RESTRICTED

AIR PUBLICATION

2557 M

VOLUME 1

GEE Mk 3
AIRBORNE EQUIPMENT
(ARI. 5816)

GENERAL AND TECHNICAL INFORMATION

Prepared by direction of the Minister of Aviation

Henry Hardman

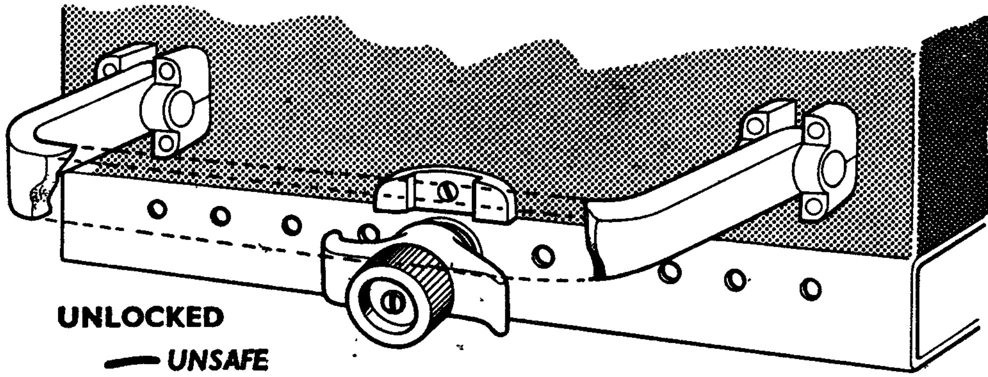
Promulgated by Order of the Air Council

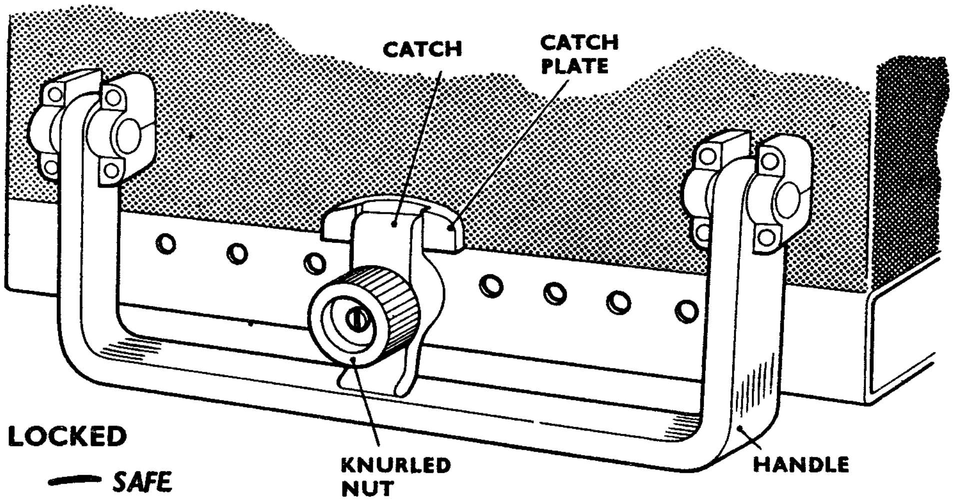
M. J. Dean.

AIR MINISTRY

Reprinted Feb. 1962

An unlocked unit means Danger!





FOLLOW THIS DRILL WHEN LOCKING

1. PULL DOWN HANDLE
2. TURN CATCH WITH LIP UPRIGHT
3. TIGHTEN KNURLED NUT

CHECK THAT HANDLE IS SECURELY HELD IN DOWN POSITION AND THAT CATCH IS HELD IN CATCH PLATE

NOTE TO READERS

The subject matter of this publication may be affected by Air Ministry Orders, or by "General Orders and Modifications" leaflets in this A.P., in the associated publications listed below or even in some others. If possible, Amendment Lists are issued to correct this publication accordingly, but it is not always practicable to do so. When an Order or leaflet contradicts any portion of this publication, the Order or leaflet is to be taken as the overriding authority.

Each leaf bears the date of issue and, when applicable, the number of the Amendment List with which it was issued. New or amended technical information on new leaves which are inserted when this publication is amended will be indicated by a vertical line on the right of the matter affected. This line merely denotes a change and is not a mark of emphasis. When a Chapter is issued in a completely revised form, the line will not appear.

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LIST OF ASSOCIATED PUBLICATIONS

The Gee system manual	*2557V*
Gee Mk. 2 airborne equipment (ARI.5083)	*2557A*

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LIST OF AIR DIAGRAMS

Receiver Type R.3673—Circuit	*5221A*
Waveform generator Type 72—Circuit	*5221B*
Indicator C.R.T. Type 26—Circuit	*5221C*
Interconnections of units	*5221D*
Stage-by-stage block diagram	*5221E*

LAYOUT OF A.P.2557M

GEE Mk. 3 AIRBORNE EQUIPMENT

(ARI.5816)

Heavy type indicates books being issued under this A.P. number ; when issued they will be listed in A.P.113 and A.P.2463

VOLUME 1	**GENERAL AND TECHNICAL INFORMATION**
Part 1	**General Information**
Part 2	**Testing and servicing**
Part 3	**Fault diagnosis**
Part 4	*Inapplicable*
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Part 3	**Minor and minor* servicing**
Part 4	**Major servicing**
Part 6	**Bay servicing and fault localization schedule**
Other parts	*Inapplicable*
VOLUME 5	BASIC SERVICING SCHEDULES
All parts	*Inapplicable*
VOLUME 6	REPAIR AND RECONDITIONING INSTRUCTIONS
All parts	*Undecided*

INTRODUCTION

1. The Gee navigational system, of which the Gee Mk. 3 forms an airborne element, is already fully described in both its general theory and practical application in the several A.P.'s referred to in the List of Associated Publications. But, in order that the user of this A.P. may have a ready guide to the basic principles of the system, an outline of Gee theory is repeated in brief form in this introduction.

2. The object of the Gee system is stated as providing "a means of navigation by which an aircraft or ship can find its position in the area served by the system", and because Gee is a radio system its application is not dependent upon visibility.

3. The system consists of chains of fixed ground radio transmitters which radiate the position-fixing signals, and airborne (or shipborne) receivers which receive and display the signals and provide information which navigators or pilots can interpret on special charts. Each chain covers a particular area, and is made up of four, carefully spaced, pulse transmitters.

4. The theory of operation requires that radio contact be made only between the transmitters and the receivers and reflected or re-transmitted waves are not involved; the ground stations need not be aware that their signals are being received and in consequence there is no limit to the handling capacity of the system and therefore to the number of aircraft which can simultaneously make use of it.

5. The basic principle applied in the Gee system is that the signals from two synchronized pulse transmitters will be received at different times at some particular point in the service area and the actual delay between the pulses is dependent upon the difference between the distances travelled and not the actual distances. Each point in the service area can therefore be defined in terms of the delay measured there, and when a series of points associated with a number of specific delays are plotted on a chart of the area, a family of curves centred about a point between the two transmitters will result. Each curve will then indicate the line along which an aircraft would have to fly in order to find a constant time delay between the two signals.

6. With a second pair of transmitters appropriately spaced from the first pair a second family of curves can be plotted on the chart; the resulting lattice formed between the two sets of curves then allows any point on the chart to be defined in terms of the co-ordinates of the two sets. For any given position in the service area, therefore, a measurement of the delay between the first pair of transmitters will identify a particular line of the first set of curves and measurement of the delay between the second pair will identify a particular line of the second set; the intersection of the two lines then provides a fix of position. Where ambiguity as to the actual position arises because of more than one intersection of the two lines the delay between a third pair of transmitters can be measured to indicate a line in a third set of curves; the alternative intersection can then be eliminated.

7. In an actual chain, one transmitter known as the master, acts as a common member of each of the three pairs, and the other transmitters known as slaves, radiate as repeaters at fixed intervals after they each receive the pulses from the master. As a result, the maximum delay between the master and any particular slave is that found at a point on the master side of a straight line passing through the two stations, and this delay is independent of the distances from the point to the stations. The maximum delay to be measured in the receiving equipment is therefore conditioned by the layout of the ground stations and not by the range of reception.

8. The sets of curves on the Gee charts are in the form of families of hyperbolæ with the transmitters at their foci. Each family relates to the master and any one slave, and each line represents a particular delay. The lines are calibrated in Gee units, one of which represents a delay of $66\frac{2}{3}$ microseconds; the separation between lines on the charts is 0·1 Gee units.

9. In normal references to the system, the signals received from the master station are referred to as *A* pulses and those from the slaves as *B*, *C*, and *D* pulses respectively. The *A* pulses are transmitted at a p.r.f. of twice the *B* and *C* pulses; the timing is such that the *B* pulses follow the odd *A* pulses and the *C* pulses follow the even *A* pulses. Every fourth *A* transmission is distinguished by an extra pulse which follows the normal pulse after an interval of 1 Gee unit.

10. The special timing of the pulses is used to allow them to be identified in the aircraft receiving equipment. This equipment comprises a receiver, display, and timing circuits. The pulses are presented on a cathode-ray tube on a timebase which is synchronized with the *A* pulses. Every second timebase sweep is displaced vertically downwards so that alternate *A* pulses appear on separate traces; when correctly set up the odd *A* pulses are displayed on the top trace and the even *A* pulses on the lower trace; the *B* and *C* pulses are then on the top and lower traces respectively. The double pulse associated with each fourth *A* pulse allows the even *A* pulses to be distinguished, and as it is also blinked on and off to a predetermined code, it also provides a means of identifying the particular chain; the extra pulse is described as a ghost because it has a lower p.r.f. than the normal *A* pulses and in consequence appears much fainter.

11. The third slave, *D*, is also a double pulse but it appears on both traces. The *B* and *C* slaves are normally sufficient to allow accurate fixes to be taken but the *D* is usually provided to allow for improved accuracy of fix in certain difficult areas and to resolve ambiguities which sometimes arise.

12. The time delay between the pulses is measured against the time standard set by the intervals between successive oscillations of a crystal oscillator.

13. The accuracy of the Gee system can be as high as plus or minus 100 yards at points close to the centre of the chain, and will not fall outside the limits of plus or minus 0·5 per cent of the range at greater distances.

14. The frequency band in which the Gee signals are transmitted is between 22 Mc/s and 85 Mc/s and in consequence only ground wave signals can be usefully employed. This limits the range at sea level to about 50 miles and at 5,000 feet to about 250 miles.

CONCISE DETAILS
OF
GEE Mk. 3

General description — Airborne receiver and cathode-ray tube display ; miniaturized and improved development of Gee Mk. 2.

Function — Navigational aid ; provides fixes of position within the service area of a Gee 7,000 chain of transmitters.

Operating principles — Pulses from a Gee chain are received and displayed on a cathode-ray tube ; the navigator adjusts strobe controls to line up the received pulses, and dials which are mechanically linked to the controls indicate the time intervals between the several pulses. The intervals in Gee units are translated on a Gee chart to show the aircraft's position.

Application — Multi-seat aircraft.

Frequency range — 22 Mc/s to 85 Mc/s in seven pre-set channels.

Type of receiver — Superheterodyne, consisting of:—

- RF amplifier
- Mixer
- Local oscillator
- Five-stage IF amplifier
- Detector and echo suppressor
- Two-stage video amplifier

Intermediate frequency — 7·5 Mc/s.

Aerial system — Rod aerial for slow-flying aircraft ; suppressed aerial, forming part of aircraft structure, for high-speed aircraft ; matching units fitted in all cases.

Display — 2½ in. electrostatic cathode-ray tube with post-deflector acceleration, displaying two vertically displaced Type A traces for main-timebase operation, and four vertically displaced expanded traces, in two pairs, for strobe timebase operation.

Timebase p.r.f. — 495, 497·5, 500, 502·5, 505, or 507·5 sweeps per second ; synchronizing pulses are sub-multiples of the output of a crystal oscillator ; a separate crystal is provided for each p.r.f.; fine control of the p.r.f. to produce exact synchronism with the received Gee pulses is carried out by manual or automatic control of the crystal oscillator frequency.

Crystal frequencies — 148·5 kc/s, 149·25 kc/s, 150 kc/s, 150·75 kc/s, 151·5 kc/s, 152·25 kc/s.

Power supplies — 80V or 115V, 400 to 2,400 c/s ; 24 volts DC.

Power consumption — AC—200 watts ; DC—20 watts.

Main items of installation

Description	*Stores Ref.*	*Size (in.)*	*Weight (lb.)*
Receiver Type R.3673	10D/16876	15 × 8 × 8	21½
Waveform generator Type 7A	10V/16045	15 × 8 × 8	21
Indicator CRT Type 26	10Q/16056	12 × 8 × 6½	16½
Junction box Type 359A	10D/18543	2½ × 8 × 3½	2¼
Junction box Type 360A	10D/18544	2¼ × 8 × 5½	2¾
Junction box Type 361A	10D/18545	2¼ × 8 × 5½	2¾

Test equipment

Description	Stores Ref.
Test set Type 210	10S/16002
or	
Test set Type 253	10S/16049
Oscilloscope Type 13	10S/825
or	
Oscilloscope Type 13A	10S/831
or	
Oscilloscope Type 10	10SB/180
Testmeter Type X	10S/16309
or	
Tester, set, Type 856G	110S/22
Attenuator unit, Type 70	10A/16129
Voltmeter, electrostatic, 0-5kV	5Q/163
Voltmeter, thermo-couple, 0-100V	5Q/704
or	
Voltmeter, AC Type 1S.185, 0-150V	110SB/102
Microammeter, 0-250 μA	5Q/14427
Tester, insulation resistance	5G/1621
Blower, air, portable, Type A	5A/1902
Signal generator, Type 106	10SB/6086

LIST OF PRELIMINARY MATTER AND PARTS

PRELIMINARIES

PARTS

Note—A list of contents appears at the beginning of each part

PART 1

GENERAL INFORMATION

PART I

LIST OF CHAPTERS

***Note.**—A list of contents appears at the beginning of each chapter*

Chapter 1

GENERAL DESCRIPTION

This chapter supersedes that issued with A.L.1

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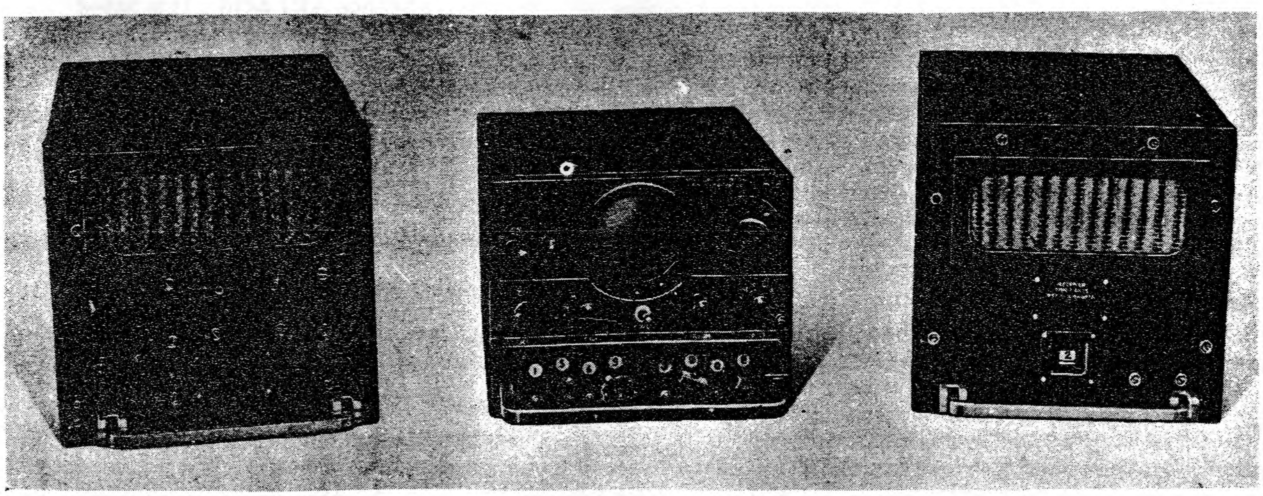

Fig. 1. General view of major units

INTRODUCTION

The Gee Mk. 3 is a radio navigational aid for in multi-seat aircraft. It is a development in an ›roved and miniaturized form from the Gee . 2.

The Gee series of receivers operate on signals ›ided by the Gee 7,000 ground radio chains, and ›ide for the accurate determination of the ›raphical position of the aircraft carrying the pment, irrespective of visibility. A reduction e time required to take a fix of position is the ›r feature which distinguishes the Mk. 3 from ‹k. 2.

The major items of the Gee Mk. 3 equipment shown in fig. 1; they comprise three separate ›, indicator, receiver and waveform generator. indicator is positioned to be accessible to the or navigator and the other two units are ioned at remote points elsewhere in the air- . All controls used in normal operation are ›d on the indicator unit.

. single aerial, with a switched matching n which provides for operation over the full ange, is fitted. The type of aerial depends the type of aircraft and will be a normal rod in slow-flying aircraft and one of several of suppressed aerial in high-speed aircraft. ›ssed aerials are necessary in high-speed 't because rod aerials are liable to damage at peeds and seriously impair the aerodynamic es of the aircraft.

5. The operational ceiling of the Gee Mk. 3 is 60,000 feet, subject to the proviso that the cabin in which the indicator is housed is pressurized to an equivalent height of not more than 35,000 feet. The other units, which may be located in unpressurized parts of the aircraft, are not separately pressurized but are designed to operate at 60,000 feet without special precautions.

6. The equipment operates from power supplies of 24 volts DC, and 80 volts or 115 volts AC at frequencies between 400 and 2,400 c/s. Power consumption is approximately 20 watts DC, and 200 watts AC.

7. The ambient temperature range in which the equipment is designed to operate is between minus 40 deg. and plus 55 deg. Celsius. A thermostatic control is included in the main AC supply line to switch off the whole equipment if the internal temperature of the waveform generator or the receiver rises more than 30 deg. Celsius above the maximum ambient temperature.

Comparison of Gee Mk. 3 and Mk. 2

8. The Gee Mk. 3 retains many of the operational features of the Mk. 2 but is very different in the major characteristics of its electrical design and is entirely different in its mechanical construction. The electrical changes have resulted in improved operating techniques, and the mechanical differences have allowed for a simplified installation and also for improved accessibility in the separate units for service and maintenance purposes.

9. In order that personnel already familiar with the Gee Mk. 2 can come to a ready understanding of the Mk. 3, a list of features in which the Mk. 3 differs from the Mk. 2, is given below:—

(1) All controls used in normal position-fixing mounted on the indicator.

(2) Only the indicator is fitted at the point in the aircraft where fixes are to be taken; the other units are stowed at convenient points throughout the aircraft.

(3) Seven preset receiver channels can be selected at the indicator unit without the need for changing units in the receiver. The motor operated switch which carries out the selection also controls the aerial loading unit in some aerial installations.

(4) Provision is made for the reception of Gee chains operating on a common frequency but distinguished by different p.r.f.s. A six-position switch is provided giving a choice of six p.r.f.s.

(5) The time needed to take a fix has been reduced by the provision of calibrated strobe controls. With these, calibrated dials indicate the strobe positions in Gee units, and the dial reading can be used directly on the Gee charts. Calibration pips need not be counted.

(6) An automatic locking system is used, whereby having once strobed the *A*-pulse, the timebase can be locked to the pulse. In operation, the drift of pulses across the screen is eliminated and continuous manual adjustments to the Xtal control are not required when a series of fixes are taken.

(7) Maintenance is simplified in the receiver by the use of plug-in sub-units, and in all units by the open construction and general use of miniature components.

(8) All interconnections between units are carried out through junction boxes fitted to the mounting racks. Individual units plug into the junction boxes and do not carry connectors.

(9) Separate miniature blowers are used for cooling purposes in the two remote units; they allow operation in conditions of high ambient temperature.

DETAILS OF INSTALLATION

Items of equipment

10. The standard installation in aircraft of the Gee Mk. 3 has the reference ARI.5816. It is fitted in several different forms according to the type of aircraft involved; the differences are almost entirely associated with the use of particular aerial systems from the several that are available. An interconnection diagram of the installation is shown in fig. 2.

11. The major items of the installation are service supply items fitted as removable equipment; they are rack-mounted and are easily removable for service and inspection purposes; they are listed in Table 1. Other items in the installation, including connectors, are fitted as fixed equipment and are listed in Table 2.

Notes on installation

12. The three major units and the junction boxes are mounted on standard S.B.A.C. rack units of the type shown in fig. 3. The particular types of rack units employed will depend upon the requirements of particular aircraft; the alternative

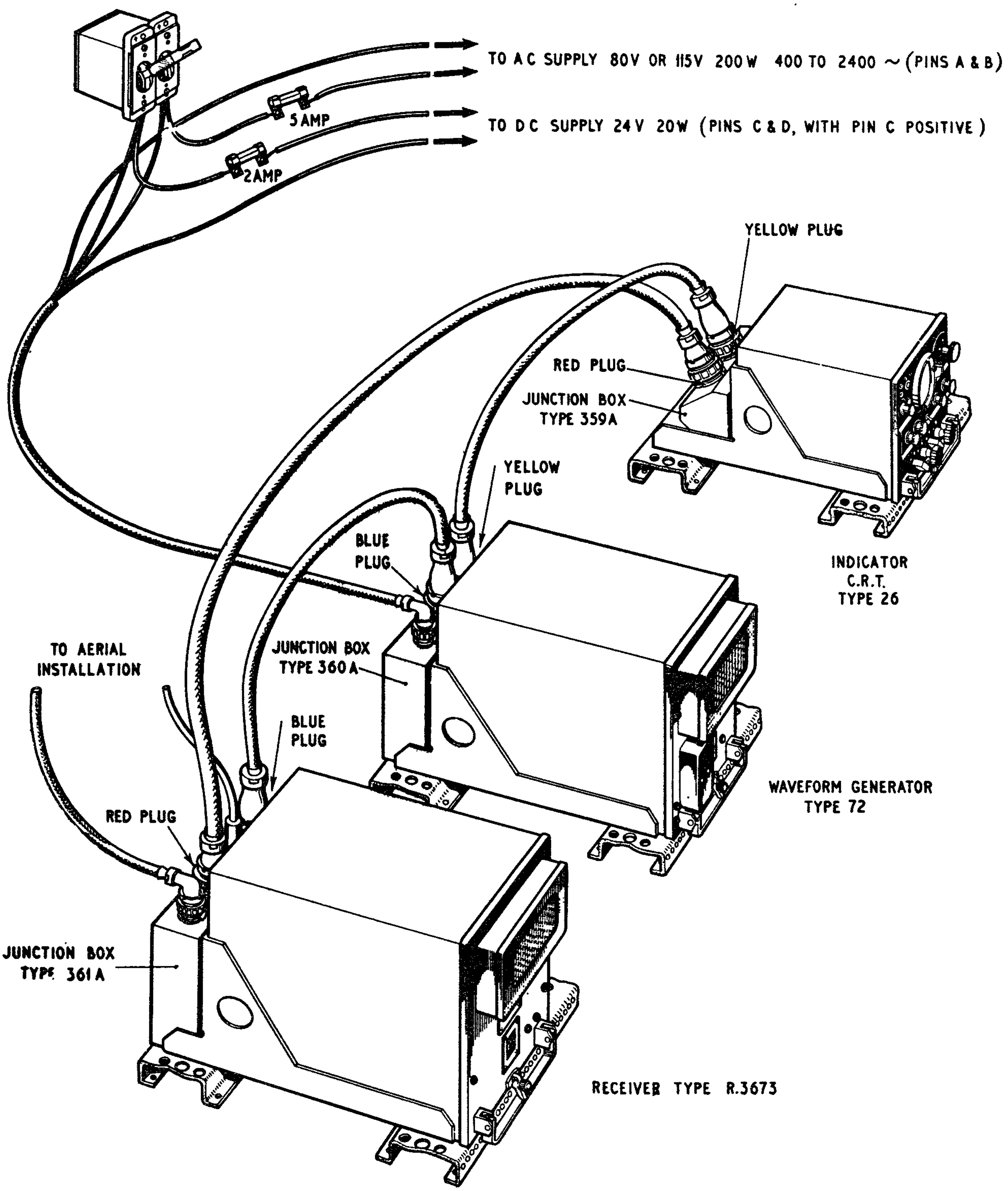

Fig. 2. Details of Gee Mk. 3 installation

arrangements are as follows:—

Three single rack units
One single rack unit and one twin rack unit
One triple rack unit.

The racks are mounted to the aircraft's structure on resilient mountings. The junction boxes, which are shown in fig. 4, are secured to the rear frameworks of the racks and the units locate into the junction boxes through dowels which project from the unit rear plates. A spring-loaded clamp on the front member of each mounting rack holds the unit position on the rack and also holds down the spring-loaded unit carrying handle.

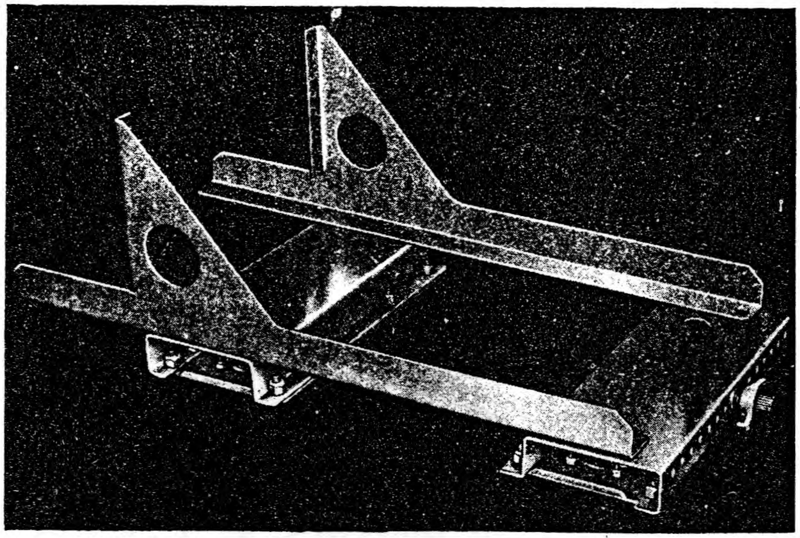

Fig. 3. S.B.A.C. type mounting rack

TABLE 1
Removable equipment

Description	Stores Ref.	Overall dimensions	Weight
Receiver Type R.3673	10D/16876	15 × 8 × 8 in.	21½ lb.
Waveform generator Type 72	10V/16045	15 × 8 × 8 in.	21 lb.
Indicator CRT Type 26	10Q/16058	12 × 8 × 6½ in.	16½lb.

TABLE 2
Fixed equipment

Description	Stores Ref.	Weight	Notes
Junction box Type 361A	10D/18545	2¼ lb.	Connects up receiver
Junction box Type 360A	10D/18544	2¾ lb.	Connects up waveform generator
Junction box Type 359A	10D/18543	2¾ lb.	Connects up indicator
Mounting tray			Standard S.B.A.C. racking in single, twin or triple units, as required
* { Switch box Type B	5C/2497		Two items required
{ Bar coupling	5C/2612		Links switches Type B to form a double-pole switch
* { Switch tumbler S.P.	5C/4184		Two items required
{ Bar coupling	5C/4324		Links tumbler switches to form double-pole switch
*Switch tumbler D.P.	5C/4198		
Connector set	10HA/		Type and Ref. numbers depend upon type of aircraft
Aerial system			Details in Chap. 5 and 6.

* *Alternatives*

13. The connections between the units and their junction boxes are made through Jones-type plugs and sockets, and the interconnections between the junction boxes are carried out through connectors terminating in Plessey Mk. 4 sockets. There are in consequence no connectors directly associated with the major removable items of equipment. In some installations, junction boxes Type 361 (Stores Ref. 10D/16879), 360 (Stores Ref. 10D/16878) and 359 (Stores Ref. 10D/16877), are used in place of those quoted in Table 2; these junction boxes are of generally similar appearance to the current types but are of less robust construction and do not carry provision for remote switching of the aerial matching units.

Indicator

14. The indicator is mounted to be accessible to the navigator or co-pilot; it must be positioned to provide a clear view of the cathode-ray tube and to allow ready access to the front panel controls. The junction box Type 359A is secured to the rear of the indicator mounting rack. The plugs on the junction box are provided with alternative mount-

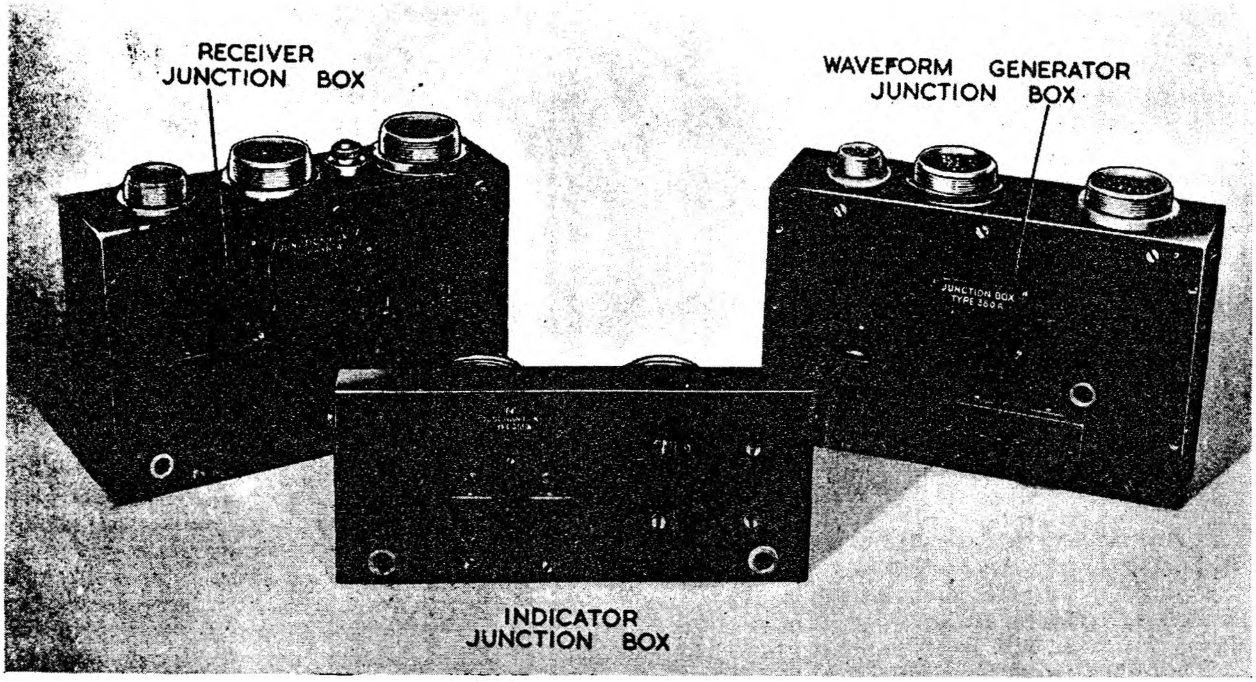

Fig. 4. General view of junction boxes

ing positions on either the upper or lower rear surfaces of the box; the two positions allow for top or bottom entry of the sockets on the connectors; the normal positon is that providing for top entry. To provide for the withdrawal of the sockets a clearance of at least 2⅝ in. must be left above and behind the plugs. Where difficulty is experienced in achieving this clearance the box can be fitted in the alternative position with the plugs projecting downwards.

Waveform generator

15. The waveform generator can be sited at any convenient point in the aircraft, but normally must be positioned so that the connector to the indicator does not exceed a length of 25 ft. The junction box Type 360A is secured to the rear of the waveform generator mounting rack. The plugs on the junction box are provided with alternative mounting positions on the top and bottom plates of the box to provide for top or bottom entry of the sockets. A clearance of at least 2⅝ in. must be left above—or below—the plugs to allow the sockets to be withdrawn.

Receiver

16. The receiver can be sited at any convenient position in the aircraft; it will normally be positioned alongside the waveform generator. The restrictions on position are that the connector to the indicator normally shall not exceed a length of 25 ft., and the connector to the waveform generator shall not exceed 3 ft. The junction box Type 361A is secured to the rear of the receiver mounting rack. The plugs on the junction box are provided with alternative mounting positions on the top and bottom plates of the box to provide for top or bottom entry of the sockets. A clearance of at least 2⅝ in. must be left above—or below—the plugs to allow the sockets to be withdrawn.

Ventilation

17. All units must be sited to allow free movement of air around them. Where possible they should be spaced well apart from other heat producing devices. Adequate ventilation is particularly important in the receiver and waveform generator and care must be taken to ensure that their air inlet and outlet vents are not blocked by other apparatus.

Aerial systems

18. Several different aerial installations are available which will be used according to the type of aircraft involved. Full details are given in Chap. 5 and 6.

Connectors

19. The connectors are in all instances service supply items bearing A.M. Ref. numbers. Except for some of the leads in the aerial systems they are all made up from screened multi-core cables and are terminated in Plessey Mk. 4 sockets. It is not anticipated that confusion will arise when the connectors are plugged into the junction boxes as the plugs on the junction boxes are coloured and any connector will be plugged into similarly coloured plugs at both ends, the problem is further eased in that 4, 12, 18 and 25 point plugs and sockets are used, and where two connectors have the same type of termination, their orientations are different.

20. The lengths of cables in the connectors will depend upon the type of aircraft in which they are being used; the type and Stores Ref. numbers of particular cables will therefore depend also upon the type of aircraft involved.

Minor items

21. Control of the DC and AC supplies into the waveform generator is provided by a double-pole switch. Three types of switch are available; the first uses separate type B single-pole switches linked by a coupling bar, the second uses single-pole tumbler switches also linked by a coupling bar, the third is a double-pole tumbler switch.

22. A 5-amp. fuse is fitted in the AC supply line and a 2-amp. fuse is fitted in the DC supply line. The power supplies in the equipment are not taken to chassis and in consequence the external supply sources may be earthed on either of their lines.

GENERAL DESCRIPTION OF UNITS

Indicator

23. A general view of the indicator is shown in fig. 5. The unit contains a cathode-ray tube display and its associated power unit, timebase and video circuits, a crystal oscillator with part of its automatic frequency correcting circuit and frequency dividing chain, and operating controls; some of the controls are connected into the other two units to provide remote control of their operation.

24. The majority of components are built on to a complex chassis structure which also carries one detachable sub-assembly. This sub-assembly is the strobe-timer switch unit which operates remotely in the waveform generator; the standard unit is switch unit Type 298 (Stores Ref. 10F/16143) but in some indicators a different type of switch unit, unclassified by Type or Stores Ref. numbers, is fitted; the unclassified switch is a provisional type which will eventually be universally replaced by direct substitution of the switch unit Type 298.

Waveform generator

25. A general view of the waveform generator is shown in fig. 6. This unit containes the main frequency-dividing network which produces calibration pulses for operating the strobe-timers and synchronizing pulses for the timebase and strobe-pulse generators; it also contains the strobe-timers, strobe-generators and the trace separation circuits. The main power unit which provides HT for the whole equipment is also contained in the waveform generator.

26. All the components are mounted on a complex chassis structure. An air filter and blower motor are fitted to the front panel to provide a ventilating flow of air through the unit.

Receiver

27. A general view of the receiver is shown in fig. 7. This unit contains the receiver circuits, including a motor-driven RF-and-oscillator tuning switch controlled from the indicator, and the control circuit which produces the correcting signals for regulating the crystal oscillator in the indicator.

28. The receiver chassis carries the main circuit components in three separate and easily removable sub-chassis; the first sub-chassis is the RF unit Type 148 (Stores Ref. 10D/18329) which carries the receiver RF and oscillator circuits, the second is the IF unit Type 125 (Stores Ref. 10D/18330) which carries the receiver IF and video circuits, the third is the synchronizing unit Type 28 (Stores Ref. 10D/18331) which carries part of the automatic A-lock circuit. An air filter and blower motor are fitted to the front panel to provide a ventilating flow of air through the unit. An indicator drum on the front panel shows the channel setting of the RF selector switch on the RF unit Type 148.

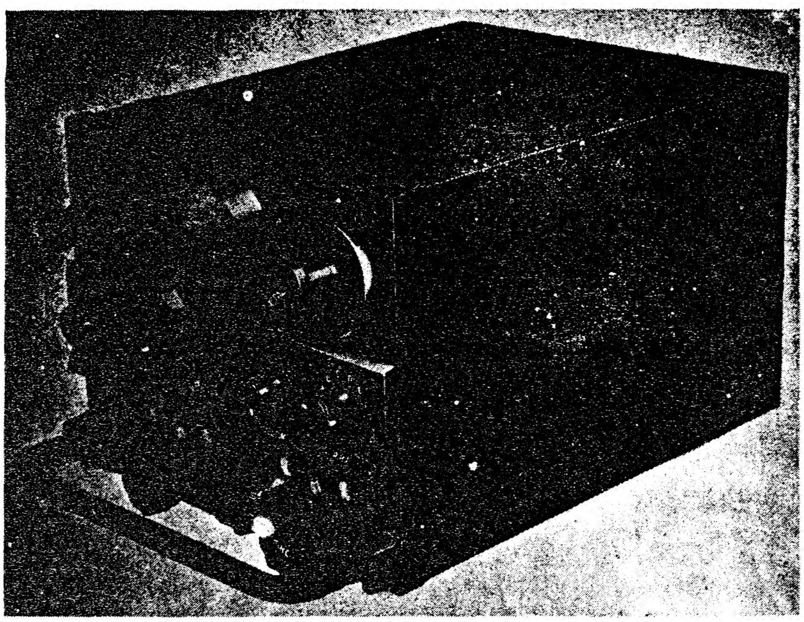

Fig. 5. Indicator CRT Type 26

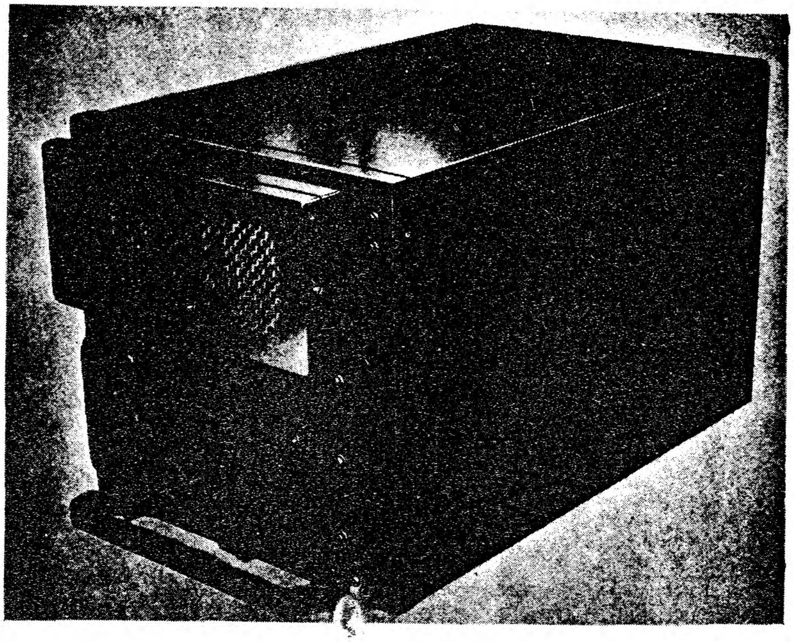

Fig. 6. Waveform generator Type 72

GENERAL DESCRIPTION OF CIRCUIT

29. The function of the Gee Mk. 3 equipment is to receive the signals from a Gee chain, display them on a timebase, and allow the time intervals between the several pulses to be compared against the time standards set by internally generated oscillations of accurately known frequency. The principle of the system is shown in the basic block diagram fig. 8.

30. In the actual equipment, the need to maintain a high order of accuracy at a high level of stability requires the use of complex circuits to carry out the simple functions of fig. 8. The main circuit elements which carry out these functions are shown, still in a simplified form, in fig. 9.

31. The receiver is a standard type of high-gain, wide-band superhet which operates in seven preset switched channels in the range 20 Mc/s to 90 Mc/s;

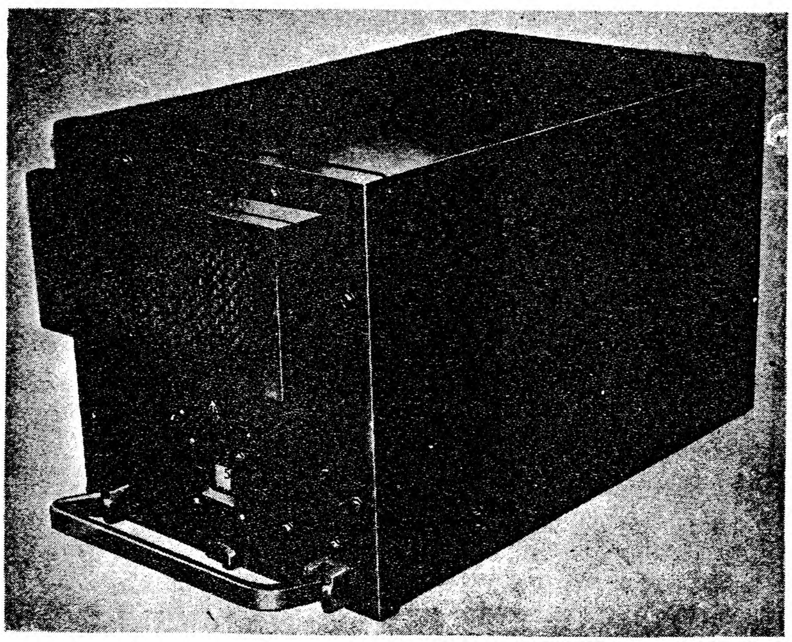

Fig. 7. Receiver Type R.3673

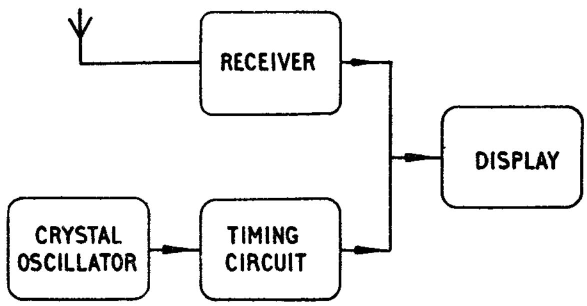

Fig. 8. Basic receiver for Gee system

the RF selector is a ten-position switch in which three positions are not wired-up but may at some later date be brought into use. The timing circuit is based on a crystal controlled oscillator, which, in normal operation, oscillates at 150 kc/s and feeds a dividing chain to be counted down to the time-base synchronizing p.r.f. of 500 per second. (Provision is also made for other p.r.f.s by the choice of five other crystals operating over the range 148·5 kc/s to 152·25 kc/s, but in normal circumstances the 150 kc/s crystal is used and this condition is considered throughout this description.) The display circuits use a three-inch cathode-ray tube with post-deflection acceleration.

Main timebase operation

32. The output of the crystal oscillator is shaped and divided in the divider chain to produce sharp pulse outputs at 75 kc/s, 15 kc/s, 3 kc/s, a rect-angular wave output at 500 per second and a square wave output at 250 per second. For the main timebase condition of operation, the 500 per second output is used to trigger the timebase and the square wave is applied to the Y-plates of the cathode-ray tube to cause alternate traces to be separated. Incoming Gee signals from the receiver are also applied to the Y-plates, and when the crystal oscillator is correctly adjusted the odd *A* pulses and the *B* pulses appear on the top trace, and the even *A* pulses and the *C* pulses appear on the bottom trace.

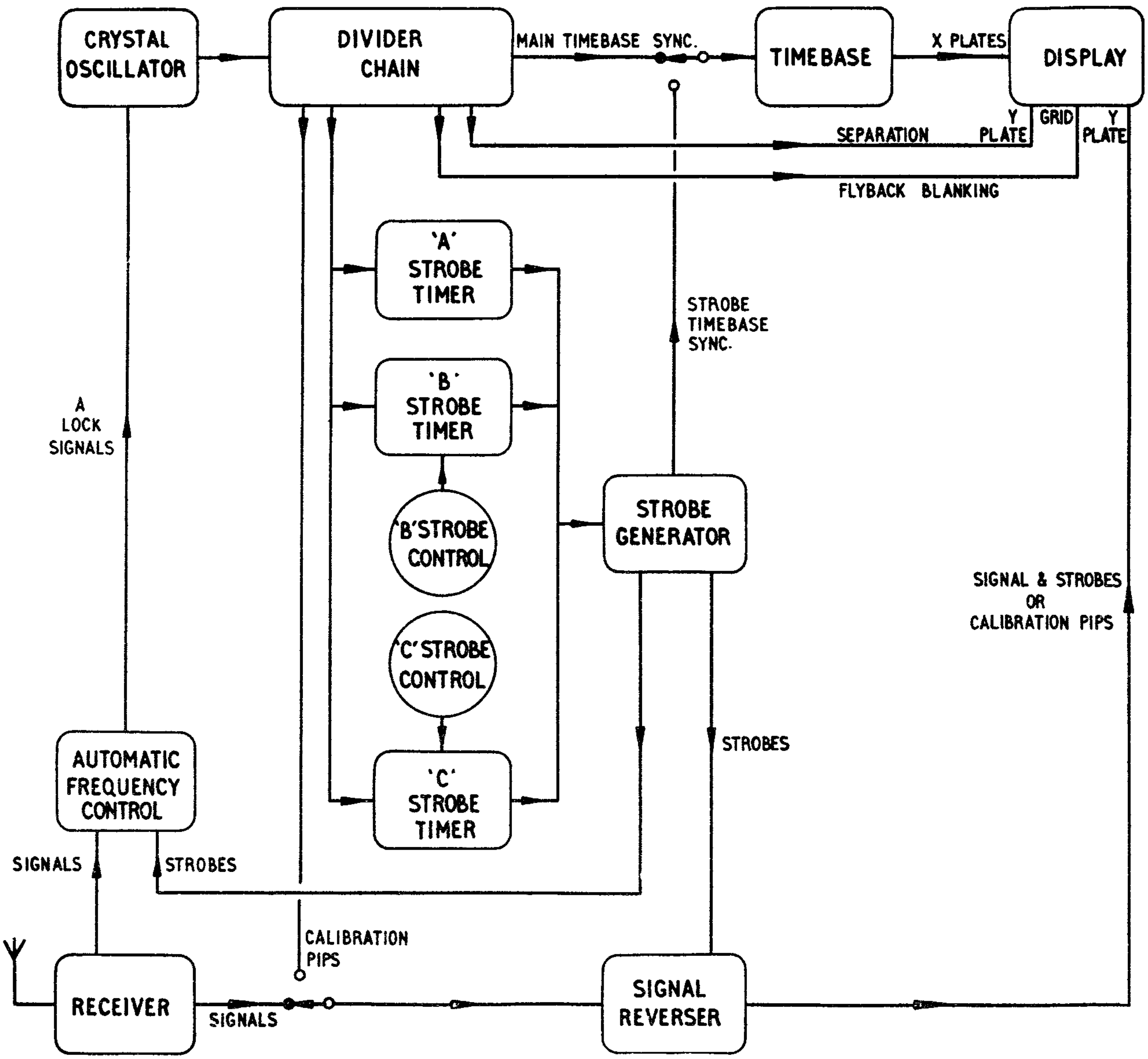

Fig. 9. Simplified block diagram of Gee Mk. 3

33. The time intervals between pulses are calculated in three strobe timer circuits. The first of these produces the *A* strobe and provides the reference time from which the adjustable delays of the *B* and *C* strobe timers are measured.

A strobe

34. The *A* strobe does not appear on the display, but the *B* and *C* strobes are applied as rectangular wells on the top and bottom traces respectively. The *B* and *C* strobes also operate, through the signal reversing stage, to cause signals which coincide in time with the strobes to be reversed in polarity and thus appear upside down on the strobe wells.

35. The *A* strobe is generated from the output of the divider chain at a controlled time after the timebase is triggered, and is made to coincide in time with the *A* pulse from the receiver by adjustment of the timebase p.r.f. The *B* and *C* strobes are also initiated from the pulse output of the divider chain, and the delay in time between the *A* pulse and the *B* and *C* strobes is measured by an electronic system of pulse counting.

B strobe

36. The circuits used to produce the *B* and *C* strobes are identical, and consist of a series of electronic gates operated by the pulse outputs of the divider chain. In the instance of the *B* strobe, the first gate is timed to open over the period of one half cycle of the 250 c/s square wave and is controlled in five steps to select any one of five pulses in the 3 kc/s train; the output of the gate therefore is a pulse which follows the start of the square wave after a delay of 5, 10, 15, 20 or 25 Gee units. The next stage provides a maximum delay of 5 Gee units and is switched in five steps in conjunction with the 15 kc/s pulse train, to add a further delay of 1, 2, 3, 4 or 5 Gee units, thus extending the range of delay to between 6 and 30 Gee units and the limit of selection to 1 Gee unit steps. The third stage provides a maximum delay of 1 Gee unit and is switched in ten steps to select pulses at 150 kc/s intervals from the 75 kc/s pulse train; it adds a further delay of 0·2, 0·3, 0·4, 0·5, 0·6, 0·7, 0·8, 0·9, 1 or 1·1 Gee units, thereby extending the range from 6·2 to 31·1 Gee units in 0·1 Gee unit steps. The final stage is not controlled from the divider chain but adds a further delay of approximately 0·09 Gee units in ten equal divisions, of 0, 0·01, 0·02, 0·03, 0·04, 0·05, 0·06, 0·07, 0·08 or 0·09 Gee units, to the final total.

37. The output of the *B* strobe timer is thus a pulse which is subject to a delay equal to the sum of the individual delays in the separate stages; the overall absolute delay provided extends between the limits of approximately 6·20 to 31·19 Gee units. The useful delay afforded by the timer is not the absolute delay, but the delay relative to the *A* strobe, and as the *A* strobe has an absolute delay which can be adjusted to be a little over 5·20 Gee units, the relative *B* strobe delay is from 1·00 to 25·99 Gee units exactly.

38. It is the relative delay which is used in taking fixes, and the mechanically linked switches which control the gate circuits are provided with indicators calibrated in Gee units to show this delay. The resulting delay which is measured with the *B* strobe is therefore an indicated delay between the theoretical limits of 1·00 and 25·99 Gee units, variable in 0·01 Gee unit steps. Because, however, the upper limit extends into the range of the *C* strobe, the practical limit is set at 24·99 Gee units.

C strobe

39. The *C* strobe is produced in a similar circuit to that producing the *B* strobe, but the initiating pulse in any period of the 250 c/s square wave is derived from the alternate half cycle to that triggering the *B* strobe. The *C* strobe delay is therefore always greater than the *B* strobe delay, and in practice is arbitrarily indicated as extending from 31·00 to 54·99 Gee units.

Strobe controls

40. The operational control of the delays of both the *B* and *C* strobes is provided by separate coarse and fine strobe controls which allow the strobes to be moved along the traces in steps of 1 Gee unit and 0·01 Gee units respectively.

Strobe timebase operation

41. In the strobe timebase operating condition, the sweep is speeded up to take place in the period of the strobe pulses, and the timebase trigger is taken from the output of the strobe generator. The display then consists of four traces, in two pairs; the top pair is separated from the bottom pair by the normal separation applied in main timebase operation, and the individual traces of the pairs are separated from one another by the normal depth of the strobe trough.

42. The *A* pulses appear centrally on traces 1 and 3, and the *B* pulses and *C* pulses appear on traces 2 and 4 respectively; operation of the strobe controls to set the *B* and *C* pulses exactly in line with the *A* pulses, allows the delay between the pulses to be found to a high order of accuracy.

Automatic frequency correction

43. A complicating factor in the circuit is provided by the automatic frequency correction which is applied to the crystal oscillator. The correction circuit compares the time relationship of the *A* pulse from the receiver and the *A* strobe in a discriminator circuit. A control voltage is produced which is used to correct the frequency of the crystal oscillator, and therefore, the p.r.f. of the *A* strobe. The effect of correction is to keep the p.r.f. of the *A* strobe, and therefore of the timebase the same as that of the *A* signal, with the result that signals on the trace are stabilized and drifting is eliminated.

Calibration pulses

44. Provision is also made for the pulse output of the divider chain to be displayed on the cathode-ray tube as calibration marker pulses. In emergency, when the strobing circuits have failed, the markers may be used to obtain fix information. They are also used in routine testing for checking the performance of the strobing circuits.

and write "(A.L. 2)" in the outer margin against the deletion. Insert this Chapter 2 to follow Chapter 1. Record the incorporation of this A.L. in the Amendment Record Sheet.

Chapter 2.—OPERATING INSTRUCTIONS

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

CONTROLS

1. The controls used in operating the Gee Mk. 3 are carried, without exception, on the front panel of the indicator as shown in fig. 1. All but one of the controls are for normal manual operation ; the exception is pre-set for screwdriver adjustment.

2. Other pre-set controls are mounted internally in all the major units but are not accessible unless the outer dust covers are removed. These controls are used to set-up and align the equipment and are not required in normal operation.

User controls

Brilliance control (RV6)

3. The brilliance control is a variable potentiometer which controls the brightness of the trace ; a clockwise rotation of the control increases the brightness level. The control knob is an insulated extension from the potentiometer spindle, and is found to the left of the cathode-ray tube indicator. The control is identified by the legend BRILL.

Gain control (RV7)

4. The gain control is a variable potentiometer which provides control of the amplification of the receiver ; a clockwise motion of the control increases the gain, and therefore the height of signals and grass (noise) appearing on the display. The control is situated at the top left-hand side of the front panel. The knob is marked with an arrow head to assist the user in re-setting to standard positions. The legend GAIN identifies the control.

RF selector (S5)

5. The RF selector is a 10-position rotary switch which controls the frequency of reception, through a motor-operated switch system in the receiver. Seven pre-set channels can be selected in which the frequency of each channel will be dependent upon operational requirement ; the general order of frequency allocations will be as follows :—

Channel	Frequency
1, 2, 3	22 Mc/s to 32 Mc/s
4, 5, 6	Not defined
7	60 Mc/s to 70 Mc/s
8, 9, 10	70 Mc/s to 85 Mc/s

6. The control is situated at the extreme left-hand side of the centre of the front panel. The knob is marked with an arrow which is used to identify the

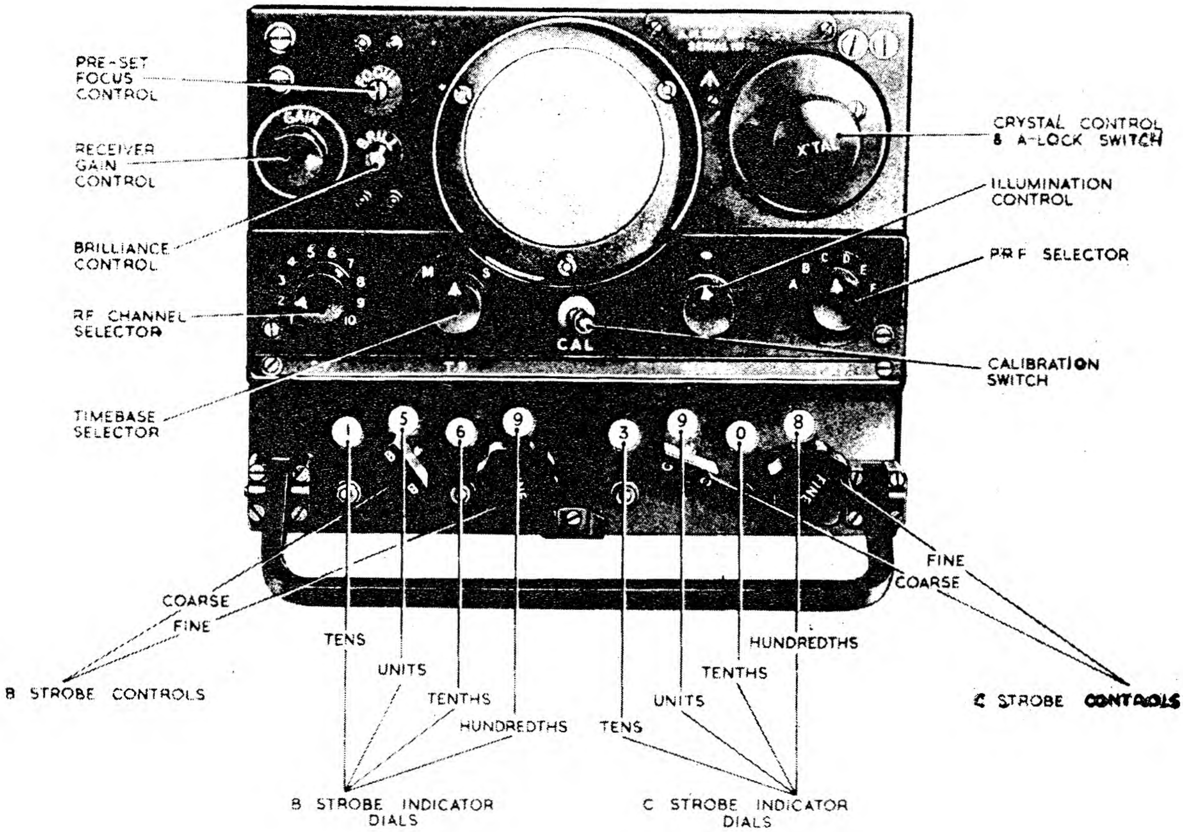

Fig. 1. Controls on indicator

setting of the control against the channel numbers 1 to 10 marked on the panel. An identifying legend on the panel below the control is marked R.F.

