Please do not upload this copyright pdf document to any other website. Breach of copyright may result in a criminal conviction.

This pdf document was generated by me Colin Hinson from a Crown copyright document held at R.A.F. Henlow Signals Museum. It is presented here (for free) under the Open Government Licence (O.G.L.) and this pdf version of the document is my copyright (along with the Crown Copyright) in much the same way as a photograph would be.

The document should have been downloaded from my website https://blunham.com/Radar, or any mirror site named on that site. If you downloaded it from elsewhere, please let me know (particularly if you were charged for it). You can contact me via my Genuki email page: https://www.genuki.org.uk/big/eng/YKS/various?recipient=colin

You may not copy the file for onward transmission of the data nor attempt to make monetary gain by the use of these files. If you want someone else to have a copy of the file, point them at the website. (https://blunham.com/Radar). **Please do not point them at the file itself as it may move or the site may be updated.**

It should be noted that most of the pages are identifiable as having been processed by me.

I put a lot of time into producing these files which is why you are met with this page when you open the file.

In order to generate this file, I need to scan the pages, split the double pages and remove any edge marks such as punch holes, clean up the pages, set the relevant pages to be all the same size and alignment. I then run Omnipage (OCR) to generate the searchable text and then generate the pdf file.

Hopefully after all that, I end up with a presentable file. If you find missing pages, pages in the wrong order, anything else wrong with the file or simply want to make a comment, please drop me a line (see above).

It is my hope that you find the file of use to you personally – I know that I would have liked to have found some of these files years ago – they would have saved me a lot of time !

Colin Hinson
In the village of Blunham, Bedfordshire.

A.P.2894H
VOLUME 1

H_2S AND ASV

TR. 3523 SERIES

Prepared by direction of the
Minister of Supply

A. Rowlands.

Promulgated by order of the Air Council

W. B. Brown

AIR MINISTRY

AMENDMENT RECORD SHEET

Incorporation of an Amendment List in this publication is to be recorded by inserting the Amendment List number, signing in the appropriate column, and inserting the date of making the amendments

A.L. No.	AMENDED BY	DATE
1	G Harvey	12.4.49
2		
3		
4		
5		
6		

A.L. No.	AMENDED BY	DATE

(Continued overleaf)

NOTE TO READERS

Air Ministry Orders and Vol. II, Part 1 leaflets in this A.P., or in the A.P. listed below, may affect the subject matter of this publication. Where possible, Amendment Lists are issued to bring this volume into line, but it is not always practicable to do so, for example when a modification has not been embodied in all the stores in service.

When an Order or leaflet is found to contradict any portion of this publication, the Order or leaflet is to be taken as the overriding authority.

When this volume is amended by the insertion of new leaves in an existing section or chapter, the new or amended technical information is indicated by a vertical line in the outer margin. This line is merely to denote a change and is not to be taken as a mark of emphasis. When a section or chapter is re-issued in completely revised form, the vertical line is not used.

Each leaf is marked in the top left-hand corner with the number of the A.L. with which it was issued.

LIST OF ASSOCIATED PUBLICATIONS

A.P. No.	**Title**
2896U	Test Sets, type 263, 263 X 1 and 263 X 2

T.R.3523 SERIES OF TRANSMITTER-RECEIVERS
This is A.L. No. 3 to A.P. 2894 H
Remove and *dispose* of the existing leaf bearing the List of Contents, etc.
Insert this leaf, and make an entry in the *Amendment Record Sheet* at the beginning of the book.

TR.3523 SERIES OF TRANSMITTER-RECEIVERS

LIST OF CONTENTS

(A.L. 6)

LIST OF ILLUSTRATIONS

G271m31593 5/47 850 C.B.&S.Ltd. Gp30

INTRODUCTION.

1. The TR.3523 series of transmitter-receivers comprises a range of universal TR. boxes. These units give an output of about 45 kilowatts on a wave length of 3 centimetres, that is, in the X band. A modulating pulse of about —3½ kilovolts at 40 or 50 amps. is required. The transmitter will handle pulse lengths of up to 1 micro-second although if it is modified (by changing the modulation transformer) pulse lengths up to 2½ micro-seconds may be used. This greater pulse length is required for use with beacons.

2. A list is given in the next paragraph showing the differences between the various sub-types indicated by suffix letters. TR.3523A is the most common type and it is this type around which this chapter is written, notes being added where other sub-types differ significantly from it.

The TR.3523 series

3. A list of the sub-types of TR.3523 is given below:

TR.3523	Preliminary production, differing mechanically, and to a lesser degree electrically, from other types.
TR.3523A	Manufacturer's main production type.
TR.3523B	This number has been allocated for sub-types which are modified for use with BGX beacons.
TR.3523C	Six experimental models only.
TR.3523D	None produced. This was to have been the production version of TR.3523C.
TR.3523E	Partly tropicalised version of TR.3523A. Tropicalisation not applied to amplifying unit type 226.*
TR.3523F	Similar to TR.3523E but with tropicalised amplifier unit.*
TR.3523 A/WW etc.	Identical with sub-types TR. 3523A, etc., but with WW plugs fitted in place of W plugs. These were modified for use in the Naval Air Arm.

4. The chief mechanical difference between the TR.3523 type and the TR.3523A type is that in the latter the AFC, head amplifier and power supply circuits are mounted on a removable chassis which can be withdrawn from the front of the unit. This chassis is known as Amplifying unit type 226.

BRIEF DESCRIPTION.

5. The circuits in transmitter-receivers of the TR.3523 series fall into the following divisions:

(i) Magnetron power oscillator and output plumbing.
(ii) TR and anti-TR devices.
(iii) Mixer waveguide assembly, including klystron local oscillators and mixer crystals.
(iv) Head amplifier, (taking IF output from mixer).
(v) Automatic frequency control circuits.
(vi) Safety circuits.
(vii) Power supplies.

These will be described briefly in the following paragraphs and more fully under Circuit Description, paragraph 28 onwards. The main part of the circuit diagram is given in fig. 14 and the safety circuits in fig. 7.

Magnetron

6. An American 725A magnetron is used, which gives a peak output power of 35 to 55 kilowatts at a wavelength of 3 centimetres (X band). No adjustments to the waveguide feeder system are required, or indeed provided for, the output system being pre-plumbed. The pulse transformer is of the double-wound type with a split secondary, which allows the pulse voltage to be kept off the filament transformer.

7. The output waveguide and magnetron filament leads are kept at sea-level atmospheric pressure regardless of flying height, thus reducing the danger of pulse or RF arcing.

TR and anti-TR cells

8. The TR cell V17 (which prevents signals passing to the mixer circuits while the transmitter is pulsing) is a CV221, which has a wider pass-band than its predecessor the CV114.

---

* Some fitted with thermal delay.

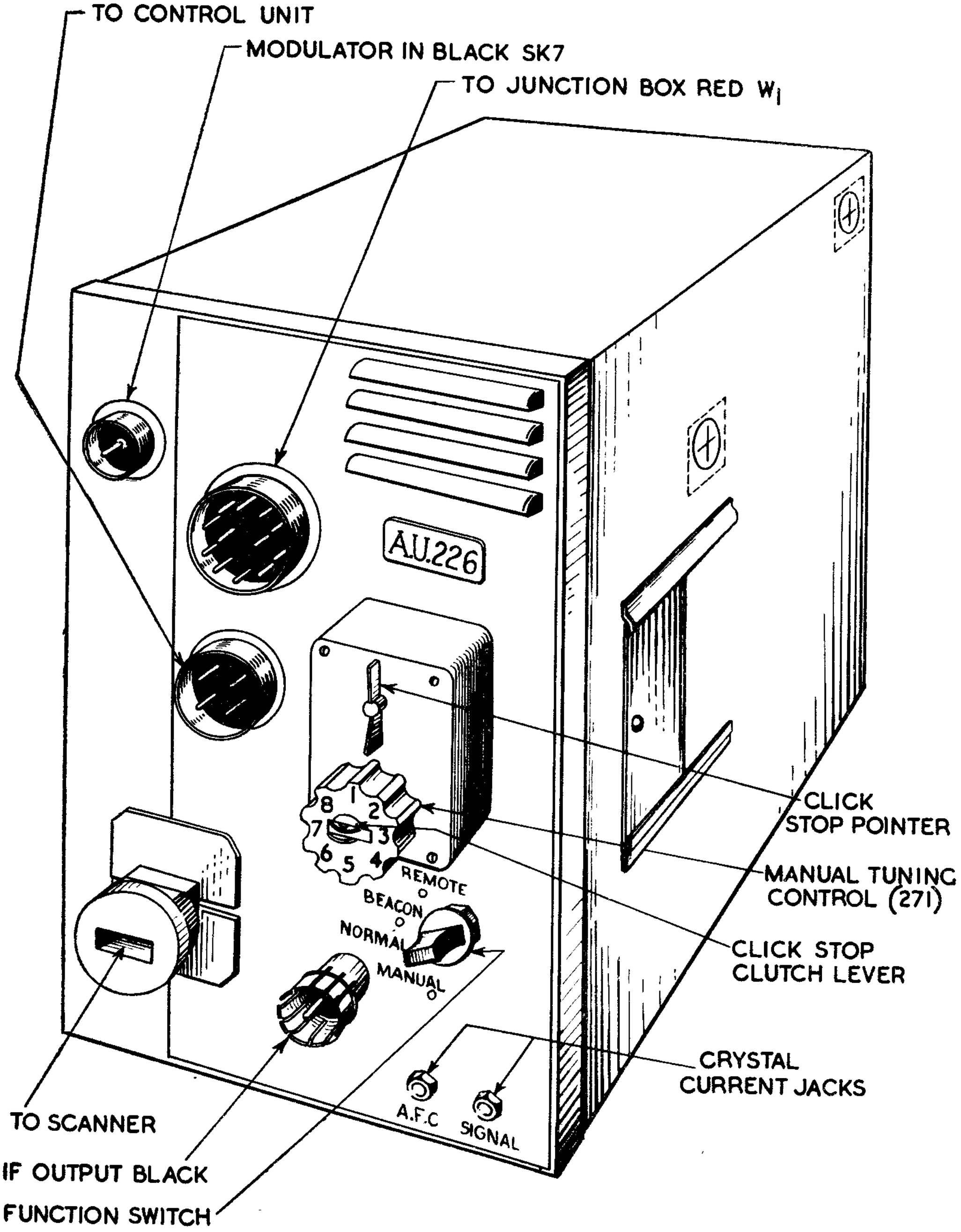


Fig. 1.—T.R.3523A—front panel

Note : (i) The manual tuning control should be labelled (R71) not (271).

(ii) The IF OUTPUT plug shown is used only on WW versions. Others employ a normal Pye plug. (*A.L.* 2)

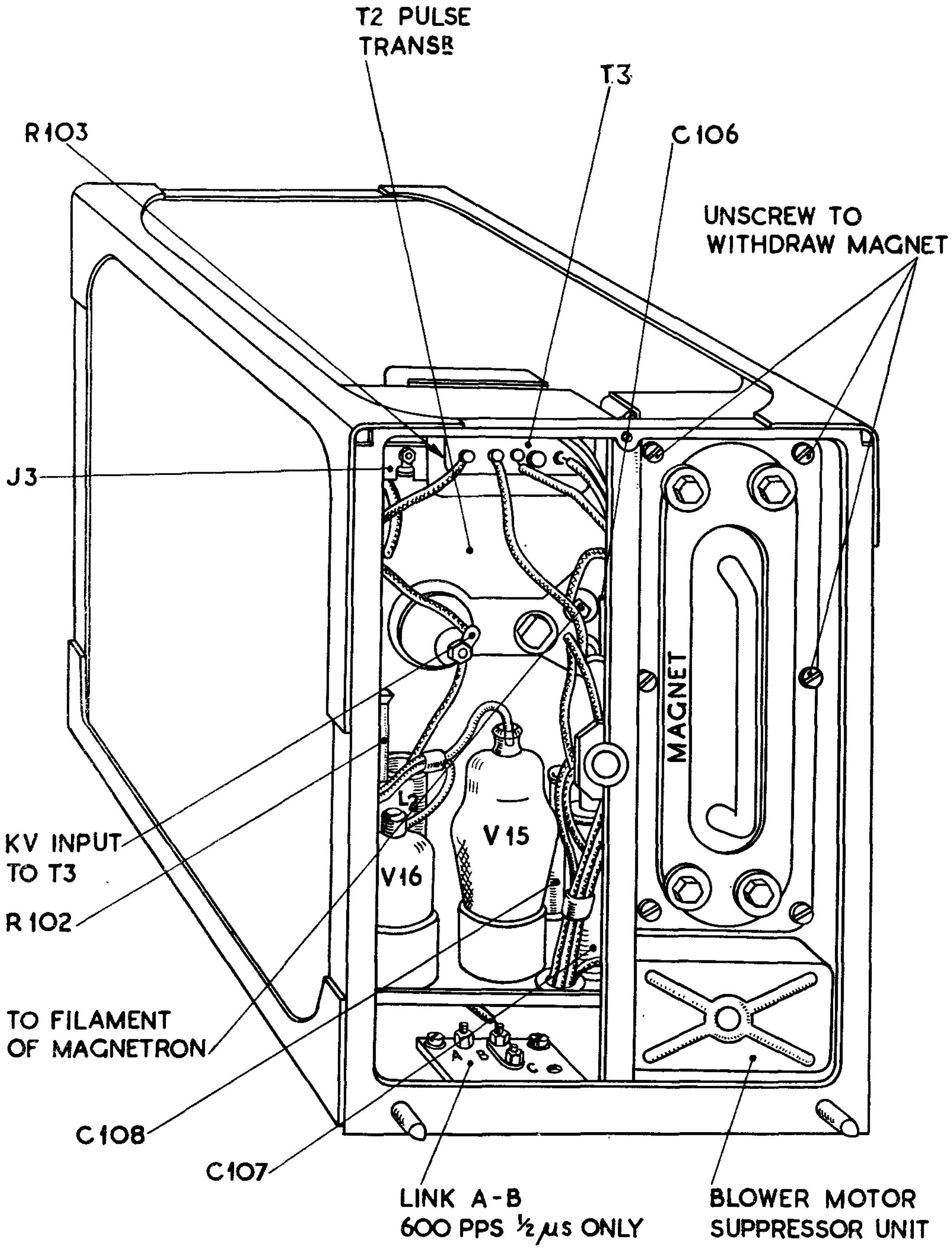


Fig. 2.—TR.3523A—rear view

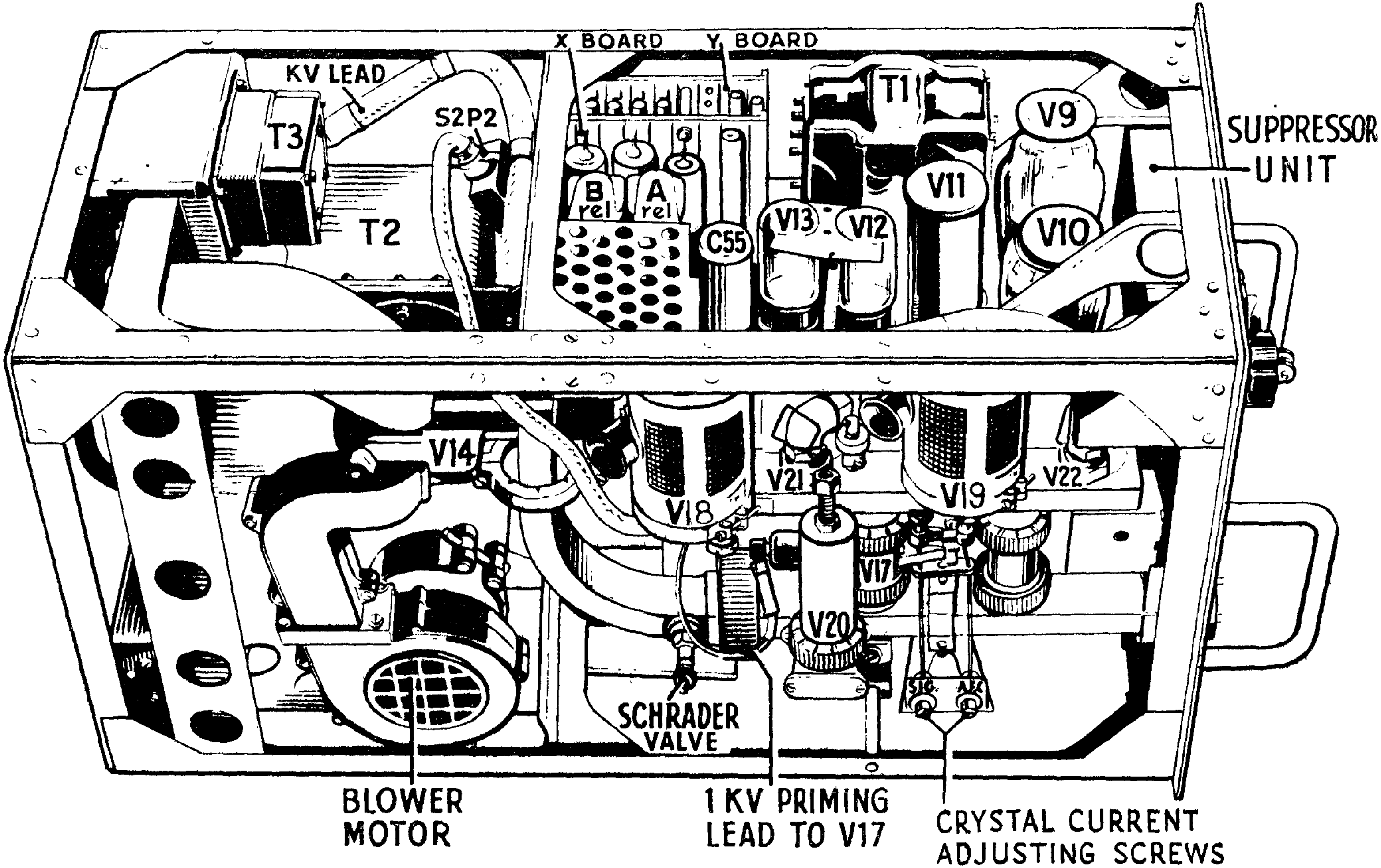


Fig. 3.—TR.3523A—top view

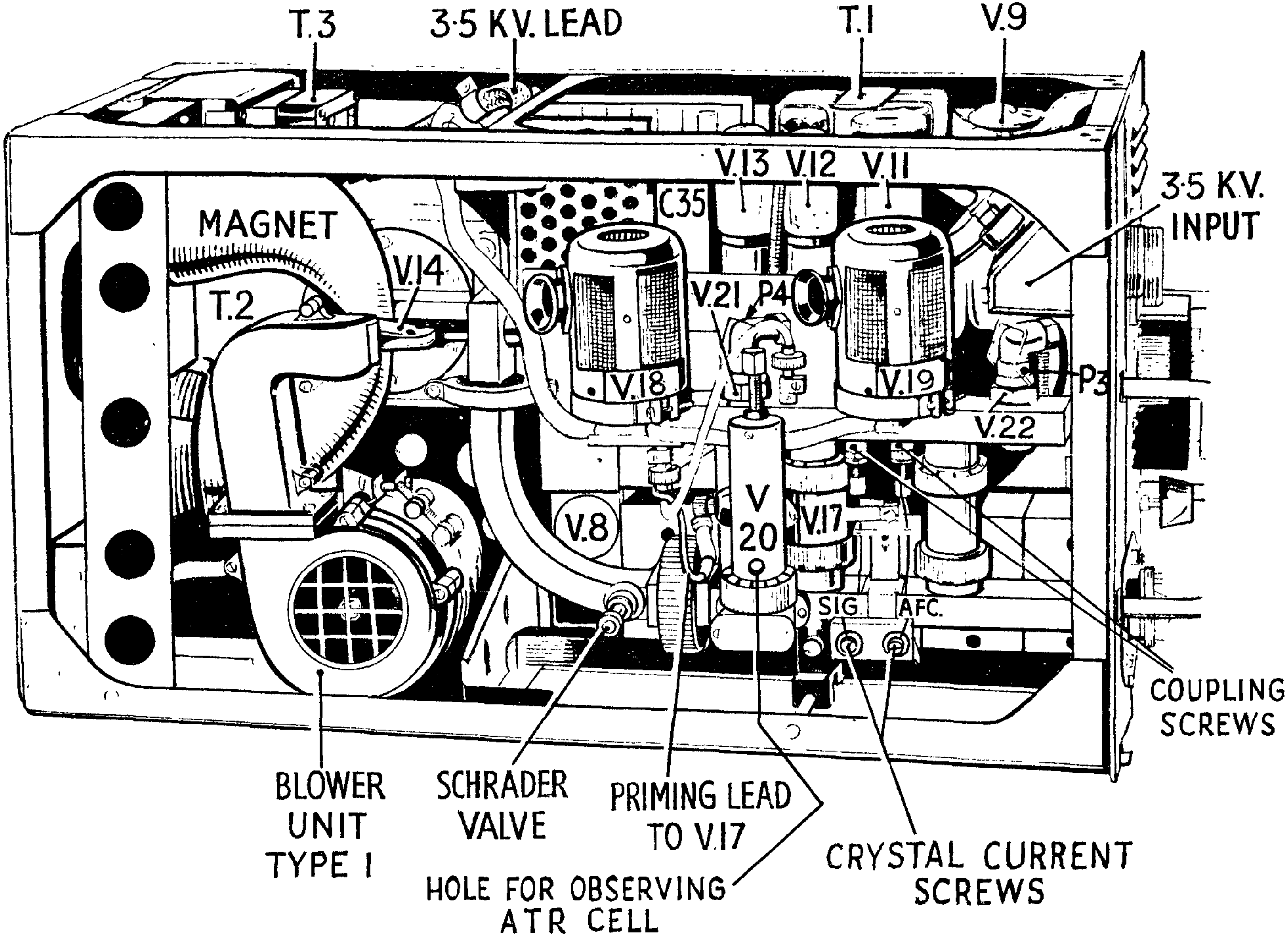


Fig. 4.—TR.3523A—left side view

9. A CV115 is used as the anti-TR cell (or " ATR " cell) V20. This prevents the loss of received signals to the transmitter valve, in the intervals between the magnetron pulses, when echoes are being received.

Mixer waveguide assembly (fig. 13)

10. There are two klystron local oscillators, both of the American 723A/B type. These are called the " Beacon klystron " (V18) and the " Signal/AFC klystron " (V19). The distribution of functions between the klystrons differs in the TR.3523 and TR.3523A types of transmitter-receivers : in the TR.3523 the signal /AFC klystron is used only for automatic frequency control tuning and the Beacon klystron is used for manual tuning.

11. In the TR.3523A type the signal/AFC klystron is used for both manual and AFC tuning and the Beacon klystron is used as a stand-by for manual tuning only, in case of trouble with the AFC klystron.

12. Switching from one klystron to the other, and from manual to automatic tuning, is done by switches on the front panel of the transmitter-receiver.

13. Manual tuning is of course essential if it is required to receive beacon transmissions : the automatic frequency control is designed to keep the klystron frequency correct with respect to the magnetron frequency, but beacons will be transmitting on different frequencies and must therefore be tuned-in manually.

14. The mixer waveguide assembly is also pre-plumbed, so that no tuning adjustments are required. This calls for the use of specially selected crystals of the CV111 type, which are marked after selection by a double green dot and become known as type CV253.

15. The provision of AFC facilities makes it necessary to employ two mixer crystals V21 and V22, one the signal crystal and the other the AFC crystal. Coupling screws (shown as SIGNAL and AFC " crystal current adjustment " in fig. 13) are provided to regulate the flow of CW energy from the signal klystron to the mixers, thus allowing the crystal currents to be aligned. The SIGNAL current adjusting screw is not intended to affect the signal crystal current when the beacon klystron is operating : in this case the crystal current is set by means of the adjustable input probe from the beacon klystron to the waveguide.

Head amplifier

16. This consists of a small two-valve IF amplifier V1 and V2, using VR91 valves. Its purpose is to amplify the IF output from the signal crystal and to pass the amplified output to the IF strip in the receiver.

Automatic frequency control

17. The AFC circuits comprise six valves V3 to V8, four type VR91 and two type VR92. There is a discriminator circuit onsisting of the valves V5, V4 and V6, V7. The discriminator is arranged to give a positive voltage output if the intermediate frequency tends to move from its correct value of 45·0 Mc/s. towards 43 Mc/s. and a negative voltage if the IF increases towards 47 Mc/s. These voltage changes are applied to the reflector of the signal/AFC klystron local oscillator and so keep the IF at approximately 45·0 Mc/s. If the IF output from the AFC crystal is outside these limits the sweep valve V8 operates and applies a voltage varying at sub-audio frequency to the klystron reflector and so sweeps the klystron frequency over the range in which the magnetron frequency may lie. This produces a sweep of similar excursion in the IF output from the AFC crystal. When the IF reaches 45 Mc/s. the operation of the sweeping valve is stopped and begins again only if the frequency of either magnetron or klystron shifts so that the IF is again outside the 43 to 47 Mc/s. cover of the discriminator.

Safety circuits

18. These safety circuits include a relay (C) which breaks the filament supply to the magnetron when the mean cathode current rises to a value sufficient to maintain the filament at its correct operating temperature. A link is provided to short circuit the relay when the transmitter is operating at 600 c/s recurrence frequency and ½ microsecond pulses, when there is not enough power dissipated to maintain the filament at a sufficient temperature.

