivibrator is provided by MR 1.

29. The multivibrator V18 is a conventional anode to grid coupled type and its operation may be explained in conjunction with fig. 6. VA is normally cut off by the negative bias, but when a negative pulse arrives at VA anode, capacitor C transfers it to VB grid and the resulting rise in VB anode voltage brings VA into conduction via CB. This causes a further fall in VA anode voltage and the circuit becomes regenerative. Regeneration is temporarily arrested when VA is fully conducting and VB is cut off by the charge across C. But this charge is leaking away through R, and when C has discharged enough to allow VB to conduct, regeneration once again takes place and the circuit returns to its original state. It can be seen therefore that a positive pulse is produced at VB anode whenever the circuit is triggered, it is of constant amplitude and of length controlled by R and C. The biasing arrangements used on V18 are to make the circuit as far as possible independent of variations in power supplies. The constant shape pulse pairs are taken from the low potential side of C36 to a cathode follower V19 which provides the pulse drive for the modulator.

Directional coupler and diode head V29 (*fig.* 7)

30. The object of the directional coupler is to accept the A.R.I. signal and connect it to the diode head V29, it attenuates the signal on its path to the variable attenuator so that this component is not overloaded. The RF output from the variable attenuator is also prevented from reaching the diode head. These properties are achieved with a network of mis-matched quarter wave sections as shown in fig. 7. As can be seen from fig. 7 the main lines are thick and the stub lines are thin thus giving different impedances. For the coupler in question, the main lines are 50 ohms and the stub lines are 100 ohms and it may be stated that since the impedance to the diode head is less than the impedance across the coupler, most of the power will go to the head.

31. When considering the basic circuit the calculations are made using admittances and the following relation is applicable.

$$\text{Coupling in decibels} = 10 \log_{10} \frac{Y^2}{1 + Y^4 + Y^6}$$

where Y is the ratio of the characteristic admittance of the stub line to that of the main lines.

When Y is small Y^4 and Y^6 can be ignored, the coupling in decibels $= 10 \log_{10} Y^2$.

Thus for this coupler

Main line $= 50$ ohms $\therefore Ym = \frac{1}{50}$

Stub line $= 100$ ohms $\therefore Ys = \frac{1}{100}$

$$\therefore Y = \frac{Y_s}{Y_m} = \tfrac{1}{2} \text{ and } Y^2 = \tfrac{1}{4}$$

$$\text{Then coupling} = 10 \log_{10} \tfrac{1}{4}$$

$$= -10 \log_{10} 4$$

$$\triangleq -6 \text{ dB}$$

Therefore there is about 6 dB attenuation across the coupler as against about 1 dB by the direct route. the latter being caused by losses.

32. The above explanation concerns a signal passing either directly through a main line or travelling diagonally across the coupler. Now consider a signal which attempts to pass from the variable attenuator to the diode head. It can split and travel through each stub line, but one path is longer than the other by twice the distance between the stubs and since this distance is a total of $\lambda/2$ it follows that when the signals again meet they cancel each other out. Therefore no output RF reaches the diode head.

33. The length of the stub concerns only the matching and in fact something slightly less than $\lambda/4$ is best. The resistive load shown on the bottom left hand corner of fig. 7 is required to absorb the unwanted signal and thus reduce standing waves. There is of course a 6 dB loss from the variable attenuator to the airborne set but this is accounted for in calibration. The diode head contains a resistive load, RF by-pass capacitance and a thermionic diode detector. The whole assembly is matched into the coupler and the detected output pulses are DC coupled to the wattmeter backing off circuits.

Wattmeter circuits (*fig.* 2)

34. These circuits are used in both range and wattmeter conditions and they are switched to the backing off condition only when the METER SELECTOR switch SW1 on the front panel is set to WATTMETER. In this condition the front panel meter and the +150V line are connected. Measurement of power is achieved by adjusting RV11 which applies a positive DC backing off voltage to the cathode of the detecting diode V29 until the diode ceases to conduct. At this point the backing off voltage equals the peak detected voltage and is proportional to the peak power. The value of this DC voltage is then read on the front panel meter which is calibrated directly from 0 – 1·5 kW peak. The method of deciding the instant at which the pulse is backed off is described in the following paragraph.

Distance pulse amplifier V30 (*fig.* 2)

35. This is a relatively high gain two valve triode amplifier built round V30. Its purpose is to amplify the small backed off pips on the wattmeter condition and to amplify and limit the pulses in the distance condition. Terminal 3 which is mounted on the front panel and marked D.M.E. SYNC is taken from a tap on the grid resistance of V30a and supplies a synchronizing point for an oscilloscope. Some extra bias is applied to V30a in the range position by switching R170 to the 28 volts line. This is to cut down the amplification of spurious signals. The grid of V30b is taken to HT potential via R141 to cut down the effects of overshoot on large input signals.

Decoder V31 (*fig.* 2 & 9 (*k*))

36. The function of this circuit is to supply a negative pulse only when a correctly coded positive pulse pair is applied to it. The decoder valve V31 is biased beyond cut-off both on the suppressor and the grid. When a positive pulse pair from the anode of V30b arrives at the decoder it divides into two routes. One route is direct to the suppressor and the other is to the grid via the delay line DL2 and, since the delay of the line is the same as the distance between pulses namely 12 μS, it follows that the second pulse will arrive at the suppressor at the same time as the first pulse arrives at the grid. The valve therefore conducts and produces a negative pulse at the anode and will do this only when a correctly coded signal is present. No bias changes are made to the circuit for range or watts. There are two connections made to the anode, one to the wattmeter indicator circuits V20 and V21a and the other to the distance phantastron V22.

Wattmeter indicator V20 & V21a (*fig.* 2)

37. The circuit V20, V21a and relay RL1 is designed to show by illuminating on the front panel, a green light LP2 when pulses are present and a red light LP1 when the pulses are either not present or backed off. The circuit uses the Miller rundown principle as in the phantastron circuits with the addition of the cathode follower V21a which is necessary to charge C39 in the short time available. Since there is no cathode coupling, the quiescent state of the circuit is for C39 to be discharged with anode volts low, screen current high and therefore relay RL1 energized.

38. When a negative pulse appears at the suppressor, the anode is cut off and its voltage rises, which in turn charges C39 via the cathode follower V21a. When the pulse has ceased the anode again begins to run down and the screen current is reduced to a small value, which de-energizes RL1. If no pulse appears during the rundown period, then the circuit reverts to its quiescent state and the relay is energized, but if a pulse does appear then the rundown is arrested and taken back to the start again with no effect upon the relay.

39. The period of rundown is arranged so that it is greater than the lowest p.r.f. encountered, so that the relay is absolutely unaffected until the pulses cease. Germanium rectifier MR3 stops any reverse current from energizing the relay and allows a crisp cut off of the relay current. The 28 volts is only connected to the lights when the METER SELECTOR switch SW1 on the front panel is switched to WATTS. A series resistance R171 reduces the current through the lamps to improve their life.

Distance phantastron V22 to V24a (*fig.* 2 & 9 (*f*))

40. This circuit, containing V22, V23 and V24a, is described in detail in para. 48 and 49. It has two functions which are selected by the relay RL2 which in turn is energized via the RANGE switch SW2 on the front panel. When this switch is in the 101 MILE position the relay is de-energized and the phantastron cycle is designed to function with a delay of about 2 millisecs in order to gate the 20 kc/s pulsed oscillator V32a and generate the necessary pulse selector gate as described later in para. 42. When the switch is in the 1 MILE position the phantastron cycle functions with about 50μS delay and the trailing edge of the waveform at the cathode of V23 is fed to the grid of V25b and used as the 1 mile reply as described in para. 43. The phantastron circuit is triggered via V22 at the anode by the negative pulses from the anode of the decoder V31.

Distance gate circuits V24b and V25a (*fig.* 2 & 9 (*g*))

41. These circuits built round V24b and V25a generate the gate which, on the 101 miles range, select the desired pulse from the pulsed oscillator V32b circuits : on the 1 mile range they allow the trailing edge of the phantastron to pass to V25b grid. The cathodes of V24a and V24b are connected together, and the grid of V24b is set at a positive potential such that V24b conducts at about two thirds down the rundown waveform of the phantastron. The resulting negative going waveform at the anode of V24b is a pulse of about 600μS duration. Since the edges of this waveform begin slowly and speed up at the more negative values, V25a grid is positively biased by R108, R110 and R111 so that this valve does not amplify until the faster part is reached. The anode of V25a produces a positive gate which is about 120μS long, the length being controlled by the differentiating action of C44 and the V25a grid resistances. This gate is then coupled to the suppressor of V14.

20 kc/s pulsed oscillator V32 (*fig.* 2 & 9 (*h*))

42. This oscillator is only used on the 101 mile range and is built round V32 and TR5. Basically this oscillator is a two-stage amplifier where the output of the second valve V32b is connected to the input of the first valve V32a in the correct phase to give positive feedback. The inter-stage coupling is by transformer TR5 which has a tuned anode winding. The grid of V32a is biased to cut off by the negative 15 volts line, therefore no oscillations are produced until the positive gate from the phantastron V23 switches the circuit on via C61. The resulting envelope of oscillations is then taken from the anode of V32b to the limiter stage V25b. The cathode of V32b is connected via R149 to the relay supply so that a positive bias is applied to this cathode when switched to the 1 mile range. This is to stop any spurious oscillations from the circuit.

Distance limiter V25b and divide by three circuits V33 (*fig.* 2 & 9 (*j*))

43. The grid of the limiter valve V25b is connected to the centre of RL2.2. On the 1 mile range it accepts the differentiated trailing edge from the phantastron V23, and on the 101 mile range the envelope of oscillations is applied from V32b. When the oscillator output from V32b is connected, V25b produces a train of square waves at its anode, the mark to space ratio being kept constant over input variations since the valve is biased by R154 and R156 to limit about the centre of the oscillations. The square waves are then differentiated by C68 and the resulting pulses are used to trigger the divide by three multivibrator V21b and V33.

44. This multivibrator is basically the same as the coding multivibrator V18 described in para. 29. In this case the time constant C69, R159 and RV6 is chosen so that once the circuit has triggered it does not recover until two triggers have passed, it then recovers and is again triggered by the third. In the 1 mile condition the multivibrator is triggered once only. The waveform at the anode of V33b is differentiated and connected to the grid of V14, the positive excursions taking it into the conduct region. The gates at the suppressor of V14 are adjusted to coincide with the required pulses at the grid to give a range reply of effective mileage shown on the front panel switch.