Crystal control (C18, C35, S1)

7. The crystal control is a combined twin ganged capacitor and switch, which is used to adjust and lock the timebase p.r.f. to that of the received signals. Two conditions of operation are provided by the control; in the first, with the knob pressed inwards, rotation of the knob turns the capacitors, through a slow-motion drive, and varies the frequency of the crystal oscillator to allow the received pulses to be stabilized along the trace; in the second condition, with the knob pulled outwards, the drive to the capacitors is disengaged and the switch is operated to bring the *A* lock circuit into use. The *A* lock cannot be applied until, by manual adjustment, the odd *A* pulses have been brought to an almost steady position at the beginning of the top trace; on being switched in, the *A* lock then applies automatic correction to the frequency of the crystal oscillator, and the resultant variations in timebase p.r.f. are such as to maintain the *A* pulses steady without the need for manual adjustment.

8. The crystal control is situated at the top right-hand corner of the panel, and is operated by a knurled knob marked X'TAL. The knob is capable of continuous rotation in both the normal and *A* lock positions, but a slipping-clutch mechanism on the slow-motion gearing removes the drive to the capacitors at their rotational limits; the useful rotation of the control is through about 3¾ turns.

PRF switch (S7)

9. The PRF switch is a six-position rotary switch which controls the repetition rate of the timebase by altering the frequency of the crystal oscillator; a separate crystal is selected in each switch position. The crystal frequencies and timebase p.r.f.'s in the six positions are as follows :—

Switch position	Crystal frequency	Timebase p.r.f.
A	150 kc/s	500
B	150·75 kc/s	502·5
C	149·25 kc/s	497·5
D	151·5 kc/s	505
E	148·5 kc/s	495
F	152·25 kc/s	507·5

Only position A is used in normal operation.

10. The PRF control is situated at the extreme right-hand side of the centre of the front panel.

An arrow head on the knob provides a marker to the six positions which are identified by the letters A, B, C, D, E, F, engraved on the panel. An identifying legend on the panel below the control is marked P.R.F.

Timebase selector (S2)

11. The timebase selector is a two-position rotary switch providing control of the timebase speed and duration, but not the repetition rate. The first position selects the main timebase operating condition in which two vertically displaced traces—each of 25 Gee units duration—display the signals ; coarse settings of the strobes are made in this position. In the second position the strobe timebase is selected, and two vertically displaced pairs of traces of 1·2 Gee units duration display the signals ; the first and third traces display the *A* pulses and the second and fourth the *B* and *C* strobes ; fine settings of the strobes to an accuracy of 0·01 Gee units can be effected in this position.

12. The timebase control is found to the right of the RF switch along the centre of the panel. An arrow head on the knob provides the marker for the two positions, which are marked on the panel by the letters M for the main timebase condition and S for the strobe timebase condition. An identifying legend on the panel below the control is marked T.B.

Strobe controls

13. The strobe controls comprise *B* strobe coarse, *B* strobe fine, *C* strobe coarse, *C* strobe fine. The coarse controls move their respective strobes in steps of 1 Gee unit and the fine controls move their strobes in steps of 0·01 Gee units.

14. The delay represented by each strobe is presented on four indicator dials. The dials are situated above the strobe controls at the bottom of the indicator front panel, and are viewed through windows. The left-hand set of dials indicate the *B* strobe delay ; the extreme left window shows the tens of Gee units, the second window the units, the third tenths, and the fourth hundredths. The total range indicated for the *B* strobe is from 1 to 25·99 Gee units. The *C* strobe delay is shown on the right-hand set of four dials ; the windows show tens, units, tenths, and hundredths in that order as before ; the total indicated range is from 31 to 55·99 Gee units.

15. The coarse and fine control knobs are of different size and shape so that they can be readily distinguished by sense of touch alone. The coarse knobs are flat and marked B and C respectively ; the fine knobs are of a more orthodox pattern and are marked FINE.

Calibration control (S8)

16. A two-position toggle switch forms the calibration control. In the left-hand position the normal operating condition obtains ; in the right-hand position the received Gee pulses are switched out of circuit and the outputs of the divider chain are applied as marker pulses in their stead. Normal operation does not require that the calibration pips be counted ; the switch is only used in setting-up and testing.

17. The calibration switch is situated immediately beneath the cathode-ray tube, and is marked with the legend CAL.

Illumination control (RV8)

18. The illumination control is a variable resistor in the LT circuit to four lamps which light the strobe dials. The control is turned in a clockwise direction to increase the level of dial illumination. This control is situated below and to the right of the cathode-ray tube indicator and is marked by the legend ILLUM on the panel below.

Focus control (RV5)

19. The focus control is a pre-set potentiometer which controls the shape and size of the spot on the cathode ray tube ; it is used to regulate the sharpness of the trace. The spindle of the control is slotted for screwdriver adjustment and fits flush with the surface of the panel in a position near the top left-hand corner. It is identified with the legend FOCUS.

Pre-set controls

20. Use of the pre-set controls is not described in this chapter but in order to give a complete picture of the functions which are controllable, a list of the pre-set controls is provided.

Receiver pre-sets

21. Pre-set controls in the receiver are provided to carry out the following functions :—

(1) Video bias control (RV1) is mounted on the rear of the IF unit and is used to adjust the level of the *B* and *C* strobe wells.

(2) Synchronizing control (RV2) is mounted on the top plate of the synchronizing unit and provides control of the *A* lock circuit.

(3) IF trimmers—seven pre-set capacitors are provided on the IF unit to allow for adjustments to the tuning of the IF circuits.

(4) RF trimmers—twenty-one pre-set inductors and three pre-set capacitors on the RF unit allow for adjustments to be made to the frequency settings of the RF channels. Three inductors are used to tune each of the seven channels ; the trimmers are provided to compensate for tuning changes which occur on all channels when valves and components are changed.

Indicator pre-sets

22. The pre-set controls on the indicator are as follows :—

(1) Main timebase amplitude control (RV1) is mounted on the inside of a small panel situated just behind the focus control ; it is used to regulate the length of the main timebase traces.

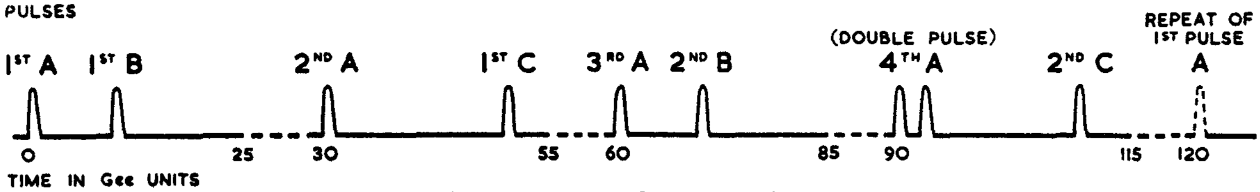

Fig. 2. Sequence of received pulses

(2) Strobe timebase amplitude control (RV3) is mounted to the left of RV1 ; it regulates the length of the strobe traces.

(3) X-shift control (RV2) is mounted at the left-hand front of the chassis immediately beneath the velocity controls ; it controls the horizontal positions of all traces.

(4) Astigmatism control (RV4) is mounted behind the X-shift control at the left-hand side of the chassis ; it regulates the shape of the spot on the cathode-ray tube and is used to produce a sharp and clear trace.

(5) Crystal oscillator control (L1) is a pre-set control accessible from the right-hand underside of the chassis ; it is a manufacturer's adjustment to ensure operation of the crystal oscillator on all crystals.

(6) 75 kc/s oscillator control (L2) is mounted alongside the crystal oscillator control ; it is a manufacturer's adjustment to ensure operation of the 75 kc/s oscillator on all crystals.

Waveform generator pre-sets

23. Pre-set controls are provided in the waveform generator to carry out the following functions :—

(1) 75 kc/s oscillator control (L1) is found below the right-hand front of the chassis ; it is a manufacturer's adjustment carried out in association with the 75 kc/s oscillator control in the indicator.

(2) DIV 2 (RV1) is found behind a removable cover on the front panel ; it is used to adjust the timing of the 1 Gee unit pulses.

(3) DIV 2 (RV2) is also found behind the cover on the front panel ; it is used to regulate the timing of the 5 Gee unit pulses.

(4) *A* strobe delay (RV3) is accessible at the top of the rear of the left-hand chassis section ; it is used to adjust the delay within fine limits of the *A* strobe.

(5) *B* strobe delay (C77) is a pre-set capacitor mounted behind the cover of a screened box on the left-hand side of the rear panel ; it is a manufacturer's adjustment to ensure accuracy of the 0·01 Gee unit steps of the *B* strobe.

(6) *C* strobe delay (C78) is mounted alongside C77 ; it is a manufacturer's adjustment to ensure accuracy of the 0·01 Gee unit steps of the *C* strobe.

(7) Anti-jitter control (RV4) is mounted on the underside of the centre chassis section ; it is used to set the anti-jitter circuit for greatest efficiency.

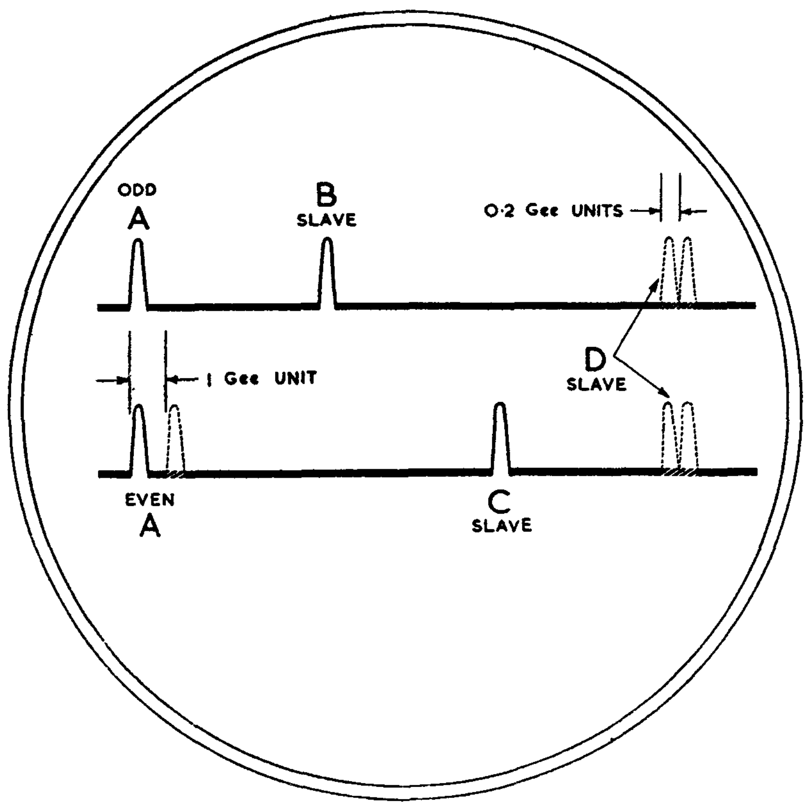

Fig. 3. Sequence of display of pulses

GENERAL OPERATING PROCEDURE

Nature of display

24. The Gee Mk. 3 is used to measure the time delays between Gee pulses and an understanding of the operating methods requires as a matter of necessity that the relationship between the pulses appearing on the Gee display and the sequence of their reception be clearly understood.

25. The sequence of reception of the pulses is shown in fig. 2. It will be seen that *A* pulses are received at intervals of 30 Gee units, *B* pulses are received at intervals of 60 Gee units, and *C* pulses are also received at intervals of 60 Gee units. The *D* pulses are not shown, but they are received at intervals of either 30 or 90 Gee units depending upon the type of ground station involved.

26. A sequence of pulses to include both *B* and *C* slaves therefore occupies an interval of 60 Gee units and recurs at the rate of 250 per second. A complete sequence however takes up 120 Gee units to allow for the distinction made at intervals of 120 Gee units when each fourth *A* pulse is accompanied by a marker.

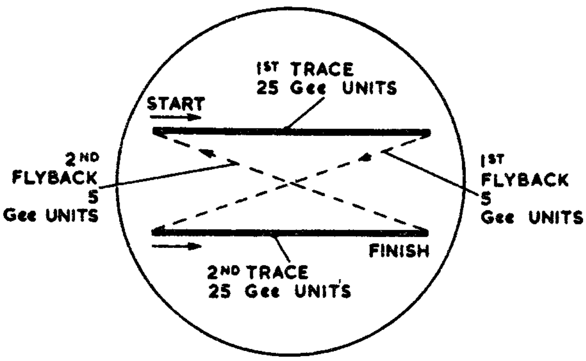

Fig. 4. Make-up of timebase

27. The pulses are displayed on the cathode-ray tube as shown in fig. 3, and the timebase sweep that produces this display is shown in fig. 4. The timebase producing the traces has a repetition rate of 500 per second, but a 250 per second square wave applied to the Y-plates causes each alternate sweep to be displaced vertically and results in the double trace with an overall repetition rate of 250 per second. Each trace has a duration of 25 Gee units and is followed by a blacked out flyback period of 5 Gee units. The total trace length is therefore 60 Gee units, and this allows the complete sequence of pulses to be displayed without confusion between the *B* and the *C* slaves.

28. The presentation of the pulses, as shown in fig. 3, is the condition produced as a result of carrying out the initial setting-up operations for taking a fix. For this condition the timebase frequency is adjusted by the X'TAL control until the double pulse which distinguishes every fourth *A* pulse appears at the left-hand end of the bottom trace. The single pulse appearing at the left-hand end of the upper trace is then the odd *A* marker, and the *B* and *C* slaves appear separately on the upper and lower traces respectively.

29. The marker pulse associated with each fourth *A* pulse is displayed only on each alternate lower trace, and therefore has a much fainter appearance than its associated pulse—hence the designation "ghost"—as well as having the appearance of rising from the trace without cutting it. A further distinguishing feature of the *A* "ghost" is that it is switched on and off at the master station to a code which allows the chain to be identified; the intermittent appearance of the "ghost" is referred to as "blinking."

30. The *D* pulses appear on both traces as closely-spaced double pulses. With the *A* pulses properly set at the beginning of the traces the *D* pulses on the upper trace should lie directly above the pair on the lower trace. Because the *D* pulses may be transmitted at different repetition rates, they can either have the appearance of normal brightness with line cutting as shown in fig. 5, or the fainter "ghost" appearance without line cutting as shown in fig. 3.

Strobes

31. The delays between reception of the *A* pulses and the slaves are measured in two timing circuits which are operated by the strobe controls. Strobe markers appear as wells on each trace, and the strobe controls move the wells in steps of Gee units and fractions of Gee units; when a strobe and pulse coincide, the pulse becomes inverted (*fig.* 5). The well on the upper trace is moved by the *B* strobe controls and that on the lower trace is moved by the *C* strobe controls. The calibration of both strobes is related to the timing of the odd

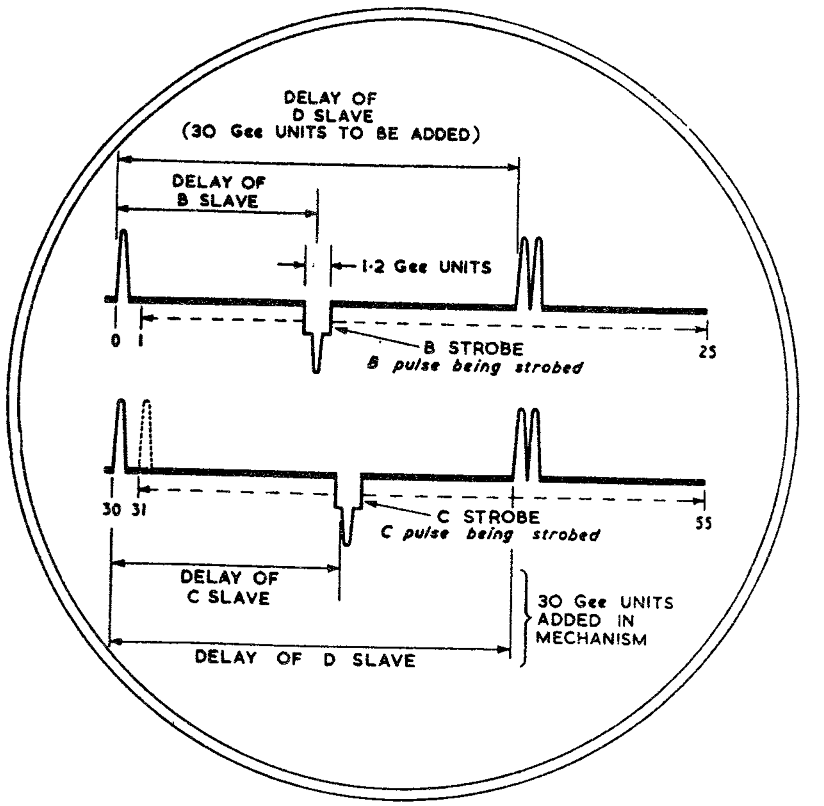

Fig. 5. Strobing—main timebase

A pulses, but the movement of the *C* strobe is limited to the interval of 25 Gee units following the even *A* pulses.

32. The *B* strobe controls are used to measure the *B* or *D* slaves; when the *B* slave is strobed, the settings of the *B* indicators show the delay directly; when the *D* slave is strobed, a fixed correction of 30 Gee units must be added to the indicated reading. The *C* strobe controls are used to measure the *C* or *D* slaves; the settings of the *C* indicators show the delay directly for both *C* and *D* slaves.

33. The procedure for strobing the pulses is carried out in two steps. In the first the timebase switch is set to M and, with the X'TAL control properly adjusted, the display shown in fig. 5 will appear. The B strobe controls are then adjusted for the strobe wells to appear symmetrically placed about the pulses, as shown in fig. 5. If the *D* slave is being strobed, with either the *B* or *C* control, the leading pulse of the pair is the one considered.

34. The approximate delays of the pulses are then shown on the strobe indicator dials, but for more accurate measurements a fine adjustment of the strobes must be made on the expanded traces which appear when the timebase switch is set to the S position. In the S position the strobe timebase appears as shown in fig. 6, and four traces in two

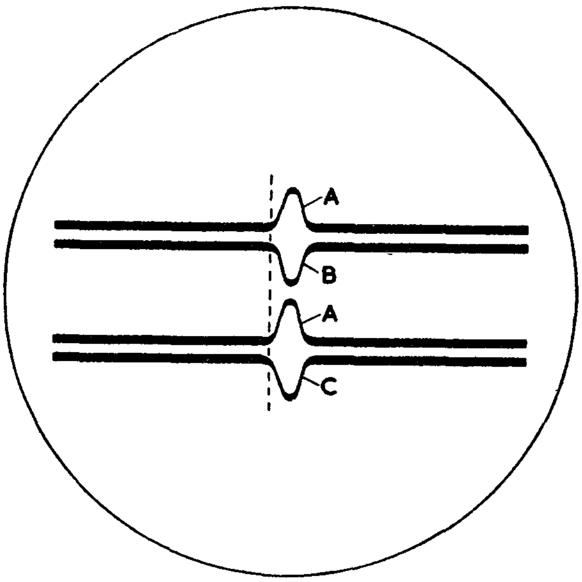

Fig. 6. Strobing—strobe timebase

pairs are displayed. The top trace is initiated by the strobe associated with the odd *A* pulse, and the second trace is initiated by the *B* strobe; the pair are displaced by the depth of the *B* strobe well. The lower pair of traces are separated from the upper pair by the normal trace separation found in main timebase operation. The third trace—the top trace of the lower pair—is initiated by the even *A* pulse, and the bottom trace is initiated by the *C* strobe; the displacement between the bottom pair is due to the well of the *C* strobe.

35. The time represented by each trace is 1·2 Gee units. The first and third traces represent expansions of the beginnings of the main timebase traces, and the expanded *A* pulses appear at the centres. The second and fourth traces are expansions of these sections of the main traces taken up by the strobes, and the signals appearing on them are expanded, and as before, inverted.

36. On the strobe timebase, the act of strobing causes the signals on the strobe traces to move across the traces, and the final strobing procedure is to use the FINE strobe controls to bring the leading edges of the slave pulses beneath and in line with the leading edges of their associated *A* pulses. With the pulses properly in line as shown in fig. 6, the exact delays of the pulses being measured are shown on the strobe indicator dials.

OPERATING DRILL

37. In actual operating conditions, the drill for taking fixes is carried out in two sequences. The first, which is necessary only when a particular chain is being used for a first fix, is described under the heading "Setting-up"; the second which must be carried out each time a fix is taken, is described under "Taking a fix."

Setting-up

38. To adjust the Gee Mk. 3 to allow fixes to be taken, the following procedure should be adopted:—

(1) Switch on the combined AC and DC mains switch; leave for at least two minutes to warm up.

(2) Set the timebase switch (T.B.) to the M position, the CALibration switch to the left-hand position, and push the X'TAL control to its "in" position.

(3) Turn the BRILLiance control carefully in a clockwise direction until a display at an appropriate level of brightness appears.

(4) If necessary, use a screwdriver to adjust the FOCUS control for sharp and clearly defined traces.

(5) Turn the GAIN control in a clockwise direction until grass appears on the traces.

(6) Adjust the RF channel switch to the required channel number, or, if the number is not known, turn the switch through each step in turn until pulses appear on the traces.

(7) If the aerial system Type A is in use, adjust the switch on the loading unit Type 51 to the correct position for the channel, or, if the channel frequency cannot be defined, turn the switch through each step in turn and set to the position in which the received signals are at their strongest.

(8) Adjust the GAIN control to the position in which the strongest pulses just reach saturation level.

(9) Adjust the P.R.F. switch to the p.r.f. of the required chain, or, if the p.r.f. is not known, turn the switch through each step in turn and

set to that position in which the received pulses are most nearly stationary on the trace. All chains in current use have a p.r.f. of 500 and the PRF switch can consequently be left in the *A* position.

(10) Turn the X'TAL control to vary the drift of the pulses on the traces until the double *A* pulse appears near the left-hand end of the lower trace.

(11) Switch to strobe timebase.

(12) Set the X'TAL control carefully for the *A* pulses to appear near the centres of the *A* strobe traces.

(13) Pull the X'TAL control to the " out " position. The *A* lock circuit is then brought into operation, the timebase p.r.f. is locked to that of the *A* pulses, and drifting is eliminated.

Taking a fix

39. Once the setting-up drill has been carried out on a particular chain, fixes can then be taken by the use of the strobe controls, and, as necessary, by occasional adjustments to the signal level by the use of the GAIN control.

40. The method of taking a fix is as follows :—

(1) Switch to main timebase.

(2) Adjust the *B* strobe coarse control for the well of the strobe on the upper trace to be symmetrically disposed about the *B* pulse or the leading *D* pulse whichever it is required to strobe.

(3) Adjust the *C* strobe coarse control for the well on the lower trace to be symmetrically disposed about the *C* pulse or the leading *D* pulse.

(4) Switch to strobe timebase.

(5) Adjust the *B* strobe FINE control for the leading edge of the *B* pulse or the leading *D* pulse to appear beneath and in line with the leading edge of the *A* pulse on the first trace.

(6) Read off the *B* strobe indicator dials to give the delay of the strobed pulse. Note—the decimal point comes between the second and third dials. When the *B* pulse is being strobed, the delay in Gee units is given directly by the dial readings ; when the *D* pulse is being strobed, 30 Gee units must be added to the dial readings.

(7) Adjust the *C* strobe FINE control for the leading edge of the *C* pulse or leading *D* pulse on the fourth trace to appear beneath and in line with the leading edge of the *A* pulse on the third trace.

(8) Read off the *C* strobe indicator dials to give the delay, direct in Gee units, of the *C* or *D* pulses.

(9) Refer to the chart of the Gee chain being used, and note the position lines appropriate to the delays found in (5) and (6). The intersection of the lines shows the position of the aircraft at the time the fix was taken.

Notes on operating

Pulse interference

41. If non-synchronous pulses from another chain or some other pulse transmitter are being received whilst the *A* lock circuit is operating, such pulses on drifting past the *A* pulses at the beginning of the traces will interfere with the operation of the *A* lock circuit and the timebase will become unsteady. Where the amplitude of the interfering pulses is small compared with that of the *A* pulses, little difficulty will be experienced, and except for a slight timebase jitter which will occur each time an interfering pulse passes through an *A* pulse, it should be possible to take fixes in the normal manner.

42. In extreme cases where pulses of large amplitude appear on the display, it is possible for the lock to be transferred from the *A* signals to the interference. In such an instance it will not be possible to keep the desired signals steady on the traces by use of the *A* lock circuit, and the X'TAL control must be set to the " in " position. The timebase is then under the manual control of the X'TAL control, and the operator must keep constant watch on its setting to check drift of the desired pulses across the traces and keep the *A* pulses at the left-hand ends.

General interference

43. No adjustments are provided on the Gee Mk. 3 to allow for control of interference. Two circuits are incorporated in the receiver, however, which provide a high degree of suppression of interfering CW signals and wide pulses. Included in the category of wide pulses are the spurious signals which often follow the required Gee signals due to radiation taking indirect paths, and which cause an apparent widening of the required signals ; the suppression circuit tends to eliminate such echoes and keep the required pulses at a constant width.

Chain identification

44. When the RF and p.r.f. of the local chain is not known, it is a comparatively easy operation, as suggested in para. 38 (6) to (10), to find the chain by adjusting the RF switch to the position in which the strongest signals are displayed. The chain can then be identified by counting the number of times in a 12-second period that the " ghost " on the *A* pulse is " blinked," and that number is the reference for the appropriate chart.

Viewing

45. A green colour filter is fitted over the face of the cathode-ray tube to facilitate viewing in daylight. Other filters may be made available at some later date to provide for special light conditions.

Strobe limits

46. The theoretical lower and upper limits on the range of the two strobes are at 1 Gee unit and 25·99 Gee units for the *B* strobe, and 31 Gee units and 55·99 Gee units for the *C* strobe. These limits are actually imposed by the mechanical arrangement of the strobe controlling switches and cannot be conveniently achieved in operation.

47. The practical limit of strobing in each instance is limited at the top of the scale by the tendency of the strobe to run on to the flyback, and difficulty will be found when readings are attempted beyond the figure of 24 Gee units on the *B* strobe and 54 Gee units of the *C* strobe. The lower limit of each strobe presents no problem.

This leaf issued with A.L. No. 15, January, 1953

Chapter 3—TECHNICAL DESCRIPTION

(This chapter supersedes that issued with A.L. No. 11.)

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LIST OF ILLUSTRATIONS

OUTLINE OF CIRCUIT

1. The outline circuit description is based on the stage-by-stage block diagram fig. 24. In this illustration each block is described by its main circuit function and includes a list of the valves involved. The layout shows the electrical association of the circuit elements and, in consequence, the distribution of the separate circuits in the various units is not readily apparent. To clarify this situation, valves and major components, for the purpose of this diagram only, are prefixed with a number indicating in which unit the item is to be found ; the code is as follows :—

Prefix	*Unit*
1	Waveform generator
2	Receiver
3	Indicator unit

2. A further guide to the general circuit layout and the distribution of circuit elements is provided by fig. 25 and 26. Fig. 25 is a simplified version of fig. 24, while fig. 26 shows the physical distribution of the circuit elements throughout the equipment.

Receiving circuit

3. The receiving circuit, which is contained almost wholly in the receiver unit, consists of :—

RF amplifier, 2V1
Grid mixer, 2V2
Local oscillator, 2V3
Five IF amplifiers, 2V4, 2V5, 2V6, 2V7, 2V8
Detector and echo suppressor, 2V9
Video amplifier, 2V10
Cathode-follower video output, 2V11

4. The RF tuned circuits are all preset and provide a choice of seven frequencies through a motor-operated mechanism remotely controlled from the indicator.

Note . . .
The control switch has ten positions but only seven of the receiver channels are connected.

5. The intermediate frequency is 7·5 Mc/s and the IF circuits include provision for the suppression of CW interference. An echo suppressor in the detector stage eliminates signals, such as non-direct path echoes, which follow immediately after the normal pulses.

6. The input to the video valve is controlled by the calibration switch on the indicator. In the normal position of the switch the input is taken from the Gee-signal output of the receiver ; in the calibrate position it is derived from the marker pulse output of the waveform generator.

Display circuits

7. The output from the receiver, either Gee signals or calibration markers, are displayed on a cathode-ray tube 3V11 in the indicator unit. A signal-reversing stage 3V3, in the input circuit to the Y-plates, causes signals or markers which appear in the period of B- and C-strobe pulses from the waveform generator to be inverted on the traces.

8. The timebase is generated in a Miller integrator valve 3V1, and is applied to the cathode-ray tube via a paraphase circuit which includes 3V2. The two alternative timebases are initiated from either the 500 c/s rectangular wave output of the divider chain, or the short-duration pulse output of the strobe generator.

9. In the main timebase condition, a 500 c/s timebase is produced in which each sweep is of 25 Gee units duration (a Gee unit is a period of 66⅔μS) ; alternate sweeps, however, are displaced vertically on the cathode-ray tube so that two sweeps, one above the other, are visible, as shown in Chap. 2, fig. 5. For strobe timebase working, four traces, each of 1·2 Gee units duration, are displayed in two vertically-displaced pairs, as shown in Chap 2, fig. 6.

10. A strobe well appears on each trace of the main timebase. Separate strobe controls allow each well to be moved, independently, along its trace. The upper well is the B-strobe, and the lower well is the C-strobe. Signals appearing on the wells are inverted.

11. On strobe timebase, the top trace of each pair represents an expansion of the beginning of the corresponding main timebase trace, and the lower trace of each pair is an expansion of the associated strobe well. The vertical displacement between the traces of each pair is the same as the depth of the strobe well from which the lower trace is derived. The traces, reading from top to bottom, can thus be described as :—

Odd A-strobe B-strobe	} Top pair
Even A-strobe C-strobe	} Lower pair

Signals on the A-strobe traces appear as upward-deflections of the traces, and signals on the B- and C-strobe traces appear inverted as downward-deflections of the traces.

12. Two EHT supplies are provided to operate the cathode-ray tube. The first of 1,200V from 3V9 provides the normal gun voltages ; the second of 1,300V from 3V8 supplies the post-deflection accelerator electrode.

Crystal oscillator and divider

13. The pulses which initiate the timebases and control the strobe generators, are produced by a chain of dividing circuits in which the output of a crystal-controlled oscillator is counted down. The crystal oscillator frequency is nominally 150 kc/s and the division is performed in steps of divide-by-two, divide-by-five, divide-by-five, divide-by-three, divide-by-two, and divide-by-two.

14. The crystal oscillator is 3V4 in conjunction with one section of the double-triode 3V5 ; the second half of 3V5 acts as a buffer amplifier to feed the oscillator output to the first divider stage. This is a self-running oscillator 3V6 which is synchronized by the 150 kc/s output of 3V5 to operate at 75 kc/s ; the grid current which flows in the input circuit of 3V6 is used to produce an AGC voltage which controls the amplitude of the 150 kc/s oscillation.

15. The sinusoidal output of the 75 kc/s oscillator is fed to a push-pull phase splitter and shaper, 1V1, 1V2, in the waveform generator. Two outputs in the form of trains of sharp positive pulses are produced, each train being at a p.r.f. of 75 kc/s ; the separation between pulses is 0·2 Gee units. The two outputs are spaced by a time interval corresponding to 180 degrees of the input waveform, and the separation between adjacent pulses, as between one train and the other, is therefore 0·1 Gee units.

16. The main output of the phase splitter is coupled into the first divide-by-five stage, a blocking oscillator 1V3A, and the output of this stage is used to trigger a second almost identical blocking oscillator 1V3B. The pulses in the output of 1V3A are at a p.r.f. of 15 kc/s and have a separation of 1 Gee unit ; those in the output of the 1V3B are at 3 kc/s with a separation of 5 Gee units.

17. The main output of 1V3B triggers a combined divide-by-three and divide-by-two stage comprising 1V4B, 1V5, 1V6A and 1V7A, in a double multivibrator circuit. The first multivibrator, 1V4B and part of 1V5, produces a rectangular wave at 1,000 c/s with a mark-space ratio of 1 :2, and this wave provides the input to the second multivibrator formed from the remainder of 1V5 together with 1V6A and 1V7A. The output of the stage, taken from the anode of 1V5, is a 500 c/s rectangular wave with a mark-space ratio of 1 :5, and this output is taken through a cathode-follower 1V7B to provide the main synchronizing pulses for the timebase and the strobe timing circuits.

18. The final divider is a square-wave generator, 1V19 and 1V8, which produces a 250 c/s true square-wave output. The edges of the square waves are approximately coincident in time with the negative-going edges of alternate cycles of the 500 c/s rectangular wave. Three outputs are taken from this stage ; the first feeds a cathode-follower valve 1V27 which supplies the trace separation square wave to the cathode-ray tube ; the second and third are used to initiate the B- and C-strobe timers.

Timing circuits

19. The timing circuits comprise A-, B-, and C-strobe timers, a strobe generator, and a subsidiary negative-A-strobe generator. The strobe timers generate pulses timed accurately by reference to the outputs of the dividing circuits. These pulses are used, after shaping and mixing in the strobe generator, to initiate the strobe timebases, control the automatic A-lock circuit, and produce the strobe wells and signal inversion. The negative-A-strobe is used to eliminate the A-strobe from the output of the strobe generator in certain of these functions.

A-strobe

20. The A-strobe timing pulse is produced by 1V18 from the 500 c/s rectangular wave and the 75 kc/s pulse train from the phase splitter. The A-strobe output is a short train of 75 kc/s pulses following shortly after the positive-going edge of the rectangular wave ; the first pulse to appear is the useful timing pulse.

21. The actual timing of the A-strobe output is retarded by approximately 5·2 Gee units on the negative-going edge of the rectangular wave, and is approximately coincident in time with the start of each main timebase trace.

B- and C-strobe timers

22. The B- and C-strobe timers are almost identical circuits producing output pulses which may be varied in time by the use of the strobe controls on the indicator. They are initiated alternately by the separate half-cycles of the 250 c/s square-wave output of the divider circuit, such that, relative to the trace-separating square wave, the B-strobe appears in the 30-Gee unit period of the positive half-cycle, and the C-strobe appears in the following 30-Gee unit period of the negative half-cycle.

23. Each timer consists of four delaying stages in cascade ; the timing of the output pulse is due to the addition of the delays in all the stages. The first stage of the B-strobe circuit uses a gating valve 1V9 and receives inputs from the 250 c/s square-wave stage and from the 5-Gee unit (3 kc/s) pulse output of the integrator valve 1V4A ; the gating action is regulated by the strobe control to produce a pulse output which is delayed in steps of 5 Gee units on the start of the input from the square-wave stage. A second valve, 1V10 in the first stage inverts and shapes the output of 1V9 to provide the input to the next stage.

24. In the second stage, the output of 1V10 and the 1-Gee unit (15 kc/s) pulse output of the integrator 1V26B are gated in 1V11, and the delay introduced is controlled in 1-Gee unit steps. The output from the second stage is taken from a shaper and inverter valve 1V12 and has a total delay controllable in 1-Gee unit steps from 6 Gee units to 30 Gee units.

25. The third stage adds further delays in steps of 0·1 Gee units in a gating valve 1V13. The 0·1 Gee unit steps are produced from the alternate use of the 0·2 Gee unit outputs from the phase splitter as input to the gating valve. The output from this stage is taken from the inverting and shaping valve 1V14 and has a total delay which is controllable in 0·1 Gee unit steps between the limits of 6·2 Gee units and 31·1 Gee units.

26. The next and final stage uses the single valve 1V15A. The delay introduced in this stage is not controlled by a pulse train, but is made up of ten steps of approximately 0·01 Gee units each, which provide for interpolation between the 0·1 Gee unit steps of the previous stage.

27. The final output at the anode of 1V15A is therefore the sum of the delays introduced in the four-stages, and it has a total delay of from 6·20 Gee units to 31·19 Gee units in 0·01 Gee unit steps on the start of the input from the square-wave

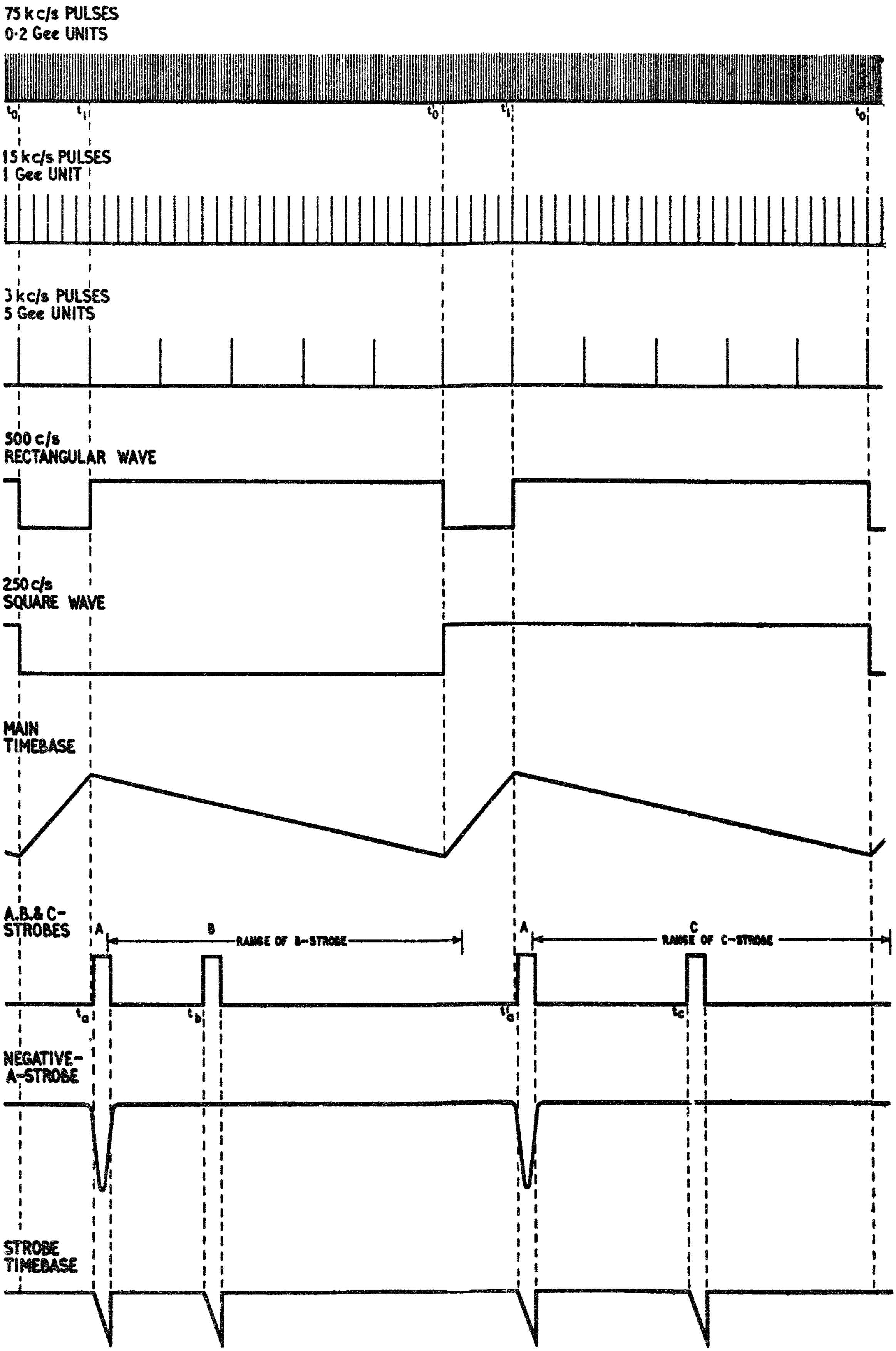

Fig. 1. Relative timing of waveforms

stage. A series of mechanically ganged switches in the indicator allow the delays to be controlled, and the settings of the switches, as shown on dials on the switch spindles, show the delays set up in Gee units.

28. The actual delays shown on the strobe indicator dials are not the absolute delays introduced in the timer but are relative delays compared with the timing of the A-strobe. The indicated figures are therefore the absolute delays minus 5·2 Gee units, so that the strobe controls operate over a range of from 1·00 Gee units to 25·99 Gee units in steps of 0·01 Gee units.

29. The C-strobe timer operates in a similar manner to the B-strobe timer, but the output pulse is delayed between 36·20 and 61·19 Gee units on the start of the input to the B-strobe, and the indicated delays are between the limits of 31·00 Gee units and 55·99 Gee units.

Strobe generator

30. The strobe generator consists of 1V16, 1V15B in a multivibrator circuit, with 1V17 as the cathode-follower output. The outputs of the A-, B-, and C-strobe timers trigger the multivibrator, and the output from 1V17 is a train of identically-shaped pulses of 1·2 Gee units duration, timed to the A-, B-, and C-strobes.

Negative-A-strobe generator

31. The negative-A-strobe is generated as a negative pulse of about 1·5 Gee units duration in 1V6B from the positive-rising edge of the main 500 c/s rectangular wave. In timing it coincides with the start of each timebase sweep and is slightly in advance of the normal A-strobe.

A-lock circuit

32. The purpose of the A-lock circuit is to maintain the timebase at the same p.r.f. as the received A-pulses, so that once the lock has been applied, manual corrections are not required to keep the Gee signals from drifting across the traces. In operation, the frequency of the crystal oscillator is regulated by an AFC circuit, which is controlled in turn by a voltage derived from the comparison in a discriminator circuit of the p.r.f. and timing of the received A-pulse and the A-strobe.

33. The A-strobe is separated from the combined A-, B-, and C-strobe output of the strobe generator in a gating circuit containing 2V12. The inputs to this valve are the strobe pulses and the negative-A-strobe, and the output, as a positive pulse, is the A-strobe only. This pulse is then used in a second gating circuit, 2V13A, to separate the A-pulses from the video signal produced in the receiver.

34. The discriminator consists of 2V13B, 2V14, 2V15, and 2V16. The two inputs to this circuit are the received A-pulses from 2V13A and the negative A-pulses ; the amplitude and polarity of the pulse output is dependent upon the relative timing of the inputs. When the A-pulse appears near the start of the gating period represented by the negative-A-strobe, the output is positive, and when it appears near the end the output is negative ; when the A-pulse appears at the middle of the period a positive-followed-by-negative pulse is produced.

35. The pulse output of the discriminator is rectified in a double-diode circuit containing 2V17, and the DC voltage produced is negative, zero, or positive according to the timing of the A-pulse. This DC voltage is amplified in a DC amplifier 2V18 in which a memory circuit is incorporated to ensure that sudden fades of the input signal do not result in loss of control.

36. The output of the DC amplifier is coupled through an amplitude limiting stage, 2V19A, to the control valve, 3V7, in the crystal oscillator circuit. This valve is connected to act as a reactance in the crystal circuit, with its inductive or capacitive value dependent upon the level of DC bias. If the p.r.f.s of the received A-signal and the negative-A-strobe fall out of step, the generated control voltage is such as to cause the frequency of the oscillator to change in the direction that brings the p.r.f. of the negative-A-strobe, and therefore the timebase, back in step.

NOTES ON TIMING

37. The complete Gee display is made up of two traces on the main timebase, so that the datum time for the operation of the timing circuits must be taken from the beginning of the overall display and not from each trace. In the outline description of the circuit this datum time has been taken as the timing of the negative-going edge of the 250 c/s square wave applied for trace separation to the cathode-ray tube, that is, the start of the flyback from the lower trace to the top trace. In the detailed circuit description a more exact definition is followed and the datum time, referred to as t_o, is defined as the timing of that 75 kc/s pulse which immediately precedes the negative-going edge of the separation waveform.

38. As an aid to following the timing sequence, several important waveforms are shown in fig. 1, and their timing relative to t_o is shown. The timing of the various pulses is indicated by subscript letters or numerals such as t_a, t_b, t_c, for the A-, B-, and C-strobes respectively, and t_1, t_1^1, for the alternate positive-going edges of the 500 c/s rectangular wave. Because two A-strobes appear in each display period, only the first to follow t_o is shown as t_a and the second is identified by a superscript numeral as t_a^1. The positive-going edge of the 250 c/s square wave which immediately precedes t_a^1, is shown as t_o^1. The timing of the pulses in the intermediate stages of the production of the B- and C-strobes is also shown by superscript numerals so that t_b^2 indicates the timing of the pulse at the second stage of the B-strobe timer.

RECEIVER CIRCUIT

RF circuits (*fig. 2*)

39. The aerial signals are connected via a co-axial cable and plug from the Jones plug D12

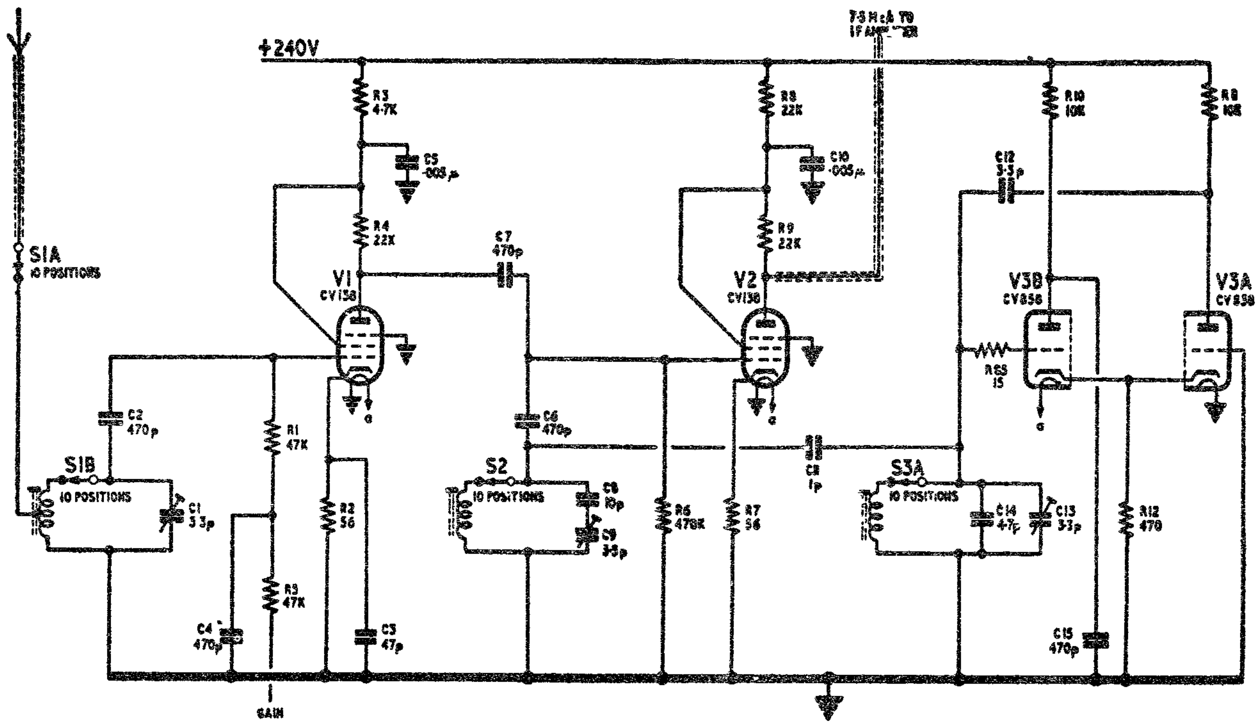

Fig. 2. RF circuit

to the co-axial input socket on the receiver unit. The aerial tuned circuit consists of a preset capacitor C1, and separate coils, selected by S1A and S1B, for each channel ; the input point on each coil is tapped down in order to provide a suitable match to the aerial circuit. Damping resistors are connected across the coils for the lower frequency channels. A shorting ring on S1B short-circuits all coils except the one actually selected by the switch. The coils are separately tuned by adjustable cores ; the tuning capacitor is made variable to allow adjustments for compensating valve and circuit tolerances.

40. The RF amplifier is a pentode V1 (CV138) which is operated at less than the maximum gain condition in order to maintain the signal-to-noise ratio at an optimum level. The actual gain is controlled, through the remote gain control on the indicator, by the level of negative bias on the grid.

41. The output of V1 is RC coupled to the grid of the pentode mixer V2 (CV138) operating as a leaky grid detector. The mixer tuned circuit uses a separate coil for each channel, each coil being tuned by an adjustable core. The tuning capacitance is provided by C9 in series with C8. Coils not in use are connected together by a shorting ring on the switch S2.

Local oscillator

42. The local oscillator V3 (CV858) is a double-triode in a cathode-coupled modified Franklin circuit. The tuned circuit includes a common tuning capacitance provided by a preset trimmer, C13, and a fixed capacitor, C14 ; the latter has a negative temperature coefficient to provide compensation for changes in the rest of the circuit capacitance which arise from temperature variations. Each channel uses a separate tuning coil, selected by S3A ; the coils not in use in any position of the selector switch are shorted together by S3B. The coils are separately adjusted for the correct channel frequencies by means of preset iron-dust cores.

43. The operation of the circuit can be considered as follows :—
A RF voltage across the tuned circuit is applied to the grid of V3B which, operating as a cathode-follower, developes an in-phase voltage across the cathode resistor R12 ; this voltage forms the input for the grounded-grid triode, V3A, and it thus appears amplified, still without change of phase, in the anode circuit at R11. A low-value coupling capacitor C12 feeds the anode output of V3A back to the grid input of V3B. The presence of a signal at the grid of V3B therefore produces an in-phase feedback voltage, and the conditions for oscillation are satisfied.

44. The practical advantages of the circuit are first, that untapped coils, earthed at one end, can be used, and second, that the oscillator frequency is sensibly independent of valve characteristics. The independence results from the use of a low-value of coupling capacitor C12 from the feedback valve, which ensures that the capacitance across the tuned circuit from the anode of V3A is small, and from the high input impedance shown at the grid of V3B because of its connection as a cathode-follower.

45. The oscillator output is at a frequency equal to that of the aerial signals plus the IF. It is loosely coupled through C11 from the tuned circuit to the grid circuit of V2. The coupling capacitor is of small value to ensure a minimum of reflected loading from the grid circuit of V2.

Mixer

46. The RF and oscillator signals are fed in parallel to the grid of the mixer valve V2, and the output signal in the anode circuit includes a component at the difference-frequency of 7·5 Mc/s. This signal is coupled through a length of co-axial cable to the free plug PL P to provide the input to the IF amplifier circuits in the IF unit.

Switching

47. The switches S1, S2, and S3, which perform channel selection in the RF circuits are mounted on separate spindles in the screened sections of the RF unit chassis relevant to the three circuits. The mechanical coupling between the switches is carried out through bevel gears operating between each spindle and a common overhead shaft. The drive to the switches is applied from a motor-driven mechanism on the main chassis through a dog clutch on the spindle of S2. This mechanism incorporates the follower switch S4A and aerial switch S4B, and carries the channel indicating drum which is visible at the front of the receiver.

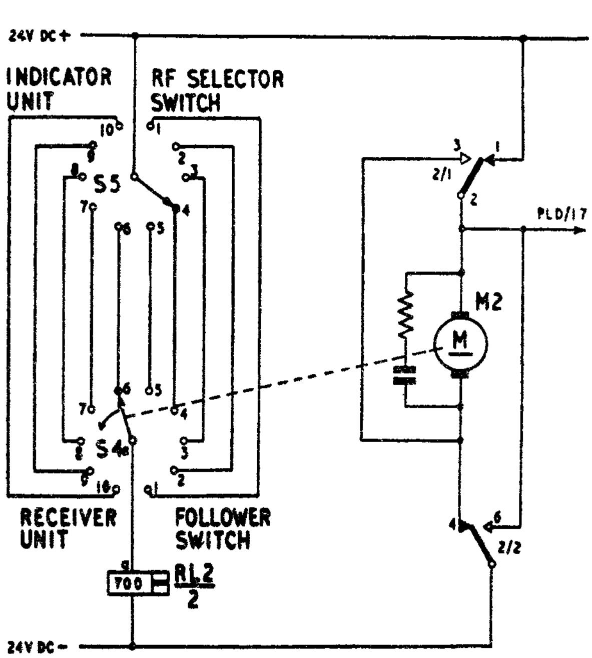

Fig. 3. RF switching and control circuit

48. The control circuit for the switching mechanism is shown in fig. 3; the conditions are as they would be with power disconnected, that is the

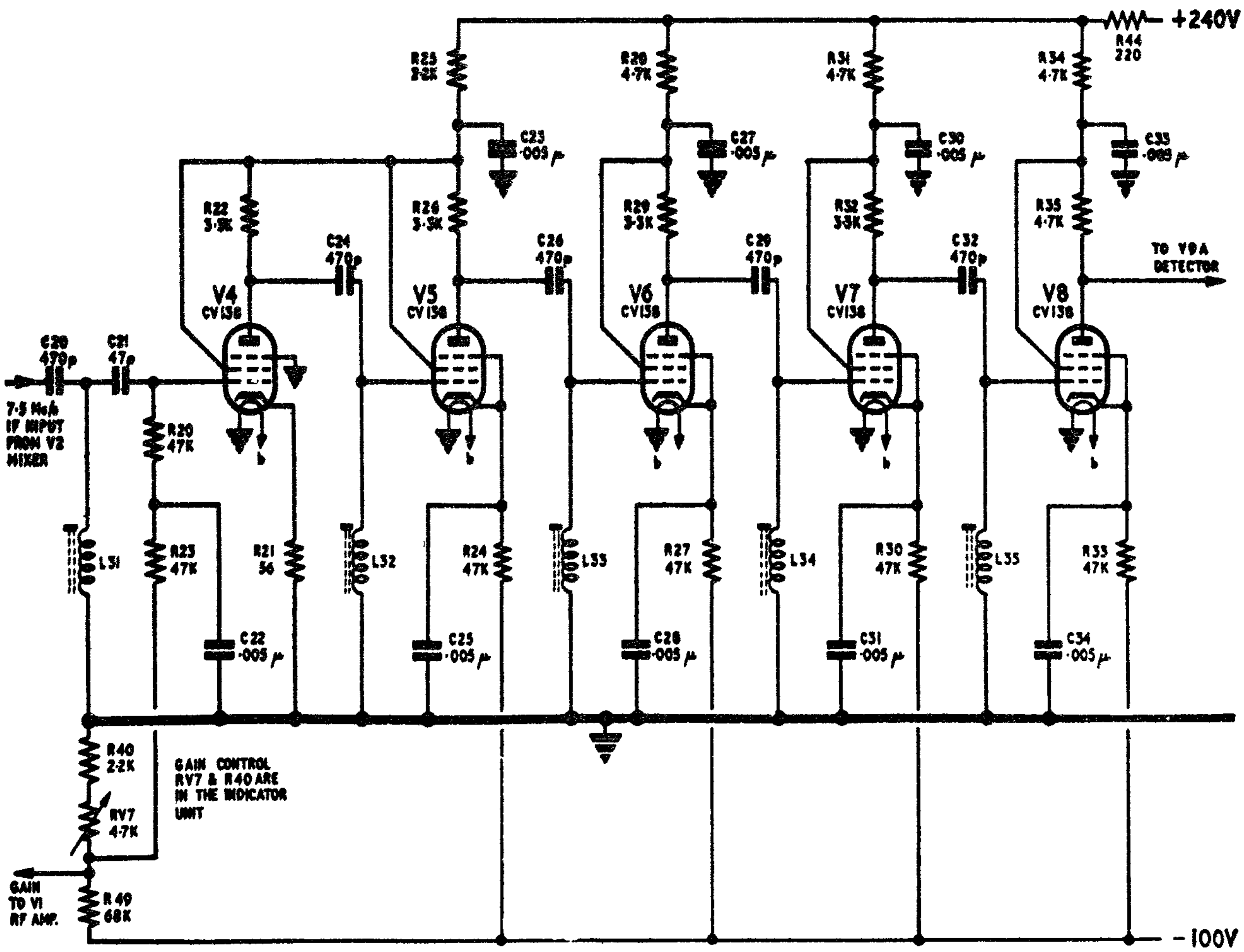

Fig. 4. IF circuit

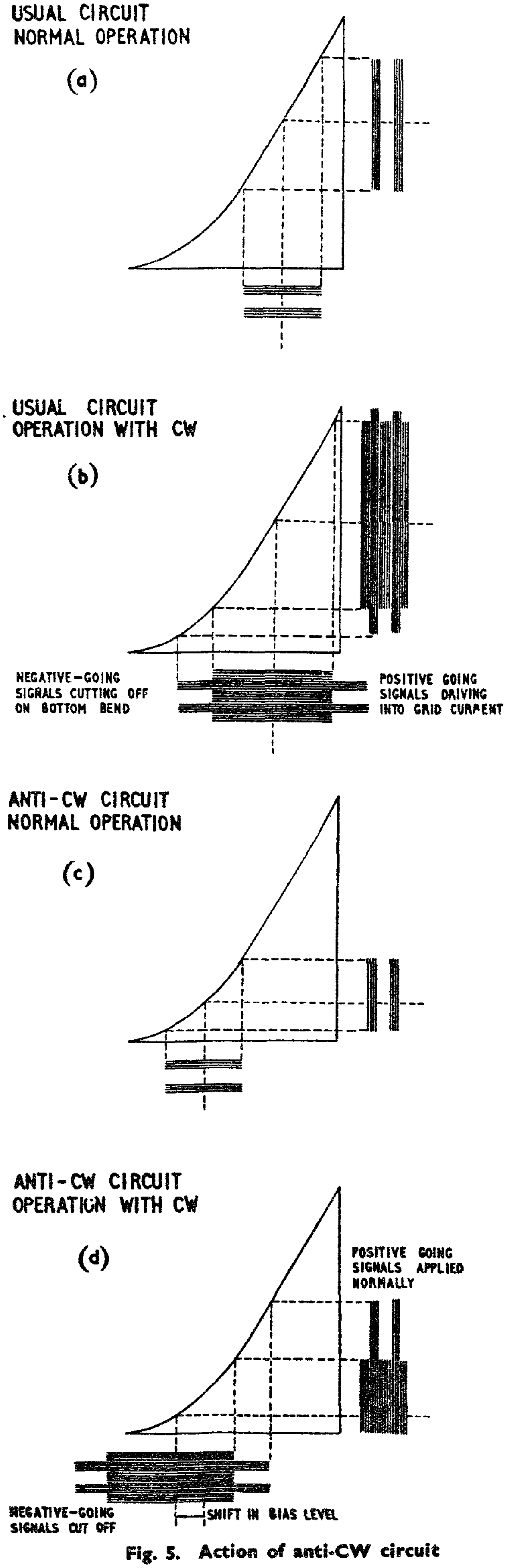

Fig. 5. Action of anti-CW circuit

relay RL2 is not energized, and the selection switch S5 is set to a channel other than that of the receiver as shown by S4a. If then power is applied, the motor is energized through contacts 2/1, 2/2, and in turning it drives S4a in the direction shown by the arrow. When the wiper of S4a reaches the No. 4 contact, the circuit, via No. 4 contact of S5, to relay RL2 is completed, the relay is energized and the contacts in the motor circuit change over. Power is thus disconnected from the motor and the motor itself is short-circuited. The back-EMF across the motor at the moment the supply is disconnected, causes a high instantaneous reverse current to flow in the motor, through the short-circuit, and a strong braking effect is produced which stops rotation with a minimum of overshoot. The slight overshoot which does result serves to drive the wiper beyond the point of first contact and leaves it more or less central in the contact.