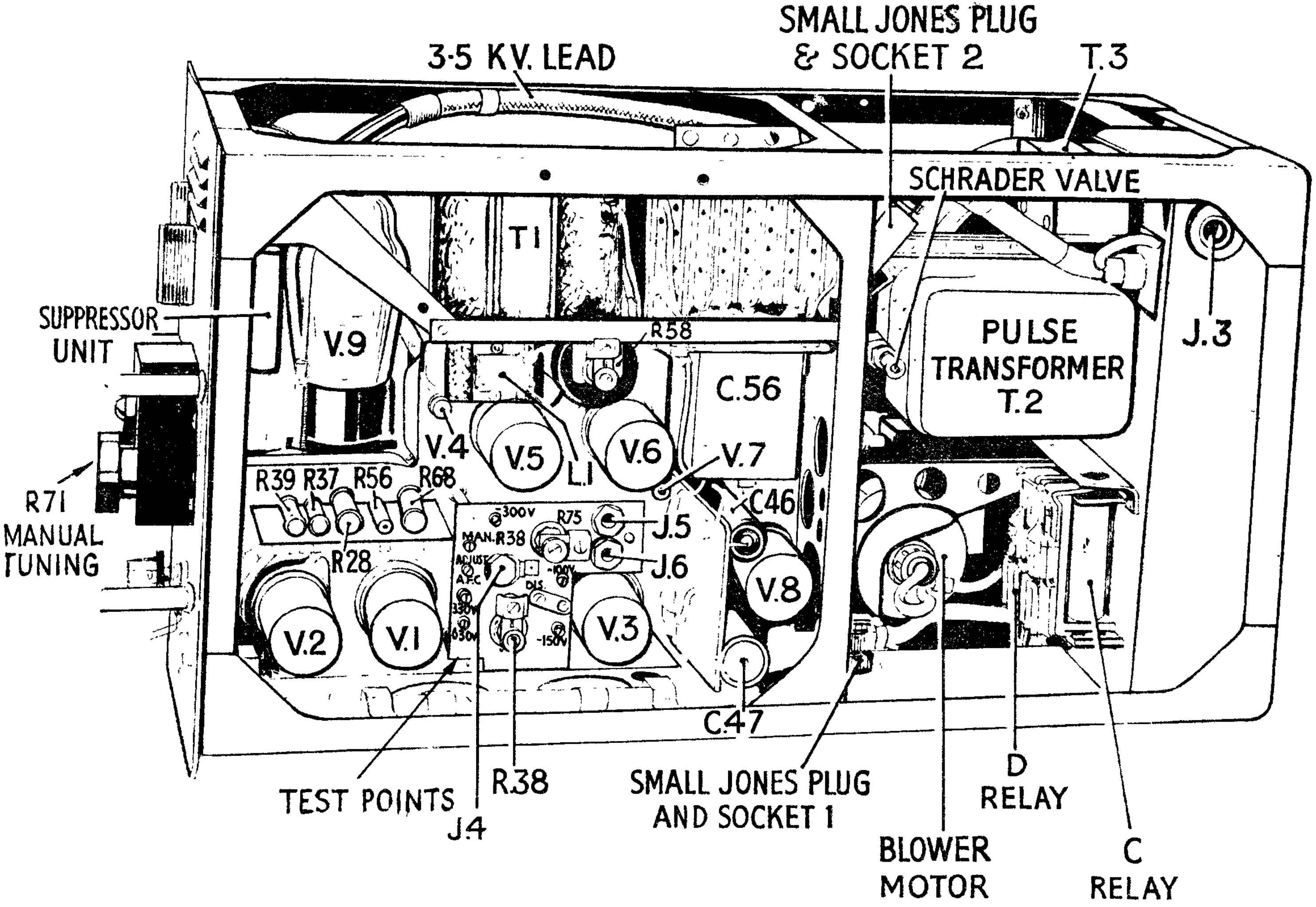


Fig. 5.—TR.3523A—right side view

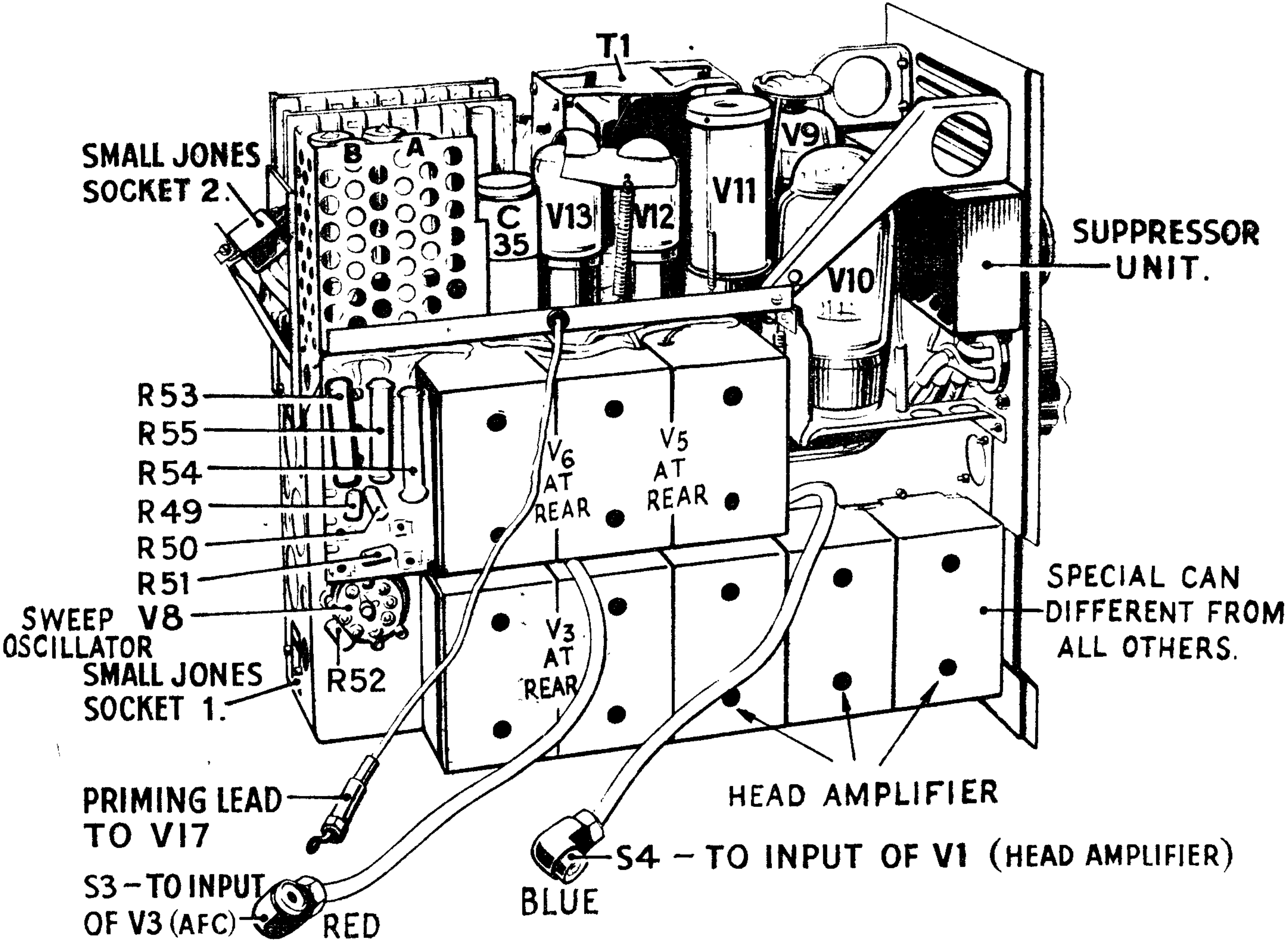


Fig. 6.—Amplifying unit, type 226—left side view

19. If a fault occurs which cuts off the magnetron current the relay automatically re-applies the filament heating supply.

20. To protect the pulse transformer from abnormal voltages which may appear on it if the magnetron should break down (thus upsetting the matching impedance presented to the pulse transformer) a CV233 hydrogen filled spark gap, (V16) is included. The break down voltage of this gap is about 5 kV. If an appreciable over-voltage appears on the spark gap the mean current passed energises a relay (D) in series with the gap. This cuts off the modulation pulses. An overswing diode V15 is provided to absorb the ringing oscillations which continue on the pulse transformer when the modulating pulse collapses. This is a hydrogen filled CV215 in TR3523, a hard valve CV265 in TR3523A, E and F. The CV265 has a longer life than the CV215 which it replaces.

Power Supplies

21. In certain models of TR.3523E and F, a thermal delay actuated by the magnetron filament transformer is fitted to ensure that the magnetron is not pulsed until the cathode has reached the required temperature.

22. Two sources of supply are included in the amplifying unit, type 226, as well as the HT supply from the external power-pack. Both are energised from the same transformer T1, which also provides all the LT supplies to this unit. A separate LT transformer is used to supply the magnetron, the overdriving diode and the thermal delay switch. A VU111 half-wave rectifier V9 gives a negative supply of about 1 kV for the keep-alive electrode of the TR cell V17. Only valves type VU111 with mica insulation, marked with the manufacturer's code letter K may be used in the V9 position. Other types of VU111 are liable to arcing in this position.

23. A 5U4G full-wave rectifier V10 gives a 300 volt supply. The negative pole of this supply is connected to the positive pole of an HT supply of 300 or 330 volts (depending on the type of power unit employed in the particular installation) from an external power pack, thus giving a total HT voltage of 600 or 630 volts.

24. The 600/630 volt line is connected to the resonators of the klystrons. This only gives a potential of 300 volts between the resonator and cathode of the klystrons, as both cathodes are returned to the negative pole of the internal 300 volt supply, and not to earth. This supply is stabilised by V11, a CV296 pentode used as an anti-jitter valve. In early units of TR.3523 and TR.3523A a CV173 was used as an anti-jitter valve in place of the CV296. CV173 valves are seldom satisfactory in this position owing to microphony and should be replaced by CV296 valves. In certain cases units may have been modified locally to use a 6AG7 with an international octal valve-base. This is satisfactory from an operational point of view and a 6AG7 should not be replaced by a CV296.

25. Where valve holders, type 329 (Stores Ref. 18583) are in use with valves, type CV296 these must be replaced by valve holders, type 316 (Stores Ref. 18070) in accordance with D.M.L. T/676.

26. The reflectors of the klystrons are fed from the incoming 300/330 volt HT voltage which is stabilised by a pair of CV188 neon bulbs, V12 and V13. This voltage is negative with respect to the klystron cathodes, which are tied to the positive pole of this external supply, and is applied across one of the manual tuning potentiometers. The slider of the potentiometer goes to the reflector of the klystron.

27. The AFC valves are fed from the 300/330 volt stabilised supply, the cathodes of the discriminator valves V5 and V6 being returned to an external negative 300 volt source. A small fraction of the same —300 volt supply is fed to the grid of the sweeping valve V8 and also to the grids of the head amplifier valves. The negative 300 volt supply is obtained from the indicator unit, type 184 or 184A in installations using these units. When an electromagnetic indicator is used it is obtained from the power unit, type 567. A modification has been introduced to help stabilise the —300 volts in the TR units used with power units, type 567. The 15K ohms resistor R56 is replaced by a centre tapped resistor of the same value (Stores Ref. 10W/16862) and a stabilised negative 150 volt supply from the power unit is brought to the centre tap via pin 10 of the 12 way plug and a link which is

positioned on the paxolin panel on the side of the amplifying unit, type 226. By closing the link on the negative 150 volt position this voltage is brought to the junction of R8 and R7 thus stabilising the voltage on the grids of the head IF amplifier valves. If there is no negative 150 volt supply but a stabilised negative 100 volt supply is available on pin 10 this may be used to stabilise the voltage on the grids of the head IF amplifiers by closing the link in the negative 100 volt position. This voltage is then connected to the junction of R7 and R10.

CIRCUIT DESCRIPTION

MODULATION AND TRANSMITTER PULSE OUTPUT SYSTEM

28. The section includes the following :—

(a) Magnetron

(b) Pulse transformer

(c) Magnet

(d) Filament transformer

(e) Filament switching arrangements

(f) Overvoltage protection arrangements

(g) Overswing elimination circuits

(h) Waveguide output line.

Mechanical details are shown in fig. 3, 4, 5 and 13.

Circuit details are shown in fig. 7 and 14.

The magnetron and pulse transformer

29. The TR.3523A uses the American magnetron, type 725A, (Stores Ref. 110E/385). The filament leads of this valve are brought out through a circular brass plate and terminated in a Pyrex boot. This boot is enclosed in the pulse transformer mounting and the enclosed volume of air has been sealed off by means of a circular gasket mounted on the lid of the transformer tank and clamped by the magnetron mounting plate. The boot is inside a neoprene well which takes up the expansion of the oil in the transformer tank. A Schrader valve fitted to the neoprene well comes out through the transformer can. This makes it possible to pump the well to a few pounds above atmospheric (sea level) pressure as a precaution before high altitude flights. One or two strokes with the pump is sufficient. Magnetrons made by " Western Electric " may have a waveguide flange 0·062 in. thick. This is thinner than the normal flange which is 0·085 in. ± 0·005 in. The original waveguide clamp which was made to fit these Western Electric valves with the thin flange will not fit Raytheon magnetrons. A new waveguide clamp (RPU Part No. A03161) has been designed for magnetrons with the thick flange, and when this clamp is used with magnetrons with the thin flange a spring shim (RPU Part No. A03966) must be used to keep the joint airtight.

30. The pulse transformer, T2 in fig. 7, has a primary and a double secondary winding. The two sections of the secondary are wound with the primary between them to reduce leakage inductance and thus give a sharper pulse rise. The outer part of the secondary is made shorter than the inner to provide additional insulation for the high voltage end of the winding. The two secondary sections are effectively in parallel as far as the modulating pulse voltage is concerned. Each section has a resistance of about 1·75 ohms.

31. The primary has 27 turns and the secondary 105 turns. This ratio serves to step up the modulating pulse from the modulator unit to about 14 kV negative. The sense of the secondary winding must be opposite to that of the primary to prevent phase inversion of the negative pulse coming from the Modulator. The pulse input is applied via a high voltage unipole plug.

32. The use of a transformer with separate primary and secondary windings makes it possible to insert a relay which operates on the mean magnetron current in the secondary winding. This relay is used to break the filament supply to the magnetron once the magnetron is operating correctly. Further details are given in paragraphs 40 to 43.

33. The use of an independent winding also permits the insertion of the jack socket J3 in the secondary. This jack socket makes it possible to measure the mean magnetron current. The normal value of this current when operating at a PRF of 670 c/s and a pulse width of 1 microsecond is of the order of 7 to 9 mA.

34. The value of this mean current reading will depend on :—

(a) Amplitude of modulating pulse.

(b) Width of modulating pulse.

(c) Emission of magnetron.

(d) Magnetron vacuum.

(e) Strength of magnet.

(f) Orientation of magnetic field with respect of axis of magnetron.

(g) Loading of magnetron.

35. If we assume normal modulator, scanner, waveguide and magnet, there will only be minor variations in the mean magnetron current due to factors (a), (b), (e), (f) and (g). Any appreciable changes in the current passed by a given magnetron will generally be due to factors (c) or (d). An abnormally low current suggests a falling magnetron emission while an abnormally high current indicates that the magnetron is going soft.

36. The magnetron current should be measured and recorded when a new magnetron is fitted. The reading should be taken again when the unit is on the bench because of a fault or for an inspection. A record of such readings will indicate any progressive deterioration of the valve and/or magnet, and may assist in localising a fault to the magnetron or magnet.

Magnet

37. The magnet used with the magnetron, type 725A is a magnet, type 7, which should have a field strength of 5450-5700 gauss measured outside the unit. The north pole can be recognised by the fact that the type and reference number is stamped on it. Magnets are fragile and should be handled with care. To preserve the field strength of stored magnets do not place them on iron covered benches or stores racks. Do not allow screwdrivers or other tools of magnetic material to touch them. Do not remove the keeper until the magnet is fitted in the transmitter unit. Magnets should not be placed near transformers, motor generators, or high current power lines.

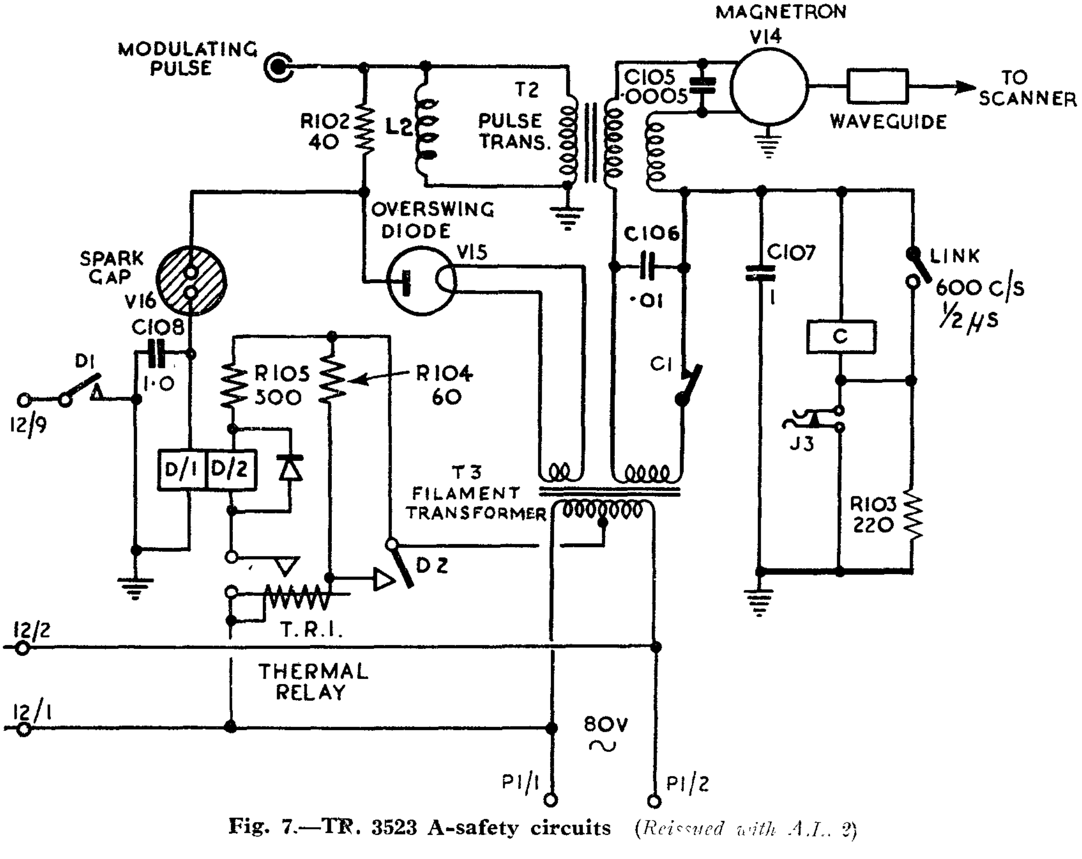


Fig. 7.—TR. 3523 A-safety circuits *(Reissued with A.L. 2)*

The magnetron filament transformer

38. Although the two sections of the pulse transformer secondary are effectively in parallel insofar as the modulator pulse voltage is concerned, these sections are in series with the secondary of the magnetron filament transformer (T3 in fig. 7). The filament transformer therefore requires no unusual insulation and should be free from the breakdown problems experienced in the past with filament transformers.

Filament voltage switching

39. The relay C has its solenoid in series with the magnetron cathode. The DC component of the magnetron current must therefore flow through this solenoid. When the mean dissipation in the magnetron rises to about 50 watts the relay is energised and the contact opens to break the filament supply. The bombardment of the cathode by returning electrons now maintains the cathode temperature sufficiently high for satisfactory operation without further heating.

40. Should any fault occur which trips the modulator and removes the modulating pulse voltage, the magnetron current will fall and the relay will be de-energised. The contact then closes to restore the filament voltage.

41. The 200 ohm resistor across the jack-socket J3 ensures that a faulty or dirty back contact does not disconnect C relay solenoid from earth to open the magnetron cathode circuit.

42. A link is provided to short out C relay solenoid when the magnetron is operated on $\frac{1}{2}$ microsecond pulses at a PRF of about 600 c/s.

43. It is essential that the magnetron pulse voltage should not be applied until the magnetron filament has been heated for at least two minutes. In certain models of TR.3523E and F an additional slow switching safety device is incorporated. The D. relay has a double solenoid which is energised from a 24 volt tap on the primary of the magnetron filament transformer. Thus the contacts D1 and D2 are closed at the instant of switching on the 80 volts to the magnetron filament transformer. D1 operates the safety valve in the modulator and opens the primary circuit of the E.H.T. transformer feeding the voltage doubler circuit. No pulses can be fed to the magnetron while D1 is closed. Contact D2 shorts out R104, 60 ohms, in series with the coil of the thermal switch and the 24 volts applied to this coil heats it sufficiently to open the thermal switch after two minutes. This removes the 24 volts which was energising the D relay and opens contacts D1 and D2. D1 closes the EHT circuits in the modulator allowing the magnetron to be pulsed. D2 puts R104 in series with the heater coil of the thermal switch and limits the current in it to a value which will keep the coil at a constant temperature and the switch open.

Over voltage protection

44. Should the magnetron become defective it will no longer present the correct impedance and abnormal voltages may appear on the pulse transformer. Fig. 7 shows that the overswing eliminator diode, V15, is paralleled by a CV233 spark gap in series with a protective relay, D/1. This spark gap is hydrogen-filled and has a breakdown voltage of 5 ± 0·5 kV. If an appreciable overvoltage appears on the transformer primary the mean current passed by the spark gap will energise the protective relay. The closing of the contact D1 operates the safety circuits in the modulator unit.

45. The result of operating the safety circuits in the modulator unit is to remove the supply voltage to the primary of the transformer which feeds the EHT power pack. There is therefore no further application of modulating pulses to the pulse transformer.

46. The 1 microfarad condenser across the relay D/1 smooths the current pulses passed by the spark gap. A transient overvoltage will not cause the safety circuits to trip because of the delaying effect of this condenser.

Overswing elimination circuits

47. Fig. 7 shows that the pulse transformer primary is paralleled by:—

(a) The overswing diode, V15, with a series resistance of 40 ohms in its anode lead.

(b) A 1 mH choke, L2.

These components have been incorporated to minimise the undesirable effects of oscillations on the pulse transformer and the pulse cable from the Modulator when the modulating pulse collapses.

48. Such oscillations may arise from two causes. For the duration of the modulator pulse the current builds up in the primary of the pulse transformer and energy is stored in the surrounding magnetic field. When the pulse collapses this energy is dissipated in the form of oscillations which will appear in the secondary circuit.

49. Oscillations after the termination of the primary modulating pulse will appear on the pulse cable and the transformer if the magnetron impedance is such as to present an appreciable mismatch to the pulse line. The amplitude of oscillations resulting from this cause will, of course, depend on the degree of mismatch present. The voltage waveform applied to the magnetron when the primary modulating pulse collapses will be the combined effect of mismatch and normal ringing.

50. Oscillations after the termination of the modulating pulse are undesirable since they may cause secondary pulsing of the magnetron on the negative swings applied to the magnetron cathode. There may also be radiation from the pulse cable and from other leads. Both effects will tend to reduce the minimum useful range.

51. The overswing diode in TR.3523A is a hard valve, type CV265. When its anode is swung positive by any overswing on the back edge of the modulating pulse it conducts heavily and presents a very low impedance. The pulse transformer primary is then shunted by about 40 ohms so the oscillations are heavily damped on the positive swings. In TR.3523 a hydrogen filled CV215 was used in the place of the CV265. In this case another 40 ohm resistor R101 was placed in series with R102.

52. During the modulating pulse a current builds up in the 1 mH choke, L2, and energy is stored in the resultant magnetic field. When the pulse collapses the choke tends to ring at a frequency governed by its inductance in parallel with its self-capacity and shunt stray capacity. The initial upswing coincides with that appearing on the transformer due to ringing so the diode anode is driven up harder than would have been the case had the choke been omitted. The ring on the choke is critically damped by the heavy current passed by the diode so it decays back to earth potential instead of oscillating. The transformer and pulse cable ringing is superimposed on this positive decaying voltage which serves to raise the mean level of the oscillations above earth potential. The diode damping is therefore applied on both positive and negative swings so that oscillations are rapidly damped out.

53. The first negative swing of the transformer ringing has sufficient amplitude to override the upswing of the choke and cause a " spike " of approximately —1kV to be applied to the magnetron. This spike should only cause very low power radiation from the magnetron.

54. The accentuated overswing resulting from the incorporation of L2, also serves to give a sharp clean termination to the primary magnetron pulse.

55. The filament supply for the overswing diode is obtained from a winding on the magnetron filament transformer.

The waveguide output line

56. From fig. 13 it can be seen that the waveguide output line is made up of three sections. The first section, supplied with the magnetron, forms an integral part of the 725A magnetron assembly. The magnetron output probe extends about half-way across this rectangular guide section. It acts as a launching probe to set up an H_{01} wave in the guide. A fixed matching stub is fitted.

57. The first rectangular guide section is fitted to the second (or bend) section with a butt flange. This point is made airtight with a rubber ring. The bend section includes the right angle bend (in the E plane) with a 2½ inch radius. With such a gradual bend very little reflection occurs and there is a reasonably smooth flow of energy down the guide.

58. The bend section terminates in a ditched flange which forms one side of an airtight joint. This joint is fitted with a mica seal which serves to seal off the air in the first two guide sections. These are therefore kept at atmospheric pressure regardless of aircraft height. This means that the magnetron probe is always at atmospheric pressure no matter what the pressure in the third and final guide section. RF arc-over at voltage maxima in the pressurised sections are unlikely if the seals

at both joints are thoroughly airtight. A Schrader valve is provided on the magnetron side of the mica seal allowing the magnetron probe to be kept at any desired pressure.

59. The mica window, 0·003 in. thick, is cemented to a circular metal backing plate. This arrangement is sandwiched between two rubber rings seated on the ditched flanges. A locking ring allows the joint to be made airtight. Care must be taken to avoid damage to the thread or it will not be possible to tighten the joint properly.

60. The pressure seal stands a pressure difference of 1 atmosphere without leak or damage provided the thrust forces the mica back against its backing plate. Obviously, the window must be inserted with the mica facing the magnetron and the backing plate facing the scanner. The single mica seal is now being replaced by double mica seals which give better performance at heights greater than 20,000 ft. The Stores Ref. of the new seal is the same as that of the old one, namely 10DB/6877.

61. The final section of the main guide run passes from the pressure seal joint to the front panel. This section has three side branches leading to the anti-TR cell, TR cell and the AFC mixer.

62. It will be noted that there are no RF output adjustments in the TR.3523 Series. A graduated neon output tester forms part of the Test Set 263. This output tester provides a means of assessing the RF output from the magnetron.

