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TEST SET TYPE 391

GENERAL AND TECHNICAL INFORMATION

FOR USE IN THE
ROYAL NAVY
ROYAL AIR FORCE

(Prepared by the Ministry of Technology)

TEST SET TYPE 391

CONTENTS

ILLUSTRATIONS

Introduction

1. The test set Type 391 is a test oscillator for carrying out performance checks on ILS airborne receiving equipments at first-line servicing. It is a Service version of the Field Test Set QA.3B manufactured by Standard Telephones and Cables Ltd. for use in civil aviation.

2. It is used to check the operation of localizer, glidepath, and marker receivers of an ILS equipment (ARI.18011) without removing the ARI from the aircraft, and includes provision for checking the aerial systems of all receivers and for independently checking the crossed-pointer ILS indicators. It should be noted that the test set is designed purely for checking receivers and in consequence it cannot be used for setting them up.

3. In its basic application the test set is used to radiate a localizer, or glidepath, or marker-type signal from built-in telescopic aerials. The indications obtained on the ILS equipment which picks up the radiations are similar to those obtained from an ILS ground installation during an approach. Thus the operational effectiveness of an equipment can be investigated while the aircraft is on the ground.

4. In a further application the signals from the test set can be fed direct to the receivers, the aerials being disconnected. This provides a check on the effectiveness of the aerials.

5. The test set operates nominally on a 24V d.c. supply and consumes approximately 85 watts; actual supplies can be between the limits of 22V and 27V. The weight of the test set complete is about 30 lb.

Details of equipment

6. The test set consists of the following items:—

Description	Stores Ref.
Test oscillator Type 9	10S/16397
Attenuator unit Type 29	10L/274
Resistor unit Type 416	10W/18311
Cable reel	10AS/416
carrying:—	
Connector Type 3705	10HA/11432
Connector Type 3706	10HA/11435
Canvas case	10AP/161
Extension rod	10AS/500

7. The main item, test oscillator Type 9, is a completely encased unit of height 13 in., width 11 in., and depth 10·5 in. A door enclosing the front of the unit gives access to the front-panel operating controls, and a flap at the top of the rear cover gives access to a battery-lead compartment; the battery lead is coiled up and stores in this compartment when the test set is not in use. Three rod aerials are included in the oscillator unit; in use they extend horizontally through the rear cover, otherwise they are telescoped to remain completely concealed within the body of the unit. The extension rod is supplied as a clip-on fitting to extend the marker aerial for situations where the normal aerial length is insufficient to provide adequate radiation.

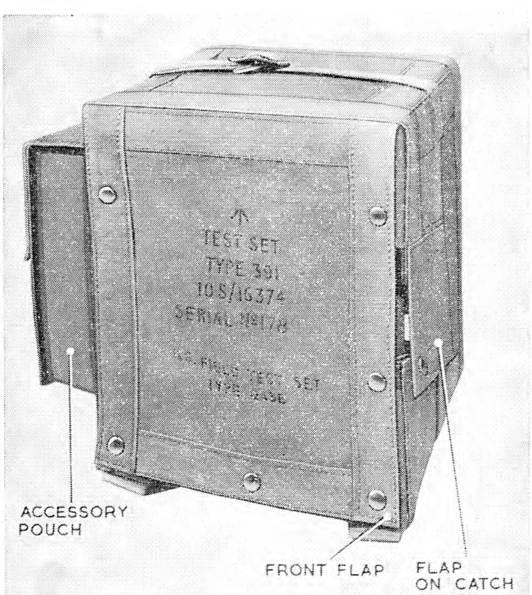

Fig. 1. Test set Type 391

8. For field use the test set is contained within a canvas case (fig. 1). Flaps at the front, rear, and side of the case allow access to the front and rear of the oscillator unit. A small pouch at one side provides storage space for the attenuator unit, resistor unit, cable reel, and extension rod; these accessories, except for the extension rod, are shown in fig. 5. The case is fitted with a webbing strap for use in carrying the complete equipment.

9. Connectors Type 3705 and 3706 are coaxial feeders (Uniradio 43) providing for direct connection between coaxial output points on the oscillator and the aerial input points on the ILS receivers. Connector 3705 is sufficiently long (30 ft.) to permit the oscillator unit to remain outside the aircraft when direct receiver tests (that is eliminating the aerials) are carried out. The attenuator unit Type 29 must be included in the feed from the test oscillator to the receivers to introduce a fixed attenuation in the oscillator output to prevent the receivers being overloaded. Two orders of attenuation are provided; one at 60dB being appropriate for localizer and glidepath receivers, the other at 40dB being for the marker receiver. The connection between the attenuator and the receivers is made through the short connector (3 ft. 6 in.) Type 3706. For convenience in storing the connectors they are supplied wound on a reel.

10. Resistor unit Type 416 consists of a battery and two resistors mounted on a 20-pole plug of the type fitted at the rear of the ILS receivers R.1964, R.1965. It is used for checking the circuits from the junction boxes through the interconnections to the indicators.

Principles of operation

11. Four types of signal are handled by the ILS receivers; their basic features and their functions in the ILS system are as follows:—

(1) *Marker:*—75 MHz carrier modulated at 400 Hz, 1,300 Hz or 3,000 Hz: operates marker lamp connected to ILS receiving equipment.

(2) *Glidepath:*—carrier at 300 kHz—spaced spot frequencies in range from 329·3 MHz to 335 MHz, carrying combined 90 Hz and 150 Hz modulation; operates horizontal pointer and flag on ILS crossed-pointer indicator: deflection of pointer depends on relative levels of two modulation tones (at equal levels of 90 Hz and 150 Hz deflection is zero).

(3) *Localizer:*—carrier at 100 kHz—spaced spot frequencies in range from 108·1 MHz to 111·9 MHz with combined 90 Hz and 150 Hz audio modulation: operates vertical pointer and flag on ILS crossed-pointer indicator: deflection of pointer depends on relative levels of the two modulation tones (at equal levels deflection is zero).

(4) *Localizer audio:*—carrier as for (3) but with keyed audio modulation at 1,000 Hz for station identification, or voice modulation for emergency communication: hear over pilot's

telephones. This signal is actually radiated as a separate modulation of the carrier of (3) but the modulations are handled separately in the outputs of the ILS localizer receiver.

Function switch

12. Signals simulating the four ILS transmissions are produced in the test set under the control of the main function switch situated at the right-hand centre of the front panel. The basic functioning of the test set under the four conditions set by the switch are illustrated in fig. 2.

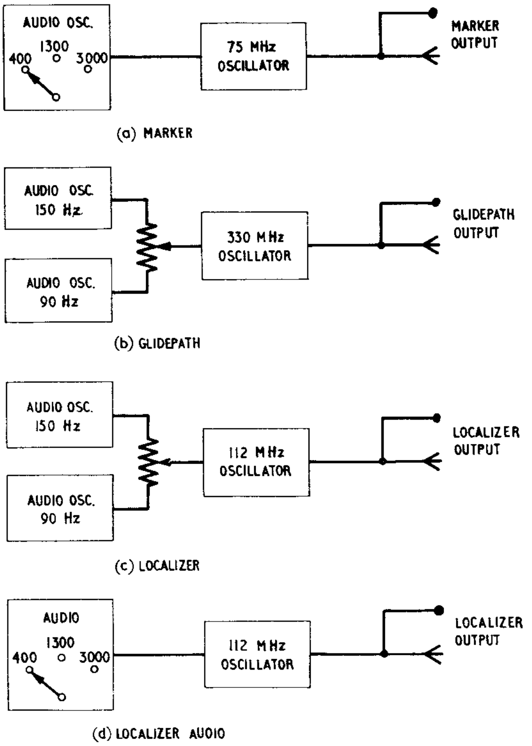

Fig. 2. Main functions of test set

13. With the switch in the MARKER position, the circuit function is as shown in (a) of fig. 2. The switch at the centre (top) of the front panel (FREQ. MOD. CPS.) provides selection of a 400 Hz, 1,300 Hz or 3,000 Hz signal from modulation of the 75 MHz oscillator. The modulation depth is approximately 60 per cent. The r.f. output is available at a coaxial socket at the rear of the set and also the output is applied to the MARKER aerial. This aerial is telescopic and an extension rod is provided to increase the field strength if necessary.

14. With the switch in the GLIDEPATH position, the circuit function is as shown in (b) of fig. 2. Separate 90 Hz and 150 Hz oscillators provide combined (ILS) modulation of an r.f. oscillator operating in the glidepath band. The relative levels of the two modulation tones may be set by adjustment of the DEFLECTION CONTROL which is situated centrally at the bottom of the front panel. The ratio between the levels of the tones may be set (by the DEFLECTION CONTROL) in the range of plus 5dB to minus 5dB. The depth of modulation (of the tone combination) is constant throughout the range at a level of 80 per cent. The r.f. output is available at a coaxial socket at the rear of the test set and also the output is applied to the GLIDEPATH aerial. This aerial is telescopic for adjustment of field strength.

15. With the switch in the LOC (localizer) position circuit function is as shown in (c) of fig. 2. Modulation control is as with the glidepath circuit (para. 14) but the modulation depth of the combined signal is 40 per cent with the localizer circuit. The r.f. output is available at a coaxial socket at the rear of the set, also the r.f. is applied to the LOCALIZER aerial. This aerial is telescopic for adjustment of field strength.

16. With the switch in the LOC AUDIO position the circuit function is as shown in (d) of fig. 2. The modulation switch (FREQ. MOD. CP/S.) provides selection of a 400 Hz, 1,300 Hz or 3,000 Hz tone for modulation of the localizer carrier. The modulation depth is 30 per cent. The r.f. output is available at the localizer coaxial socket and also from the localizer aerial as for the localizer ILS signal (para. 15). The LOC AUDIO signal is provided for test of the airborne receiver audio circuits.

17. The relative levels of the 150 Hz and 90 Hz ILS modulation tones are indicated on the meter on the front panel of the test set. When the two tone levels are equal, the meter indicates centre zero. For conditions of unbalance the meter deflect to the left or right indicating which tone has the greater level. The meter scale is calibrated in microamps; the particular meter reading at which "three dots" deflection of an ILS airborne indicator should be produced is marked on a label fitted to the inside of the test set front cover.

Note . . .

The circle on the airborne ILS indicator is considered as the "first" dot.

Tuning controls

18. A tuning selector switch at the centre of the front panel provides selection of three tuning arrangements for the r.f. circuits. In the clockwise position (XTAL), the three r.f. carriers (marker, glidepath and localizer) are crystal controlled, the output frequencies being predetermined. The marker frequency must be 75 MHz but the glidepath and localizer frequencies may be of any convenient channel frequency. With this arrangement one crystal-controlled frequency is available for each ILS function; for any other frequency a different crystal must be fitted.

19. With the tuning selector set to MANUAL, the frequency of all three r.f. carriers is manually controlled. The MANUAL tuning control is situated to the left of the front panel (fig. 3). No calibrated frequency scale is provided but the range of control is sufficient to cover the complete localizer and

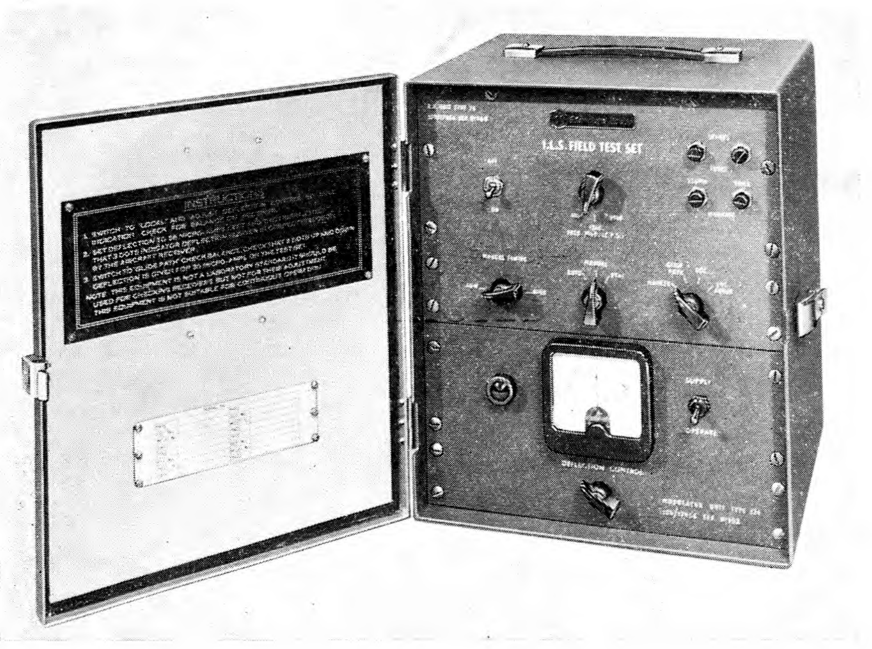

Fig. 3. Front panel

glidepath bands. With the MANUAL TUNING control turned counter-clockwise, the frequencies generated are at the low frequency extremes of the bands; high frequency signals are generated with the control turned to a clockwise position. The manual tuning circuit is subject to tuning drift and, because mistuning can produce misleading results, manual control should be used only when no (test set) crystal is available for the channel under test.