49. The aerial switch S4B is a simple selector leaf coupled to the driving mechanism of the follower switch. It is used to control the operation of an aerial matching unit. The positive DC voltage appearing at one motor terminal when switching takes place is also taken to the aerial matching unit to inhibit the operation of that unit for the period of the switching action.

50. It should be noted that the motor rotates in one direction only. In consequence, to go from channel 1 to channel 10 the switch must first turn through all the intervening channel contacts.

IF circuit (*fig. 4*)

51. The input point is the co-axial socket 2SK P. The input signal at the IF of 7·5 Mc/s is capacitatively coupled to the grid of the first IF amplifier V4 (CV138) the input tuned circuit consists of L31 tuned by the stray capacitances of the grid circuit and the input cable; the frequency of the tuning is controlled by an adjustable core. The gain is controlled by the parallel connection of the grid-return into the negative bias circuit which includes the gain control RV7; this control also operates on the RF stage.

52. The output of V4 is amplified in four further stages of identical circuitry in cascade. Each stage includes a conventional grid-tuned circuit with adjustable-cored coils and stray-capacitance tuning; the cathodes of the valves V5, V6, V7, and V8 (all CV138) are connected in a CW-interference reducing circuit.

Anti-C W circuit

53. The cathodes of the last four IF amplifiers are returned to the 100-volt negative bias line through 47,000-ohm resistors. The cathode currents are at about 2 mA and the effective bias between grids and cathodes is about minus three volts. In this condition the valves are biased near the bottom bends of their mutual characteristics.

54. Consider the first of these valves. Because it is biased for non-linear operation, in the presence of a normal pulse signal the mean anode current rises; but, because the time constant of the cathode components, C25, R24, is large compared with the duration of the pulse, the cathode voltage does not rise with the current and the bias on the valve remains the same. The gain of the stage is therefore not affected by the presence of the pulse.

55. With a CW signal, however, because the CW has a duration at least equal to the time constant of the cathode circuit, the cathode voltage rises with the rise in current and the valve is biased back. Thus, if a pulse appears during the CW it will be superimposed, and its positive-going peaks will appear across the linear portion of the valve characteristic and be amplified in the normal way.

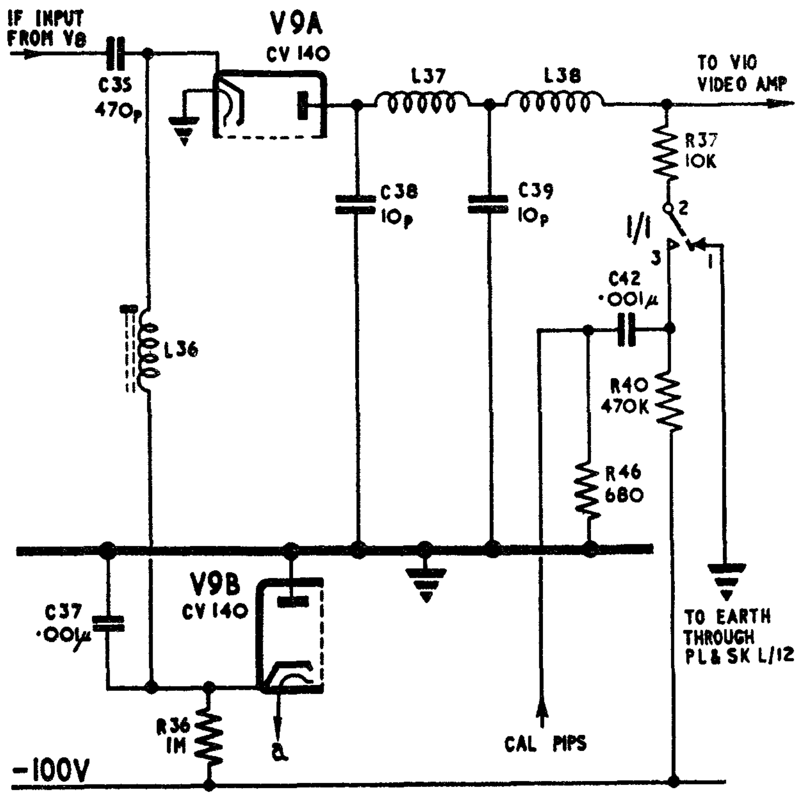

Fig. 6. Detector and anti-echo circuit

56. Fig. 5 demonstrates the action of the circuit. In (a) is shown the amplifying action of a normally biased valve in the presence of a pulse ; this should be compared with (b) where, under the same biasing conditions, a CW input is superimposed upon the pulse. It will be seen that the working portion of the valve characteristics is occupied almost completely by the interfering signal and that the amplification of the desired pulse signal is greatly reduced through operating into grid current on the positive-going half-cycles, and working over the non-linear characteristics towards cut-off in the negative half-cycles.

57. In (c) and (d) the conditions obtaining in the anti-CW circuit are shown. In (c) it will be seen that with a pulse input the gain is reduced relative to the conditions in the standard type of circuit operating as at (a) due to working on a non-linear portion of the characteristic. But in the presence of CW, (d) the change in cathode voltage biases back the valve. This tends to cause all the CW negative input to be cut off and the CW positive input to operate over the non-linear portion of the characteristic, so leaving the positive-going pulse input to operate over the linear part of the characteristic. As will be seen from comparing (b) and (d), the pulse gain of the anti-CW circuit is far superior to that of the normal circuit under the demonstrated interference conditions.

Detector (fig. 6)

58. The IF signals are detected in a diode valve V9A, part of a double-diode CV140. The output is a negative-going signal developed across a diode load consisting of a low-pass " pi " filter terminated by the load resistor R37. The filter provides a high order of attenuation of the IF signal content of the diode output and thus prevents IF injection into the video stages. At the same time it passes the video signals with a minimum of attenuation and phase-shift and thus preserves the shape of the pulses.

59. The two coils in the filter are wound in series on a ceramic former. The two shunt capacitors C38 and C39 are provided by silvered patches formed on the walls of the former, and used as connection points. The output capacitance of the filter is provided by the circuit strays and the input capacitance of the video amplifier V10.

Echo-suppression

60. The echo suppressor circuit is also shown in fig. 6. The second diode V9B is connected in the earth return of the detector input circuit and acts to suppress wide pulse inputs, that is, normal Gee pulses received from radiation along indirect paths, which by appearing immediately after the true pulses make them appear wider than normal and introduce difficulties into the operation of the A-lock circuit.

61. The action of the circuit can be considered as follows :—

(1) The diode V9B is connected in series with R36 across the bias supply. The diode is normally conducting and the voltage drop across the high resistance of R36 holds the cathode at a small negative potential.

(2) When a pulse signal is received, detector current flows through the tuning coil, and for the period of the pulse, the cathode capacitor C37 charges.

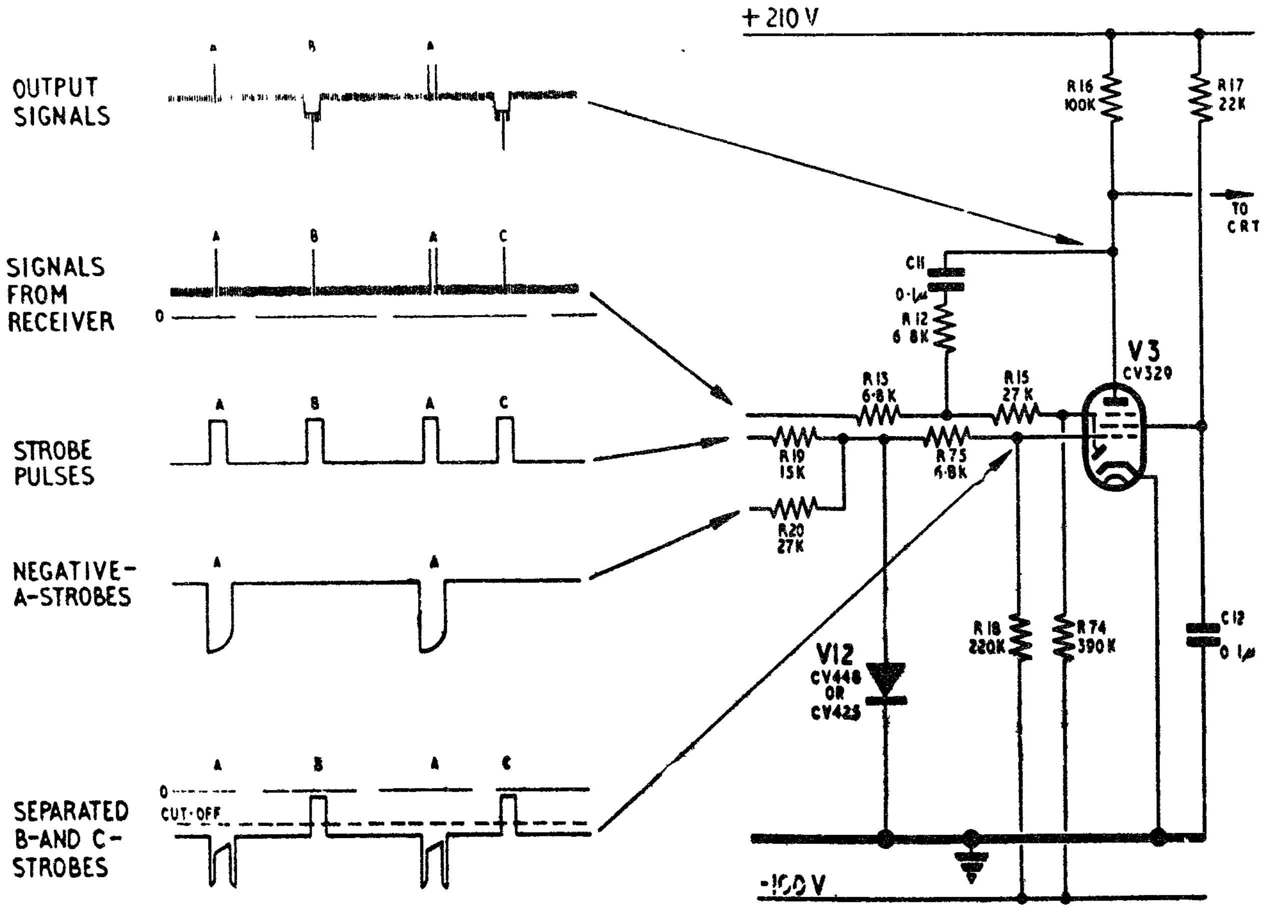

Fig. 7. Reversing stage

(3) As the potential across the capacitor rises above earth, the diode V9B stops conducting.

(4) At the end of the pulse the capacitor starts to discharge through R36 and the cathode potential of both diodes is held positive for the discharge period of about 100 microseconds.

(5) Weak signals, such as indirect echoes appearing immediately after the true signal, if of less amplitude than the discharge potential do not operate the detector and are suppressed ; strong signals appearing in the same period are reduced in amplitude.

(6) At the end of the discharge, the cathode voltage of V9B tends to go negative as the capacitor starts to recharge towards the potential of the negative supply ; the diode again conducts and the normal working conditions are re-established.

Video amplifier

62. The video output of the detector valve feeds a pentode video amplifier V10 (CV138) followed by a further pentode, V11 (CV136) connected as a cathode-follower. The bias on the grid of V11 is adjustable, through RV1 in a potentiometer across the bias supply, to allow the standing current in the valve, and therefore the DC component of the cathode voltage, to be controlled.

Calibration pulses

63. A changeover switch operated by the relay RL1 is included in the input circuit to V10 ; the circuit of the switch is shown in fig. 6. When the relay is open, the diode load resistor R37 is returned to earth through the contacts 2, 1, and pin 12 on the plug and socket L/12. This provides normal reception. When the calibration switch in the indicator is made, the relay is energized and contacts 2 and 3 close ; R37 is then returned to the negative bias line through R40 and the calibration marker input from the waveform generator is applied into the video grid circuit through C42. The negative bias mutes V9A, so preventing the detection of normal signals and leaving only the calibration markers as the input to the video stages.

DISPLAY CIRCUITS

Reversing stage

64. The output of the receiver in the form of Gee pulses or calibration markers is applied to the Y2 plate of the cathode-ray tube in the indicator through a reversing stage V3. Fig. 7 shows the reversing valve and the idealized waveforms of the reversal process.

65. The control and suppressor grids of V3 are returned to the 100V bias line so that the valve is normally cut off. The receiver output is fed as positive-going signals to the suppressor

through R13 and R15, and strobe pulses are fed to the grid through R19/R20 and R75 · the signal appearing at the grid is made up of the positive-going A-, B-, and C-strobes together with the negative-A-strobe. As shown in the bottom waveform of fig. 7, the A-strobe appears during the period of the negative-A-strobe and is cancelled, and as a result, only the B- and C-strobes rise above the base line of the composite signal.

66. During the period that the valve is cut off (that is in the absence of the B- and C-strobes) the receiver signals pass through a network (R12, C11) connected between the anode and the suppressor circuit, and appear in the anode circuit, slightly attenuated but otherwise unchanged. They are therefore fed through a coupling capacitor (C14) as positive-going signals to the cathode-ray tube Y-plates.

67. Each B- and C-pulse is of sufficient amplitude to raise the bias on the grid and allow anode current to flow. During these periods the signal at the suppressor grid modulates the flow of current and an inverted signal appears in the anode circuit ; C11 and R12 then provide a feedback path from the anode to the input at the suppressor and an anode-follower action ensures that the phase inverted signals are of approximately the same amplitude as the normal signals.

68. The pulse of anode current flowing during the period of each B- and C-pulse has a duration of about 1·2 Gee units and appears in the anode circuit as a square negative pulse with the negative receiver signal super-imposed upon it. The level of the negative pulse is determined by the level of bias on the suppressor grid and this is controlled by the DC content of the input signal from the reeciver. The regulation of this DC level by means of the bias control on the receiver output valve therefore allows the depth of the pulses to be controlled.

69. On main timebase operation the pulses appear as strobe wells with the signals on them appearing inverted and the depth of the wells controlled by the receiver output bias control. On strobe timebase operation the pulses provide the separation between the upper A and B, and the lower A and C traces. The depths of the wells and the separation of the traces are therefore controlled by the receiver output bias control.

70. A germanium crystal diode (V12, CV448 or CV425) is connected in the grid circuit of the reverser valve to prevent the grid going positive. It functions as a limiter on the B- and C-strobe input pulses and squares off the peaks, thus ensuring that the strobe wells displayed on the cathode-ray tube are square. In early equipments the function was carried out by a diode valve (V4B, part of V4, CV137).

Square-wave Y-pulse

71. A second input to the Y-plates is derived from the 250 c/s square wave generated in the waveform generator. This waveform, of equal positive and negative periods, has a repetition rate which is equal to two full sweeps of the timebase trace. The leading and trailing edges of the square wave are approximately coincident in time with the start of alternate traces ; alternate traces are therefore displaced vertically one above the other.

Timebase generator (*fig. 8*)

72. The timebase generator is a pentode V1 (CV329) in a Miller integrator circuit. It is controlled by a two-position switch S2, to produce two display conditions, main timebase and strobe timebase.

73. For main timebase operation the valve is triggered by the 500 c/s rectangular wave output of the divider circuits in the waveform generator. The sweep therefore has a repetition frequency of 500 c/s and a duration equal to that of the positive period of the input, that is, of 25 Gee units ; the flyback has the period of the negative portion of the input, that is, of 5 Gee units.

74. For strobe timebase operation the valve is triggered by the output of positive pulses from the strobe generator, each of 1·2 Gee units duration. The first and third pulses, the A-strobes, are timed to the beginnings of the main timebase traces, and the other pulses, the B- and C-strobes, appear at any time between adjacent A-strobes, with the B-pulses always following the odd A-pulses, and the C-pulses always following the even A-pulses. The A-traces display normal signals on expansions of the beginnings of the traces; the B- and C-traces display inverted signals on expansions of the strobe wells.

75. During the fly-back period the timebase valve is cut off by the negative excursion of the triggering waveform at the suppressor grid, and the anode-grid capacitance (C3 on strobe timebase, and C3 in parallel with C4 on main timebase) charges to about the level of the HT line. The grid is passing current due to its return to HT plus through the preset adjustments, and is at some slightly positive potential. The screen is passing a large current and its voltage is low.

76. When the triggering waveform goes positive, the suppressor rises above cut-off and anode current starts to flow. The initial flow is limited to a low value by the feedback of the initial fall in anode voltage to the grid, which is driven negative almost to the cut-off point. The flow of grid current ceases as the grid is driven negative, and after the initial drop, the grid voltage starts to rise as the grid-anode capacitance discharges through the grid return resistor, (R3 on strobe timebase, and R4 on main timebase) to the potential difference between the anode and the slider of the timebase preset (RV3 on strobe timebase, and RV1 on main timebase).

77. The rate of discharge of the anode-grid capacitance is determined by first, the setting of the preset adjustment, RV1 or RV3, and second

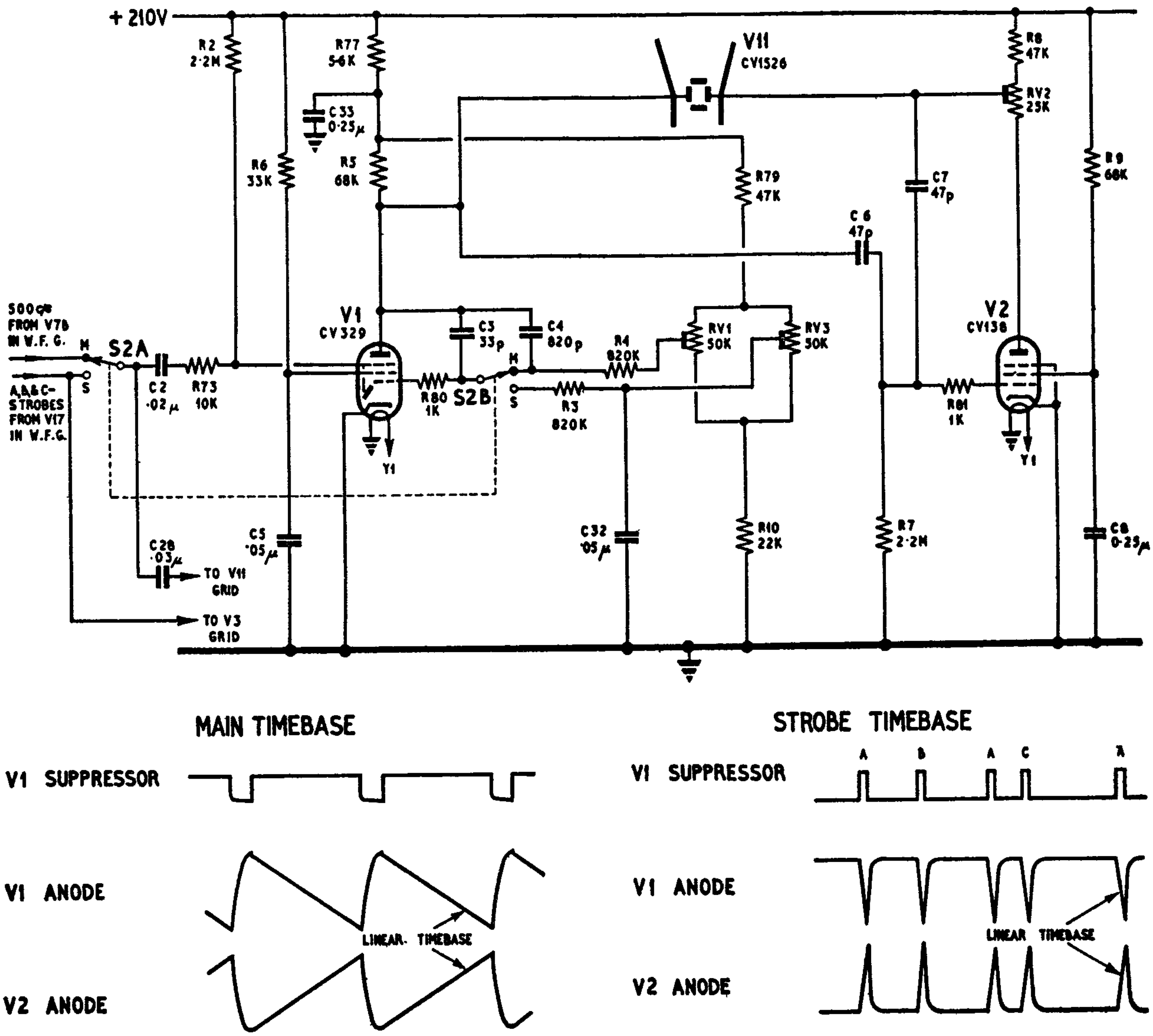

Fig. 8. Timebase circuit

by the feedback from the anode to the grid. In the first instance, as the time for which the action takes place is limited by the triggering pulse to be either 25 Gee units or 1·2 Gee units, alteration of the rate by an adjustment to the presets alters the amount of the discharge and therefore the amplitude of the sweep as it appears at the anode. In the second instance the feedback operates to make the rate of discharge almost constant so that the sweep at the anode, instead of being exponential, is practically linear.

78. When the waveform goes negative, the suppressor grid is again driven beyond cut-off and anode current ceases. The anode voltage rises to the level of HT positive as the anode-grid capacitance again charges up to the HT level, and the grid again takes current. The rise of anode voltage, as the anode-grid capacitance charges, provides the fly-back sweep. On main timebase the time of this rise is approximately that of the negative part of the triggering waveform and the fly-back therefore occupies most of the waiting period between traces. On strobe timebase the rise is more rapid, and for the greater part of the negative period of the trigger waveform the anode voltage is steady at the HT level ; the spot on the cathode-ray tube is therefore held steady at the beginning of the trace.

Paraphase amplifier

79. The sweep at the anode of the timebase valve is applied direct to one X-plate of the cathode-ray tube, and through a phase-inverting stage V2, to the second X-plate. This stage uses a pentode valve in a paraphase amplifying circuit with a gain of unity. The valve is connected as an anode-follower and its output is reversed in phase relative to its input ; the X-plates thus receive a balanced input.

80. DC couplings are used from the anodes of V1 and V2 to the CRT, and the difference in DC potential at the two anodes provides the centring bias for the sweep. This bias is controlled by the X-shift preset forming part of the load in the anode circuit of V2. The standing current in V2 produces a voltage drop across RV2 but in order that the sweep output shall not be reduced as the slider of the control is

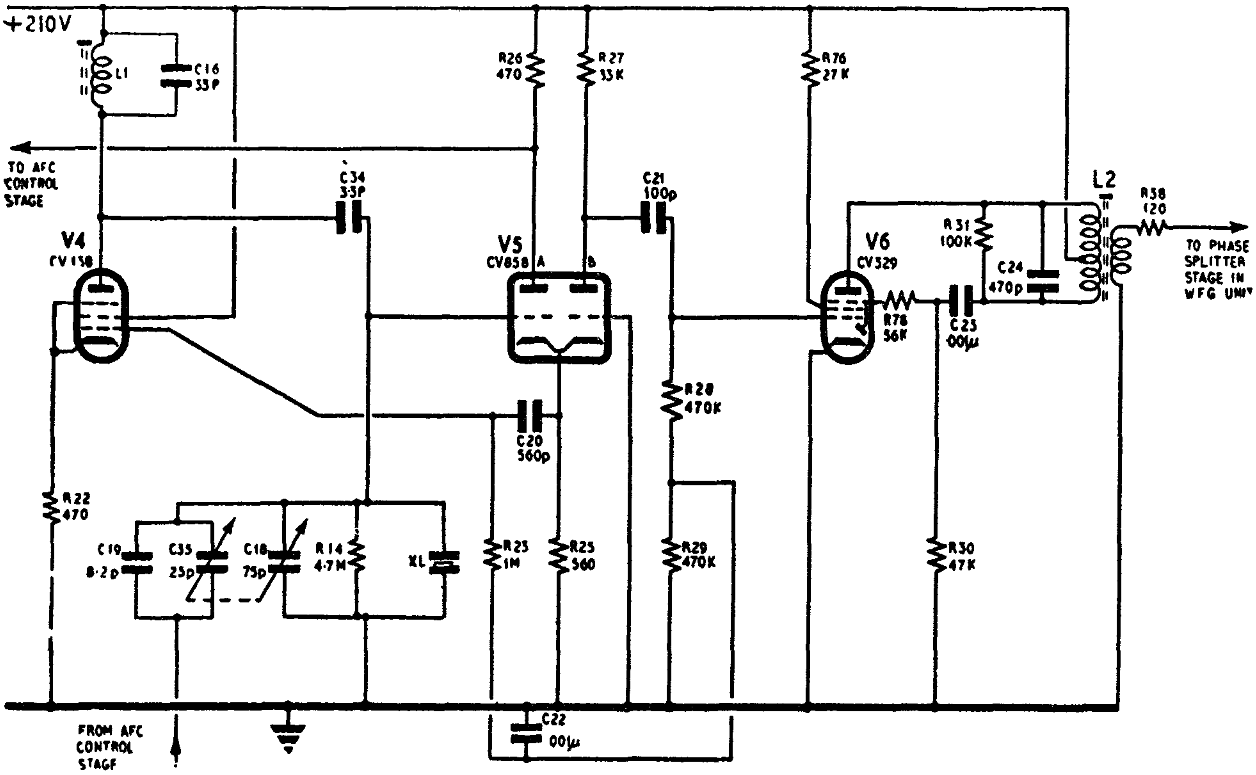

Fig. 9. Crystal oscillator and 75 kc/s oscillator circuit

moved away from the anode, the feedback to the grid is taken from the slider. In operation therefore a movement of the slider away from the anode raises the DC potential at the second X-plate. At the same time the feed-back through C7 is reduced and the gain of the valve rises ; thus although a smaller proportion of the signal at the anode is being fed from the slider, the actual output at the slider remains practically constant.

Flyback blanking

81. The triggering waveform to the suppressor of the timebase valve is also applied, through C28, to the grid of the cathode-ray tube. In the negative, flyback, periods the grid is driven beyond cut-off and the tube is blacked out ; in the positive periods the trace is made visible.

82. A DC restoring diode V10 (CV1092) is connected into the grid circuit to ensure a constant brightening level during the visible periods and to prevent the grid being driven positive.

Cathode-ray tube

83. The cathode-ray tube V11 (CV1526) is electrostatically focused and deflected and uses post-deflection acceleration in order to achieve a high level of brightness and sharp focus. The potential between the final anode and the accelerator electrode, approximately 1,300V, is controlled by RV4 as an adjustment for astigmatism. The final anode is approximately at earth potential and about 1,200V positive to the cathode. The potential at the second anode is controlled by RV5 as an adjustment of focus. The grid-cathode voltage is regulated by RV6 to control brightness.

84. The potentiometer supplying EHT to the cathode-ray tube includes in all but the earliest indicator units two resistors, R47 and R45, in series with the bottom end of the brightness control. These resistors can be shorted out, either separately or together, in order to extend the range of the brightness control and allow the use of cathode-ray tubes whose grid-cathode voltage for maximum brightness puts them outside the normal range.

CRYSTAL OSCILLATOR AND DIVIDER

Crystal oscillator (*fig. 9*)

85. A crystal oscillator circuit which includes V4 (pentode, CV138) and V5A (section of double triode, CV858) provides the master frequency from which the strobe timing and timebase generating pulses are derived. Any one of six crystals is selected by S7 to produce an output at any of the six frequencies in 0·75 kc/s steps between 148·5 kc/s and 152·25 kc/s. In early equipments, the main valve of the oscillator circuit was a triode (V4A, part of diode triode CV137) but a change was found necessary in order to improve the control that could be exercised over the frequency.

86. Operation of the oscillator can be considered as being similar to that of the tuned-plate tuned-grid type of circuit (T.P.T.G.). The anode tuned circuit is provided by L1, C16, and the grid tuned circuit is provided by the crystal ; the anode-grid feedback path is through C34, the cathode-follower coupling of V5A, and C20. The resonant frequency of the anode circuit is set by the preset core of L1 to be greater than the highest frequency (152·25 kc/s) at which the circuit has to operate ; as a result, the anode load is always inductive and the phase shift in the feedback circuit satisfies the requirements for oscillation.

87. A variable capacitor (C18) is connected across the crystal to provide for fine control of the oscillation frequency ; it is used as a manual adjustment permitting the frequency to be set to an exact multiple of the p.r.f. of the received Gee signals. Further capacitors (C19, C35) also connected in the crystal circuit, form part of the automatic frequency control (AFC) system which is described later. The purpose of the cathode-follower in the feedback path is to isolate the grid capacitance of V4 from the crystal, and hence to minimise frequency variations which might result, particularly during warming-up periods, from changes in the valve's characteristics.

88. The feedback signal to the grid of V4 is taken from the cathode load (R25) of V5A, and as this resistor is also the cathode load of V5B, the signal thus appears on the cathode of V5B. This valve is connected as a grounded-grid amplifier, so that the signal at its cathode is its input, and in consequence an amplified waveform appears in the anode circuit across R27. The main output of the oscillator circuit is provided by this waveform ; a secondary output, for use in the AFC circuit, is taken from the anode of V5A.

AGC

89. From V5B, the oscillator output is fed to the grid of V6 (pentode, CV329). This valve is operated without standing bias, and consequently grid current flows during the positive half-cycles of the input transformer, resulting in the build up of a negative potential across the grid return resistors (R28, R29). A reservoir capacitor (C22) across R29 smooths this potential which is fed as a negative bias through R23 to the grid of the oscillator valve V4. The level of this bias potential is proportional to the amplitude of the output from the oscillator circuit, and as the effect of the bias is to decrease the oscillator output, the amplitude of the oscillation is reduced, and tends to remain constant at the lower level. Without this form of automatic gain control (AGC) the amplitude would vary between 20V and 100V peak-to-peak as crystals were changed or if the HT level varied ; with AGC the amplitude remains steady at about 2V peak-to-peak.

75 kc/s oscillator

90. As well as providing AGC to control the oscillator, V6 is also a divide-by-two stage on the oscillator output. A tuned circuit (L2, C24) is connected between the anode and the suppressor grid, and, because the suppressor is able to exercise a high degree of control of the anode current, that part of the valve forms a Hartly-type oscillator. The natural oscillation frequency is about 75 kc/s, but the tuned circuit is damped by R31 and the loading of the output circuit so that the frequency is easily 'pulled' by external influences.

91. In operation, because the grid is biased off by grid current (para. 89), cathode current only flows during the positive half-cycles of the input at the control grid, so that the oscillator section of the valve can only pass current during such periods. If each positive half-cycle on the grid were to cause anode current as well as cathode current to flow, alternate half-cycles of the 75 kc/s oscillation would be inhibited and consequently oscillation would not take place. In practice the 75 kc/s oscillatory voltage across the coil is phased such that the suppressor is driven negative as each alternate positive half-cycle appears at the grid, and as a result anode current does not flow.

92. The overall effect is therefore that a waveform is developed in the tuned circuit in which each cycle is synchronized accurately to alternate cycles of the input from the main oscillator ; that is, the output is locked rigidly to half the frequency of the crystal oscillator. Because the crystal oscillator operates over the range from 148·5 kc/s to 152·25 kc/s the output will therefore be in the range from 74·25 kc/s to 76·125 kc/s. In existing Gee ground installations the operating p.r.f. is 500 ; the crystal frequency to produce a 500 c/s timebase is 150 kc/s so that the normal output from V6 is at 75 kc/s. In consequence all further references will be to these frequencies but it must be borne in mind that the description refers equally to the conditions which obtain with other p.r.f.s and which call for slightly different crystal and divider frequencies.

Phase splitter ***(fig. 10)***

93. The 75 kc/s output of V6 in the indicator is taken from a secondary winding on L1 and fed through a screened cable to an input transformer (L1) in the waveform generator. The secondary centre-tap of this transformer is connected to earth so that the signals at the ends of the winding are in anti-phase (see second and third waveforms of fig. 10).

94. The secondary winding of L1 is preset to the centre frequency of 75 kc/s by means of an adjustable dust-iron core. The tuning is sufficiently broad to cover all the possible range of inputs without undue losses at the extremities. The tuning capacitance (marked with an asterisk [*] in fig. 10) is a single fixed capacitor (C1, 100p) in early equipments, but is a fixed capacitor (C1, 82p) together with a trimmer (C2, 30p max.) in later equipments. The trimmer was introduced to compensate for manufacturing tolerances that could not be taken up by the core adjustment.

95. The 75 kc/s sine-waves are applied, in anti-phase, to the grids of the phase-splitter valves V1, V2 (pentodes, CV136). These valves operate without standing bias, but grid current, which flows during the peaks of the positive half-cycles of input, biases the valves back and pre-

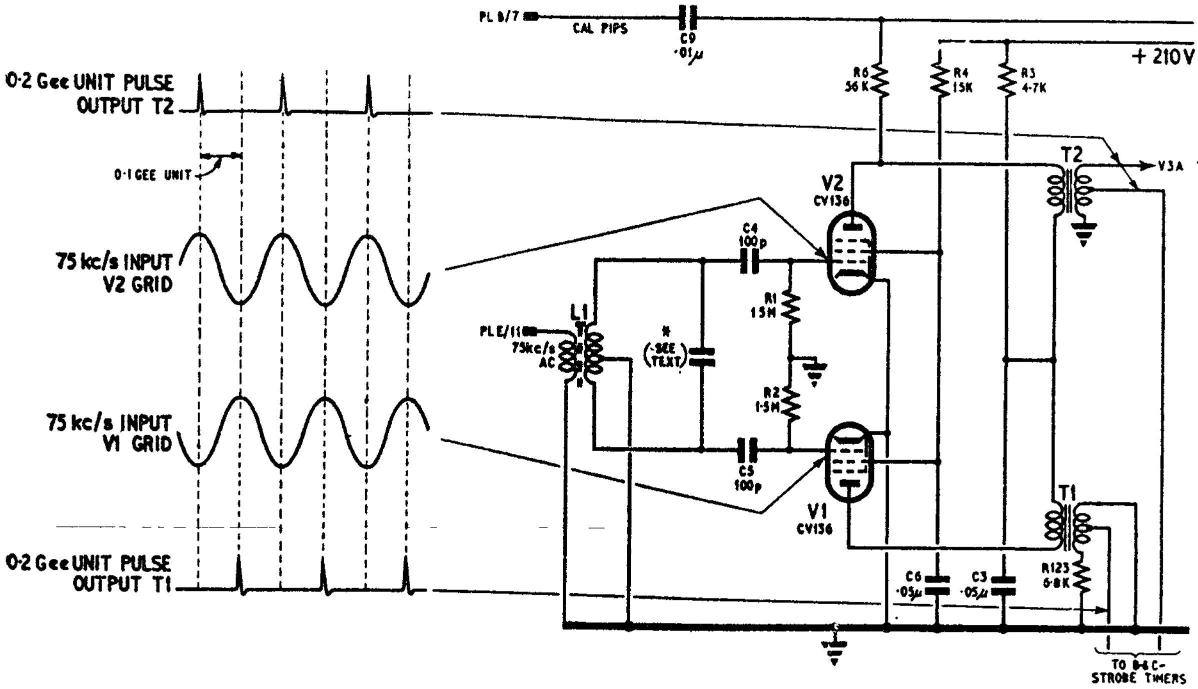

Fig. 10. Phase splitter

vents the flow of anode current for all but short periods in each input cycle. A train of short pulses is thus generated in each valve.

96. Although the inputs to V1 and V2 are provided in a push-pull type of circuit, the output in the anode circuits are not push-pull derived. Instead each valve feeds a separate output transformer, of identical design, to produce two separate positive-going pulse trains. The main output, from the full secondary winding of T2 in the anode circuit of V2, is used to trigger the divider stages, and a second output from a tap on T2 feeds timing pulses to the strobe circuits. T1 in the anode circuit of V1 provides only a single output, from the tap, which is fed as further timing pulses to the strobe circuits ; the main secondary winding is however loaded by R123 to ensure that both transformers operate under identical conditions.

97. The two pulse trains produced in the phase splitter have each a repetition frequency of 75 kc/s, so that displacement between adjacent pulses in each train is the same at 0·2 Gee units. The originating waveforms for the two trains are however 180 deg. out of phase, so that the pulses generated from each input cycle will be separated by the duration of half a cycle (as shown in the waveforms of fig. 10). In consequence, the displacement between adjacent pulses as between the two trains is that of half a cycle of the 75 kc/s input that is, 0·1 Gee units. Particular care has been taken in the design of the stage to ensure that this displacement is exact, as the accurate interlacing of the two pulse trains is essential for the correct counting of the strobe timers.

Divide-by-five circuits (*fig. 11*)

98. The main 75 kc/s output pulse of the phase splitter is fed through R5 to the grid of a triode valve V3A (half of double triode, CV858) in a blocking oscillator circuit. This valve is self-oscillatory at a frequency a little less that 15 kc/s and each fifth input pulse pre-triggers the oscillatory action so that operation takes place at exactly 15 kc/s.

99. The operation of the blocking oscillator, starting from a condition mid-way in its cycle, can be considered as follows :—

(1) The valve is held beyond the cut-off point by a positive-rising negative voltage on its grid as, due to the action of the previous cycle, the grid capacitor C7 discharges. The rate of discharge is controlled by the setting of the locking control RV1. The 75 kc/s pulses from the phase splitter are connected into the grid circuit through R5 to appear superimposed upon the positive-rising voltage.

(2) The first four pulses to appear on the grid after the valve has cut off do not raise the grid voltage above the cut-off level, but with RV1 appropriately set, after the fourth pulse the rising level of the grid is such that the next pulse, the fifth, does rise above cut-off and a pulse of anode current flows. (The grid pulses are coupled through the transformer T3 and appear as low-amplitude negative pulses at the anode during the cut-off period;

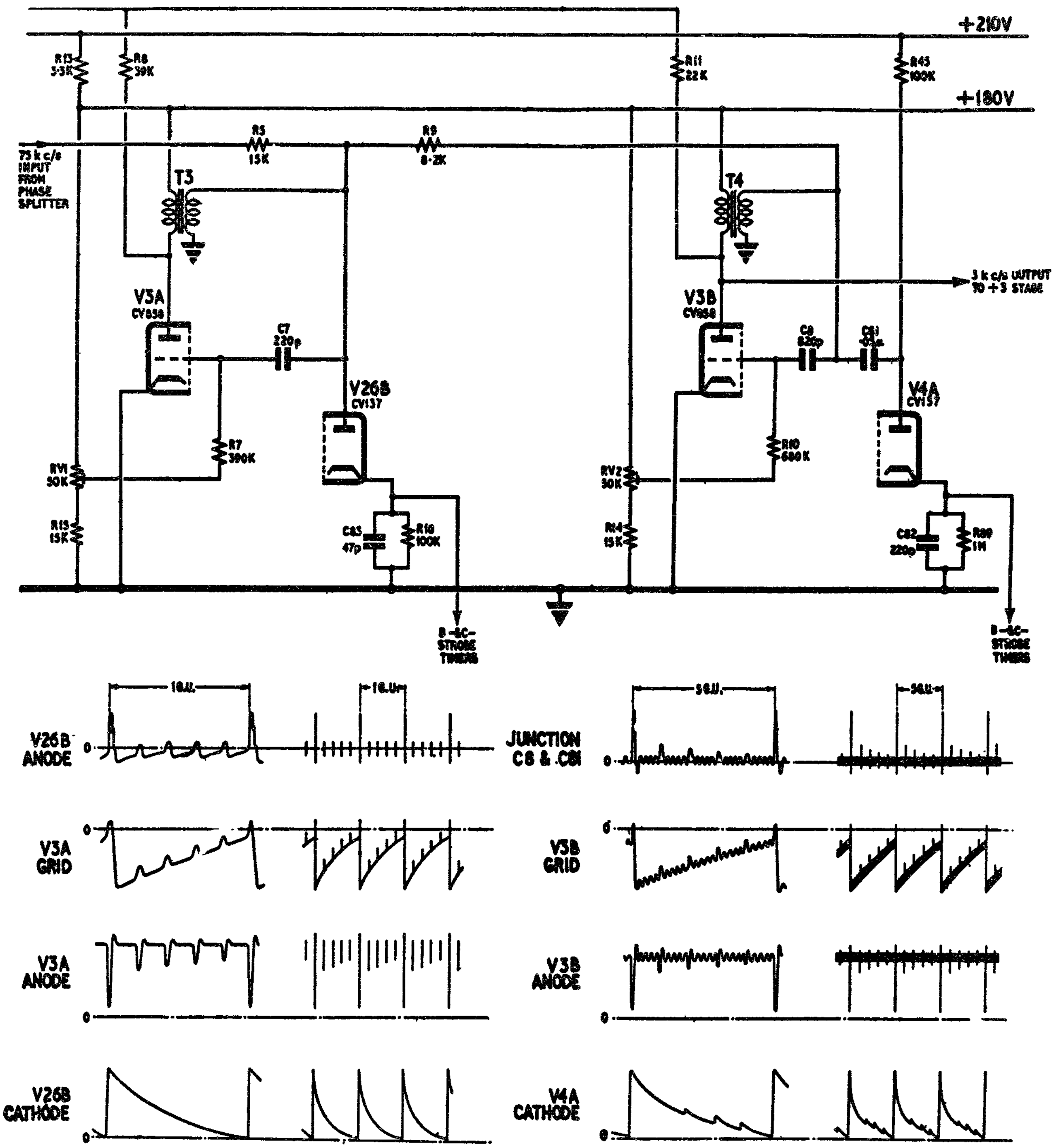

Fig. 11. Divide-by-five circuits

they do not affect the operation of the circuit.)

(3) The initial flow of current produces positive feedback to the grid through the transformer T3, and a cumulative action takes place in which the feedback drives the valve rapidly to pass maximum current. The rise in current is conditioned by the transformer, and has the form of a quarter-cycle of 'shock' oscillation, at a high frequency, as determined by the constants of the transformer and the circuit capacitances.

(4) As the feedback voltage rises, the potential at the grid rises to some slightly positive value, as limited by the on-set of grid current, and the further rise of feedback voltage charges the grid capacitor, through the impedance of the grid-cathode circuit, to almost the full value of the feedback voltage.

(5) When the current in the valve and transformer passes through its maximum, the feedback voltage falls to zero and the grid, falling by an equal amount, is driven negative well beyond the cut-off point. The sudden fall in anode current 'shocks' a

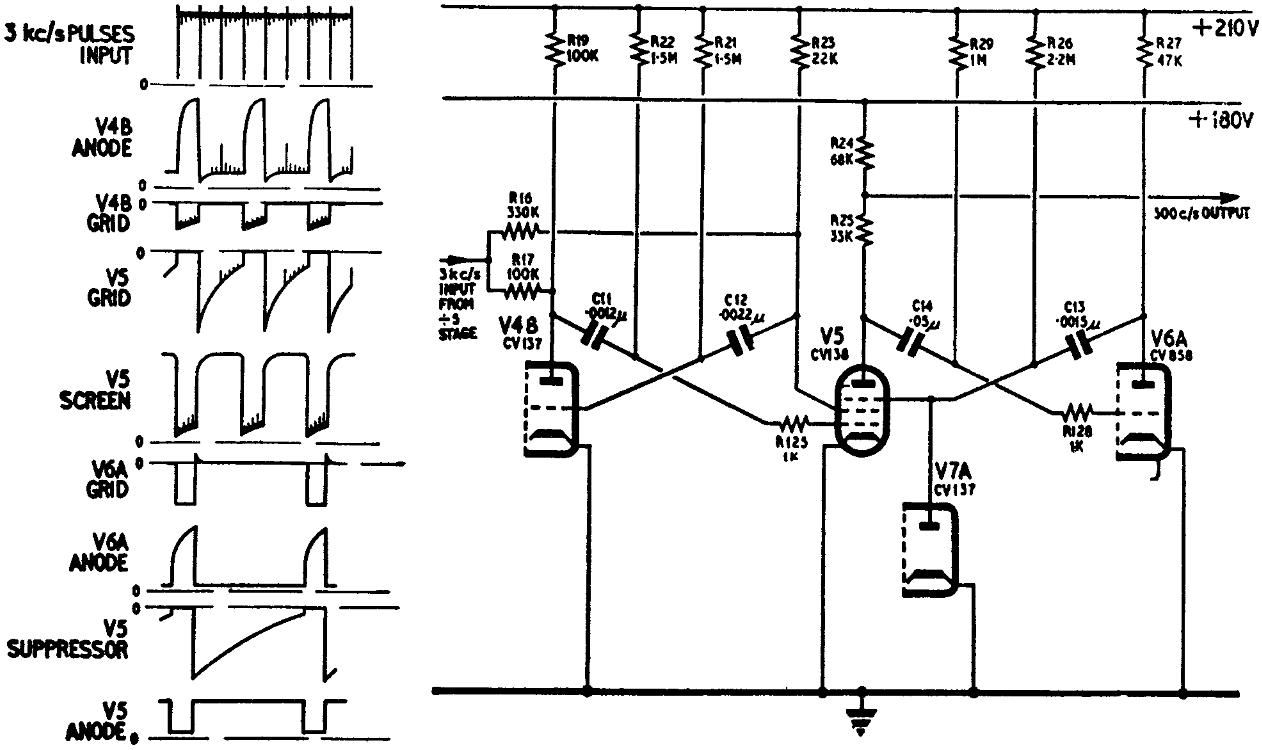

Fig. 12. Divide-by-six stage

further oscillation in the transformer and the grid is driven still further negative.

(6) When the grid current ceases to flow, the charge on C7 begins to discharge to the level set by RV1 and a positive-rising negative voltage is produced across R7. Thus, as the feedback pulse disappears, the negative voltage across R7 continues to hold the valve cut off. The conditions specified in (1) are thus re-established, and the cycle repeats.

100. The voltage at the secondary of the transformer therefore includes a sharp positive pulse super-imposed on each fifth 75 kc/s pulse. This pulse, at a frequency of 15 kc/s and at a separation of 1 Gee unit, is the trigger pulse for the next stage. Both the 75 kc/s and 15 kc/s pulses are applied through R9, but only the 15 kc/s pulses are of sufficient amplitude to provide a trigger for V3B.

101. The second divide-by-five stage uses V3B in a similar circuit to that of VRA. The time-constant of the grid circuit is such that this valve only fires on each fifth input pulse, and it therefore operates at a frequency of 3 kc/s. Adjacent pulses have a separation of 5 Gee units. The dividing ratio is controlled by RV2. The output of the second divide-by-five stage is taken as a negative pulse from the anode circuit to trigger the combined divide-by-three and divide-by-two stage.

Calibration pulses

102. The anode circuits of V2, V3A, and V3B are connected through R6, R8, and R11 respectively to a common output point, and from there to the receiver through C9. The combined signal of 75 kc/s, 15 kc/s, and 3 kc/s pulses is used to provide negative going calibration markers. Each resistor forms with the common component R12 a potentiometer across the respective anode loads, and the values are chosen so that the output level decreases as the output frequency increases.

Integrating circuits

103. A diode V26B, part of diode triode (CV137), is connected into the grid circuit of the first divide-by-five stage, in series with the parallel circuit of R18 and C83. Each time the divider stage operates the diode passes current and C83 is charged, and in the period between pulses the charge leaks away through R18. The output at the cathode of the diode is a train of widened 1-Gee unit pulses which is used for controlling the operation of the strobe timers.

104. A second diode V4A, part of diode-triode V4 (CV137), is connected in the grid circuit of the second divide-by-five stage to integrate the 5-Gee unit pulses generated therein. The output across the cathode components, C82, and R89 in parallel, is also used for controlling the strobe timers.

Divide-by-six stage (*fig. 12*)

105. The next stage divides the output of the second divide-by-five stage by six. This is accomplished in two steps, first, divide-by-three and second, divide by-two. In the first step V4B, triode section of diode-triode V4, and the triode formed by the cathode-grid-screen of V5 (CV138),

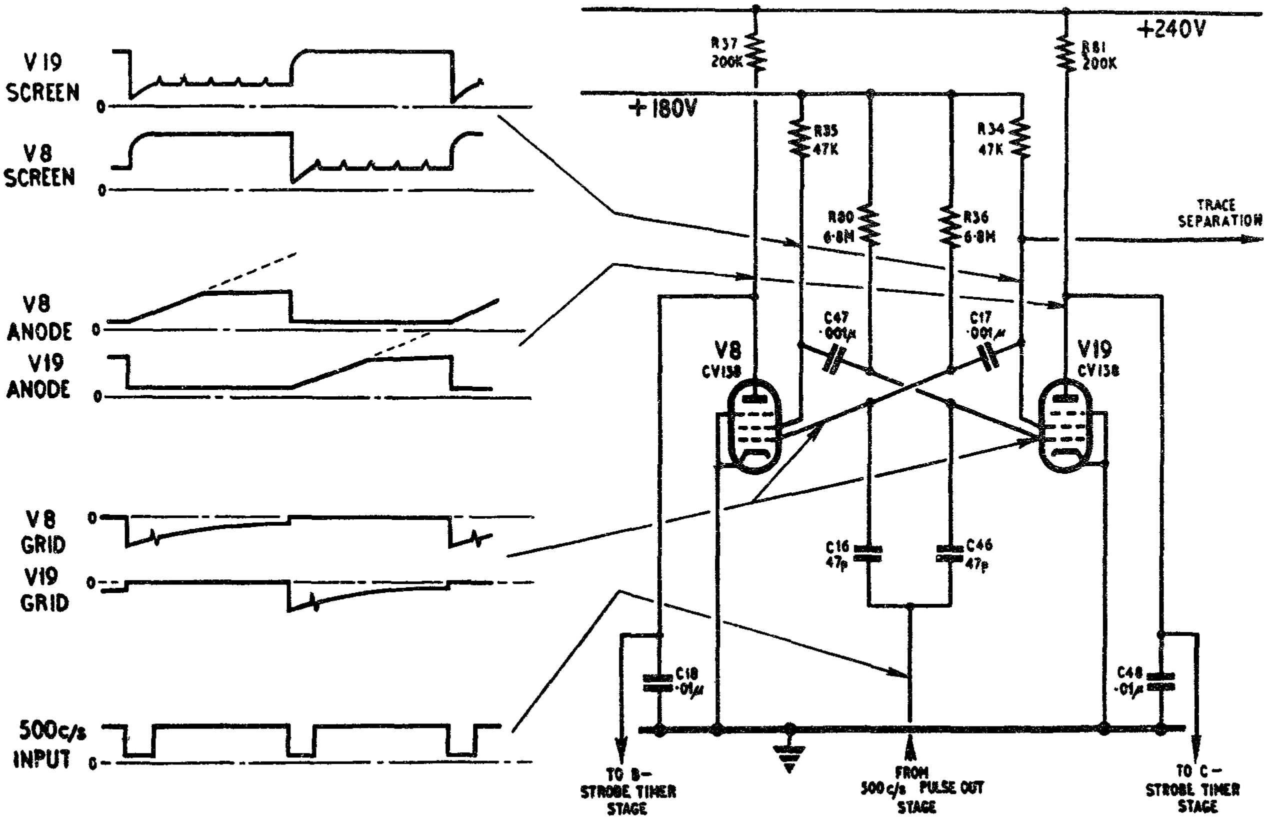

Fig. 13. 250 c/s square-wave generator

form a multivibrator which divides by three. The further electrodes of V5 together with V6A, one section of double-triode V6 (CV858), form a second multivibrator which suppresses every alternative pulse from the first section.

106. The action of the circuit is illustrated in the waveforms of fig. 12. Consider first the action of the divide-by-three section. The anode-grid coupling from V4B to V5 and the screen-grid coupling from V5 to V4B make the free-running condition of the circuit asymmetrical. The negative-going pulses at the anode of the final divide-by-five stage are coupled to the grid of V5 through R17, C11, and R125, and to the grid of V4B through R16 and C12. The amplitude of the pulse appearing at the grid of V4B is smaller than that at the grid of V5 due to the greater attenuation in the potentiometer formed by R16, R23, than in that formed by R17, R19.

107. At some point in the operating cycle when V5 is not passing current, V4B is fully open; V5 is held cut-off by a negative voltage on its grid developed across R22 as C11 discharges; the grid of V4B is slightly positive and grid current flows. The negative trigger pulse from V3B appears, greatly attenuated by R16 and R23, in the grid circuit of V4B and is amplified to appear as a positive-going pulse in the anode circuit; the resultant pulse in the anode circuit is compounded of the amplified positive pulse and the direct negative pulse through R17, and this pulse forms a positive-going trigger of low amplitude for application to the grid of V5.

108. The first of these pulses appearing on the grid of V5 after that valve is cut off is insufficient to lift the grid voltage above cut-off, but the second pulse is effective and anode current flows; this initiates a multivibrator changeover action in which V5 is driven rapidly from cut-off to fully conducting and V4B is driven from fully-conductive to beyond cut-off. In this state V4B is held cut off due to the discharge of C12 through R21; the grid of V5 is slightly positive and both anode and grid current flows.

109. The negative pulses appearing on the gr of V5 from V3B are now amplified in V5 and the positive-going pulse at the screen of V5, compounded of the positive amplified voltage and the small negative direct voltage through R16 is of large positive amplitude. This pulse is applied to the grid of V4B, and the first trigger pulse appearing after that valve cuts-off is sufficient to cause anode current to flow and the operating conditions to be reversed.

110. V5 thus remains cut off for a period equal to two periods of the input pulses, that is for 10 Gee units, and V4B is cut off for one period of the input pulse, that is, 5 Gee units. The total period of the circuit is therefore 15 Gee units and the repetition rate is 1,000 c/s.

111. Current flows to the screen of V5, as a result of the multivibrator action just described, for a period of 5 Gee units in each cycle of 15 Gee units; thus each conductive period is equivalent to the application of a triggering wave

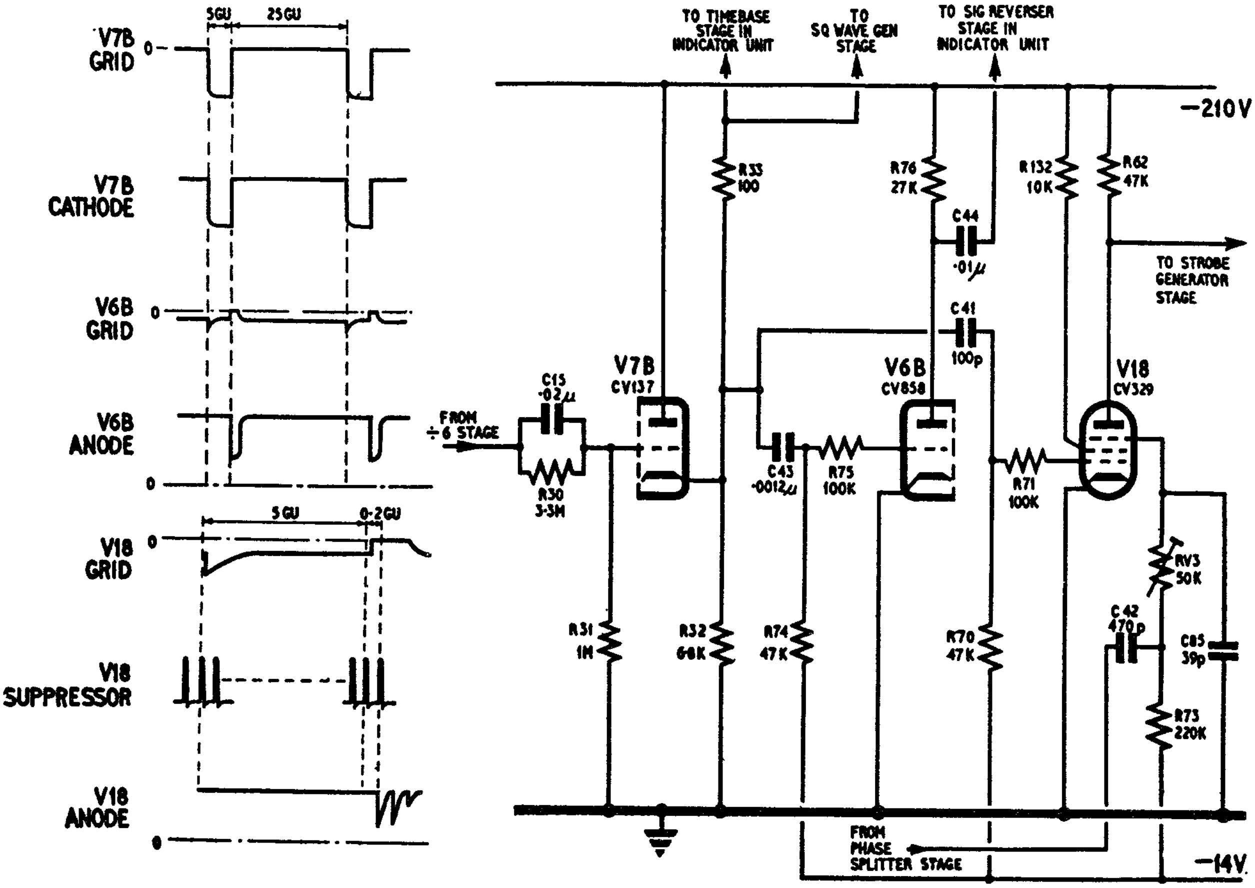

Fig. 14. A-strobe and negative-A-strobe generators

of mark-space ratio 1:2 to the effective triode formed by the screen-suppressor-cathode. The action of the second multivibrator formed between this triode and V6A is to suppress the effect on the anode circuit of V5 of each alternate pulse at the screen, so that the output at the anode is a series of 5-Gee unit pulses in a rectangular wave of mark-space ratio 1:5. The total period of output is therefore 30 Gee units, and the repetition frequency is 500 c/s.