RECEIVER SECTION

63. This section may be considered under the following major headings :—

(a) The anti-TR cell.

(b) The TR cell.

(c) Details of the 723 A/B klystron local oscillators.

(d) Local oscillator power pack and switching.

(e) The mixer bridge.

(f) The AFC system.

(g) The head amplifier.

The anti-TR cell

64. An argon-filled CV115 valve is used as the anti-TR cell. The tuning piston is adjusted to obtain the maximum flow of echo signal energy into the TR cell, using the method described in paragraph 168 or 180.

The TR cell

65. The appearance of the TR cell and its location in the waveguide assembly can be seen in fig. 13.

66. The probe, or " keep-alive " electrode, of the TR cell (which is a CV221 or 1B25 type of valve) has its own power pack which provided about —1,000 volts, V9 being the rectifier. The current passed by the probe must not exceed 100 to 200 microamps and a resistance of 5½ megohms is placed in series with the probe to limit the current.

67. If the probe lead has an appreciable stray capacity the initial surge of positive ions to the probe (when the Tx pulse causes flash-over) will charge this capacity sufficiently positively to prevent any further flow of positive ions to the probe. The capacity must discharge through the resistance in series with the probe before there can be another heavy flow to the probe. This means that any appreciable capacity in the probe lead may cause the TR cell to behave like a relaxation oscillator. To prevent this type of action in the CV 221 the series resistance is provided in two resistors, one of which is fitted right up against the probe.

68. The TR cell must be tuned to the magnetron frequency in order that the maximum flow of echo signal energy may pass into the signal mixer crystal. The method of doing this is described under " setting-up procedure."

Klystron local oscillators

69. The 723 A/B klystron uses a very small resonator. A special tuning tool is used to turn the square-headed mechanical tuning control, which varies the effective length of the tuning bows. As the tuning screw is rotated in a clockwise direction the bows shorten and the top of the resonator is pressed down. This increases the capacity between the top and bottom of the cavity and so decreases the frequency of oscillation. Counter-clockwise rotation of the tuning screw will lengthen the bows and increase the frequency. The range of frequency variation given by the mechanical tuning is about 1,000 Mc/s.

70. In paragraph 17 it was pointed out that the frequency of the 723 A/B can also be varied by altering the reflector voltage. Fig. 8 shows that for a suitable setting of the mechanical tuning and a resonator-cathode voltage of +300 volts the 723 A/B will oscillate for five different ranges of reflector-cathode volts. Corresponding to each of these five voltage ranges there will be a specific type of electromagnetic field pattern in the cavity. We describe this behaviour by saying that the cavity oscillates in five different " modes."

71. The different values of the maximum amplitude of oscillation for the five modes arise out of the fact that the electromagnetic field patterns in the cavity are such as to produce different values of electric field intensity in the resonator orifice, and hence different values of positive feedback.

72. If the mechanical tuning is altered the modes shown in fig. 8 are displaced along the horizontal axis of the graph. If the adjustment is turned clockwise to decrease frequency the pattern is displaced to the left. Increase of frequency by turning the adjusting counter-clockwise will move the pattern to the right. The mode corresponding to the highest value of reflector-cathode voltage is frequently missing.

73. A method of demonstrating the various voltage modes is outlined in para. 265.

74. For any setting of the mechanical tuning the 723 A/B oscillates at the same frequency in each of the voltage modes obtainable, provided that the reflector-cathode potential is adjusted for the maximum amplitude of oscillation. As the reflector potential is varied from this point for any mode the frequency

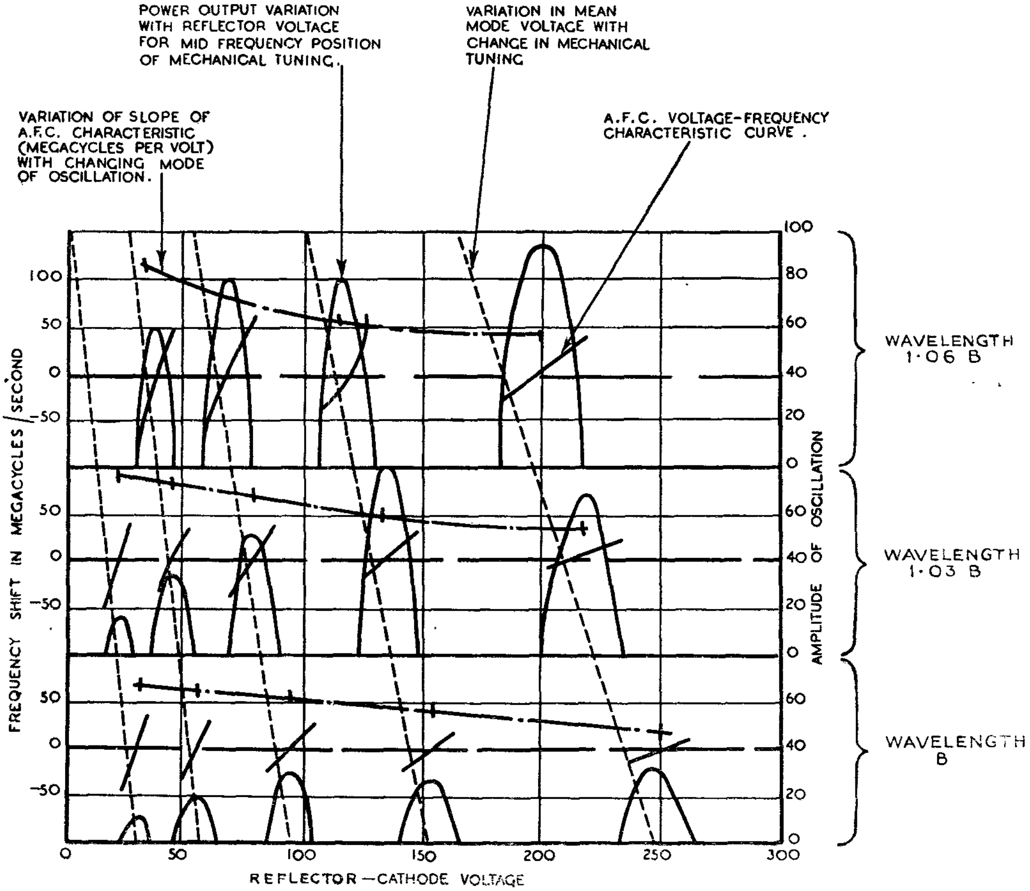


Fig. 8.—723A/B klystron characteristics (1)

is also varied. Fig. 8 shows the frequency swing obtainable in this way depends on the mode. Also, the frequency shift per volt varies considerably over the five modes. Tuning the 723 A/B klystron oscillators by varying the reflector-cathode voltage by means of a potentiometer is termed " Manual tuning" to distinguish this method of tuning from mechanical tuning. As the reflector-cathode voltage is decreased the frequency falls and vice versa.

75. The klystron mode used is that which occurs for a reflector-cathode voltage of —75 to —135V. The maximum amplitude of oscillation will normally occur for a reflector-cathode voltage of about —90 to —100V. The useful frequency range obtainable by swinging the reflector-cathode voltage about the maximum amplitude point is about ± 20 Mc/s. The AFC system uses changes in the IF to develop a change in the reflector-cathode voltage which shifts the klystron frequency to again give the correct intermediate frequency.

76. The range of frequency variation with reflector voltage and the frequency change per volt will depend on the type of load on the klystron and on the tightness of coupling. As the tightness of coupling is increased the frequency range is increased.

77. The materials used in the mechanical tuning mechanism have been especially selected so that their thermal expansion and heat conduction coefficients will co-operate with those of the other parts of the valve to produce a desirable temperature coefficient of —0·05 to —0·25 Mc/s. per degree Centigrade. This means that as temperature rises the frequency falls.

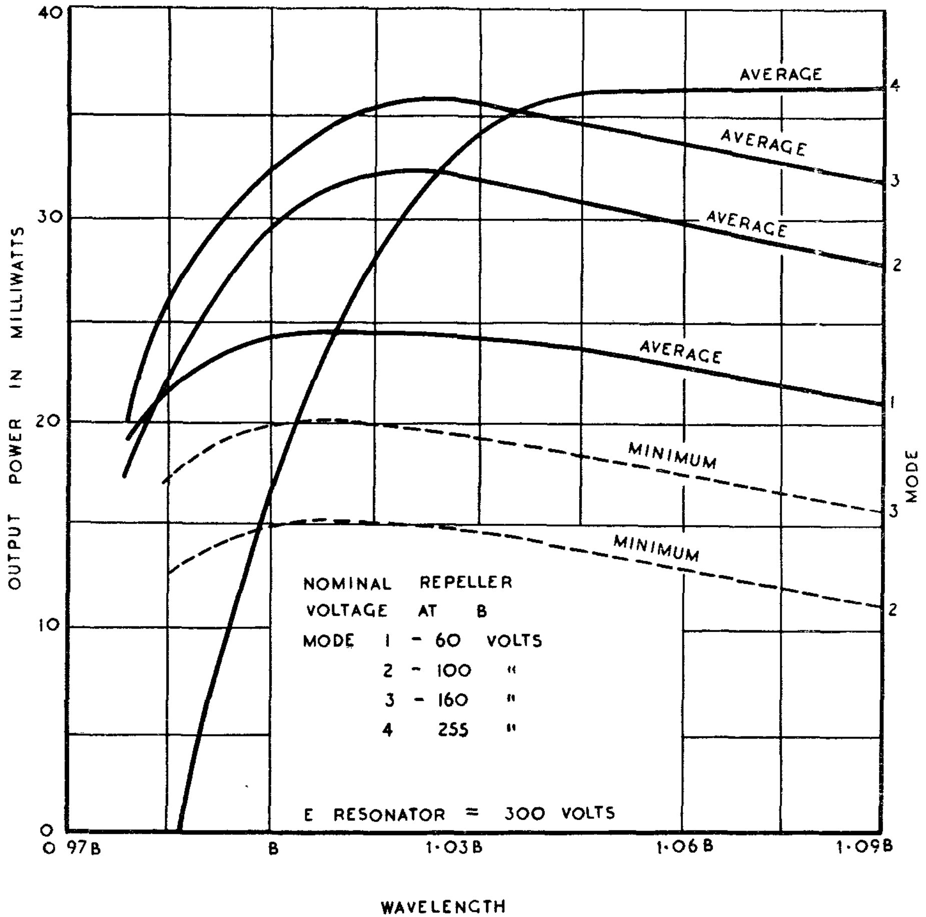


Fig. 9.—723A/B klystron characteristics (2)

78. Varying draughts playing on the valve will produce fluctuations in the oscillating frequency. The screening cans placed over the klystrons serve to minimise this effect.

79. The frequency of oscillation of the 723 A/B is effected by atmospheric pressure, i.e., by the aircraft height. If temperature effects were negligible the frequency could be expected to rise by about 12 Mc/s. as the aircraft climbed to an altitude of 30,000 feet. At 20,000 feet the expected increase due to pressure changes would be about 9 Mc/s. Thermal effects will, of course, always be superimposed on these pressure effects.

80. Fig. 13 shows that the 723 A/B output is taken off by means of a section of coaxial cable. The resonator end terminates in a pick-up loop. The other end is brought out through the valve base in the form of a probe for feeding directly into the mixer guide as a launching probe. The temperature of the probe below the valve base must not exceed 75 deg. C.

Klystron power pack

81. The operating conditions of the 723 A/B klystron oscillators are as follows :—

Heater volts	6·3 v.
Heater-cathode volts	0 v.
Cathode volts	+ 300 to 330 v.
Resonator-cathode volts	+ 300 v. ± 2 v. (Stabilised)
Resonator volts .. .	+ 600 to 630 v.
Reflector-cathode volts (mean)	— 100 v. (app.) (Stabilised)
Reflector volts	+ 200 v. (app.)

The klystron supplies are brought to the valves from the power pack via an 8-way Jones plug and socket, S2.

82. The cathode voltage is produced externally and supplied via pin 6 on the 12-way plug. This line serves as the reference level for the klystrons. The value is 300 to 330 volts positive with respect to earth, depending upon the type of external power pack.

83. The resonator-cathode voltage is an output from a 5U4G full-wave rectifier stabilised by a CV 296 high slope pentode which has a mutual conductance of 12. R58 determines the grid-cathode voltage of the stabiliser and thus the DC drop across its 5K anode load, R61. R58 sets the resonator-cathode voltage to give a value of 300 ± 2V.

84. R58 is situated on a panel on the side of the TR. box, below the klystron power pack assembly. It is adjusted until the voltage across tags 2 and 3 on the same panel is 300 ± 2V. Tag 3 is positive.

85. J4 is in series with the klystron resonator, so that the klystron current can be measured. This should be 20 to 25 mA.

86. A suitable reflector-cathode voltage range is provided by two CV188 neon stabilisers in series with R62 (14K) between earth and the + 300/330 volt HT line. The neons have a constant drop of about 200 volts across them. R70, R71, and R78 therefore have a constant voltage across them and the voltage tapped off R71 is constant with respect to the klystron cathode supply. R71 is the manual tuning control on the panel for use during alignment. The range is from about —60V to —160V. Clockwise rotation of R71 increases the reflector-cathode voltage and increases frequency.

87. In the earlier TR.3523 models the network used to develop the neon-stabilised reflector-cathode voltage is rather different from that shown in fig. 14. In these models the network includes two 180K series resistors between the foot of R78 and the junction of R64 and R65 instead of having the foot of R78 tied to earth through 14K. The values of R70, R71 and R78 in these models are R70 —100K, R71 —200K, R78 —100K.

88. The resistors across 4/3 and 4/4 in the control unit are in parallel with the network R70, R71, R78. The voltage taken off at the slider of the 200K potentiometer in the control unit will then also be stabilised with respect to the klystron cathodes. This potentiometer is the remote tuning control. In the TR.3523 it can only be used to vary the reflector-cathode voltage of the beacon klystron. In the TR.3523A it is possible to use this control to manually tune both klystron oscillators.

89. The mechanical tuning control is at the same potential as the resonator, i.e., at about + 600V with respect to earth. It is therefore necessary to use the insulated tuning tool provided when adjusting the mechanical tuning.

The click stop pointer

90. A special pointer is fitted to the MANUAL TUNING control on the front panel of the transmitter-receiver. This allows a pre-

viously determined setting to be regained after other adjustments have been made to the MANUAL TUNING control.

91. The knob is fitted with a small clutch lever and there is a pointer located above the tuning control. It is used in the following way :—

(a) Engage clutch (by pressing the lever) and rotate the tuning control until the pointer clicks into its stop, in a vertical position.

(b) Release the clutch lever and carry on with the tuning adjustments.

(c) Engage the clutch, and any further adjustments made to the tuning knob will not affect the click stop setting. The clutch lever must be kept down during these adjustments or the stop setting will be lost.

(d) To return to the setting reached at the end of stage (b) rotate the tuning knob back to the point where the pointer clicks into position, still keeping the clutch lever pressed, and the original setting will have been regained.

Local oscillator switching (TR.3523 only)

92. The panel of the TR.3523 has two switches. One of these has three positions labelled NORMAL, INTERNAL and REMOTE. This is a two-card Yaxley switch, SW1. The second panel switch has two positions labelled NORMAL and ADJUST. This is a double-pole, double-throw switch, SW2.

93. The Control Unit 499 also has a three-position switch. These positions are labelled MAN. SIGS, AFC and MAN. BEAC.

94. SW1, SW2 and the Control Unit switch are best studied under the settings required to provide the following facilities :—

(a) Manual tuning of the signal klystron using R71, the panel tuning control.

(b) Manual tuning of the beacon klystron using R71.

(c) AFC on the signal klystron on the bench and in the aircraft.

(d) Remote tuning of the beacon klystron using the tuning control on Control Unit 499.

95. To have manual tuning of the signal klystron on R71, SW1 is set to NORMAL and SW2 to ADJUST. With SW1 set to NORMAL the solenoid of the A relay is floating and the relay is not energised. The contact A2 then connects HT to the resonator of the signal klystron via pin 3 of S2 and P2. The slider of R71 is linked via the second contact of SW1 to the ADJUST contact of SW2 and hence via SW2 and pin 5 of S2 and P2 to the reflector of V18 the signal klystron. Hence the reflector-cathode voltage of V18 can now be varied by altering the setting of R71.

96. The slider of R71 is also connected to the reflector of the beacon klystron via pin 6 of S2 and P2, but since there is no HT on V19 resonator the valve cannot operate.

97. To tune the beacon klystron with R71 we must put HT on V19 resonator. This is done by setting SW 1 to INTERNAL. A relay solenoid in series with R68 is now connected between +300V and earth via the upper section of SW1. The relay is then energised and A 2 changes over to put HT on V19 resonator via pin 4 of S2 and P2. R71 slider is connected to V19 reflector via the other card of SW1 regardless of the setting of SW2.

98. To put AFC on the signal klystron we want HT on V18 resonator and the reflector of V18 connected to the AFC circuits. To achieve the latter requirement we must set SW2 to NORMAL. V18 reflector is then connected to the AFC circuits via SW2 and pin 5 of S2 and P2. What we do with SW1 depends on whether or not we wish to bring the Control Unit 499 into the circuit. When working with a TR.3523 on the bench where the Control Unit 499 is of no interest SW1 is set to NORMAL.

99. If the TR.3523 is to be remotely controlled from Control Unit 499 SW1 must be set to REMOTE. If the Control Unit 499 switch is in the AFC position A relay solenoid is still floating so the relay is not energised. HT is then applied to the signal klystron resonator via A2 just as is the case when SW1 is set to NORMAL. With SW2 also at NORMAL we have AFC on the signal klystron reflector. Hence for normal aircraft operation we have the combination of settings :—

SW1	Remote
SW2	Normal
CU 499 switch ..	AFC

100. Should no display be obtained the fault may be due to a defective signal klystron or to faulty operation of the AFC circuits. The operator can attempt to manually tune in signals on the beacon klystron by setting his Control Unit 499 switch to either MAN. BEAC.

reflector of the Beacon klystron is connected, through position 3 on the switch, to the MANUAL TUNING control R71 so that it may be tuned from the front panel. The BEACON switch position is therefore used when tuning the Beacon klystron on the bench.

110. The REMOTE position (position 4) delegates the tuning of the transmitter to the Control unit, type 499, which can be mounted in the navigator's position in the aircraft. Manual tuning of either the signal/AFC or Beacon klystron may then be carried out from the control unit if required, and this is the only position in which the three-way switch on the control unit has any effect. With this switch at AFC neither of the relays A/2 or B/2 is energised so the situation is just as it is when the switch on the transmitter itself is at NORMAL. When the control unit switch is at MAN. SIGS. the lead W2/1 is connected to earth inside the control unit through the 62K resistor thus energising A/2 but not B/2. The situation is then similar to that which occurs with the transmitter switch at MANUAL, except that the reflector of the signal/AFC klystron is taken through position 4 of the transmitter switch to the slider of the manual tuning potentiometer in the control unit instead of that in the transmitter. The third position of the control unit switch is MAN. BEAC., in which the W2/1 lead is earthed directly through the control unit switch, thus energising both relays and giving manual tuning on the Beacon klystron from the control unit.

111. The switch settings for the TR.3523A may be summarised as follows :—

(a) Manual tuning of signal/AFC klystron on bench.	TR switch—Manual
(b) Manual tuning of Beacon klystron on bench.	TR switch—Beacon
(c) AFC on bench.	TR switch—Normal
(d) AFC in aircraft (usual setting).	TR switch—Remote CU switch—AFC
(e) Manual tuning of signal/AFC klystron in aircraft.	TR switch—Remote CU switch—Man. Sigs.
(f) Manual tuning of Beacon klystron in aircraft.	TR switch—Remote CU switch—Man. Beac.

The mixer bridge

112.

(a) Mechanical details of the mixer bridge are shown in fig. 13.

(b) A schematic presentation is shown in fig. 10.

113. It has been pointed out that the mixer bridge incorporates both a signal mixer and an AFC mixer. The right half of the bridge forms the AFC mixer and left half the signal mixer. The signal klystron is mounted on top of the bridge and its output probe is brought out through the valve base and into the mixer guide through a hole in the upper guide wall. The CW output is then fed simultaneously into both mixers.

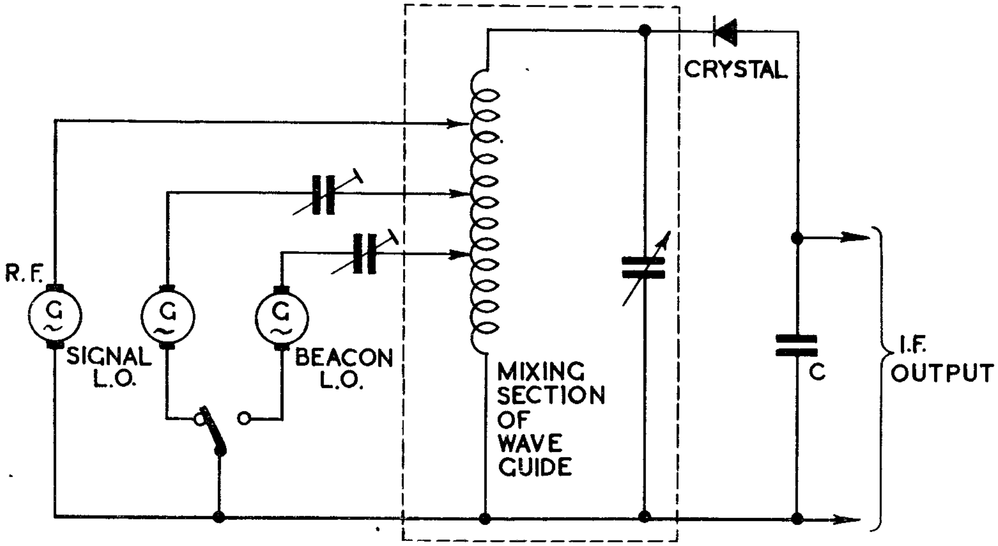


Fig. 10.—Mixer bridge, equivalent circuit

114. The inner and outer conductors of the coaxial output line are the same DC potential as the klystron resonator, i.e., at 600v or 630 above earth. As the guide wall is at earth potential some insulation is required to prevent shorting the klystron power pack output to earth where the probe passes through the guide wall. This insulation is provided by a mica washer through which the probe enters the guide. If this mica washer breaks down the output of the 5U4G rectifier is earthed through R61 (5K).

115. Both mixers are pre-plumbed, i.e., there is no adjustable tuning stub behind the crystal. Since no tuning is available crystals must be used which have suitable impedance characteristics to match the pre-plumbed mixers. To meet this requirement the manufacturer selects CV111's which will operate satisfactorily in the mixer bridge. These especially selected CV111's are then marked with a double green spot and distributed as CV253 crystals. Certain models of TR.3523 and TR.3523A have been sent from the manufacturers with the crystals marked CV111 although they are actually valves, type CV253. There is no need to change these crystals.

116. For optimum heterodyning action the CW voltage applied to the crystal must be set to some particular level which can be indicated by some specific value of crystal current. The value of this optimum CW input voltage will depend on the strength of the signals to be heterodyned. In the case of the AFC mixer the optimum crystal current is taken to be 1 mA. For the signal mixer it is 0·6 mA.

117. The CW input from the signal klystron to either mixer is regulated by means of a coupling screw mounted in the bottom wall of the mixer guide, shown in fig. 13.

118. As coupling screws are provided for each mixer the input from the signal klystron to each mixer can be independently adjusted to give the crystal current of 1·0 mA. in the AFC mixer and a value of 0·6 mA. in the signal mixer. Since the impedance of the tuned circuit formed by the coupling screw in the waveguide will depend on the frequency of the klystron, any appreciable change in the klystron frequency will obviously cause a change in the value of the impedance presented to the klystron by the mixer, and hence of the energy flow into the mixer. The crystal current will therfore vary if the klystron tuning is altered appreciably. Final crystal current adjustment must therefore be made when the klystron frequency is known to be correct.

119. When the coupling screws are adjusted for the correct crystal current the impedance of the tuned circuit will not be equal to the wave impedance of the guide so there will be some reflection of energy at the diaphragm and screw. That is, there will be a standing wave between the klystron probe and the diaphragm. The presence of this standing wave means that the mixer presents a load to the klystron which is partly resistive and partly reactive. The value of this reactive component will vary with the frequency of the klystron. Over parts of the required frequency range the magnitude may be sufficiently great to cause frequency jumps in the klystron instead of a smooth frequency variation as the reflector-cathode voltage of the klystron is varied.

120. To minimise this effect a resistive attenuator has been inserted across the guide close up to the klystron probe. This attenuator is a $1\frac{1}{8}$ inch x $\frac{1}{2}$ inch strip of panilax coated on one side with graphite. It is inserted through two slots in the $\frac{1}{2}$ inch side of the guide. The power absorption in this resistive attenuator is such that the standing wave is reduced to small proportions. No serious difficulty due to frequency jumping should be encountered when the klystron is operating in the —100 volt mode.

121. The signal input to the AFC mixer consists of a suitable portion of the Tx pulse power. A small hole is cut in the top wall of the main guide run to permit some Tx pulse leakage into a short section of circular guide, which can be seen in fig. 13. This section has a diameter below the cut-off value for any wave in a circular guide. It follows then that no wave is actually propagated in this section. What happens is that an evanescent wave is produced, i.e., a wave that is very heavily attenuated and would transmit no energy whatever for distances comparable with a wavelength. The length of this attenuating section is so chosen as to permit a suitable flow of energy into the wider section which will then transmit a low-power Eo wave. This converts into an H_{10} wave in the mixer.

122. The output from the AFC mixer crystal consists of the rectified DC component due to the CW input plus the rectified 1 microsecond pulses at the PRF of the

or MAN. SIGS. and using his remote tuning control. A relay solenoid in series with R68 will be connected between +300V and earth if the switch is set to MAN. SIGS. If it is set to MAN. BEAC. a further 62K is connected in series. In either case the relay is energised and A2 changes over to put HT on the beacon klystron resonator. The slider of the remote tuning control is connected via 4/2 and SW1 to the reflector of V19 which can now be tuned manually with the remote tuning control.