Front panel meter M1 (*fig.* 2)

45. The function of this meter is controlled by SW5 the METER SELECTOR rotary switch also mounted on the front panel. There are three voltage checks, namely 300 volts, 150 volts and 28 volts and positions for setting the RF level and watts readings.

Rotary transformer RT1 and filter units (*fig.* 2)

46. The rotary transformer accepts the 28 volts supply and supplies the positive 300 volts and the negative 150 volts. These outputs are protected by fuses FS1 (250 mA) and FS2 (50 mA) on the front panel. The 5 volts 1800 c/s output is not used. The filter unit on the front panel contains the 28 volts input plug PL1, the 28 volts indicator lamp LP3, the push button thermal cut out which provides protection against overload on the 28V line, the three LC filters L3, L4 and L5 which filter the spurious RF from each output, and the heavy duty relay RL3 for switching the power to the rotary transformer. This relay is operated by the thermal delay switch in the bridge unit and delays the input to the rotary by about half a minute after the heaters are switched on.

Set zero control (*fig.* 2)

47. When the mechanically biased switch SW5 is depressed, the drive to the modulator and RF unit is removed so that the thermistor bridge may be balanced by RV12 see para. 64 and 65.

Phantastron (*fig.* 8)

48. The cathode coupled phantastron is a monostable pulse generator using Miller feedback as the timing method. In the typical circuit shown in fig. 8, the voltages marked are those in the quiescent state. The current through the screen and cathode resistor of V3 is determined by the clamping voltage on the cathode of V2 and for correct operation the cathode of V3 should be slightly above that of V2. The suppressor is biased back relative to the cathode to cut off the anode. The anode voltage is determined by the voltage on the cathode of the clamping diode V1.

49. The action of the circuit may be started by a positive trigger pulse on the suppressor, or a negative one on the cathode of one of the diodes, but triggering on the anode clamping diode is more satisfactory. The trigger pulse cuts off the grid, and the cathode and screen currents fall. When the cathode falls below the suppressor, anode current starts to flow. The anode voltage falls rapidly (note initial step in the anode waveform), until the cathode is within a volt or two of ground. The Miller action now starts ; current through R tends to make the grid rise, but this rise is opposed by the fall in the anode voltage. The result is that the anode voltage falls steadily as C is discharged, and the grid voltage rises only slightly. This rundown continues until the anode comes within a few volts of ground. At this point the grid can rise more rapidly as there is now no feedback. The cathode and screen currents rise slowly at first, and then rapidly as the suppressor cuts off the anode again which in turn rises and turns on the grid. This regenerative action produces the sharp change in the cathode and screen current. The anode voltage rises as C is recharged by current flow through the anode load and V2 until the anode is again clamped by V1. The recovery period can be speeded up, as shown by the dotted line in the waveforms, by using a cathode follower between the anode and C. The duration of the cathode and screen pulses is proportional to the clamping voltage on the cathode of V1.

MODULATOR UNIT (*fig.* 10)

50. This unit consists of the mixer stages for 15—135 c/s and pulse input, also the regulating circuit for the 150V HT fed to the mounting unit.

Mixer stages V4 to V6.

51. The input pulses from the main chassis are applied to V4 in the modulator unit, a cathode follower stage. This valve is normally biased to cathode current cut-off from the—150 volt supply. Positive pulses from the main chassis cause pulses of anode current in V4. V5 is biased to cathode current cut-off and when V4 is switched on, almost the entire cathode current of V4 becomes the grid current of V5, as the grid of V5 moves into the positive voltage region. The limit to rising grid current during the pulse is set by the crystal diode MR1 connected to the grid of V5.

52. V6 valve is a cathode follower which has the composite modulation applied to its grid and the resultant cathode current charges and discharges the 1 microfarad condenser C6. The resultant variable bias on the diode MR1 causes the tops to be cut off the pulse train delivered from V4 in sympathy with the LF modulation pattern. When the pulse voltage rises to that of the prevailing bias on the MR1 diode cathode, the cathode current of V4 is partly diverted through the diode and charges the capacitors of 1 and 8 microfarads in series (C6 & C7). This charge causes small spikes to be superimposed on the modulation pattern which can produce bearing errors in the airborne equipment. To counter this effect, C7, the 8 microfarad capacitor, is made the reservoir which supplies the pulse current required for V4 and V5. A downward step in the potential on this capacitor takes place at the same time as the spike is developed by the high pulse rate in the marker trains on the combination of C6 and C7. The resultant of these two effects is a cancellation of the spikes and a cleaning up of the modulation pattern. Some pulse drop is also introduced by the characteristics of the modulation transformer TR1.

Output stage V5.

53. The pulse input to the grid of V5 is therefore amplitude modulated and resultant pulses of anode current feed the RF unit with pulse HT via the output transformer TR1. Output level is varied by means of the SET RF control which is RV13A in the mounting unit, this has a maximum value of 250 ohms. Full output is obtained from the RF unit when this control is adjusted to zero, but as its value is increased, the impedance of the HT supply to the modulator pulse stages is increased so that output power of the modulator is reduced. On the secondary of the output transformer TR1, the high potential terminal is wired direct to the RF unit. On the low potential side, the secondary is connected to earth through two ten ohm resistors in parallel (R8 & 9). The voltage across these resistors can be used to operate the video unit in the airborne equipment and it is brought out to terminal 4 VIDEO OUTPUT on the front panel (0·8 volts negative going pulse train) of the test unit.

150V regulator stages V1 to V3

54. V1, V2 and V3 comprise the series regulator circuit. This is a conventional circuit with V2 amplifying changes in the HT voltage and feeding these to the grid of V1 to oppose the changes by altering the resistance of V1. V3 is a gas-filled reference voltage valve for the regulator circuit and also for controlling the negative line to the rest of the equipment.

RF UNIT (*fig.* 11)

55. This unit consists of a crystal oscillator, buffer and frequency multiplier amplifiers, an output attenuator, a filter unit and RF output monitoring arrangements.

Crystal oscillator V1

56. With the output frequency of the unit at 1000 Mc/s, the crystal oscillator V1 generates a signal at 37·037 Mc/s from a Butler type oscillator and one section of the CV4024 valve is connected as a cathode follower to feed the voltage across the tuned circuit through the crystal to the other section which is connected in an earthed grid arrangement.

The stage oscillates using the crystal in a series mode as a very narrow band pass filter, an overtone of the crystal plate being selected.

Buffer stages V2 and V3

57. The output from the crystal oscillator V1 is fed to V2 whose anode circuit is tuned to the fundamental frequency with L2. The input to V3 has a grid stopper resistance included which also has the effect of broadening the tuning of V2 anode circuit and reducing the coupling between the crystal oscillator and other circuits. V3 anode circuit is again tuned to the fundamental frequency and output is taken to the grid of V4.

First multiplier stage V4

58. The anode circuit of V4 is tuned to the third harmonic, i.e. 111·1 Mc/s and is pulse moderated. The screen circuit is fed from the DC HT supply as. this improves the buffering between the pulsed stages and the crystal oscillator and also achieves a better pulse shape in these conditions. The small value of the screen by-pass capacitor C15 allows the screen voltage to rise rapidly under pulse conditions while remaining low in quiescent periods. The coupling loop between the anode tuning coil L4 and the input coil to the next stage (L5) is earthed to reduce detuning effects when the lid of the unit is screwed into position.

Penultimate stage V5

59. V5 is connected as an earthed-grid-double-triode stage with the anode circuit tuned to 333·3 Mc/s. Drive from V4 is applied to the cathodes via C17 and 18 which are adjusted as required to make the drive on the cathodes equal. Coil L5 tunes with the resultant capacity to 111·1 Mc/s. Coil L7 and L8 are bifilar wound to conserve space and provide a high impedance to RF.

Output stage

60. Input from V5 is fed to the cathode of 2C39 (CV2516) valve via a 47 pF capacitor. Bars connecting the heater terminals of the 2C39 valve to the by-pass capacitors, made integral with the output stage construction, serve to conduct some of the heat away from the valve and also to act as a HF choke and avoid too much of the input from V5 passing to earth. This stage may be considered as an earthed grid triode as far as the input circuit is concerned. A bifilar wound choke L10 is connected between the bypass capacitors and the heater supply, to avoid the pulse self bias developed by the 2C39 being short circuited by the heater supply. This produces more favourable conditions for obtaining 3rd harmonic (1000 Mc/s) from the output. The body of the output stage (the inside surface) acts as a resonant cavity tuned to 1000 Mc/s with the plugs in the side of the body.

Attenuator and power measuring elements

61. Power at 1000 Mc/s is passed from the output stage to the thermistor launching element in the piston attenuator, through a plug and socket connection. This thermistor serves as a power output measuring device, in addition to a launcher. When power is dissipated in the thermistor its resistance goes down ; when connected in a bridge circuit, the front panel meter on the test set can be made to indicate power into the attenuator. The outer end of the thermistor is earthed to RF current by a capacitor built into the attenuator head, but the DC connection is taken out to the unitor plug. Also mounted in the attenuator housing are three more thermistors used for voltage and temperature compensation whose operation is described in para. 64. The purpose of this mounting is to make all the thermistors experience the same ambient temperature as far as is possible.

Filter unit

62. This unit is screwed to the RF unit below the attenuator barrel and contains filters for all connections to the RF unit, with the exception of the wires going to the attenuator housing. All sections of the filter unit have identical components except the filter used on the input from the modulator which has to handle the pulse waveforms.

BRIDGE UNIT (*fig.* 12)

Power circuit

63. Included in the bridge unit is the delayed starting circuit for the rotary transformer. When the cut-out on the front panel is closed, the 28V input is applied to terminal 9 of the bridge unit and current passes through the heater of the thermal delay switch via relay contacts RL1/1, R6 and earth. After approximately 30 seconds the thermal delay switch contacts close and relay RL1 energizes from the 28 volts supply. RL1/1 contacts change over, disconnecting the thermal delay switch heater and providing a holding circuit for RL1 relay. RL1/2 contacts change over and close a circuit for the power relay to the rotary transformer.

Thermistor bridge circuits

64. This consists essentially of two parts

(1) The compensating circuit.

(2) The bridge circuit proper.