112. Consider the period when V5 grid is cut off. The anode voltage of V5 is high, and the grid of V6A is slightly positive and grid current flows ; the anode voltage of V6A is low and C13, coupling the anode to the suppressor of V5, is discharging through R26 ; the voltage at the suppressor is heavily negative. The first pulse opening V5 causes current to pass to the screen, but because of the negative voltage on the suppressor, anode current does not flow. At the second pulsing of V5 current again passes to the screen but by this time the charge on C13 has fallen sufficiently to allow the voltage on the suppressor to rise above cut-off, and anode current also flows for the 5-Gee unit period for which the grid is open.

113. The pulse of anode current causes a fall in anode voltage and this fall drives the grid of V6A negative and that valve cuts off. The rise in anode voltage on V6A is coupled through C13 to the suppressor of V5 and holds the suppressor at about earth potential, as limited by the diode V7A, part of diode-triode V7 (CV137), which serves to prevent it going positive. At the termination of the pulse at the grid of V5, anode current ceases and the rise in anode voltage is coupled through C14 to open up V6A, and the sudden fall in anode voltage in that valve drives the suppressor of V5 rapidly negative to re-establish the original conditions.

114. The 500 c/s rectangular wave at the anode of V5 is fed through C15 and R30 in parallel (*fig.* 14) to the cathode-follower V7B, triode section of diode-triode V7, for distribution to the final divide-by-two stage, the main timebase, the A-strobe timer, and the negative-A-strobe generator.

250 c/s square-wave generator (*fig. 13*)

115. The final stage of the divider chain is a square-wave generator using the pentode valves V8 and V19, both CV138. These valves are connected in a symmetrical multivibrator circuit triggered from the 500 c/s output of 1V7B.

116. The multivibrator action takes place between the cathode-grid-screen sections of both valves, and the outputs in anti-phase at the anodes are used to initiate the actions of the B- and C-strobe timers. A further output is taken from the screen of V19 through the cathode-follower output valve V27, triode-connected pentode (CV136), for application as a trace-separating waveform on the cathode-ray tube in the indicator.

117. The operation of the circuit is generally similar to that of the divide-by-three circuit, in that the 500 c/s triggering waveform is applied to the screens of both valves ; the negative-going leading edge of the wave is amplified and inverted in that valve which is passing current, and is applied to the grid of the other valve to lift the bias and start conduction. Each valve is fired in turn by successive negative input pulses, and the output pulses at the screens are symmetrical, due to the use of identical coupling circuits between the valves. Thus the outputs are true square waves at a recurrence frequency of 250 c/s.

118. The outputs at the anodes are not true square waves, but as a result of the integrating actions of anode capacitors C18 and C48, have saw-toothed, almost linear, positive-going edges. The peaks of the saw-tooth pulses are flattened by the limiting action of the input circuits of the following timer stages. As will be seen from the waveforms of fig. 1 and fig. 13, the timing of the beginnings of the positive edges is approximately that of the negative-going edges of the 500 c/s rectangular wave.

TIMING CIRCUITS

A-strobe generator (*fig. 14*)

119. The 500 c/s output of the cathode-follower V7B is applied to V18 (CV329) to generate an A-strobe timing pulse. The valve is normally cut off by the return of its grid and suppressor through R70 and R73 respectively to the negative bias line. The input to the grid consists of the rectangular wave from V7B ; the input to the suppressor is the 75 kc/s, 0·2 Gee unit, pulse output from the phase splitting circuit.

120. The rectangular wave is differentiated by the grid components C41 and R70 to appear at the grid as a sharp negative pulse derived from the negative leading edge, and as a sharp positive pulse derived from the trailing edge. Only the positive pulse lifts the bias on the valve and the flow of grid current serves to flatten the top of the actual firing voltage. The valve is therefore opened for a short period after each positive edge, but because of the bias on the suppressor, anode current only flows with the arrival of the positive 75 kc/s pulses ; thus the output at the anode is a short train of negative-going 75 kc/s pulses starting immediately after the positive edge of the rectangular wave.

121. The input circuit of the 75 kc/s pulse to the suppressor includes an integrating circuit RV3 and C85. Adjustment of RV3 allows a controlled delay " d " to be introduced into the timing of the pulses at the suppressor. The control is preset and is used to balance out indeterminate delays which occur in the B- and C-strobe timers, and which, if not otherwise accounted for, would introduce inaccuracies into the counting of the timers.

122. The timing, t_1, of the positive-going edge of the 500 c/s rectangular wave is delayed by 5 Gee units on the datum time t_0 ; the timing of the A-strobe generator output, t_a, is still further delayed by the period of about 0·2 Gee units between t_1 and the operative 75 kc/s pulse. The delay of t_a on t_0 is therefore 5 Gee units plus 0·2 Gee units, plus the additional unspecified delay " d ", making a total of 5·2 + " d " Gee units.

Negative-A-strobe generator (*fig. 14*)

123. A second 500 c/s rectangular wave output from the cathode of V7B is taken to the grid of the negative-A-strobe generator V6B, part of double-triode V6 (CV858). This valve is biased to cut off by the return of its grid through R74 to the negative bias line, and each cycle of the input waveform appears at the grid as sharp negative and positive pulses due to differentiation in the coupling components.

124. Current only flows in the valve with the application of the positive pulses, and due to the flow of grid current flattening the peaks of the input, the pulse appearing at the anode is negative and almost square. The duration of the output pulse is determined by the time constant of the grid circuit and is about 1·5 Gee units. The timing is coincident with the positive edge of the 500 c/s rectangular wave, and is therefore slightly in advance of the A-strobe, and the same as the start of the main timebase traces.

B-strobe timer

125. The circuit of the first stage of the B-strobe timer is shown in fig. 15, and the waveforms illustrating the overall operation are shown in fig. 27. The input, supplied from the square wave generator, is an almost linear rising sweep of 30 Gee units duration followed by a quick fall and a quiescent period of a further 30 Gee units. The period of the rising sweep is coincident with that of the top trace on the main timebase display.

126. The first valve of the timer V9 (CV138) is normally cut off by the return of its cathode to a positive source controlled by the strobe switching; the grid is returned to the HT line through the anode circuit of V8, but the potential at the grid during the quiescent period is not more than about five volts. The screen, which is at a fixed proportion of the cathode voltage as determined by the potentiometer R38 and R40 connected between the cathode and the 45 volts bias line, is fed with 5-Gee unit (3 kc/s pulses) at an amplitude of about 100 volts from the integrating valve V4A in the circuit of the second divide-by-five stage.

127. The start of the linear sweep on the grid is initiated when, as part of the multivibrator action of the square wave generator, V8 is cut-off, and the anode capacitor C18 begins to charge up to the HT supply. When the grid voltage rises to the level of the cathode voltage, grid current starts to flow and limits the further rise in grid voltage. Anode current is still cut off because of the low level of screen voltage, but each 5-Gee unit pulse subsequent to the opening of the grid raises the screen voltage to produce a pulse of anode current.

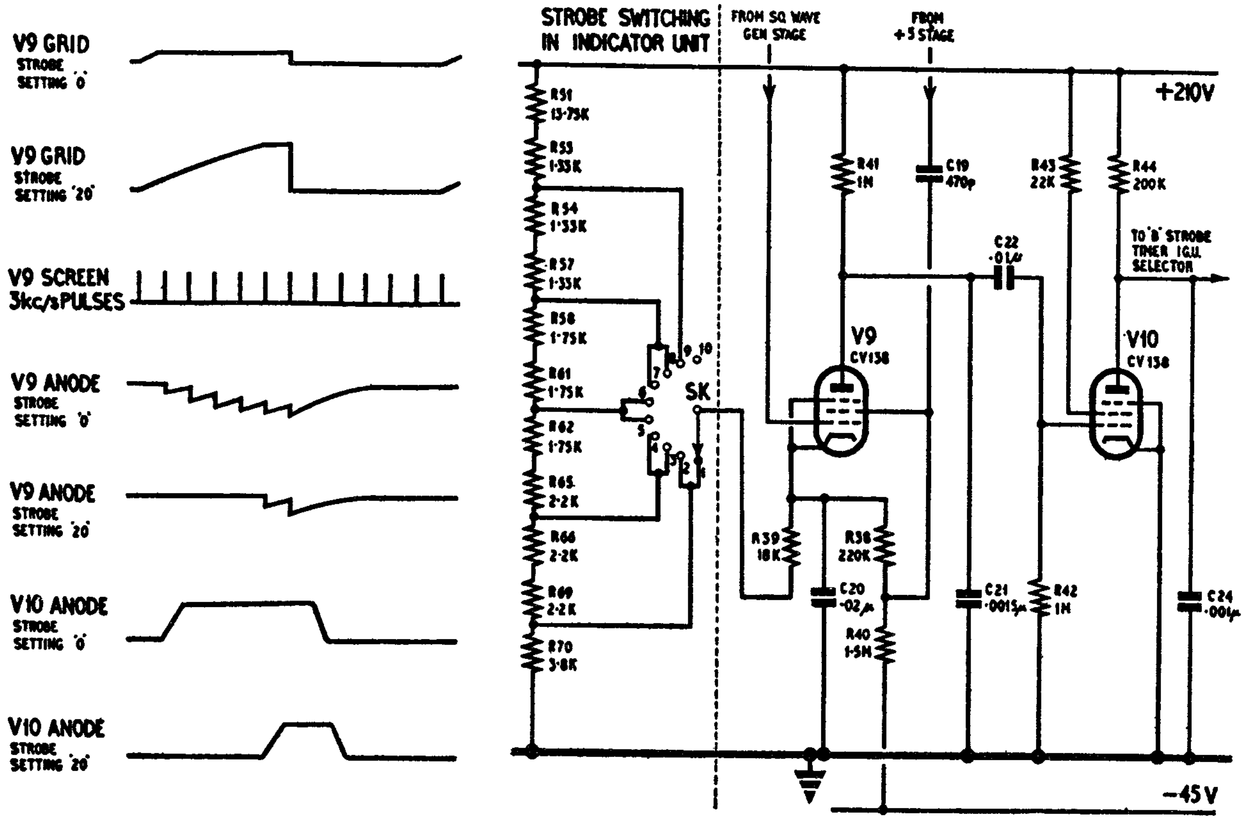

Fig. 15. B-strobe timer—5-Gee unit stage

128. The five positions of the strobe switch raise the level of the cathode at each step by approximately the order of increase in grid voltage taking place over one sixth of the period of the rising voltage applied to the grid, that is, the rise in grid voltage over each 5-Gee unit period. In consequence, at each increasing step a progressively later pulse applied to the screen is the first to cause a flow of anode current, and the five positions select the first, second, third, fourth, and fifth 5-Gee unit pulses respectively after the start of the sweep. As the sweep starts at the datum times, t_0, the output, at t_b^1, is a train of pulses delayed by 5, 10, 15, 20, or 25 Gee units.

129. The anode voltage of V9 is normally that of the HT line and the shunt capacitor C21 is therefore charged to this same level. With the first effective pulse at the screen a partial discharge of C21 takes place and the anode falls by about ten volts ; in the subsequent 5-Gee unit period in which anode current does not flow the anode voltage tends to rise slowly as C21 charges through R41 towards the HT level. Following pulses produce further falls in anode voltage succeeded by slow rises, so that a falling step waveform is produced. The first step cuts off the normally fully-conductive shaper valve V10 (CV138) the anode voltage of which tends to rise as C24 charges through R44. The time constant of the charging circuit is slightly greater than the time represented by 5 Gee units, so that in the 5-Gee unit interval after the valve cuts off the anode voltage tends to rise over the greater part of the relatively linear section of the exponential charging curve. The voltage across C24, which provides the grid input to the next stage, is therefore a rising sweep, except in so far as it is modified by the onset of grid current, of 5 Gee units duration ; the start of the sweep is delayed in steps of 5 Gee units on the datum time.

130. The next stage consists of V11 and V12, both pentodes CV138, in a similar type of circuit to that of V9 and V10 in the first stage. V11 is biased off by a controlled voltage in five steps on its cathode, and the screen is fed with positive pulses derived from the 1-Gee unit output of the integrator valve V26B in the first divide-by-five, 15 kc/s, stage of the divider.

131. According to the setting of the strobe switch, the time required before the rising grid voltage is limited by grid current increases in approximately 1-Gee unit steps, so that for each increasing step a progressively later pulse at the screen is the first to cause a flow of anode current. The five positions therefore select the first, second, third, fourth and fifth 1-Gee unit pulses respectively after the 5-Gee unit pulse from the first stage.

132. The first pulse appearing at the anode of V11 is consequently delayed on the datum time by 5, 10, 15, 20 or 25 Gee units due to the delay in the first stage plus 1, 2, 3, 4, or 5 Gee units

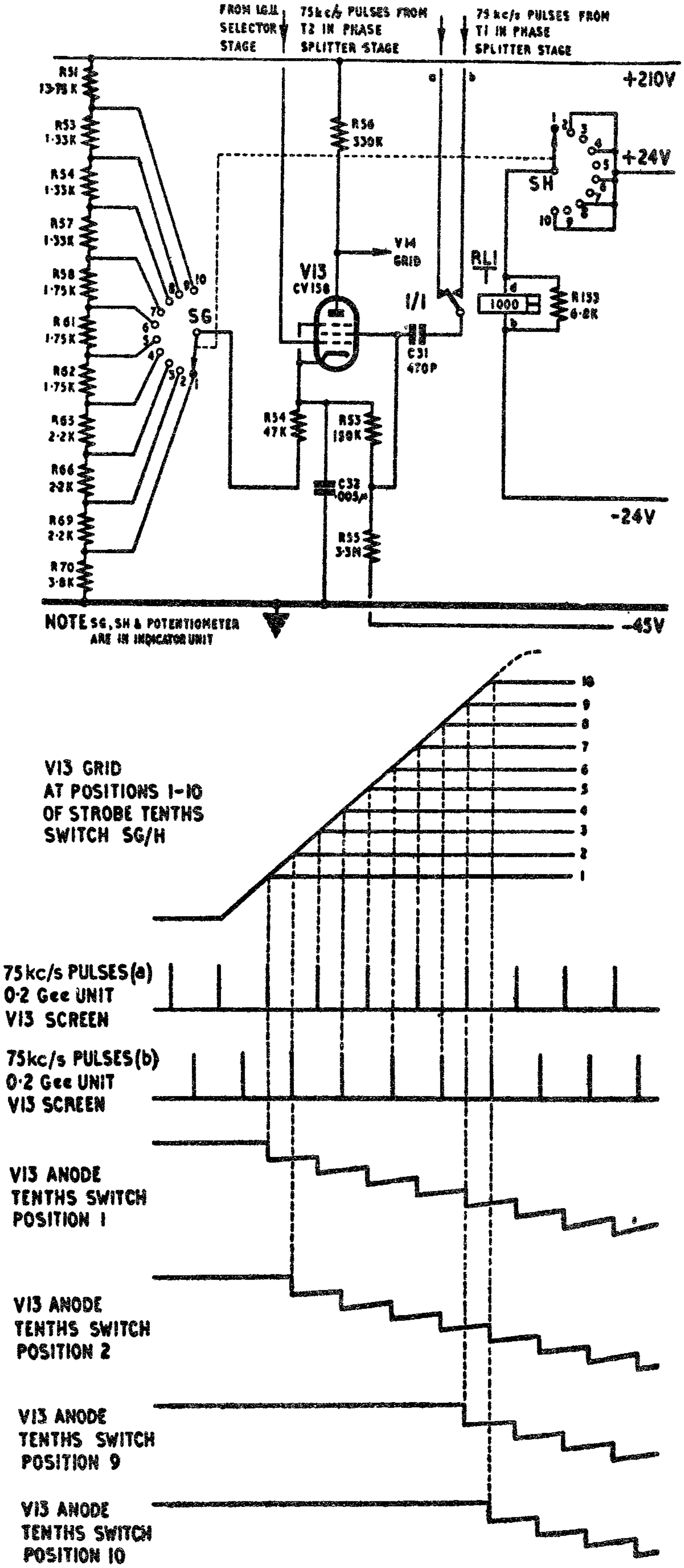

Fig. 16. B-strobe timer—0·1-Gee unit stage

due to V11. The total delay at this point, t_b^2, is therefore controllable in 1-Gee unit steps from a minimum of 5 plus 1, that is 6 Gee units, to a maximum of 25 plus 5, or 30 Gee units.

133. An integrator circuit in the anode of V11 shapes the pulses of anode voltage to appear as a negative-going step waveform, and the first step cuts off the shaper valve V12. The rise of anode voltage on this valve is controlled by the integrating circuit R52 and C30 to take place over an approximate period of 1 Gee unit, and this sweep becomes the input to the grid of the third stage.

134. The gating valve in the third stage (*fig.* 16) operates in a similar manner to the gating valves in the first two stages, but its cathode voltage is controlled in ten steps instead of five, and the input pulses to the screen are derived from two sources through a relay controlled switch. The strobe switching circuit for this stage automatically connects the two pulse trains alternately to the screen circuit as the cathode voltage is altered step by step. The two input pulses are taken from the outputs of the phase splitting stage which are 0·2 Gee unit (75 kc/s) pulse trains, differing only in that one is derived from the positive-going peaks of the 75 kc/s input sinusoid to the phase splitter, and the other is derived from the negative-going peaks. The two pulse trains considered together are therefore equivalent to a 150 kc/s pulse train, and the separation between adjacent pulses as between the two trains is 0·1 Gee units.

135. At each increasing step of the strobe switch a progressively later pulse is selected alternately from the two 0·2 Gee unit pulse trains to be the first to appear in the anode circuit, so that the delay introduced at each step is in multiples of 0·1 Gee units. The actual delay in this stage is therefore 0·2, 0·3, 0·4, 0·5, 0·6, 0·7, 0·8, 0·9, 1·0, or 1·1 Gee units, and the total delay, at t_b^1, becomes from a minimum of 6 plus 0·2 (6·2 Gee units) to 30 plus 1·1 (31·1 Gee units) in steps of 0·1 Gee uits.

136. The pulses at the anode of V13 are shaped in the anode circuit to appear as a negative step input to the grid of the shaper valve 1V14, which, as in the two previous stages produces a rising sweep at its anode

TABLE 1

Counting sequence

Required number	Number of fives	Total of fives	Number and total of ones	Reading of tens dial	Reading of units dial
1	0	0	1	0	1
2	0	0	2	0	2
3	0	0	3	0	3
4	0	0	4	0	4
5	0	0	5	0	5
6	1	5	1	0	6
7	1	5	2	0	7
8	1	5	3	0	8
9	1	5	4	0	9
10	1	5	5	1	0
11	2	10	1	1	1

over the approximate time between the adjacent steps. The value of the integrating capacitor across which the rising voltage develops is preset by the inclusion of C77 to provide adjustment for the actual rise of voltage over the 0·1 Gee unit period of the sweep.

137. The final stage uses a triode valve V15A, part of diode-triode V15 (CV137), and it is not controlled by timing pulses. The cathode voltage is controlled in ten steps by the strobe switching so that according to the setting of the switch, the input sweep has to rise to a different level before anode current begins to flow. The input sweep is regulated by the preset input capacitor so that the difference in time of rise required between each step is approximately one tenth of the time of the sweep ; that is, the stage interpolates in ten steps between the setting of the 0·1 Gee unit steps.

138. In the first position of the switch the final stage fires practically at the beginning of the input sweep, so that the delay applied in this valve is approximately 0·00, 0·01, 0·02, 0·03, 0·04, 0·05, 0·06, 0·07, 0·08, and 0·09 Gee units, and the total delay, at t_b, becomes from 6·20 Gee units to 31·19 Gee units in steps of 0·01 Gee units.

139. The sharp negative wave-front appearing at the anode of V15A forms the B-strobe timing pulse and is used to trigger the strobe generator to produce the B-strobe used in the display and the A-lock circuits. The timing, , of the wave-front can be adjusted to follow the datum time t_o after delays of from 6·20 Gee units to 31·19 Gee units plus minor circuit delays " d_1 ", including that due to the approximation in the final stage. Thus the delay of the B-strobe relative to the A-strobe is from $(6{\cdot}20+d_1)$ minus $(5{\cdot}2+d)$ Gee units to $(31{\cdot}19+d_1)$ minus $(5{\cdot}2+d)$ Gee units ; when " d " is made equal to " d_1 " by adjustment of the preset timing control RV3, the actual delays are controllable between the limits of 1·00 Gee units and 25·99 Gee units. The B-strobe therefore can appear at any time over the period during which the top trace appears on the main timebase display.

140. The particular advantage of the gating method of timing just described is that the delays set up in each stage are tied rigidly to the timing pulses, which in turn are timed to a high order of accuracy by their dependence upon the crystal oscillator. And, as the selection of particular timing pulses is a switch-controlled step process, the switch positions give direct indications of the delay involved. A counting mechanism is therefore used in which the switches for the different stages are coupled through the mechanism ; the delays set up on each switch can then be read directly as a series of numbers on the counter indicator dials.

Switching

141. The calibration of the indicator dials is related to the relative delay between the B-strobe and the A-strobe and not the absolute delay from the datum time. A separate spindle is used for the switches of each stage but the numbering of the tens and units dials, 5-Gee unit on the first stage and 1-Gee unit on the second stage switches, do not relate directly to the electrical steps involved in the switch actions because of the need for performing the electrical counting in steps of five. The tenths and hundredths dials, 0·1 Gee unit on the third stage and 0·01 Gee unit on the fourth stage switches, indicate directly the effective delays set up. The circuit of the switches is shown in fig. 30.

142. The complications in the first two stages are necessitated by the difficulties of counting in steps of one and five. These difficulties are demonstrated in Table 1 in which the counting sequence from one to eleven is shown. It should be noted that this table shows only the relative delays set up by the timer ; thus, although the count at the first position of the 5-Gee unit switch is given as zero, the absolute electrical count of the 5-Gee unit stage is 5 Gee units.

143. From the table it will be seen that counts from one to five are provided by a movement of the units switch only. At six, a count of five is provided by the tens switch and the units switch reverts to a count of one ; the tens dial reading does not alter from zero. For seven, eight, and nine, the units switch provides two, three, and four, to add to the static count of five on the tens switch. At ten, the units switch provides a count of five and the tens switch moves another step to produce a dial reading of one without a change in the counting. For a count of eleven the tens switch moves a further step to provide a count of ten but its dial remains at one ; the units switch reverts to its original sequence and produces a count and dial reading of one.

144. The spindle of the 0·1 Gee unit switch carries two leaves. The first of these performs the normal switching of the gating valve and the second controls the relay RL1 in the waveform generator. This relay is brought into circuit in alternate positions of the switch and changes over the 0·2 Gee unit feed to the screen of the gating valve alternately from the two supplies from the phase splitter.

145. The strobe switch is controlled from the spindle of the 0·01 Gee units switch, hundredths dial, the operation of which turns all the switches in the appropriate sequence. That is, at a setting of 09·99, one step of the hundredths control moves all the switches for the new reading of 10·00. A second control is also fitted to the spindle of the 1-Gee unit switch, units dial, to allow for coarse setting of the 1-Gee unit and 5-Gee unit switches only. Further details of the switching system are given in Chap. 4.

Counting system

146. The steps-of-five system used in the build-up of the strobe delay is necessitated by the use of RC integrating circuits to provide the coarse gating of the several stages. The tolerance in such circuits does not permit more than five separate steps to be selected on any pulse train without the possibility of passing the wrong pulse.

147. In the first two stages the problem is overcome by making up the total count in steps of one, up to a maximum of five, and further steps of five, as shown in Table 1. In the third stage two pulse trains are used, so that although the switching divides the RC sweep into ten parts, at any one step the maximum possible sweep of 1 Gee unit duration is gating a pulse train of 0·2-Gee unit separation, and therefore the counting ratio still does not exceed five.

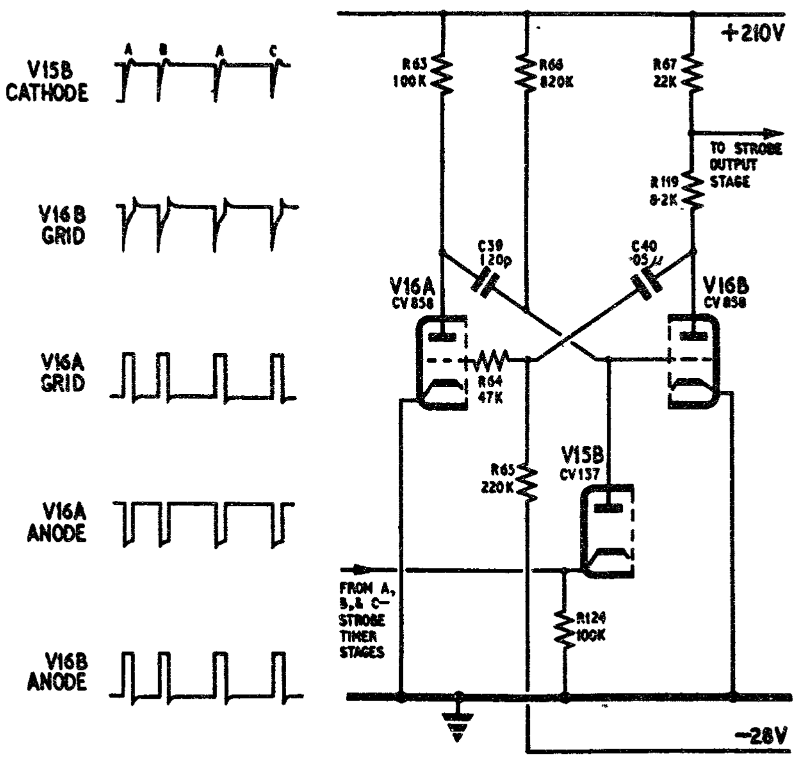

Fig. 17. Strobe generator

C-strobe timer

148. The C-strobe timer operates in exactly the same manner as the B-strobe timer, with V20 and V21 forming the first, 5-Gee unit selector stage V22 and V23 forming the second, 1-Gee unit selector stage, V24 and V25 forming the third, 0·1-Gee unit selector stage, and V26A forming the final, 0·01 Gee unit selector interpolating stage. The first five valves are all pentodes (CV138) and V26A is a triode forming part of the diode-triode V26 (CV137).

149. The timing of the C-strobe is, however, related to the period when the B-strobe is quiescent, that is, when the multivibrator action of the square-wave generator has V6 fully open and V19 cut off. As the period for which V19 cuts off is that in which the bottom trace on the main timebase display appears, the C-strobe can appear over the greater part of the bottom trace.

150. Taking the datum time t_0 as the beginning, of the positive-going sweep at the input to the first valve V20, the total delay set up in the C-strobe is therefore the same as the absolute delay set up in the B-strobe timer, that is, from 6·20 to 31·19 Gee units. The total delay from the absolute datum time is the above figures plus 30, or from 36·20 to 61·19 Gee units. The useful delay from t_a, the start of the top trace as indicated on the C-strobe dials, is the absolute delay minus the 5·2 Gee units delay of t_a, that is, from 31·00 Gee units to 55·99 Gee units.

Strobe generator

151. The pulses at the anodes of the A-, B-, and

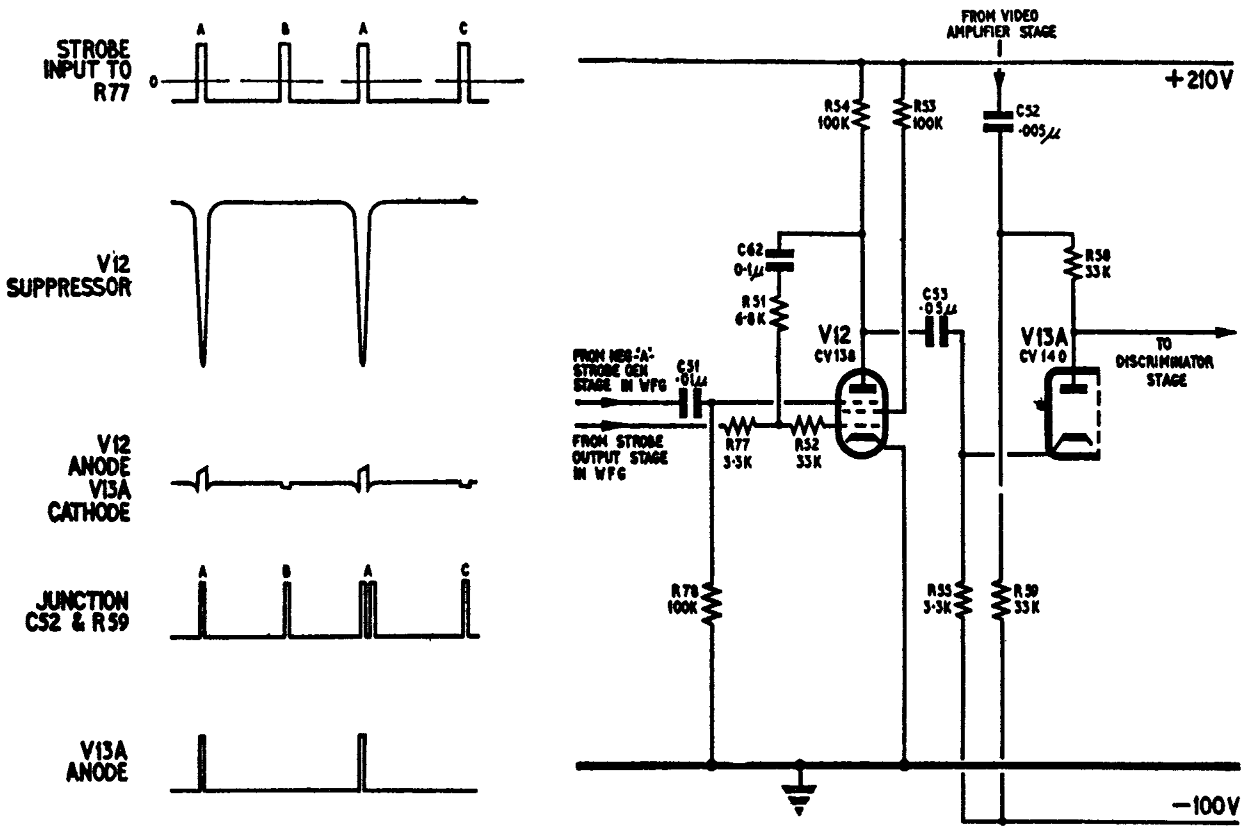

Fig. 18. A-pulse separator

C-strobe output valves V18, V15A and V26A, are parallel connected into the grid circuit of the strobe pulse generator V16, double-triode (CV858), operating as a flip-flop. The circuit and waveforms are shown in fig. 17.

152. The two triode sections of V16 are connected in a flip-flop circuit which is not free-running because of the bias on the grid of V16A due to the return of the grid resistor R65 to the negative bias supply. Under normal circumstances therefore, V16A is cut off and V16B is passing full current. The potential at the grid of V16B is at some slight positive value due to the flow of current through the potentiometer formed by R66, the diode V15B, part of diode-triode V15 (CV137), and R124, and also to the flow of grid current.

153. The negative leading edge of each input to V15B is differentiated in the coupling condenser and the common resistor R124, and appears at the diode cathode as a short negative pulse. Each pulse causes an increased conduction in the diode, and the potential at the diode anode, and therefore at the grid of V16B, falls. With the fall in grid potential the anode current in V16B also falls and the anode voltage rises ; this rise is coupled to the grid of V16A and conduction takes place. The fall in anode voltage at V16A is coupled to the grid of V16B which is thereby cut off.

154. The circuit conditions then remain steady for a period of 1·2 Gee units while the falling charge on C39 holds the grid of V16B beyond cut off. At the end of this time V16B conducts and its negative-going anode voltage drives V16A to cut off to re-establish the normal conditions.

155. Each timing pulse at the cathode of the diode therefore produces a positive-going square-topped pulse at the anode of V16B, of 1·2 Gee units duration. This pulse is coupled to the grid of V17, parallel-connected double-triode (CV858), which is connected as a cathode-follower output valve for the strobe pulses. The output at the cathode of this valve is a train of positive-going pulses, timed in each 60-Gee unit period as follows :—

(1) A-strobe—t_a—timing fixed at approximately the start of top trace.

(2) B-strobe—t_b—timing continuously adjustable by B-strobe controls.

(3) A-strobe—t^1_a—timing fixed at approxi mately the start of the lower trace.

(4) C-strobe—t_c—timing continuously ad justable by C-strobe controls.

156. The method of biasing the strobe outp valve whereby the cathode is returned to a poi in the potentiometer R131, R121 across the bi supply, and the grid returned to a second poi across the bias supply, provides the corr biasing conditions and maintains the DC le of the output at about minus 15 volts.

157. The strobe outputs are used for the f lowing purposes :—

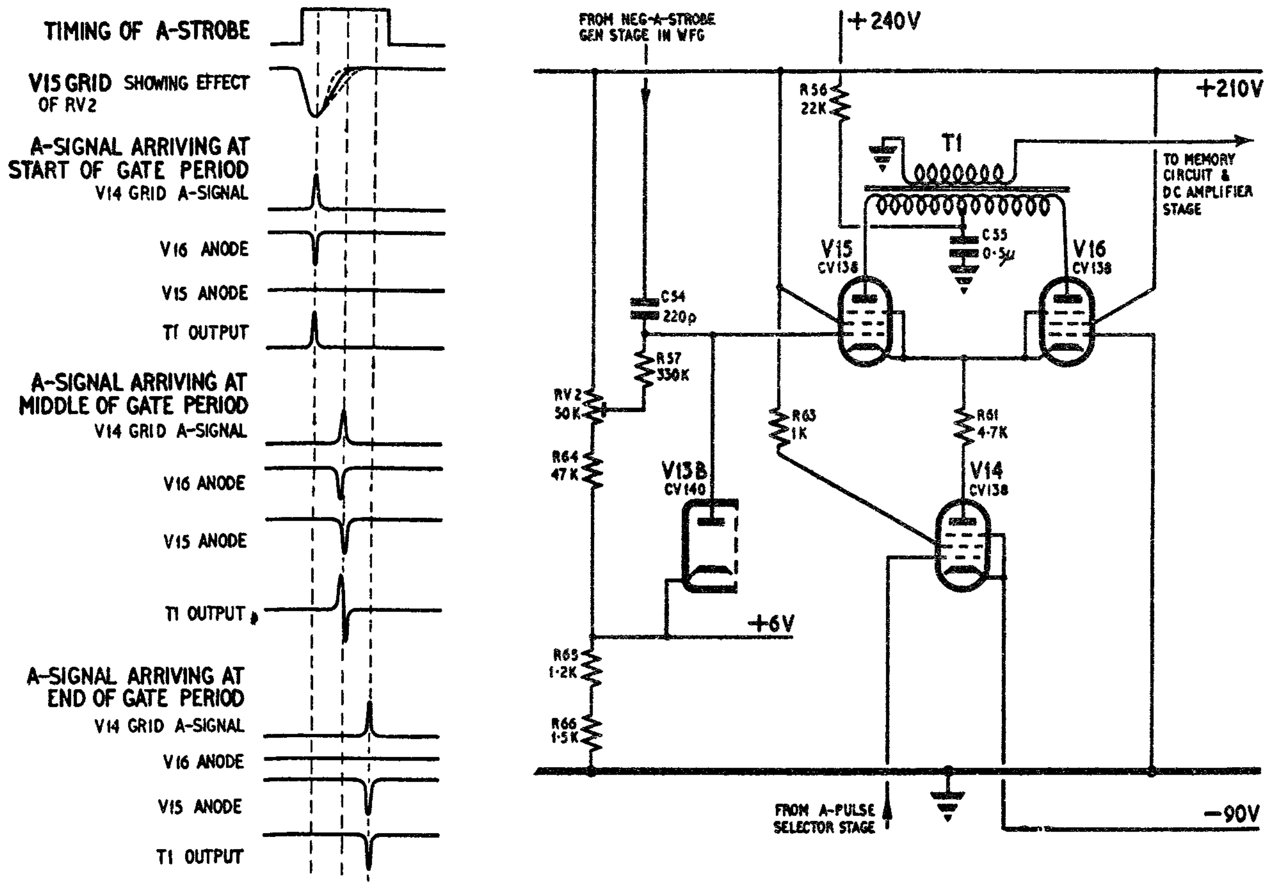

Fig. 19. A-lock discriminator

(1) To produce strobe wells and signal inversion in the signal reverser stage of the indicator

(2) To initiate the strobe timebase sweeps

(3) To separate the received A-pulses from other signals in the A-lock circuit.

A-LOCK CIRCUIT

A-pulse separation (*fig. 18*)

158. The strobe pulses from V17, together with the negative-A-strobe from V6B (both in the waveform generator), are applied to V12 (pentode, CV138) in the receiver, where, in a gating circuit, the A-strobe is separated from the B- and C-strobes. The strobe pulses are fed to the grid circuit, and the negative-A-strobe is applied to the suppressor ; the negative bias of about 15V on the strobe input is normally sufficient to hold the valve cut off. A high level of feedback is applied from the anode to the grid through C62 and R51, so that if the bias if lifted the valve operates as an anode-follower.

159. When a B- or C-strobe appears at the grid, the valve acts as a phase inverter with low amplification due to the high feedback, and the B- and C-strobes appear as negative-going pulses of small amplitude in the anode circuit. When the A-strobe appears at the grid, the negative-A-pulse is also appearing at the suppressor, and, although the bias on the grid is raised, the pulse at the suppressor cuts off the anode and no current flows. There is thus no amplification and the feedback components R51 and C62 become a series circuit to feed the A-pulses to the anode circuit, where they appear without change of sense, that is, as positive-going pulses. The signal at the anode of V12 therefore consists of low-amplitude negative-going B- and C-strobes and positive-going A-strobes.

160. This signal is applied to the cathode of the diode V13A, part of double-diode V13 (CV140), which serves as a further gating stage. The anode of this diode is fed, through R58, with the positive-going receiver signals from the video amplifier, and is also connected to the grid of V14 ; the return of the diode anode and cathode circuits to the bias supply line is for the purpose of applying bias to the grid of V14 only, and not to the diode which is unbiased but normally conducting.

Note . . .

A slight negative voltage must be applied to the anode of a diode for zero conduction ; with zero applied voltage, current flows and the anode takes up a small positive potential.

161. In the absence of pulses from V12 the signals appearing at the anode of the diode cause increased conduction and, because of the drop in R58, the signal voltage at the anode is attenuated and is insufficient to lift the bias on V14. In the presence of the negative-going B- and C-strobes on the cathode, the diode conduction is increased further so that signals appearing at the anode at the same time are further reduced in amplitude. When the positive-going A-strobes appear at the cathode however, the diode is cut off, and because the amplitude of the cut-off voltage is greater than that of the signals, any signal pulse appearing on the anode at the same time does not cause conduction of the diode and no drop takes place in R58. The signals appearing at the diode anode therefore, are of normal amplitude in the presence of A-strobes, but otherwise are of very low amplitude.

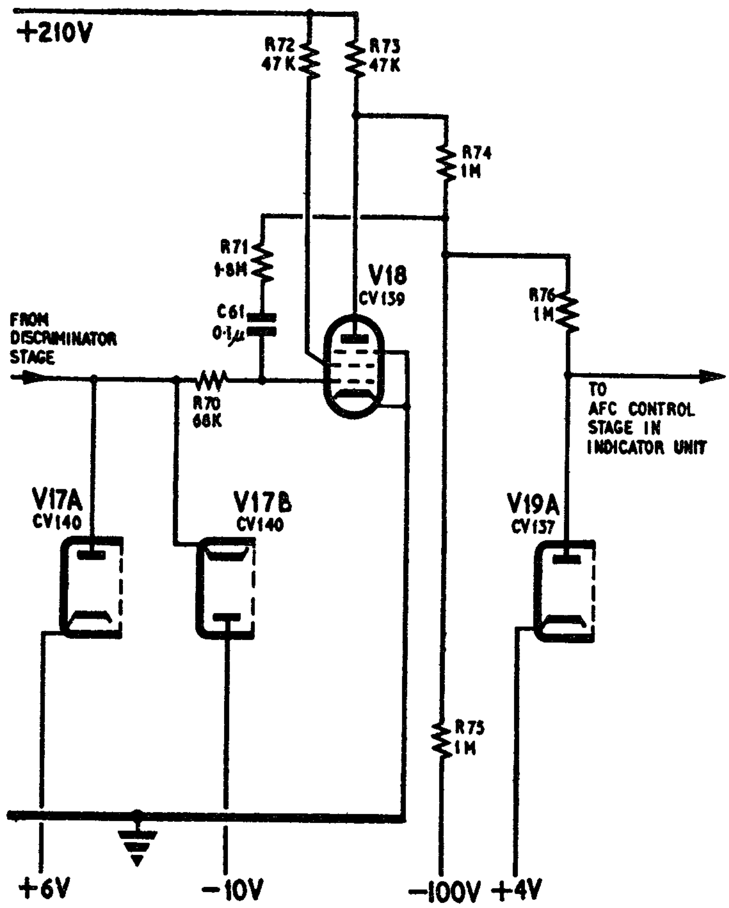

Fig. 20. A-lock rectifier and DC amplifier

Discriminator *(fig. 19)*

162. The discriminator circuit consists of the pentode V14 (CV138) connected in series with the two valves V15, V16 ; the anodes of V15 and V16 are push-pull connected to the transformer T1. V14 is biased to beyond cut-off by the return of its grid and cathode to the bias supply, so that no current flows in V15 and V16. The grid of V16 is returned to ground and the grid of V15 receives a negative-A input, through a differentiating circuit C54 and R57. The differentiating circuit shortens the pulse to about 40 microseconds at its base, and the preset control RV2 allows the actual width to be adjusted within narrow limits. The diode V13B, part of double-diode V13 (CV140), is biased positively from RV2 and prevents the trailing edge of the differentiated pulse from going positive.

163. The two discriminator valves can operate therefore only during the period when V14 is conductive, that is for the period of any A-pulse which appears during the 1·2 Gee unit period (80 microseconds) of the A-strobe ; and because of the 40-microsecond negative pulse on its grid, V15 is cut off for the first half of the strobe period and can only conduct in the second half. Three conditions of operation are therefore possible depending upon the time, relative to the A-strobe, at which the A-signal is received.

164. If the signal is received in the first half of the A-strobe it lifts the bias on V14 and, V15 being cut off, current flows for the 3-microsecond period of the pulse through V16. The resultant signal in the secondary of the transformer in this condition is a positive 3-microsecond pulse.

165. If the signal is received in the second half of the A-strobe it lifts the bias on V14, and current tends to flow through both V15 and V16. As V15 is positively biased through RV2, and because the bias on V16 is the voltage across V14 and R61, the initial flow of current through V14 raises the cathode voltage of V16 beyond cut-off. Thus only V15 conducts and the resultant signal in the secondary of the transformer is therefore a negative 3-microsecond pulse.

166. If the signal is received at about the middle of the A-strobe, for the first microsecond or so of the signal the first condition obtains and V16 conducts. As the negative pulse on the grid of V15 dies away, that valve also starts to conduct and in so doing cuts off V16. The second condition then obtains. The resultant signal in the secondary is therefore a narrow positive pulse followed immediately by a narrow negative pulse, the total width being about 3 microseconds.

167. The output voltage of the transformer is thus either positive, negative, or a mixture of both, depending upon the time of appearance of the received A-signals relative to the A-strobe. The desirable condition indicating that the A-strobe and signal are synchronous, and therefore that the timebase and signals are synchronous, is when the signal is exactly central and steady in the centre of the strobe and an equally balanced positive-negative output appears.

168. The adjustment of the width of the cut-off pulse on V15 allows the time at which V15 opens

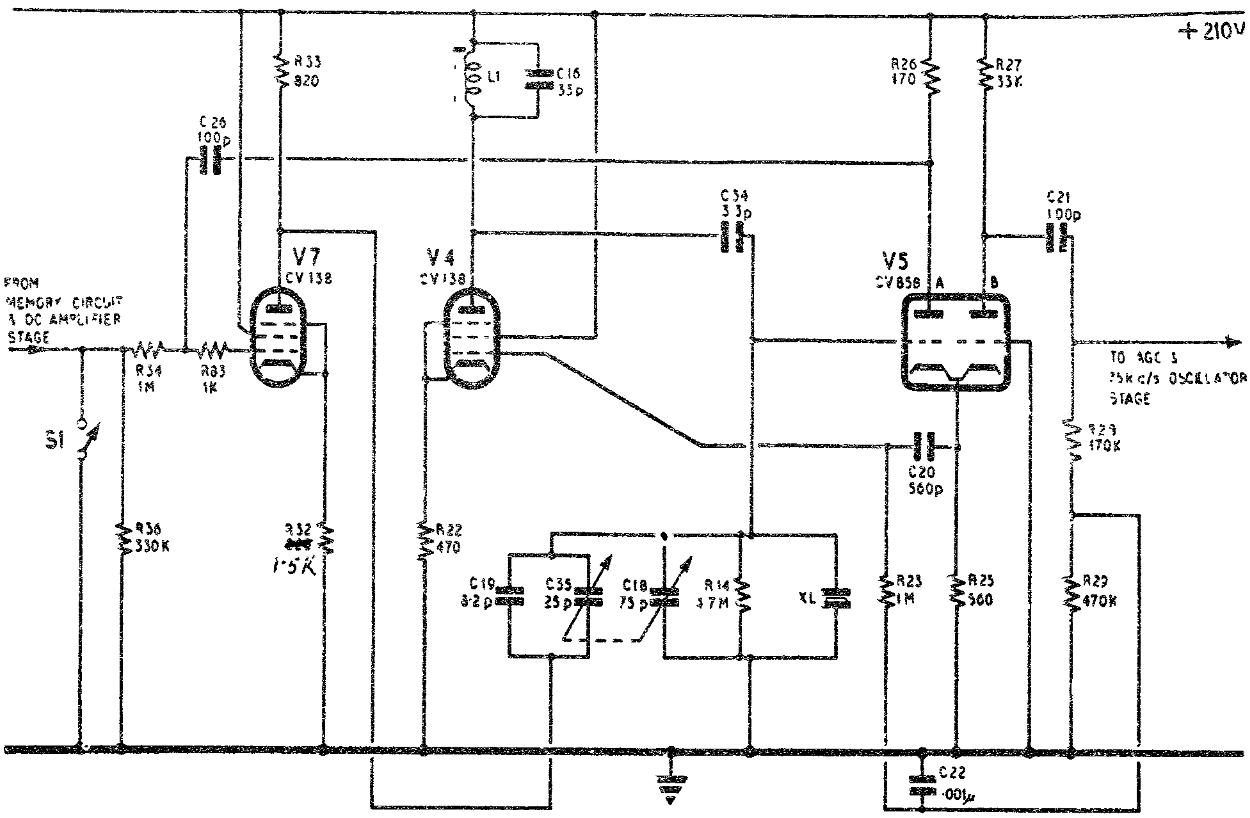

Fig. 21. AFC circuit

AL28

to be set at about the centre of the A-strobe. In the event of a high level of noise appearing with the A-signal the adjustment also allows the circuit to be set to a condition where the noise balances out and so prevents the presence of the noise from affecting the control exercised on the later circuits.

DC amplifier *(fig. 20)*

169. The output pulses from the discriminator have a peak amplitude of about plus or minus 20 volts when a single pulse is produced, and a peak of about 15 volts on a double pulse. These pulses are fed through C59 to a rectifier circuit consisting of diodes V17A and B, double-diode V17 (CV140), connected in opposition. Diode A is biased to 6 volts positive so that the anode voltage has to rise above 6 volts before the diode conducts, and diode B is biased to about 10 volts negative so that the cathode voltage must rise to about 10 volts before it conducts.

170. The load for the two diodes, that is the DC return path from anode to cathode, is formed by the insulation resistance of the associated circuit, mainly C59 and C61; the load resistance is therefore very high. The grid input capacitance of the DC amplifier V18 (CV138) is an effective shunt across this load, and because of the feedback circuit from the anode to the grid, this capacitance is very high. The diode load is therefore a parallel RC circuit of long time constant.

171. Conduction of either diode develops a DC voltage across the load ; when diode A conducts the voltage is negative, when diode B conducts the voltage is positive ; when both diodes conduct the signal is either positive or negative with a value depending upon the relative amplitudes of the input peaks, and when these peaks are such that the currents in the diode are equal, the voltages in the load are balanced and the DC output is zero.

172. The smoothing provided by the long time constant grid circuit of V18 ensures that the control voltage produced from the diodes does not disappear should the signal momentarily fade out, nor does it rise disproportionately should a wide interfering pulse appear over the required signal. It provides therefore a " memory " of the normal working conditions and prevents loss of control under non-recurrent abnormal circumstances.

173. The DC voltage at the grid is amplified and reversed in V18, and appears as a rise or fall in the DC level at the anode dependent upon the input conditions to the discriminator. The output from V18 is taken from a potentiometer R74, R75 connected from the anode to the negative bias line. The actual output potential therefore is a rise or fall on the normally about-zero potential at the junction of the resistors. This potential provides the control voltage for correcting the frequency of the crystal oscillator via the AFC circuit.

Automatic frequency control *(fig. 21)*

174. The output of the DC amplifier is coupled to the grid circuit of the AFC control valve V7 (CV138) via a limiting circuit using the diode

V19A, part of diode-triode V19 (CV137) ; the triode section of this valve is not used. The diode is biased to about plus four volts and it acts to limit the positive excursions of control voltage to about this value.

175. V7 is also supplied with a 150 kc/s sinusoidal input to the grid from the anode of V5A in the crystal oscillator circuit. The gain of V7 is controlled by the DC input from the A-lock circuit so that the amplitude of 150 kc/s signal in the anode circuit is proportional to the bias. The limits of control provided on the grid are from a cut-off bias of about minus eight volts to a peak positive bias of about three volts, and the amplitude of the anode signal varies from zero at cut-off to a level approximately equal to the signal voltage across the crystal at zero bias, and to about double the voltage across the crystal at plus three volts bias. The phase of the anode signal is that of the crystal voltage because of the double reversal taking place, first in V5A and then in V7.

176. The output from the anode is fed to the crystal via C35 and C19 in parallel. Thus when the output of the control valve is zero, the two capacitors, in series with the anode load R33 of V7, act as a shunt capacitance across the crystal and the oscillator frequency is decreased. When the output of the control valve is equal to the voltage across the crystal, and because the phases are the same, the anode circuit of V7 looks like an infinitely high impedance to the crystal and the frequency is unaltered. When the output of the control valve is double that across the crystal the anode circuit appears as a negative capacitance, that is, the effective circuit capacitance is reduced and the frequency is increased.

177. Variation in the control bias over the complete range therefore allows the frequency of the crystal oscillator to be varied. Because the outputs of the divider chain are tied rigidly to this oscillator frequency, the A-lock circuit in the receiver provides automatic control to keep the timebase frequency, which is the same as that of the A-strobe, in line with the A-signals.

178. The coupling capacitor from V7 to the crystal circuit is made variable by the inclusion of C35 which is ganged with the main crystal oscillator tuner C18. By this means the coupling of the control signal from the anode of V7 to the crystal is maintained constant whatever the position of the tuning control. A shorting switch S1 is connected across the grid input to V7 to cut out the control bias when manual control of the oscillator frequency is required. Under these conditions, the bias on V7 provided by the cathode resistor R32 is such as to hold the gain at a level whereby a small negative capacitance is fed back to the crystal. This helps to overcome the effects of stray capacitance and enables a greater swing of frequency to be obtained by rotation of the tuning control.

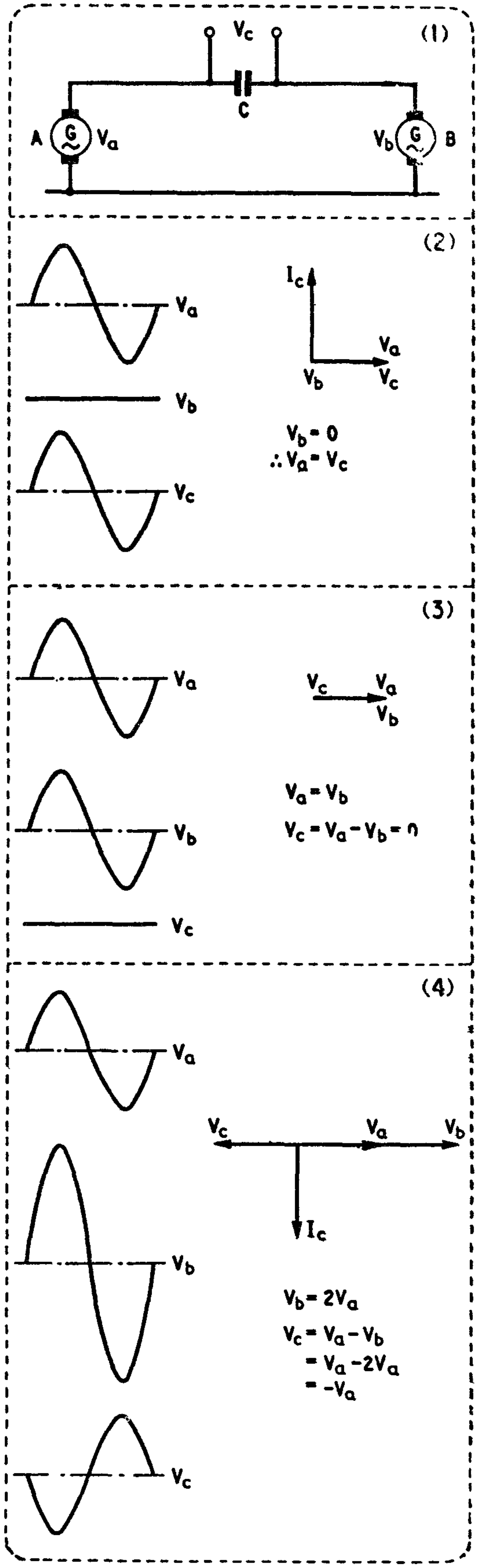

Fig. 22. Principle of frequency control

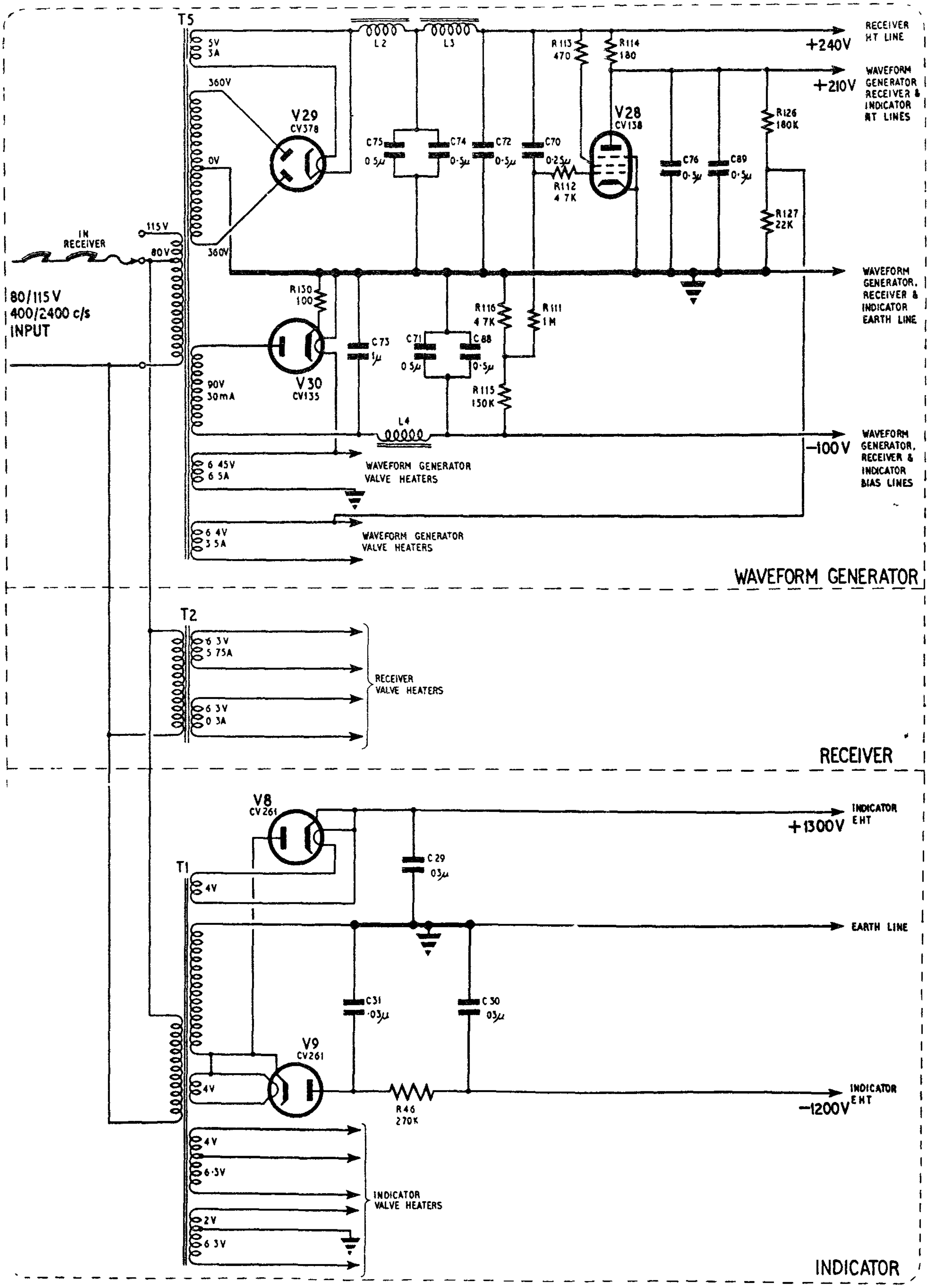

Fig. 23. Power supplies

Theory of control circuit

179. The principle of frequency correction used in the oscillator circuit is demonstrated in fig. 22. The crystal oscillator and the control source V7 are shown in (1) as the two generators A and B respectively, and the coupling capacitor as C.