101. The reason for having both the MAN. BEAC. and MAN. SIGS. position on the Control Unit 499 will not be apparent at this stage. This arrangement is designed for use with the TR.3523A.

102. We may summarise the settings of the klystron power switches on TR.3523 as follows :—

(a) Manual tuning of signal klystron.	SW1—Normal SW2—Adjust
(b) Manual tuning of beacon klystron.	SW1—Internal SW2—Immaterial
(c) AFC on signal klystron on bench.	SW1—Normal SW2—Normal
(d) AFC in aircraft.	SW1—Remote SW2—Normal CU499 switch—AFC
(e) Remote manual tuning of beacon klystron.	SW1—Remote SW2—Normal CU499 switch—Man. Beac. or Man. Sigs.

103. Should a TR.3523 be installed in an aircraft with SW2 still in the ADJUST position there is no AFC on the signal klystron reflector. If SW1 is set to REMOTE and the Control Unit switch is set to AFC the A relay is not energised so we have HT on the signal klystron. The reflector of the signal klystron is now tied via SW2 and SW1 to the slider of the remote tuning control. Hence, the signal klystron would now have remote manual tuning.

104. If the Control Unit switch were set to either MAN. BEAC. or MAN. SIGS. the A relay would be energised and A2 would switch the HT to the beacon klystron. As the slider of the remote tuning control is connected to the beacon klystron reflector via SW1, the beacon klystron could now be tuned manually as before. A unit with faulty AFC circuits could therefore have manual tuning on both klystrons if SW2 were left in the ADJUST position with SW1 set to REMOTE.

Local oscillator switching (TR.3523A type only)

105. The panel of the TR.3523A has one switch with four positions which are labelled MANUAL, NORMAL, BEACON and REMOTE. The switch has two wafers which are connected in the local oscillator power supply circuits and the A/2 and B/2 relay circuits.

106. In the MANUAL position the A/2 relay is connected through R69 and R68 to earth and is therefore energised. The B/2 relay which is connected in series with it is not however energised as it has a much lower resistance solenoid and consequently requires a higher operating current than A/2. In this switch position, shown as position 1 on the circuit diagram, the 62K resistor R68 limits the current to a value that is sufficient to operate A/2 but will not affect B/2.

107. With the A/2 relay operated then, the signal/AFC klystron reflector is connected to the slider of R71, the MANUAL TUNING control, through the contact A1 and position 1 on the switch. The resonator of the same klystron is connected to the 600/630 volt line through the B2 contact. The Beacon klystron resonator is disconnected so that only the signal/AFC klystron oscillates, and it can be tuned manually by R71. The MANUAL switch position is therefore suitable for setting up the signal/AFC klystron when running on the bench, the Control unit type 499 having no effect.

108. In the NORMAL position (position 2 on the diagram) neither the A/2 nor the B/2 relay is energised, so the signal/AFC klystron reflector is connected through A1 to the AFC control voltage and its resonator is taken to the HT line as before. The Beacon klystron is completely disconnected. HT is applied to the sweep valve V8 through the A2 contact so that it can oscillate. In this position then the signal/AFC klystron is controlled by the AFC circuits and the control unit still has no effect.

109. At BEACON, the A/2 and B/2 relays are both operated as they are connected to earth via the fairly low resistances R66, R63 and R69. The coil A/2 is shunted by R67 which carries part of the current that would otherwise overload the coil. R66 and R63 are brought into circuit to limit the current to a suitable value. The signal/AFC klystron is then put out of action by having its resonator disconnected from HT by the contact B2. The

magnetron. These pulses will be at the mean of the magnetron and klystron frequencies with an envelope at the difference frequency. The crystal output lead passes out through a mica washer which by-passes the RF to the earth provided by the guide wall. The output voltage applied to the coaxial cable which links the AFC mixer to the pulse amplifier in the AFC circuits, will then be the DC component plus the 1 microsecond I.F. pulses at the difference frequency.

123. This output is applied to the red input Pye plug on the AFC section. L8 is an IF choke which blocks the IF pulses but passes the DC component. If a suitable milliameter is jacked in at J2 this DC component will produce the meter indication we call the AFC mixer crystal current. A suitable meter with a 1·5 mA full-scale deflection is incorporated in the indicating unit 242 of the Test Set 263.

124. The signal input to the signal mixer is fed through the TR cell which should be tuned to the magnetron frequency. The output from the signal crystal will be the rectified CW input to the signal mixer plus the rectified echo pulses. A mica washer by-passes the RF to the earthy guide wall. The output voltage applied to the coaxial cable passing from the mixer to the head amplifier then carries the DC component plus the superimposed IF signal pulses and Tx pulse breakthrough which gets through the TR cell.

125. The signal mixer is coupled to the blue Pye input plug on the head amplifier and J1 is the jack used for measuring the signal mixer current.

126. Fig. 13 also shows the method of coupling the beacon klystron output into the mixer bridge. Since this klystron has no AFC its output is only coupled into the signal mixer. The valve is probe-coupled into a separate section of wave-guide in the same way as the signal klystron is coupled into the mixer bridge. Failure of the insulating mica washer through which the probe enters the guide will earth the 5U4G output through R61 just as in the case of the signal klystron.

127. A 9 inch length of Uniradio 41 carries the beacon klystron output to the signal mixer. The cable terminates in probes at each end, both of which can be adjusted. It is obviously undesirable to have any echo signal energy fed back along the cable into the beacon klystron waveguide when the beacon klystron is inoperative. Such a flow can be reduced to the minimum by pushing the output probe in hard (to put the maximum energy on the cable) and withdrawing the input probe as much as possible. In practice the output probe is therefore set for maximum coupling and the input probe is used to adjust the CW input to the mixer for a crystal current reading of 0·6 mA at J1 when the beacon klystron is operating.

The AFC circuits

128. Referring to fig. 14, the IF pulses from the AFC mixer are applied to V3 grid via C18. V3 is a 45 Mc/s. pulse amplifier. The output from V3 therefore consists of the amplified 1 microsecond IF pulses at the PRF decided by the main equipment.

129. These IF pulses are applied via C29 and C40 to the grids of V5 and V6. The transformer in the anode of V5 is tuned to 47 Mc/s. and that in the anode of V6 is tuned to 43 Mc/s. These valves act as frequency discriminating amplifiers. If the input on their grids consists of 45 Mc/s. pulses, i.e., 2 Mc/s. off frequency for both valves, the voltages developed on the transformer secondaries should be equal. These voltages are applied to the rectifiers V4 and V7. For V4 the smoothing time constant is C25, R24 and for V7 it is C43, R45. With a time constant of 0·015 seconds these will smooth out the rectified DC pulses into a negative DC voltage whose value will depend on the frequency of the signal pulses applied to the grids of V5 and V6.

130. Obviously the negative DC voltages developed by these smoothing circuits should be equal when the IF is 45 Mc/s. As the IF moves towards 46 Mc/s. the input to V4 will exceed that applied to V7 and the negative DC voltage applied to V5 grid will exceed that applied to V6 grid. Conversely, when the IF moves towards 43 Mc/s. the negative DC voltage applied to V6 grid will exceed that applied to V5.

131. V5 and V6 can operate as a cathode-coupled DC amplifier, with R75 and R56 acting as the common cathode load. R28 provides an anode load of 18K for V5, and R38 plus R39 provides a load for V6 which can be varied by means of the potentiometer, R38. If we assume a current of about 7 microamps in

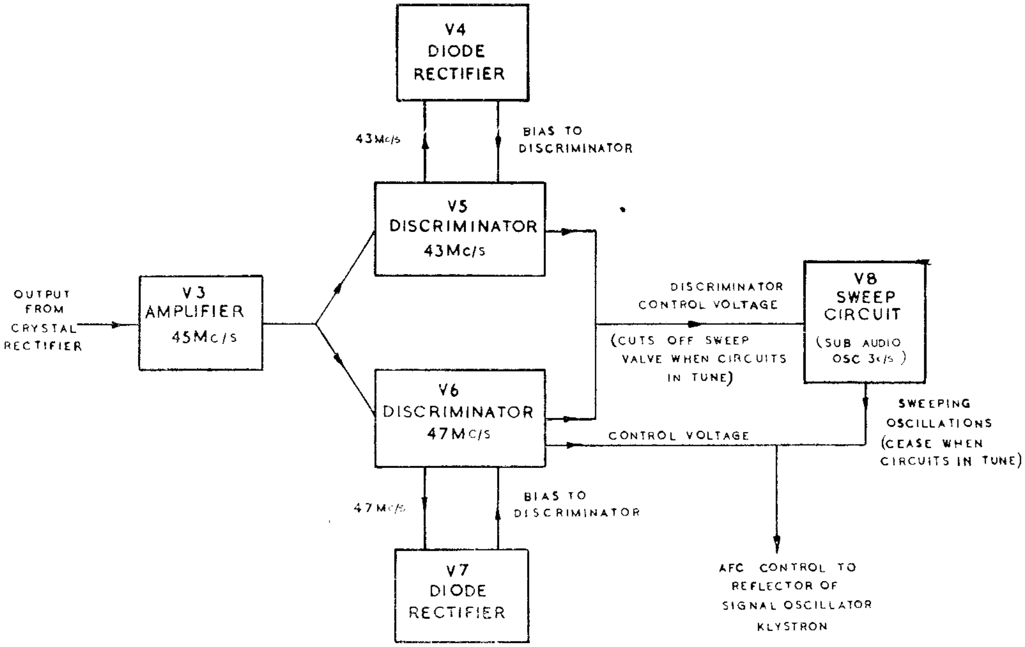


Fig. 11.—AFC. circuits, block diagram

the 1·5 Meg diode loads, R24 and R45, when the IF is 45 Mc/s., the grids will sit at about —10·5 volts with respect to earth. The cathodes will sit at about —8V with respect to earth. The common cathode current through R56 (15K) will be about 20 mA. With equal voltages on the grids of V5 and V6 this current will divide equally between the two valves. If the IF input to the valves shifts from 45 Mc/s. towards 46 Mc/s. the input to V4 exceeds that to V7. The current in R24 will then rise while that in R45 will fall. This behaviour is shown in the diode current curves of fig. 12. This means that V5 grid falls with respect to earth and V6 grid rises. The current flow to V5 than falls and that to V6 rises so the voltage at V6 anode falls as shown in the discriminator output curve. For an input shift from 45 Mc/s. to 46 Mc/s. the voltage at V6 anode is seen to fall 30 volts. The difference in the diode currents is shown to be about 2·3 microamps. The resultant difference in the DC levels of V5 and V6 grids results in the 30 volt fall at V6 anode. If the IF shifts towards 43 Mc/s. the effects outlined above are reversed and the current passed by V6 decreases and the anode voltage rises. The discriminator curve shows that for frequency shifts between 45 and 47 Mc/s. V6 anode potential falls while for shifts between 45 and 43 Mc/s. it rises.

132. V6 anode potential can be applied to the signal klystron reflector by suitable switching combinations. If a change in the magnetron frequency causes a change in the frequency of the IF pulses applied to V3 grid from 45 Mc/s. towards 47 Mc/s. the anode potential of V6 falls and this fall is applied to the signal klystron reflector. Since the klystron cathode voltage is the same as that of the AFC HT line, a fall of the reflector voltage means an increase in the negative value of the reflector-cathode voltage and this causes an increase in the klystron frequency. Since the signal klystron is tuned below the magnetron an increase in klystron frequency means a fall in IF, i.e., the klystron is automatically retuned to correct for the shift in the magnetron frequency. Had the IF shifted in the opposite direction, i.e., towards 43 Mc/s., V7 would receive the greater input and V6 grid potential would go down while V5 grid went up. V6 anode potential would then rise to decrease the reflector-cathode voltage and drop the klystron frequency thus shifting the IF back towards 45 Mc/s.

133. When setting up the AFC circuits it is necessary to adjust the DC voltage supplied from V6 anode to the signal klystron reflector to the value which will produce an IF of 45 Mc/s. This will be equal to the voltage taken

from the slider of R71 when the signal klystron has been tuned manually on signals, R38 being adjusted during the setting up procedure to fulfil this condition. Figs. 14 and 5 show two test points which can be used for this purpose. If a sensitive voltmeter across these points reads zero the voltage tapped off from V6 must be equal to that taken from the slider of R71. If the reading is not zero R38 can be adjusted to make it zero. The method of adjusting R38 is discussed in paragraph 171.

134. Figs. 5 and 14 show jack sockets in series with the AFC diode loads R24 and R45. These jack sockets, J5 and J6, permit measurement of the diode currents on a suitable microammeter. The Indicating Unit Type 242 of the Test Set 263 contains a 0-50 microamps full scale deflection meter which is suitable for this purpose. When this meter is jacked in at either of these sockets a meter indication of about 5—7 μA should be obtained when the signal klystron is tuned to the correct frequency and the PRF of the Transmitter is about 670 with a pulse width of 1 microsecond.

135. The jack sockets J5 and J6, the potentiometer R38 and the AFC test points are all located on a panel on the right hand side of the unit.

136. C24, R23 and C44, R46 act as filters to keep the IF voltages off the jack sockets J5 and J6. C30, R33 and C37, R36 are similar filters which decouple the cathodes of V5 and V6. Additional filtering is introduced on the grids, anodes and screens of V3, V5 and V6.

137. C46 and R47, with a time constant of 0·025 seconds, serve to smooth out variations in the DC voltage applied to the signal klystron from V6 anode.

138. C61 (·02 microfarad) effectively ties the grids of V5 and V6 and prevents one grid potential shifting relative to that of the other in the period between pulses. If the time constants C25, R24 and C43, R45 were equal in value there should be no need for C67. Since component tolerances must be allowed for there is a possibility of a greater exponential

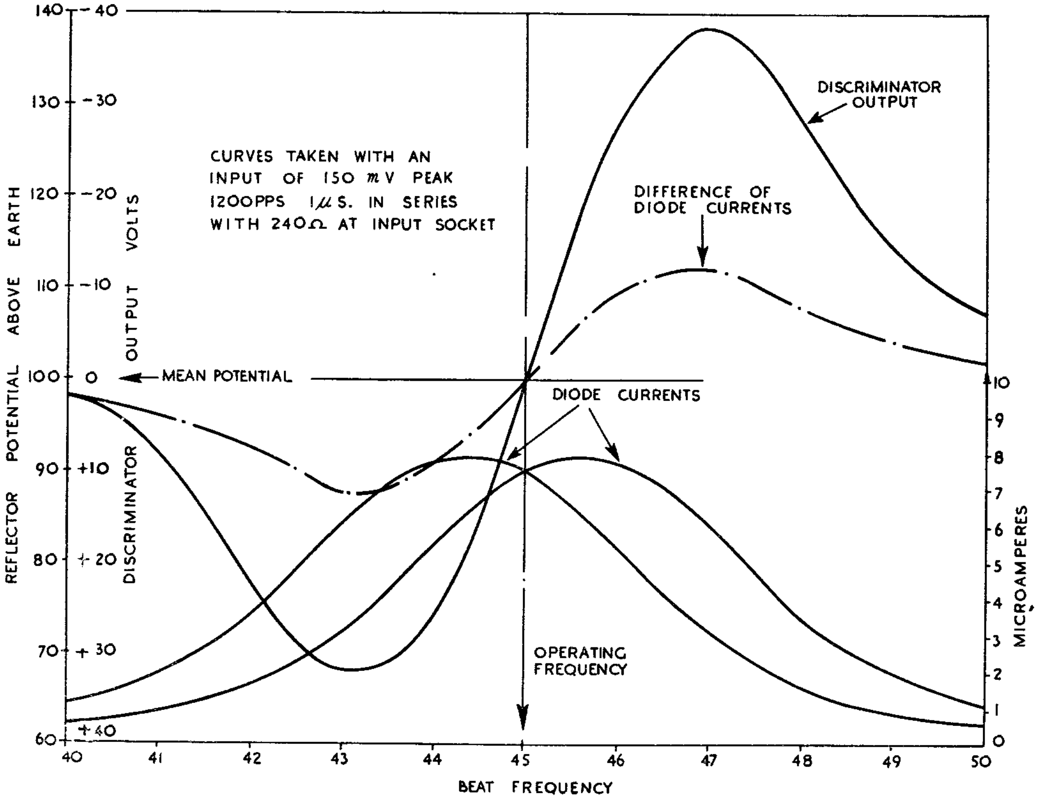


Fig. 12.—Discriminator curves

decay at one grid than at the other in the 100 microsecond period between pulses. Such a difference is equivalent to an input voltage to the cathode-coupled amplifier V5, V6 and will tend to cause frequency shifts in the klystron. By tying the grids with C67 any such effect due to component tolerances can be effectively counteracted.

139. Fig. 12 shows that the curves for the diode currents do not have their maxima at the 43 and 47 Mc/s. marks. This may at first seem rather odd in view of the fact that the anode transformers of V5 and V6 are tuned to these frequencies. It must be remembered that the anode circuit of V3 is tuned to 45 Mc/s. so its ouput falls somewhat as the frequency shifts from 45 Mc/s. toward 43 Mc/s. or 47 Mc/s. Hence, the fall in input applied to the grids of V5 and V6 outweighs the increase in the output from V5 and V6 transformer secondaries at the 47 Mc/s. and 43 Mc/s. points. The design of the AFC circuits to give a suitable discriminator output voltage involves a co-ordinated performance from V3, V4, V5, V6 and V7. Changes in the emission of these valves, or in the characteristics of their tuned circuits or DC loads, will upset AFC performance.

140. Another significant point to bear in mind about the cathode-coupled amplifier V5, V6, is the relation between anode current and grid voltage. We have pointed out in paragraph 131 that for a 45 Mc/s. input we might expect the grids to sit at about —10·5 volts and the cathodes at around —8 volts, when the common cathode current would be approximately $\frac{308}{15}$ or 20·5 mA. Suppose there were no pulse input. The grids would then be at zero volts and the cathodes at say —2·5 volts. The common cathode current would then be about $\frac{297 \cdot 5}{15} = 19 \cdot 8$ mA. The slight decrease in the common cathode current would appear mainly as a drop in screen current and the anode current would be hardly affected. This feature makes it possible to adjust R38 without applying any signal from the AFC mixer to the AFC stages since the absence of this input has no significant effect on the anode current passed by V6. To change this current it is necessary to shift the potential of V6 grid relative to that of V5 by injecting an input whose frequency differs from 45 Mc/s.

141. We have seen that the AFC circuits can correct the reflector voltage of the signal klystron for IF changes between 43 Mc/s. and 47 Mc/s. It should be noted that, if a correction is called for, the voltage at V6 anode must change. This means that the grids of V5 and V6 must be unbalanced. This means in turn, that the IF cannot be exactly 45 Mc/s. Now if it is necessary to drop the reflector voltage by 1 volt the IF will shift from 45 Mc/s. to 45·05 Mc/s. If the magnetron frequency shifted up 10 Mc/s. the klystron frequency should follow up 10 Mc/s. This calls for a reflector voltage drop of about 5 volts and this would result in an IF of about 45·15 Mc/s. This shows that appreciable corrections can be applied without shifting the IF sufficiently to affect the sensitivity of the receiver.

142. If the set is lined up on the bench and later switched on in the air where the pressure and temperature are materially different, it may be that the initial input to V3 from the AFC mixer is so far off 45 Mc/s. as to apply negligible inputs to the grids of V5 and V6. Consequently there will be negligible change in the current passed by V6 and the klystron frequency cannot then be corrected to give an IF of 45 Mc/s. To cover this contingency the sweep valve, V8, has been incorporated in the circuit.

143. The following points should be noted about V8 :—

(a) The grid leak R5, 470K ohms is returned to the slider of a potentiometer situated above R38 on the side panel of the amplifying unit, type 226. This potentiometer is in series with R56 in the common cathode load of V5 and V6 and the potential on its slider is therefore dependent on the cathode current of V5 and V6. This is a minimum when the discriminator circuit is in operation. The potential then applied to V8 is sufficient to cut off the valve. Should the IF be outside the 43-47 Mc/s band the discriminator circuit will not be working and V5, V6 cathode potential will be high due to the valves passing maximum cathode current. The potential of the R75 slider will rise at the same time cutting V8 on its grid and will cause the IF to sweep at 2 c/s through the 43-47 Mc/s band. The input level at which the sweep valve will be cut off can be varied by adjusting R75 but this setting is critical and should only be varied when it is absolutely certain that such adjustment is necessary.

(b) The anode of V8 is coupled back to the grid via the CR combinations C48 R49, C49 R50, C50 R51. The sum of the phase shifts introduced by the condensers is such as to provide positive feedback on the grid of sufficient amplitude to produce sustained oscillation. That is, V8 is a phase shift oscillator stage. The frequency of the sine wave appearing at the anode is about 2 c/s.

(c) This 2 c/s sine wave is applied via C47 and R48 to the signal klystron reflector to vary the reflector voltage sinusoidally about the mean level set by R38.

144. If when the equipment is switched on in the aircraft the IF pulse input to V3 is so badly off frequency that V5 and V6 grids are not biassed back, the current passed by the valves rises sufficiently to switch V8 on. The 2 c/s sine wave on the klystron reflector causes the klystron frequency to swing sufficiently widely to make the IF pass through the 43-47 Mc/s. range, when V5 and V6 grids will be biassed back and V8 will be cut off. The AFC circuits will " lock " at the point where the IF sits off 45 Mc/s. by the amount required to correct the klystron frequency by the amount required to give this offset. V8 thus serves as a " search " oscillator which sweeps the klystron frequency until the AFC circuits lock.

145. It should be noted that R75 must be set to fulfil two requirements :—

(a) V8 must cut off before it can sweep the klystron frequency through the band that will give an IF inside the 43 to 47 Mc/s. band. Trouble of this sort will show as continued sweeping, indicated by the variation in diode current on a meter jacked in at either J5 or J6.

(b) V8 must not cut off on the current passed by V5 and V6 when the IF passes through the sub-harmonic 22½ Mc/s. This fault will appear as a locking of the AFC with a low diode current but very small echoes or no echoes at all. Details of adjustment are discussed under the setting-up procedure.

(c) In certain early models of TR.3523 R48 varied from 0·5 M ohms to 2 M ohms. This was a common cause of failure of the AFC circuit to lock and units in which this fault occurs should be examined to verify that R48 is 1 M ohm.

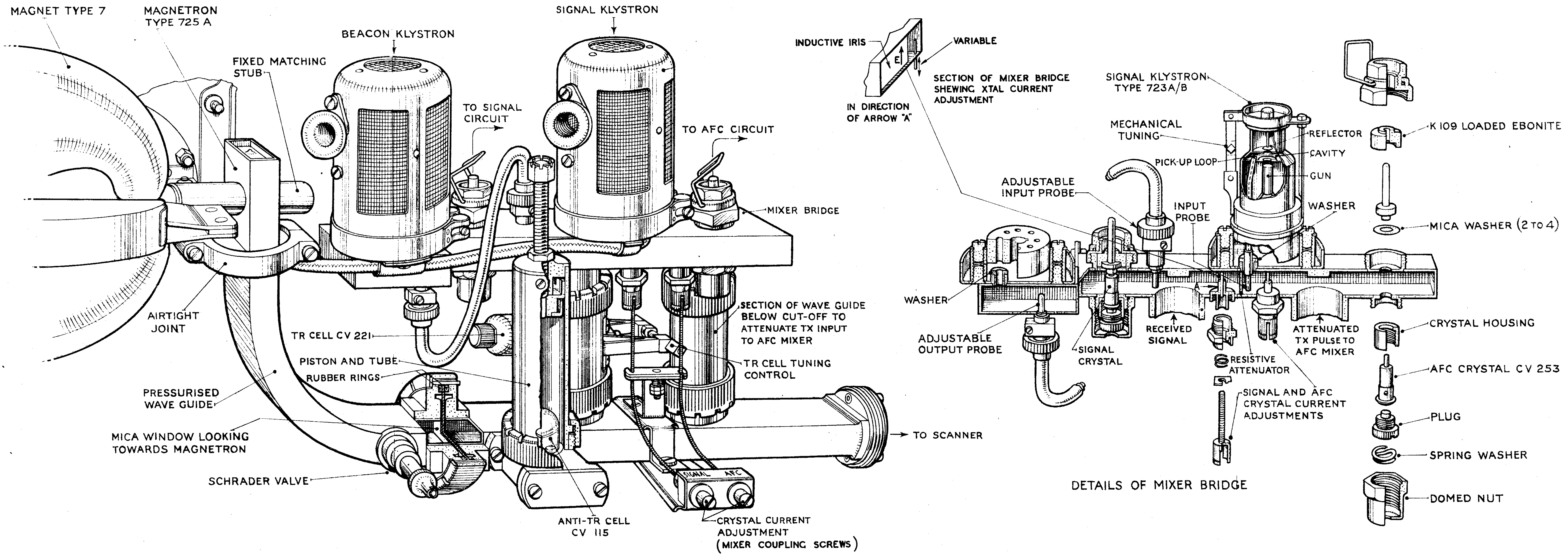
146. In the TR.3523 units with serial Nos. 1 to 35, R75 has a fixed value between 82 and 220 ohms. This value will be selected by the manufacturer for satisfactory AFC performance on test. In units after No. 35 R75 is a 250 ohm potentiometer which is reached by a screwdriver through a hole provided in the right hand side of the main chassis.

147. The —300 volt line must remain at the level used when the set is lined up on the bench if the AFC circuits are to operate properly in the aircraft. Failure of the CV296 to hold the resonator-cathode voltage at —300 volt will likewise upset the AFC operation by shifting the mean level of the reflector-cathode voltage on the signal klystron.

Head amplifier

148. The circuit details of this sub-unit appear in the complete circuit diagram shown in fig. 14. The sub-unit is the universal unit, Amplifying Unit Type 226, a two-stage 45 Mc/s. head amplifier for use with crystal mixers. It is intended to be used in close proximity to the mixer and to feed through a low impedance cable into another box containing the main IF strip. This box may be located some distance from the transmitter unit housing the head amplifier. The gain of the unit is suitable for use with a universal 45 Mc/s. IF strip, such as Receiver Unit 153. The overall gain of the VR91 stages is about 25 db, i.e., a voltage amplification of about 17 times when the screens are at 170V. The bandwidth is slightly in excess of ± 2 Mc/s. for 3 dB. down i.e. for half maximum on the response curve. If the output is taken off through a 95 ohm cable to the Receiver Unit 153 (or modified forms of this unit with the same input stage) the performance of the head amplifier is independent of cable length.