20. With the tuning selector switch set to AUTO and the function selector switch set to GLIDEPATH, the localizer and glidepath r.f. carriers are repetitively frequency-swept throughout the ILS bands (108 MHz to 112 MHz and 329 MHz to 335 MHz). The sweep frequency is 150 Hz and the waveform of the sweep signal is sawtooth. When a carrier sweeps past an ILS channel to which a receiver is tuned, a pulse appears at the detector output, the return sweep is at a different rate (because the sweep waveform is sawtooth) and hence a pulse of different duration is produced by the detector. The pulses of longer duration are predominant in producing an output which thus has a tone frequency component of 150 Hz. With this arrangement, the test signal produces a tone output at 150 Hz whatever channel is selected on the receiver control unit. The test produces ILS indicator deflections corresponding to those produced in an aircraft flying an ILS approach but in the 150 Hz predominant sector (i.e., "up" on glidepath and "left" on localizer).

21. Three tuning conditions are provided for checking ILS receivers on all ILS channels (39 localizer and 20 glidepath) without the need for including in the test set crystals for all these channels. Thus if an ILS installation is tested on any one channel of each of the localizer and glidepath bands using the crystal controlled channels of the test set, a complete check of the main receiver, filter and indicator circuits is made. It is then only necessary to check in a general way that operation on remaining channels is possible. This general check is made using the AUTO facility of the test set.

22. The test oscillator is fitted with crystals for operating on ILS channel No. 7 (localizer 108·7 MHz, glidepath 330·5 MHz), because this is a channel normally allocated to master diversion airfields and all ILS receivers are fitted for its reception. On an airfield operating on channel No. 7 however, the test set cannot conveniently be used on this channel. For this reason, a spare set of crystals is included for operation of ILS channel No. 17 (localizer 109·7 MHz, glidepath 333·2 MHz). The ILS channel No. 7 is known as the test set channel No. 1 and the necessary crystals are localizer, 9·0583 MHz, glidepath 9·18056 MHz. The alternative channel is known as the test set channel No. 2 and the crystal frequencies are localizer 9·1416 MHz and glidepath 9·2555 MHz. To change the channel of the test set it is necessary to dismantle the test set and interpose the active and spare crystals.

23. If neither set of test set crystals satisfies the test requirement the test may be conducted using the MANUAL TUNING facility. Inherent difficulties in the operation of the manual tuning control necessitate the exercise of great care and, in general, the manual tuning should be used only in an emergency.

Note . . .

Marker operation is always at a frequency of 75 MHz and only one crystal is necessary for this test. The frequency of the marker crystal is 18·75 MHz.

Power switching

24. The input power switch is situated at the top (right-hand side) of the front panel. With this switch in the ON position, power is applied to both h.t. and l.t. circuits. A 250mA fuse protects the main h.t. line and a 50mA fuse protects a subsidiary h.t. circuit. Spares for both fuses are provided on the front panel. A red lamp on the lower half of the front panel indicates when the supply is ON. The power input cable of the test set is two core, the red wire being for supply positive and the black wire for supply negative. No plug is supplied for connection to the source. The cable is directly wired in to the test set, being cleated to the wall of the battery lead compartment. For normal use a Niphan plug would be fitted to the free end of the power cable; to accomodate this plug in the battery lead compartment of the test set for stowage, a slot would be cut in the case (Mod. No. 4634). When other terminations are used it is essential that the polarity of connection be checked before switching on. If the set is switched on with the wrong polarity, the 50mA fuse will blow.

25. The deflection meter on the front panel of the test set may be used to indicate the polarity and potential of the supply. A switch situated to the right of the meter is normally in the OPERATE position for reading relative modulation levels (para. 17). A non-locking position of this switch connects the meter to read the input voltage. In this position (SUPPLY), the meter has a full scale deflection (from centre) of 30V and a red sector on the right-hand side of the scale indicates the limits within which the input voltage must fall.

Operating instructions

26. To prepare the test set for use in a field test of a complete ILS receiving equipment:—

(1) Unclip the front side and rear flaps of the canvas cover.

(2) Clip the rear cover to the studs provided at the top of the canvas cover.

(3) Open the flap at the top-rear of the test set and remove the battery lead.

(4) Check that the ON/OFF switch is in the OFF position.

(5) Connect the lead to a 28V d.c. supply (ensuring correct polarity).

(6) Open the door at the front of the test set for access to the controls. (The door is held by a self-locking catch at the right-hand side; a stud on this catch must be drawn towards the front of the test set before the catch will release).

(7) Set the power switch to ON.

(8) Press the SUPPLY-OPERATE switch to the SUPPLY position and check that the test set meter reads within the red marking at the right-hand end of the scale.

(9) Switch on the ILS receiving equipment and allow a short warming-up period.

27. To check operation of the localizer receiver on one channel completely:—

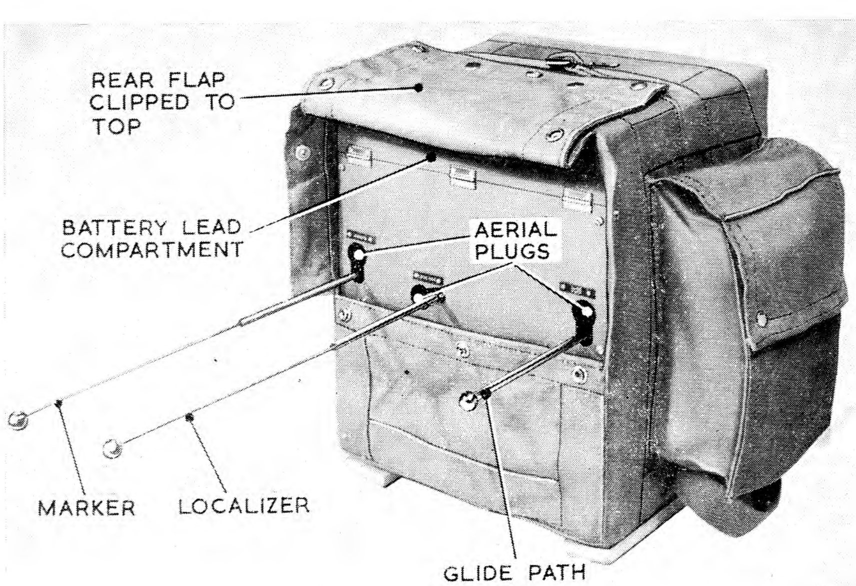

Fig. 4. Test set with aerials extended

(1) Position the test set near the aircraft localizer aerial.

(2) Turn function switch on test set to LOCAL and tuning switch to XTAL.

(3) Extend the localizer aerial (centre of three rods terminating in knobs situated across the width of the test set at the rear).

(4) Set the channel selection switch of the ILS control unit to that channel corresponding to the working frequency of the crystal-controlled localizer channel of the test set.

(5) Adjust the deflection control on the test set for a centre-zero reading of the deflection meter.

(6) Check that the localizer pointer of the ILS indicator is "on course" (undeflected from the centre) and that the localizer flag is not visible.

(7) Refer to the label on the inside front cover of the test set and note the meter deflection required for a three-dot deflection of the localizer pointer.

(8) Set the deflection control for a left deflection of the meter to the reading given on the label.

(9) Check that the localizer pointer reads three dots to the left.

(10) Set the deflection control for a right deflection of the meter to the reading given on the label.

(11) Check that the localizer pointer reads three dots to the right.

(12) Turn test set function switch to LOCAL AUDIO and the modulation switch to 1,300.

(13) Check that a 1,300 Hz note is heard in the pilot's telephones.

(14) Check also that the localizer pointer returns to its centre-zero position and the localizer flag becomes visible.

(15) Return the localizer aerial to its non-extended position.

28. To check completely the operation of the glidepath receiver on one channel:—

(1) Place the test set near the glidepath aerial.

(2) Extend the glidepath aerial (rod at right-hand side of rear of test set: only about half the length of the localizer aerial).

(3) Set the test set function to GLIDEPATH.

(4) Set the channel selector switch on the ILS control unit to that channel corresponding to the working frequency of the crystal-controlled glidepath channel of the test set if it differs from para. 27 (4).

(5) Adjust the test set deflection control for a centre-zero reading of the deflection meter.

(6) Check that the glidepath pointer of the ILS indicator reads "on course" (undeflected from centre) and that the glidepath flag is not visible.

(7) Refer to the label on the test set front cover and note the meter deflection required for a three-dot deflection of the glidepath pointer.

(8) Set the deflection control for a left deflection of the meter to the reading given on the label.

(9) Check that the glidepath pointer reads three dots upwards.

(10) Set the deflection control for a right deflection of the meter to the reading of the label.

(11) Check that the glidepath pointer reads three dots downwards.

(12) Switch the test set power switch off for a few seconds and then on again. Note that the glidepath pointer returns to the centre-zero position and the glidepath flag becomes visible.

29. Check the general operation on all remaining localizer and glidepath channels as follows:—

(1) Extend the localizer aerial so that both localizer and glidepath aerials are out.

(2) Position the test set centrally between the aircraft glidepath and localizer aerials.

(3) Leave the function switch in the glidepath position and set the tuning switch to AUTO.

(4) Turn the ILS channel selector switch, in turn, to each channel for which crystals are fitted. (Note the ILS control unit has provision for 24 crystals, 12 glidepath, 12 localizer, but the full complement will not necessarily be fitted).

(5) Check that in each position the localizer pointer reads at least two dots to the left and the glidepath pointer reads at least two dots upwards. The readings need not be the same on all channels.

(6) Return both glidepath and localizer aerials to their non-extended positions.

30. Check operation of the marker receiver, as follows:—

(1) Position the test set close to the aircraft marker aerial.

(2) Extend the test set marker aerial (longest aerial at left-hand rear of test set); if the aircraft marker aerial is more than about 12 ft. from the test set, clip the extension rod to the end of the test set aerial.

(3) Set test set function switch to MARKER, tuning switch to XTAL, and modulation switch to 400.

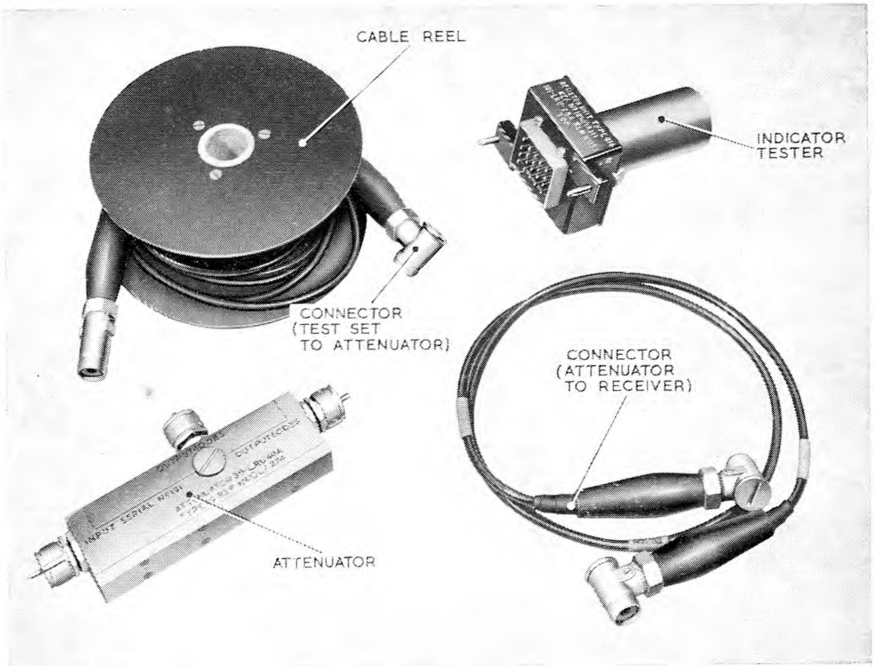

Fig. 5. Accessories

(4) Check that ILS marker lamp in the aircraft is alight and that a 400 Hz note is heard in the pilot's telephones.