The 28 volt supply is fed through RV2 and R5. The resultant current flow has two paths ; one path leads through RV1 and out of the unit to the RF unit where three thermistors TH2 to 4 are connected in series and mounted on the back of the attenuator head. The end connection of the thermistors is returned to the bridge unit for earthing to avoid trouble with currents flowing in the chassis. The other current path is through the SET ZERO control RV12 and to the bridge, one side being composed of R1 and R2 and the other of R4 and the thermistor TH1 in the attenuator on the RF unit. RV3 is a preset meter calibration resistance.

65. The RF output indication is zero when the thermistor TH1 in the attenuator has a resistance of approximately 100 ohms. This condition is obtained by varying the current through the bridge using the set zero control RV12 until the current passing through the thermistor brings its value to 100 ohms. When the correct amount of RF power is being dissipated in the thermistor in addition to the DC input, its resistance falls to about 70 ohms. The bridge is unbalanced in this condition and the test set front panel meter reads RF output.

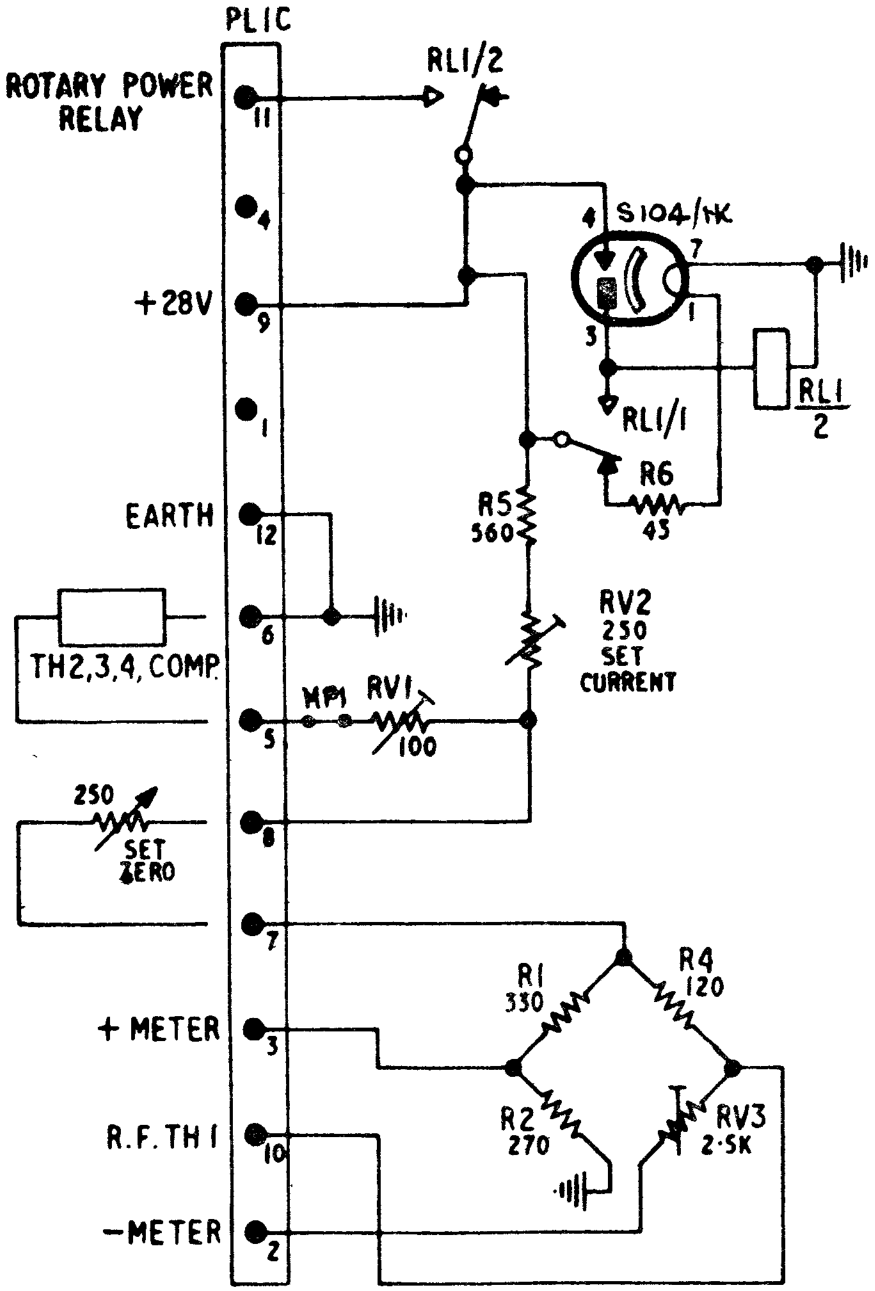


Fig. 12. Bridge Unit—Schematic

66. The bridge is very sensitive to changes of DC input and moderately so to changes in ambient temperature, so the compensating branch through RV1 is fitted to take care of these variations. As thermistor material has a negative temperature coefficient, i.e. its resistance decreases with rising temperature (or an increase of current flow) so with RV1 adjusted to a suitable value (around 60 ohms) very good compensation for changes of input voltage may be obtained such that between 26 and 30 volts the variation of voltage at terminal 8 of the unitor plug will not be more than 0·01V throughout this range, at normal ambient temperature. When the ambient temperature in the equipment rises during operation, the resistance of all the thermistors falls but, as the compensating branch is in parallel with the bridge, the applied voltage to the bridge is decreased, so allowing the power measuring thermistor to operate over the same range as at normal ambient. Similarly in low temperature conditions, the volts at terminal 8 on the bridge unit becomes higher, so increasing the current through the bridge and maintaining bridge balance conditions.

375/6 Wt. No. 24272 D. No. 7311

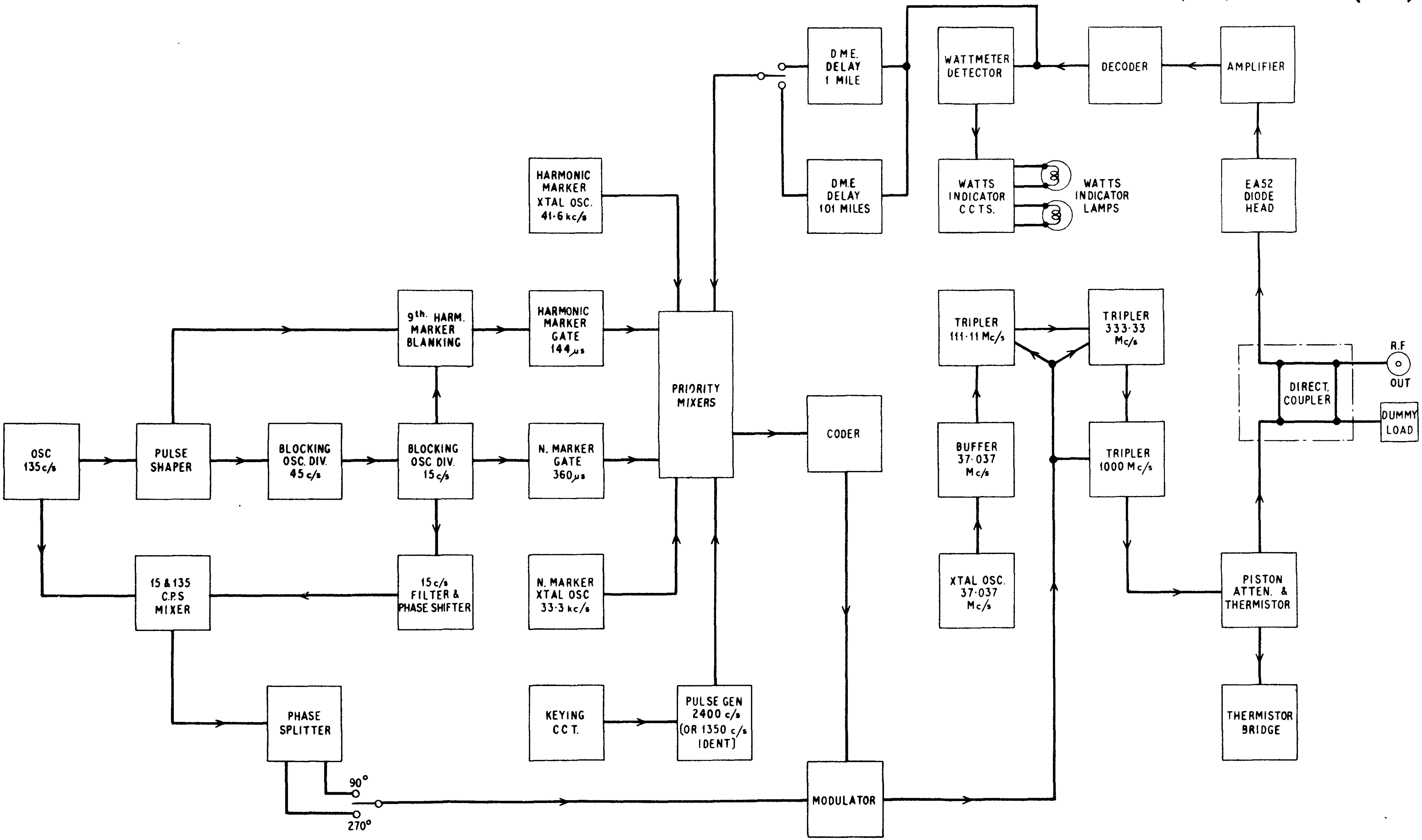


Fig. 1

Performance tester block diagram

Fig. 1

Fig.2

Mounting unit schematic

Fig.2

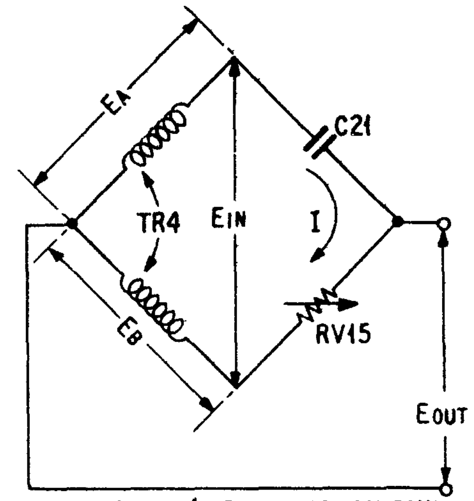


FIG. 3 135 c/s PHASING CIRCUIT

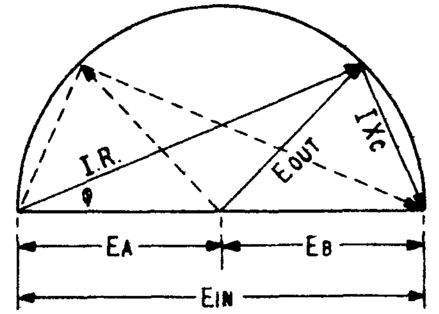


FIG. 4 VECTOR DIAGRAM OF FIG. 3.