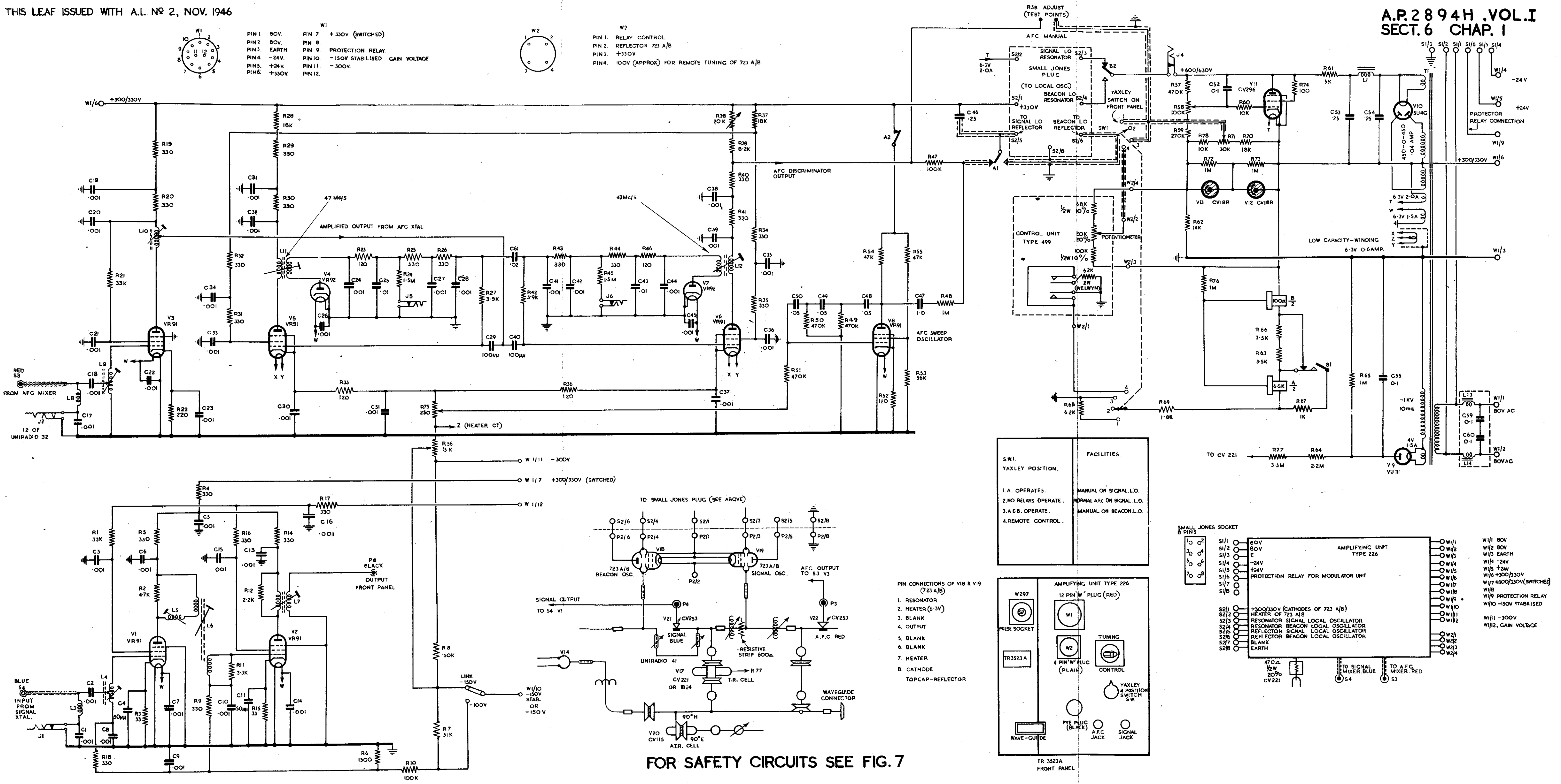
149. The HT supply is obtained from the 300 volt jack in the power unit, type 280, or from the 300 volts switched line in the power unit, type 567 via pin 7 of the 12-way plug.



DETAILS OF MIXER BRIDGE

G942 M15606 7/46 850 C.B.&S. LTD. GP.55.

FIG. 13, T.R. 3523 A WAVE GUIDE ASSEMBLY



S.W.1. YAXLEY POSITION.	FACILITIES.
1. A. OPERATES.	MANUAL ON SIGNAL L.O.
2. NO RELAYS OPERATE.	NORMAL A.F.C ON SIGNAL L.D.
3. A & B. OPERATE.	MANUAL ON BEACON L.O.
4. REMOTE CONTROL.	

FOR SAFETY CIRCUITS SEE FIG. 7

FIG.14—T.R.3523A CIRCUIT DIAGRAM

G2011 M23685 12/46 850 C.B.&S.LTD GP55.

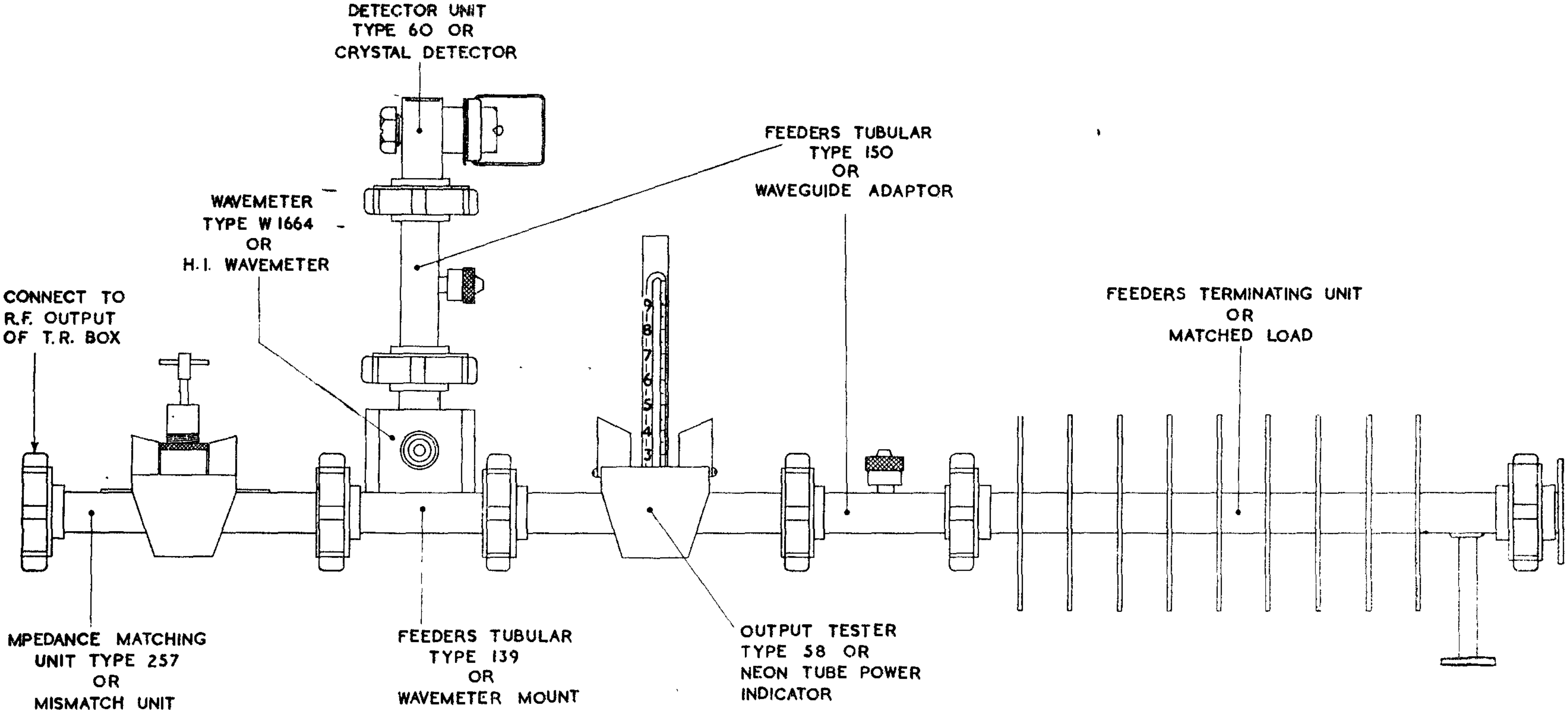


Fig. 15.—Method of assembling test set, type 263

the signal and AFC crystal currents, and two 0-50 microammeters are used to monitor the discriminator diode currents. Provision is made for switching one of the microammeters to measure the Forward-Backward Resistance ratio of crystals. This test set also provides for tapping the 12-way connector to the unit for power supply measurements. A fuller description will be given when this test set becomes available.

157. Test set, type 289 is described in A.P.2896AB.

158. Test kit, type 25 is a kit of connectors and adaptors to enable American FM test sets to be used with British X-band equipment. The main parts in the kit are an American-to-British waveguide adaptor, a directive feed, and a 230-115 volt transformer.

159. The TS-146/UP and its production version, the TS-147/UP are described in the American "Handbook of Maintenance Instructions," number CO-AN 08-35 TS 146-2. The TS-13/AP is an X-band signal generator which can provide exactly the same facilities as the TS-146/UP except that it does not produce a "swept" output. Provision is made, however, for external modulation of the output frequency, and a simple modification to the monitor will give a sawtooth waveform of the required amplitude and duration which, when fed to the TS-13/AP will produce the required output. A full description of the TS-13/AP is given in the American "Handbook of Maintenance Instructions," number CO-AN 08-35 TS13-2. The TTX-10(RH) and the TTX-6(RH) perform the same functions as the TS-146/UP, but are earlier versions and are more liable to interference troubles They are described in the Radiation Laboratory Report M-169.

160. The two basic procedures are described in detail. It is pointed out that the procedures using an FM test set is based on American test sets and is applicable to any of them. A further section details the differences which have to be noted when using the TS-13/AP as an FM test set. The use of the British test set is somewhat different and a separate procedure will be prepared when this test set becomes available.

161. *Note*: The usual meticulous care of crystals must be observed. In particular the modulator must be switched off at all times when connection is being made to, or broken from, the mixed outputs.

PROCEDURE USING TEST SET, TYPE 263 AND ECHOES

162. *Crystal checks.* Before applying power, the Forward-Backward Resistance ratios of the signal and AFC crystals must be checked, using the test panel connected to J1 and J2. The forward resistance should not exceed 200 ohms, and the backward should not be less than 1,000 ohms. This test will only reject bad crystals, and it should not be assumed that a crystal is good if it passes the test.

163. *Preliminary checks*

(i) Check that the "—100/150" Link and the "$\frac{1}{2}$ μsec 600 cps" links are in the correct positions.

(ii) Ensure that the klystron is firmly seated and held in its base, to prevent any coupling change.

164. *Power supply checks*

(i) Measure the —300V supply, and check that it lies within 5V of its nominal value, which may or may not be 300V depending on the TR. box. If it is outside these limits the voltage regulator control on the appropriate power unit must be adjusted to bring the voltage to the correct value. It is important that the supply voltage should be the same during setting-up as it is under operating conditions in the aircraft. If it becomes necessary to adjust the voltage control panel, checks should be made on the other unstabilised supplies, e.g., the +300V or +330V, filament volts, etc.

(ii) Set the internal stabilised supply for the local oscillators to 300V by means of R.58. This should be measured between the external 300V supply and the junction of R.61 and R.57. Clearly labelled test points are provided in Bush production units. R58 should then be locked.

(iii) Check the stabilising valve for microphony by tapping the valve and seeing that the output remains constant.

165. *Magnetron checks*

(i) The test set, type 263 assembly is connected to the waveguide output of the unit and the dummy load used to absorb the power. The probe of the mismatch unit should be withdrawn. The output of the detector unit is connected to the monitor, type 28 set to 10 µsec and X20. Switch on the modulator.

(ii) Check that the ATR Cell is functioning by observing the glow, which should be only across the iris lips. If it extends widely, or if there is sparking across the glass dome, the CV.115 must be changed. Failure to glow and abnormal glow may also be caused by mistuning of the chamber, and this should be checked.

(iii) The power output of the unit is then measured by noting the length of glow in the neon output tester. This reading should be recorded as a comparative method of assessing the power output, since the length of glow is proportional to the peak voltage. (It is also proportional to the PRF and the pulsewidth but this is negligible within the limits of H2S.) Calibration of later models may be such that a quantitative measurement may be taken.

(iv) Tune the wavemeter, type W.1664 until a pulse is visible on the monitor and carefully maximise.

(v) If the pulse is blurred on the apex or if a trace is showing through its base, the magnetron is moding, and must be replaced. Frequency splitting will be indicated by double-humped tuning or in severe cases by two discrete tuning points, and such magnetrons must again be replaced.

(vi) If the magnetron appears satisfactory, note the wavemeter reading. This may be converted to a figure in megacycles if it is remembered that the calibration figure on the wavemeter is for 9375 Mc/s and that one division on the micrometer head is equal to ½ Mc.

(vii) Set the mismatch probe in, and slide the carriage through its full travel. This introduces a mismatch standing wave ratio of 0·7 to 1 varying in phase, corresponding to the worst scanner conditions. If frequency pulling is occurring, the pulse seen on the monitor will decrease in amplitude or disappear. The upper and lower limits of frequency pull must be determined with the wavemeter. If these differ by more than 15 divisions (7·5 Mc.) from the reading obtained in (vi), the magnetron must be rejected. Watch for signs of moding or frequency splitting with varying mismatch also. The indications will be as in (v) above. Withdraw the probe.

(viii) Record the magnetron current at J3, which should lie between 7 and 9 mA.

166. *Tuning TR cell*

(i) If strong, steady signals are available, this adjustment may be carried out using these signals after the local oscillator has been tuned.

(ii) If not, switch to INTERNAL on the TR.3523 or MANUAL on the TR.3523A or E, and adjust the tuning control (R71) until no crystal current is observed in the signal crystal, i.e. the klystron is set between modes.

(iii) Fit the iris attenuator between the main waveguide and the TR cell, and observe the pulse from the signal mixer Pye plug on the monitor type 28 on 10 µsec and X20.

(iv) Carefully adjust the TR cell tuning for maximum amplitude of the transmitter pulse.

(v) Reconnect the Pye plug to the head amplifier.

(vi) Remove the iris attenuator and reassemble the waveguides.

167. *Tuning beacon klystron for signals*

(i) In the TR.3523, the beacon klystron is used for Manual tuning of signals on both MANUAL and BEACON switch positions in the control unit, and the signal klystron is exclusively used for AFC. In the TR.3523A or D however, the signal klystron is employed for AFC and for manual tuning on the MANUAL switch position, whilst the beacon klystron is operative only on the BEACON switch position, and in Mk. III H2S is merely used as a stand-by klystron for manual tuning of signals.

(ii) Disconnect the test set, type 263 and connect the unit to the scanner. Connect the receiver output to the monitor, type 28 on 100 µsec and X5. Jack in the test panel meters to read the crystal currents and discriminator diode currents. The microammeters should not be connected until the unit has warmed up, if it was switched off fully on the completion of the tests detailed in para. 168.

(iii) On the TR.3523, switch SW1 to INTERNAL and SW2 to NORMAL. On the TR.3523A or E switch to BEACON. In both cases this results in making the beacon klystron operative and tuning it by the internal stabilised manual tuning control, R71.

(iv) Ensure that the coupling probe into the beacon klystron waveguide is at maximum coupling, and lock it there. Set the mixer coupling screws fairly well out ($\frac{1}{2}$ to $\frac{5}{8}$ in. protruding below the base).

(v) Vary the setting of R71 to determine the number of modes obtainable, i.e., the number of positions which give signal crystal current, adjusting the coupling into the mixer bridge, if necessary, to keep the crystal current in the region of ·5 mA. If only two modes are obtained, use the more clockwise setting, if three, the middle setting. This should be the " 90 volt " mode, and may be checked by measuring the voltage between the reflector and the external 300 volt supply, which should lie between 75 and 135 volts. Adjust R71 for maximum signal crystal current on the correct mode.

(vi) Now tune the beacon klystron mechanically through its range, keeping the signal crystal current approximately at maximum by means of R71 until signals appear. It may be necessary to adjust the probe into the mixer bridge if the current changes widely from 0·5 mA.

(vii) Two tuning points will be found on the mechanical tuning, 45 Mc/s above and below the magnetron frequency. If any wide difference in crystal current obtained on the two points exists, select the point with the higher current; if not, select the lower frequency point, which is the more clockwise of the two.

(viii) The mechanical and manual tuning must now be very carefully adjusted so that the klystron is producing the maximum amplitude of oscillations at the correct frequency, i.e. so that it is operating on the peak of the mode. The coupling into the mixer bridge will then be reduced to a minimum, in turn reducing back-coupling losses and pulling by the klystron waveguide. This is done by the following step-by-step method.

(a) Determine the direction of rotation of R71 which increases the crystal current. Move the control slightly in this direction.

(b) Turn the mechanical tuning in the same direction to bring the signal amplitude back to maximum. The crystal current may now be higher or lower than that obtained before.

(c) Make alternate adjustments as above, until signal amplitude and crystal current are both at a maximum.

(ix) When the optimum position of mechanical tuning has been determined, "rock in " the control to its final position very carefully, thus ensuring that the spring bows are relieved of all strains tending to shift the tuning.

(x) Adjust the probe coupling the output of the klystron into the mixer bridge until the signal crystal current is 0·6 mA.

168. *Tuning the ATR chamber*

(i) Adjust the ATR chamber tuning plunger through its range, observing the signals on the monitor, type 28, and periodically inspecting the ATR cell through the observation hole.

(ii) The control will be found to have little effect except that at one point the signal amplitude will be reduced, and elsewhere the glow across the ATR cell may be extinguished or become abnormal.

(iii) The plunger must be left so that neither of these conditions is obtained.

169. *Tuning Signal/AFC klystron*

(i) In the TR.3523, switch to NORMAL on SW1 and ADJUST on SW2. In the TR.3523A and E switch to MANUAL. In either case this applies the internal stabilised manual tuning control, R71 to the signal/AFC klystron.

(ii) Vary the setting of R71 to determine the number of modes obtainable, i.e. the number of positions which give crystal current in the two crystals, adjusting the coupling screws, if necessary, to bring the currents to approximately 0·7 mA on the milliammeters. If only two are obtained, use the more clockwise setting, if three, the middle setting. This should be the " 90 volt " mode, and may be checked by measuring the voltage between the reflector and the external 300 volt supply, which should lie between 75 and 135 volts. Adjust R71 for maximum crystal currents on the correct mode.

(iii) Now tune the klystron mechanically through its range, keeping the crystal current approximately at maximum by means of R71, until signals appear. It may be necessary to readjust the coupling screws if the currents change greatly from ·7 mA. Diode current will also appear when the klystron becomes on tune.

(iv) Two tuning points will be found on the mechanical tuning, 45 Mc/s above and below the magnetron frequency. The *lower* frequency which is the more *clockwise* of the two points, must be selected.

(v) The mechanical and manual tuning must now be *very carefully* adjusted so that the klystron is producing the maximum amplitude of oscillations at the correct frequency i.e. so that it is operating on the peak of the mode. This adjustment is even more important than that for the beacon klystron, detailed in para. 167 (viii) and is done by the same step by step method, viz.

(a) Determine the direction of rotation of R71 which increases the crystal current. Move the control slightly in this direction.

(b) Turn the mechanical tuning in the same direction to bring the signal amplitude back to maximum. The crystal current may now be higher or lower than that obtained before.

(c) Make alternate adjustments as above until the signal amplitude and crystal current are both at maximum. The diode currents should then be equal (± ·5 μA) and between 5 and 8 μA.

170. *Adjustment of mixer coupling screws*

Adjust the mixer coupling screws so that the signal crystal current is 0·6 mA, and the AFC crystal current 1 mA.

171. *Adjustment of AFC circuit*

(i) The adjustments to the AFC circuit are two in number, and must be carried out with meticulous care.

(a) Adjustment of the static balanced output voltage from the circuit to be equal to the optimum reflector voltage required by the klystron when on tune, i.e. under the conditions obtained in para. 169 (R38 setting).

(b) Adjustment of the amplitude of the voltage change on the cathodes of the discriminator valves, occurring when the klystron frequency is correct, which is fed to the sweep valve, so that the AFC circuit readily locks from the sweeping state, and locks at the correct point (R75 setting).

(ii) With the switches and mechanical and manual tuning as set in para. 169, connect a voltmeter between the two test points. These are the output of the AFC circuit, and the output of the internal stabilised manual tuning control. The meter should initially be on at least a 250 volt range.

(iii) Adjust R38 until the meter reading is zero. Repeat on the lower ranges of the meter in turn. The setting of R38 is now nearly correct, i.e. the mean output voltage from the AFC circuit is approximately equal to the optimum voltage found on the manual tuning control.

(iv) The exact setting of R38 must next be determined.

(a) On the TR.3523 switch SW2 to NORMAL and on the TR.3523A and E switch again to NORMAL.

(b) Detune the klystron mechanically in each direction, and note the AFC crystal currents at which the AFC ceases to hold for both directions of mistuning.

(c) Check the locking of the AFC with mistuning in each direction by switching the modulator off and then on, successively reducing the AFC crystal current by the mistuning in steps of 0·1 mA. Note the AFC crystal currents at which the AFC ceases to lock after two sweeps for mistuning in both directions.

(d) If the AFC does not sweep at all, adjust R75 until it does.

(e) If there is any inequality of performance with clockwise and anti-clockwise mistuning in (b) and (c) above, rotate R38 *very* slightly in the same direction as the mistuning producing poor results. Repeat the tests of sub-paras. (b) and (c).

(f) The process should be repeated step by step until a setting of R38 is reached where the performance with clockwise and anti-clockwise mistuning are equal. R38 is then correctly adjusted and may be locked.

(v) The AFC should hold with the klystron mistuned to reduce the AFC current to less than ·3 mA in each direction, and should lock with mistuning which reduces the current to less than ·5 mA in each direction.

(vi) If the AFC will not lock with mistuning to AFC current of more than 0·5 mA, or if on repeated tests it locks on any occasion on a 22½ Mc/s tuning point, R75 needs adjustment.

(a) To improve locking, rotate R75 in a clockwise direction, in the TR.3523, or anti-clockwise in the TR.3523A and E.

(b) To reduce the tendency to lock at the wrong tuning point, rotate R75 in an anti-clockwise direction, in the TR.3523; or clockwise in the TR.3523A and E.

(c) The correct setting is that which gives the best locking performance without any tendency to lock on the wrong tuning point. R75 should be locked at this setting.

(d) If the R75 adjustment is badly out, it may be necessary to readjust R38 by the procedure of (iv) above after it has been corrected. R75, however, should not require a second adjustment.

(vii) The mechanical tuning should finally be set to the position for maximum crystal current. It should be " rocked in " to this position very carefully thus ensuring that the spring bows are relieved of all strains tending to shift the tuning.

172. *Checking remote control*

(i) In the TR.3523, switch SW1 to REMOTE and leave SW2 at NORMAL. In the TR.3523A or E, switch to REMOTE.

(ii) Check that the AFC locks when the control unit is switched to AFC, and that the manual tuning is satisfactory on both MANUAL and BEACON. (These two positions use the same klystron in the TR.3523, but different klystrons in the TR.3523A and E).

Sensitivity

173. It is only possible to assess the sensitivity of the unit from a knowledge of the character of the permanent echoes available from the look-out.

PROCEDURE USING AMERICAN FM TEST SET AND PARTS OF TEST SET, TYPE 263

Crystal, preliminary and power supply checks

174. These checks must be carried out as laid down in paras. 164 to 166.

175. *Connection of test gear and initial adjustments*

(i) The FM test set should be coupled to the output of the TR box by means of a waveguide directional coupler, being connected directly to the attenuated arm of this coupler. If this is inconvenient, the attenuated arm may be coupled to the test set by means of the waveguide coax. adaptors, and a length of coaxial cable. The former method is preferable, however.

(ii) The direct output from the directional coupler should be connected to the test set, type 263 dummy load via the mismatch unit, type 257 and the wavemeter, type W.1664 with detector unit, type 60 (See para. 176). The mismatch unit probe should be out.

(iii) The TS-146 must be switched to TRIGGER and in both cases the INPUT plug must be connected to a modulator violet Pye plug.

(vi) Allow the FM test set at least 10 min. to warm up.

(v) Set the attenuator to maximum attenuation, POWER SET and PHASE fully anti-clockwise, and SIGNAL WIDTH fully clockwise. Now adjust the ZERO SET control in the TTX-10RH for zero meter current, or in the TS-146, the

METER BALANCE control for the meter needle to be at the BALANCE point. This adjustment should be checked periodically throughout the procedure as the Thermistor bridge is liable to drift.

(vi) Switch on the modulator.

176. *Magnetron checks*

(i) Check that the ATR cell is functioning by observation of the glow, which should be only across the iris lips. If it extends widely, or if there is sparking across the glass dome, the CV115 must be changed. Failure to glow and abnormal glow may also be caused by mistuning of the chamber, and this should be checked.

(ii) Connect the output of the detector unit, type 60 to the monitor, type 28, set to 10 μsec. and X20.

(iii) Tune the wavemeter, type W.1664 until a pulse is visible on the monitor and carefully maximise.

(iv) If the pulse is blurred on the apex or if a trace is showing through its base, the magnetron is moding, and must be replaced. Frequency splitting will be indicated by double-humped tuning, or in severe cases by two discrete tuning points, and such magnetrons must again be replaced.