(5) Turn modulation switch to 1,300 and check that lamp remains alight and that note changes to 1,300 Hz.

(6) Turn modulation switch to 3,000 and check that lamp remains alight but note changes to 3,000 Hz.

(7) Switch the test set on and off two or three times and note that the marker lamp goes out each time the test set is switched off.

31. Revert the test set to its non-operational state as follows:—

(1) Switch off the test set, and also the aircraft equipment.

(2) Disconnect power lead and coil-up into compartment at top rear of test set. Close flap over compartment.

(3) Return marker aerial to its non-operational position and check that localizer and glidepath aerials are not projecting.

(4) Close front cover of test set.

(5) Pull down and secure front and rear flaps of the canvas cover and secure the side flap.

32. If a control unit is not fitted to operate on either of the test set crystal-controlled channels suitable crystals should be obtained and fitted so that the checks can be carried out as stated. If suitable crystals are not available, manual tuning of the test set will be necessary and should be carried out as follows:—

(1) Set the ILS channel selector to any working channel.

(2) Set the test set tuning switch to MANUAL.

(3) Set the test set function switch to GLIDEPATH or LOCALIZER as appropriate and extend the appropriate aerial.

(4) Adjust the test set deflection control for a three-quarter scale deflection on the meter.

(5) Adjust the MANUAL TUNING control on the test set for maximum deflection of appropriate needle of the ILS indicator.

Note . . .

False peaks in the pointer deflection will be noted as the control is tuned and some difficulty might be experienced in assessing the correct tuning point. A safeguard in finding this point is that it will always be associated with the greatest deflection of the flag.

33. If on carrying out any one of the tests, unsatisfactory results are obtained, a check that the particular aerial system is not responsible can be carried out using the connectors and attenuator unit supplied in the test set as follows:—

(1) Remove the connector reel and attenuator from the puch at the side of the test set canvas cover.

(2) Remove the connectors from the reel and connect the long connector between the appropriate output socket on the rear of the test set and the input point on the attenuator.

(3) Connect the short lead between the output point on the attenuator (60dB for localizer and glidepath or 40dB for marker testing) and the aerial input point on the appropriate receiver.

(4) Check the unsatisfactory channel by repeating the appropriate tests of para. 26 to 29.

A satisfactory result to the tests will show that the aerial system is defective; a continuing unsatisfactory result will show that the defect lies somewhere in the equipment.

34. A check that the indicator is not a cause of unserviceability is given by using the resistor unit Type 416. This is used independently of the test set

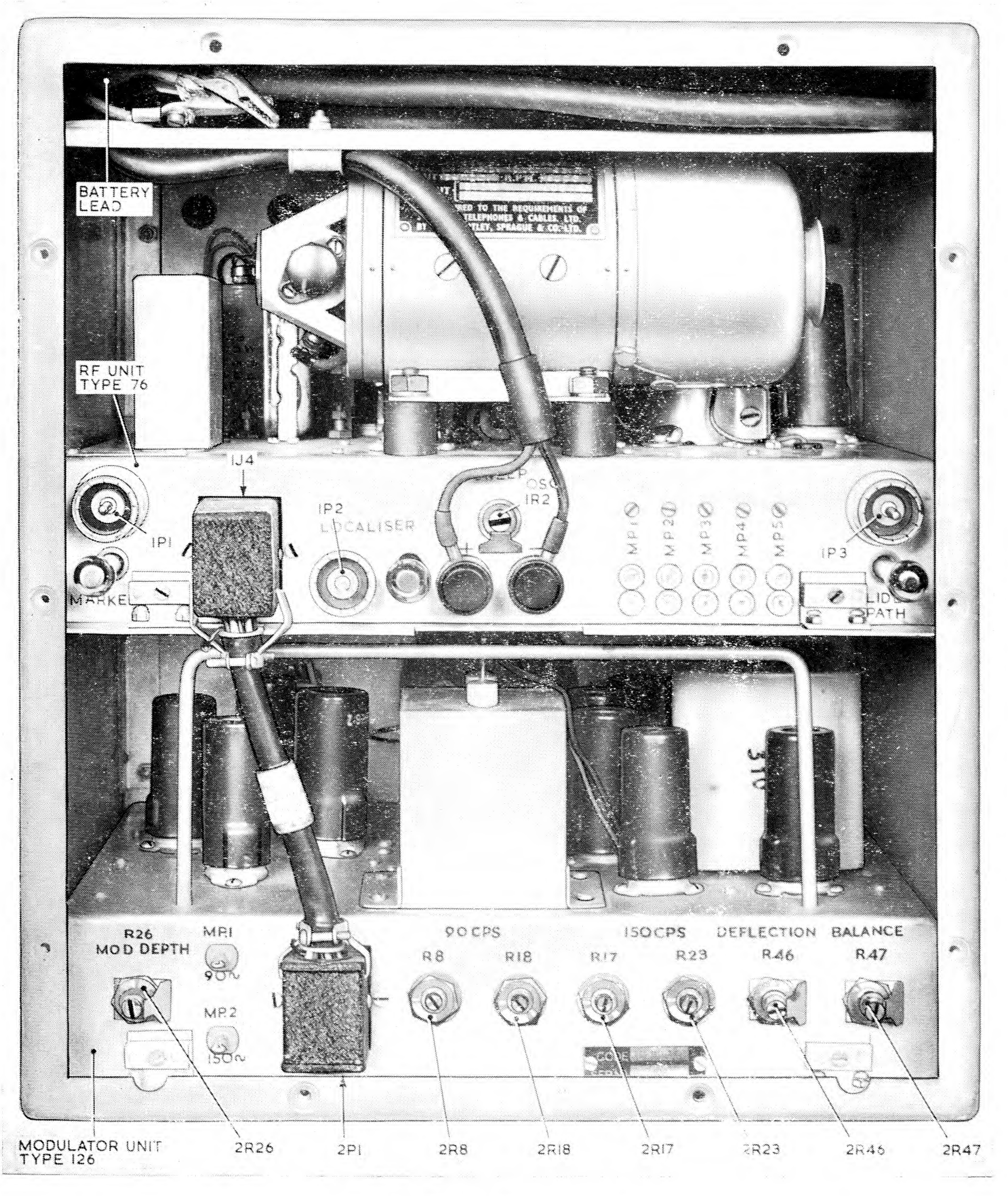

Fig. 6. Test oscillator: rear view

and with the ILS equipment switched off. The procedure is:—

(1) Remove the receiver R.1964 from its rack if the localizer pointer or flag are inoperative or the receiver R.1965 if the glidepath pointer or flag are inoperative.

(2) Fit the resistor unit to the socket on the junction box at the back of the empty rack and clip it firmly in position by means of the wing-end fasteners provided.

(3) Check that the appropriate pointer and flag show deflections.

A faulty indicator, or wiring through the junction box to the indicator, is indicated if the pointer and flag do not show deflections.

Changing crystals

35. Crystals are fitted on the top deck of the upper chassis of the test oscillator unit. The three operational crystals are found in a socket strip fitted behind the front panel near the centre of the unit and spare crystals are in a similar panel at the left-hand side. For access to the crystals to permit changing:—

(1) Remove six red-painted screws from the upper front panel.

(2) Remove the rear cover.

(3) Remove two red-painted screws from the rear flange of the upper chassis.

(4) Disconnect the spade connections of the battery lead.

(5) Detach the Jones connector from the upper chassis.

(6) Remove the upper chassis through the front of the unit.

TEST OSCILLATOR TYPE 9

36. The main unit of the test set Type 391 is the test oscillator Type 9 (10S/16397). It is made up of the following separate items:—

Description	Stores Ref.
Modulator unit Type 126	10D/17855
R.F. unit Type 76	10D/17854
Connector Type 3704	10HA/11431

37. Fig. 6 shows the rear view of the test oscillator with the rear cover removed. The modulator unit is a sub-chassis occupying the lower part of the interior and the r.f. unit is an assembly, of similar size, fitted above the modulator. A small compartment at the very top of the interior provides a stowage space for the power supply lead.

38. Details of the modulator unit can be seen in fig. 15 and 17 and its circuit appears in fig. 21. It will be noted that components in the unit are referenced in the normal way from one (C1, R1, etc.) and many of them are marked with these references on the actual equipment. The components in the r.f. unit are also numbered in the same sequences and so to prevent confusion in this publication, components of the modulator are given a "2" prefix (2C1, 2R1, etc.) and components of the r.f. unit are given a "1" prefix.

39. Details of the r.f. unit can be seen in fig. 8 and 10, and its circuit diagram appears in fig. 20. It will be seen that the r.f. unit carries not only the r.f. stages of the equipment, but also the main h.t. power unit, a rotary transformer (Type 263, 10K/17045).

40. Although the two sub-assemblies are described as r.f. and modulator units, their functions are not completely indicated by these titles, and in fact, certain modulator components are contained, for convenience, on the r.f. chassis, and, as previously stated, the same chassis also includes a major element of the power supplies. In the following technical descriptions therefore the circuits of the two units are treated as one, and no special mention is made to indicate which unit is being considered; the necessary information, however, is automatically provided by the pre-fixes to the references of the components under discussion.

41. The connector is a short length of multi-core cable terminating in a 12-pole Jones plug at one end and a 12-pole Jones socket at the other. The plug-end fits a complementary socket on the upper r.f. unit, and the socket mates with a plug on the modulator unit.

Outline of circuit

42. Fig. 7 shows the circuit of the complete test oscillator in block form. The heart of the circuit is a master oscillator-doubler (1V3) operating at frequencies under the control of the tuning switch S2 and the function switch S1.

43. In the CRYSTAL position of S2 any one of three crystals can be selected by S1 to give signals which after frequency multiplication produce carriers at marker, glidepath, or localizer frequencies. In the M position of S1 a marker crystal (18·75 MHz) is selected; the output of the master oscillator at double the crystal frequency is then doubled again in a separate stage (1V4a) to produce a marker output at 75 MHz).

44. In the GP position of S1 the glidepath crystal is selected. The crystal frequency is 1/36th the frequency of the required glidepath channel; normally about 9·2 MHz. The master oscillator circuit provides a 2 times frequency multiplication of this signal, and is followed by a separate doubler stage (1V5a) and two trebler stages (1V6a, 1V6b). The final output is thus in the glidepath range about 330 MHz.

45. On L or LA of S1 a localizer crystal is selected at 1/12th the frequency of the required localizer

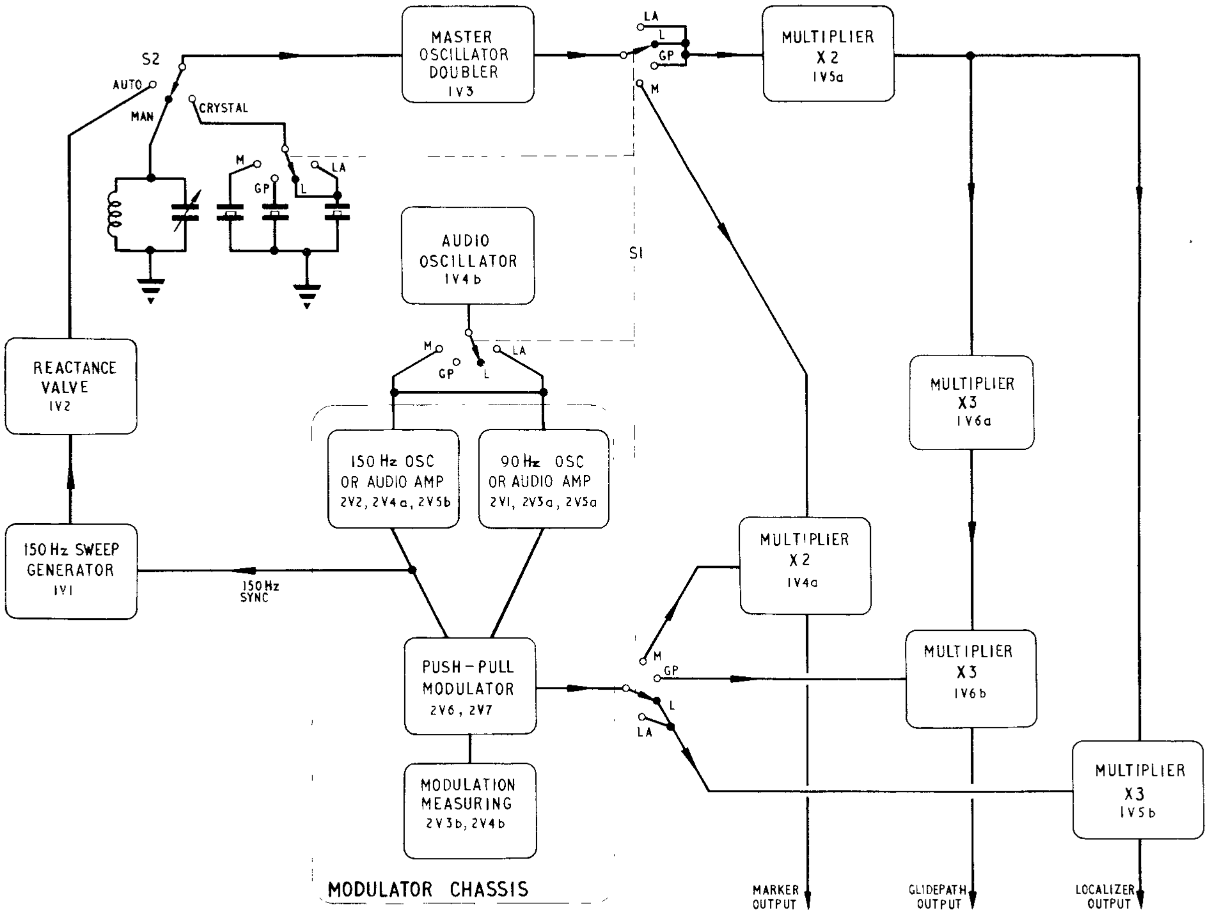

Fig. 7. Block diagram

channel; normally also about 9·2 MHz. The stages used by the glidepath circuit (the master oscillator and 1V5a) are then used to frequency-multiply this signal, and a further, separate, X3 stage (1V5b) provides the final localizer output at about 110 MHz.