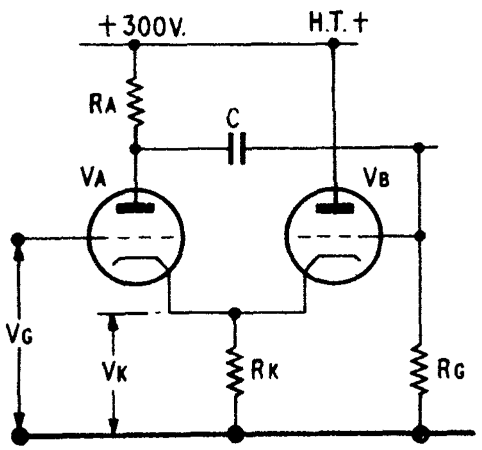


FIG. 5 BASIC CIRCUIT OF A CATHODE COUPLED MULTIVIBRATOR.

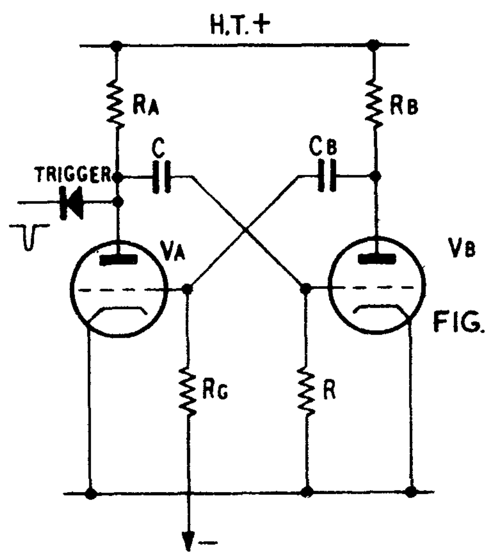


FIG. 6 BASIC CIRCUIT OF ANODE TO GRID COUPLED MULTIVIBRATOR.

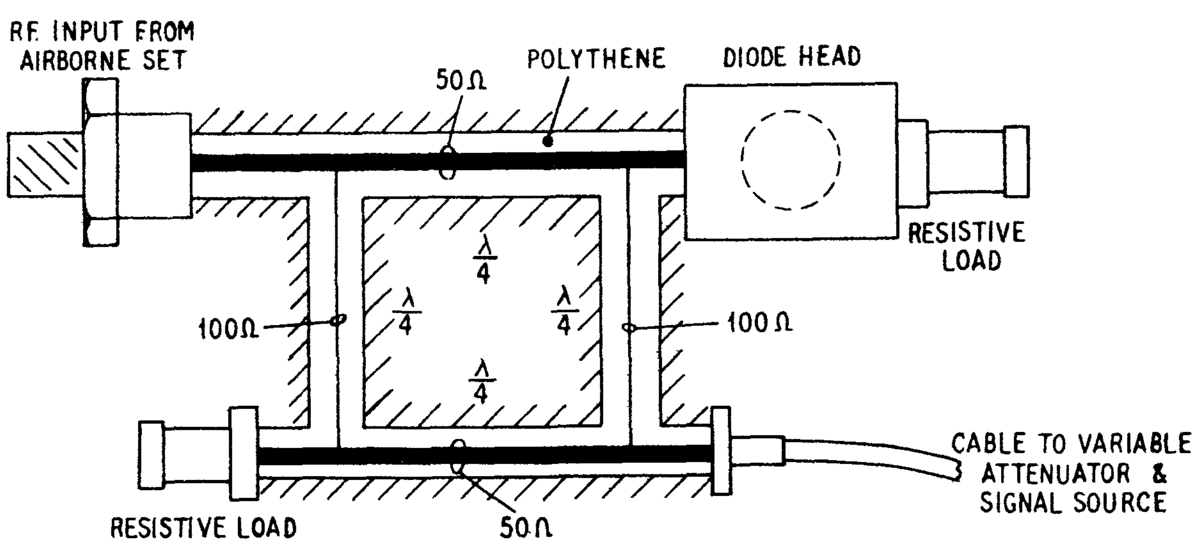


FIG. 7 DIRECTIONAL COUPLER & DIODE HEAD

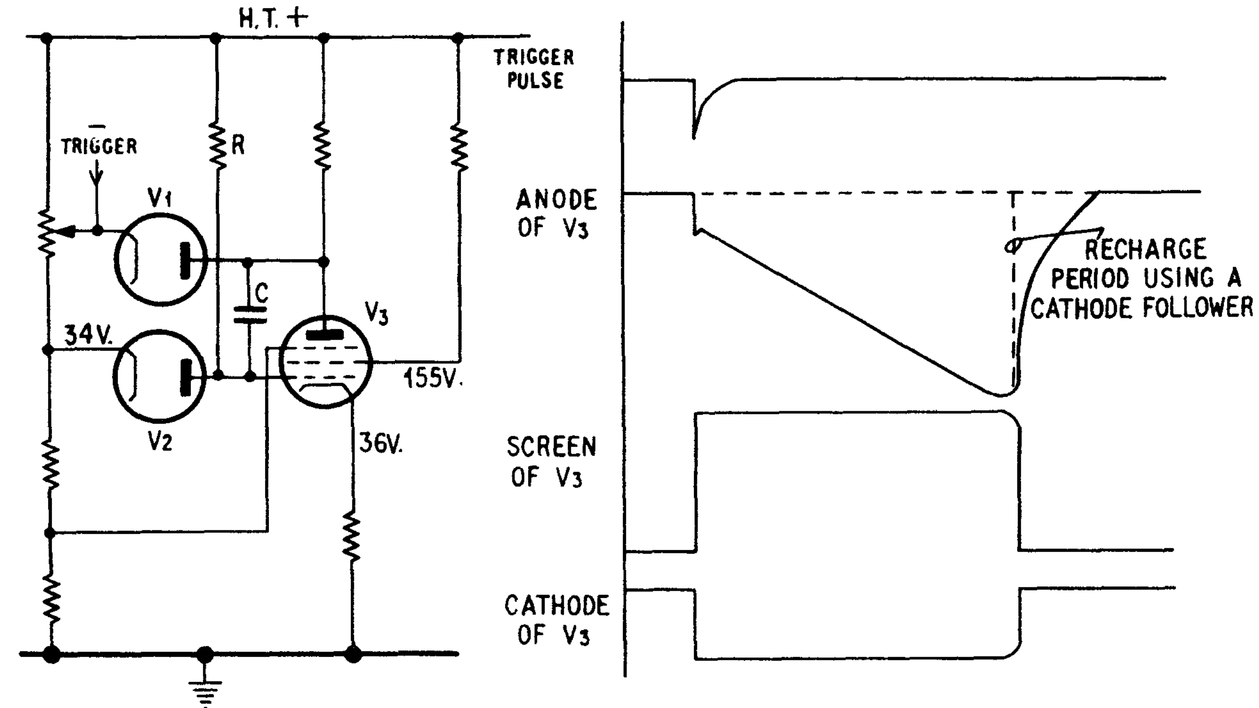
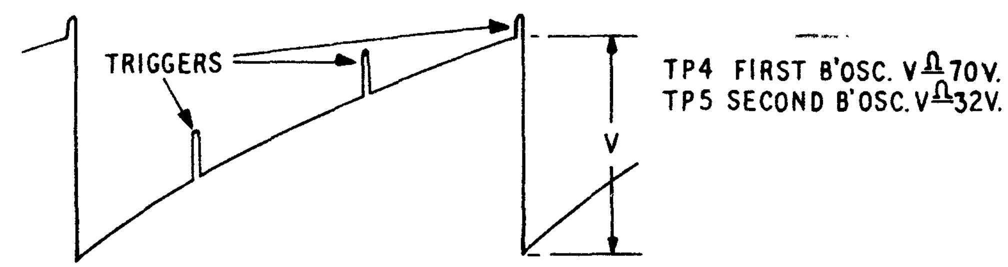


FIG.8 BASIC CIRCUIT OF CATHODE COUPLED PHANTASTRON WITH WAVEFORMS

(a) TYPICAL BLOCKING OSCILLATOR DIVIDER WAVEFORM.



(b) HARMONIC MARKER GATE AT TP7.