180. In (2) the condition of normal output from A and zero output from B is shown. The voltage Vc across C must therefore be the same as that generated by A, Va. The current Ic in C must lead Vc by 90 deg. so that a leading current must be provided by A. The circuit external to is therefore a capacitive shunt on A.

181. In (3), the condition of equal output from A and B, the voltage across C is the difference between V_a and V_b, and is therefore zero. If there is no voltage across C there can be no current flowing through it, therefore there is no load on A due to the external circuit.

182. In (4), the condition where the output of B is twice that of A, then the difference between V_a and B_b is numerically equal to V_a. But as in the first instance V_c was taken as positive when V_a was greater than V_b, in this instance, with the conditions reversed, V_c must be taken as negative. Therefore V_c is in phase opposition to V_a and V_b; as the current I_c must still lead V_c by 90 degrees, this current now lags on V_a by 90 degrees. The external circuit therefore has the effect of either a negative capacitance, or what is the same thing, a shunt inductance, on the generator A.

Overall operation of A-lock circuit

183. If a signal is received and the oscillator frequency is adjusted manually for the A-signals to appear, first at the beginnings of the main timebase traces, and second more or less stationary at the centre of the strobe traces, then, if the A-lock circuit is brought into operation, the oscillator frequency is automatically corrected to ensure that the timebase frequency remains the same as that of the A-pulses. Thus the tendency for the oscillator frequency, and therefore the timebase frequency, to change with variations in temperature and pressure is avoided, and constant adjustments are not required to ensure that the signals do not drift across the traces.

184. The overall operation of the circuits is as follows:— A small change in oscillator frequency, due for example to a change in temperature of the crystal as the equipment warms up, causes a small change in the frequency of the A-strobe and the timebase; there is thus a tendency for the received signals to drift along the timebase traces. The change in A-strobe frequency however causes the A-signal to appear off-centre in the discriminator gate and the discriminator output changes. This change is applied to correct the crystal oscillator frequency and re-establish the conditions of synchronism.

POWER SUPPLIES

AC supplies *(fig. 23)*

185. An AC input of 80 or 115 volts 400 to 2,400 c/s is required at approximately 200 watts. The input is applied to the waveform generator mains transformer through the junction box Type 360A. The input circuit includes two thermostats, one in the waveform generator and one in the receiver, which open if the ambient temperature rises above about 55 deg. Celcius; the limiting temperature in the receiver is about 77 deg. and in the waveform generator about 83 deg.

186. The primary winding of the mains transformer in the waveform generator is rated for 115 volts input with an auto-transformer tapping at 80 volts for supplying the mains transformers in the receiver and the indicator.

HT

187. The HT supplies for the whole equipment are supplied from the HT rectifier V29, double-diode (CV378) in the waveform generator. This valve is connected in a bi-phase half-wave circuit, and the positive output taken from the cathode is smoothed by a two stage choke-input filter. The smoothed output of this circuit at 240 volts is used in the receiver only. The main HT output at 210 volts is derived from an anti-jitter circuit using V28 (CV138).

188. The anti-jitter valve is connected across the main HT line in series with a dropping resistor, R114; the grid of the valve is taken to a bias source at the junction of a potentiometer (R115, R116) across the 100V bias supply; ripple and jitter on the HT line is coupled to the grid through the capacitor C70. At an early stage in the development of the waveform generator a modification introduced a preset potentiometer (RV4) into the bias circuit to enable the operation of the valve to be adjusted, but this was later found unnecessary and removed by a further modification action.

189. In operation, transient changes in the mains supply produce jitter on the main HT line, and the jitter voltages, together with any hum that might still exist after smoothing, are applied to the grid to alter the conduction of the valve. If the change on the grid is positive-going (that is the HT voltage is rising) conduction of the valve increases and an increased drop results in R114; similarly, if the HT voltage is falling the grid is negative-going and the decreasing conduction of the valve causes a decreased drop across R114. The circuit constants are arranged to be such that the change in potential across R114 is equal to the rise or fall in potential that would otherwise have resulted, and the potential at the anode tends to remain constant. A stabilized source is thus available for supplying the more critical circuits of the equipment.

Bias

190. A separate winding on the waveform generator mains transformer supplies a rectifier V30 (CV135) to produce the bias supply. This valve is connected in a half-wave circuit with its cathode earthed; the smoothing circuit is a capacity-input filter.

EHT

191. The EHT supplies for operating the cathode-ray tube in the indicator are provided by

V8 and V9 (CV261) in a voltage doubling circuit. The two rectifiers are connected to the live end of the EHT winding of the indicator mains transformer and a negative output is produced at the anode of V9 and a positive output at the cathode of V8. The negative output is smoothed in an RC circuit and supplies the normal EHT to the first three anodes of the cathode-ray tube at a level of about 1,200 volts. The positive output, which is in series with the normal EHT, supplies the post-deflection accelerator electrode at a potential of about 1,300 volts.

LT

192. Most valves in the waveform generator are supplied with LT from a single winding on the mains transformer. The exceptions are the HT rectifier, which has its own winding, and the gating valves in the B- and C-strobe timers. The gating valves, V9, V11, V13, V15, V20, V22, V24 and V26 are supplied from a separate winding in which one side is raised to an HT potential from a potentiometer across the 210 volts line ; this is necessitated by the use of high positive voltages on the cathodes of these valves.

193. LT on all but one valve in the receiver is supplied from a single winding on the mains transformer. The exception is V14 in the synchronizing unit ; this valve is supplied with a separate unearthed supply because its cathode is returned to a source of high negative voltage in the bias line.

194. The indicator LT supplies are drawn from several windings on the indicator mains transformer. The valves in the EHT circuits are supplied from unearthed windings. The main winding supplying the rest of the unit is tapped to earth ; one section at 6·3 volts supplies the valves, and the other section at 2 volts supplies the strobe indicator dial lamps.

DC supplies

195. A DC supply of 24 volts 20 watts is required. It is used to operate the blower motors and relays in the waveform generator and receiver, and the RF selector motor in the receiver.

196. Damping resistors are shunted across the relay windings to reduce surges which occur when switching actions take place. Without such damping, transients in the DC supply lines are capable of radiating into the timer circuits and produce spurious operation of the strobes.

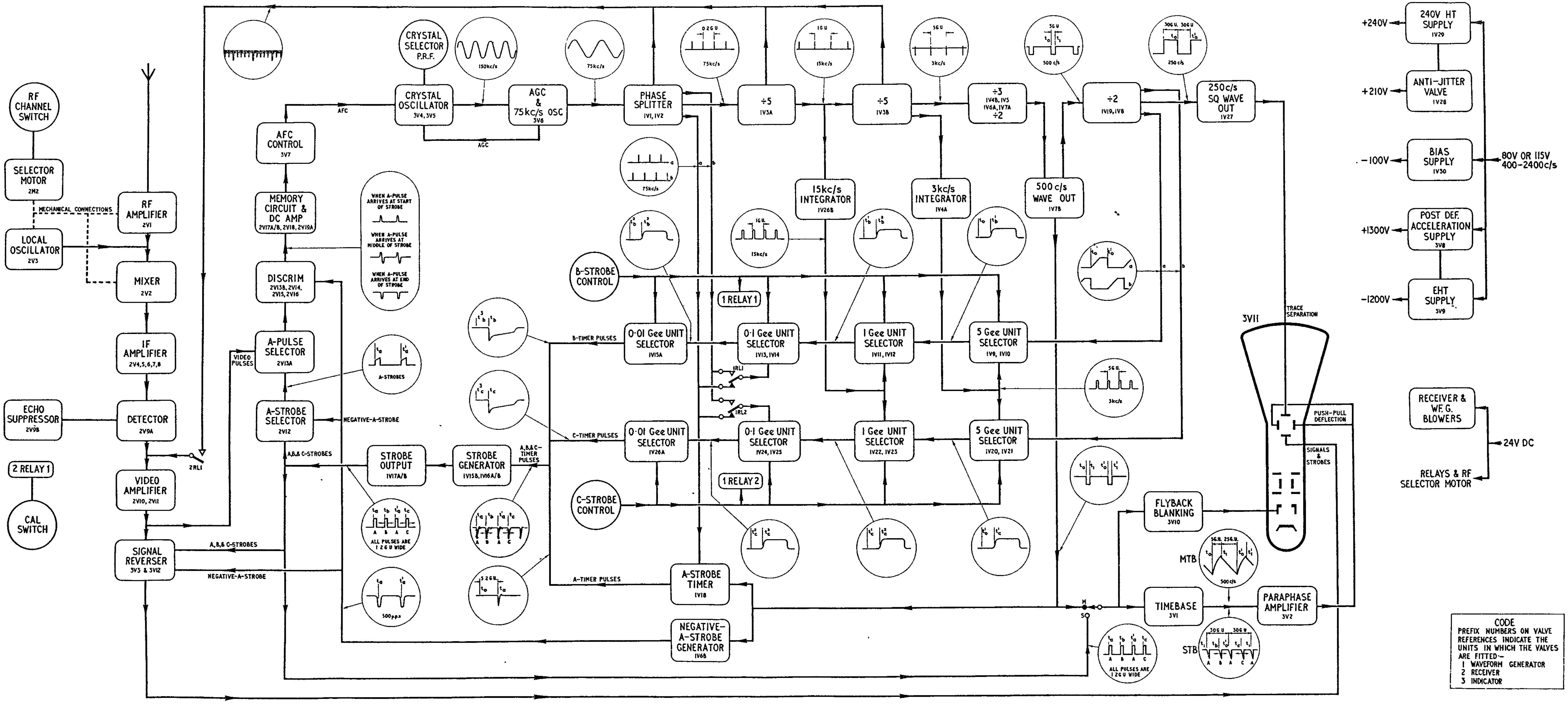

Fig. 24 Stage-by-Stage block diagram Fig. 24

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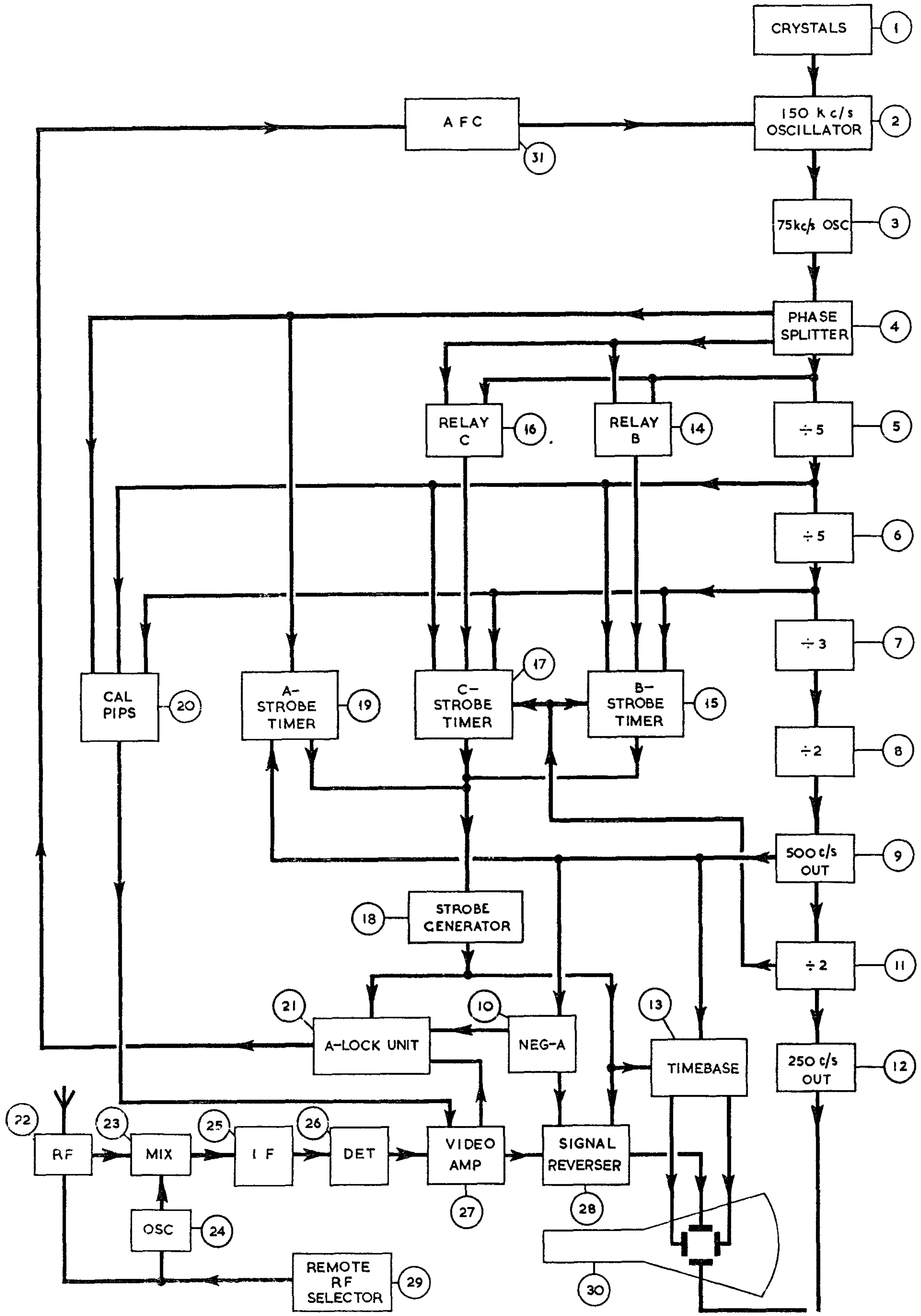

Fig. 25 Simplified block diagram

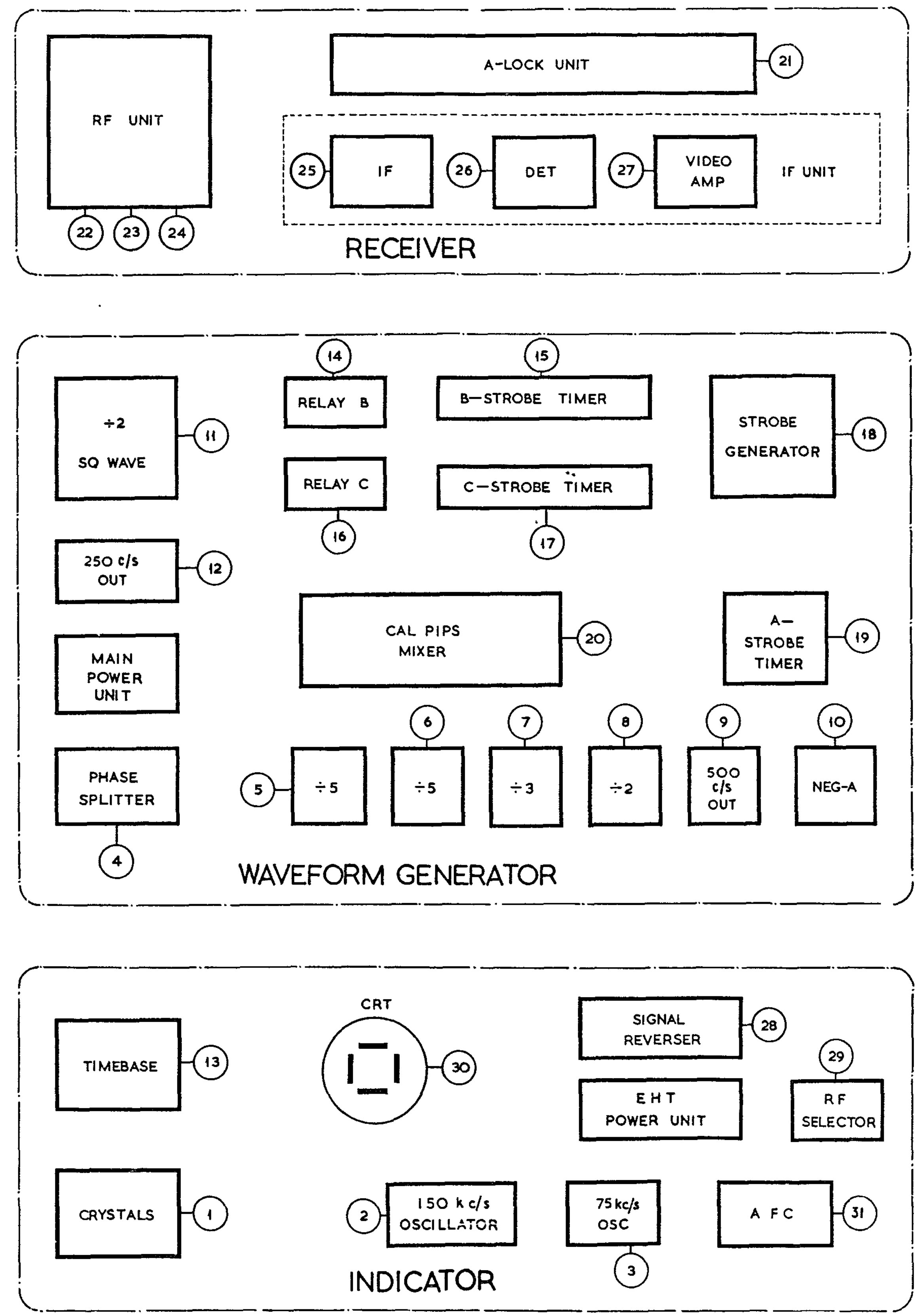

Fig. 26 Location of circuit elements in units

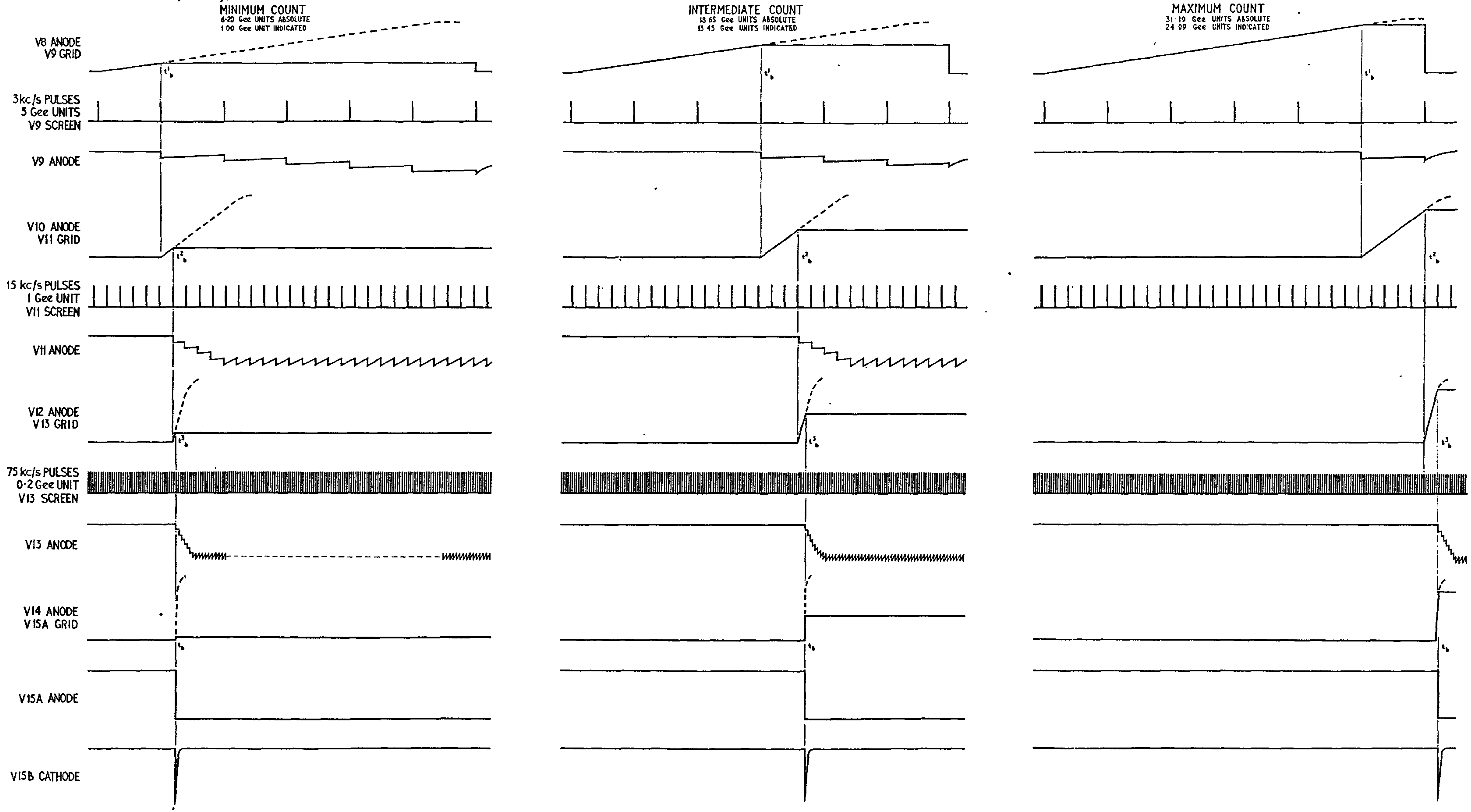

Fig. 27 B-Strobe timer waveforms Fig. 27

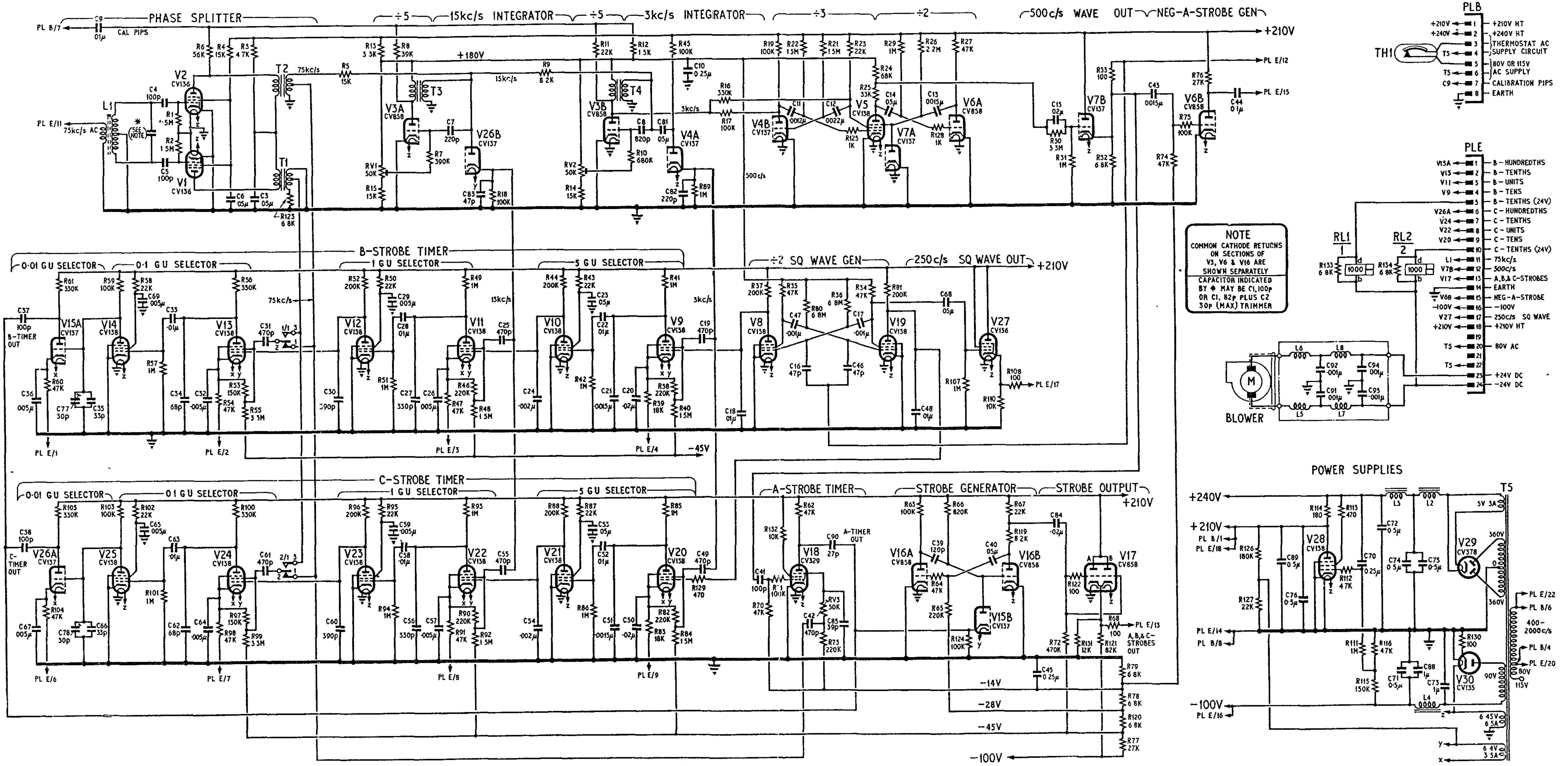

Fig.28 Waveform generator Type 72-circuit Fig.28

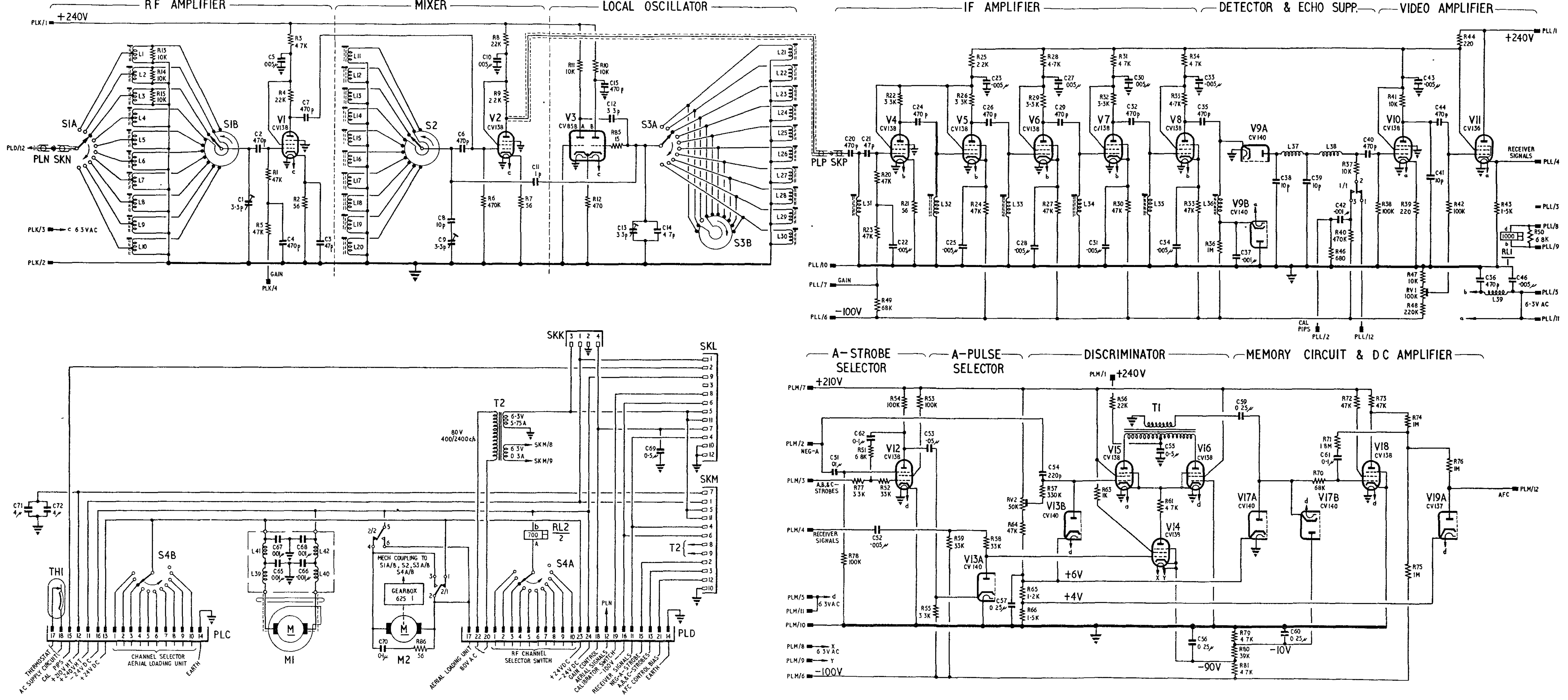

Fig. 29 Receiver Type R.3673 – circuit Fig. 29

STROBE SWITCH POSITIONS RELATIVE TO DIAL READINGS

SWITCH POSITION	TENS	UNITS	TENTHS	HUNDREDTHS
B—DIAL				
1	0	1	0	0
2	0	2	1	1
3	0	3	2	2
4	1	4	3	3
5	1	5	4	4
6	1	6	5	5
7	1	7	6	6
8	2	8	7	7
9	2	9	8	8
10		0	9	9
C—DIAL				
1	3	1	0	0
2	3	2	1	1
3	3	3	2	2
4	4	4	3	3
5	4	5	4	4
6	4	6	5	5
7	4	7	6	6
8	5	8	7	7
9	5	9	8	8
10		0	9	9

1 SWITCH CONTACT NUMBERS SHOW SWITCH POSITIONS, NOT DIAL READINGS
2 ALL SWITCHES ARE SHOWN IN THE POSITION FOR MINIMUM DIAL READINGS
3 OPERATION OF CONTROLS THROUGH STRIKING POSITIONS (SHOWN BY EXTERNAL ARROWS) CAUSES MOVEMENT OF PRECEEDING SWITCH THROUGH ONE STEP

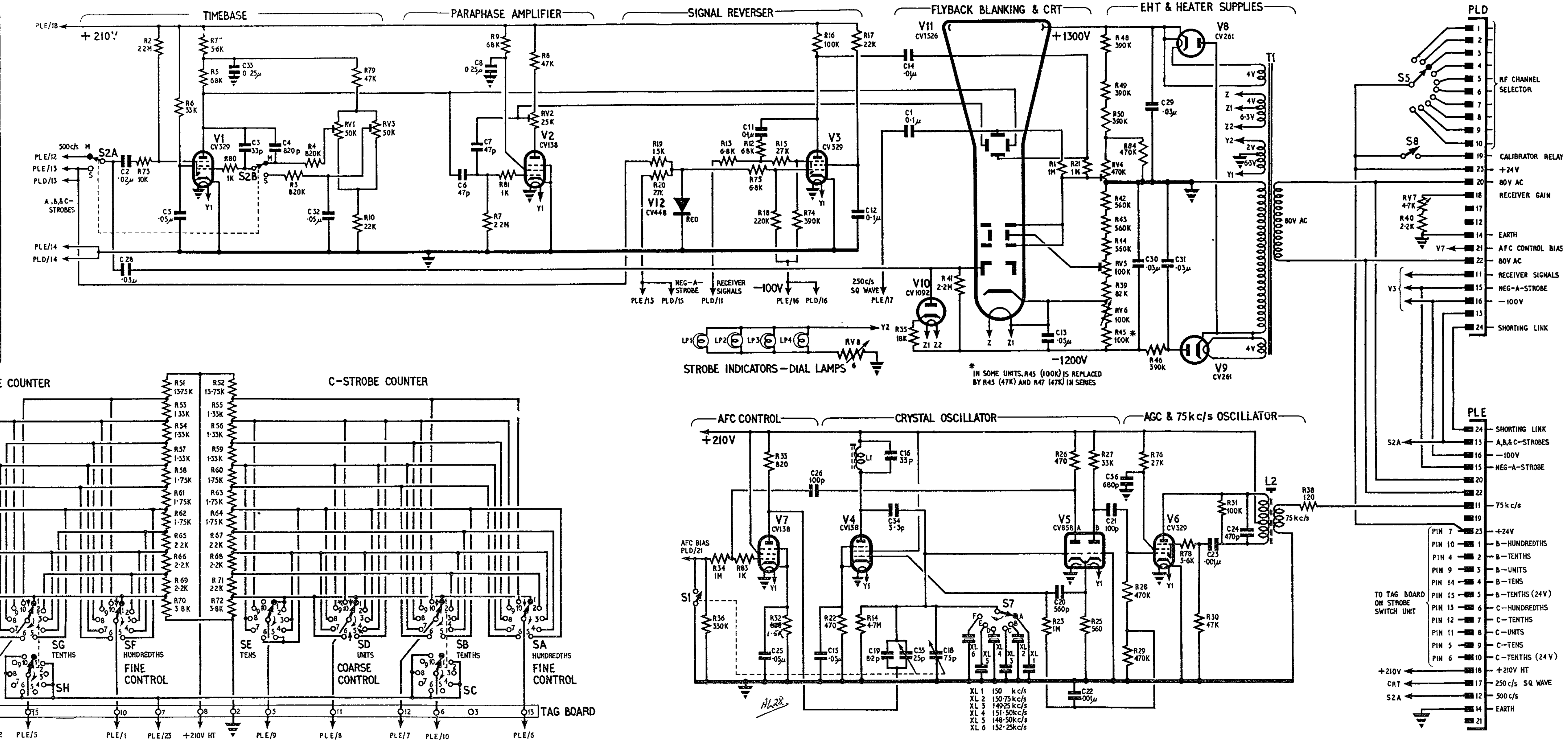

Fig.30 Indicator CRT Type 26—circuit Fig.30

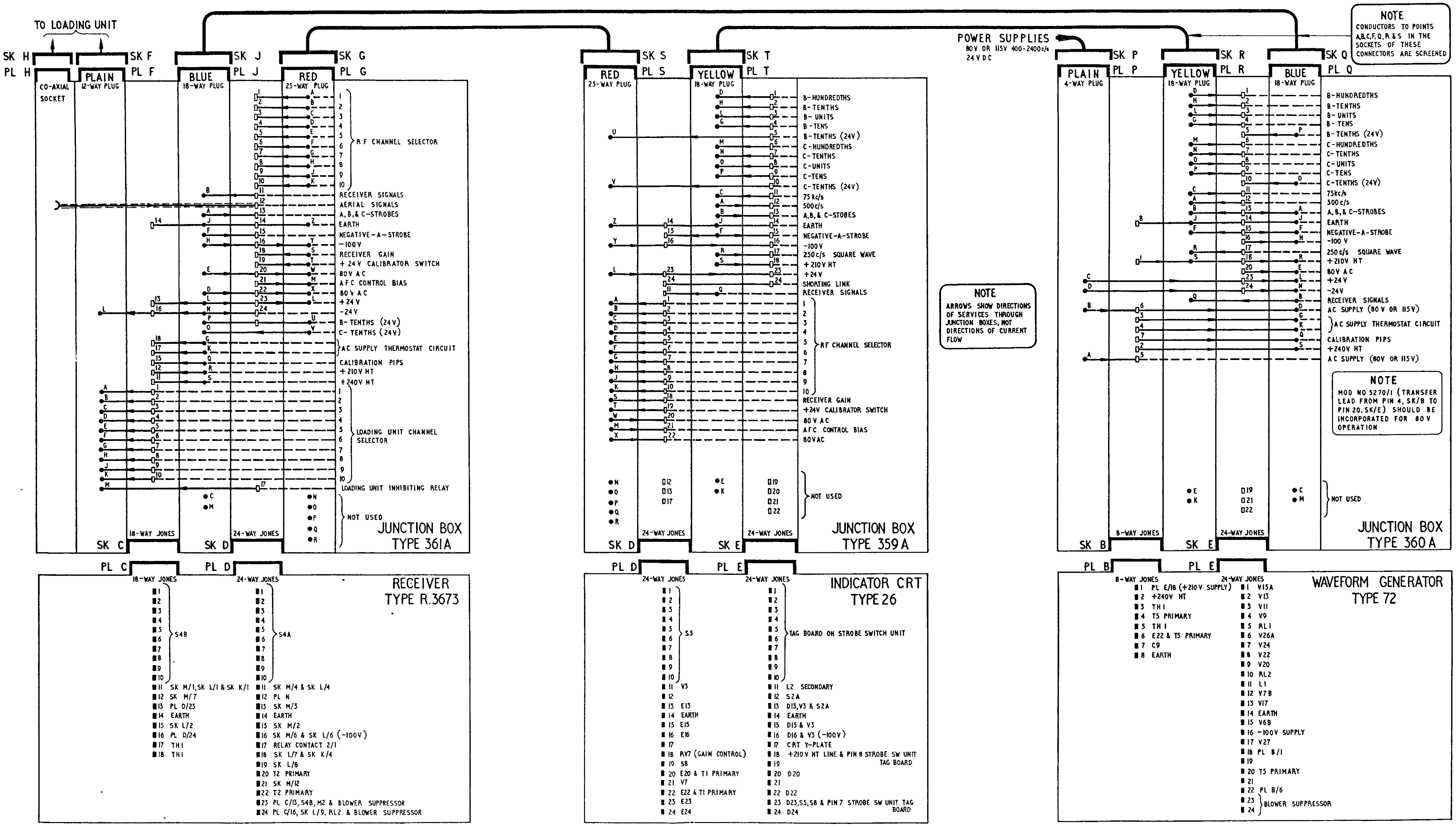

Fig. 31 Interconnections of units Fig. 31

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Chapter 4

CONSTRUCTIONAL DETAILS

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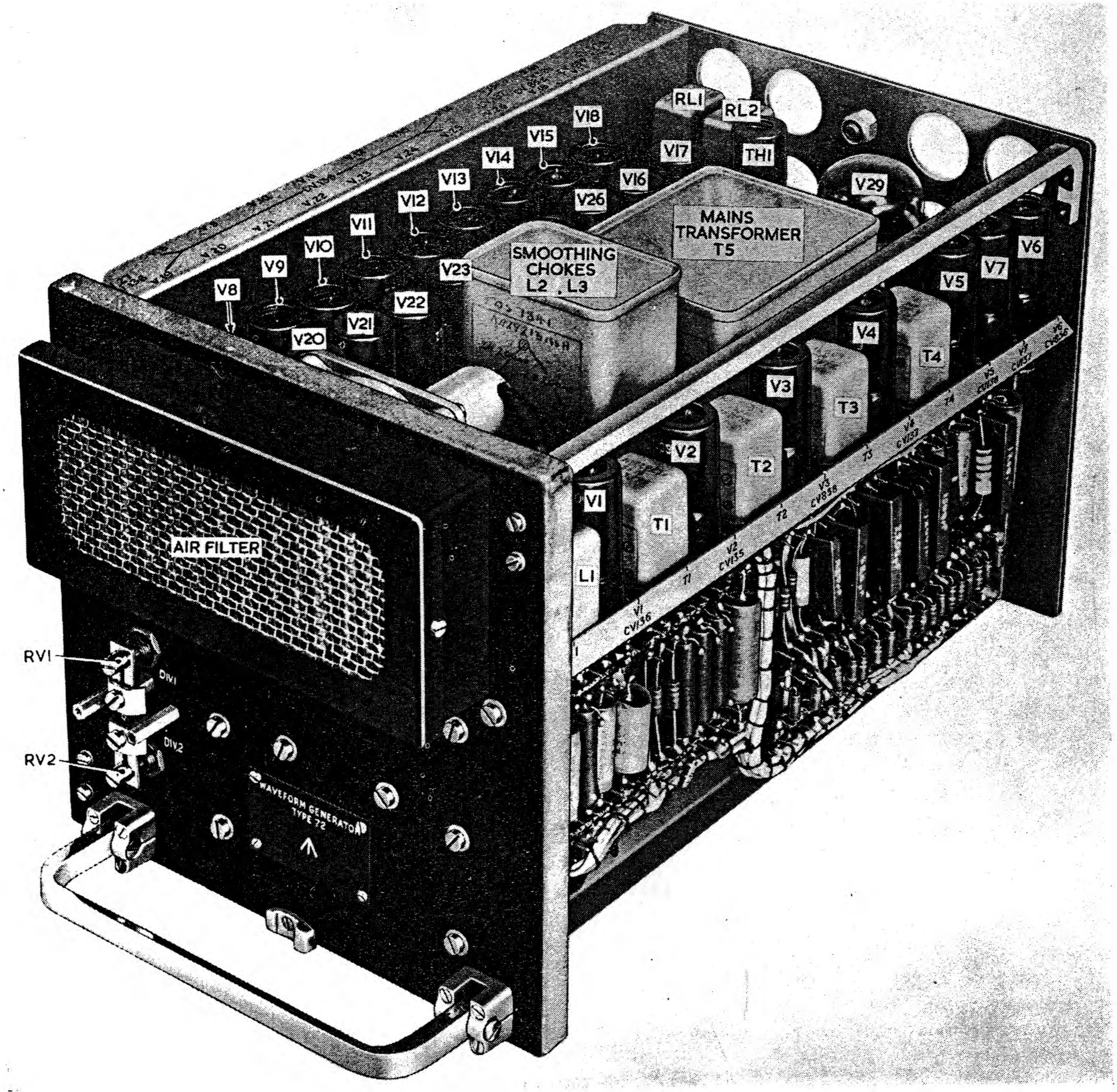

Fig. 1. Waveform generator—front view

WAVEFORM GENERATOR

1. General views of the waveform generator, with dust cover removed, are shown in fig. 1, 2 and 3. The chassis assembly is made up of three sections mounted between the front and rear end-plates. The sections and end-plates are secured together by screws and nuts; the complex wiring forms running between the sections make it impossible for them to be considered as separate elements for service and replacement purposes.

2. The left-hand chassis section carries the strobe-timer circuits, the strobe generator and the square-wave generator circuit. The right-hand chassis section carries the valves and components of the divider circuits. The centre chassis section carries the main HT and LT power circuits.

3. The front end-plate carries the blower assembly and its associated electrical interference suppressor and the two divider pre-sets RV1 and RV2. The blower motor is mounted on a fan chamber behind the end-plate, air being drawn in through a Vokes air filter mounted in a compartment at the front of the end-plate. A small detachable cover on the front allows access to the screwdriver adjustments of RV1 and RV2.

4. The rear end-plate carries the strobe-timer

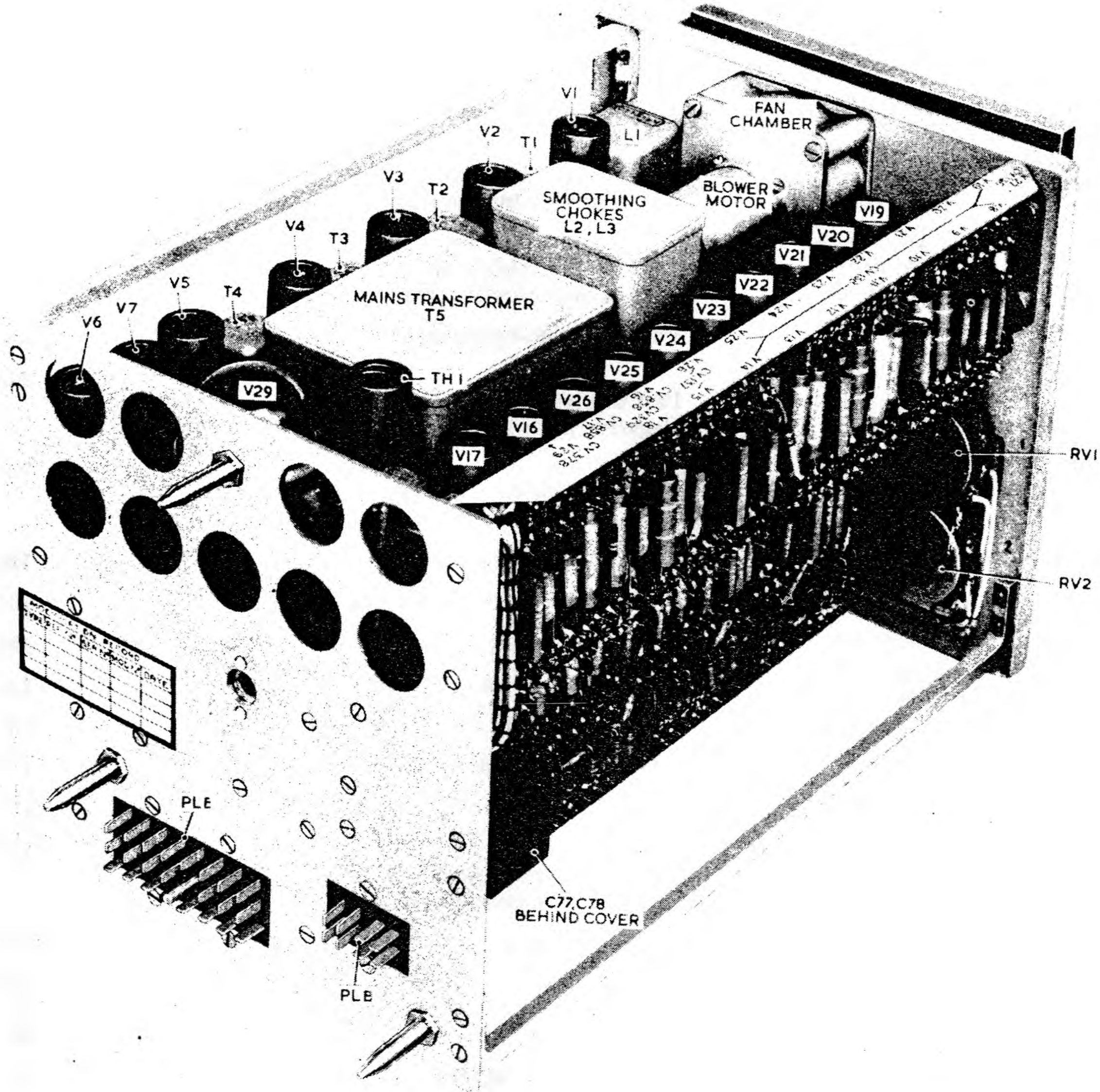

Fig. 2. Waveform generator—rear view

adjustments, C77 and C78, and the Jones plugs PL B and PL E; C77 and C78 which are shown in fig. 4 are fitted behind an insulated cover and are accessible for screwdriver adjustment through two holes in the front of the cover. Three pins project from the back of the rear end-plate; the bottom two are dowels which locate the back of the waveform generator into the junction box when the unit is in position on the mounting tray, the top pin provides a third leg which allows the unit to be placed on its back for test purposes. An Oddi-clip socket near the centre of the end-plate secures the dust cover.

TABLE I

Waveform generator—list of valves

Circuit Ref.	Valve type	Circuit function	CV No.
V1	Pentode	75 kc/s phase splitter	136
V2	Pentode	75 kc/s phase splitter	136
V3	Double-triode		858
	(A) triode	First divide-by-five stage	
	(B) triode	Second divide-by-five stage	
V4	Diode-triode		137
	(A) diode	3 kc/s pulse integrator	
	(B) triode	Part of divide-by-six stage	
V5	Pentode	Part of divide-by-six stage	138
V6	Double-triode		858
	(A) triode	Part of divide-by-six stage	
	(B) triode	Negative A-strobe generator	
V7	Diode-triode		137
	(A) diode	Part of divide-by-six stage	
	(B) triode	500 p.p.s. pulse output	
V8	Pentode	Part of 250 p.s. square-wave generator	138
V9	Pentode	5-Gee unit selector — B-strobe	138
V10	Pentode	Shaper for output of V9	138
V11	Pentode	1-Gee unit selector — B-strobe	138
V12	Pentode	Shaper for output of V11	138
V13	Pentode	0·1-Gee unit selector — B-strobe	138
V14	Pentode	Shaper for output of V13	138
V15	Diode-triode		137
	(A) triode	0·01-Gee unit selector — B-strobe	
	(B) diode	Part of strobe generator	
V16	Double-triode	Strobe generator	858
V17	Double-triode	Strobe output	858
V18	Pentode	A-strobe timer	329
V19	Pentode	Part of 250 p.s. square-wave generator	138
V20	Pentode	5-Gee unit selector — C-strobe	138
V21	Pentode	Shaper for output of V20	138
V22	Pentode	1-Gee unit selector — C-strobe	138
V23	Pentode	Shaper for output of V22	138
V24	Pentode	0·1-Gee unit selector — C-strobe	138
V25	Pentode	Shaper for output of V24	138
V26	Diode-triode		137
	(A) triode	0·1-Gee unit selector — C-strobe	
	(B) diode	15 kc/s pulse integrator	
V27	Pentode	250 p.s. square-wave output	136
V28	Pentode	Jitter stabilizer—210-volt line	138
V29	Double-diode	Bi-phase half-wave rectifier—HT	378
V30	Diode	Half-wave rectifier—bias supply	135

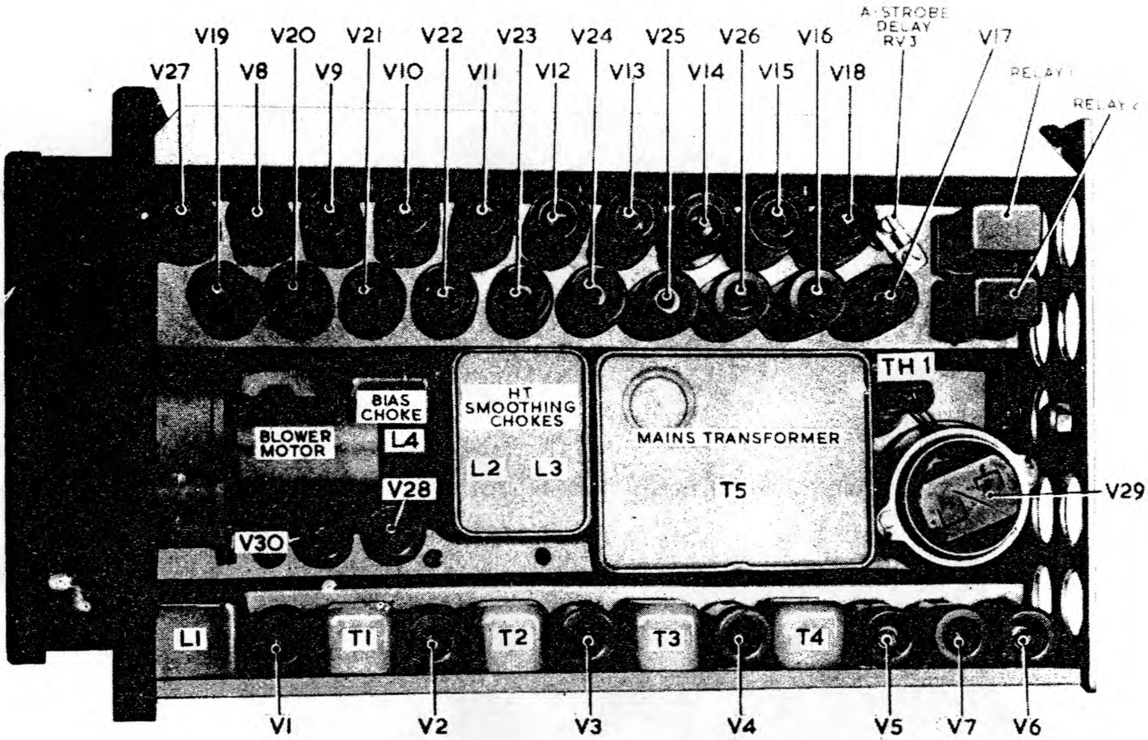

Fig. 3. Waveform generator—plan view

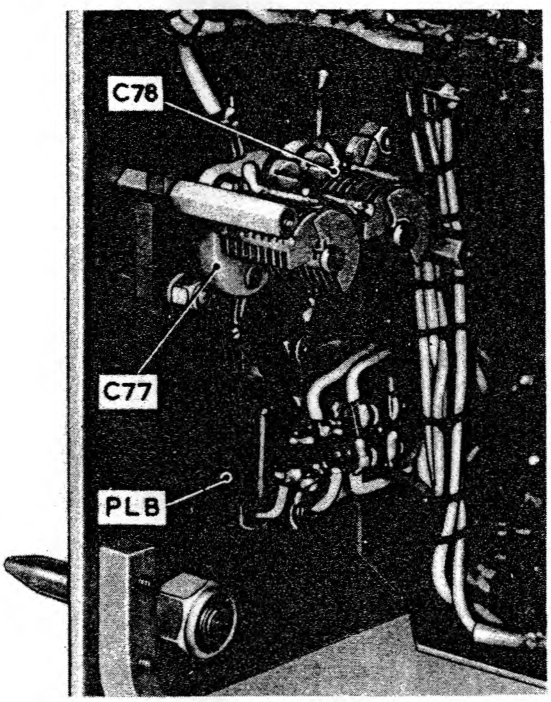

Fig. 4. Strobe-timer trimmers

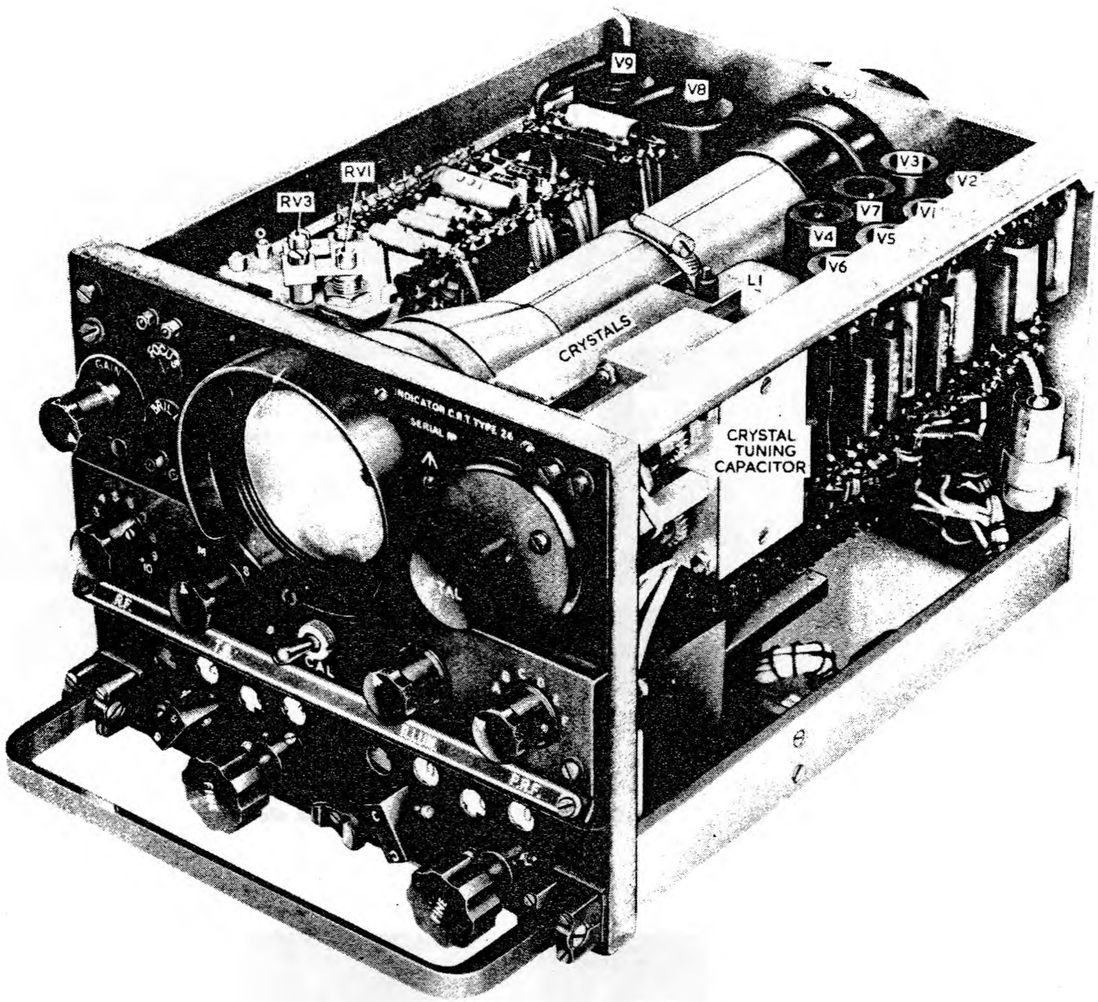

Fig. 5. Indicator—front view

INDICATOR

5. General views of the indicator, with dust cover removed, are shown in fig. 5 and 6. The chassis is made up of two main sections and a sub-assembly. The two sections are secured together between the front and rear end-plates, with the sub-assembly mounted below them at the front. The two sections are not considered separable for service and replacement purposes. The cathode-ray tube is mounted between the two end-plates at the top of the chassis.

6. The left-hand chassis section carries the EHT supplies and the electrode supply chain to the cathode-ray tube. The EHT rectifiers are protected and held in position by spring-loaded insulated covers which screw on to the valve mounting bases ; adaptors are fitted to the top cap connections to allow the stud-fixing anode leads to be connected. The EHT transformer and smoothing components are mounted on the underside of the left-hand section, together with the fly-back blanking diode V10.

7. The right-hand chassis section carries the crystal oscillator circuit, the timebase circuit and the video output (reversal) stage. The six crystals are plug-in types ; they are fitted on a socket-plate and held in position by a retaining plate with a rubber spacer.

8. The operating controls are on the front panel. A detachable moulding across the centre of the front panel carries the dial lamps which illuminate the strobe indicator dials ; the four lamps are strip-type bulbs held in clips in a recess at the bottom of the moulding. The strobe switch unit is at the back of the front panel.