46. In the MANUAL position of S2 a manually-controlled tuned circuit provides the frequency-determining element of the master oscillator. This tuned circuit covers a range about 9·2 MHz and the oscillator output after multiplication is in the range covered on localizer and glidepath crystal operation. In the GP, L, and LA position of S1, therefore, the actual carriers may be set to any frequency in the glidepath or localizer ranges.

47. In the AUTO position of S2 the frequency of the master oscillator is controlled to swing automatically over the approximate frequency range covered by the manual control at a controlled rate of 150 sweeps per second. A reactance-valve (1V2) driven by a sawtooth sweep generator (1V1) provides the necessary control.

48. Modulation for the final stages of whichever channel is selected by S1, is provided from a push-pull circuit (2V6, 2V7) whose input is derived from one of two sources also controlled by S1. In the GP or L positions two separate oscillators produce signals at 90 Hz and 150 Hz, and these are mixed in the modulation stage to provide typical ILS-type modulations on the glidepath or localizer carriers. The 150 Hz signal is also fed to the reactance-valve selection of the master oscillator circuit, to synchronize the 150 Hz sweep.

49. In the M and LA positions of the function switch, the circuits which otherwise produce the 150 Hz and 90 Hz signals act as amplifiers for the output of an audio oscillator whose frequency may be set to 400 Hz, 1,300 Hz or 3,000 Hz. The marker and localizer audio channels are thus provided with simple audio modulation at any of these three frequencies.

50. A further circuit in the modulator stages (2V3b, 2V4b) provides for measuring the relative levels of 150 Hz and 90 Hz signals applied to the carriers. The DDMs (difference in depth of modulation) shown by the meter indicator of this circuit permits direct checks of the operation of the ILS receivers and indicators.

Master oscillator

51. From the circuit of the r.f. unit (fig. 20) the master oscillator 1V3 is seen to be a pentode valve whose grid circuit is switched by 1S2A and whose cathode circuit is switched by 1S2B. In all three positions of 1S2 the valve operates as an electron coupled oscillator, with the screen grid acting as effective anode for the oscillatory circuit, and the anode load being tuned to produce frequency multiplication in the output. In position 3 of the switch, however, the oscillator is crystal controlled, in position 2 it is manually tuned in a Hartley circuit, and in position 1 it is automatically tuned over a carrying frequency range through a further Hartley circuit.

Crystal operation

52. For crystal operation the grid is taken to any one of three crystals through a further switch (1S1A), and the cathode is taken to a tap on a capacitive potential divider (1C11, 1C12) connected across the chosen crystal: the circuit therefore operates as a Colpitts-type oscillator with the crystal replacing the tuned circuit. A resistor (1R10) across 1C12 provides a d.c. return to negative h.t. for the cathode of the valve.

53. Position 1 of 1S1A selects a crystal, in socket X1, cut for one quarter the frequency of the marker channel, or 18·75 MHz. In this same switch position 1S1B in the anode circuit selects the anode load to be 1LS, which is preset-tuned by the circuit

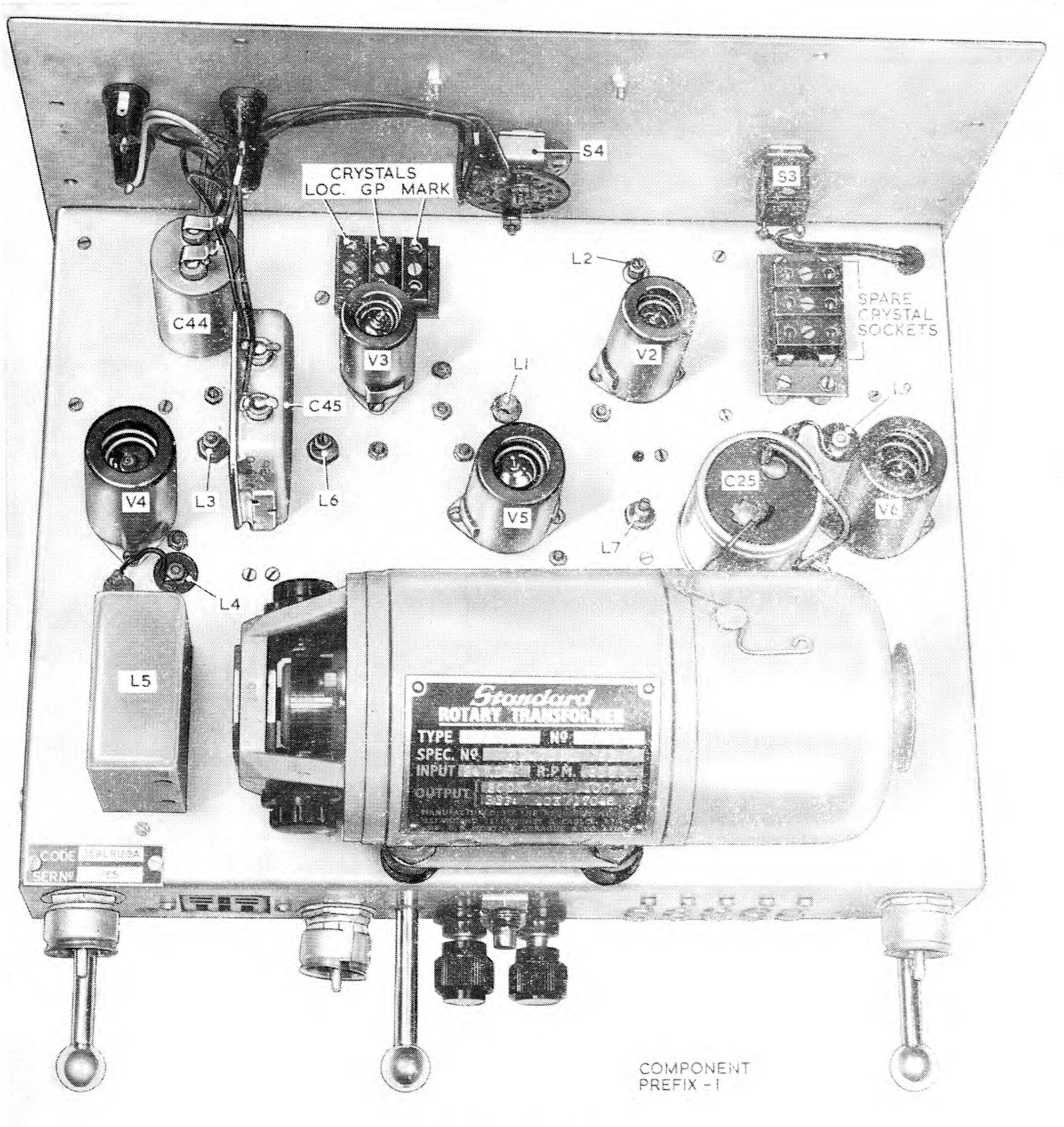

Fig. 8. R.F. chassis

stray capacitances and an adjustable core to twice the crystal frequency, 37·5 MHz.

54. In position 2 of 1S1A the crystal in socket X2 is selected. This crystal operates at one thirty-sixth of the frequency of glidepath channel No. 7 at 9·1805 MHz. The anode switch 1S1B then selects a second circuit 1L6 which is preset to a frequency of 18·33 MHz and is flatly tuned to accommodate the doubled frequencies in the range around this frequency, should other crystals be used.

55. Positions 3 and 4 of 1S1A select a third crystal in socket X3. This crystal operates at one-twelfth the frequency of No. 7 localizer channel at 9·0583 MHz. In these positions 1S1B continues to select 1L6 which tunes to the second harmonic and as before covers a range around this frequency, should other crystals be used.

Manual operation

56. For manual tuning of the master oscillator a tuned circuit consisting of 1L2, 1C2, 1C9, 1C10 is substituted for the crystal circuit. One end of the tuned circuit is earthed and the cathode is taken to a tap on the coil to produce a straightforward Hartley oscillator. The range of the tuning capacitor 1C10 (MANUAL TUNING) is limited by 1C9 to produce a frequency range from 9·0 MHz to 9·33 MHz.

57. The output of the master oscillator on manual is therefore in the range from 18·0 MHz to 18·66 MHz in the glidepath and localizer position of 1S1; that is, it covers the full range possible with glidepath and localizer crystals. The oscillator output is not highly stable, but when properly adjusted is adequate to allow general checks on channels not covered by the crystals.

58. Manual tuning is not intended to cover marker operation in position 1 of 1S1, although a manually controlled marker output is produced. The marker tuned circuit (1L3) has however to select the fourth harmonic of the oscillator frequency so that the final output is very small.

Automatic operation

59. The important features of the master oscillator circuit together with its control circuit for automatic sweeping is shown in fig. 9. In this circuit 1V1 (CV243) is a sawtooth generator synchronized from a 150 Hz sine wave on its cathode. The circuit is a simple type of relaxation oscillator in which 1C3 and 1C4 in series charge through 1R2 and 1R3. When the potential across the valve reaches the firing level of 85V the valve conducts and discharges the capacitors until the potential falls below extinction level, about 55V; conduction then ceases and the charging action repeats.

60. The time taken in the charging cycle is adjusted by means of preset 1R2 to be about 7 milliseconds, so that in normal operation actual firing is initiated by the negative peaks of the 150 Hz sawtooth, rising from a potential of about 55V to about 85V appears at the anode of 1V1; because the period of the saw-tooth is small compared with the time-constant of the charging circuit, the rising sweep is fairly linear.

61. The output of the oscillator is taken from across one half of the charging capacitance (1C4) so that the actual output is a sawtooth rising from a positive potential of 27V to 42V approximately. This sweep provides an input to the grid of the reactance modulator valve (1V2 CV131); a positive bias of about 6V is taken to the cathode of the valve from the heater circuit of 1V5. Ostensibly

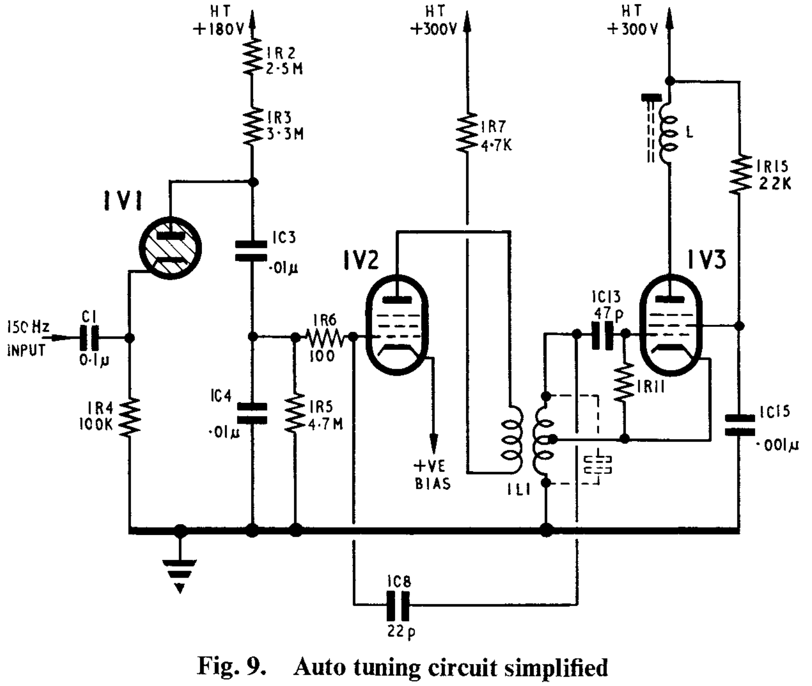

Fig. 9. Auto tuning circuit simplified

therefore the grid-cathode input is a positive sweep of from 21V to 36V, but because of the flow of grid current a standing negative bias is developed across the grid leak 1R5 which biases the valve back until practically the whole of the sweep takes place across the negative portion of the grid-base, and only a small part of the sweep, sufficient to produce the necessary flow of grid current, drives positively.