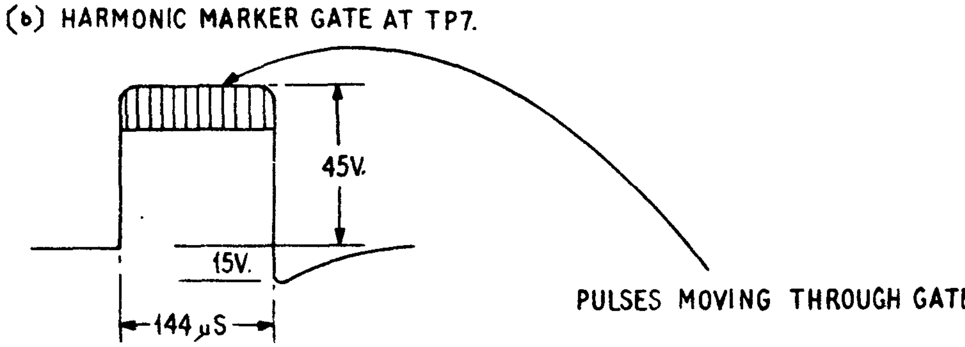


FIG. 9 WAVEFORMS

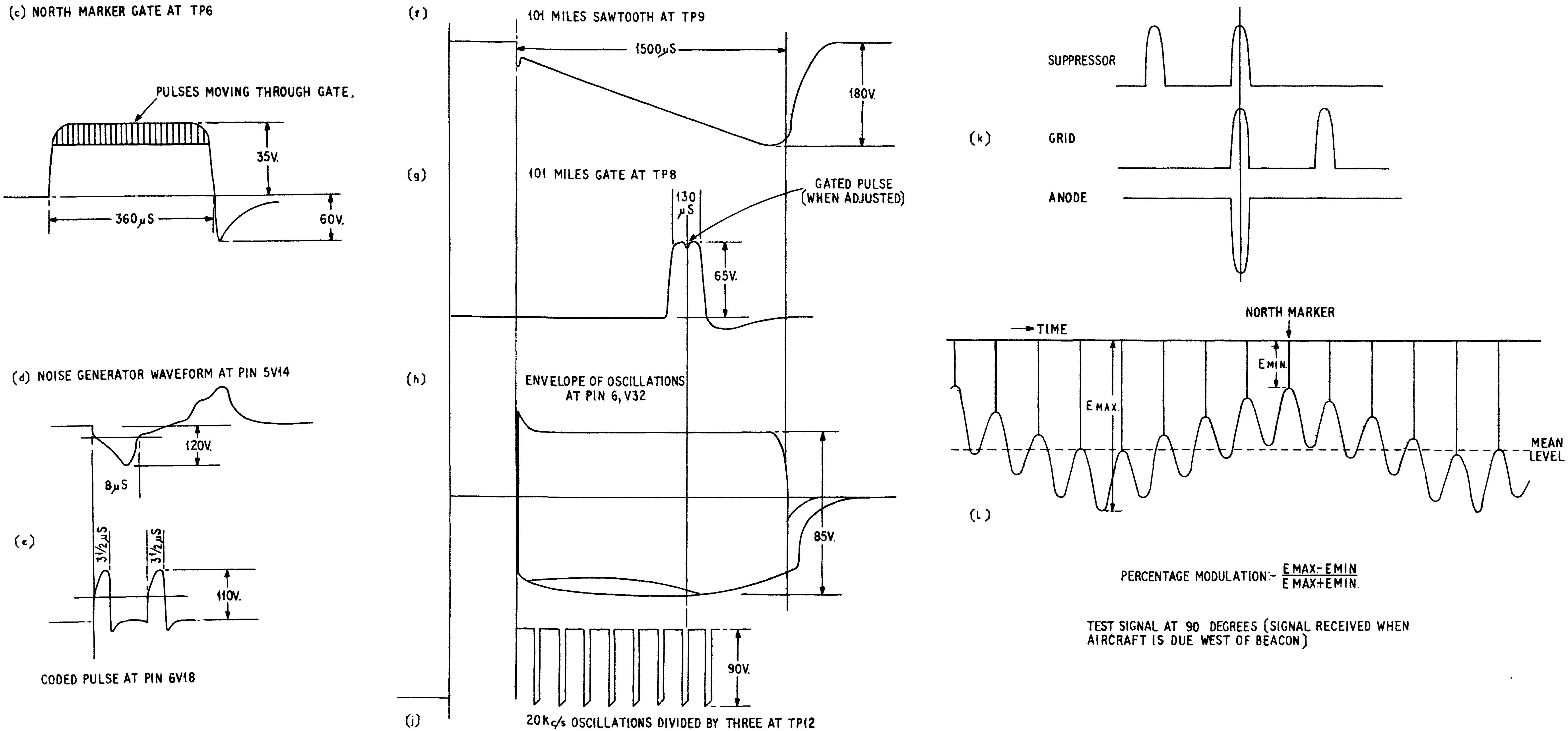


Fig.9

Waveforms

Fig.9 C/L

(A.L.2, Aug.58)

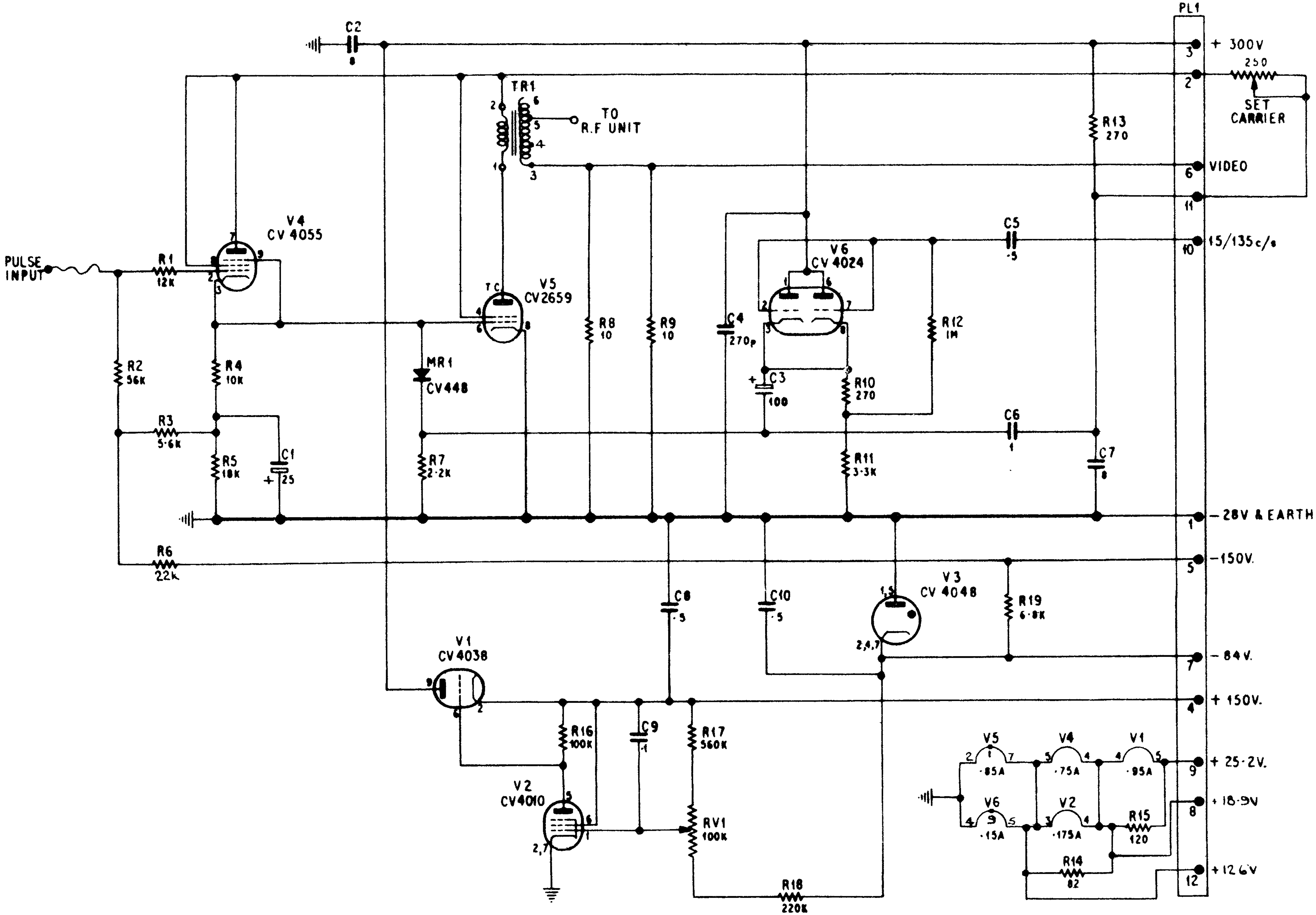


Fig.10 Modulator schematic Fig.10

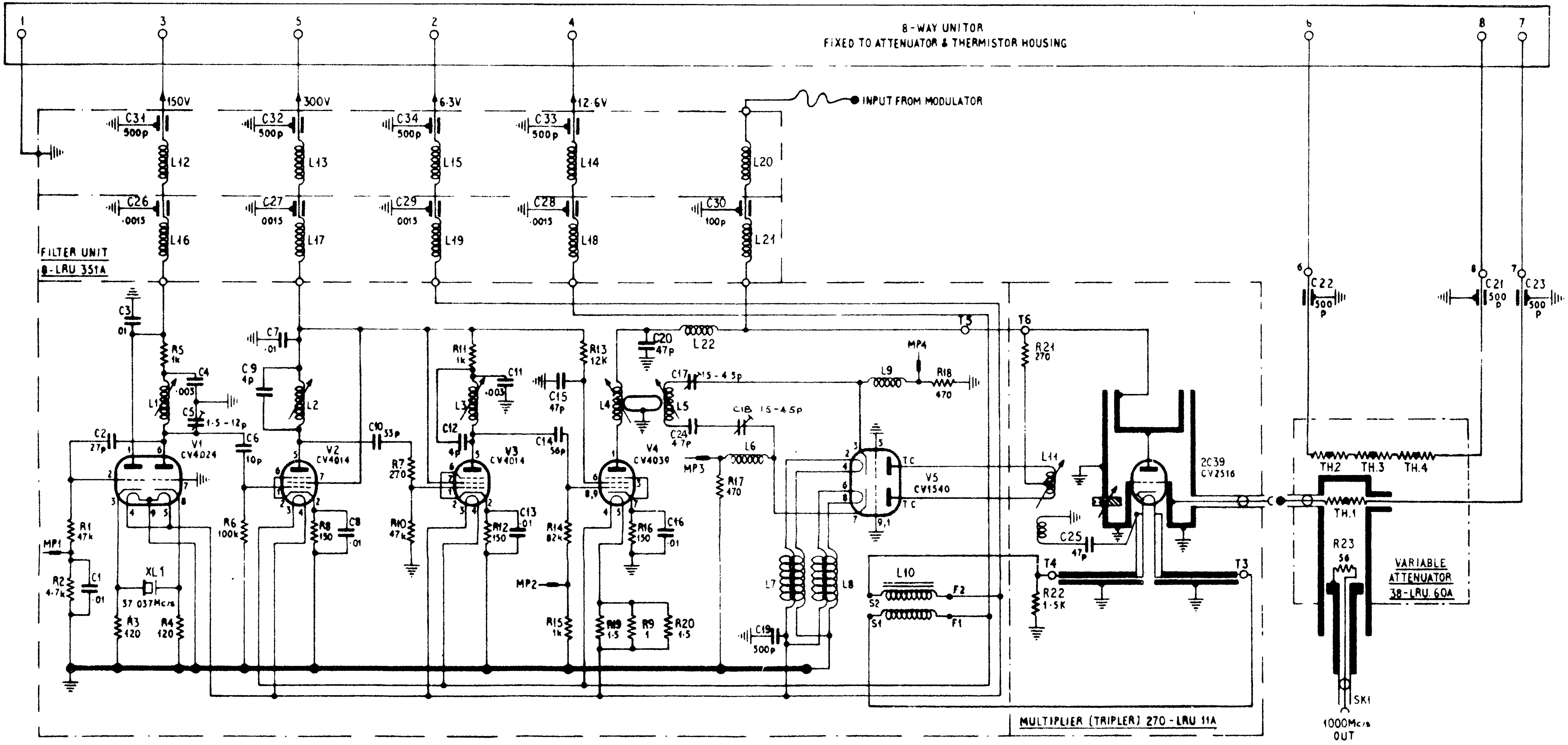


Fig.11 R.F. unit schematic Fig.11

Chapter 3

SETTING UP

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General

1. These instructions are intended to enable the user to adjust all the pre-set controls in the test set. These controls should not however be touched unless the equipment is known to be faulty. A (Solartron D300) Oscilloscope CT316 is recommended but other types can be used. Unless a delayed timebase facility is available, there may be difficulty in examining some of the waveforms.