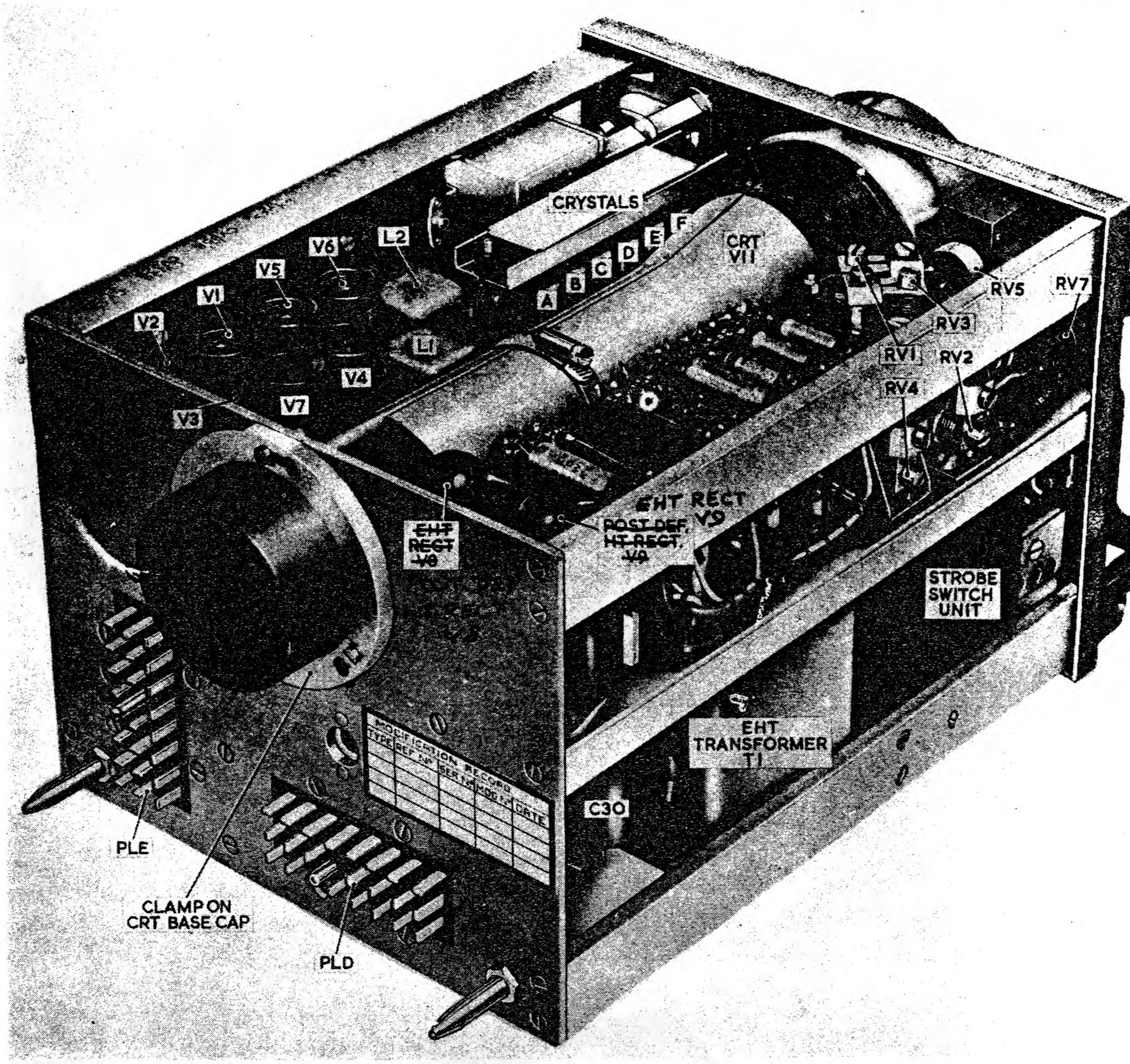

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Fig. 6. Indicator—rear view

9. The cathode-ray tube is held with its face in a flange which projects from the rear of the front plate; its base is held in an insulated base-cap which projects through the rear end-plate and is secured by a metal ring. The base-cap can be adjusted to allow all tubes to be held firmly despite slight differences in length.

10. Two dowels are fitted at the foot of the rear end-plate; they locate the indicator on the junction box when the unit is in position on the mounting rack; when the unit is on its back on the bench, the dowels, together with the base-cap on the cathode-ray tube form a tripod mounting. An Oddi-clip socket which secures the dust cover is fitted near the centre of the end-plate.

Crystal control

11. The crystal tuning assembly (*fig.* 5) is made up of a slow-motion drive mechanism and the tuning capacitors C18 and C35. The drive operates from the control spindle through a clutch to the reduction mechanism which drives the two capacitors separately through gear wheels. The control spindle normally engages with the slow-motion mechanism through the clutch; when the control knob is pulled outwards, the control spindle is disengaged from the reduction gear and rotation of the knob does not rotate the capacitors. A positive locating action in the two positions of the spindle is provided by a spring-loaded mechanism in the spindle bearing. The slow-motion mechanism forms a slipping clutch at the limits of rotation of the capacitors. The A-lock switch is operated by the in-out movement of the spindle.

Strobe switch unit

12. The strobe switch unit consists of two Geneva counting mechanisms each of which

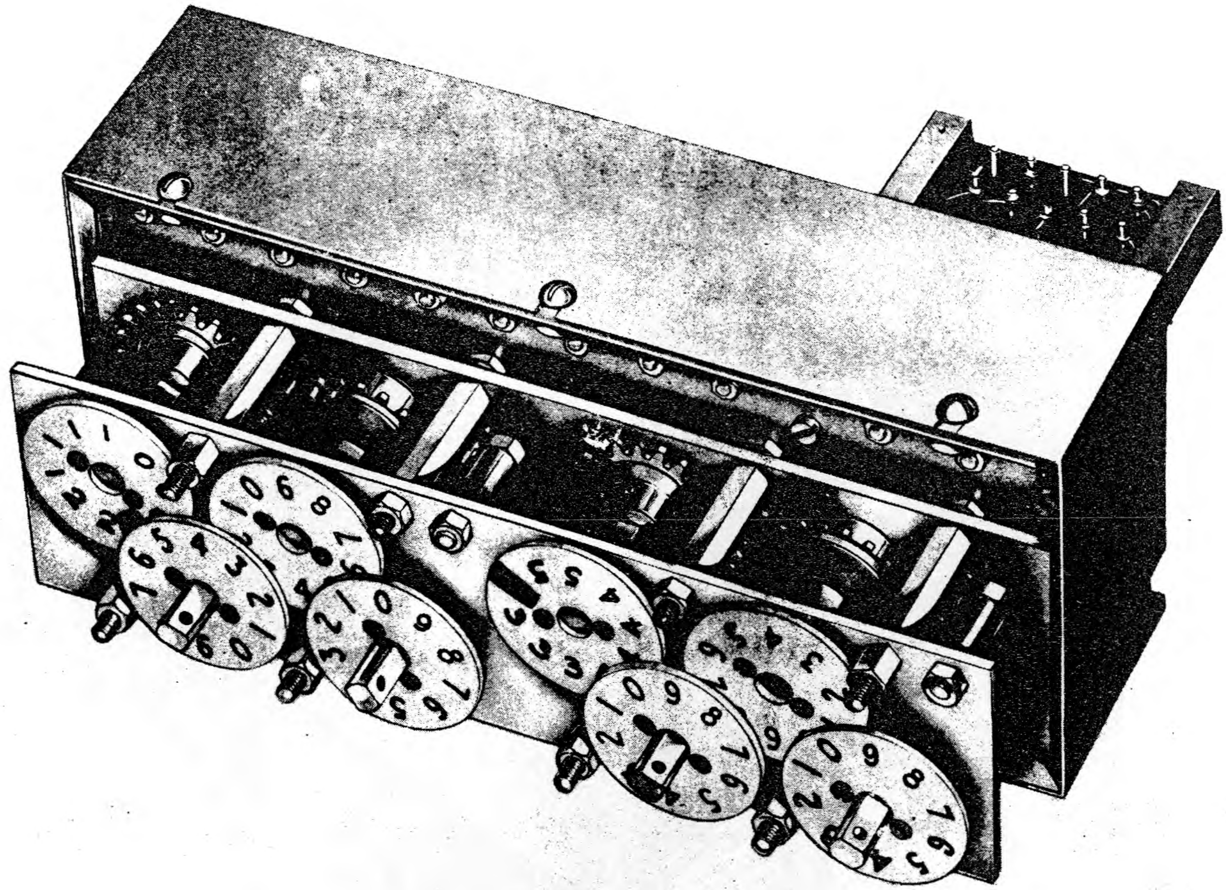

Fig. 7a. Strobe switch unit

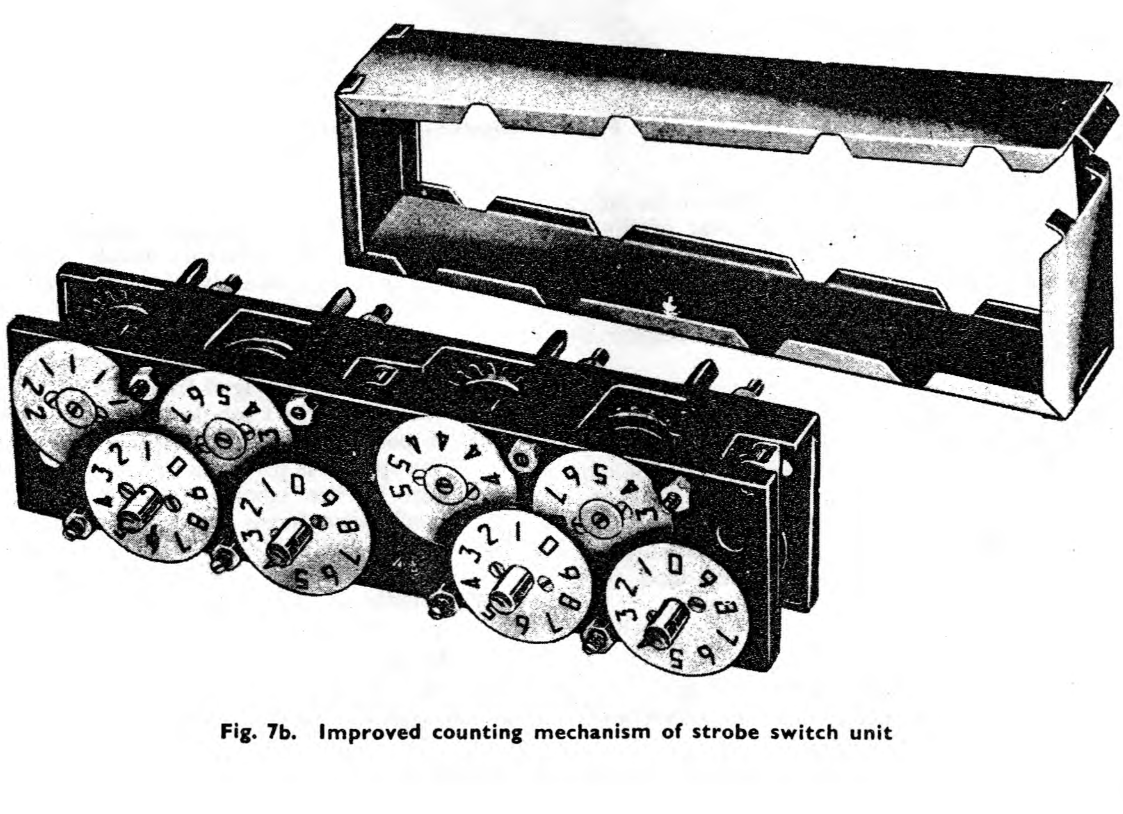

Fig. 7b. Improved counting mechanism of strobe switch unit

operates four wafer switches and four indicator dials. The two Geneva mechanisms are identical, but their dials, which show in Gee units the electrical delays set up on the switches, are calibrated differently to provide for the different operational counts required in the two strobes. Two types of switch units are in use, both described as strobe switch unit Type 298 (Stores Ref. 10F/16143). The type fitted in most production equipment is shown in fig. 7a and 8; the later, improved type, which is mechanically and electrically interchangeable, is supplied as a servicing replacement and is fitted in later productions. The counting mechanism of the improved unit is illustrated in fig. 7b.

Geneva mechanism

13. An exploded view of the switch mechanism is shown in fig. 10. The operating action between spindles is provided by a system of striking plates and gears. The hundredths-spindle, which is the prime-mover, is fitted with a spring-loaded ratchet to give the spindle a click action of ten steps per revolution, and a striking plate in which is set a single lipped V-cut. The striking plate rotates against an eight-tooth pinion in which every second tooth is a half-tooth; in the non-striking positions of the spindle the edge of the striking plate is above the pinion in the gap above a half-tooth. When the spindle is moved through the striking position the lip on the V-cut strikes the half-tooth and the following tooth is driven by the V-cut; the total movement of the pinion is, therefore, through one tooth and one half-tooth.

14. The pinion is in constant mesh with a twenty-tooth gear on the tenths-spindle; each step of the pinion moves the gear through two teeth and a complete revolution of the gear and therefore the tenths-spindle takes place in ten steps. A similar striking action to that detailed above operates between the tenths-spindle and the units-spindle; the drive from the gear wheel on the units-spindle is taken to the spindle through a spring-loaded friction clutch which slips when the units-spindle is turned independently for coarse control; the clutch is necessary as the gearing does not allow for drive back to the first two spindles. The spring-loading of the clutch is also used in a ratchet to provide a click action for the ten steps of the units-spindle when it is rotated for coarse setting of the switch..

15. The action between the striking plate on the units-spindle and the twenty-tooth gear on the tens-spindle is similar to that taking place between the other spindles, but it takes place four times in each complete revolution of the units-spindle. The striking plate on the units-spindle carries six V-cuts

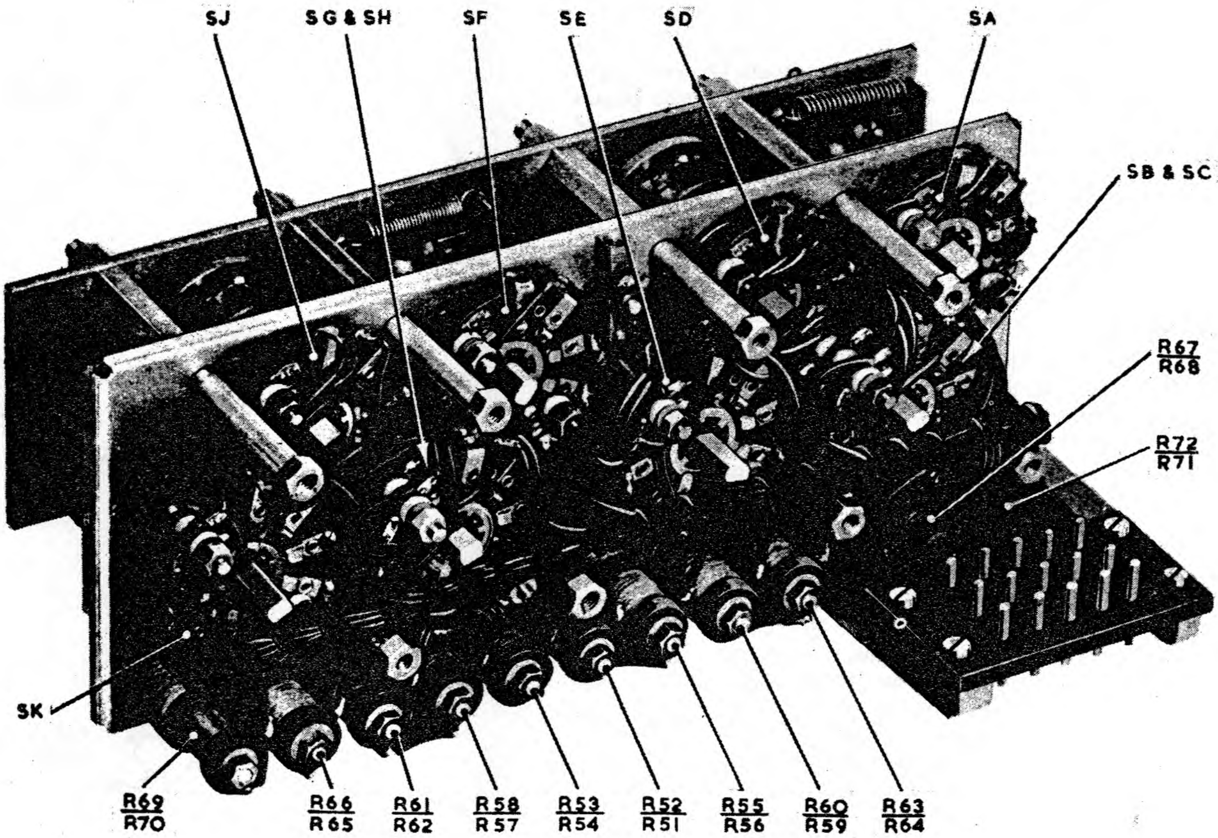

Fig. 8. Strobe switch unit—cover removed

in two diametrically opposed sets of three. Only the two outer V-cuts in each set provide striking actions, as the centre cuts, which are inserted to simplify manufacture, ride through the pinion in the striking actions of the other two. The operating sequence is illustrated in fig. 9.

16. A stop on the tens-spindle restricts the movement of that spindle to nine positions only, and also limits the movement of the other spindles to set the upper and lower limits of the complete counting action.

Strobe indicators

17. The relationship between the switch positions and the indicator dials of the B-strobe is shown in fig. 11. The dials of the B-strobe are shown in the minimum position, and as indicated by the arrows on each dial, operation causes a clockwise rotation of each dial. The positions of the strikers are shown as shaded V's on the edges of the dials and the points at which striking actions take place are indicated by bold arrows.

18. The relationship between the switch positions, dial readings and the electrical delays set up by each switch are shown in Table 2. The action of the mechanism is as follows:—The hundredths-spindle is turned by the FINE control and at each step the number on the hundredths-dial increases by one; as the dial passes from 9 to 0 the striker operates and the tenths-spindle is moved one step and the tenths-dial reads 1; subsequent movements of the hundredths-dial through 9 to 0 are accompanied by further movements of the tenths-spindle and dial. When the tenths-spindle passes from 9 to 0 the units spindle is moved one step and subsequent movements of the tenths-spindle through 9 to 0 produce further steps of the units-spindle. When the units-dial passes from 4 to 5 the tens-spindle is turned one step, and similar actions result as the units-dial passes from 5 to 6, 9 to 0, and 0 to 1.

19. The dial arrangements on the hundredths-, tenths- and units-spindles are straightforward sequences, but the tens-dial is complicated by the requirements of the special electrical counting action of the tens- and units-switches. As will be seen from Table 2, the useful electrical counts of the units-switch are in steps of 1 from 1 to 5, and the electrical counts of the tens-switch are in steps of 5 from 0 to 20. In consequence, in counting from 1 to 11, the tens-switch is turned to vary its electrical count after 5 and 10, but the change in the indicated count of the tens-switch takes place after the electrical count of 9. Three strikers are therefore required on the units-spindle, two which provide the electrical switching of the tens-spindle, strikers B and D (*fig.* 11), the other which provides change of indication only, striker C; a fourth striker, striker A, which moves the tens-spindle without altering either the electronic or the indicated count, is merely to simplify manufacture of the striking plate.

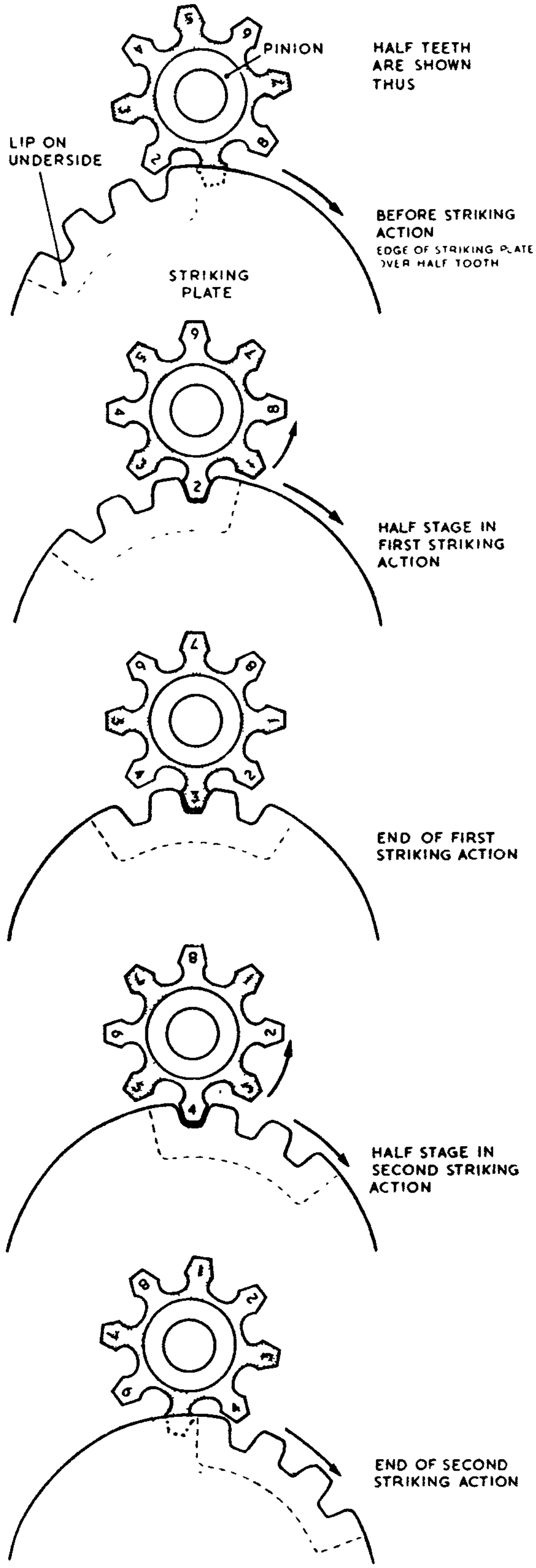

Fig. 9. Action of units striking plate

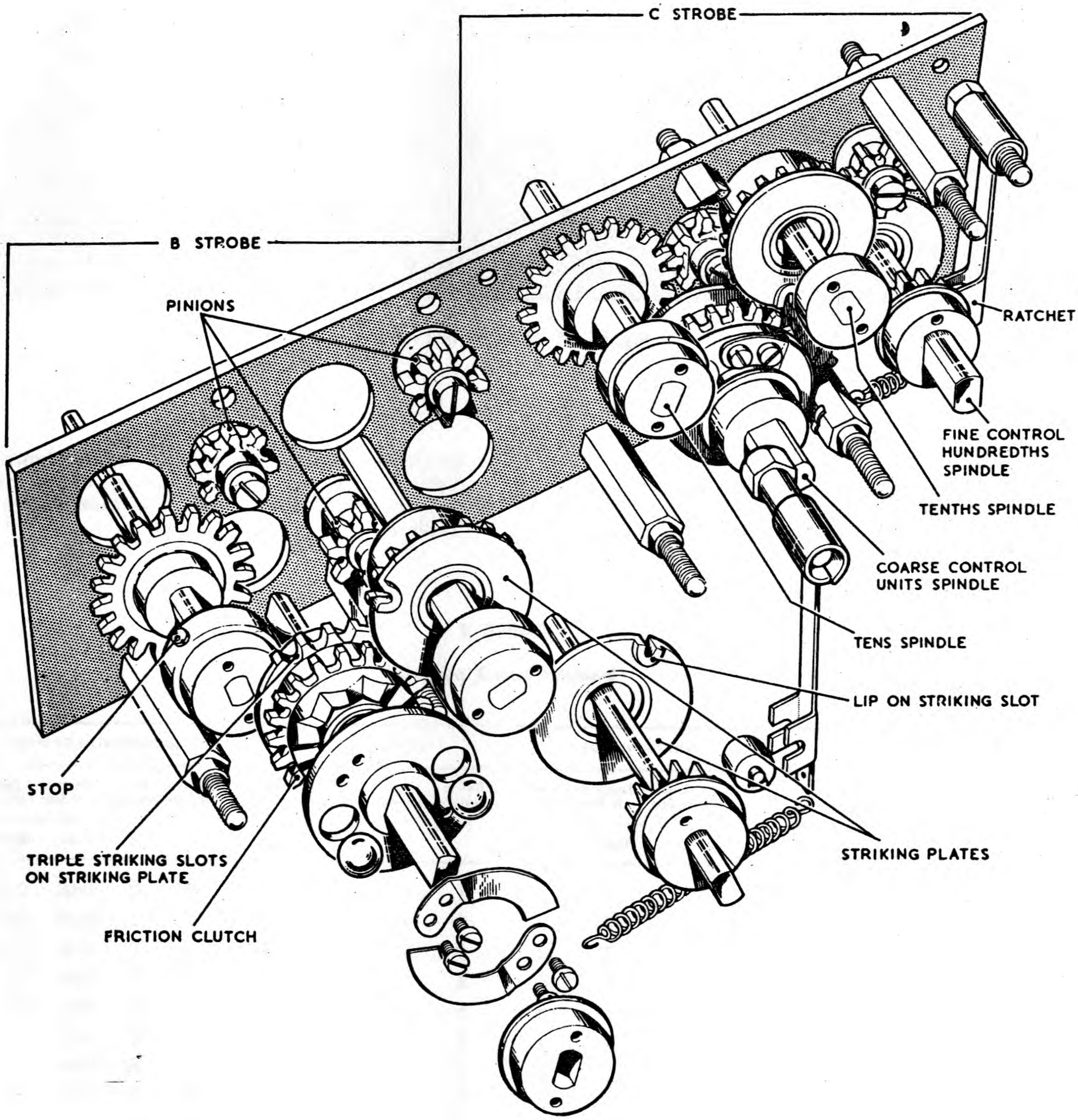

Fig. 10. Details of Geneva mechanism

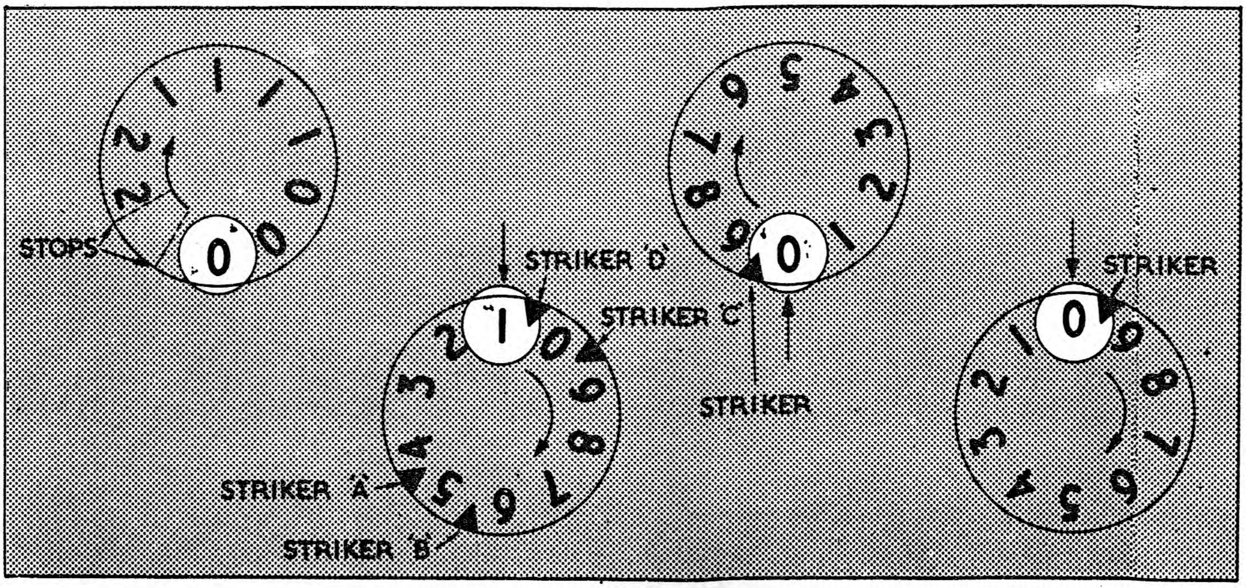

Fig. 11. Calibration of B-strobe

C-strobe

20. The mechanics and operational action of the C-strobe switches are the same as those described, but the electronic delays indicated and provided on the tens-switch only are different, as shown in Table 3. The positions and readings of the other C-strobe switches are the same as those shown in Table 2.

TABLE 2

B-strobe switch positions

TENS-SWITCH				UNITS-SWITCH				TENTHS-SWITCH				HUNDREDTHS-SWITCH			
Switch position	Dial reading	Electronic delay in Gee units		Switch position	Dial reading	Electronic delay in Gee units		Switch position	Dial reading	Electronic delay in Gee units		Switch position	Dial reading	Electronic delay in Gee units	
		Total	Useful			Total	Useful			Total	Useful			Total	Useful
1	0	5	0	1	1	1	1	1	0	0·2	0·0	1	0	0·00	0·00
2	0	5	0	2	2	2	2	2	1	0·3	0·1	2	1	0·01	0·01
3	0	10	5	3	3	3	3	3	2	0·4	0·2	3	2	0·02	0·02
4	1	10	5	4	4	4	4	4	3	0·5	0·3	4	3	0·03	0·03
5	1	15	10	5	5	5	5	5	4	0·6	0·4	5	4	0·04	0·04
6	1	15	10	6	6	1	1	6	5	0·7	0·5	6	5	0·05	0·05
7	1	20	15	7	7	2	2	7	6	0·8	0·6	7	6	0·06	0·06
8	2	20	15	8	8	3	3	8	7	0·9	0·7	8	7	0·07	0·07
9	2	25	20	9	9	4	4	9	8	1·0	0·8	9	8	0·08	0·08
Stop	—	—	—	10	0	5	5	10	9	1·1	0·9	10	9	0·09	0·09

TABLE 3

C-strobe tens-switch positions

Switch position	Dial reading	Electronic delay in Gee units	
		Total	Useful
1	3	35	30
2	3	35	30
3	3	40	35
4	4	40	35
5	4	45	40
6	4	45	40
7	4	50	45
8	5	50	45
9	5	55	50
Stop	—	—	—

Early strobe switch unit

21. In some early indicators a provisional type of strobe switch unit is fitted in which a simpler Geneva mechanism is used with a more complex electronic switching circuit. The dial and counting system of the tens-spindle of this type of switch differ radically from those of the switch Type 298. The provisional switch unit, which is unclassified for Type and Stores Ref. numbers, is intended to be replaced by the Type 298.

22. The unclassified switch unit can be recognized by the calibration of the tens-dials, which have five positions only, as follows:—

B-strobe — 0, 0, 1, 1, 2

C-strobe — 3, 3, 4, 4, 5

The counting system differs in that only two striking actions take place between the units-spindle and the tens-spindle in each ten steps of the units-spindle; they occur between positions 5 and 6, and 9 and 10 of the units-spindle; the striking plates on the units-spindles are therefore provided with only two V-cuts.

TABLE 4

Indicator—list of valves

Circuit Ref.	Valve type	Circuit function	CV No.
V1	Pentode	Timebase generator	329
V2	Pentode	Timebase paraphase amplifier	138
V3	Pentode	Video amplifier and signal reverser	329
V4	Pentode	Crystal oscillator	138
V5	Double-triode		858
	(A) triode	Part of crystal oscillator	
	(B) triode	150 k/cs output	
V6	Pentode.	75 k/cs oscillator	329
V7	Pentode	AFC control on crystal oscillator	138
V8	Diode	Half-wave rectifier—post def. EHT	261
V9	Diode	Half-wave rectifier—EHT	261
V10	Diode	DC restorer—fly-back blanking	1092
V11	Cathode-ray tube		1526
V12	Crystal diode	Clamp and limiter	448

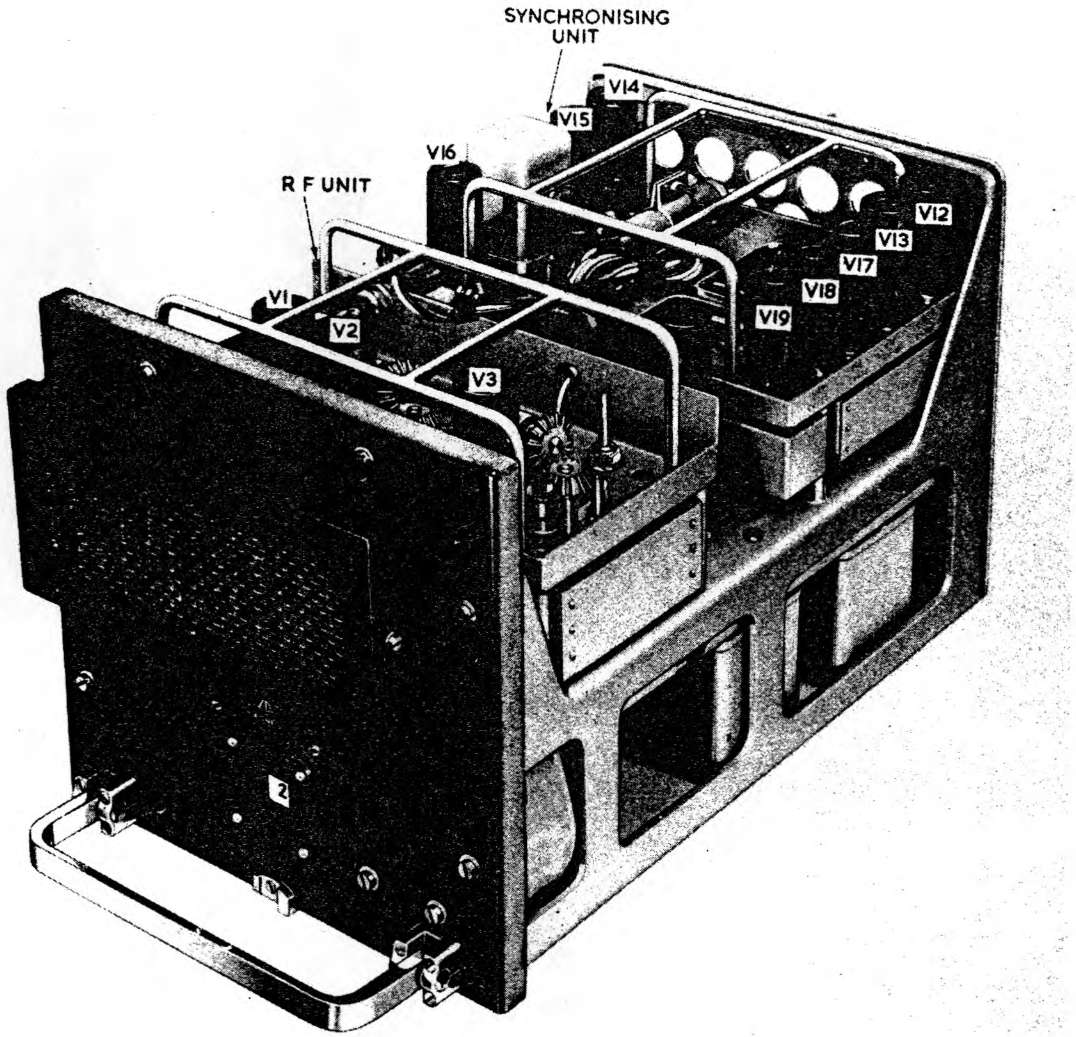

Fig. 12. Receiver—front view

RECEIVER

23. General views of the receiver with its dust cover removed are shown in fig. 12 and 13. The chassis of the receiver is a framework on which the receiver circuits are carried on separate sub-assemblies. The sub-assemblies are as follows :—

RF unit Type 148 (Stores Ref. 10D/18329)

IF unit Type 125 (Stores Ref. 10D/18330)

Synchronizing unit Type 28 (Stores Ref. 10D/18331)

24. The RF and synchronizing units are fitted to the top chassis plate ; a four-pin miniature Jones plug on a flying lead carries the RF unit power connections from the general wiring ; a twelve-pin miniature Jones plug on a flying lead carries the connections to the synchronizing unit. The RF input to the RF unit is taken to a fixed co-axial socket, and the IF output of the same unit is carried by a co-axial lead terminating in a co-axial plug.

25. The IF unit is fitted across the bottom of the underside of the chassis framework ; it is connected into the general wiring through a fixed twelve-pin miniature Jones plug ; its IF input point is a fixed co-axial socket.

RF unit

26. A general view of the RF unit is shown in fig. 14 ; the unit is built on a single plate with screening partitions between the three stages, and a screening cover, which completely protects the

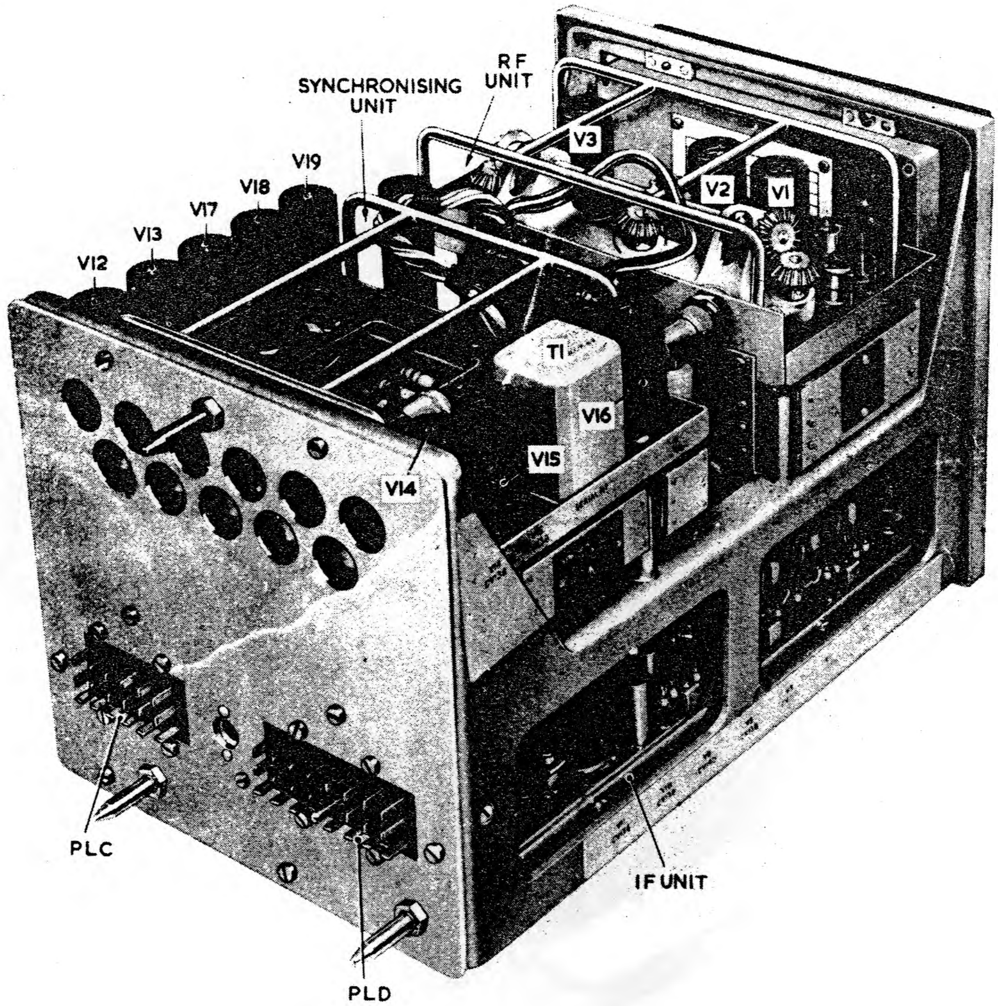

Fig. 13. Receiver—rear view

coils and switches, on the underside. A wire framework is fitted above the top plate to protect the valves when the unit is inverted on the bench ; it also facilitates the removal and replacement of the unit into the main structure.

27. The three switches on the RF unit are mechanically ganged through a gear mechanism which is mounted in a casting to the top plate ; the drive to the mechanism comes to the spindle of the centre switch from the motor-driven selector mechanism which is fitted underneath the top plate of the main chassis structure. A free coupling is used between the drive shaft and switch spindle ; it is self-locating and allows the RF unit to be lifted clear of the main structure and replaced without the need for adjustment other than a general lining-up of the switches with the selector mechanism's indicator. The settings of the switches in the RF unit can be seen by comparison of the position of the slider on the aerial switch S1 against an engraved scale set around an access hole in the bottom screening cover.

28. In some early RF units a less substantial gear mechanism was fitted to provide the drive to the switches. In these units, an indicator dial is fitted at the top of the mechanism to show the switch positions. An RF unit with the old type of mechanism fitted is shown in fig. 15.

29. The tuned circuits in the RF unit include separate coils for each RF channel in each stage. Provision is made for ten coils to be fitted in each stage to allow for a maximum of ten RF channels, but in current equipments seven coils only are fitted to provide operation on channels 1, 2, 3, 7, 8, 9, and 10 only. The coils are wound on light ceramic formers with silver patches forming their terminations ; the contacts on to the silver patches

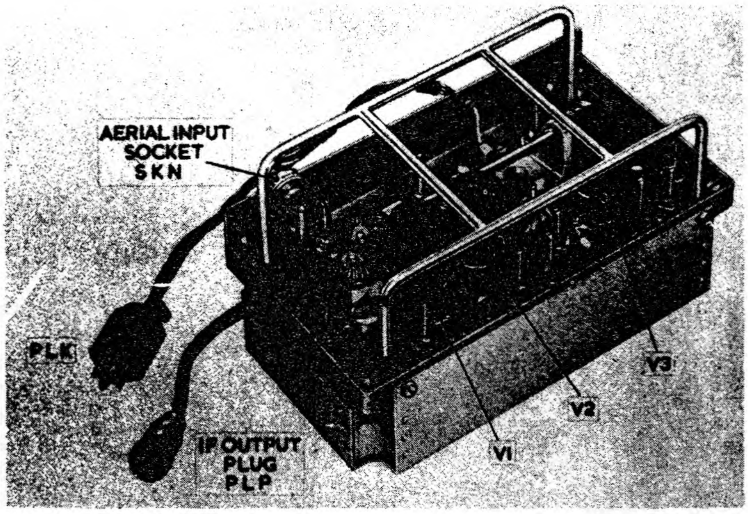

Fig. 14. RF unit

are made with low-temperature solder, and only such solder applied with a low temperature iron must be used when work is done on the coils ; the use of normal soldering techniques will result in the melting of the silver and the effective destruction of the coils.

IF unit

30. A general view of the IF unit is shown in fig. 16. The unit is built on a fully screened chassis, with a detachable cover on the underside and the IF coils and diode filter enclosed in screening cans. The coils are of the same construction as the RF coils and similar precautions must be taken when they are handled.

Synchronizing unit

31. A general view of the synchronizing unit is shown in fig. 17 ; the unit is built on a small metal plate in which flanged holes have been punched to reduce weight without impairing strength. A cover encloses the components set around the outer edges of the underside of the unit ; it is fitted as a protection for the components when the unit is being removed from or fitted into the main structure. A framework above the top plate of the unit allows the unit to be handled on the bench and in removal and replacement operations.

Main chassis structure

32. A detailed view of the top of the main chassis structure is shown in fig. 18 ; the top plate of the main structure provides a platform on which the RF and synchronizing units are mounted ; it carries also the Jones sockets, which connect up the two units, and the thermostat in the main AC input control circuit.

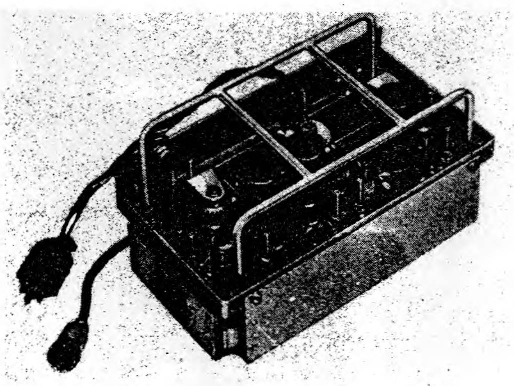

Fig. 15. Early type of RF unit

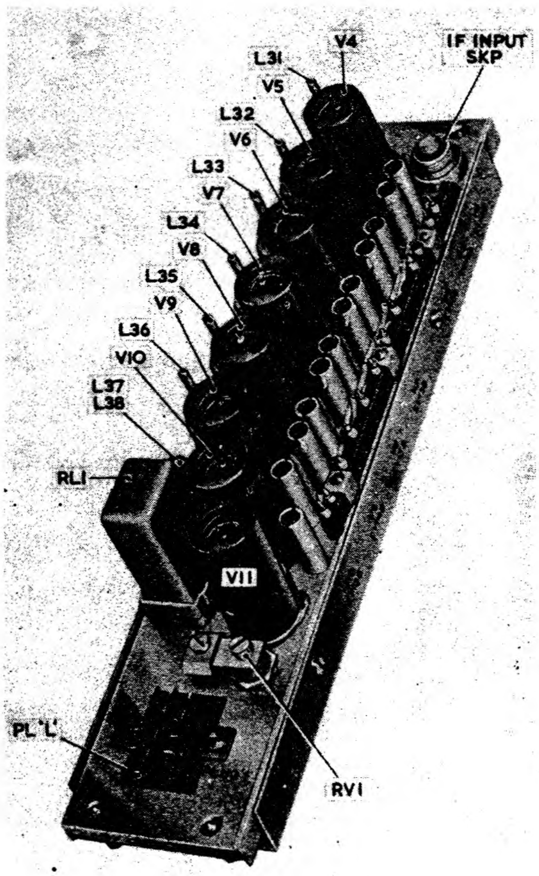

Fig. 16. IF unit

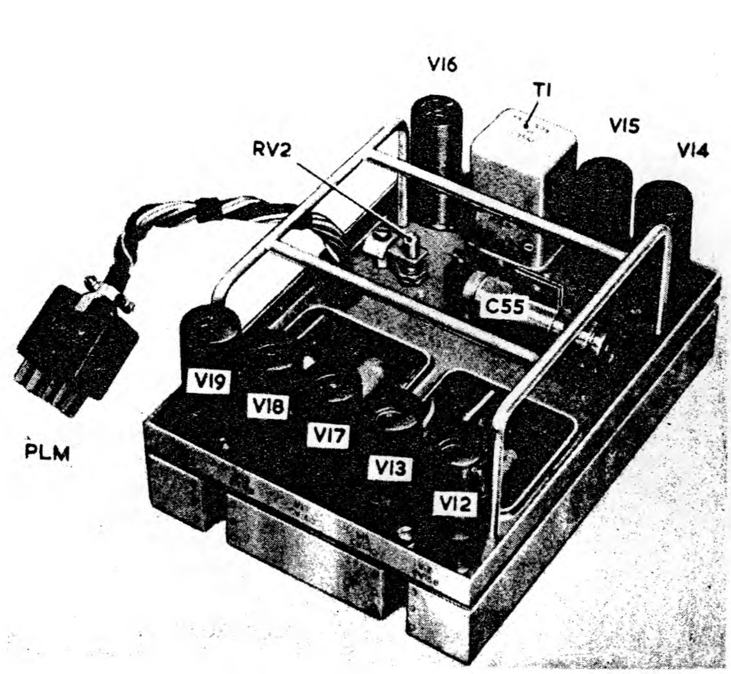

Fig. 17. Synchronizing unit

33. A view of the underside of the main structure is shown in fig. 19; the IF unit is fitted across the length at the bottom, and is held on brackets secured to the front and rear end-plates. The RF switch selector mechanism is fitted beneath the top plate; other components on the underside, the heater transformer, T2, and the smoothing capacitors C71 and C72, are secured beneath the top plate.

34. The blower unit consisting of motor and fan chamber is secured to the rear of the panel; the air passage from the Vokes air filter, which is fitted at the outside top of the front panel, to the fan chamber is a duct secured to the rear of the panel.

35. A trimming tool is fitted in a clip on the rear of the front panel; the tool, which consists of a combined 4 BA spanner and screwdriver, is provided for adjusting the RF coil pre-set cores.

36. The rear plate of the receiver chassis carries two dowels near the bottom; the dowels locate into the junction box when the receiver is fitted into its mounting rack. A third pin near the top of the rear plate forms, with the two dowels, the third leg of a tripod mounting, and allows the receiver to be positioned on its back plate without danger to the Jones plugs.

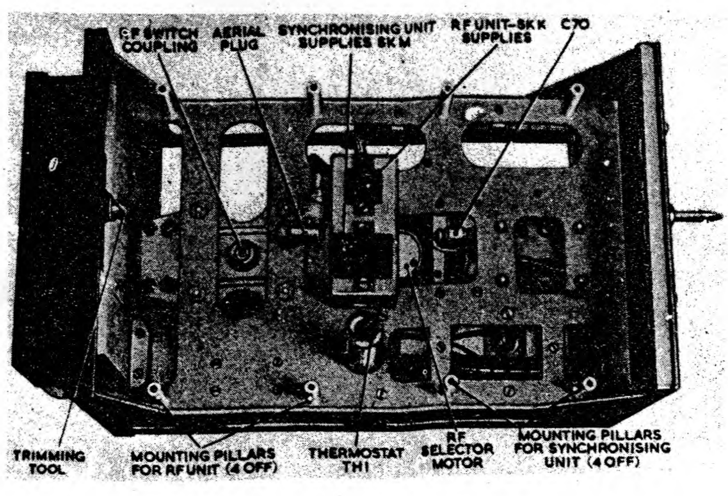

Fig. 18. Receiver—plan view, units removed

RF switch mechanism

37. The RF switch mechanism is shown in fig. 20; it consists of a motor-operated reduction drive with a ratio of 625 to 1 and two switches S4A and S4B. S4A operates in conjunction with a relay to provide control of the action of the mechanism; the relay is mounted separately from the mechanism at a nearby point on the underside of the top plate; the spindle of S4A is extended to provide the drive through a dog coupling to the RF switches in the RF unit on the upper chassis. S4B provides control of the channel switching in a remote aerial matching unit; its spindle carries an edge-calibrated indicator drum which indicates the channel being selected by the switch.

38. The reduction drive consists of a train of gears which rotate in Oilite bearings; it is mounted on resilient pillars from the base plate of the mechanism; other pillars which are fitted adjacent to the resilient pillars restrict vibration of the mechanism to the vertical plane and limit the amplitude of its movement. Detachable side-plates exclude dust from the gear mechanism, and a further detachable dust cover is fitted over the top plate.

39. The dog-coupling which drives the switches in the RF unit rotates clockwise—as viewed from the top of the main structure—when in operation; the direction of rotation is important as the set of the dogs in the coupling is such that correct lining up of the RF unit switches is not possible when the direction is reversed and the drive is applied by the non-working faces of the dogs.

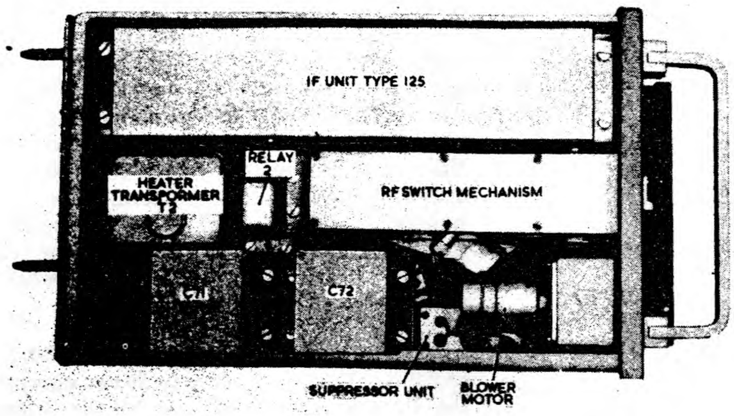

Fig. 19. Receiver—underside

40. The two switches, S4A and S4B, are mounted on the outside of the mechanism on rocking plates which allow the switch positions to be adjusted relative to the positions of the switches in the RF unit. Felt washers are introduced on the spindles to protect the switches from oil which seeps from the Oilite bearings of the gears.

41. The motor operates under the control of a relay RL2 which is in turn controlled through S4A by the remote RF channel switch in the indicator. When the motor is turning, the relay is open and it remains thus throughout the switching action until S4A takes up the position appropriate to the channel selected at the indicator when the relay is energized and power is disconnected from the motor. The overshoot on the rotation of the system when the motor is de-energized is designed to cause the slider of S4A to stop centrally about the selected contact on the switch.

42. In practice, loose contacts on S4A and other tolerances associated with the design of the switch leaf introduce tracking difficulties in the mechanism which can lead to inaccurate settings of the RF switches. Measures to overcome this difficulty include, in early units, the application of a fixative to the contacts, and, in later equipments, an improvement in the mechanical stability of the leaves.

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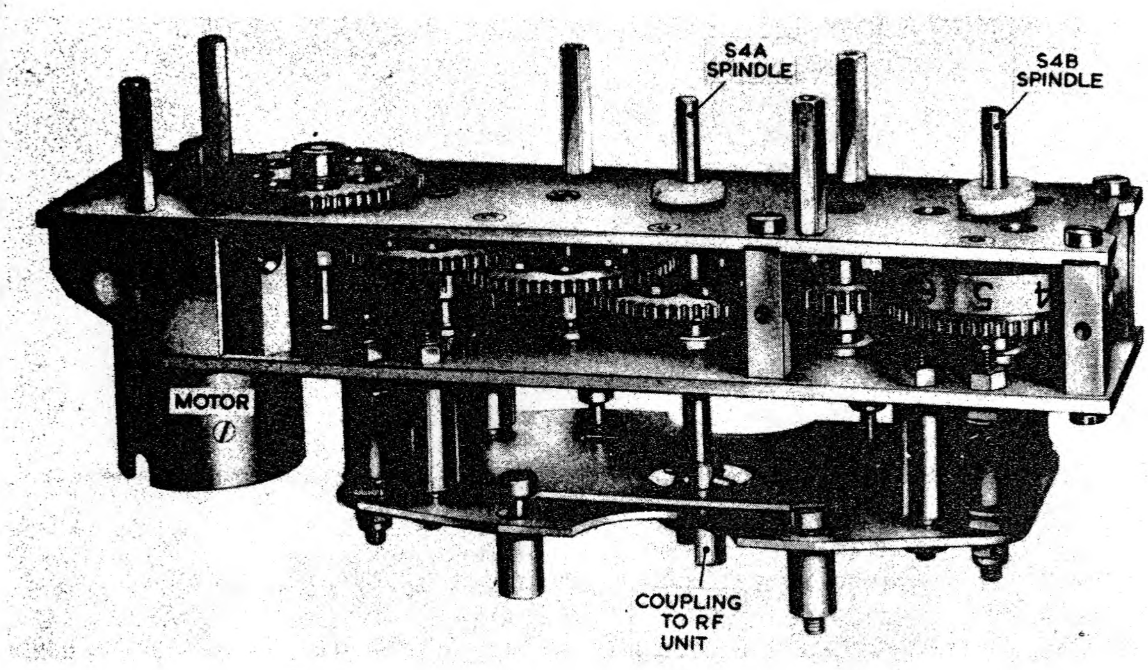

Fig. 20. RF switch mechanism

WIRING NOTE

43. The wiring of all three major units of the Gee Mk. 3 equipment is insulated with coloured sleeving in which the colours used distinguish the circuits involved. The code is as follows:—

Colour of sleeving	*Circuit*
Red	HT—240-volt and 210-volt lines
Orange	Anodes
Mauve	Pulse circuits
Blue	Control grids
Slate	Cathodes
Green	Divider HT line (waveform generator only)
Brown	Heaters
Black	Earth
White	Bias line
Yellow	General wiring

JUNCTION BOXES

44. The interiors of the junction boxes are shown in figs. 21, 22, and 23. In the junction boxes Type 360A and 361A, for the waveform generator and receiver respectively, the box is made up of a single compartment closed by a detachable back plate. The output plugs are secured to a plate fitted either to the top or bottom inside face of the box ; the alternative positions allow the plugs to protrude either from the top or bottom. The holes in the unused top or bottom plate are obscured by a plain metal plate and a rubber gasket. The front plates of each box carry two Jones sockets which connect up with their respective units.

45. In the junction box Type 359A, for the indicator, the box is made with two compartments ; the front compartment carries the Jones sockets which connect up with the indicator, and the rear compartment carries the output plugs. The output plugs are fitted on a metal plate which can in turn be fitted to either the upper or lower surfaces of the rear compartment.

46. The front plates of all the boxes carry bushes which act as locating holes for dowels on the rear plates of the units ; they also carry threaded bushes for securing the boxes to the mounting racks.