62. The valve, which has a variable-mu characteristic, is therefore subjected to a variation in its bias level such that the effective gain of the valve is varied from almost zero at the start of each sweep to maximum at the peak, the process repeating 150 times per second.

63. The tuned circuit of the master oscillator on automatic operation consists of the secondary of 1L1 together with circuit capacitances and reactance introduced from the modulator 1V2. The main circuit capacitance, 1C8, is effectively across the coil via the low resistance of 1R6 and the low reactance of 1C4. The cathode of 1V3 is taken to a tap on the coil to produce the required Hartley coupling conditions.

64. To follow the effect on the tuned circuit of the reactance modulator it is necessary to consider the phase relationship in the oscillator tuned circuit. For convenience the current in this circuit is taken as the reference vector, and as this current flows in a circuit consisting essentially of 1L1, 1C8, 1R6 in series (1C4 can be ignored), the potential across 1R6 is in phase with the current. This potential then provides an r.f. input to the grid of 1V2 and produces a corresponding in-phase anode current of amplitude dependent at any time on the level of the 150 Hz sawtooth seep.

65. The anode load of 1V2 is the tightly-coupled primary of 1L1, and the flow of anode current therefore induces a potential in the secondary that is into the tuned winding. From normal transformer theory this potential is considered to be introduced in series with the secondary and to be either 90 deg. leading or lagging the primary current according to the manner of connection of the winding. In fact the potential is lagging by 90 deg. and is therefore lagging by 90 deg. on the current in the tuned circuit so that the induced potential is equivalent to that produced by the introduction of the capacitance in series with the secondary winding.

66. When therefore the gain of 1V2 is low, at the negative peak of the sawtooth on the grid, very little potential is fed into the tuned circuit and the frequency of oscillation is practically the natural frequency of the inductive and capacitive elements of the circuit. At the positive peak of the sawtooth the large potential fed into the tuned circuit is equivalent to the introduction of a series capacitance of large reactance (small value) and the frequency of oscillation is considerably increased. The complete sweep therefore has the effect of introducing a decreasing series capacitance as the sweep rises so that the frequency of oscillation is swept from a low to a high value in synchronism with the sawtooth.

67. The approximate frequency range covered by the sweep oscillator is from 8·95 MHz to 9·35 MHz and, because of the 150 Hz sweep rate, at any frequency within this range the actual output is a complex signal including modulation components at 150 Hz. Thus on automatic operation an ILS receiving equipment set for any channel will receive a signal giving a deflection on the indicator in the 150 Hz direction, that is "up" on glidepath and left on localizer.

68. In actual use of the test set for automatic sweeping it is found that indicator deflections are greater on high and low-frequency than on middle-frequency channels. This is due to non-linearity in the characteristics of the reactance modulator 1V2 whose gain is swept more slowly at the ends of each sawtooth input than in the middle. The low and high-frequency ends of the tuning range are thus swept more slowly and therefore produce more energy than the middle frequencies.

69. The frequency range covered by automatic sweeping of the oscillator covers the range produced on manual operation and after frequency doubling in the master oscillator anode circuit is in the appropriate range to provide inputs to the localizer and glidepath multiplier stages. Automatic operation is not intended to be used on the marker range.

Marker multiplier

70. For marker operation the function switch 1S1 is set to position 1 and the tuning switch 1S2 is set to position 3 (Crystal). Section A of 1S1 then selects the 18·75 MHz marker crystal and section B selects the doubler tuned circuit 1L3 (tuned by stray capacitance) at the anode of 1V3. The doubled signal at 37·5 MHz in the anode circuit is then fed to the grid of a further doubler stage 1V4a (CV455).

71. No standing bias is applied to 1V4a and the drive of about 20V and 1V3 produces a flow of grid current which biases the grid back to the non-linear working point required for frequency multiplication. The primary of 1L1 in the anode circuit is tuned by 1C17 to 75 MHz and an output is taken from the secondary to the marker coaxial output plug 1P1, and the marker telescopic rod aerial.

72. H.T. for 1V4a anode is provided via 1S1C. In the number 1 (marker) position this switch connects the anode circuit to one side of the modulation output transformer, and 1S1D supplies 90V h.t. to the other side of the transformer. Sections F and G of 1S1 select the modulation to be from the audio oscillator 1V4b.

Localizer multiplier

73. In positions 3 and 4 of 1S1, localizer operation is selected, and a second harmonic of the master oscillator frequency (crystal, manual, or auto) in the range centred on 18·33 MHz is selected by 1L6. This signal is then fed to the grid of a doubler 1V5a where stray-capacitance tuned 1L7 in the anode circuit selects a second harmonic about the centre frequency of 36·66 MHz.

74. From the anode of 1V5a a feed is taken to the grid of 1V5b through 1C32. This valve operates as a trebler, with the primary of 1L8 in the anode circuit, tuned by 1C31, selecting the third harmonic in the localizer frequency range about 110 MHz; the secondary of 1L8 feeds the localizer output plug 1P3 and the localizer telescopic rod aerial.

75. H.T. is applied to the anode of 1V5b, through 1S2C, 1S1C and 1S1D. In the 2 and 3 positions of 1S2 (crystal and manual) the h.t. supply is taken from the 180V h.t. via the modulation source through 1S1C and 1S1D; sections F and G of 1S1 then control the input circuit of the modulator such that in the localizer position (3) of 1S1, modulation is the mixed 150 Hz and 90 Hz ILS tones, and in the localizer audio position (4) modulation is from the audio oscillator 1V4b. In the number 1 position of 1S2 (auto) the modulation is cut out and h.t. is fed direct from the 300V line; a higher output without amplitude modulation is then available over the range of the effectively frequency-modulated localizer signal.

Glidepath multiplier

76. In the glidepath (No. 2) position of 1S1, the master oscillator 1V3 and doubler 1V5a operate exactly as for localizer operation, and a signal in the frequency range about 36·66 MHz appears at the anode of 1V5a. A feed from this point is then

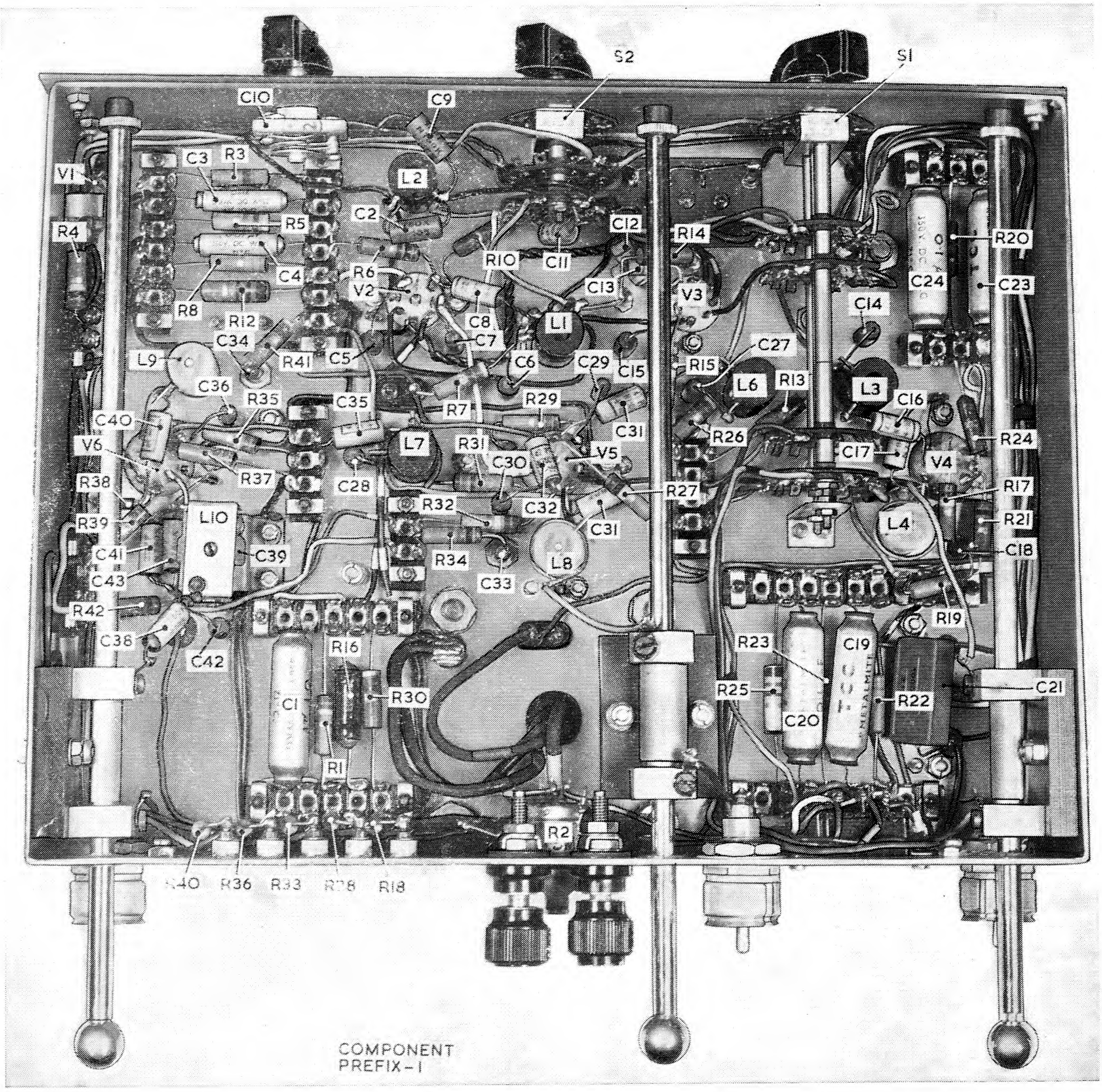

Fig. 10. R.F. chassis: underside

taken via 1C35 to the grid of trebler 1V6a, in whose anode circuit the third harmonic centred at 110 MHz is selected by 1L9. This signal is then coupled to a further trebler 1V6b in whose anode circuit 1L10 tuned by 1C39 selects the third harmonic at 330 MHz.

77. The output coil 1L10 is a strip of silver-plated copper bent to form three sides of a rectangle, and the output to the glidepath plug and telescopic rod aerial is taken from a point on the strip. Decoupling of the anode circuit is provided by three capacitors 1C41, 1C42, 1C43, in parallel; they are connected in this way to reduce inductance in the leads which would otherwise impair the effectiveness of the decoupling.

78. As with the localizer output stage a complex switching arrangement provides for the supply of h.t. to the glidepath output valve, and additionally to the first trebler. Section D of 1S2 connects the anode circuit of 1V6b to the modulator switch sections 1S1C and 1S1D in the crystal and manual positions, so that when the modulator sections are in the glidepath position h.t. is taken from the 90V line together with 150 Hz and 90 Hz ILS tone modulation. In the auto position (1) of 1S2D, unmodulated h.t. at 300V is fed direct to the anode circuit. H.T. to the anode of 1V6a is fed through 1S1E only in the glidepath position.

79. A special feature of the switching ensures that with 1S2 selecting automatic operation, and 1S1 selecting glidepath, both glidepath and localizer multiplier and output circuits are operating and visible indications on operation of both glidepath and localizer receivers may be seen simultaneously.

Summary of r.f. services

80. On CRYSTAL operation, therefore, any one of three carriers can be selected at the spot frequency of:

(1) Marker channel (75 MHz).

(2) Localizer channel No. 7.

(3) Glidepath channel No. 7.

Accurately tuned signals are therefore available for careful checks on each of the three ILS receivers, but on only one of the twelve possible channels of each localizer and glidepath receiver. Spare localizer and glidepath crystals are also supplied for ILS channel No. 15.