2. For lining up the distance markers it is essential to have a Tacan ARI which has been calibrated recently against test set 7478, this is also true for the bearing signals if these are to be set up accurately. However the bearing signals can be set up by visual inspection of the video output if no aircraft set is available. RF output can only be checked if a calibrated signal generator is available.

Bearing dividers

3. The two blocking oscillator dividers can be set up by adjusting RV1 and RV2. For the first divider, trigger the oscilloscope from TP2 (**Warning:** *There is 300V on this point*) and examine the waveform at TP4. Adjust RV1 for a division by 3 as in fig. 9 (a) Chap. 2. For the second divider, trigger from the 15 c/s terminal 2 on the front panel and examine the waveform at TP5. Adjust RV2 for a division by 3 as in fig. 9 (a) Chap. 2.

Modulation depth

4. Trigger the oscilloscope from the 15 **c/s** terminal 2 on the front panel and examine the **video output** waveform at terminal 4. Adjust RV8 (**135 c/s**) and RV4 (**15 c/s**) to give 20% of each frequency, total 40%, as shown on fig. 9 (1) in Chap. 2. If a 1 000 Mc/s receiver is available, a more accurate measurement will be achieved by using this to detect the RF output of the test set. A Tacan ARI should only be used for this if the modulation can be observed clearly.

Phasing of bearing signal

5. Using the same connections as in para 4, adjust RV15 so that the markers are at the peaks of the 135 c/s waveform (270 deg. bearing). Adjust RV7 so that the North marker is at the peak of the 15 c/s modulation. The North marker coincides with the 15 c/s trigger and can be identified by looking at this trigger pulse and noting its position. When the 15 c/s modulation is correctly phased, the peaks of the 135 c/s modulation on each side of the North marker should be the same height.

6. A more accurate method of adjusting the phasing is by comparison with a Tacan ARI that has just been set up against test set 7478 (3rd line video simulator). Adjust RV15 to give the same reading on the indicator and RV7 until the North marker is in the same relative position in the 40° gate pulse. The gate pulse can be observed at the screen of V3 in the azimuth gate unit in British sets and at E.301 in American ARN–21 sets.

North and harmonic markers

7. Trigger the oscilloscope from the 15 c/s terminal 2 and examine the waveforms at TP6 (North marker) and TP7 (Harmonic marker) fig. 9 (b) & (c) Chap. 2. Adjust RV3 until the width of the North marker gate pulse is 360 µS and RV5 until the width of the Harmonic marker gate is 140 µS. It will be necessary to use the time base delay facility on the oscilloscope to examine the Harmonic marker pulse unless satisfactory results can be obtained by triggering from the marker gate pulse itself.

Distance circuits

8. Connect a Tacan ARI to the test set and switch the aircraft set to transmit. Trigger the oscilloscope from the **DME** terminal 3 on the front panel and examine the waveform at TP8, fig. 9 (g) Chap.

2. Adjust RV9 until the pip appears in the middle of the gate. The distance switch on the front panel should be set at 101 miles.

9. No further adjustments should be made to the distance circuits unless the ARI has been recently calibrated against the test set 7478. If this is so, slacken the lock nut on the dust core of TR5 and adjust the core until the ARI indicator reads 101 miles. If the error was more than ½ mile, check that the pip is still in the middle of the gate at TP8. If the distance divider is suspect, examine the waveform at the cathode of V21b (pin 8) and adjust the timebase so that each cycle of the waveform takes up two lines on the graticule. Check that each cycle of the waveform at TP12 takes up six lines on the graticule and adjust RV6 if necessary. The one mile marker can be checked by setting the distance switch at one mile and noting that the indicator reads one mile. Adjust RV10 if necessary.

Wattmeter calibration

10. If the power reading is suspect and requires checking, measure the following resistances:

(1) Fixed attenuator—end to end—should be 276 ohms ± 5% for group A (17.2 dB) and 334 ohms ± 5% for group C (19dB).

(2) RF socket on the front panel to ground—should be between 16·5 and 19 ohms.

(3) RF socket on the front panel to TP10—should be more than 100 K ohms with no power on; this reading should drop to between 1 and 5 K ohms with power on as V29 heats up. The positive lead on the ohmmeter is connected to the RF socket, the terminal on multimeter Type 1 marked –ve is positive on the ohms range. The front panel meter switch should not be placed in the "wattmeter" position for this test.

11. The backing-off volts on V29 cathode may be checked with a valve voltmeter having a resistance of not less than 10 M ohms. For serial numbers X1–X6 the voltage at TP10 (front panel meter switch on "wattmeter") should be 29·7V for a power reading of 1 kW. For serial numbers X7 & A1–24 it should be 41·8V for a power reading of 1·5 kW. On serial numbers X1–X6 RV14 can be adjusted to take up errors. On the later models, no adjustment is provided; if the reading differs by more than 2V from the nominal figure, check the resistances of R130, R132 & R133 on tag board.

150V HT supply

12. Adjust RV1 in the modulator to give 150V on the front panel meter.

RF tuning

13. Remove the cover of the RF unit by unscrewing the 16 screws securing it. If care is taken to avoid touching live points on the tag board of the main chassis, tuning can be accomplished without removing the unit. Trimming tools for L4, 5 and 11 are clipped to the cover of the RF unit.

Crystal oscillator

14. Connect a multimeter Type 1 to MP1 (2·5V DC range) with the positive lead to ground and tune L1 for a maximum reading which should be between 0.7 and 0·4V. Lock the dust core in this position.

Buffer amplifier stages

15. Transfer the multimeter Type 1 to MP2 and tune L3 for a maximum reading. Tune L2 to increase this reading and lock in the best position. Return to L3 and readjust if necessary; lock L3 in this position. The meter should read between 1·2 and 1·6 volts.

First tripler stage

16. With the multimeter connected to MP3 (negative lead to ground) adjust L4 and then L5 to obtain a maximum reading (between 2 and 2·5V). Transfer the meter to MP4 and check that the reading is within 0·5 volt of that at MP3. If this is not so, it will be necessary to make slight adjustments to C17 and C18 located under the chassis between L5 and V5. L4 and L5 should be retuned after this.

2nd tripler and output stages

17. Using the non-metallic tuning tool provided, adjust the metal slug in the anode coil L11 of V5 for a maximum reading on the RF output meter on the front panel (meter switch on "normal"). Adjust the outer tuning slug in the output stage cavity for a maximum reading on the RF output meter. (The inner slug, adjacent to V5, should not normally require re-adjustment.) Lock the outer tuning slug in position. Replace the cover on the RF unit and remove the screened plug in the cover. Return L11 for a maximum on the RF output meter and replace the plug.

Thermistor bridge adjustments: bridge unit.

18. These will normally only need adjustment if the thermistors have to be renewed or if an RF unit is changed, and can only be done if the battery supply can be varied from 26 to 30 volts. RV3 should not be touched unless the RF output is being calibrated (*see para. 20*); this can only be done if a 1 000 Mc/s calibrated signal generator and 1 000 Mc/s receiver are available. If the settings of RV1, 2 and 3 in the bridge unit have been disturbed, they should be reset to 60 ohms for RV1, 80 ohms for RV2 and 1000 ohms for RV3.

19. Remove the thermal delay switch SW1 and switch on the 28-volt supply. Set the zero on the RF output meter and vary the input volts from 26 to 30. If the reading moves appreciably from zero, it is necessary to compensate for voltage changes as follows:—Switch off the supply and disconnect the link MP1 in the bridge unit. Allow the test set to cool down before proceeding further. With multimeter set on the 100 mA range across MP1 switch on the supply, adjust the volts to 28 as shown by the front panel meter. Set the zero

on the RF output meter and adjust RV2 until the current through the multimeter is 17 mA. Adjust RV1 and the set zero control so that there is no change in the zero reading of the front panel meter ('Normal' position) when the battery volts are varied from 26 to 30. Switch off and replace the link MP1. Switch on again and reset the zero with RV1 only to compensate for the resistance of the multimeter. Switch off and replace the thermal delay switch.

RF output calibration

20. This can only be done if a recently calibrated 1 000 Mc/s pulsed signal generator and 1 000 Mc/s receiver are available. The receiver should have a bandwidth of at least one Mc/s and have only a manual gain control. Connect the test set to the receiver using the fixed attenuator supplied with the test set, the 25 foot RF cable and adaptor for connecting the cable to the HN socket on the test set. Set the zero and then the RF output level as described in the operating instructions and tune the receiver for maximum signal. Set the test set attenuator at 110 dB W and note the level by connecting the oscilloscope to the receiver. Make sure that the receiver is not overloaded by adjusting the gain controls. The level to be measured is the mean level as shown on fig. 9 (1) Chap. 2.

21. Replace the test set with the signal generator and tune the generator for maximum signal using a pulsed output (3–20 μS, 1 000–10 000 pulses/second) at a nominal frequency of 1 000 Mc/s and at a level of 100 dB below one watt (80 dB below one mW). Note the level on the oscilloscope. Set the test set up to the same level as the signal generator output by adjusting the position of the locking ring on the piston attenuator on the RF unit so that the attenuator knob can be turned to give the right output. The locking ring should be adjusted to give 110 dB W when the piston attenuator is fully in. Switch off and remove the bridge unit so that the flexible drive shaft can be disconnected and the counter set to 110 before reconnecting.

22. If test sets 7478 and 7760 (Tacan video simulator and signal generator) are available, it is preferable to set up the test set against this standard using a Tacan ARI to compare the two. In this case the comparison should be made on a bearing of 270 deg. and at the signal level at which the aircraft set just unlocks on bearing.