TABLE 5

Receiver—list of valves

Circuit Ref.	Valve type	Circuit function	CV No.
V1	Pentode	RF amplifier	138
V2	Pentode	Mixer	138
V3	Double-triode	Local oscillator	858
V4	Pentode	IF amplifier	138
V5	Pentode	IF amplifier	138
V6	Pentode	IF amplifier	138
V7	Pentode	IF amplifier	138
V8	Pentode	IF amplifier	138
V9	Double-diode		140
	(A) diode	Detector	
	(B) diode	Echo suppressor	
V10	Pentode	Video amplifier	138
V11	Pentode	Video amplifier	136
V12	Pentode	A-strobe selector	138
V13	Double-diode		140
	(A) diode	A-pulse selector	
	(B) diode	Pulse limiter	
V14	Pentode	Part of discriminator	138
V15	Pentode	Part of discriminator	138
V16	Pentode	Part of discriminator	138
V17	Double-diode	Discriminator pulse rectifiers	140
V18	Pentode	DC amplifier	138
V19	Diode-triode		137
	(A) diode	Limiter on AFC output	
	(B) triode	Not used	

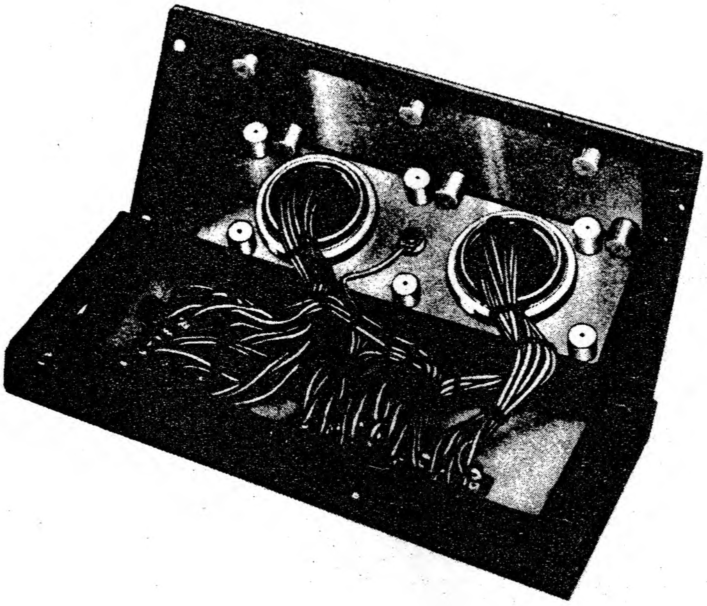

Fig. 21. Junction box Type 359A

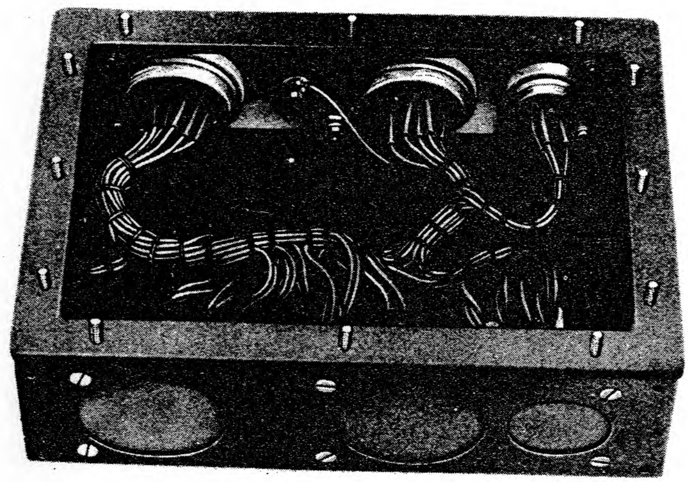

Fig. 22. Junction box Type 360A

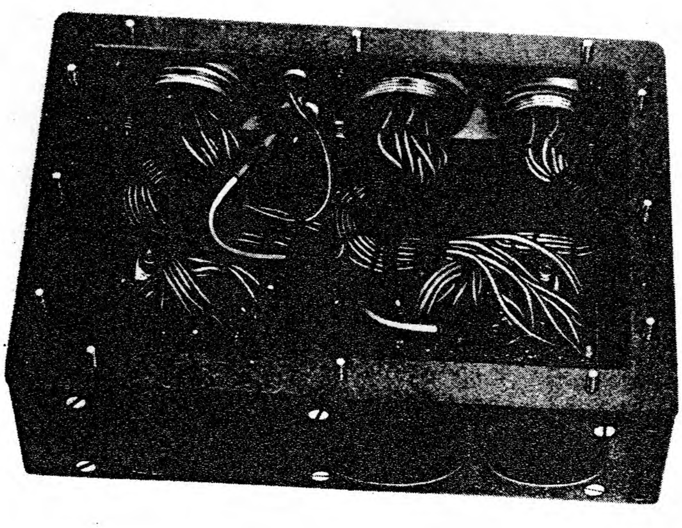

Fig. 23. Junction box Type 361A

Chapter 5

ROD AERIAL SYSTEMS

This chapter supersedes that issued with A.L. No. 16

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LIST OF ILLUSTRATIONS

Introduction

1. The wide frequency coverage of the Gee system makes necessary the use of a wide-band aerial system. In low-speed aircraft this takes the form of a single whip aerial rod and a switched matching unit; in high-speed aircraft, where the drag of even a short whip would be prohibitive, a suppressed aerial is used, usually with a switched matching unit.

2. Two different systems, aerial schemes A and B, are available for low-speed aircraft, and a series of further systems, each one designed specifically for a given aircraft type is provided for high-speed aircraft. Application of any particular scheme depends first on the speed range of the aircraft and then on the suitability of the aircraft's structure for incorporation of the necessary equipment

3. All the schemes undergo modification to adapt them for the particular requirements of specific installations, particularly the suppressed types, which differ widely from the basic designs. This chapter describes only the items of equipment involved in schemes A and B; for details of actual installations, reference must be made to the appropriate aircraft handbook. Equipment used in the suppressed aerial schemes is described in Chap. 6, under separate headings for each aircraft.

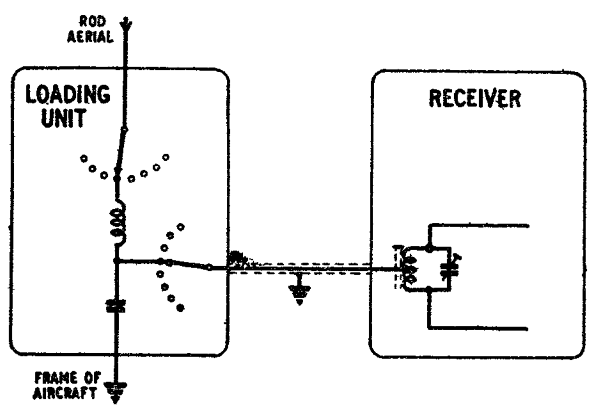

Fig. 1. Outline of aerial scheme B

AERIAL SCHEME B

4. The simplest aerial system is scheme B. This is identical with the system used in earlier Gee Mk. 2 installations and consists of a simple whip aerial and a switch-controlled matching unit. The basic system is shown in fig. 1.

5. Items involved in the aerial scheme B are as follows:—

(1) Aerial, aircraft, Type 329, Stores Ref. 10B/1026.
(2) Loading unit (aerial), Type 51, Stores Ref. 10B/1979.
(3) Connector, Stores Ref. 10HA/—— (number depending on the type of aircraft).

Aerial, aircraft, Type 329

6. The aerial proper, shown in fig. 2, consists of four main parts as follows:—

(1) Rod aerial, Type 257, Stores Ref. 10B/1979.
(2) Body (bollard), Stores Ref. 10B/13178.
(3) Tray (mounting), Type 369, Stores Ref. 10A/14029.
(4) Plug (aerial), Stores Ref. 10H/20209.

7. The rod, 3 ft. 7⅝ in. long, is screwed into the insulated body, and the tray is fitted, together with an insulated cap, to the underside of the body. The plug screws on the inside end of the rod through the tray and cap.

8. Four anchor nuts set in the corners of the main body permit the complete unit to be fitted to the aircraft structure. A rubber gland, not provided as part of the aerial, is required between the aerial body and the aircraft structure.

9. Three bayonet slots in the flange of the tray are for securing the loading unit to the aerial. Spring clips on the inside of the tray provide holding pressure when the loading unit is fitted.

10. In the original design of the aerial a plug Type 587 was fitted. This plug has now been replaced by modification action (Mod. No. 2891) to make the aerial suitable for use with both the loading units Type 51 and 55. Additionally the new plug provides improved electrical contact.

Loading unit, Type 51

11. The loading unit Type 51 is similar in construction to the earlier aerial loading units, Type 2 and 8, and is of simple cylindrical form. The diameter of the body is approximately 3⅜ in. and its length is about 2⅝ in., the overall length, taking into account the projecting control knob, is about 3⅞ in.

12. The body of the loading unit is a complete metal screen within which is mounted a rotatable coil turret; details are seen in fig. 3. The turret consists of a circular insulated plate mounting seven coils (space for an eighth is not used), fitted on a spindle which projects through the end plate of the screening cover and carries the control knob.

13. The turret has eight positions. Location is by means of the control knob which has two spring-loaded balls set into its inside face. Eight indentations are set regularly in the surface of the end plate, and the balls bed into the indentations to give a positive location.

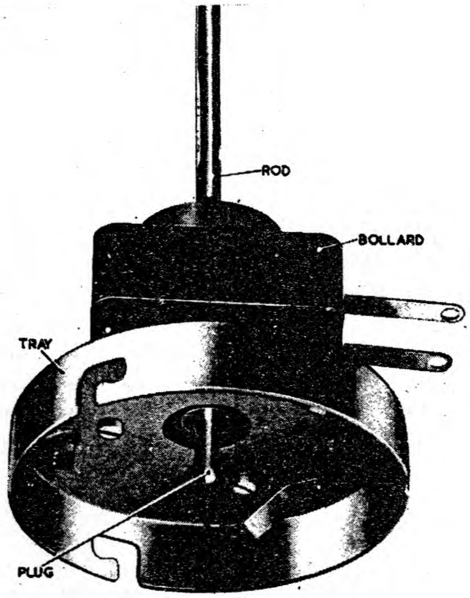

Fig. 2. Aerial, aircraft, Type 329

14. One end connection of each coil on the turret is taken to a tag on the plate beside the coil, and extends through the plate to a stud contact on the other side. A fixed spring contact mounted from the end plate provides connection to a Pye plug which is the loading unit output terminal. The other end connection comes out to a stud contact on a circular insulated plate at the end of the turret-operating spindle. The associated spring contact connects to the aerial input point which is a socket mounted centrally in the end of the screening cover. An earthing plate on the spindle provides a return via a further spring contact to the body of the unit for the earthy ends of the matching components.

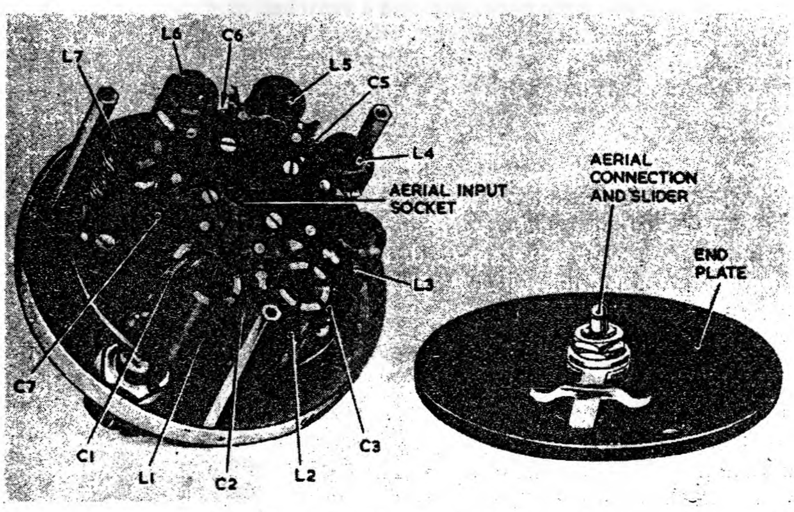

Fig. 3. Details of loading unit Type 51

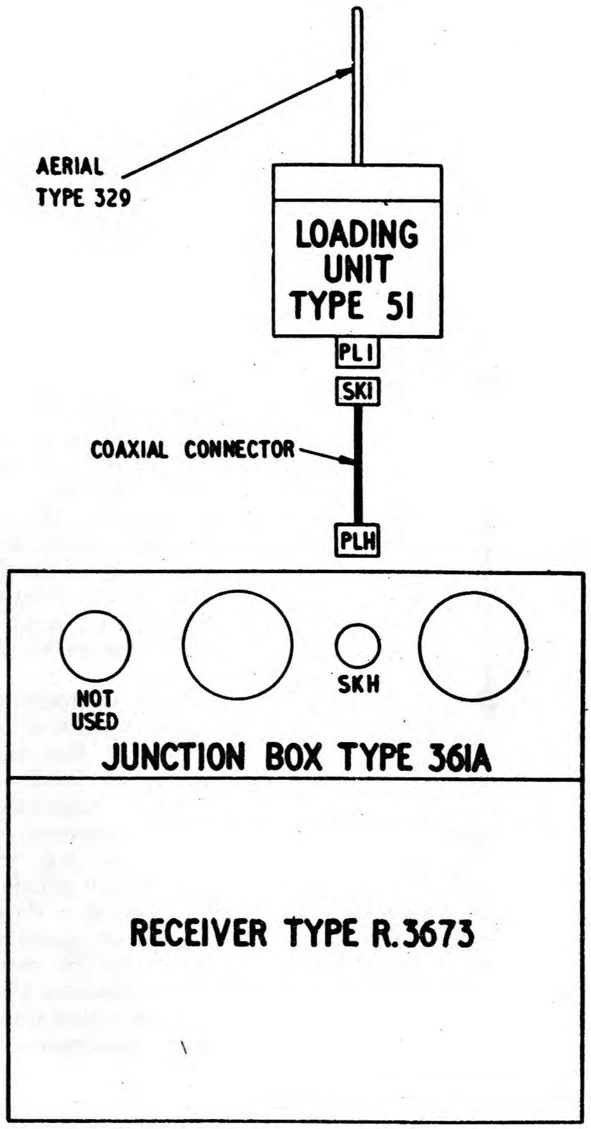

Fig. 4. Layout of aerial scheme B

Installation of aerial scheme B

15. In normal applications, the aerial is mounted from within the aircraft with the rod protruding through the skin. For aircraft whose maximum dive speed is less than 260 knots, the siting position can be such that in level flight the rod points vertically, either up or down. For aircraft with dive speeds up to 360 knots, the rod must be canted by about 20 deg. backwards from the line of flight. The aerial cannot be used on aircraft with higher speeds.

16. Basic details of the electrical layout are shown in fig. 4. The aerial rod is mounted through the aircraft's skin in a position such that the top surface of the bollard is within a $\frac{1}{4}$ in. of the skin surface; the rubber gland is fitted between the body and the skin. The loading unit is then fitted in position on the mounting tray by a twist and push action. The appearance of the loading unit when in position on the tray is shown in fig. 5.

17. Because it might be necessary to alter the setting of the loading unit when a different reception frequency is required, the siting of the aerial must be such that the control knob on the loading unit is readily accessible to an operator.

18. A coaxial connector is fitted between the loading unit and the receiver. Details of the connector will differ in different installations, but they will have the common features of a Pye socket termination (socket Type 213) at the aerial end, and a coaxial plug (Ref. Z.560040) at the receiver end. The cable is Uniradio 43. The receiver-end connection is taken to the receiver via SKH on the receiver junction box Type 361A.

Circuit details of aerial scheme B

19. At a frequency of approximately 65 Mc/s, the aerial rod is a quarter-wave in length and is therefore resonant. Its characteristics are then such that it has an omnidirectional response and a resistive impedance of about 45 ohms. As the receiver has a similar input impedance, a 40–ohm cable between the two provides a satisfactorily matched coupling.

20. At other frequencies, however, the aerial impedance varies appreciably from this optimum and, without correction, serious mismatching would be introduced. Such mismatching would introduce standing waves and loss of signal and, because the loading of the receiver input circuits would be affected, would cause also a serious reduction in second-channel and IF rejection.

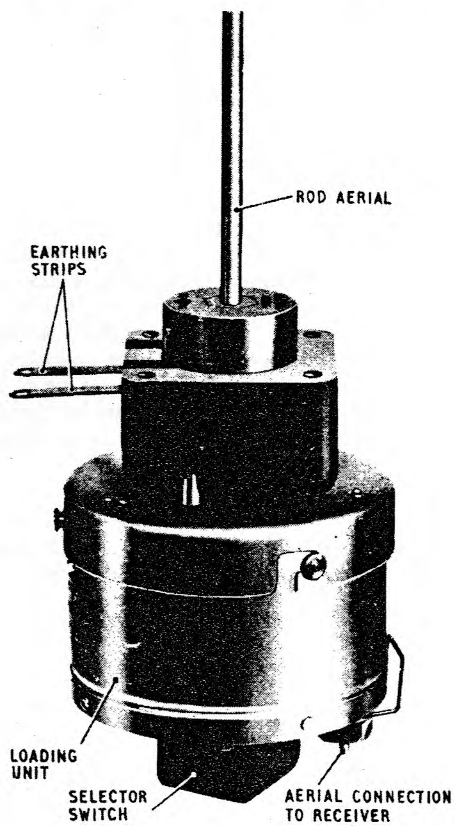

Fig. 5. Aerial 329 with loading unit 51

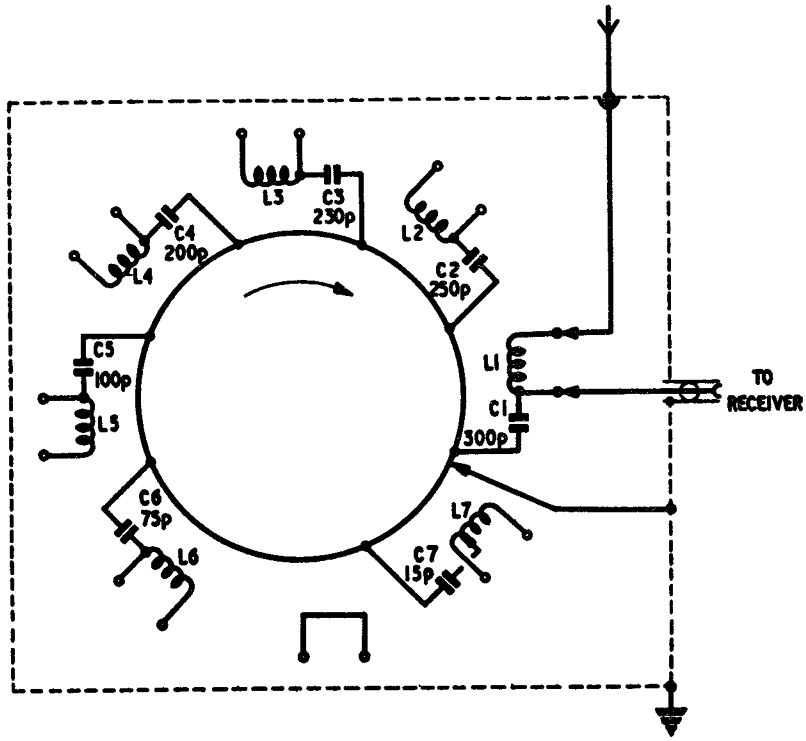

Fig. 6. Circuit of loading unit 51

21. At frequencies lower than 65 Mc/s the aerial is less than a quarter-wave in length and its impedance is compounded of a capacitive reactance in series with a resistance; the reactance increases with decreasing frequency and the resistance decreases. At frequencies higher than 65 Mc/s the aerial length is greater than a quarter-wave, and its impedance is compounded of an inductive reactance in series with a resistance; both the resistance and the reactance increase with increasing frequency.

22. Compensating circuits are thus necessary to avoid serious mismatching at other than the resonant frequency. In theory, a separately tuned circuit is required for each frequency to be used, but in practice, because a certain amount of mismatching can be tolerated, the complete Gee range can be covered in eight bands. One of these bands (No. 7) is the coverage provided by the uncorrected aerial rod alone. Switching is carried out in an RF turret assembly.

23. The bands are:—

Switch position	Range (Mc/s)
1	22·1 to 23·6
2	23·6 to 25·7
3	25·7 to 28·0
4	28·0 to 30·8
5	42·0 to 47·5
6	47·5 to 54·5
7	54·5 to 73·0
8	73·0 to 85·0

24. The complete circuit of the loading unit is shown in fig. 6. In the first six positions of the control switch, a series LC circuit is connected between the aerial and earth (represented by the body of the aircraft), and the output is taken from across the capacitive element. In the seventh position the aerial connects straight through to the output socket. In the final (eighth) position a series LC circuit connects between the aerial and earth as before, and a series inductance feeds from the capacitance to the output socket.

Low-frequency operation

25. On frequencies below the aerial resonant frequency the effective circuit of the aerial system is shown in fig. 7. The aerial rod is represented as a capacitive reactance (X_a) in series with a resistance (R) between the plug end of the rod and the earth provided by the body of the aircraft. Components of the matching unit, in any one of the first six position, are shown as the reactances X_b, X_d, X_c.

26. The first loading reactance (X_b) is chosen to be of equal and opposite reactance to X_a, so that the combined impedance of $R+X_a+X_b$ is equal to the pure resistance of R alone. This resistance is then considered in series with the second loading reactance (X_d), which is so chosen that the equivalent parallel circuit (*fig.* 8) has a resistive component (R′) equal to the desired output impedance of 45 ohms. A capacitance of equal and opposite reactance to the remaining shunt reactance (X'_d) is then connected across the circuit to cancel X'_d, so that the output impedance consists of the 45-ohm resistive component only.

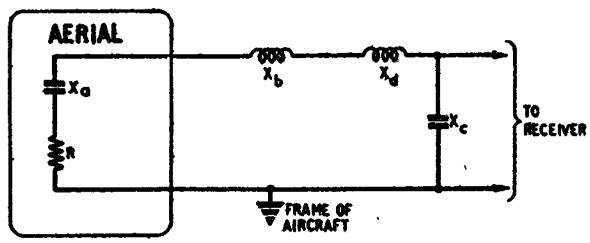

Fig. 7. Low-frequency equivalent of aerial system

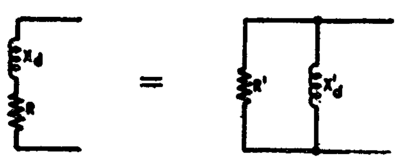

Fig. 8. Equivalent parallel circuit

27. As an example, at 52 Mc/s (range 6) the aerial has a resistance of 20 ohms and a capacitive reactance of 90 ohms; X_b is therefore made to be 90 ohms inductive so that it cancels X_a and leaves a resistance of 20 ohms. X_d of 22·5 ohms in series with this resistance produces a circuit which is equivalent to a parallel circuit of 45 ohms resistive and 40 ohms inductive; a shunt capacitance (X_c) of 40 ohms thus cancels the inductive component leaving only the resistive component.

28. In practice, the two elements of inductance, being in series, are wound together and fitted as a single coil. The capacitive reactance X_c (C6 on range 6) is fitted between the end of the coil and earth.

Resonant operation

29. At and around 65 Mc/s the aerial rod is self-resonant and has an impedance of the desired 45 ohms resistive. The matching unit on range 7 which covers this frequency band contains a shorting link which couples the aerial straight through to the output terminal.

High-frequency operation

30. At frequencies above the aerial resonant frequency the effective circuit of the system is shown in fig. 9. As before, the aerial is represented as a reactance and resistance in series to earth, but the reactance (X_a) is inductive and not capacitive, because the aerial its greater than a quarter-wave in length. Components of the matching unit, on range 8 only, are shown as before.

31. The first loading reactance is inductive like the aerial so that it raises the effective reactance of the circuit. The equivalent parallel circuit of the combination is, as in fig. 8, equal to different values of inductance and resistance. This circuit is shunted by the capacitance X_c which more than cancels the inductive component so that effective impedance becomes that of a resistance in parallel with a capacitive reactance; the equivalent series impedance of the circuit (*fig.* 10) is that of a resistor R′ (of value 45 ohms) in series with a capacitive reactance (X'_c). The final loading element (X_d) is then chosen to be equal and opposite in reactance to that of X'_c leaving the output impedance as that of the resistance R′ alone.

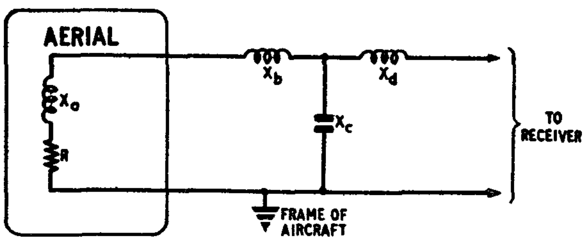

Fig. 9. High-frequency equivalent of aerial system

32. At the particular frequency of 80 Mc/s the aerial has a resistance of 100 ohms and a reactance of 150 ohms inductive. The added reactance is of the order of 50 ohms inductive, giving a total reactance of 200 ohms inductive. The equivalent parallel circuit has a resistance of 500 ohms and a reactance of 250 ohms inductive. At 80 Mc/s X_c has a reactance of about 100 ohms so that the circuit impedance at this point is of a 500 ohm resistance in parallel with a 166 ohm capacitance. This circuit has a series equivalent of 45 ohms resistive and 150 ohms capacitive, and the final inductance, of 150 ohms, cancels out the capacitance, and leaves the output impedance as the 45 ohms resistive component only.

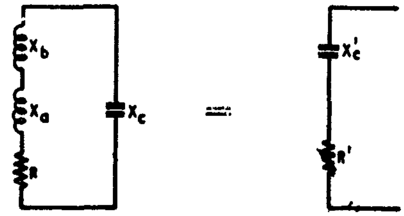

Fig. 10. Equivalent series circuit

33. Part of the reactance X_c, is provided by C7, and the remainder is contributed by the circuit strays. The two inductances are provided by the single coil, L7, which is tapped along its length to take the earth return through C7.

AERIAL SCHEME A

34. Application of the aerial scheme B is limited by the layout of the aircraft as well as by its speed range, because it can only be fitted in aircraft where direct access is possible to the switch on the loading unit. Where such access is not possible, but the speed range is suitable for the use of a whip aerial, the aerial scheme A is used. The basic system is shown in fig. 11.

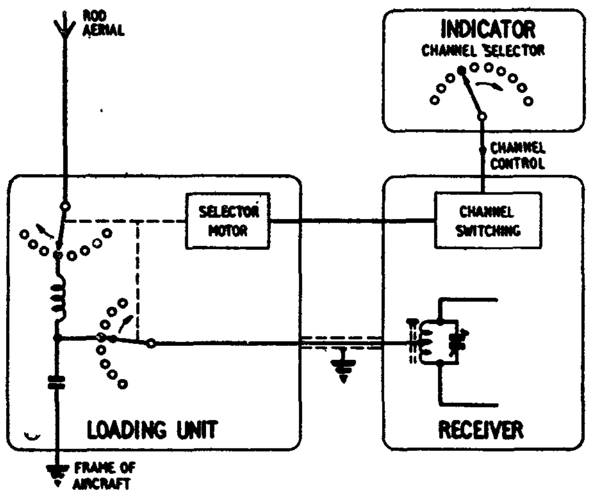

Fig. 11. Outline of aerial scheme A

35. The items of equipment involved are as follows:—

(1) Aerial aircraft Type 329A, Stores Ref. 10B/17322.

(2) Loading unit, aerial (motorised) Type 55, Stores Ref. 10B/17184.

(3) Junction box Type 399, Stores Ref. 10D/18894.

(4) Connector—loading unit to junction box.

(5) Connector—junction box to receiver junction box.

(6) Connector—junction box to DC supply.

(7) Connector—loading unit aerial point on receiver junction box.

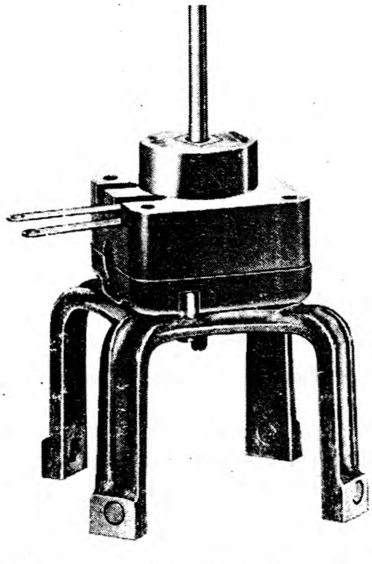

Fig. 12. Aerial, aircraft, Type 329A

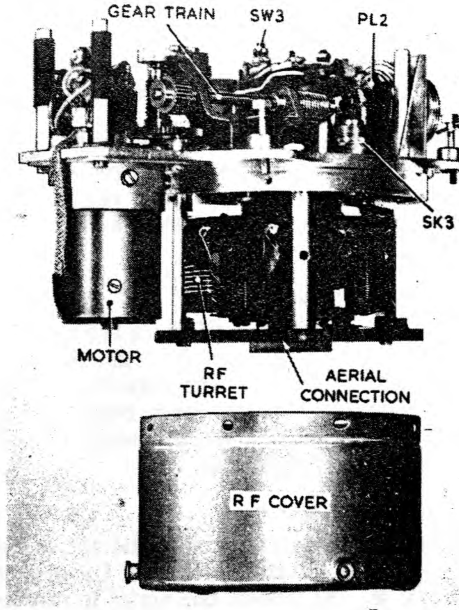

Fig. 15.—Under view of loading unit 55

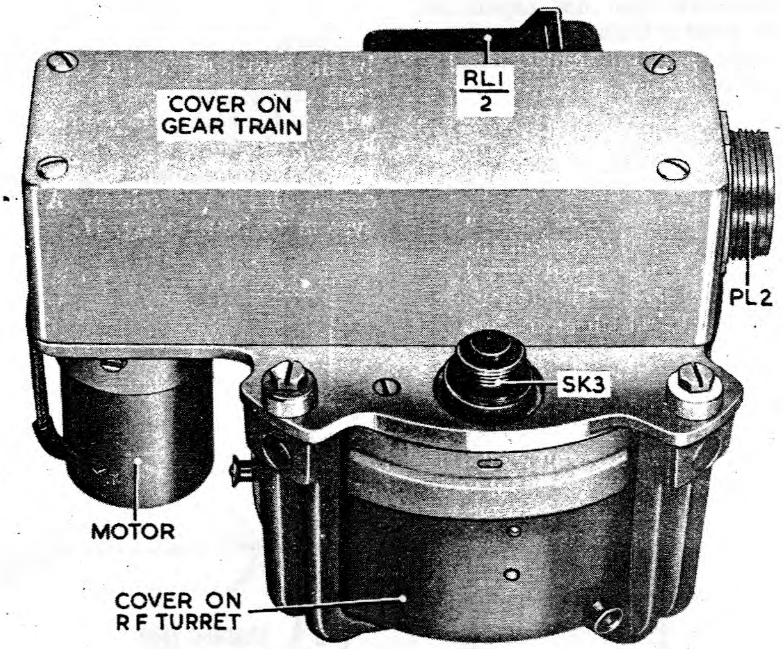

Fig. 13. Loading unit Type 55 with support

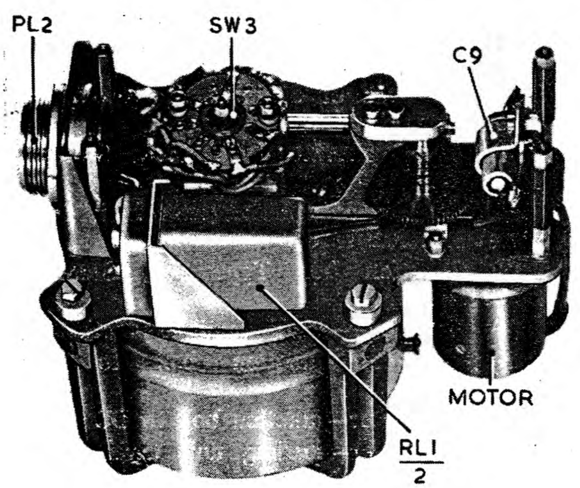

Fig. 14. Top view of loading unit 55

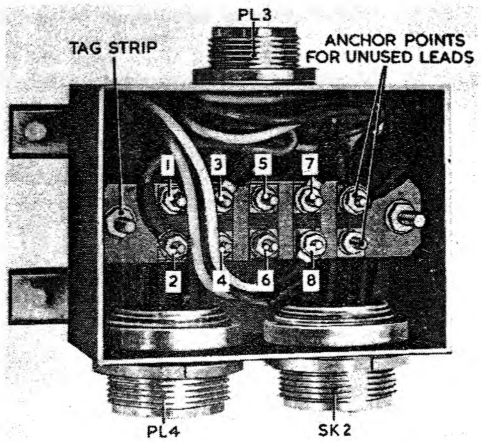

Fig. 16. Junction box Type 399

Aerial, aircraft, Type 329A

36. The aerial proper, shown in fig. 12, consists of four main parts as follows:—

(1) Rod aerial Type 257, Stores Ref. 10B/1979.
(2) Body (bollard), Stores Ref. 10B/13178.
(3) Support Type 109, Stores Ref. 10AQ/602.
(4) Plug (aerial), Stores Ref. 10H/20209.

37. The only difference between the aerial Type 329A and the previously described 329, is in the fixing element provided for the associated loading unit, as can be seen from a comparison of fig. 2 and 12.

38. In early versions of the equipment, the support Type 109 was included as part of the loading unit (combined Stores Ref. 10B/17349) and the aerial Type 329 was fitted after first discarding the tray Type 369. Subsequently the aerial Type 329A was introduced and Mod. No. 2890 authorized the necessary changes to convert the 329 to the 329A. A point of note is that the 329A must have the improved plug introduced by Mod. No. 2891.

Loading unit Type 55

39. The loading unit for aerial scheme A is the RF section of the previously described loading unit Type 51 with a motor-operated switching system in place of the manual control. From fig. 13, 14, 15, it will be seen that the RF turret is mounted to an assembly plate which carries also a gear train operated from a miniature motor, and control equipment consisting of a relay and switch. In fig. 13 and 14 the support is shown in position on the loading unit.

Junction box Type 399

40. The junction box Type 399 is illustrated in fig. 16. It is a link box in which connections between the channel switching of the Gee equipment and the motor of the loading unit can be adjusted, so that any range of the loading unit can be selected in any position of the Gee channel switch.

41. Eight tags in the junction box are connected via SK2 to the loading unit, and connections from the Gee receiver are brought through PL3 to ten flying leads. Each flying lead represents a particular Gee channel. The leads are connected to the tags as appropriate. The additional plug on the junction box, PL4, provides for a 24V DC input to the controlling motor.

Installation of aerial scheme A

42. Installation requirements for aerial scheme A are the same as for scheme B as regards aerial angle, but, because control of the loading unit is carried out remotely from the Gee indicator, the aerial position is not limited to being within easy reach of an operator. In consequence it may be placed at any electrically-suitable position in the

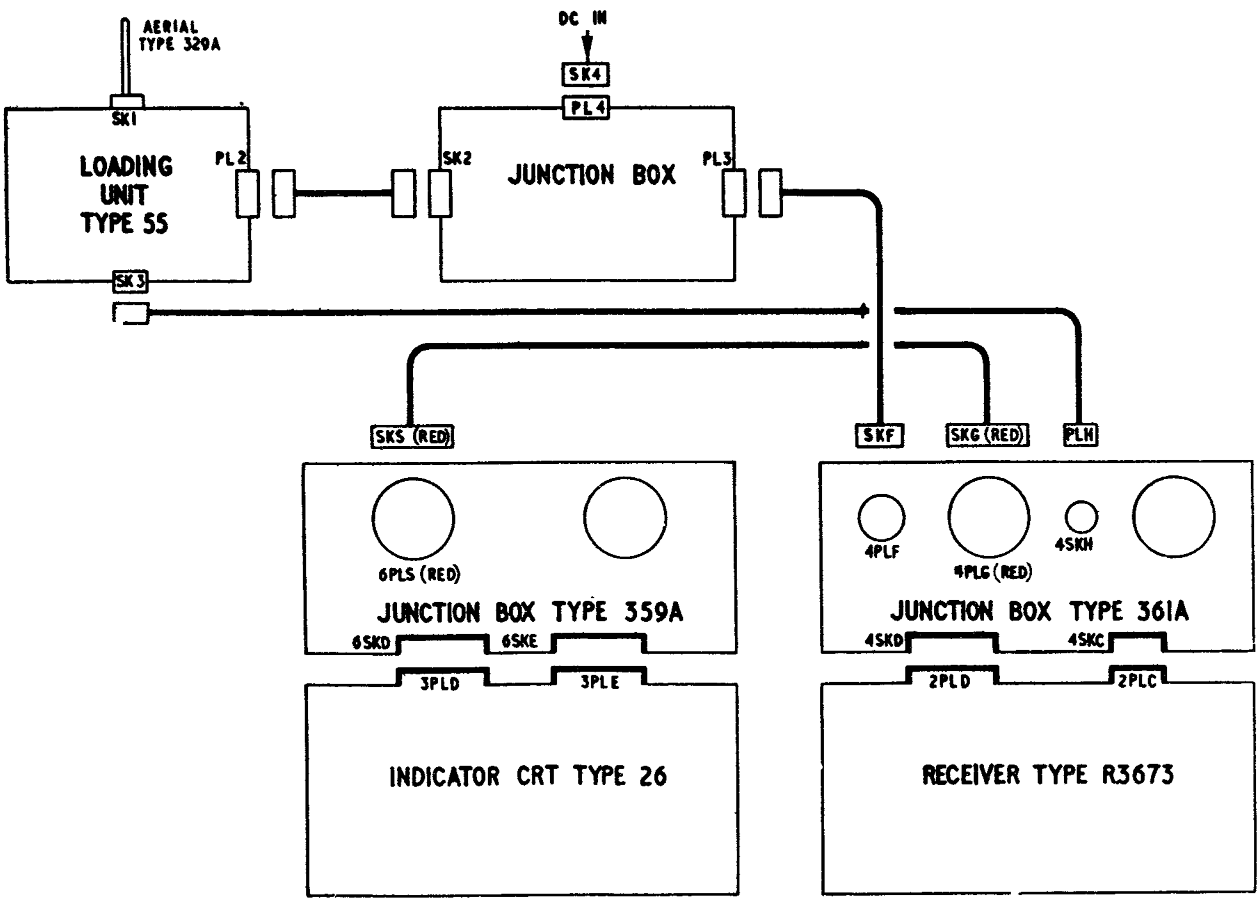

Fig. 17. Layout of aerial scheme A

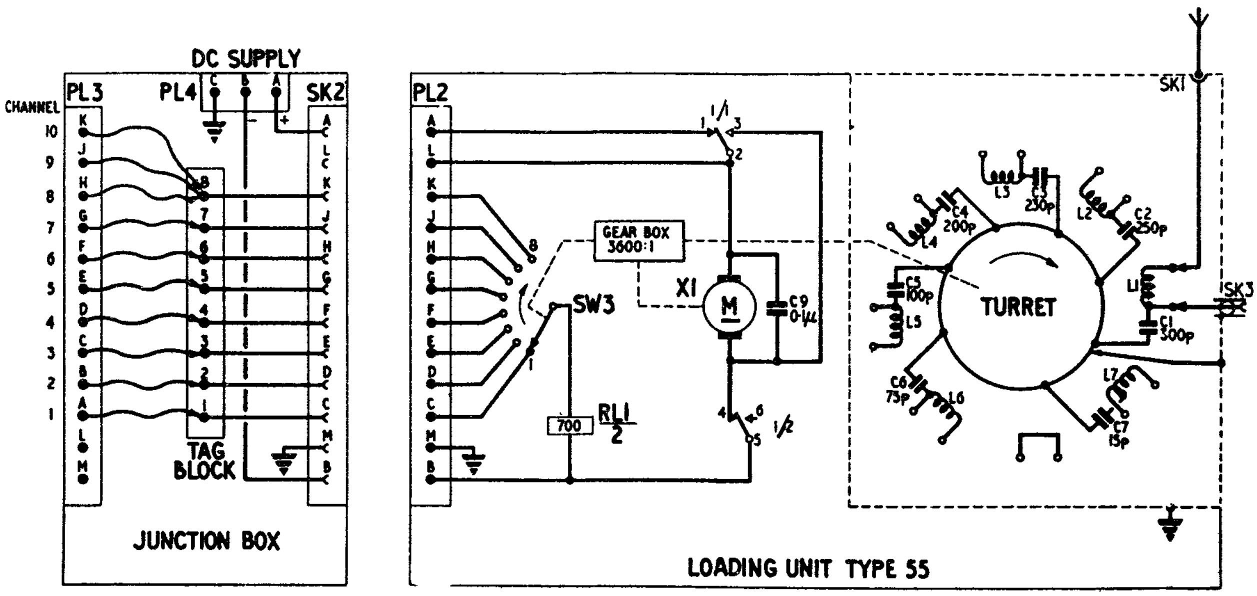

Fig. 18. Circuit of loading unit 55 and junction box

aircraft. The junction box may be sited anywhere, but it must be sufficiently accessible to permit changes to the connecting links in situ.

43. For securing to the aircraft, the aerial unit is inserted through a hole in the aircraft skin and the body is secured by four screws. The turret part of the loading unit is then fitted into the legs of the support and secured by means of four hexagonal head screws which are captive to the loading unit.

44. The electrical layout of the installation, showing also the wiring of the Gee equipment proper which contains part of the aerial control circuits, is shown in fig. 17. The aerial output connection from the loading unit goes to 4SKH on the receiver junction box, and the control connections extend between 6PLS and 4PLG in the Gee equipment wiring, and from 4PLF to PL2 on the loading unit via PL3 and SK2 of the junction box. A 24V DC input from the aircraft supply is brought to PL4 of the junction box.

Circuit of aerial scheme A

45. The circuits of the loading unit and junction box are shown in fig. 18, from which it will be seen that the junction box consists of wiring only but has provision for the ten connections to PL6 to be made to any of eight of the connections to SK4 via a tag block. The loading unit includes the RF turret driven through a gear box by a motor which is relay controlled from a circuit including a follower switch (SW1) also driven by the motor; the relay contacts connect the circuit to the power input points (A and B on PL3) when the relay is not energized. The RF turret is identical with that used in the loading unit Type 51.

46. An outline of the circuit of the aerial scheme is shown in fig. 19. In this illustration, for the sake of simplicity, the connections for one channel only are shown, and the conditions are as they would be when that channel (No. 1) is being selected, but, following normal convention when drawing relays, power is not connected.

47. The master control of the system is the channel selector switch (3S5) in the Gee indicator unit. This switch is a ten-way selector connected through the inter-unit wiring to a further ten-way selector (2S4A) in the receiver unit. The slider of 2S4A is connected to a relay (2RL2) so that when the two switches are in the same position (as shown) the relay circuit is complete. The contacts of the relay control the DC supply to a motor (2M2) in the receiver; when the relay is not energized the circuit to the motor is complete.

48. The circuit considered so far forms the normal channel switching in the Gee equipment. When power is applied under the conditions shown in fig. 19, 2RL2 is energized and the contacts 2/1 and 2/2 open to break the circuit to the motor; the receiver RF switches also controlled by the motor will thus be at channel 1. If 3S5 is turned to some other channel, the circuit to 2RL2 is broken and contacts 2/1 and 2/2 are made: power is then applied to the motor which operates and turns the RF switches and 2S4A until 2S4A moves round to the channel newly selected by 3S5; the circuit to 2RL2 is thus again completed and the motor is disconnected.

49. A second ten-way selector switch (2S4B) is also operated by 2M2. This switch is connected through the link panel of the aerial system junction box to the contacts of the follower switch SW3 of the loading unit. In fig. 19, contact 1 of 2S4B is shown connected to contact 1 of S1, but in practice by appropriate connection within the junction box, any contact of 2S4B may be connected through to any of the contacts of S1, so that any of the channels of the loading unit may be selected in any channel position of the receiver.

50. The follower switch in the loading unit controls a relay (RL1) which in turn controls the application of power to a motor (X1) in the loading unit. As with the master circuit, when the relay is not energized, the relay contacts complete the circuit to the motor. The motor drives the RF turret through a gear box and also controls the follower switch (SW3).

51. If the selector switch is turned, as in para. 48, and the receiver motor operates, 2S4B is turned and the circuit to SW3 is broken so that RL1 is de-energized. Contacts 1/1 and 1/2 then apply power to motor X1 which turns, and rotates the turret and SW3. When the following action in the receiver is complete, the slider of 2S4B will rest on the contact of the channel newly selected by 3S5; the following action of X1 will however continue until the slider of S1 meets that contact which again completes the circuit through RLA when the motor X1 is again de-energized.

52. Operating the selector switch in the indicator unit, therefore, as well as remotely controlling the setting of the channel switches in the receiver and thereby tuning the receiver, also remotely switches the loading unit to set the aerial conditions appropriately for the channel selected. The coverage of the eight positions of the loading unit is not related to the ranges of the ten channels controlled by the receiver, so that the linkages in the junction box have to be adjusted in accordance with the frequencies on which the channels are being used.

Operating

53. With the aerial scheme B it is necessary to set the loading unit control switch to the appropriate aerial channel each time a channel is selected at the indicator. In practice therefore, after each channel change, the aerial control can either be set to the corresponding position, or turned through all positions and set at that position giving maximum signal strength.

54. With the aerial scheme A the links of the junction box must be adjusted, before use, so that the correct aerial channel is automatically selected when the indicator switch is turned. The frequencies represented by the ten receiver channels will be determined by local requirements, hence no standard linking sequence can be recommended. As a guide to linking, however, the frequencies covered by the receiver and aerial are tabulated below:—

Receiver Channel	*Frequency Range (Mc/s)*	*Aerial Channel*	*Frequency Range (Mc/s)*
1	22–32	1	22·1–23·6
2	22–32	2	23·6–25·7
3	22–32	3	25·7–28·0
4		4	28·0–30·8
5		5	42·0–47·5
6		6	47·5–54·5
7	64–78	7	54·5–73·0
8	70–85	8	73·0–85·0
9	70–85		
10	70–85		

Note . . .

All links in the junction box must be connected otherwise the motor of the loading unit will continue running if the channel associated with the disconnected link is selected at the indicator.

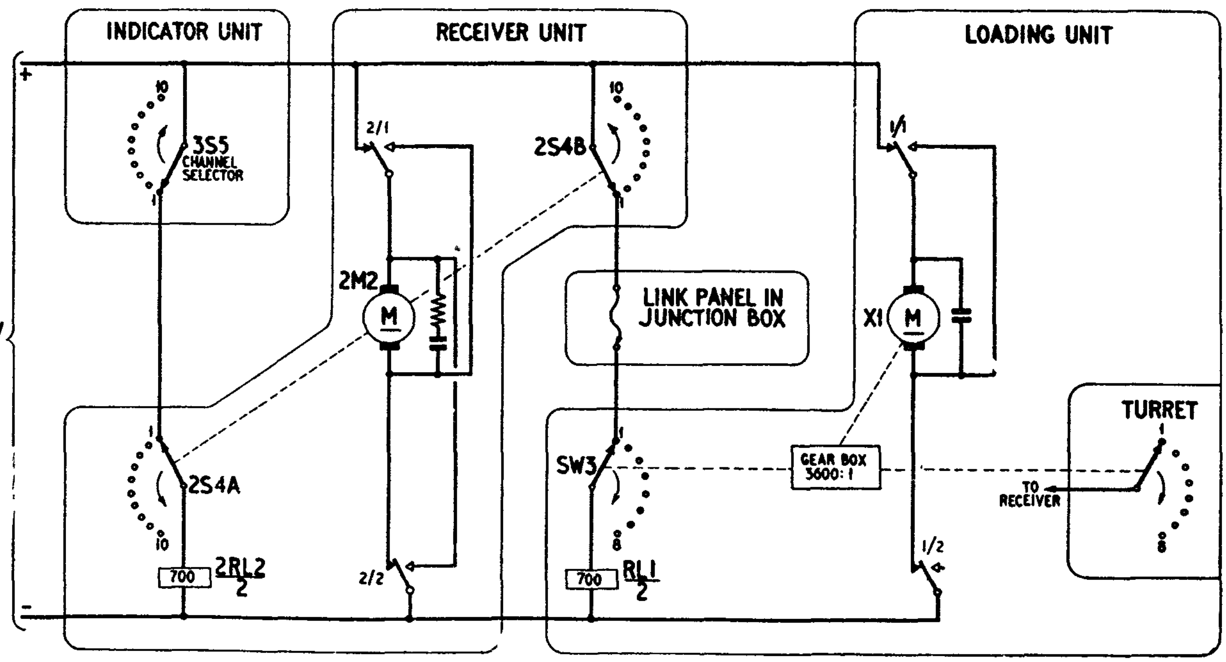

Fig. 19. Outline circuit of aerial scheme A

Chapter 6

SUPPRESSED AERIAL SYSTEMS

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LIST OF ILLUSTRATIONS

Introduction

1. Gee Mk. 3 aerials of the traditional rod type can not be fitted to high-speed aircraft without seriously impairing aerodynamic efficiency. Such aircraft, therefore, require suppressed aerial systems in which some part of the aircraft structure or outer skin is used as the aerial element.

2. In general, suppressed aerials are designed separately for each type of aircraft, and the associated fittings, which provide for matching and extending useful operation over the full Gee range, are "tailored" to fit. Such aerial equipment, therefore, being associated with particular aircraft types, is discussed in some detail in the associated aircraft handbook; but as these publications make no provision for detailed information on sub-assemblies it is necessary to describe them herein.

3. This chapter will contain, therefore, details of such aerials and their matching fittings under the title headings of the parent aircraft. As new aircraft types with special Gee aerials are introduced, the chapter will be amended accordingly.

METEOR NF 11, 12 AND 14

4. In the Meteor NF 11, 12, 14 aircraft the upper rudder is used as the Gee aerial. The basic technique, illustrated in fig. 1, involves insulating the bottom of the upper rudder from the framework and ensuring good electrical contact across the rudder hinge to connect the top of the rudder to the fin. The resulting aerial when fed between the bottom of the upper rudder and the torpedo fairing operates as a folded unipole resonant in the region of 75Mc/s.

5. The practical methods of using the rudder are also illustrated in fig. 1. The torque tube, which provides the rudder turning action, is modified by the insertion of an insulating section, and the capacitance between the rudder and the top of the fairing is reduced by cutting part of the fairing away and substituting a dielectric material. Additionally it is necessary to control the gap size between the rudder and fin more carefully than was previously necessary. A phosphor bronze strip is connected across the upper hinge to provide electrical contact.

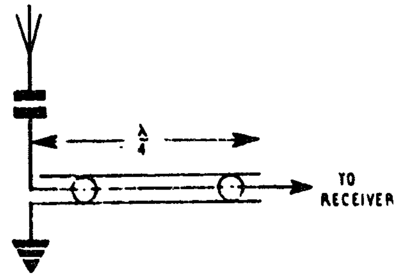

Fig. 2. Basic matching circuit

6. The electrical characteristics of this system are such that over the wide range from 30Mc/s to 85Mc/s a satisfactory match is provided to a standard 45-ohm feeder, but over the additional Gee range from 22Mc/s to 30Mc/s some compensation is necessary to prevent undue loss of signal due to mismatching. At all frequencies the aerial has a vertically polarized all-round coverage, as required.

Impedance matching

7. The band from 22Mc/s to 30Mc/s is divided as follows for the purposes of matching the aerial:—

Band A—22Mc/s to 26Mc/s
Band B—26Mc/s to 28Mc/s
Band C—28Mc/s to 30Mc/s

8. Over all these frequencies the aerial is inductive, and the matching technique consists of introducing series capacitance into the aerial circuit to neutralize the inductance, followed by a transformer to raise the resistive component of the aerial impedance to the required 45 ohms. The transformer consists of a concentric line of 15 ohms impedance and of length equivalent to a quarter-wavelength at 24Mc/s. The basic system is shown in fig. 2.

9. The practical system is complicated first by the need for the matching change-over to take place automatically as the receiver is tuned, and second because the receiver channels may be preset over wide ranges. Thus a switching system is used which is operated remotely from the receiver and which makes provision for any one of the four aerial conditions to be available on any receiver channel.

10. The outline aerial system therefore is shown in fig. 3. The aerial is connected through a matching unit to the receiver, and a junction box is included in the channel switching from the receiver to this matching unit. The junction box providies facilities for selecting the aerial channels to be appropriate for the receiver channels.

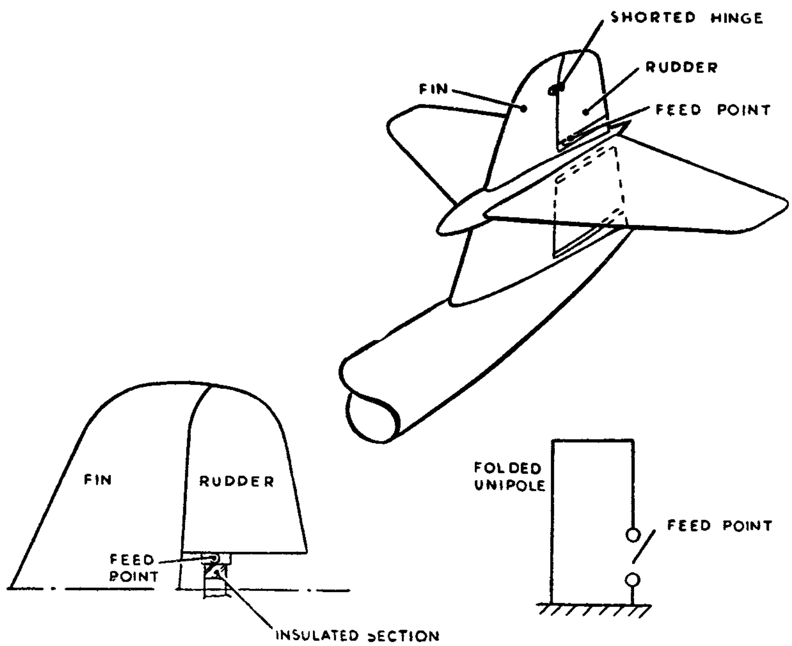

Fig. 1. Meteor rudder as aerial

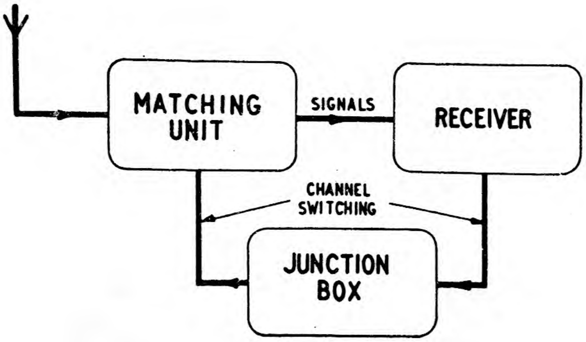

Fig. 3. Outline aerial system

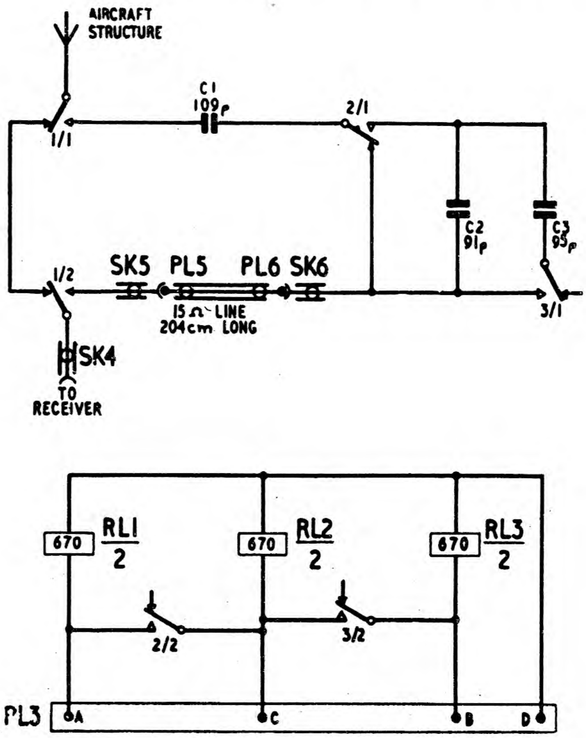

Fig. 5. Circuit of IMU.267

Matching equipment

11. The equipment involved is as follows:—

(1) Impedance matching unit Type 267, Stores Ref. 10B/16283

(2) Connector, moulded (matching) 10HA/13286

(3) Junction box Type 502, Stores Ref. 10D/18937.

12. The impedance matching unit is illustrated in fig. 4 and its circuit is shown in fig. 5. The complete unit is fitted inside the torpedo fairing beneath the fin and rudder with the rudder connection at the end extending through a vertical connecting rod to the rudder support flange above. When fitted, the unit is upside down as compared with the views of fig. 4. As seen from fig. 5, the circuit consists of three relays, whose contacts are in the relay control circuit and in the circuit including three capacitors, between the aerial connection point and the output to the receiver. The connector, which is the concentric transformer, is also connected into the circuit via sockets SK5 and SK6.