(v) If the magnetron appears satisfactory, note the wavemeter reading. Set the mismatch probe in, and slide the carriage through its full travel. This introduces a mismatch standing wave ratio of 0·7 to 1 varying in phase, corresponding to the worst scanner conditions. If frequency pulling is occurring, the pulse seen on the monitor will decrease in amplitude or disappear. The upper and lower limits of frequency pull must be determined with the wavemeter. If these differ by more than 15 divisions on the micrometer head (7·5 Mc) from the reading obtained above, the magnetron must be rejected. Watch for signs of moding or frequency splitting with varying mismatch also. The indications will be as in (iv) above. Withdraw the probe.

(vi) The wavemeter in the FM test set may be used for the above checks, but as its indication is by a slight meter dip, the adjustments are more tedious, and further, no clear indication of moding or splitting is given, the only indication being a broadening of the resonance point.

(vii) Reduce the attenuator setting on the FM test set until the meter is at " 1 " or " SET " on the TTX-10RH or TS-146 respectively. The final setting must be arrived at from the direction of minimum attenuation to avoid back-lash. Swing the wavemeter control to ensure that it is not near the resonance point. Note the reading in dB on the attenuator. In the case of the TTX-10RH, the dB reading at the red index line must be subtracted from the reading. If the coupling losses are accurately known, they may be added to this figure to give the output power of the unit, in dB above 1 milliwatt. This may further be converted to mean watts or to peak kW by the standard formulae, but in practice it is sufficient to use the dial readings qualitatively.

(viii) Tune the wavemeter very slowly through its range until a dip in the meter indication is observed. Carefully minimise the dip, note the reading. In the case of the TS-146, multiply the reading by 10 and add to 9285 to give the magnetron frequency in Mc/s. The direct reading from the TTX-10RH is similarly added to 9285.

(ix) Record the magnetron current at J3, which should lie between 7 and 9 mA.

177. *Tuning FM test set klystron to magnetron frequency*

(i) Set ATTENUATOR to maximum attenuation. Turn POWER SET to approximately half-setting in a clockwise direction, and leave SIGNAL WIDTH fully clockwise thus removing the frequency modulation.

(ii) Rotate PHASE (static reflector volts) slowly in a clockwise direction, noting the modes available from the klystron, as indicated by deflection of the meter. POWER SET may need to be adjusted to maintain an approximately mid-scale reading. Select the most clockwise mode, which will have the highest output, and set PHASE for maximum output. Usually this will be fully clockwise.

(iii) Tune the wavemeter slowly through its range until a dip is observed in the meter reading. Minimise the meter reading and note the wavemeter reading, which gives the frequency at which the test set klystron is oscillating. If no dip is found, the klystron is oscillating outside the range of the wavemeter and the TUNING control (klystron mechanical tuning) should be rotated and a further search made.

(iv) The klystron must now be mechanically and manually tuned by the TUNING and PHASE controls until it is oscillating on the peak of the mode at the magnetron frequency.

(a) The TUNING control is rotated slightly in the same direction as that in which the wavemeter has to be turned to bring the reading towards that for the magnetron frequency.

(b) Re-adjust PHASE for maximum meter deflection, if necessary, and then measure the frequency again.

(c) When the frequency is within approximately 5 Mc/s of the magnetron frequency, reset the wavemeter to the magnetron frequency, and adjust SIGNAL TUNING in the appropriate direction until a sharp dip in the meter reading occurs. Ignore any slow change of output. Adjust SIGNAL TUNING for maximum amplitude of this dip.

(v) Leave the wavemeter set accurately to the magnetron frequency.

178. *Tuning beacon klystron for signals*

(i) In the TR.3523, the beacon klystron is used for manual tuning of signals on both MANUAL and BEACON switch positions in the control unit, and the signal klystron exclusively for AFC. In the TR.3523 A or E, however, the signal klystron is employed for AFC and for manual tuning on the MANUAL switch position, whilst the beacon klystron is operative only on the BEACON switch position, and in Mk. III H2S is merely used as a standby klystron for manual tuning of signals.

(ii) Connect the receiver output to the monitor, type 28 set to 1,000 μsec. and X5. Jack in the test panel meters to read the crystal currents and discriminator diode currents.

(iii) On the TR.3523, switch SW.1 to INTERNAL and SW.2 to NORMAL. On the TR.3523A or E, switch to BEACON. In both cases this results in making the beacon klystron operative and tuning it by the internal stabilised manual tuning control, R.71.

(iv) Ensure that the coupling probe into the beacon klystron waveguide is at maximum coupling (i.e. at maximum crystal current) and lock it there. Set the mixer coupling screw fairly well out ($\frac{1}{2}$ to $\frac{5}{8}$ in. protruding below the base).

(v) Vary the setting of R.71 to determine the number of modes obtainable, i.e. the number of positions which give signal crystal current, adjusting the coupling probe into the mixer bridge, if necessary, to keep the crystal current in the region of ·5 mA. If only two modes are obtainable, use the more clockwise setting, if three, the middle setting. This should be the 90 VOLT mode, and may be checked by measuring the voltage between the reflector and the external 300 volt supply, which should lie between 75 and 135 volts. Adjust R.71 for maximum signal crystal current on the correct mode.

(vi) Set the test set ATTENUATOR to approx. 30 dB and SIGNAL WIDTH fully anticlockwise. It is then transmitting. frequency modulated signals sweeping through the magnetron frequency, and locked to the presentation.

(vii) Now tune the beacon klystron mechanically through its range, keeping the signal crystal current approximately at maximum by means of R.71 until signals appear. These will appear as a series of three or four pulses, and should be tuned roughly to maximum amplitude.

(viii) If necessary, bring the largest pulse, which is usually the second from the left, towards the start of the trace by means of PHASE, and switch the monitor to 100 μsec. Broaden out the pulse by rotating SIGNAL WIDTH in a clockwise direction, keeping it central on the trace by means of PHASE until with judicious adjustment of the Gain control, a bell-shaped curve is formed. This curve shows the response curve of the receiving chain, and may not at this stage be perfectly shaped. The beacon klystron has been tuned so that part of the sweep of the FM test set is now being received, but not necessarily the part occurring at the correct frequency, i.e. the magnetron frequency.

(ix) Retune the mechanical tuning slightly, keeping the crystal current at approximately maximum by R.71 and the pulse in approximately the same position by means of PHASE until a negative pip is seen to pass across the bell-shaped curve. This is the resonance curve of the wavemeter, previously set to the magnetron frequency, and when it is centred on the top of the bell, the beacon klystron is tuned so that the magnetron frequency would be received.

(x) Two such tuning points will be found on the mechanical tuning, 45 Mc/s above and below the magnetron frequency. If any wide difference in crystal current obtained on the two points exists, select the point with the higher current; if not, select the lower frequency point, which is the more clockwise of the two.

(xi) The mechanical and manual tuning must now be carefully adjusted so that the klystron is producing the maximum amplitude of the oscillations at the correct frequency, i.e. so that it is operating at the peak of the mode. The coupling into the mixer bridge will then be reduced to a minimum, in turn reducing the back-coupling losses and pulling by the klystron waveguide. This is done by the following step by step method.

(a) Determine the direction of rotation of R.71 which increases the crystal current. Move the control slightly in this direction.

(b) Turn the mechanical tuning in the same direction to bring the wavemeter pip back to the centre of the bell-shaped curve. The crystal current may now be higher or lower than that obtained before.

(c) Make alternate adjustments as above until the crystal current is at a maximum and the pip is still at the centre of the bell.

(xii) When the optimum position of mechanical tuning has been determined, " rock in " the control to its final position very carefully, thus ensuring that the spring bows are relieved of all strains tending to shift the tuning.

(xiii) Adjust the probe coupling the output of the klystron into the mixer bridge until the signal crystal current is 0·6 mA.

Tuning the TR cell

179. Tune the TR cell very carefully for maximum amplitude of the bell-shaped curve.

180. *Tuning the ATR chamber*

(i) Adjust the ATR chamber tuning plunger through its range, observing the bell-shaped curve on the monitor, and periodically inspecting the ATR cell through the observation hole.

(ii) The control will be found to have little effect except that at one point the signal amplitude will be reduced, and lesewhere the glow across the ATR cell may be extinguished or become abnormal.

(iii) The plunger must be left so that neither of these conditions obtains.

181. *Tuning Signal/AFC klystron*

(i) In the TR.3523, switch to NORMAL on SW1 and ADJUST on SW2. In the TR.3523A or E, switch to MANUAL. In both cases this applies the internal stabilised manual tuning control, R71, to the signal klystron.

(ii) Vary the setting of R71 to determine the number of modes obtainable i.e. the number of positions which give crystal current in the two crystals, adjusting the coupling screws if necessary, to bring the currents to approximately 0·7 mA. If only two are obtained, use the more clockwise setting, if three, the middle setting. This should be the " 90 volt " mode, and may be checked by measuring the voltage between the reflector and the external 300 volt supply, which should lie between 75 and 135 volts. Adjust R71 for maximum crystal currents on the right mode.

(iii) The FM test set controls should still be set as described in para. 178.

(iv) Now tune the klystron mechanically through its range, keeping the crystal currents approximately at maximum by means of R71, until the bell-shaped curve appears, and then the wavemeter pip, which must be centred. It may be necessary to readjust the coupling screws if the currents change greatly from 0·7 mA. Diode current will also appear when the klystron becomes on tune.

(v) Two such tuning points will be found on the mechanical tuning, 45 Mc/s above and below the magnetron frequency. The *lower* frequency, which is the more *clockwise* of the two points must be selected.

(vi) The mechanical and manual tuning must now be *very carefully* adjusted so that the klystron is producing the maximum amplitude of oscillations at the correct frequency, i.e. so that it is operating on the peak of the mode. This adjustment is even more important than that for the beacon klystron, detailed in para. 178, sub-para. (xi) and is done by the same step-by-step method, viz.

(a) Determine the direction of rotation of R71 which increases the crystal current. Move the control slightly in this direction.

(b) Turn the mechanical tuning in the same direction to bring the wavemeter pip back to the centre of the bell-shaped curve. The crystal current may now be higher or lower than that obtained before.

(c) Make alternate adjustments as above, until the crystal currents are at a maximum and the pip is still at the centre of the bell. The diode currents should also be equal, and lie between 5 and 8 μA.

Adjustment of mixer coupling screws

182. Adjust the mixer coupling screws so that the signal crystal current is 0·6 mA, and the AFC crystal current 1 mA.

183. *Adjustment of the AFC circuit*

(i) The adjustments to the AFC circuit are two in number, and must be carried out with meticulous care.

(a) Adjustment of the static balanced output voltage from the circuit to be equal to the optimum reflector voltage required by the klystron when on tune, i.e. under the conditions obtained in para. 181 (R38 setting).

(b) Adjustment of the amplitude of the voltage change on the cathodes of the discriminator valves, occurring when the klystron frequency is correct, which is fed to the sweep valve, so that the AFC circuit readily locks from the sweeping state, and locks at the correct point. (R75 setting).

(ii) With the switches and mechanical and manual tuning set as described in para. 181, connect a voltmeter between the two test points. These are the output of the AFC circuit and the output of the internal stabilised manual tuning control. The meter should initially be on at least a 250 volt range.

(iii) Adjust R38 until the meter reading is zero. Repeat on the lower ranges of the meter in turn. The setting of R38 is now nearly correct, i.e. the mean output voltage from the AFC circuit is approximately equal to the optimum voltage found on the manual tuning control.

(iv) To determine the exact setting of R38, check the performance of the AFC, and adjust R75, if necessary, proceeding as in para. 181 (iv), (v) and (vi) above.

184. *Checking remote control*

(i) In the TR.3523, switch to REMOTE and leave SW2 at NORMAL. In the TR.3523 A or E, switch to REMOTE.

(ii) Check that the AFC locks when the control unit is switched to AFC, and that the manual tuning is satisfactory on both MANUAL and BEACON. (These two positions use the same klystron in the TR.3523, but different klystrons in the TR.3523A or E).

185. *Sensitivity*

(i) The FM test set provides a means of measuring the sensitivity of the receiving chain as a whole which can be reproduced to within 1dB provided coupling and operating conditions are identical. If the coupling losses are accurately known, the value of the sensitivity may be measured in dB below 1 milliwatt. Normally it is sufficient to use the ATTENUATOR reading as a qualitative measurement, coupling and receiver gain being maintained constant. Considerable care must be taken with all adjustments and in particular the assessment of the correct attenuator setting if accurate results are to be obtained. The use of a special bench set for TR box alignment is essential here, for a change of receiver and switch unit would render comparisons of TR boxes invalid.

(ii) Set the attenuator to maximum attenuation, POWER SET and PHASE fully anti-clockwise, and balance the bridge for zero meter reading with ZERO SET on the TTX-10RH or to bring the meter to BALANCE with the METER BALANCE control on the TS-146.

(iii) Set SIGNAL WIDTH fully clockwise to remove the frequency modulation. Set POWER SET midway, and maximise the PHASE (static reflector volts) on the mode chosen in para. 177 sub-para. (ii).

(vi) Check that the klystron is then still oscillating at the magnetron frequency by adjusting TUNING for maximum dip, with the wavemeter still set to the magnetron frequency.

(v) Detune the wavemeter, and adjust POWER SET until the meter is at full scale or SET in the TTX-10RH and TS-146 respectively. The instantaneous output from the test set as it passes through the magnetron frequency has now been accurately set.

(vi) Switch the control unit to AFC, and set gain to maximum.

(vii) Set the attenuator to 40 dB, and rotate SIGNAL WIDTH fully anti-clockwise. Adjust PHASE and SIGNAL WIDTH as before to produce a bell-shaped curve at the centre of the trace; the curve will, in this case, be a broad saturation pulse, however.

(viii) Now increase the attenuation to a maximum, and then reduce it very slowly until the average top of the shadow under the pulse is just level with the average top of the noise on the rest of the trace. This corresponds to a signal/noise ratio of unity and the attenuator reading should be recorded as the sensitivity figure for the TR box. Since the exact setting of the attenuator is difficult of assessment it is recommened that a set of six readings are taken, and the average result recorded.

(ix) With the TTX-10RH, in some cases it may be found impossible to reduce the amplitude of the pulse sufficiently to reach a signal/noise ratio of unity no matter how far the attenuator control is rotated. This is due to internal leakage, and the only remedy is to *standardise* measurement on a signal/noise ratio of 2 : 1 with a slight reduction of gain to a *standard* setting, if necessary to avoid saturation.

186. *Further checks possible with the FM test set.*

(i) The bell-shaped curve observed on the monitor is, of course, a plot of the frequency response of the receiving chain and should be perfectly symmetrical. If, from previous experience, the receiver IF response is known to be satisfactory, an assymetric pattern will indicate that the head amplifier response is unsatisfactory, providing that RF adjustments have been correctly carried out.

(ii) A check that the AFC follows any pulling of the magnetron frequency may be made as follows :—

(a) With the AFC in operation and the FM test set adjusted to produce a broad pulse, as in para. 185, sub-para. (vii) above, reduce the attenuation to 30 dB, and the gain until the bell shaped curve is produced.

(b) Tune the wavemeter to the magnetron frequency, when the pip will be at the centre of the curve.

(c) Insert the probe of the mismatch unit into the guide, and slide the carriage throughout its range.

(d) Note that the curve remains locked and that the wavemeter pip moves only slightly along the top of the curve.

187. *Use of test set, type TS-13/AP as an FM test set* :—

(i) The test set TS-13/AP is very similar to the test sets TTX-10/RH and TS-146/UP, providing a source of RF power at X-band from a 723/AB klystron, a direct reading thermistor bridge, and a calibrated RF attenuator. It does not, however, generate a sawtooth voltage waveform for frequency modulating the output, instead being provided with a pulsing modulator circuit.

(ii) The TS-13/AP may be used to align the TR.3523 in the same way as the TS-146/UP, i.e. as an FM test set, provided it is supplied with a sawtooth waveform of at least 100 volts amplitude, locked to the monitor time-base or the main timing pulse. This is used for frequency modulating the klystron, the pulsing circuits being switched out. The simplest and most convenient way of doing this is to use the actual time-base waveform from the monitor, type 28.

(iii) In order to bring out the time-base waveform, a Pye plug is mounted on the right hand side of the monitor chassis on the bracket just behind the front panel, a slot being cut in the screening cover to clear it. The anode of V2, the time-base Miller valve, is connected to the Pye plug via a ·05 μF, 500 volt working condenser.

188. *Connection of and initial adjustments to TS-13/AP* :—

(i) The RF connector to the transmitter-receiver should be by an American-to-British waveguide transformer and a directional coupler, as in the case of the TS-146/UP.

(ii) Connect the Pye plug on the monitor, type 28 (sawtooth) to INPUT SYNCH on the TS-13/AP.

(iii) Switch INPUT SEL to SAWTOOTH, thus connecting the reflector of the klystron to the INPUT SYNC plug, and rendering inoperative the pulsing circuit and its controls. These controls are the PULSE WIDTH and PULSE SHIFT potentiometers and the SYNC/SELF SYNC and PULSE/SQUARE WAVE switches, and can now be ignored.

189. *Controls* :—

(i) All the controls on the TS-13/AP, with the exception of those for the pulsing modulator, perform functions exactly similar to those on the TS-146/UP. The controls are given in Table II.

(ii) The power meter is used in the same way as that in the TS-146/UP, except that it is calibrated 0-200 μA and therefore —

(a) BALANCE on the TS-146/UP means 0 μA on TS-13/AP.

(b) SET on the TS-146/UP means 100 μA on the TS-13/AP.

(iii) No control is provided similar to the SIGNAL WIDTH control on the TS-146/UP (sawtooth amplitude), but there is no necessity for it. It should be noted that the PULSE WIDTH on the TS-13/AP refers to the modulating pulse only, and is inoperative.

TABLE II

Controls on TS-146/UP

TS-146/UP	*Equivalent on TS-13/AP*
Power set	Adjust output
Phase	Reflector
Signal tuning	Tuning
Meter balance	Zero set
Attenuator	Attenuator
Frequency	Frequency

190. *Use of test set TS-13/AP*

(i) The procedure detailed in paras. 174 to 186 should be followed, reference being made to the above changes in nomenclature of the controls, and taking note of the ensuing points :—

(ii) Where it is necessary to adjust the test set on CW i.e. as described in paras. 177 to 178, remove the sawtooth by disconnecting the Pye socket at the monitor. Reconnect when FM is required. This replaces the adjustment of SIGNAL WIDTH on the TS-146/UP.

(iii) The monitor, type 28 must throughout be operated on the 1,000 μsec time-base, as this gives the best-proportioned bell-shaped curve.

(vi) The adjustment to obtain the bell-shaped curve (para. 178 vii and viii) are considerably simplified. Only one pulse will be seen on the first tuning and this will be the bell-shaped curve itself. It is then merely centralised on the trace (para. 178, viii) using REFLECTOR (corresponding to PHASE in TS-146/UP) the monitor remaining on the 1,000 μsec time-base.

FAULT FINDING

TRANSMITTER

Frequency moding and splitting

191. This should have been revealed by routine tests. Frequency splitting may occur particularly with long lengths of guide run between the transmitter and the scanner.

192. Splitting arises when the wrong impedance in magnitude and phase is presented to the magnetron by the waveguide and scanner or when there is a fault in the unit, such as a poor anti-TR cell, which produces a similar effect. Adjustment of a line lengthener, which may be included in the waveguide run near the transmitter, will cure the large majority of faults due to mismatch between waveguide and scanner. The phenomenon is recognised by the appearance of a double trace of echoes, having different magnitudes, which can be separately tuned on MANUAL. One of these traces may be very faint and can be seen on the monitor, using the 10 microsecond scale.

193. Examination of the AFC mixer output may show double humped tuning or two separate tuning points.

194. If the waveguide run is short and there is no line lengthener the trouble may almost certainly be cured by changing the magnetron. The magnetron which has been removed must not be scrapped, as it may be perfectly serviceable in another transmitter.

195. The anti-TR cell should be examined for sparking in unnatural places; there should not be any sparking or discharge across the glass dome. The glow should be concentrated at the tip of the iris. A faulty cell may introduce a mismatch during the transmitter pulse period sufficiently serious to cause splitting so it should be changed if it does not seem to be working normally.

196. The mismatch unit of Test Set, type 263 may be used to check whether the magnetron is particularly prone to frequency splitting: it repays in increased power, to spend a considerable amount of care in obtaining clear sharp echoes.

197. A further check which should be applied, if no relief is given by the remedies already suggested, is measurement of the magnet field strength with a Magnetometer (5G/304) or with the Cambridge fluxmeter. The result should be between 5450 and 5700 gauss: a value outside these limits may be responsible for the trouble.

Use of the Cambridge fluxmeter

198. The Cambridge fluxmeter is used to measure the field strength of the magnet in the following way:—

(i) Level the instrument by means of the spirit level fitted in it. The bubble should be vertically below the marked circle and the pointer should remain stationary at any point on the scale.

(ii) Return the pointer to zero by pressing the button at the bottom front centre of the instrument.

(iii) Insert the search coil in the magnet gap and centre it visually, if necessary. (Most search coils exactly fit the gap of the magnet with which they are designed to be used).

(iv) Return pointer to zero.

(v) Withdraw the search coil from the gap and record the deflection of the meter.

(vi) Return pointer to zero.

(vii) Reverse the search coil and re-insert it.

(viii) Return pointer to zero.

(ix) Withdraw search coil and record the deflection. (This will be in the opposite direction to the deflection previously obtained).

(x) Repeat stages (v) to (ix) inclusive, so that four readings altogether are obtained. Take the arithmetical average of these four deflections.

(xi) Note the coil constant, which is the number marked prominently on each search coil.

(xii) The field strength of the magnet, in Gauss, is that given by the following formula.

$$\frac{\text{Average deflection (in divisions)} \times 10{,}000}{\text{Coil constant}}$$

Double modulator pulse

199. It is found with a few spark gap modulators that at a certain recurrence-frequency the pulse fed to the magnetron is double. This naturally gives a bad RF spectrum and dirty echoes. This may be cured by slightly

adjusting the MODULATOR PRF control. The modulator pulse may be inspected by inserting Transformer, type 782 in the pulse lead between the modulator and TR box, and connecting the terminals to the Monitor, type 28.

Faulty overswing diode

200. To check the overswing diode V15 (type CV215) the AFC mixer is connected by as short a lead as possible to the Monitor input. The Monitor is set to 10 microseconds and X20. If the CV215 is faulty a series of pulses, occupying up to 20 microseconds will be seen. These are produced by the pulse transformer ringing and carrying the magnetron cathode down on the negative swings. Even with a failing diode the overswings may not be very noticeable if the pulse transformer properly matches the magnetron to the modulator.

Mica window

201. There is a mica disc inside the waveguide about 12 inches inside the front panel. The disc is located in the large knurled nut on the guide.

202. If this disc fails or sparks over the magnetron may be damaged. If therefore the magnetron is found to have failed this mica seal should be inspected by dismantling the waveguide.

203. When putting the seal back after inspection make sure that the locating pins are properly engaged and that the nut is tight. There must be no gaps between the metal rings of the flanges and the plate holding the mica seal, or sparking may occur. It is also important to replace the seal so that the side to which the mica is fixed faces away from the front of the TR. box.

204. Take great care to avoid mis-matches caused by putting screw drivers across the waveguide output or by running the TR box facing a metal wall. Either of these may set up a large RF voltage in the waveguide and produce an arc across the mica window, which may not go out when the mismatch is removed until the transmitter is switched off.

205. The magnetron will operate without the seal up to about 20,000 or 22,000 feet. The mica seal, by maintaining the air pressure in the output section, enables the unit to be used up to 35,000 feet.

Pulse transformer magnetron seal

206. This seal is tested by the manufacturer. If there is any doubt about its airtightness the magnetron and transformer tank should be removed, the neoprene sack gently blown up and the rubber seal examined under water for leaks.

Checking mechanical aspects of magnetron and waveguides

Waveguides

207. The interior of all waveguides and other inside surfaces must be clean and free from rough edges and excess solder. Waveguides should also be inspected for corrosion and signs of " snow." See that the waveguide flanges are securely tightened to ensure metal to metal contact.

Pulse transformer, waveguide seal and mica window

208. Inspect the condition of the rubber rings in the pulse transformer, the waveguide seal to the magnetron and the waveguide seal to the mica window. The mica window must be on the side facing the magnetron.

Magnet

209. Immediately before assembly into the unit the magnet should have a field strength of between 5450 and 5700 gauss. It must be placed with its North pole adjacent to the face of the magnetron nearest the cathode lead.

Visual checks on transmitter

210. When the magnetron is running at full power the following points should be looked for :—

(i) There must be no sparking or RF leakage at any of the waveguide joints.

(ii) The CV221 (TR cell, V17) should have a diffused glow across the lower window and a concentrated glow between the internal posts.

(iii) The CV115 (anti-TR cell, V20) should have a concentrated discharge across the gap. There should be no discharge leaving the gap or travelling across the glass dome. There should be no variation in the discharge of the anti-TR cell at different positions of the mismatch unit.

RECEIVER

Poor sensitivity

211. Poor sensitivity may be caused by any of the following defects :—

(i) Poor signal crystal.
(ii) Faulty TR cell.
(iii) Low output from either klystron, resulting in right coupling and back coupling losses.
(iv) Poor head amplifier.
(v) AFC tuning.

Check on local oscillator output and crystal performance

212. Both crystals and also the local oscillator output may be checked as follows :—

(i) The unit should be fully operational, but the modulator switched off. Apply the internal manual tuning R71 to the signal/AFC klystron. (On TR.3523, SW1 should be NORMAL ; SW2, ADJUST while on TR.3523A or E, MANUAL) and adjust R71 for maximum crystal current. The klystron will have previously been set up to the correct frequency in accordance with the procedure laid down.

(ii) Withdraw one of the mixer coupling screws to its limit. Connect a jack plug to an avometer set to the 10 mA range. Insert the jack plug into the jack for the other mixer and adjust its coupling screw for maximum crystal current.

(iii) Repeat for the other mixer.

(iv) The following are the lowest maximum currents which should be obtained.

AFC mixer : 3·5 mA
Signal mixer : 4·5 mA

(v) Failure to achieve *both* these values means either :—
(a) The klystron output is low.
(b) Both crystals are faulty.

(vi) Failure to achieve *one* of the values means that the crystal concerned is at fault.

213.