Chapter 4

SERVICING

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ROUTINE MAINTENANCE

Air filters

1. Every six months inspect the air filters in the sides of the test set case. These can be removed by unscrewing the four red screws in each side of the case. Most of the air flow is through the lower half of the filters, so it will usually be satisfactory to shake off loose dust and replace the filter after turning it round. The air is sucked in through the filters and blown out through the front panel, hence it is essential that the dirty side of the filter is facing outwards. The air filters are the same as those used on the ARI. The older type made with cloth and wire mesh cannot be washed and must be replaced when dirty. The newer filters, made of plastic material, can be washed in warm water to which a small amount of detergent has been added. They must be dry before they are replaced.

Overall check

2. Every six months the test set should be compared with test sets 7478, 7760 and CT 324 which comprise the 3rd line Tacan simulator, using an ARI for the comparison. Any lining up necessary should be carried out as described in Chapter 3.

Rotary transformer

3. This item should give long service and should **not** be removed for routine maintenance as this cannot be done very easily. If it does have to be changed refer to para. 24.

Fault location

4. The circuits have been divided into six groups, and Table 1 is provided to assist in the location of the fault. Each group is covered in more detail in para. 6 to 21. Oscilloscope CT316 and multimeter Type 1 are recommended for servicing this test set.

5. An adaptor to replace SW1, the thermal delay switch in the bridge unit, will be found useful. This can be made from the protective cap normally supplied with B7G valves by inserting two wires of the same thickness as the valve pins through adjacent holes in the cap and securing these with solder each side. Insert the adaptor in the socket for SW1 in pins 3 and 4. The adaptor allows the HT to be switched on without waiting 30 seconds each time for the thermal delay switch to operate. When first switching on, allow 30 seconds before closing the wires of the adaptor. If the HT is to be switched off, press the OFF button on the front panel which will release the rotary transformer starting relays, then press the ON button. The valve heaters will now be on again and the adaptor wires can be closed whenever desired. These wires do not have to be held together as there is a hold-on circuit for the rotary transformer. The fault location Table 1 is based on results obtained with an ARI known to be fully serviceable.

DC circuits

6. Refer to fig. 1 and 12 in Chap 2. (Mounting unit and bridge unit schematics). The most likely reason for non-starting of the rotary transformer is a failure of one of the starting relays, RL1 in the bridge unit or RL3 located under the filter box on the front panel. The thermal delay switch SW1 in the bridge unit can be checked by replacing it with the adaptor mentioned in para. 5.

Check the resistance between pins 9 and 12 on the bridge unit plug; it should be approx. 60 ohms (R6 + delay switch heater).

7. The +150V line can normally be set by adjusting RV1 in the modulator using the multimeter in preference to the front panel meter. A very high voltage is probably due to a fault in V2 or V3 in the modulator. A very low voltage is probably due to a partial short circuit on the 150V line (red wire, blue marker) or a fault in V1.

Table 1

GENERAL FAULT LOCATION

	Effect	Possible cause	Remedy
1.	Orange lamp does not glow.	No power reaching set	Check battery volts on front panel meter.
2.	Rotary transformer fails to start after 30 secs.	Time delay or starting circuits faulty	See para. 6
3.	No 150 or 300 volt readings	HT or bias fuse blown. Short circuit on HT lines	Check both fuses and bias volts on V3 in modulator (82–87 volts).
4.	No 150V but 300V is correct (275–350V limits)	Faulty regulator	See para. 7
5.	Meter switch on "normal" and RF level cannot be set up correctly	(a) Thermistor bridge faulty (b) No power from RF unit (c) No drive to RF unit	See para. 8 to 14 See para. 15 See para. 18
6.	RF level low and aircraft set does not work on tone, bearing or distance	Coding faulty	See para. 18
7.	RF level correct but no lock-on on bearing	15 & 135 c/s modulation faulty Marker trains faulty	See para. 20
8.	40° error in bearing	15 c/s phasing out of adjustment	Adjust RV7, see para. 5
9.	Small bearing error (say 2—10°)	135 c/s phasing out of adjustment	Adjust RV15, see para. 5
10.	No lock-on on distance and no power reading	V29 faulty	Check that heater is glowing. If it is, refer to para. 21.
11.	Lock-on at 1 mile but not at 101 mile	Pulsed oscillator not working. 120 μS gate not aligned correctly	See para. 21

Thermistor bridge circuits

8. If the RF unit is dismounted from the main chassis, a solid earth return must be provided between the RF unit frame and the main chassis. When replacing, note that the flexible drive to the front panel should be connected when the Veeder reads '070' and the attenuator shaft is fully in. If a fault is detected, from Table 2, in the thermistors and wiring contained on the attenuator head housing, it will be necessary to remove the RF output stage and the attenuator from the casting. Adopt the procedure in the following para.

Table 2

THERMISTOR BRIDGE FAULT LOCATION

Effect	Possible cause	Remedy
No reading in "Normal" meter switch position	No 28V output to thermistor bridge circuits	Check input voltage between pins 9 and 12 on bridge unit plug.
	Set zero control branch o/c.	Check wiring and set zero potentiometer.
	R5 and RV2 branch o/c	Should have total series value of 630 ohms ± 20 ohms.
Reverse reading regardless of set zero control	Short to ground in compensating thermistor branch. Broken RF measuring thermistor	Check wiring to RF unit plug and wiring to lead-through capacitors on the RF unit
Full scale reading regardless of set zero control	Open circuit in compensating branch. Short circuit in RF measuring thermistor circuit	Check wiring to RF unit plug and wiring to lead-through capacitors on RF unit. R2 branch faulty or o/c.

9. Carefully prise off the two anode clips from V5 and arrange that they do not catch on the anode caps when the output stage is being withdrawn from the RF unit. Unsolder both wires leading to the insulated star tag from the output stage. This star tag is located close to the multiplier chassis end and below the output stage. Unscrew the two tags connecting the heater supply to the output stage and unsolder the earthed end of the 1 500 ohm resistor. Lay clear the heater wires. Release the four 6BA screws holding the output stage mounting plate to the main RF unit frame and pull the output stage away from the frame, remembering that the connection between the output stage and attenuator is via a coaxial plug and socket.

10. The thermistors used for temperature and battery compensation will now be visible mounted on the end of the attenuator head. Turn the RF unit round and release the attenuator barrel and gearbox as an assembly by unscrewing the *inner* ring of four screws holding the attenuator to the main frame of the RF unit. Also release the two screws holding the clamping piece at the gearbox end of the barrel. The barrel is a light push fit into the attenuator head and is best released by pulling gently while twisting backward and forward a little.

11. Turn the RF unit round again. Release the four screws holding the coaxial plug and gently pull the plug away from the attenuator head. The RF thermistor is soldered to the centre contact of the plug and should come away complete when the plug is removed. The inner end of the thermistor is gripped by a spring contact protruding slightly into the attenuator tube. E type thermistors are very delicate and must be handled with the greatest care in order to avoid damage. When bending or cutting the connecting wires, always hold the thermistor by gripping the wire being cut between the point of cutting and the glass tube.

12. If the fault lies in the rear wiring to the RF thermistor or in the three compensating thermistors it will be necessary to remove the attenuator head from the casting. Having removed the RF thermistor, disconnect the wires on the two nearest lead-through capacitors and also the two leads to the thermistor mount.

13. Release the four screws holding the attenuator head in the casting. The attenuator head can now be rotated in order to remove the spring contact and plate for the RF thermistor. After these fittings have been removed, taking care to preserve the mica plate and insulating bushes under each screw, the attenuator head can be withdrawn and the compensating thermistors inspected

14. To re-assemble, reverse the operations for dismantling, taking care to mount the RF thermistor spring contact centrally in the opening into the attenuator tube.

RF circuits

15. Should the RF unit be removed from the main chassis and tested on an extension lead, be sure that a good earth return connection is maintained between the RF unit and the main chassis. When replacing the RF unit, move the attenuator Veeder counter to '070' and couple the drive to the RF attenuator when the latter is fully in.

Table 3

RF CIRCUIT FAULT LOCATION

Effect	Possible causes	Remedy
Low indicated output from RF unit, and larger than correct pulse on VIDEO terminal	Short in RF unit pulse HT system	Check for short in pulse HT line. Check V5 anode coil circuit C20, L22 for touching chassis and damaged. Also coupling band between L4 and L5 for position (should be a third of the way down coils).
	PTFE tape on V6 cavity damaged and/or punctured. C20 faulty	Check for shorting before removing anode ring. If faulty, be sure to solder replacement condenser into exactly the same position, as bad connection impairs the tuning of L4.
Low indicated RF output and smaller than correct pulse on VIDEO terminal	Defective valve heater circuits	Voltage between terminals 4 & 2 and between terminal 2 and ground should be 6·0 to 6·6 volts
	Inadequate drive prior to pulsed stage	Check crystal current at MP1 (–0·4 to –0·7 volts to ground with multimeter). Check V4 grid current at MP2 (–1·2 to –1·6 volts to ground unit multimeter). If necessary, tune crystal oscillator with C5 and grid current to V4, with L3.
	Low cathode drive voltage on MP3 & MP4 (2 to 2·5 volts positive to ground)	Inspect coupling band between L4 and L5. It should be half way down the coils and the earthing tab should be clamped between the base sleeve and the retaining clip of V5. Check the tuning of L4 and L5 for a peak reading. The voltages between MP3, 4 and ground should be equal to within 0·5 volts. Check V5 or substitute if these readings cannot be obtained when the RF unit is being normally pulse modulated.
	Output stage defective or off tune	Using oscilloscope triggered from '15 c/s' terminal inspect (at low trace speed) video waveform across 1500 ohm resistor on top plate of output stage. Amplitude of signal should be 10 to 15 volts peak. Release clamping screw on output stage tuning slug sufficient only to allow it to be adjusted with large screwdriver or metal plate. A small adjustment of half a turn either way should be all that is necessary to locate the tuning peak on the RF output meter on the front panel.

Table 3 (Continued)

Effect	Possible cause	Remedy
Low RF output but video signal appears normal	Video signal not complete	Check video signal for correct coding and pulse length as described in para. 17.
Correct video signal but no bearing readings	Distortion of amplitude modulation pulse train, due to low mutual conductance of V5.	Check V5 or substitute for another CV1540.
Incorrect bearing readings when video signal is correct	RF unit not tuned up properly	Check drive to V4 (MP1,2) and tuning of L4, L5 and anode coil of V5.