81. If necessary localizer and glidepath channels for which a crystal check is not available can be tested on MANUAL operation, by tuning of the test set to the required channel. Because, however, of the possibilities of misleading readings of the ILS indicator through mistuning, MANUAL operation is not normally advised.

82. AUTO operation is intended for use in the glidepath position of the channel switch when both localizer and glidepath signals are radiated, without amplitude modulation, but with their carriers varied automatically over the full frequency bands. Both localizer and glidepath pointers on any channel will then be operated simultaneously and a quick check can be made that the receivers are operating on those channels.

90 Hz oscillator

83. The 90 Hz tone which forms a component of the modulation to the main localizer and glidepath functions is produced in a circuit containing 2V1, 2V3a, 2V5a, as shown in fig. 21. The essential features of the circuit appear in fig. 11.

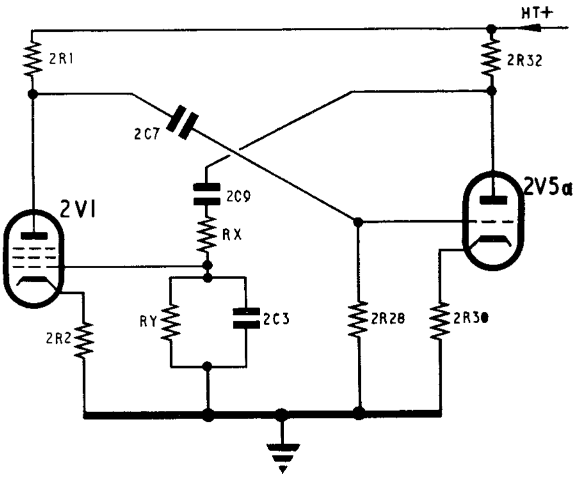

Fig. 11. 90Hz generator circuit simplified

84. The basic circuit is described as a Willan oscillator, and is often called a Wien Bridge oscillator because of the similarity between the frequency discriminating network and the main elements of a Wien Bridge. The Wien network, shown as 2C9, RX, RY, 2C3, in fig. 11, consists of a series R and C in series with a parallel R and C and it has the property that at some frequency determined by the values of the several components the potential across the parallel components is in phase with the potential across the complete network.

85. In the oscillator the network is included as the coupling circuit between 2V5a (CV491) and 2V1 (CV454) so that at 90 Hz, the in-phase frequency of the network, any signal at the anode of 2V5a is in phase with that at the grid of 2V1. The anode of 2V1 is coupled back to the grid of 2V5a through 2C7 which produces negligible phase shift at 90 Hz. As each valve introduces a phase shift of 180 deg., a total of 360 deg., at 90 Hz the overall phase shift is 360 deg., thus the input to 2V1 is in phase with the output of 2V5a and the system oscillates.

86. The frequency stability of the circuit is determined almost entirely by the constancy of the Wien network. The two capacitive components (2C9, 2C23) are therefore high stability capacitors and the resistive elements RX and RY are made independent of temperature by use of

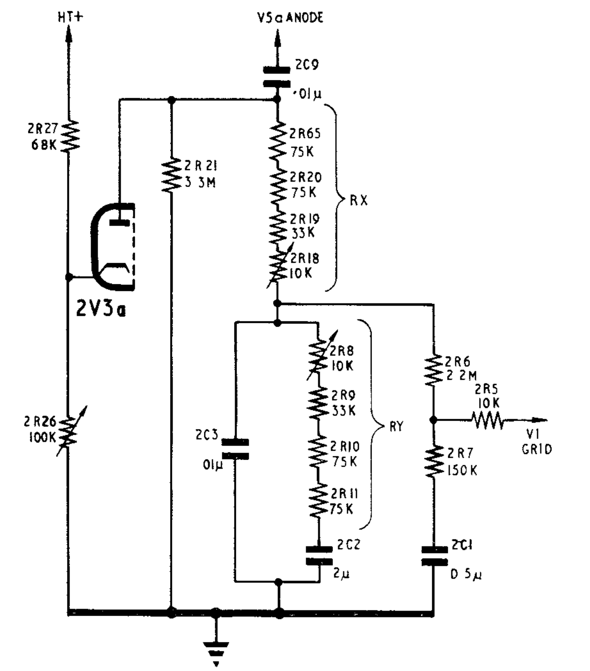

Fig. 12. Wien network

several components of compensating temperature co-efficients in series. Details of RX and RY are seen in fig. 12, where each resistance is seen to consist of three fixed resistors and one variable; the two variables concerned, 2R18 and 2R8, provide for RX and RY to be set to exactly the same particular value at which oscillation is at 90 Hz.

Amplitude regulation

87. The additional components of the coupling stage shown in fig. 12 provide for control of the oscillator output. In the basic circuit of fig. 11 the overall gain would be much greater than the minimum necessary for oscillation and overloading would occur with a resultant distortion of the output.

88. Two measures are taken to limit the gain of the system so that oscillation is only just maintained thereby ensuring a constant amplitude of output and a minimum of distortion. The first is that the output of the Wien network is reduced by a factor of about 15 to 1 in a potential divider, 2R6, 2R7. The second is that a variable-mu valve is used for 2V1 and an a.g.c. voltage developed by diode 2V3a (part of CV140) makes its gain dependent upon the output voltage.

89. The diode is biased by a preset potential on its cathode so that conduction takes place only when the anode signal rises above the bias level. Such conduction then tends to limit the peak level of the anode signal to the bias level and the flow of diode current produces the a.g.c. bias potential across 2R21.

90. The a.g.c. bias is a negative potential whose value is dependent upon the difference between the peak valve of the signal input on the anode of 2V3a and the cathode potential. A high order of a.g.c. is required to ensure stability of output and therefore the Wien network and its subsequent potential divider are made ineffective at d.c. by the introduction of blocking capacitors 2C2 and 2C1. The bias on 2V1 is therefore dependent on the output of 2V5a and not on the greatly reduced input feed to 2V1. If then the output of 2V5a tends to rise, the a.g.c. action produces a fall in gain which limits the actual rise to a negligible proportion.

91. As a result, the bias on the diode provides a direct control of the output level of the oscillator, and the h.t. source from which the bias is derived is therefore made constant to ensure that h.t. variations do not influence the output. The preset bias control 2R26 thus acts as a control of output level, and in fact is used as a control of the modulation depth produced by the tone generator.

150 Hz oscillator

92. The 150 Hz tone forming the second component of the ILS-type modulation is produced in a circuit identical in general design with that just described and differing only in the value of components in the Wien network. The valves concerned are 2V2, 2V5b. The frequency is set by the variable resistors 2R17 and 2R23, and a.g.c. is provided by 2V4a. Output level as before is controlled by the cathode bias of the a.g.c. diode and this level is exactly the same as that on the 90 Hz diode, derived from 2R26, so that the 150 Hz output is exactly the same as the 90 Hz output.

93. In both circuits, adjustment of 2R26 tends to alter the loading across the Wien network as well as varying the circuit outputs. The loading variation therefore introduces a slight variation in frequency when the modulation depth (of both tones) is varied, hence modulation depth must be set up before the frequencies are adjusted.

Audio oscillator

94. Oscillations providing the source of audio modulations for the marker and localizer audio functions are generated by 1V4b. A detailed circuit of this stage is shown in fig. 20 and its simplified outline appears in fig. 13.

95. The oscillator is a conventional Hartley with a centre-tapped coil (1L5) tuned by a selection of three capacitors to give a choice of three frequencies, 400 Hz, 1,300 Hz, 3,000 Hz. Identical load resistors are fitted in the anode and cathode feeds to the valve, so that the valve operates as a balanced phase splitter, with anti-phase signals, of equal amplitudes, appearing across each load.

Audio amplifier

96. The audio oscillator operates continuously, but is connected into the modulation circuits in position 1 and 4 (marker and localizer audio) only of the function switch 1S1. Amplification of the audio signal then takes place in a multi-stage push-pull circuit shown in outline in fig. 8. Each phase of the oscillator output is fed through a two-valve amplifier in which a high order of feedback controls the actual output level.

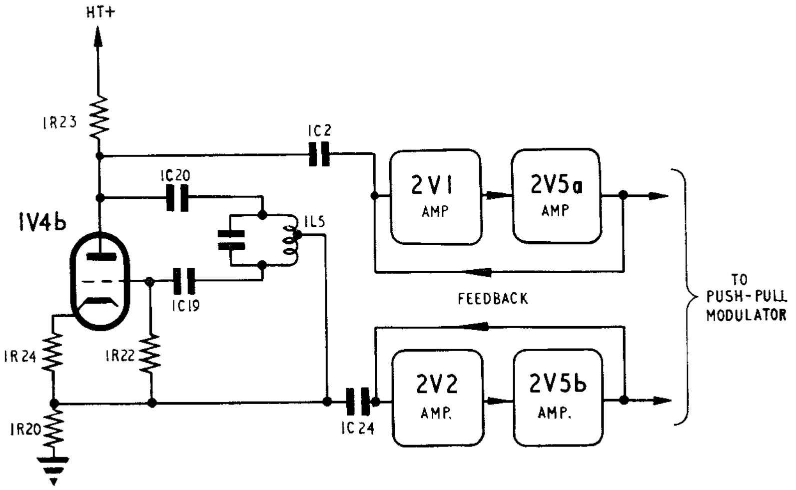

Fig. 13. Audio circuit simplified

97. The detailed circuit of one of the amplifiers appears in fig. 14. The valves concerned are those which generate the 90 Hz oscillation in the localizer and glidepath operating condition. When the audio oscillator is switched into circuit the low impedance of the load shown by the audio oscillator increases the attenuation in the feedback loop from 2V5a anode to 2V1 grid and oscillation at 90 Hz cannot take place.

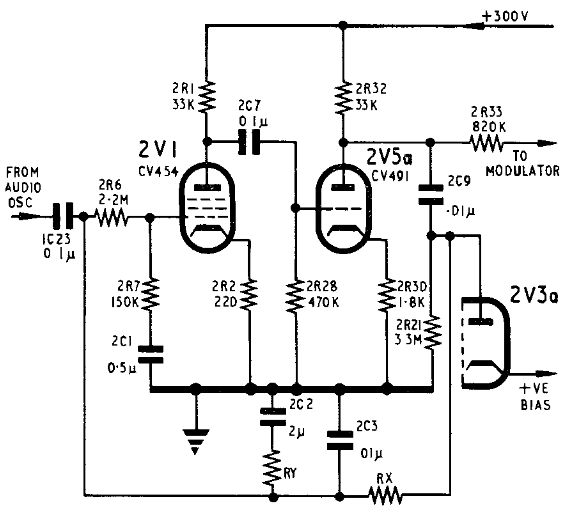

Fig. 14. Audio amplifier simplified

98. 2V1 and 2V5a then act as a straightforward amplifier with some small order of feedback through the Wien coupling, but with the a.g.c. action of 2V3a acting in full to control the amplitude of the output. The output at the anode of 2V5a is not however the same as in the 90 Hz oscillation condition.

99. The second amplifier circuit for the audio signal uses 2V2 and 2V5b of the 150 Hz oscillator circuit. Conditions are exactly as with the circuit of 2V1 and 2V5a.

Modulator

100. On glidepath and localizer operation the 90 Hz tone appears at the anode of 2V5a and the 150 Hz tone at the anode of 2V5b; both tones have amplitudes of about 50V. A resistance chain is connected between the two anodes and a centre-tap to earth is taken from the slider of 2R35, the DEFLECTION CONTROL (fig. 21). The grid of modulator valve 2V6 is taken into the chain at the 90 Hz side, and that of 2V7 at the 150 Hz side.

101. The level of tone applied to each valve is dependent on the setting of 2R35 such that when the slider is central the amplitude of 90 Hz fed to 2V6 is equal to the amplitude of 150 Hz fed to 2V7; a movement of the slider in either direction from centre increases the feed to one valve and decreases the feed to the other. Over the useful range of 2R35 the increase in feed to one valve is approximately equal to the decrease in feed to the other; as a result, inputs to 2V6 and 2V7 can be controlled continuously from a point where the 90 Hz tone is 5dB greater than the 150 Hz tone, through equality, to a point where the 150 Hz is 5dB greater than the 90 Hz, and over this range the sum of the two tones remains substantially equal.

102. The two modulator valves, although supplied with separate inputs, have a centre-tapped transformer as a common anode load in whose secondary the two tones appear combined. One side of this secondary is connected to h.t. through 1S1D and the other side is fed through 1S1C, 1S2C, 1S2D, to the anode circuits of the r.f. output valves. In the appropriate switch position, therefore, the r.f. valves receive an h.t. supply to which is added the modulation output of the transformer.