(i) *First* check the crystals by substitution, and then, if necessary, change the klystron, realign the tuning, and repeat this test.

(ii) When the crystals have been cleared, switch over to the beacon klystron (TR.3523, SW1 INTERNAL, SW2 NORMAL, TR.3523A or E BEACON) and adjust R71 for maximum signal crystal current.

(iii) Reduce the signal mixer coupling screw to minimum, and increase the coupling from the beacon klystron by the probe into the mixer bridge until the maximum signal crystal current is obtained, as measured on the Avometer on the 10 mA range.

(iv) This value should be at least 3 mA, and if not the beacon klystron must be changed, the tuning realigned, and the test repeated.

(v) The power supplies to the klystrons should, of course, be checked before any change is made. Further, the current through the klystrons as measured at J4 should lie between 20 to 25 mA.

Treatment and testing of crystals

214. It cannot be too strongly emphasised that crystals must at all times be screened from RF energy. Stocks of crystals must be kept in metal boxes and individual crystals out of these boxes must be wrapped in metal foil. Before any crystal is exposed all transmitters in the workshop must be switched off.

215. It is recommended that spare crystals should all be tested for sensitivity and records kept of each crystal. A standard " good " crystal should be selected and used as a basis against which to check new crystals.

216. If a frequency-modulated test set is available the testing may be carried out accurately as follows :—

(i) Adjust the test set for sensitivity measurement, as described in paragraph 185.

(ii) Insert the " standard " crystal into the signal mixer and adjust the signal crystal coupling screw for a current of 0·6 milliamp. Measure the sensitivity of the system as described in paragraphs 185 (viii) and (ix). Note the attenuator reading.

(iii) Substitute the crystal to be tested in the signal mixer and measure the crystal current, which will probably be different from 0·6 milliamp.

(iv) Re-adjust the crystal current to 0·6 milliamp with the coupling screw and again measure the sensitivity of the system. The difference in the attenuator reading is a direct measurement of the relationship in decibels between the sensitivity, at unity signal/noise ratio, of the test crystal to the standard.

(v) Before removing the crystal, readjust the coupling screw to bring the crystal current back to the value obtained in (ii) above with the test crystal.

217. Thus for each crystal a figure may be obtained which represents its sensitivity relative to that of a standard crystal. This may be used to ensure that only crystals above a certain standard are used, by grading all crystals in order of sensitivity. A careful watch must of course be maintained on the standard crystal to prevent false results.

TR cell

218. A normal TR cell (CV 221) has a diffuse glow inside and over the window. Mechanical failure, which may be a cracked window or damaged flexible diaphragm, will cause the cell to go soft. The discharge across the inner gap will no longer appear diffused and the signal crystal will be damaged by transmitter break through. If only CV114 valves are available for replacement make sure that the serial number is above 4,000.

219. Electrical failure as a result of age will cause deterioration in the valve filling, giving slow ionisation and de-ionisation. Such a failure will cause a " spike " of transmitter RF breakthrough to appear in the AFC mixer output. This output can be examined on the monitor type 28 by disconnecting the signal mixer lead from the head amplifier (the transmitter being switched off at the modulator) and connecting it to the AFC mixer. The AFC output is then fed to the receiver unit. The receiver suppression must be removed and the gain turned down to avoid overloading.

220. The pulse obtained (after tuning the local oscillator, if necessary), should be clean and free from a spike at the beginning. If a spike appears the TR cell may be faulty. The same indication will however appear if the mixer coupling screws are too far in. This can be checked by turning up the gain : if the coupling screws are in too far echoes will be observed, although reduced in amplitude.

221. There are two other indications of electrical failure which may be encountered. One is a blob of noise on the monitor trace seen when the receiver output is examined. This noise moves along as the cell is tuned. The other indication, which only appears in severe cases of failure, is that the tuning of the cell varies with the ranges of different echoes.

Klystron checks

222. For prolonged satisfactory operation of the AFC circuit it is essential that all factors causing unwanted change in the frequency of the output of the klystron are eliminated. If not, such stray variations may combine with the very effects which the AFC is provided to counteract (such as temperature and pressure drift, magnetron frequency drift) to produce a condition outside the range of control of the AFC circuit.

223. Frequency pulling by the load into which the klystron is coupled is one source of trouble, and change of coupling is the greatest single source of pulling. Under critical conditions a change of coupling of 1/32 of an inch may cause a change in frequency of 50 Mc/s.

224. Therefore make sure that the klystrons are tight in their sockets. If necessary the sockets may have to be closed up to grip the valves more firmly.

225. Over-coupling will bring the klystron towards an unstable condition where it is far more liable to pulling and, in the limit, refuses to oscillate.

226. Over-coupling will result from using low-current crystal in either signal or AFC position or from the use of a meter with too high resistance (over 50 ohms) for setting up crystal current. The tight coupling produced by either of these factors will also cause other external variants, such as the TR cell, to be more tightly back-coupled to the klystron, which again tends to increase pulling.

227. Crystals giving low currents must therefore be avoided and suitable low-resistance meters must be used for carrying out measurements of crystal current.

228. There is a technique which must be observed in mechanically tuning the klystrons if the tuning is to remain constant and not creep with vibration. When tuning in one direction tension is built up opposing this

direction; the bows are set from their previous position and the screw threads bind on one side. Thus, if the final position desired is reached from one direction of tuning only, the stresses and tensions will tend to relieve under vibration and the tuning will shift. Shifts of up to 6 Mc/s. can result from this cause alone.

229. To avoid this trouble when tuning klystrons tune past the desired setting, then back again through it but not so far as before, thus rocking in to the final tuning point by a series of approximations. This relieves strains which would otherwise cause shift.

Head Amplifier

230. If it is necessary to change a valve in the head amplifier to cure low gain it is highly desirable that the tuned circuits immediately before and after the valve should be re-aligned. This is because of variations in valve characteristics.

231. If a frequency modulated test set is available the oscillogram of the IF response curve (the bell-shaped curve observed on the monitor when the FM test set is used) may be used as a very convenient means of selecting a suitable replacement valve which will not necessitate coil adjustments. Alternatively, if such a valve cannot be found, the FM test set makes a convenient way of lining up the coils.

232. In either case the aim is to obtain a perfectly symmetrical, flat topped curve.

233. If no FM test set is available a pulsed or CW signal generator may be used instead for aligning the coils. The output of the signal generator is connected to the input of the head amplifier, in series with a 200 ohm resistor. A 30 pF condenser must be connected across the input of the head amplifier to simulate the capacity of the mixer. If a CW generator is used a suitable milliameter must be connected across the diode detector load in the receiver to provide an indication.

234. Now tune the signal generator to 45 Mc/s. and align the coils for maximum signal amplitude or diode current, as the case may be. The frequencies to which the coils will be tuned are:

Input circuit (L4)	....	45 Mc/s.
Coupling between V1 and V2 (L5 and L6)	....	47·5 Mc/s.
Output circuit (L7)	....	45 Mc/s.

235. When tuning L5 and L6 it must be borne in mind that these coils give a square topped response curve.

236. After the coils have been aligned the cores must be re-stuck.

AFC troubles

Tests to discover causes

237. No diode current, or low current, from both diodes.

- (i) Faulty AFC crystal. See paragraphs 233 to 245 and try substitution. See also paragraph 226.
- (ii) Faulty V3. Try substitution, but see paragraphs 252 and 253.

238. No. diode current, or low current, from one diode only.

- (i) At J5. V4 or V5 faulty. Try substitution, but see paragraphs 252 and 254.
- (ii) At J6. V7 or V6 faulty. Try substitution, but see paragraphs 252 and 254.

239. Failure to sweep.

- (i) R75 wrongly adjusted.
- (ii) V8 faulty. Try substitution.

240. Failure to pass holding tests without discrimination as to direction of mistune.

- (i) Faulty AFC crystal. See paragraphs 233 to 245 and try substitution.
- (ii) TR cell spike causing complications. See paragraphs 246 to 251.
- (iii) Faulty AFC chassis. See paragraphs 259 to 264.

241. Failure to pass locking tests without discrimination as to direction of mistune.

- (i) All three reasons given in paragraph 240.
- (ii) R75 wrongly adjusted.

242. Failure to pass locking or holding tests with one direction of mistune only.

- (i) R38 incorrectly set.
- (ii) Faulty klystron.

AFC crystal input

243. The unit should be in working condition, with the modulator switched off. Apply internal manual tuning to the signal/AFC klystron (by switching to MANUAL in TR.3523A and E, or SW.1 to NORMAL and SW.2 to ADJUST in TR.3523) and adjust R71 until there

is no crystal current. The klystron will then not be oscillating.

244. Connect the AFC crystal Pye plug to the microammeter (with 4 microfarads in parallel), or jack in the meter at J2, and switch on the modulator. The current registered should be between 7 and 12 microamps.

245. If the current is below this value the following possible faults should be investigated:

(i) Poor crystal. Check by substitution.
(ii) Poor magnetron. Should have been revealed by routine magnetron tests.
(iii) Faulty "below cut-off" waveguide section. Remove and inspect hole for dirt.

Check on pulse output from AFC crystal

246. With the modulator switched off, connect the Pye plug which normally is connected to the signal mixer to the AFC mixer instead.

247. Switch on the modulator. Apply internal manual tuning to the signal/AFC klystron (by putting SW.1 to NORMAL and SW.2 to ADJUST in TR.3523 or by switching to MANUAL on TR.3523A). Now tune R71 until the pulse is seen on the monitor type 28, which should be coupled to the receiver output. Receiver suppression must of course be removed and the gain must be turned down. This pulse is the 45 Mc/s. output from the AFC crystal.

248. The pulse seen should be clean, clear and free from a spike at the beginning.

249. If a spike is present at the beginning of the pulse it is because of one of the two following causes :—

(i) Faulty TR cell.
(ii) The coupling screws are too far in.

250. The second of these two causes is only likely to occur if the klystron output is too low : this may be checked by turning up the gain, when echoes (or FM test set signals, if the FM test set is in use) of moderate size will show through if the klystron output is at fault. If this does not occur the TR cell is undoubtedly to blame and must be changed.

251. If the pulse is not reasonably clean and clear, the fault lies with either the magnetron or the ATR cell, and should have been diagnosed in the routine magnetron checks.

*VR*91 *valves in AFC chassis*

252. The valves in the AFC chassis should not under any circumstances be haphazardly changed. This is because, owing to the wide tolerances of the VR91 specification, the cross-over point on the discriminator characteristic may wander as much as $\pm \frac{3}{4}$ Mc/s. by random insertion of valves in V3, V5 and V6 positions. If it becomes abundantly clear, from logical evidence obtained by checking anode volts and other tests, that a particular valve is at fault the best course is to change the complete AFC chassis. If this is not possible, and the unit is urgently required, the proper facilities and knowledge for correct readjustment not being available, the best course is to select from several valves the one which appears to give the best results.

253. V3 circuit can be readjusted reasonably accurately in the following way :—

(i) Unstick the core of L10 (in the centre Pye can of the middle row).
(ii) Using a non-magnetic screwdriver tune the core for maximum current on microammeters jacked in at J5 and J6.
(iii) Finally restick the core with pitch or wax.

254. If V5 or V6 has to be changed, select the valve, from several samples, which gives the most nearly correctly tuned picture on AFC. It will usually not be found difficult to find an adequate valve, although the signal/noise ratio may suffer slightly. R38 will have to be readjusted as described in paragraphs 171 or 178.

255. The procedure for re-aligning the AFC unit when V5 or V6 has been changed is as follows :—

(i) Remove the AFC chassis from the transmitter and take off the screening cans of V3, V5 and V6. Unstick the dust iron cores and put the cans back. The tuning of V3 grid coil is not critical and it need not be readjusted. Connect the AFC input lead to the 100 ohm output of a signal generator which gives 45 Mc/s. modulated CW. The 12-pin W plug on the front panel of the chassis should be connected in the usual way. Jack the two microammeters into J5 and J6.

(ii) Switch on the signal generator and set its frequency to 45 Mc/s. Switch on the internal modulation of the signal generator and set its output level. This will probably involve adjusting the SET RF control until the output meter needle is opposite the marked reference point. Now, by using the attenuator on the signal generator, set its output to give diode currents of about 20 microamps.

(iii) Tune the signal generator to 43 Mc/s. and tune the core of V6 anode coil (L12) for maximum current at J6. Similarly, with the signal generator tuned to 47 Mc/s. adjust V5 anode coil (L11) for maximum current at J5. Both discriminator coils have now been aligned and all that remains is to tune V3 anode coil to 45 Mc/s.

(iv) Tune the signal generator back to 45 Mc/s. and adjust V3 anode coil (L10) for maximum diode currents at J5 and J6.

(v) Finally check that the diode currents at J5 and J6 are equal and reseal the iron dust cores.

256. To avoid misunderstanding it should be pointed out that if the signal generator frequency is swept between 43 and 47 Mc/s., after this lining-up process has been carried out, the diode currents will not peak at 43 and 47 Mc/s. but at two points between these two frequencies and 45 Mc/s. This is because the output from V3, tuned by L10, drops off as the frequency deviates from 45 Mc/s.

Microphonic valves

257. Microphonic VR91 valves are prevalent. They will particularly upset the working of the DC amplifiers V5 and V6 and the sweep oscillator V8.

258. The CV173 stabiliser may also be troubled by microphony. It can be checked by tapping it and noting if any change occurs in the 600 volt output.

Check on AFC discriminator operation

259. An overall check of the discriminator circuits is possible if a 45 Mc/s. signal generator, preferably pulsed, is available. Suitable signal generators are the type 106 or type 52 together with the modulator type 67. With either of these a response curve of the discriminator may be plotted and compared with the required shape, which is shown in fig. 12.

260. The output from the signal generator should be connected to the discriminator input Pye plug through a 220 ohm resistor. An Avometer, set to the 400 volt range, is connected to measure the discriminator output voltage. It is connected between the test point, at the junction of R39 and R40, and the external 300/330 volt HT supply.

261. Now switch to INTERNAL on TR.3523 or to MANUAL on TR. 3523A, etc. An RF pulse from the signal generator of about 1 microsecond duration and 300 millivolts amplitude should be used. The amplitude should be set to give a diode current of about 15 microamps, measured at J5 or J6, with the frequency set to 45 Mc/s.

262. The output frequency of the signal generator is now varied, in steps of 0·5 Mc/s. from 40 to 50 Mc/s. and the voltages shown on the Avometer at each step taken.

263. Now plot a graph of AFC voltage, as measured, against frequency. This should conform in shape with that shown in fig. 12. Particularly, the cross-over point must occur at 45·0 Mc/s.

264. The calibration of the signal generator may be checked at 45 Mc/s. against an IF strip by feeding the pulse into the receiver and adjusting the signal generator frequency for maximum output. The average reading of the two settings where this output just starts to fall off (that is, the extremes of the pass band) will then be the reading for 45 Mc/s.

Observing the modes of a klystron

265. The modes in which the 723A/B klystron oscillates can be observed on the Cossor oscilloscope (Oscilloscope type 7, 10SB/102) in the following way :—

(i) Disconnect the output from the signal crystal to the head amplifier and connect the crystal output instead to the A1 terminal of the oscilloscope.

(ii) Connect a lead from the X1 terminal of the oscilloscope through a 4 microfarad condenser to the klystron reflector. This connects the time base wave form of the oscilloscope to the klystron and so sweeps the klystron reflector through a voltage range of the same shape and amplitude as the time base saw-tooth. If the amplitude is sufficient it will cover all the modes, but this will probably not occur. By altering the mechanical or manual tuning it will however normally be possible to obtain all the modes, although only three or four of them may be displayed at the same time.

(iii) Set the amplifier switch on the oscilloscope to 2Y1 to obtain sufficient amplification.

(iv) The other oscilloscope controls should be set as usual to obtain a well defined picture.

(v) On TR.3523 put SW1 to NORMAL and SW2 to ADJUST when testing the signal klystron and, to test the beacon klystron put SW1 to INTERNAL. For TR.3523A, etc., switch to MANUAL for testing the signal klystron and BEACON for the beacon klystron.

(vi) The envelopes of the rectified frequency modulated response curves appear as broad negative going excursions of the oscilloscope time base.

(vii) The transmitter must be switched off at the modulator for this test.

266. The mode which is used is the third from the left (if there are four on the trace) or the second (if only three modes are displayed). This mode, which occurs with a reflector voltage of the order of 90 volts should be entirely free from kinks. Such kinks indicate that at some frequencies the oscillator output falls to zero. There may also be dark gaps in the envelope; these indicate unstable regions where the output changes very rapidly with voltage, and can be tolerated if they only appear below half amplitude.

267. When checking klystrons in this way the mechanical tuning may be varied about three quarters of a turn about both sides of the mean position, in order to obtain all the modes. The check should therefore be carried out after the klystron has been correctly tuned in the transmitter—receiver so that the mechanical tuning is set to approximately the correct position to start with.

268. If kinks appear in the wanted mode or if dark gaps appear at more than half amplitude the klystron is unsuitable for use in the particular unit in which it is installed. Owing to the fairly wide tolerances to which the mixer assembly is manufactured (wider in the TR.3523 than in the TR.3523A and subsequent developments) a particular klystron may not be satisfactory in one unit but will work perfectly in another unit, and perhaps in the same unit with a magnetron which oscillates at a slightly different frequency. 723A/B valves should not therefore be discarded because of poor performance in one unit alone.

G941M15605 7/46 850 C.B &S.Ltd Gp 30

APPENDIX I

TEST SET, TYPE 319

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

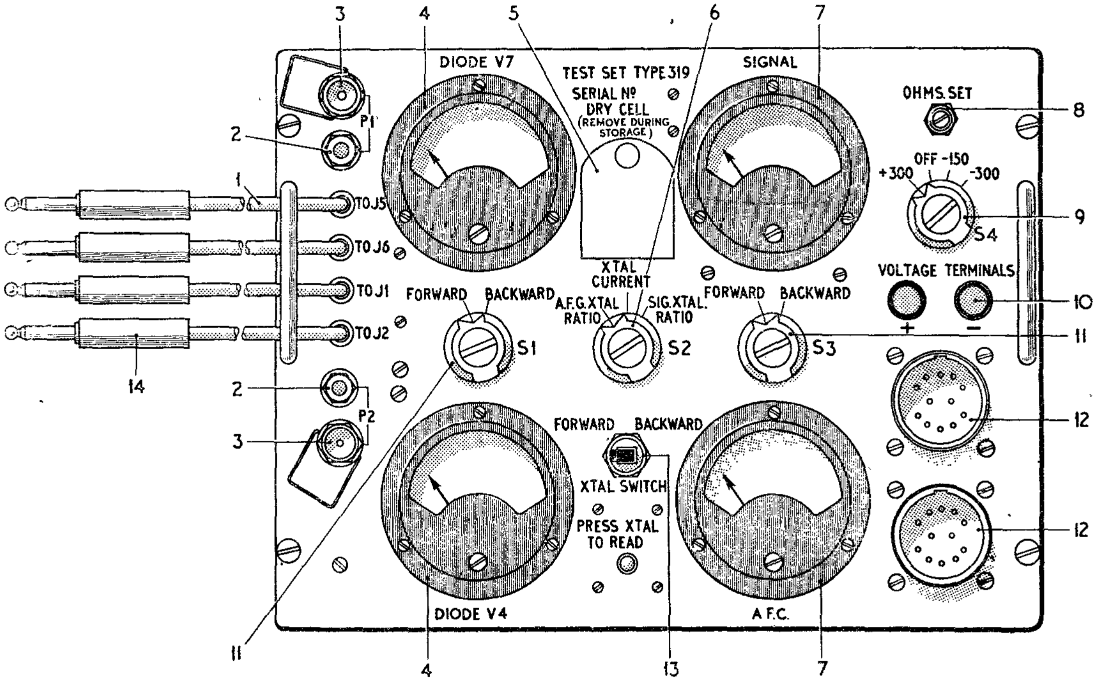


Fig. 1.—Front panel

Item	*Description*	*Stores Ref.*	*Item*	*Description*	*Stores Ref.*
1	Cord instrument, Type 52	10H/5042	8	Resistance, 20K.	10W/15629
2	Jack, Type 8	10H/343	9	Switch, 2-pole, 4-way	10FB/1249
3	Plug, Type 229	10H/528	10	Terminal, Type 49	10H/2770
4	Microammeter	10A/14384	11	Switch, 4-pole, 2-way	10FB/644
5	Housing cell	—	12	Plug, Type W202	10H/395
6	Switch, 6-pole, 3-way	10FB/1055	13	Switch, Type 975	10F/1211
7	Milliammeter	10A/7207	14	Plug, Type 1	10H/488

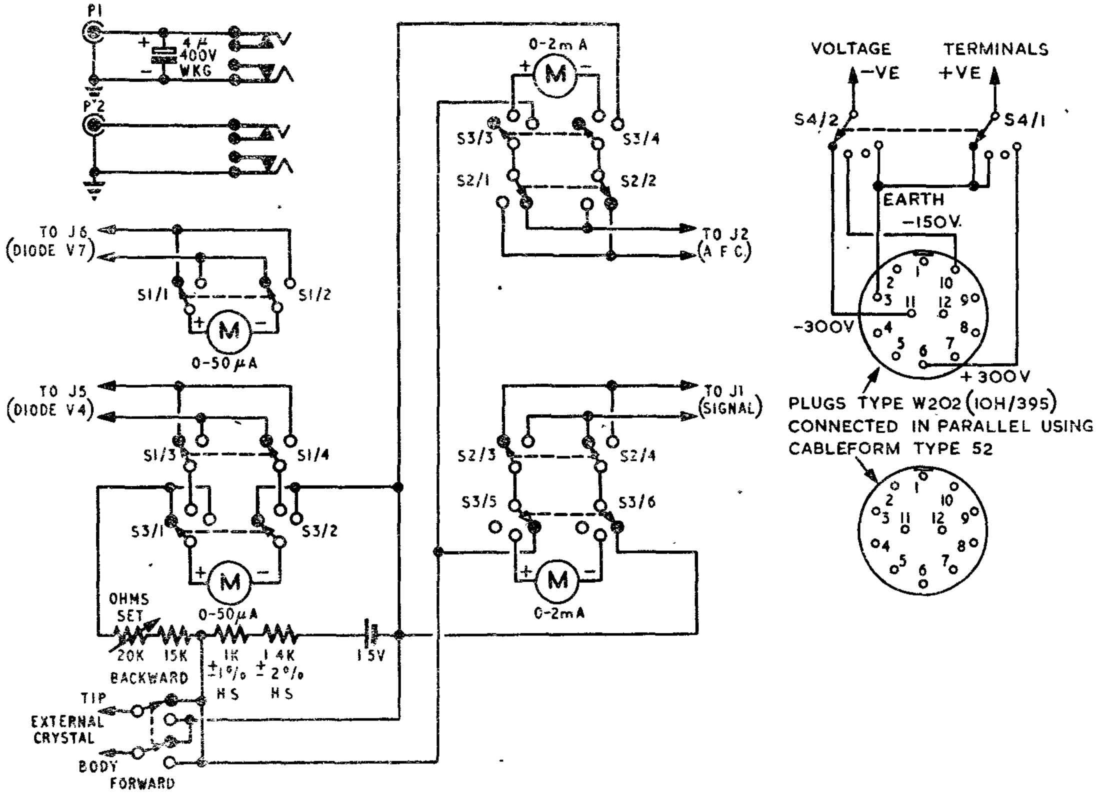


Fig. 2.—Circuit diagram

INTRODUCTION

1. The test set, type 319 is designed to facilitate the setting-up of transmitter-receivers in the TR.3523 series by providing means for checking the following :—

(1) Signal and AFC crystal currents
(2) AFC diode currents
(3) Signal and AFC crystal ratios
(4) Transmitter pulse current in AFC crystal mixer
(5) Principal supply voltages to the HT box

Provision is also made for the external checking of crystal ratios. A view of the front panel is given in fig. 1.

GENERAL DESCRIPTION

2. The test set consists of a meter panel containing two milliammeters for measuring crystal currents and two microammeters for measuring the discriminator diode currents. Each meter is provided with a lead fitted with a jack plug and labelled with the number of the corresponding jack socket in the TR. 3523. Polarity switches are provided for each pair of meters in order to cope with the non-standard wiring of the jack sockets. Two Pye sockets are also provided as alternative input connections to the meters.

3. The lower microammeter is also connected up as a resistance meter so that the backward and forward resistances of the signal and AFC crystals may be checked. A crystal holder is also provided to permit the external checking of crystal ratios.

4. On the right-hand side of the panel, two W-plugs wired in parallel are provided in order to allow the tapping of the red 12-way feed to the transmitter-receiver. A selector switch is used for bringing out the —300, —150 and +300 volts supplies to a pair of terminals, to which a meter (e.g. an Avometer) may be attached. A circuit diagram is given in fig. 2.

5. The panel is mounted on a wooden box approximately 17 in. by 10 in. by 6½ in., the jack leads being stowed in a compartment on the left-hand side.

OPERATION

6. For full setting-up procedure for the TR.3523 series, reference should be made to para. 154 onwards.

Checking of crystal and diode currents :—

7. Set centre switch (S3) to XTAL CURRENT and read off directly. If desired, the crystal current may be taken directly from the Pye output socket on the waveguide assembly. In this case the appropriate jack plug should be inserted in the lower jack socket on the panel, and the input taken to P2.

Checking of crystal ratios :—

8. Switch to AFC X-TAL RATIOS or SIG X-TAL RATIO as appropriate, withdraw the corresponding jack plug, and adjust OHMS SET to give scale deflection on the lower microammeter.

9. Replace the jack plug and note the reading. The reverse reading is obtained by using the milliammeter polarity switch S2.

10. Readings of less than 11 and greater than 50 scale divisions should be obtained.

11. If an external crystal is to be measured, do not replace the jack plug, but insert the crystal in the holder on the panel and use the X-TAL SWITCH.

Checking of transmitter pulse current in the AFC crystal mixer :—

12. Check that the transmitter-receiver is fully operational with the modulator switched off. Apply internal manual tuning to the signal AFC klystron, and adjust R71 until the klystron is not oscillating, i.e. until there is no crystal current.