Replacement of valve V5

16. Care should be taken when the valve V5 is removed and replaced in the chassis. Carefully prise off the anode clips of V5 and move the coil leads so that the clips will not catch on the caps when the valve is being lifted clear of the valve-holder. Release the screw which makes the clamp grip the valve, also remove the screws and washers holding the clamp to the mounting pillars. Carefully slide the coupling band off the coils L4 and L5, together with the earthing tab which fits between the base sleeve of V5 and its clamp. V5 can now be lifted from its valveholder. The efficient working of V5 stage depends on very thorough bonding to chassis of all parts shown as grounded on the circuit diagram. When replacing V5, make sure that the base pins are clean and straight and that the valve holder is in good condition. Note that the coupling band looping L4 and L5 should be placed about a third of the way down the coils.

Coding and modulation circuits

17. This section covers the circuits in the modulator unit (except the +150V HT regulator) and the coding circuits on the main chassis. If it is necessary to remove the modulator unit, unsolder the two wires connecting this unit to the RF unit and the main chassis. Remove the 12-way socket and unscrew the 8 red screws which should allow the unit to be lifted out of the mounting unit frame.

18. Lack of drive to the RF unit will be shown by the waveform at the "video output" terminal 4. With 28V input and the "Set RF" control turned right up the mean amplitude of this waveform should be about one volt. If the drive appears to be correct but the ARI will not work on bearing, tone or distance, synchronize the oscilloscope from the anode of V26b (pin 6) and use a fast timebase speed to check that the coding is correct. Pairs of pulses approx. 3·3 µS wide and 12 µS apart should be visible at the video output terminal.

19. If there is no output at the video output terminal check the input to the modulator on the flying lead from the main chassis. This should be the complete pulse train without 15 and 135 c/s modulation at an amplitude of about 100 volts positive. If there is no signal here, check the pulses at the anodes of the priority mixers V14–17. This is the complete pulse train but single pulses only and is a negative signal of 120–270 volts amplitude. This point is the earliest in the circuit at which all the signals are combined. The bearing and distance circuits are covered in para. 20 and 21 respectively. If a fault is suspected in the tone circuit, check V26.

Bearing circuits

20. Faults in these circuits usually fall into three classes and can be checked by examining the waveform at the " video output " terminal 4.

(1) *No marker pulses.* Check the crystal oscillators V27 and 28. There should be 25–50 volts peak to peak at the anodes (pin 2). Check the North and harmonic marker gates at TP6 and 7 (see fig. 9 (b) & (c)) of Chap 2.). If the North marker is missing, the complete signal may still contain 9 marker bursts but these will all be harmonic markers since the blanking gate circuit (V10) will not be working.

(2) *Dividers faulty*, This will probably show up as a jitter in the modulation waveform. If necessary, reset the dividers as described in Chapter 3.

(3) *Phasing faulty.* The 15 and 135 c/s phasing can be reset by referring to Chapter 3. The harmonic markers should appear at the peaks of the 135 c/s waveform and the North marker at the peak of the 15 c/s waveform for a bearing of 270 deg.

Wattmeter and distance circuits

21. Faults affecting the wattmeter and both the distance circuits are likely to be in the circuits associated with V29 to 31. If the wattmeter lights do not change colour and it is known the aircraft set is working, check V20, V21a and RL1 on the main chassis. If the wattmeter circuit functions but no lock on is obtained at 1 or 101 miles, the fault is likely to be in the distance phantastron V22, V23 and V24a, the 120 μS gate generator V24b, V25a or the distance divider V25b, V21b and V33. If the aircraft set locks on at 1 mile but not at 101 miles, first check the alignment of the pip on the gate pulse at TP8 (see fig. 9 (g) chap. 2). This can be adjusted by varying RV9. If the gate pulse is present but there is no pip on it check the pulsed oscillator V32 by examining the waveform at V32b pin 6 (see fig. 9 (b) Chap. 2).

Table 4

VALVES AND THEIR EQUIVALENTS

Ruggedised valve		Normal valve	
CV code	Maker's code	CV code	Maker's code
4003	6067, M8136	491	12AU7, ECC82
4010	5654, M8100	850	6AK5, EF95
4014	6064	138	6AM6, EF91
4024	6060, M8162	455	12AT7, ECC81
4025	6058, M8079	140	6AL5, EB91
4031		858	6J6, ECC91
4038			
4039	6062, M8096	2129	5763
4048	M8098	449	85A2
4055	6132	2127	6CH6
		2659	3D21A
		2209	
		2516	2C39A
		1540	STC 33B/152M
		448	

Notes 1. *The CV329 may be used in place of the CV2209, the only difference being that the 2209 has a higher screen dissipation limit.*

2. *Prototypes X1 to 7 use the E2293 in place of the CV4038, the difference being that the E2293 is a plug in version and the CV4038 has flying leads. The E2293 is sometimes coded A2293.*

3. *A short version of the CV4025, the the CV4007, makers code 5726, can be used if a suitable retainer is available.*

Valve electrode potentials—main chassis

22. The figures in Table 5 are given as a guide to servicing should the unit fail to meet the limits quoted in this specification. The DC test figures were taken with a multimeter. The front panel controls, are set so that the 'Meter Selector' switch is at normal and the 'Range' switch is at 101 miles (except where otherwise stated). The input was 28V.

Table 5

VALVE ELECTRODE POTENTIALS

Test point	Voltage	Range
V1b cathode (pin 8)	2·3V	2·5V DC
V1a cathode (pin 3)	18V	25V DC
V2b anode (pin 6)	58V	100V DC
V2a cathode (pin 3) and V3b cathode (pin 8)	3·6V	10V DC
V4b anode (pin 6)	312V	1000V DC
V5a cathode (pin 3)	7·5V	10V DC
V5b cathode (pin 8)	5·3V	10V DC
V4a anode (pin 1)	260V	1000V DC
V6b cathode (pin 8)	1·9V	2·5V DC
V7b cathode (pin 8)	1·05V	2·5V DC
V7a cathode (pin 3)	1·25V	2·5V DC
V8 cathode (pin 2)	48V	100V DC
V8 suppressor (pin 6)	30V	100V DC
V8 screen (pin 7)	165V	250V DC
V10 anode (pin 5)	305V	1000V DC
V10 grid (pin 1)	–34V	100V DC
V11 anodes (pins 2 and 7)	48V	100V DC
V12 cathode (pin 2)	45V	100V DC
V12 suppressor (pin 6)	32V	100V DC
V12 screen (pin 7)	185V	250V DC
V14, V15, V16 and V17 anodes (pin 5 on all valves)	305V	1000V DC
V14, V15, V16 and V17 screens (pin 7 on all valves)	150V	250V DC
V14 grid (pin 1)	–17·5V	25V DC
V15 grid (pin 1)	–18·5V	25V DC
V16 grid (pin 1)	–18V	25V DC
V17 grid (pin 1)	–18V	25V DC
V18a anode (pin 1)	150V	250V DC
V18b anode (pin 6)	115V	250V DC
V19 cathode (pins 2 and 6)	3·6V	10V DC
V20 screen (pin 7)	90V	250V DC

Table 5 (Continued)

Test point	Voltage	Range
V21a cathode (pin 3) "Meter Selector" switch at Watts and the red light illuminated	65V	100V DC
V22b cathode (pin 5)	230V	1000V DC
V22a cathode (pin 1)	45V	100V DC
V23 screen (pin 7)	155V	250V DC
V23 cathode (pin 2)	48V	100V DC
V24 cathodes (pin 3 and 8)	230V	1000V DC
V24b anode (pin 6)	300V	1000V DC
V25a anode (pin 1)	33V	100V DC
V25b cathode (pin 8)	3·4V	10V DC
V26a anode (pin 1)	200V	250V DC
V26b anode (pin 6)	150V	250V DC
V27 anode (pin 2)	290V	1000V DC
V27 grid (pin 5)	0·75V	2·5V DC
V28 anode (pin 2)	290V	1000V DC
V28 grid (pin 5)	0·75V	2·5V DC
V30 a cathode (pin 3)	4·9V	10V DC
V30b anode (pin 6)	130V	250V DC
V31 anode (pin 5)	305V	1000V DC
V31 suppressor (pin 6)	–14V	25V DC
V32a anode (pin 1)	150V	250V DC
V32b cathode (pin 8) 100 mile position	2·8V	10V DC
V32b cathode (pin 8) — 1 mile position	14V	25V DC
V33a anode (pin 1)	150V	250V DC
V33b anode (pin 6)	51V	100V DC

Removal of sub-units

23. (1) *Bridge unit*. Remove the four red screws and disconnect the 12–way socket.

(2) *Modulator*. Unsolder the two flying leads to the RF unit and the main chassis. Remove the eight red screws and disconnect the 12–way socket.

(3) *RF unit*. This is more easily removed if the modulator is out of the way first. Unscrew the flexible drive shaft and the coaxial connector on the end of the piston attenuator. Disconnect the 8–way socket and the four red screws.

WARNING

Do not disturb the setting of the locking ring on the piston attentuator as the position of this controls the calibration of the RF output, *When replacing the RF unit push the piston attenuator right in and set the attenuator counter to* 070 *before re-connecting the flexible drive shaft.*

Removal of rotary transformer

24. Before this can be done, it is necessary to remove the blower. Disconnect the 8–way plug just above the rotary transformer and proceed in the following order:—

(1) Remove the cowl over the air vent on the front panel (four 6BA screws)

(2) Remove the bridge unit (four 6BA screws)

(3) Remove the plate on the blower housing (five 6BA screws)

(4) Remove the blower impeller; use a box spanner on the centre nut, holding the impeller with the hand.

(5) Remove the blower housing and the baffle on the front panel (ten 6BA screws). It is not necessary to lift the blower housing right out of the test set.

(6) Unscrew the four 2BA screws on each side of the filter box on the front panel and it should now be possible to lift the rotary transformer out of the test set.

When replacing, ensure that the blower impeller is fixed in the right position so that it does not touch the blower housing or the plate on the end of the housing.

Removal of front panel

25. This may be necessary if components have to be replaced behind the panel. All the wires connecting to the main chassis run via the tag strip adjacent to the bridge unit; this allows the panel to be pivoted about the tag strip if the eight 2BA and two 4BA screws at the corners of the panel are removed. It is advisable to make up temporary brackets to hold the panel in the extended position to avoid putting any strain on the connecting wires.

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