103. The transmission from a working localizer beacon is modulated to a depth of 40 per cent and that from a glidepath beacon to greater than 90 per cent. To achieve comparable differences of

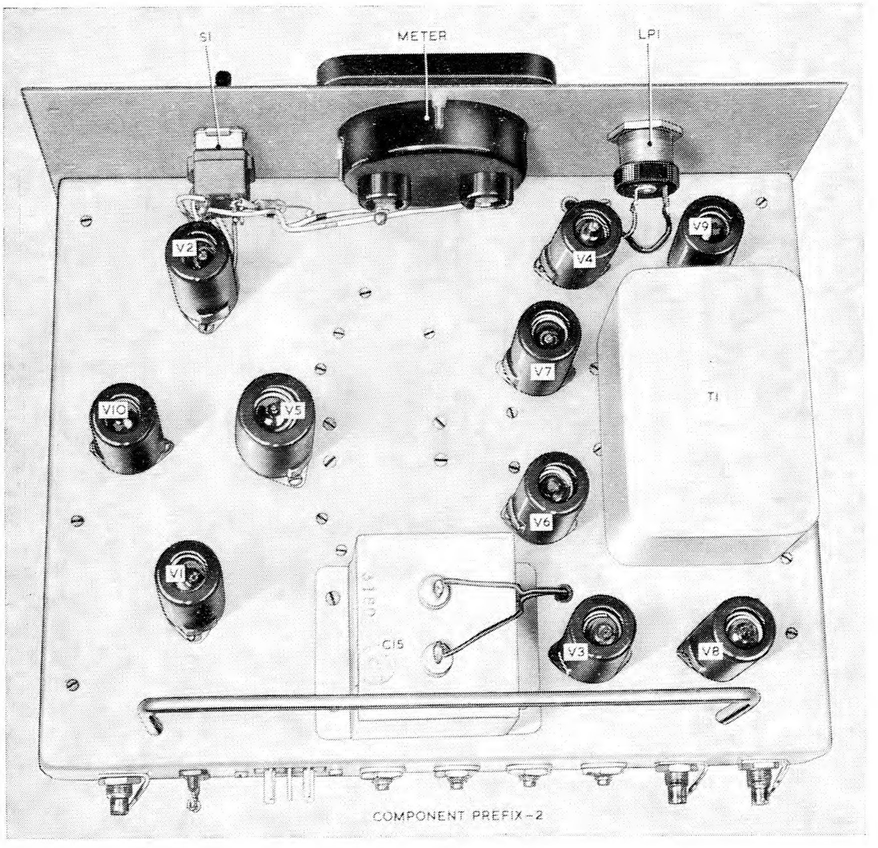

Fig. 15. Modulator chassis

modulation levels in the test set outputs which simulate the two transmissions, therefore, it is necessary either to reduce the modulation on localizer with identical levels of localizer and glidepath carriers, or reduce the carrier on glidepath with identical levels of modulation. In practice, however, it is important that localizer modulation be exactly 40 per cent (because of the design of the receiver system) but the exact level of glidepath modulation is unimportant. As a result the test set modulation is made exactly 40 per cent when the localizer carrier is conditioned by a 180V supply (this being a convenient stabilized h.t. level provided from two regulator valves in series), then by using the same modulation on a glidepath carrier of level determined by a 90V h.t. supply (one regulator valve only) the modulation depth is sufficiently near that of the glidepath transmission at 80 per cent. The necessary switching is effected by 1S1D.

Audio modulation

104. In the marker and localizer audio positions of 1S1 (positions 1 and 4) the two outputs of 2V5 for a push-pull input to the DEFLECTION CONTROL chain and the modulator valves operate as a straightforward push-pull amplifier. The DEFLECTION CONTROL, as before, is capable of altering the relative drives to the two valves, but this merely has the effect of unbalancing the drive to the output transformer, and the sum of the drives remains constant.

105. The modulation depth of an actual localizer audio transmission is 30 per cent and the audio modulation level is therefore made such that when the localizer carrier is produced from an h.t. supply of 180V the test set output is also modulated to 30 per cent. Actual marker transmissions have a modulation depth of at least 90 per cent, but with an h.t. supply of 90V to the marker r.f. valve the modulation depth is 60 per cent and this level is a satisfactory compromise. As in para. 67 the modulation level switching is controlled by 1S1D.

Modulation monitor

106. The main function of the test set is to provide an ILS-type signal in which a localizer or glidepath carrier is modulated by combined 90 Hz and 150 Hz tones. The relative levels of the tones, and therefore their relative modulation depths on the r.f. output, are controlled and measured within known limits.

107. An equipment permitting the modulation levels to be accurately measured and controlled becomes a laboratory instrument (as the signal generators Type 62 and 69) and is too unwieldy for field use; the test set therefore has been designed to produce a compromise between the needs of stability and portability. To this end no provision has been made for direct measurement of the modulation levels, but instead the test set modulation is set up on a receiver previously calibrated on the laboratory equipment, and a monitoring

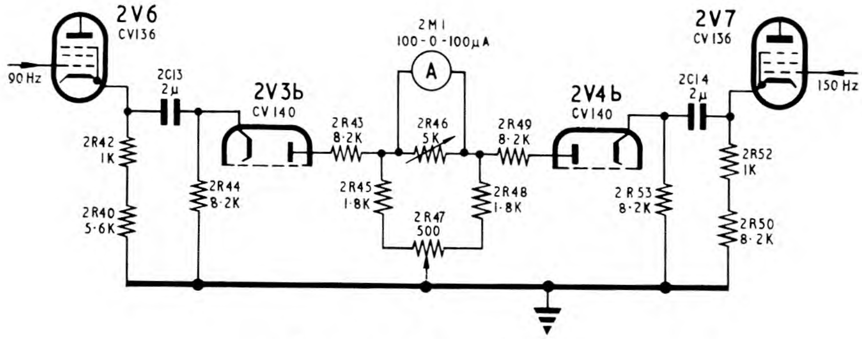

Fig. 16. Metering circuit

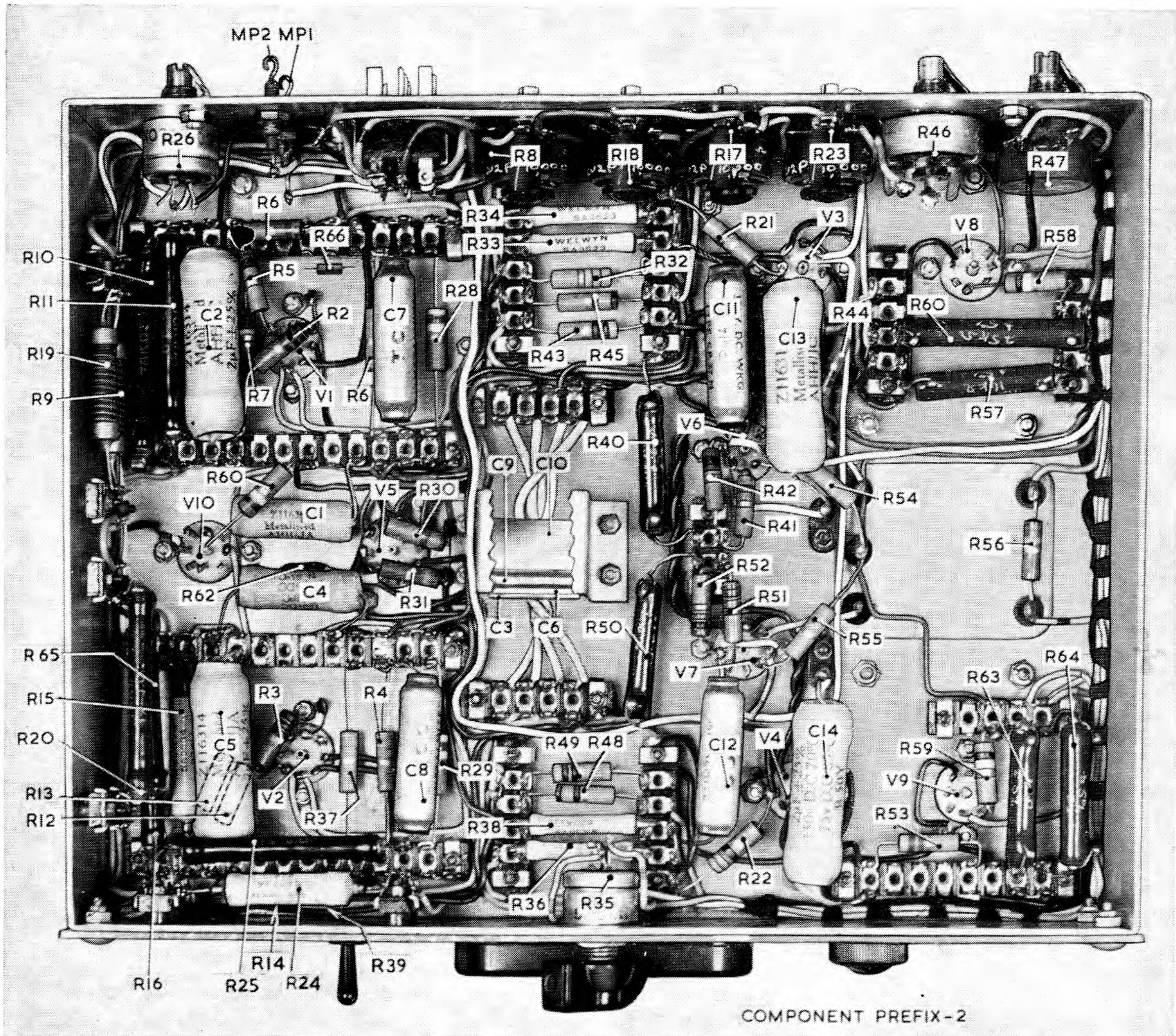

Fig. 17. Modulator chassis: underside

circuit and meter indicates on predetermined readings when the required output conditions are satisfied.

108. The test set therefore can be used to provide signals indicating particular modulation conditions of sufficient accuracy for normal checking purposes. Short term stability is then provided by relating all important signal levels to h.t. potentials produced by voltage regulators, as previously mentioned.

109. Actual metering of the modulation signals is done in the cathode circuits of the modulator valves 2V6, 2V7, as shown in fig. 16. The two valves are pentodes whose anode currents are independent of their anode voltages; this point is significant when it is noted that because of the common winding connecting the anodes, the voltage actually generated at each anode will appear in anti-phase at the other anode. If then the anode currents were affected by anode voltage (as in a triode) the cathode current and potential would contain a 150 Hz component in the instance of the 90 Hz valve 2V6, and a 90 Hz component in the other valve.

110. The voltage across the cathode load of 2V6 therefore consists of a standing d.c. level together with a 90 Hz component proportional to the 90 Hz current in the modulation transformer primary. Similarly the a.c. cathode potential of 2V7 is proportional to the 150 Hz current in the transformer. Unfortunately the transformer response is such that with equal 90 Hz and 150 Hz currents in the primary, a greater 150 Hz voltage would be induced in the secondary. As a result equality of the tones in the secondary is indicated not when the cathode currents are equal, but when that in 2V6 is some definite proportion greater. The cathode load of 2V6 is therefore made smaller than that of 2V7 and the increased current which must then flow in 2V6 for the two a.c. cathode potentials to be equal is sufficient to produce equality of tones in the transformer secondary.

111. The a.c. components at the cathodes of 2V6 and 2V7 are fed to separate detector circuits containing 2V3b and 2V4b, and rectified outputs appear across load components linked by the meter circuit. If then equal a.c. voltages are fed to the diodes, equal rectified voltages appear across 2R45 and 2R48 and the voltage across the meter circuit is zero; the meter therefore remains undeflected at its centre-zero position. If one diode receives a greater input than the other, the rectified outputs differ and the meter then reads in a direction according to which tone is the greater and to a setting dependent upon the difference in inputs.

112. Differences in depth of modulation of the two tones (for short DDM) are therefore registered on the meter and adjustment of 2R47 alters the meter zero setting. Thus any unbalance in the modulation or metering circuit can be eliminated, so that when the output of the test set produces a null reading on a properly calibrated ILS indicator, the meter also reads zero. 2R46 is a shunt on the meter and controls its sensitivity: this preset is adjusted for a given deflection on an ILS indicator to be associated with a particular reading of the test set meter. Thus meter readings at certain points indicate chosen DDMs in the test set output.