13. Connect the AFC crystal Pye plug to the plug P1 (which has a 4μF condenser across it so that the meter will register the mean DC current) and connect one of the microammeters to it by inserting J5 or J6 into P1.

14. Switch on the modulator and check that the registered current is between 7 and 12 μA.

Checking of principal supply voltages :—

15. The red 12-way cable from the junction box should be connected to the test set, type 319 and another 12-way cable connected between the test set, type 319 and the transmitter-receiver. The selector switch is then used to bring the desired voltage to the meter terminals.

G272m31588 5/47 850 C B.&S.Ltd Gp30

APPENDIX II

TEST SET, TYPE 320

LIST OF CONTENTS *Para.*

LIST OF ILLUSTRATIONS *Fig.*

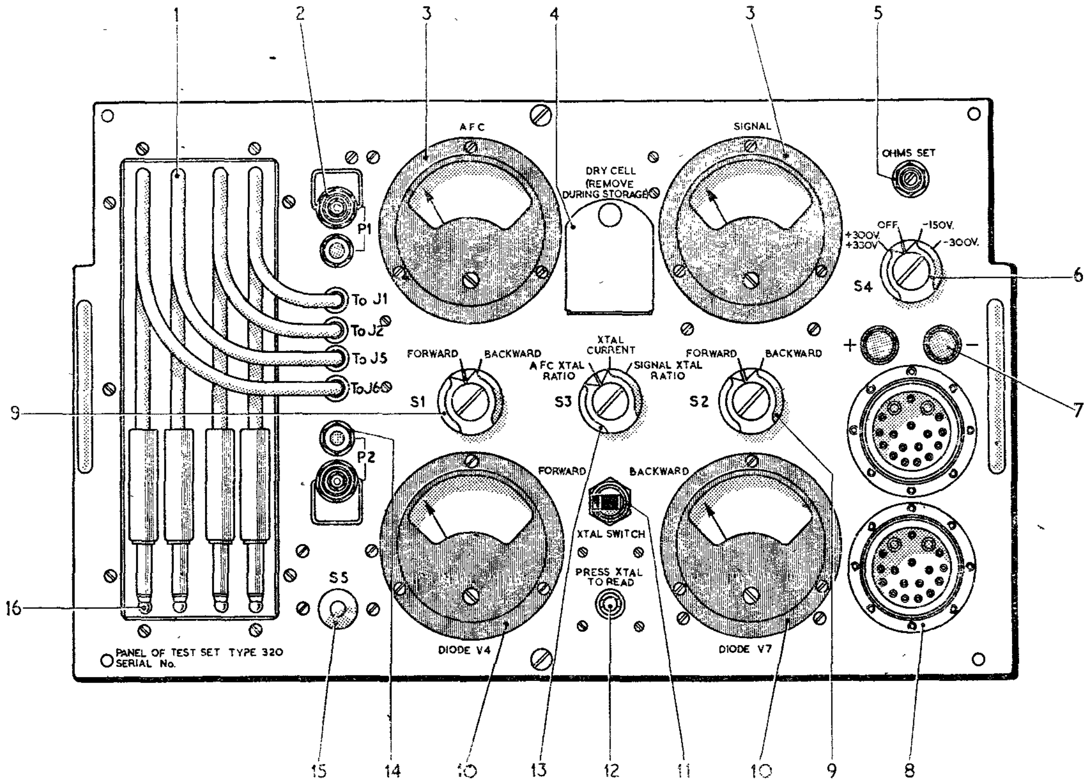


Fig. 1.—Front panel

Item	*Description*	*Stores Ref.*
1	Cord instrument, Type 61	10H/5604
2	Plug, Type 229	10H/528
3	Milliammeter	10A/7207
4	Housing cell	—
5	Resistance, variable, 25K.	R.C.S.C. Cat. No. Z261887
6	Switch, 2-pole, 4-way	10FB/1249
7	Terminal, Type 49	10H/2770
8	Plug, Type WW601	10H/4526
9	Switch, 4-pole, 2-way	10FB/644
10	Microammeter	10A/14384
11	Switch, Type 975	10F/1211
12	Switch, Type 975	10F/1211
13	Switch, 6-pole, 3-way	10FB/1055
14	Jack, Type 8	10H/343
15	Switch	5C/2126
16	Plug, Type 1	10H/488

INTRODUCTION

1. The test set, Type 320 serves the same purpose as the test set, Type 319, which is to facilitate the setting-up of transmitter-receivers in the TR.3523 series. However, the test set, Type 320 is for use with the WW version of this series.

GENERAL DESCRIPTION

2. A view of the front panel of the test set is shown in fig. 1, and the circuit diagram is given in fig. 2. These show the following changes from the test set, Type 319 :—

(1) The 12-way W-plugs have been replaced by 18-way WW-plugs.

(2) Two of the meters have been repositioned.

(3) A microswitch (S5) has been fitted, and is connected to switch off the battery when the test set is not in use. The lid of the instrument case must be closed to ensure this.

(4) The variable resistor (ohms set) is 25K. instead of 20K.

(5) The wooden instrument box has been changed to one made of metal.

OPERATION

3. The setting-up procedure and operation of the test set, Type 320 are exactly as for the test set, Type 319. Reference should therefore be made to Appendix I, and to para. 154 onwards.

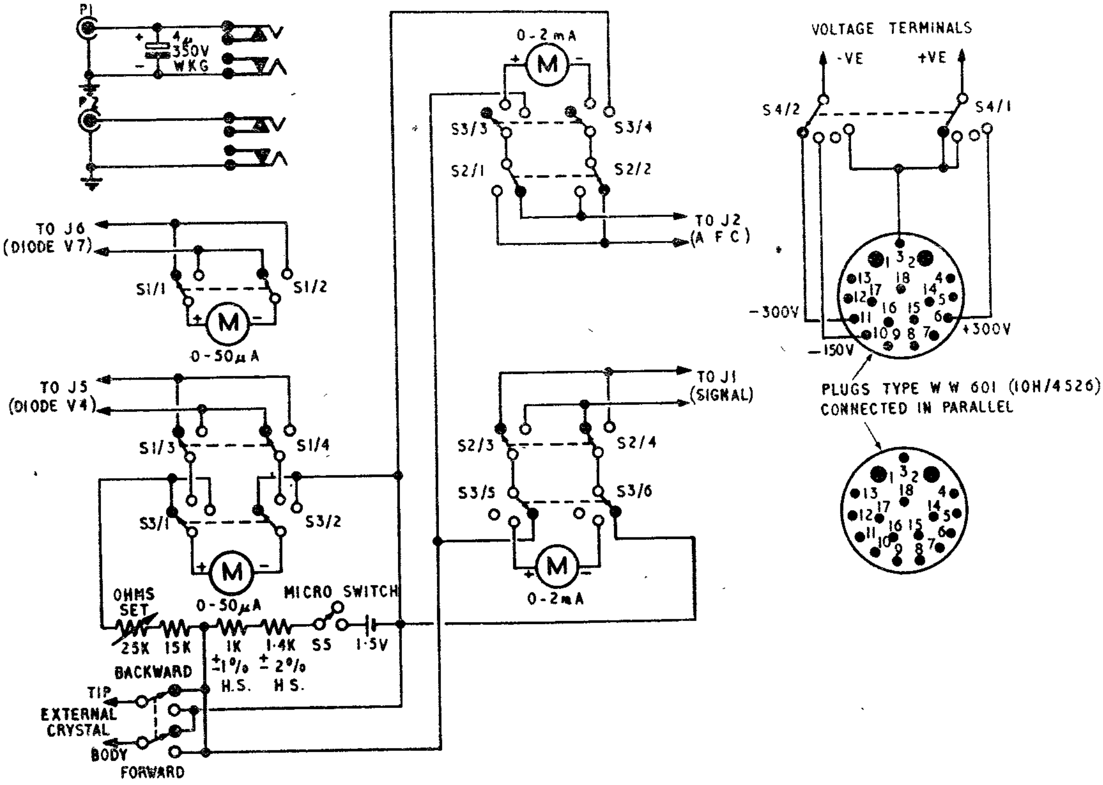


Fig. 2.—Circuit diagram

APPENDIX III

TEST KIT, TYPE 25

LIST OF CONTENTS *Para.*

LIST OF ILLUSTRATIONS *Fig.*

INTRODUCTION

1. Test kit, Type 25 (Stores Ref. 10SB/6500) has been designed to adapt the American test sets for use with the TR.3523 series of transmitter-receivers. The kit comprises:—

(1) Instrument case	Stores Ref. 10SB/6517
(2) Transformer unit, Type 169	Stores Ref. 10KB/6332
(3) Adapter unit	Stores Ref. 10SB/6520
(4) Feeder tubular, Type 201	Stores Ref. 10BB/6893
(5) Coupling unit, Type 105	Stores Ref. 10DB/8455
(6) Feeder tubular, Type 202	Stores Ref. 10BB/6894
(7) Connector, Type 7122	Stores Ref. 10HA/4358
(8) Waveguide, Type 272	Stores Ref. 10BB/8302

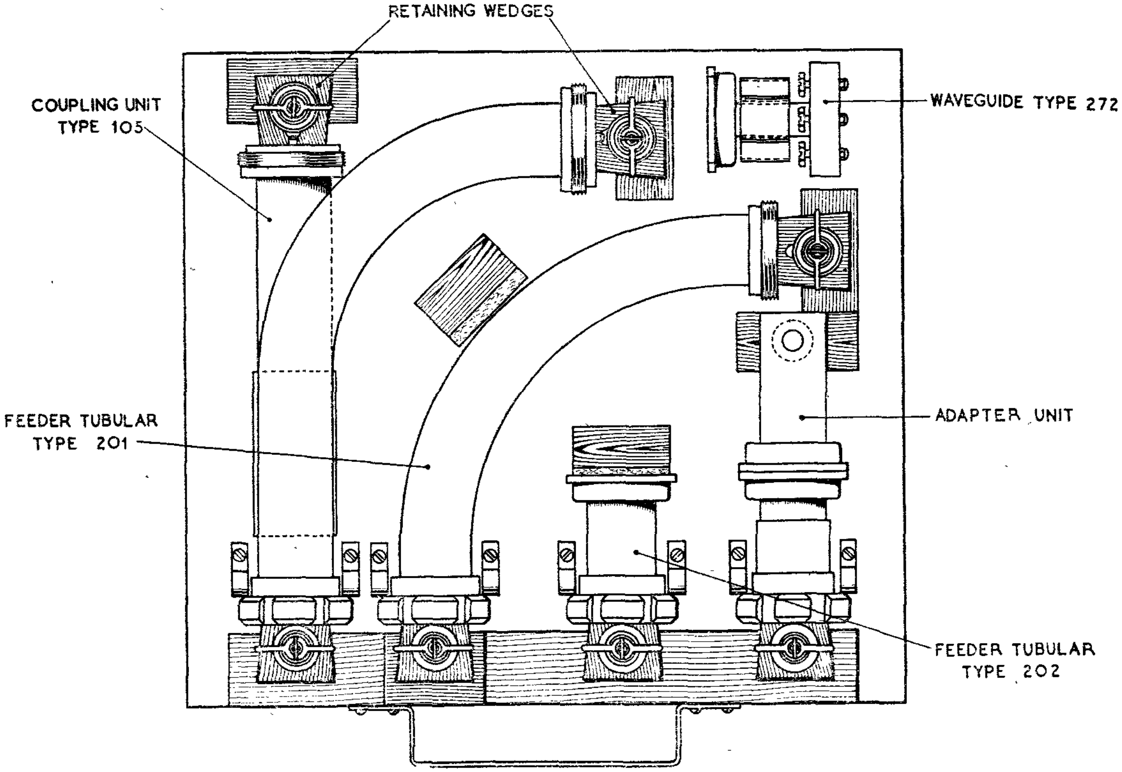


Fig. 1—Test Kit Assembly

2. The transformer unit provides the required 110-volt supply; it is tapped for 230 volts 50 c/s. and 80 volts 1,000 c/s. The connector, Type 7122 is used when the test set is triggered from the modulator prepulse. The transformer and connector unit are both located in the instrument case.

3. The British test sets, Type 289, Stores Ref. 10SB/6238 (see A.P.2896 AB), and Type X220 (which is under development) are similar to the American test sets, but are provided with the necessary waveguide couplings to enable them to be used with the transmitter-receivers. The addition of the waveguide adapter, Type 272 enables the American test set TS-13/AP to be used. The test kit, Type 25 is not required when the British test sets are used.

USE OF TEST KIT, TYPE 25

4. When using the test kit, Type 25, an American test set may be connected to the transmitter-receiver by waveguide, as in fig. 2, or by the coaxial cable supplied with the test set, as in fig. 3. The waveguide connection is preferable, since readings are liable to variation when the cable is moved or touched. The straight section of the aerial coupler (coupling unit, Type 105) joins the transmitter-receiver to the scanner or the dummy load, the latter is a part of the test set, Type 263. Slots in the upper wall of the straight section give attenuative coupling to the upper bend section, or vice versa; the attenuation is about 24 dB., and is marked on each coupling unit, so that absolute measurements may be made if desired. The directional coupler also has the property that reflections or signals from the dummy load or the scanner are not coupled to the test set.

5. For waveguide connections, the normal bend section is introduced so that the transmitter-receiver may be set out conveniently on the test bench. The British-American adapter joins the bend to the test set with 4 BA. screws.

6. When coaxial couplings must be used as, for example, when the directional coupler is part of the aircraft installation, the coaxial adapter is substituted for the bend section. The coaxial cable matching unit on the test set is screwed down and the connection is completed by means of a cable provided with the test set. In this case, allowance must be made for the attenuation of the cable in a calculation such as that set out in the following paragraphs. This attenuation is 4 dB. for a six-foot length of cable.

To find the peak transmitter power.

7. The method is given by reference to the following example:—

If, for full-scale meter reading, attenuator reading = 10·9 dB (above 10mW.) and attenuation of directional coupler (marked thereon) = 23·9 dB (adding attenuation of cable, if used)

Total mean power, P = 23·9 + 10·9 dB above 10mW.
= 34·8 dB
= 10 × (antilog 3·48) mW.
= 10 × 3,020 mW.
= 30·2 watts.

With pulses of 0·5 microsecond duration and with a p.r.f. of 1,200 per second, the actual transmitting time per second is 1,200 × 0·5 = 600 microseconds.

Hence peak power = $P \times 10^6 \div 600$
= $30{\cdot}2 \times 10^6 \div 600$ watts.
= 50 kW.

This leaf issued with A.L. No. 5
May, 1947

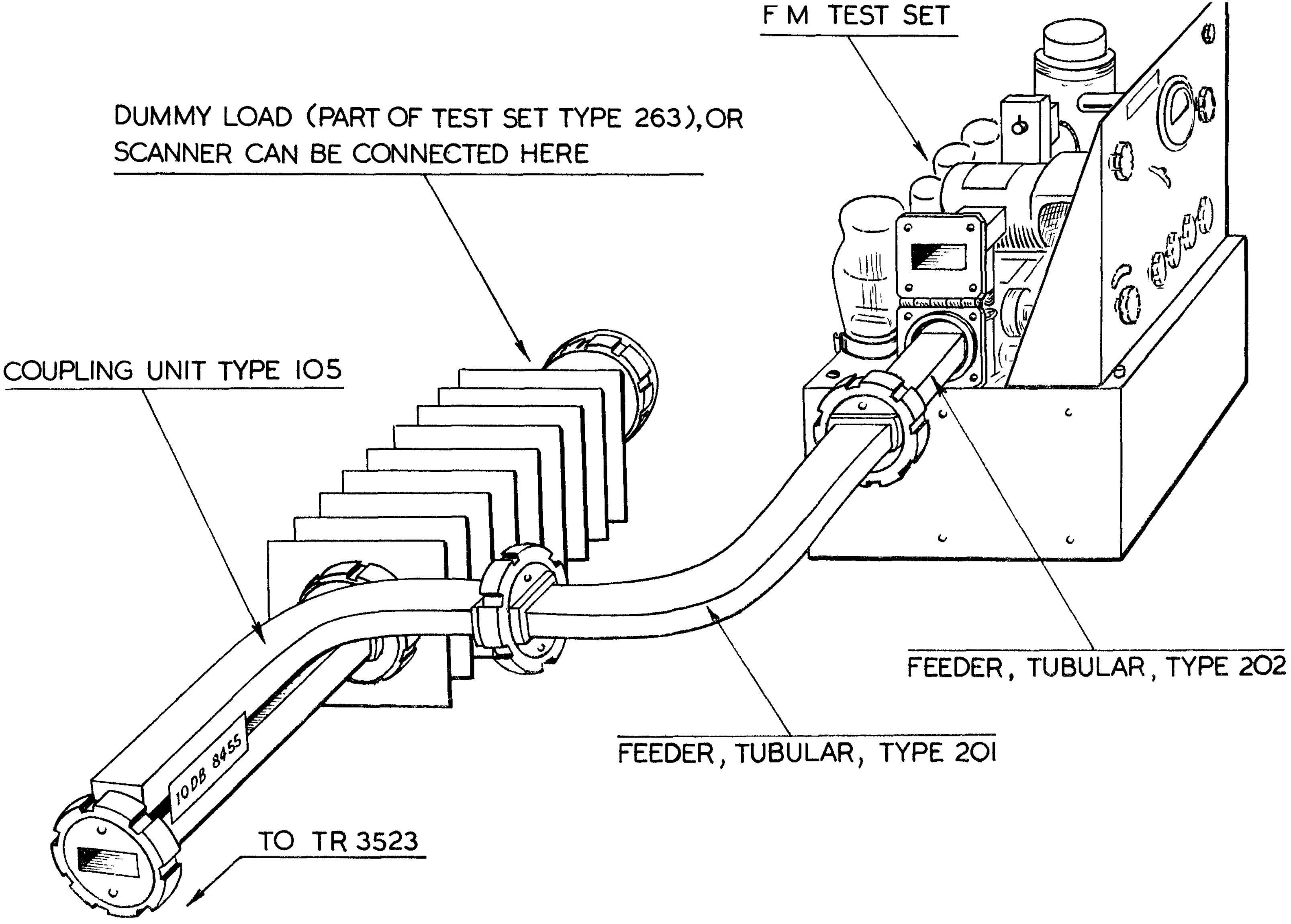


Fig. 2 – Arrangement with waveguide connection

G337m32216 5/47 850 C.B.&S.Ltd. Gp30

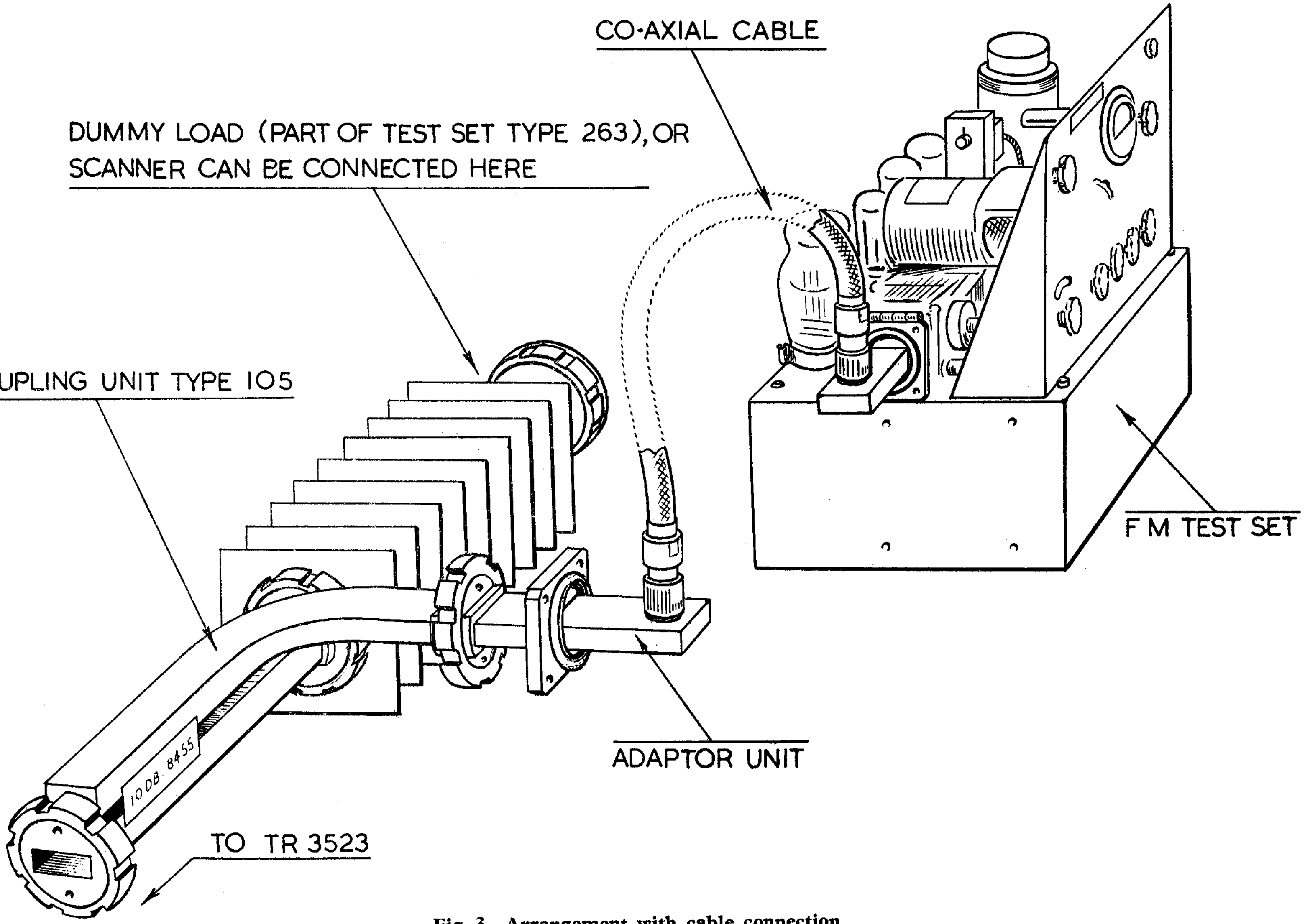


Fig. 3—Arrangement with cable connection

This leaf issued with A.L. No. 6
November, 1948

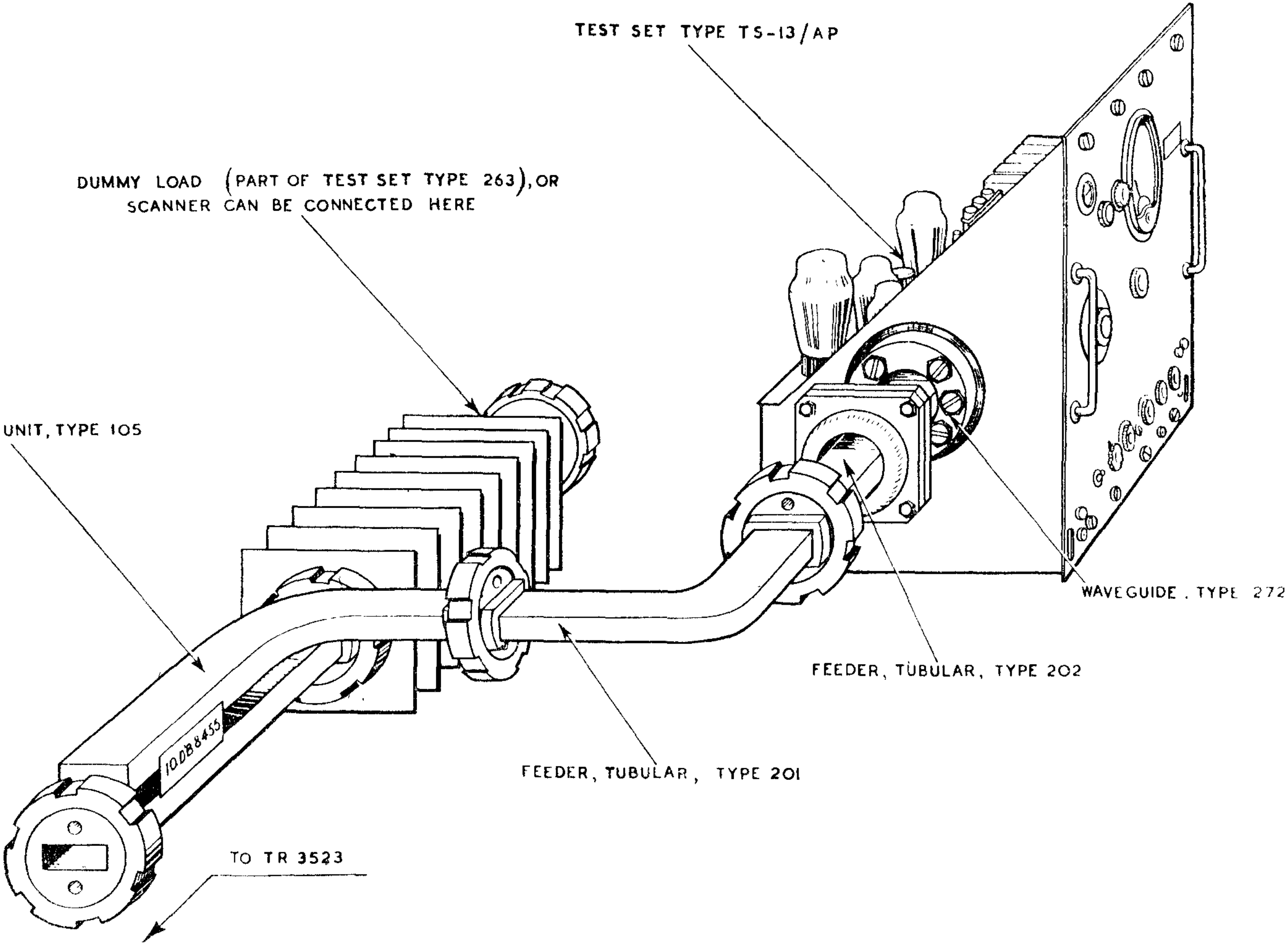


Fig. 4—Arrangement with test set, Type TS13/AP

G2138 M12556 12/48 850 C.B &S Ltd. Gp 30