113. It should be noted that a feature of the circuit tending to maintain the accuracy of the equipment, once it has been set up, is the use of a high order of feedback on the modulator valves. The load resistors 2R40 and 2R50 are not decoupled so that the voltage gains of the stages are kept low. A further point of note is the presence of 2R56 across the modulation transformer secondary: this places a resistive load on the transformer which swamps any change of loading reflected into the circuit by alterations in drive to the r.f. valves.

Power supplies

114. The 24V d.c. supply required by the test oscillator is applied through an ON/OFF switch 1S3 to a rotary transformer, to the series-parallel connected valve heaters of both sub-chassis, and a pilot lamp. The 24V line on the modulator chassis is also taken to a change-over switch 2S1 through 2R39; in the SUPPLY position the modulation meter is connected to read the supply voltage.

115. The rotary transformer provides 300V h.t. at up to 100mA. A 250mA fuse protects the main h.t. line which is smoothed by 2C15. A secondary h.t. line protected by a 50mA fuse provides h.t. to the 90 Hz and 150 Hz circuits of the modulator unit; this fuse is provided mainly to protect the smoothing capacitor of this line, 1C25, which is an electrolytic, and which could be damaged if the d.c. input were accidentally connected with wrong polarity.

116. A gas-filled regulator valve 2V10 is fed from the 300V line through 2R60 to provide a stabilized 90V supply to the 90 Hz and 150 Hz stages, and two similar valves in series 2V8, 2V9 provide 180V and 90V for the r.f. output stages.

ATTENUATOR TYPE 29

117. The attenuator Type 29 (102/274) is a separate unit supplied for inclusion in the output circuits of the test oscillator when feeds are taken from the plug outputs direct to the aerial plugs on the receivers. The circuit of the attenuator appears in fig. 18.

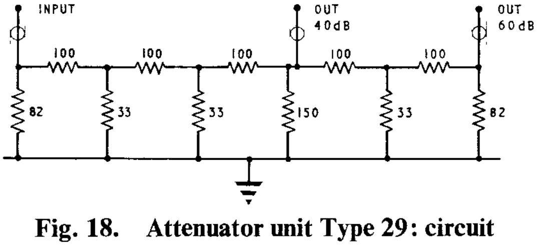

Fig. 18. Attenuator unit Type 29: circuit

118. The attenuator consists of five "pi" sections with an input point at a coaxial plug and two output points also on coaxial plugs. An output reduced by 40dB in the input is available at the third section and the full reduction of 60dB appears at the end of the attenuator.

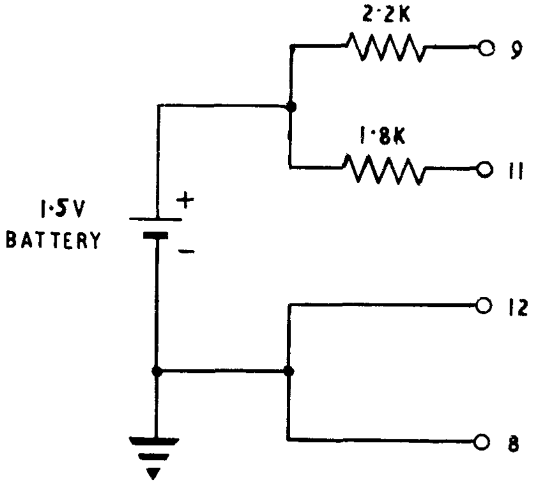

Fig. 19. Resistor unit Type 416: circuit

119. The test oscillator is designed to produce a radiated output which provides an adequate signal strength at the receiver aerials. The level then available at the direct output points is too large to be fed directly in the receivers, and the attenuator unit is necessary as a pad to reduce the signal to a desirable level.

RESISTOR UNIT TYPE 416

120. Resistor unit Type 416 (10W/18211) is a plug-in unit for making rapid checks of the continuity of ILS indicators and their circuit interconnections.

121. The unit consists of a 1·5V battery fitted in a metal case and mounted behind a 20-pole plug. The positive pole of the battery is taken through two different resistors to pins 9 and 11 of the 20-pole plug, the negative terminal of the battery case connects directly to pins 8 and 12 of the 20-pole plug as shown in fig. 19.

122. To test an ILS indicator, substitute, in turn, the receivers (R1964 and R1965) for the resistor unit Type 416 which is to be fitted to the 20-pole plug in the junction box from which the receiver concerned was removed. The battery circuit of the resistor unit passes a current through pins 8 and 9 to the pointer circuit of the indicator and through pins 11 and 12 to the flag circuit of the indicator. The 2·2 kilohms resistor limits the pointer current to 200mA per indicator (with 1·5 battery) and the 1·8 kilohms resistor limits the indicator circuit flag current to 500 μA.

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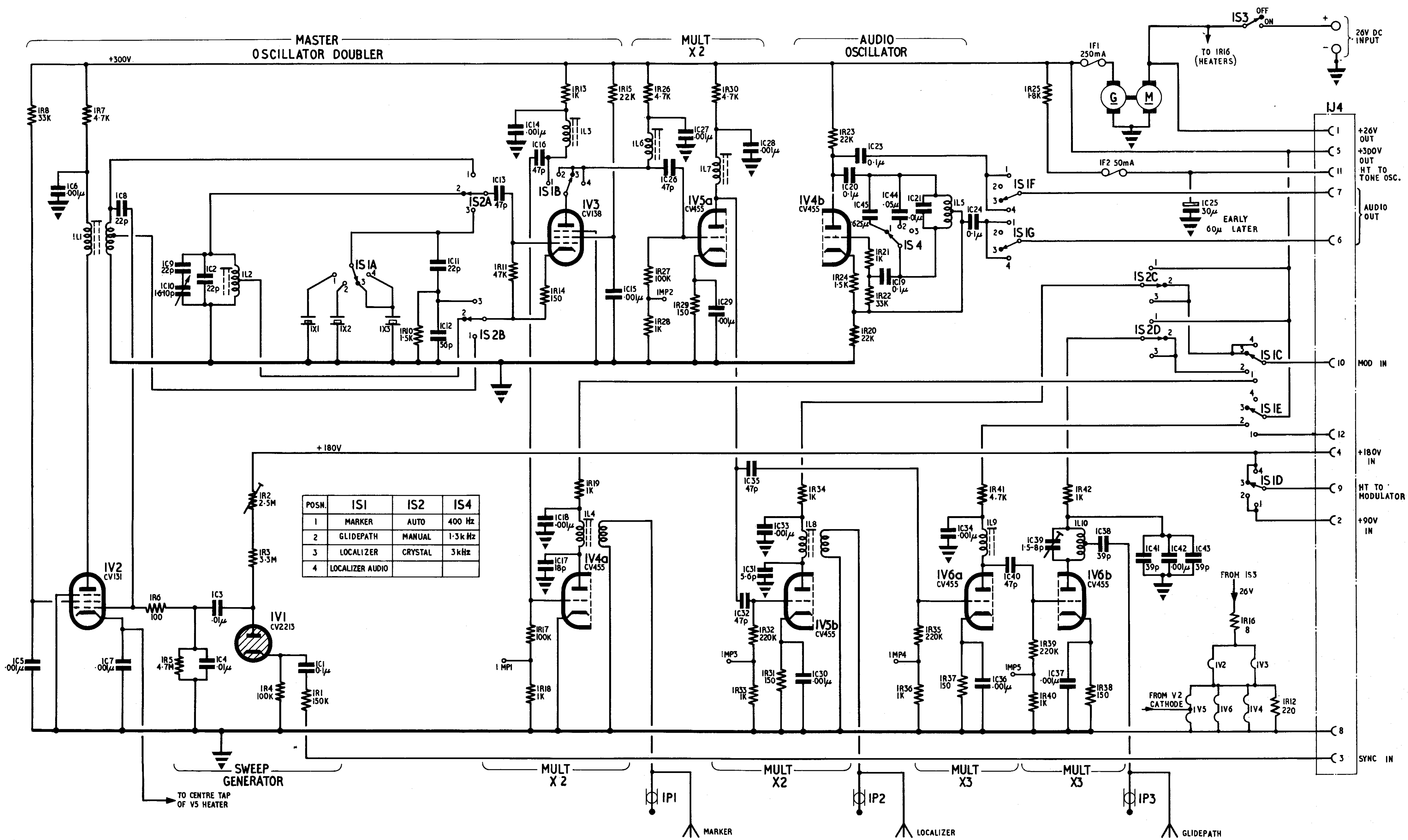

POSN.	1S1	1S2	1S4
1	MARKER	AUTO	400 Hz
2	GLIDEPATH	MANUAL	1·3kHz
3	LOCALIZER	CRYSTAL	3kHz
4	LOCALIZER AUDIO		

Fig. 20 RF unit Type 76: circuit Fig. 20

D.629418. 370771. S.W. 7/68

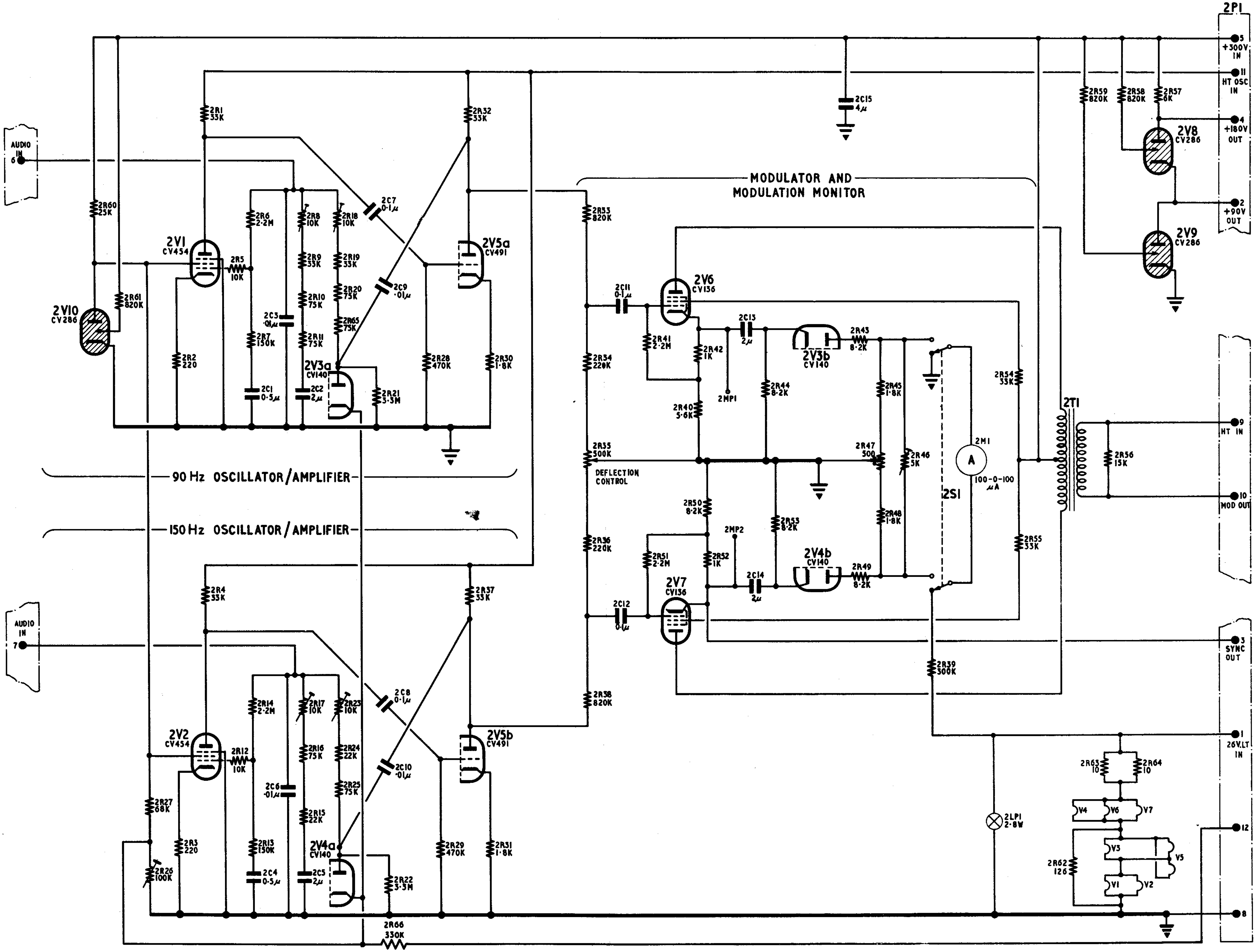

Fig. 21 Modulator unit Type 126: circuit Fig. 21

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