13. The junction box (*fig.* 6 *and* 7) is a simple unit containing only a relay and connector panel. Six connections from the input plug, which are control lines for channels 1 to 6 of the Gee receiver, go to six points on one side of the connector panel; three

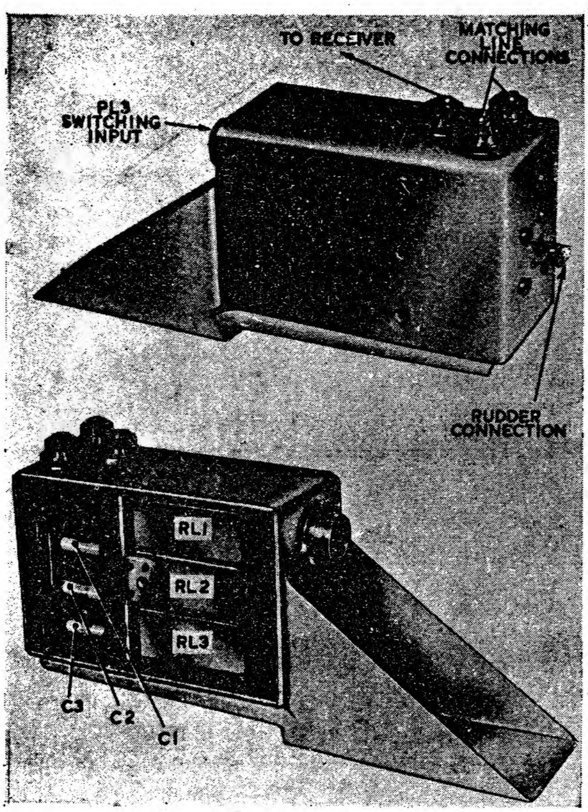

Fig. 4. Impedance matching unit Type 267

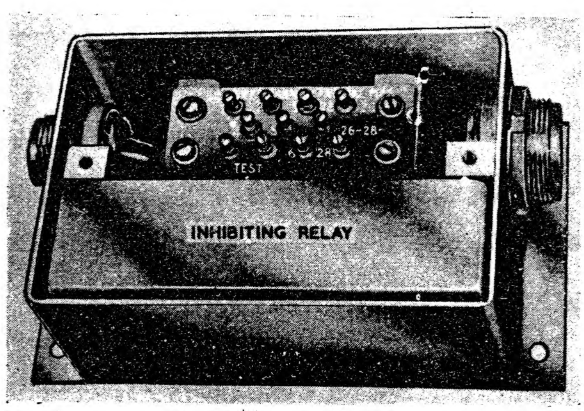

Fig. 6. Junction box Type 502

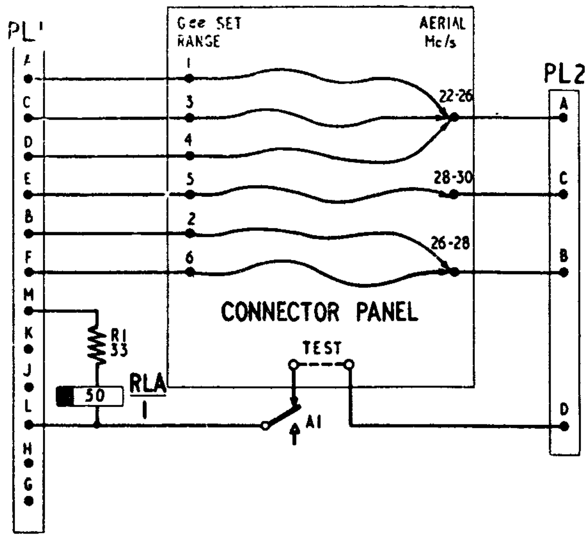

Fig. 7. Circuit of JB.502

points on the other side take the control outputs to the output plug and the matching unit. Links can be connected, as required, between the channel points and the aerial points to allow appropriate matching conditions to be selected. Two other tags on the panel are test points, normally shorted together.

Aerial circuit

14. From fig. 5 it will be seen that when no relay supply is being fed to PL3, the circuit from the aerial to the receiver goes direct through contacts 1/1 and 1/2. When the relays are being energized three separate paths through the unit are possible. Thus four operating conditions are available as follows:—

(1) No relay supply: all relays non-energized, aerial circuit straight through; working condition for frequencies above 30Mc/s.

(2) Supply between A and D: relay RL1 energized: contacts 1/1 connect aerial through C1, 2/1, the concentric line, and 1/2 to the receiver: working condition for 22Mc/s to 26Mc/s.

(3) Supply between C and D: relay RL2 is energized and contacts 2/2 energize RL1 also: aerial circuit via 1/1, C1, 2/1, C2, concentric line, and 1/2: working condition for 28Mc/s to 30Mc/s.

(4) Supply between B and D: relay RL3 is energized, and contacts 3/2 energize RL2, and contacts 2/2 energize RL1: aerial circuit via 1/1, C1, 2/1, C2 and C3 in parallel, 3/1, concentric line and 1/2: working conditions for 26Mc/s to 28Mc/s.

The basic circuits of the four conditions are shown in fig. 8.

15. Functioning of the system as a whole is shown in fig. 9. The starting point is the channel switching arrangement consisting of channel selector 3S5 in the indicator which controls motor 2M2 through follower switch 2S4A, in the receiver. In the quiescent state, when a particular channel is in use, the circuit to relay 2RL2 is made through 3S5 and 2S4A and contacts 2/1 and 2/2 break power to the motor. If then 3S5 is turned to select a different channel, the circuit to the relay is broken and the motor is energized as contacts 2/1, 2/2 operate. The motor then runs, turning 2S4A and 2S4B. As 2S4A turns, it moves through each position until it meets the contact which connects to the selected contact on 3S5; the circuit is therefore completed to the relay which energizes and cuts out the motor.

16. Selection of a particular channel in the receiver, therefore, turns 2S4B to a particular position which puts the 24V positive supply to a particular input line of the junction box. As required, then, this line is connected to any one of the three input points to the matching unit, or left disconnected, in the junction box, and the relays of the matching unit are energized according to the channel required.

17. Relay RLA in the junction box is described as an inhibiting relay; if it were not fitted, then, depending on the channel being selected, the relays of the matching unit might be energized as the selecting action proceeded, and, because of the interlocking connections between the relays, would

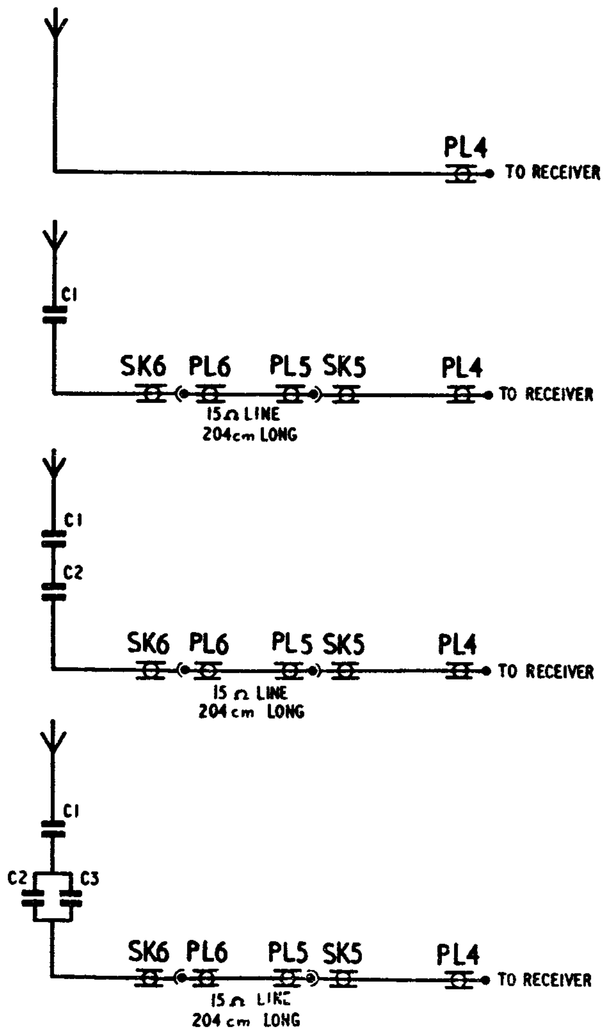

Fig. 8. Operating conditions

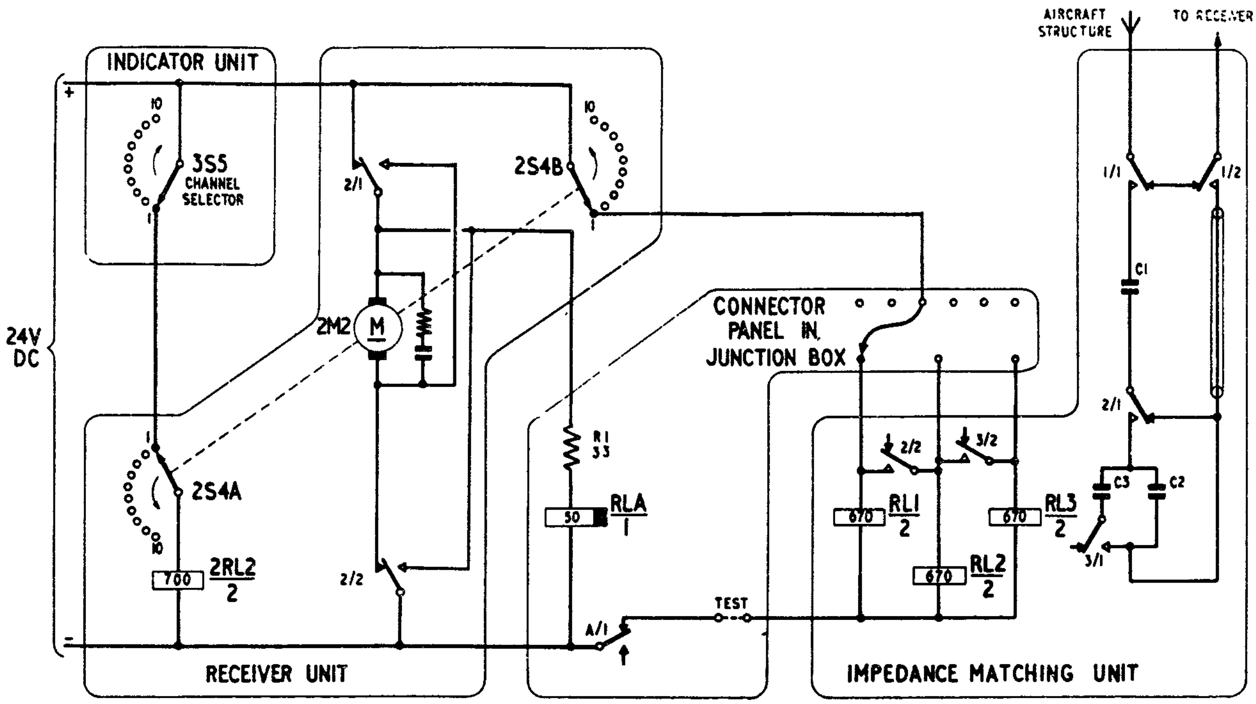

Fig. 9. Outline of complete circuit

not necessarily release to the required channel at the end of the action. The operation of the relays is therefore inhibited during a selecting action by relay RLA. When, therefore, a channel is selected and the motor starts to turn, the motor supply is immediately connected to this relay which energizes; contacts A1 are thereby opened and the negative line to the matching unit is broken. When the channel selection is complete and the motor supply is broken, the relay RLA is short-circuited through contacts 2/2, and contacts A1 close to connect the negative supply to the matching unit. A fraction of a second elapses between the de-energizing of RLA and the closing of A1, because of the slow-release operation of RLA, so that the main selection action is completely finished before the aerial relays can operate.

18. The general layout of the system is shown in fig. 10. The connector between the indicator and the receiver carries the main switch selector circuits, that from the receiver to the matching unit is the aerial lead, and that from the receiver to the junction box is the control supply.

19. Apart from the inhibiting line and the negative return, ten control lines are taken to the junction box. However, only receiver channels 1 to 6 inclusive might operate between 22Mc/s and 30Mc/s, therefore the lines for channels 7 to 10 are not connected in the box, so that when these channels are selected the straight-through connection of the matching unit is ensured.

20. A typical connection condition for the junction box is shown below:—

Receiver channel	*Frequency (Mc/s)*	*Connections*
1	24	1 to 22–26
2	27	2 to 26–28
3	23·5	3 to 22–26
4	25	4 to 22–26
5	29·5	5 to 28–30
6	26·5	6 to 26–28

If any of these channels were required to work above 30Mc/s, their tags would be left disconnected.

Testing

21. A pair of test tags are placed in the negative line to the matching unit, in the junction box. They are normally connected together, but for test purposes they allow the current drawn by the relays to be measured. A check that the relays are operating is carried out as follows:—

(1) Remove the short-circuit from the test tags.

(2) Connect a 0–150mA milliameter between the tags.

(3) Set the receiver to select the three aerial bands in sequence: the current reading (with DC supply at 24V and in proportion at other voltages) should vary in the following manner:—

Band 22–26— 36mA
Band 28–30— 72mA
Band 26–28—108mA.

22. To check that the RF switching is operating correctly, select a channel on each band in turn, and on each band note the effect of removing the short-circuit from the test tags. For correct operation there should be a noticeable reduction in signal strength, as viewed on the indicator, on each band when the short-circuit is removed.

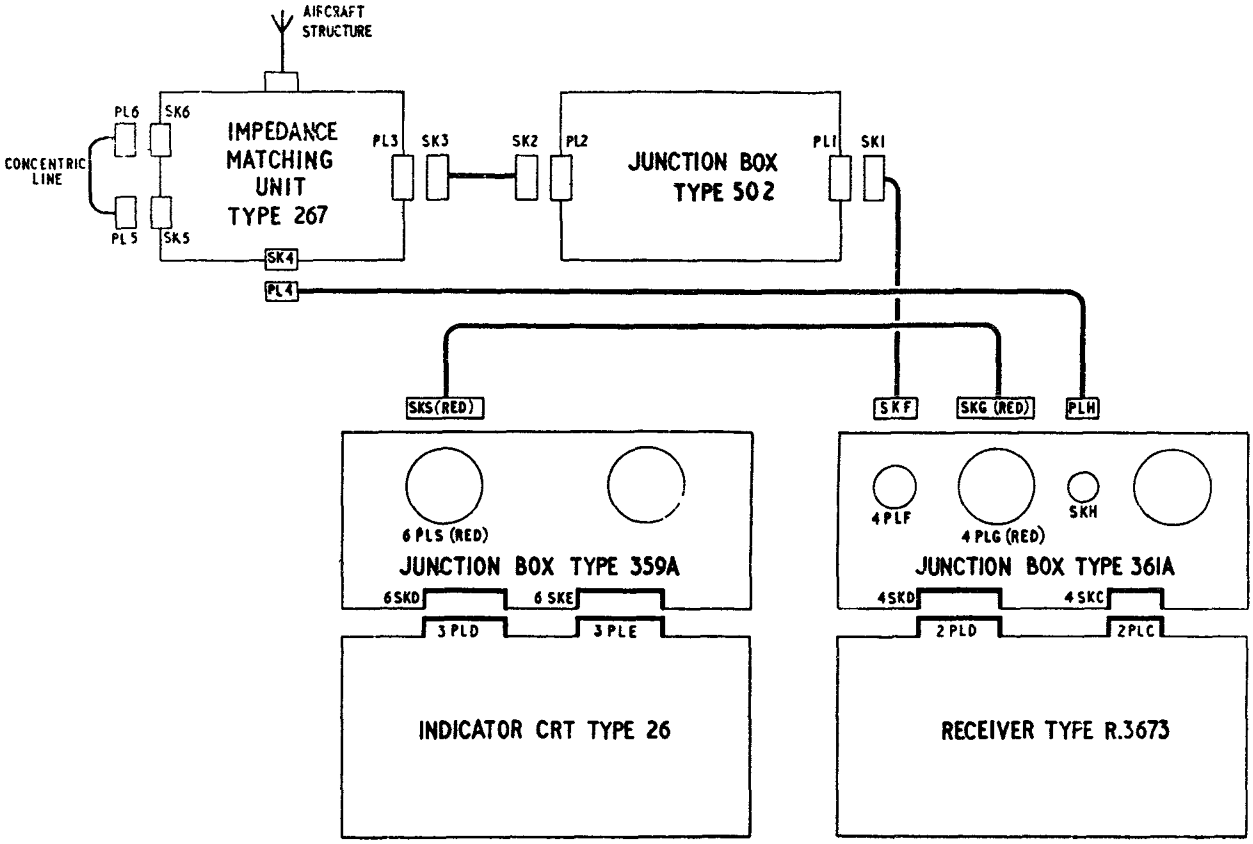

Fig. 10. Layout of Meteor system

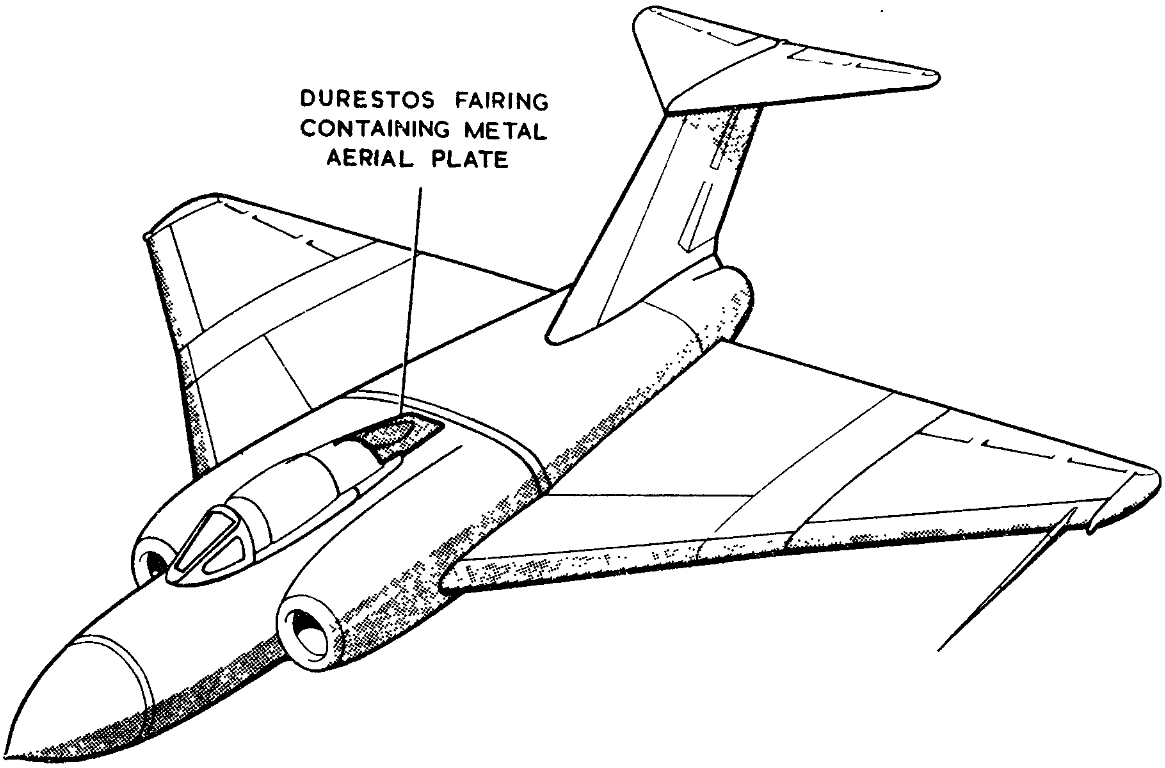

Fig. 11. Javelin: position of aerial

JAVELIN

23. In the Javelin aircraft the aerial consists of a metal plate, approximately four feet by two feet, which is moulded into a Durestos fairing situated behind the observer's cockpit. The position and shape of the aerial are illustrated in fig. 11.

24. Although the metal sheet which forms the aerial has considerable extension in the horizontal plane, the height of the centre of its forward edge above its port, starboard and after edges, provides a sufficient vertical distribution of metal to permit the reception of the vertically polarized transmission from the Gee ground stations. Roughly speaking, the aerial may be regarded as equivalent to a short vertical rod.

Impedance matching

25. The aerial is required to operate over the frequency band 22 to 85 Mc/s. The aerial impedance has a resistive component which is low throughout the band and a reactive component which varies considerably with frequency in both magnitude and nature, being capacitive at the low frequency end of the band and inductive at the high-frequency end. It is therefore necessary to insert an impedance-matching circuit between the aerial and the cable that conveys the signal to the receiver, and to provide means to change the matching circuit as the receiver frequency is switched from one value to another. For this purpose the frequency band 22 to 85 Mc/s is divided into six parts:—

(1) 22 to 28 Mc/s.
(2) 28 to 31 Mc/s,
(3) 31 to 48 Mc/s,
(4) 48 to 63 Mc/s,
(5) 63 to 84 Mc/s,
(6) 84 to 85 Mc/s.

Four matching circuits are provided, as illustrated in fig. 12, each of which is used in either one or two of the six divisions of the band.

26. Referring to fig. 12, the signal for the receiver is taken from the aft end of the sheet which forms the aerial. Over most of the Gee band the aerial is terminated by a coaxial stub consisting of 25 cms. of 95-ohm cable (fig. 12 (a), (b), and (d)). In fig. 12 (a) the circuit is tuned to 24 Mc/s by inserting a fixed capacitor, C1, between the forward end of the aerial and earth; in fig. 12 (b) the stub is used without additional capacitors; in fig. 12 (d) the circuit is tuned to 60 Mc/s by inserting a fixed capacitor, C3, between the aft end of the aerial and earth. In fig. 12 (c) the stub is omitted and the resistive component of aerial impedance is stepped up to approximately 45 ohms by means of a length of 110 cms. of 15-ohm cable which acts as a matching transformer; the capacitor, C2, tunes the circuit to 43 Mc/s.

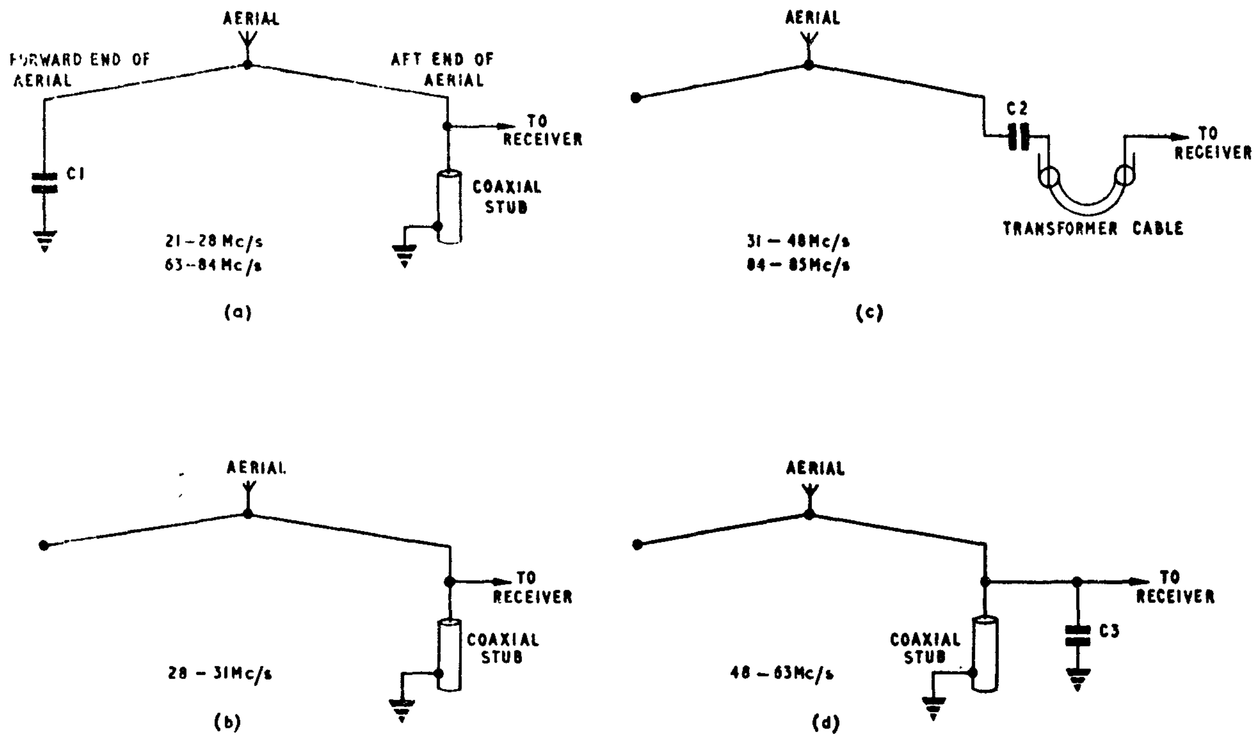

Fig. 12. Matching circuits

27. The required matching circuit is selected by a system of relays. To control the operation of the relays, use is made of the aerial-switching wafer of the wave-change switch in the Gee receiver. This wave-change switch (which is remotely controlled by the channel-selector switch on the Gee indicator unit) also selects the receiver frequency; thus, when the operator switches from one receiver frequency to another, the appropriate matching circuit is introduced automatically.

Matching equipment

28. The matching systems and associated circuits are located in three separate units:—

(1) Impedance matching unit (aft) 4708;

(2) Impedance matching unit (forward) 4707;

(3) Junction box 4706;

in addition, the transformer cable (*fig. 12 (c)*) is mounted externally on the matching unit (aft) and forms a separate item:—

(4) Connector (moulded) 10205/2

Circuit description

29. The circuit diagrams of the two matching units and the junction box are given in fig. 13, which also includes the circuit of the associated portion of the receiver and shows the individual connections between the units.

30. The matching unit (aft) contains two relays, RL2 and RL3. The signal is taken to the unit from the aft end of the aerial and fed out to the receiver via the two sets of contacts of relay RL2. When this relay is de-energized the 25-cm. coaxial stub is connected to the aerial; when it is energized, the stub is disconnected and C2 and the 110-cm. transformer cables are connected in series into the RF-signal line. The capacitor C3 is connected to the aerial when the relay RL3 is energized.

31. The matching unit (forward) contains a relay RL1, and the capacitor C1. A short connector is taken to the unit from the forward end of the aerial and is connected to C1 when the relay is energized.

32. The conditions of the three relays corresponding to the four circuits of fig. 12 are as follows (where "E" denotes that the relay is energized and "U" denotes that it is un-energized):—

Circuit	*RL1*	*RL2*	*RL3*
Fig. 12 (a)	E	U	U
Fig. 12 (b)	U	U	U
Fig. 12 (c)	U	E	U
Fig. 12 (d)	U	U	E

It will be observed that it is never required to energize more than one relay at a time.

33. The relays operate on 24V DC. The DC supply is connected to the appropriate relay by the switch-wafer 2S4B (in the receiver unit) whose position is controlled by the channel-selector switch on the indicator unit by means of a follower motor. Which relay is to be energized in any given position of the switch depends on the corresponding receiver frequency, and in order to facilitate any changes that may be necessary if a

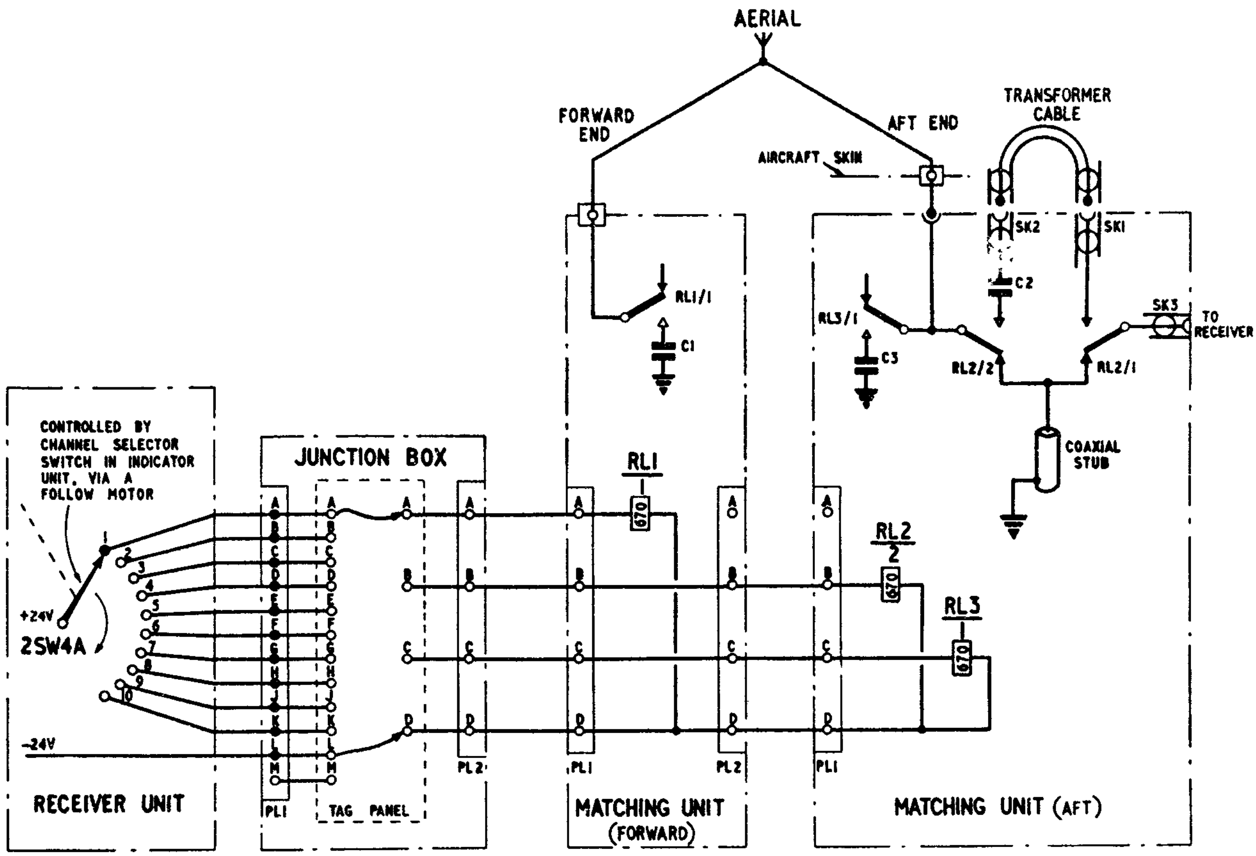

Fig. 13. Aerial system: circuit diagram

channel is tuned to a new frequency, the connections between 2S4B and the relays are completed in the junction box.

34. The positive side of the 24V DC supply is connected to the wiper arm of 2S4B and each of the ten switch contacts is connected to a corresponding terminal on a tag panel in the junction box. These ten terminals form part of a 12-terminal strip and are lettered A to K; the eleventh terminal L, is connected to the negative side of the 24V supply and the twelfth is not used. The junction box also contains a four-terminal strip; terminals A, B and C of this strip are connected to RL1, 2 and 3 respectively; terminal D is connected to the common return lead from the three relays. From each of the ten terminals A to K on the 12-terminal strip, a connection is taken to terminal A, B or C on the four-terminal strip, depending on the frequency of the corresponding channel; if the matching circuit of fig. 12 (b) is appropriate, no relays are required to be energized and no connection is made. Terminal L is connected permanently to terminal D on the four-terminal strip.

Physical description

35. The layout of the system is shown in fig. 14.

36. The matching unit (aft), illustrated in fig. 15, is mounted on the inside of the skin of the aircraft underneath the rear end of the fairing. The connection between the aft end of the aerial and the matching unit is made through a length of tinned copper braid terminated in a plug 975. This plug consists of a metal pin held in a block of PTFE insulating material; the insulating block is fixed into a hole in a square metal panel, 1¼ in. × 1¼ in. approximately, which is bolted permanently to the skin of the aircraft with the pin projecting downwards into the interior of the aircraft. The braid is fastened to the upper end of the pin by means of a nut. The corresponding socket is mounted on the matching unit; the unit is offered up to the plug and secured to a mounting plate which projects approximately ⅛ in. below the inside surface of the skin. It is most important that the top of the unit and the surface of the mounting plate are clean; the performance of the system depends on a satisfactory connection existing between the matching unit and the frame of the aircraft through the mounting plate.

37. The matching unit (forward), illustrated in fig. 16, is mounted on the bulkhead inside the aerial fairing. It is essential that good contact be maintained between the unit and the metal bulkhead. Access to the unit may be obtained, and

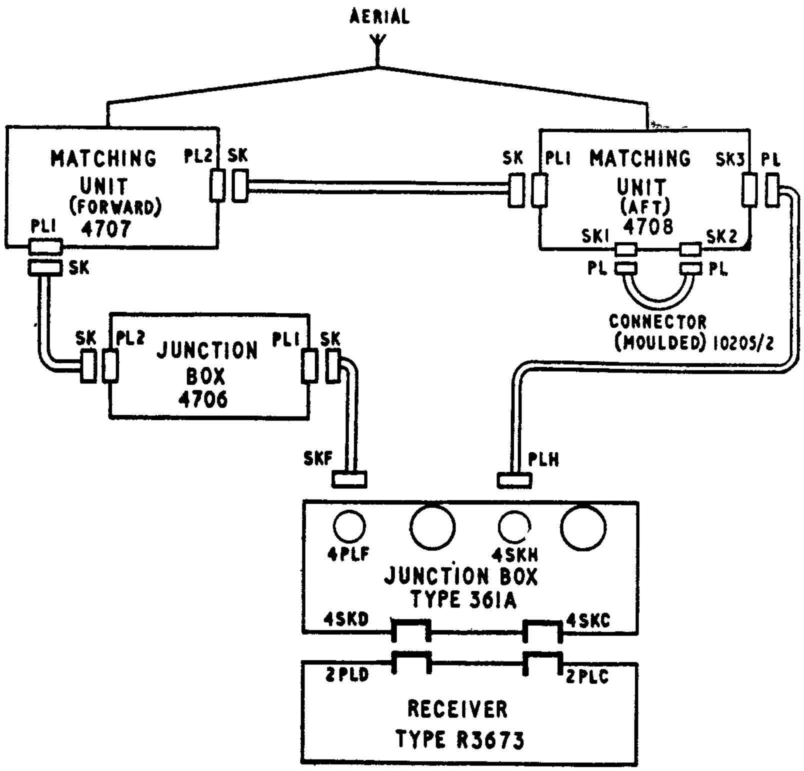

Fig. 14. Aerial system: layout

the unit installed, through two pressurized inspection ports in the bulkhead behind the armour plate behind the observer's seat. The fairing itself may be removed if desired, but the removal is a lengthy process and should not normally be necessary. To facilitate installation, the two plugs, at which the DC switching lines enter and leave, are arranged on sides of the box which face away from each other. The connection between the forward end of the aerial and the matching unit is made through a length of approximately 2½ in. of tinned copper braid. The braid is secured by a nut to one end of a metal pin which leads into the matching unit. The pin is held in an insulator mounted on the unit.

Junction box connections

38. The junction box is illustrated in fig. 17. The connections in this box determine the matching circuit in use for each position of the channel selector switch on the indicator unit. The soldering tags lettered A to K on the 12-terminal strip correspond respectively to the positions 1 to 10, of the switch. The soldering tags lettered A, B and C on the 4-terminal strip correspond respectively to relays RL1, 2 and 3, in the matching units, which select the various matching circuits.

39. Each of the ten tags A to K should be connected to one of the tags A, B or C on the four-terminal strip, or left unconnected, depending on the frequency of the corresponding channel, as follows:—

Channel frequency	*Tag on four-terminal strip*
22–28 Mc/s	A
28–31 Mc/s	No connection
31–48 Mc/s	B
48–63 Mc/s	C
63–84 Mc/s	A
84–85 Mc/s	B

Tag L on the 12-terminal strip and tag D on the four-terminal strip are common negative connections and should always be strapped together.

40. A typical set of cross-connections between the two terminal strips would be as follows:—

Channel	*Frequency*	*Tag on 12-terminal strip*		*Tag on four-terminal strip*
1	24 Mc/s	A	connected to	A
2	26·36 Mc/s	B	connected to	A
3	30·7 Mc/s	C	not connected	—
4	Not used	D	not connected	—
5	Not used	E	not connected	—
6	Not used	F	not connected	—
7	69 Mc/s	G	connected to	A
8	73·8 Mc/s	H	connected to	A
9	83·5 Mc/s	J	connected to	A
10	84·5 Mc/s	K	connected to	B
—	—	L	connected to	D

The connections required in any particular installation will not necessarily conform to this list, which is given merely as an example.

PART 2

TESTING AND SERVICING

PART 2

LIST OF CHAPTERS

***Note**—A list of contents appears at the beginning of each chapter*

A.L.4

Chapter 1

DISMANTLING

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

WAVEFORM GENERATOR

Air filter

1. Remove the Vokes air filter as follows:—

(1) Remove two screws found one either side of the projecting compartment at the top of the front panel.

(2) Pull the front cover away from the compartment; a plated metal grille will come away with the cover.

(3) Pull out the filter insert.

Note . . .
The rubber gasket which fits between the insert and the front panel should also be removed if the insert is not to be replaced or renewed immediately.

2. When fitting a filter insert, the sequence of insertion of items into the compartment is as follows:—

(1) Rubber gasket.

(2) Filter insert—felt side facing outwards.

(3) Grille.

(4) Front cover.

Blower assembly

3. Remove the blower motor as follows:—

(1) Remove the Vokes air filter.

(2) Remove the four screws revealed in the filter compartment by the removal of the filter.

(3) Detach the motor, with fan chamber attached, from the panel.

(4) Remove two screws from the rear plate of the motor and detach the rear plate to give access to the terminals.

(5) Note which lead goes to which terminal and remove the nuts from the terminals using a thin-walled box spanner.

(6) Detach the soldering tags with leads attached.

(7) Remove four screws from the corners of the rear plate of the fan chamber and detach the front framework of the chamber.

(8) Loosen two grub screws on the motor spindle and detach the fan.

(9) Remove the four screws holding the front of the motor in the flange on the rear plate of the fan chamber and remove the motor.

4. The motor itself should not in any circumstances be dismantled; faulty motors must always be renewed. Note that the motor connections must be replaced on the exact terminals from which they were removed; if the connections are reversed the motor will run in the reverse direction and a reduced air flow will result.

Interference suppressor

5. The interference suppressor for the blower motor is sited beneath the blower assembly; to remove the suppressor proceed as follows:—

(1) Remove the blower assembly.

(2) Unsolder the two leads from the terminals on the suppressor.

(3) Remove four 4 B.A. screws at the centre of the front panel.

Access to smoothing capacitors

6. The capacitors are mounted below the centre chassis section at the front; their fixing nuts are accessible from above the chassis. The nuts on C71 and C74 can be removed directly by using a long box key; the nuts on C72 and C73 require that the blower assembly be removed before the box key can be used; the nuts on C75, C76, C88 require that the blower assembly and the suppressor unit be removed before access is possible.

Timing pre-sets

7. The timing pre-set controls RV1 and RV2 are fitted behind a small cover at the bottom left-hand corner of the front panel; the cover is held by two screws. Locking screws must be loosened before the controls can be adjusted.

Strobe delay pre-sets

8. The A-strobe delay control, RV3, is fitted above the chassis at the rear of the left-hand chassis section; a locking screw must be loosened before the control can be adjusted. The B-strobe and C-strobe delay trimmers C77 and C78 are fitted behind a small cover on the inside of the rear panel; the cover is held by two screws. The trimmers are accessible for adjustment through two holes in the front of the cover.

Thermostat

9. The thermostat TH1 is mounted on a flange of the left-hand chassis section adjacent to the h.t. rectifier V29. To remove the thermostat:—

(1) Unscrew the cover.

(2) Push the thermostat down in its holder, rotate it slightly in a counter-clockwise direction, and lift it away.

If difficulty is found in removing the cover over the thermostat, a box key which will fit over the shaped base of the cover should be manufactured locally.

Important note . . .

There have been numerous instances of the counter unit mechanism on the indicator C.R.T. Type 26 being damaged due to negligence during servicing. This occurs if the indicator is placed face downwards while removing the cover. This usually results in the spring loaded handle cutting into its tray locking position, causing the indicator to drop on to the counter unit mechanism. The symptom of this damage is considerable end play on the fine control spindles which causes the counter mechanism gears to fail to mesh. The indicator C.R.T. Type 26 must be removed from its cover by gripping the cover with one hand, while the unit is laid flat on the bench, and easing the indicator firmly forward by the handle, with the other hand. On no account is the indicator to be placed face downwards without being adequately supported so that all the controls, etc., are clear of the bench.

INDICATOR

Cathode-ray tube

10. Remove the cathode-ray tube as follows:—

(1) Loosen three screws which hold a metal ring around the base-cap on the rear panel.

(2) Turn the ring to its counter-clockwise limit, and remove.

(3) Hold the base-cap of the tube in one hand and the neck of the tube in the other, and pull the tube carefully backwards until the face clears the flange on the front plate.

(4) Raise the face of the tube until access can be gained to the connector on the post-deflection accelerator electrode at the underside near the front.

Note . . .

In handling the tube, care must be taken to avoid straining the leads to the base-cap, and damaging the cap by straining it against the hole in the rear plate.

(5) Remove a rubber band which holds the lead to the post-deflection accelerator cap and remove the cap.

(6) With the tube held at an angle and the face uppermost, pull the base-cap carefully away from the tube, and remove the tube from the chassis.

11. The neck of the tube is covered by a mu-metal screen. When a faulty tube is being discarded the screen must be removed and fitted to the replacement tube. To remove the screen proceed as follows:—

(1) Remove the screw from the strap fitted around the screen, or, if a Jubilee clip is fitted, loosen the screw in the clip.

(2) Slide the screen over the base of the tube.

12. When replacing the cathode-ray tube the sequence given in para. 10 should be followed in the reverse order and the following points noted:—

(1) Check that the rubber spacing piece is in position inside the front flange.

(2) Start by inserting the base of the tube into the base-cap.

◄(3) Dress the leads to the base-cap so that they are parallel to the axis of the tube and do not overlap each other.►

(4) Replace the metal ring around the base-cap with the flat uppermost; if this is not done, the ring will foul the dust cover when an attempt is made to fit it.

13. When a new tube is being substituted the base-cap might require to be adjusted to ensure that the tube is held firmly between the front and rear plates. The procedure is as follows:—

(1) Fit the tube in position.

(2) Screw the cover on the base-cap in to its limit of travel.

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(3) Place the metal ring over the base-cap and tighten up.

(4) Slacken the screws on the ring just sufficiently to allow freedom for the base-cap cover to rotate.

(5) Unscrew the base-cap cover—this should cause the tube face to be pushed further into the front flange—until a limit is reached.

(6) Tighten the screws around the ring.

Strobe switch unit

14. To remove the strobe switch unit :—

(1) Loosen the grub screws from the four control knobs, remove the securing nuts and screws from the knobs, and then remove the knobs.

(2) Remove one screw set to the lower-left of the RF selector switch, and one screw set to the lower-right of the PRF selector switch ; detach the moulding fitted across the centre of the front panel—the strobe dial lamps are mounted on the rear of this moulding.

(3) Remove two nuts left exposed by the removal of the moulding.

(4) Remove four nuts set in a line below the strobe knobs.

(5) Turn the indicator on its top—cathode-ray tube downwards—with the front panel facing outwards.

(6) Remove two screws which hold the rear of the strobe switch unit to the lower side members of the chassis.

(7) Pull-out the lead to the tag panel from the clip on the rear of the unit.

(8) Grasp the strobe switch unit at each side and pull it backwards (away from the front panel), until the control spindles clear their holes in the panel.

(9) Raise the front of the unit upwards, and pull the whole unit upwards and outwards, keeping the front upwards in order to clear the tag panel at the rear.

The leads to the tag panel are long enough to permit the unit to be drawn completely clear of the chassis so that unlimited access to the panel is possible to allow the leads to be unsoldered.

15. The switches and resistances in the strobe switch unit are protected by a cover at the rear of the unit. To remove the cover :—

(1) Remove four screws holding a bar inset into the bottom edge at the back of the cover, and remove the bar.

(2) Remove one screw from the centre of the underside of the cover.

(3) Remove three screws from along the front edge of the top of the cover ; the cover can then be withdrawn.

16. The Geneva mechanisms which operate the strobe switches are protected by a cover which is held by a single screw at the left-hand top end ; this cover is not intended to be removed in normal use. The procedure for removal of the cover is as follows :—

(1) Remove the cover from the rear of the switch unit.

(2) Remove eight extension studs with hexagonal heads situated four along the bottom edge of the switch panel and four near the top edge behind the line of resistors.

(3) Pull the switch panel, complete with switch wafers, resistors and tag panel, away from the front of the unit.

(4) Remove the screw from the top left-hand end of the cover.

(5) Open out the loose ends of the cover and remove it from the mechanism.

Note . . .
In order to avoid difficulties in lining up the switches and indicators when the unit is re-assembled, the controls should be turned to set all switches and indicators to their minimum positions before the switch panel is removed.

Crystals

17. To remove the crystals :—

(1) Slacken the knurled nuts set at the ends of the crystal retaining plate.

(2) Allow the rearmost of the two nuts to fall backwards on its hinged screw.

(3) Remove the retaining plate.

(4) Insert the ends of a crystal removing tool into the loops on the top of the crystal and withdraw the crystal with a clean vertical pull. If the crystal is rocked in an attempt to loosen it in its holder or pulled out at an angle the glass seals might be broken and the crystal rendered useless.

A suitable crystal removing tool can be made up locally as required.

Crystal control assembly

18. To remove the crystal manual control assembly :—

(1) Loosen two grub-screws from the XTAL control knob and remove the knob.

(2) Remove two screws holding the circular plate positioned behind the knob.

(3) Remove three screws exposed by the removal of the plate.

(4) Disconnect two leads to the switch on the spindle immediately behind the front panel and two leads to the underside of the box containing the crystal tuning capacitors.

(5) Remove two screws holding the bracket at the rear of the tuning box to the nearby vertical chassis member, and withdraw the unit.

Three screws on the outside face of the box can be removed to allow access to the tuning capacitors.

EHT rectifiers

19. To remove the EHT rectifiers :—

(1) Pull off the top-cap connectors.

(2) Unscrew the insulated protective covers.

(3) Pull out the valves.

20. When fitting rectifier valves it should be noted that a spring is included between the top of each valve and the outer cover ; the narrow end of the spring fits over the valve top-cap. Before EHT rectifiers are discarded the top-cap adaptors should be removed for fitting to the replacement valves.

Fly-back blanking diode

21. The fly-back blanking diode V10 is fitted below the chassis and held in place by a spring retainer. Little difficulty will be experienced in removing this valve but complications can result when refitting ; the limitations are due to the difficulty of handling the spring retainer. The recommended way of replacing the valve is to insert the valve in the holder with the clip lying forward of the valve, that is towards the front of the chassis ; insert the index finger of one hand beneath the plate of the clip and use the other hand to hold the valve steady ; press the plate lightly against the valve and slide it upwards and over the shoulder below the top connection ; it is necessary to hold the plate against the valve in order to maintain the finger on the rear flange of the plate.

Indicator lights

22. The lights for the strobe indicator dials are carried in clips behind the moulding which fits across the centre of the front panel. To obtain access to the lights, remove the mouldings as instructed in para. 14 (2).

RECEIVER

Air filter

23. The air filter is identical with that of the waveform generator and is dismantled and assembled in the manner described in para. 1 and 2.

Blower assembly

24. To remove the blower motor :—

(1) Loosen the earth bonding strip which connects the body of the motor to the suppressor unit by removing one fixing screw.

(2) Remove two screws from the bottom flange of the air duct on the rear of the front panel to release the fan chamber from the air duct ; the screws are accessible to a screwdriver inserted in the gap between the duct and the front of the RF unit.

(3) Remove two screws from the outside of the front panel to release the fan chamber from the front panel ; one screw is immediately above the right-hand mounting of the carrying handle, the other screw is situated to the left of the first screw.

(4) Detach the fan chamber with motor and bonding strip attached from the panel.

(5) Remove two screws from the rear plate of the motor and detach the rear plate to give access to the terminals.

(6) Note which lead goes to which terminal and remove the nuts from the terminals using a thin-walled box spanner.

(7) Detach the soldering tags with leads attached.

(8) Remove four screws from the corners of the rear plate of the fan chamber and detach the front framework of the chamber.

(9) Loosen the two grub screws on the hub of the fan and pull off the fan.

(10) Remove four screws holding the front of the motor into the flange on the rear plate of the fan chamber.

(11) Extract the motor from the flange.

25. As mentioned previously, the motor itself should not under any circumstances be dismantled; faulty motors must always be replaced. Note that the motor connections must be replaced on the exact terminals from which they were removed ; if the connections are reversed the motor will run in the reverse direction and a reduced flow of air will result.

RF unit

26. To remove the RF unit :—

(1) Unscrew the co-axial aerial plug, PL N, at the rear left-hand of the unit, and remove the plug.

(2) Remove the miniature Jones plug, PL K, from the socket panel at the centre of the main structure.

(3) Unscrew the co-axial IF input plug, PL P, from the front of the IF unit on the lower deck; if difficulty is experienced in removing this plug because of insufficient clearance to allow for obtaining a firm grip, the IF unit will have to be released and dropped until complete access is possible.

(4) Unscrew four captive screws found one at each corner of the top plate of the RF unit.

(5) Lift the RF unit clear of the main structure.

27. The underside of the RF unit is covered by a metal screen which can be removed after the extraction of four screws found two down each long side.

28. When replacing the RF unit the following points should be kept in mind:—

(1) The flying lead carrying the Jones plug must be taken below the wire framework or the lead will be trapped when the dust cover is re-fitted.

(2) The switch coupling shaft must be turned by hand to set the switches to the channel which is one greater in number than that indicated on the receiver front panel, i.e. if the front panel indicator reads channel "5" set the RF switches to select channel "6."

Synchronizing unit

29. To remove the synchronizing unit:—

(1) Remove the miniature Jones plug, PL M, from the socket panel at the centre of the main structure.

(2) Unscrew four captive screws, found, two along each short side of the unit.

(3) Lift the unit clear of the main structure.

30. The underside of the synchronizing unit is protected by a cover which can be removed after the extraction of four screws from the underside.

31. When replacing the synchronizing unit the flying lead carrying the Jones plug must be taken below the wire framework or the lead will be trapped when the dust cover is re-fitted.

IF unit

32. To remove the IF unit:—

(1) Turn the receiver to lie on its top side—underside facing upwards.

(2) Unscrew four captive screws, found, two at each end of the unit.

(3) Lift the unit away from the main structure until access is possible to the Jones socket, SK L, and the co-axial IF input plug, PL P, which are found at the upper rear and upper front ends of the unit respectively.

(4) Remove the Jones socket and unscrew the co-axial plug.

(5) Lift the unit clear.

RF switch mechanism

33. The RF switch mechanism is found on the underside of the receiver unit. To remove the mechanism:—

(1) Remove the synchronizing unit to allow access through the top chassis plate to the rear plate of the RF switching motor.

(2) Remove two screws from the rear plate of the motor and remove the plate.

(3) Note which lead goes to which terminal of the motor and remove the nuts from the terminals using a thin-walled box spanner.

(4) Detach the soldering tags with leads attached from the terminals.

(5) Turn the receiver on its top-side—underside facing upwards.

(6) Remove five screws from the cover plate of the RF switch mechanism and remove the cover.

(7) Remove the screw from the cleat which holds the cable-form to the switches S4A and S4B (1 in *fig.* 1).

(8) Remove four screws which secure the rocking plates on which S4A and S4B are mounted—note these screws are shouldered and they must not be replaced by any other type (2 in *fig.* 1).

(9) Lift the two switch leaves with mountings and leads attached away from the spindles.

(10) If the mechanism is not to be re-assembled immediately, remove the two felt washers, exposed on the switch spindles on removal of the leaves, to avoid their being lost.

(11) Unscrew four captive screws on the base plate of the mechanism (3 *in fig.* 1).

(12) Lift the mechanism clear of the chassis structure.

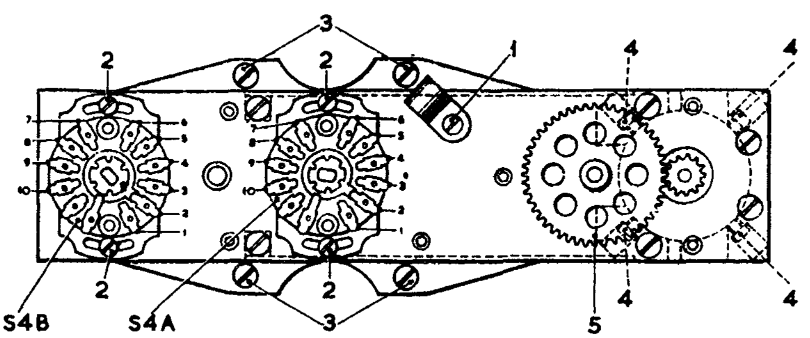


Fig. 1. RF switch mechanism—dismantling information

34. To remove the motor, remove four screws set through the sides of the casting in which the motor is held, the positions of the screws are identified at 4 in fig. 1. The motor itself should not under any circumstances be dismantled ; faulty motors must always be replaced.

35. When replacing a motor it is of the utmost importance that the connections are made correctly or the motor will run in the reverse direction and the switches in the RF unit will not track properly. The motor is connected correctly when the coupling shaft to the RF unit rotates clockwise as viewed from above.

Setting-up the switch mechanism

36. When the switch mechanism is re-fitted it is necessary to check the operation of the system to ensure that all the switches are locating correctly on the several channels. The procedure for replacing and setting-up the mechanism is as follows :—

(1) Remove the IF unit to allow the switch position indicator on the underside of the RF unit to be seen.

(2) Note the channel to which the RF unit is set; if the slider of the visible switch is not centred properly under a contact, adjust the coupling spindle by hand for correct alignment.

(3) Turn the RF switch mechanism, by hand, for the channel number one less than that selected by the switches in the RF unit to appear centrally on the indicator at the front of the mechanism; i.e. if the RF switch is set to channel " 5," set the indicator to channel " 4." The mechanism can be operated by rotating the large toothed wheel on the outside plate (5 *in fig.* 1).

(4) Place the mechanism in position on the chassis and tighten the four captive screws on the base plate (3 *in fig.* 1).

(5) Check that the sliders on S4A and S4B are set to the appropriate contacts for the channel shown on the indicator; fig. 1 shows the channels represented by the contacts.

(6) Place the felt washers over the switch spindles.

(7) Place the switch leaves over the spindles.

(8) Insert the fixing screws on the rocking plates, centre the rocking plates about the screws, and tighten the screws.

(9) Replace the cleat.

(10) Connect up the motor and replace its rear plate.

(11) Connect the receiver into a working installation and switch on the DC supply.

(12) Set the RF switch on the indicator to channel 1.

(13) Check the position taken up by the slider on the RF unit relative to the channel 1 contact.

(14) Turn the RF switch on the indicator to each channel in turn ; note at each step the position taken up by the slider.

37. If in each of the ten positions of the switch on the RF unit, the slider stops approximately near the centre of the contact, or if, in each position the slider stops at the right contact without any possibility arising of the adjacent contact being shorted, the rocking plate is correctly positioned. If at some settings the slider touches more than one contact, or clearances to adjacent contacts are small, the position of the rocking plate of S4A must be altered slightly, and the slider positions again noted on each channel ; this process must be repeated until in each position the slider stops without danger of an adjacent contact being shorted.

38. With the tracking between S4A and the RF switches set correctly, check that in each switch position the appropriate channel number appears centrally in the window on the front panel of the receiver. If they do not, adjust the setting of the indicator drum as follows :—

(1) Set the RF selector switch to any one of the channels 1, 5, or 9.

(2) Remove the two screws from the locking plate on S4B.

(3) Remove the leaf with mounting attached of S4B.

With S4B removed, three small holes will be exposed through which the setting screws on the indicator drum can be seen and adjusted.

(4) Loosen the three screws.

(5) Turn the drum by hand for the required number to appear central.

(6) Tighten up the screws and replace the switch leaf and its securing screws.

39. The tracking of S4B must now be adjusted as follows :—

(1) Loosen the locking screws on the rocking plate of S4B.

(2) Turn the rocking plate for the slider to lie centrally about the appropriate contact.

(3) Turn the RF switch on the indicator to each position in turn; note at each step the position taken up by the slider.

(4) Correct the position of the rocking plate until in each position of S4B the slider connects only with the correct contact without danger of shorting adjacent contacts.

40. If over the whole range of adjustment of the rocking plate of S4A, adjacent contact shorting in the RF unit switch still occurs, it is likely to be due to loose contacts on S4A ; in such instances no attempt should be made to tighten the contacts but the leaf must be renewed.

JUNCTION BOXES

Junction box Type 359A

41. To gain access to the indicator junction box:—

(1) Position the box on its front—Jones sockets downwards.

(2) Remove four screws found two down each narrow side of the rear of the box.

(3) Pull the rear of the box away from the front to give access to the wiring.

42. To transfer the output plugs from the upper surface of the rear compartment to the lower surface :—

(1) Remove the rear compartment.

(2) Remove six screws from the upper surface of the rear compartment and six screws from the lower surface of the rear compartment.

(3) Remove the plate carrying the Plessey Mk. 4 plugs with its rubber gasket from the inside of the upper surface.

(4) Remove the blank plate with its rubber gasket from the inside of the lower surface.

(5) Transfer the plug plate with its gasket to the inside of the lower surface and secure with the six screws.

(6) Transfer the blank plate with its gasket to the inside of the upper surface and secure with the six screws.

(7) Place the rear compartment in position on the front section and secure with the six screws.

Junction box Type 360A

43. To gain access to the waveform generator junction box :—

(1) Position the box on its front—Jones sockets downwards.

(2) Remove twelve Simmonds nuts from around the edges of the rear plate and remove the plate.

44. To transfer the output plugs from the top plate of the box to the bottom plate :—

(1) Remove the back plate.

(2) Remove five cheese-head screws with washers from the top plate of the box and remove five counter-sunk screws from the bottom plate.

(3) Remove the plate carrying the Plessey Mk. 4 plugs and the rubber gasket from the inside of the top plate.

(4) Remove the blank plate and the rubber gasket from the inside of the bottom plate.

(5) Transfer the plug plate with its gasket to the inside of the bottom plate and secure with the counter-sunk screws ; take care in carrying out the transfer to avoid straining the connections to the plugs.

(6) Transfer the blank plate with its gasket to the inside of the top plate and secure with the cheese-head screws and washers.

(7) Replace the back plate.

Junction box Type 361A

45. To gain access to the receiver junction box :—

(1) Position the box on its front—Jones sockets downwards.

(2) Remove twelve Simmonds nuts from around the edge of the rear plate and remove the plate.

46. To transfer the output plugs from the top plate of the box to the bottom plate :—

(1) Remove the back plate.

(2) Remove six cheese-head screws and washers from the top plate of the box and remove six counter-sunk screws from the bottom plate.

(3) Remove the plate carrying the Plessey Mk. 4 plugs and the rubber gasket from the inside of the top plate.

(4) Remove the blank plate and its rubber gasket from the inside of the bottom plate.

(5) Transfer the plug plate with its gasket to the inside of the bottom plate and secure with the counter-sunk screws ; take care in carrying out the transfer to avoid straining the connections to the plugs.

(6) Transfer the blank plate with its gasket to the inside of the top plate and secure with the cheese-head screws and washers.

(7) Replace the back plate.

Chapter 2

ALIGNMENT AND SETTING-UP INSTRUCTIONS

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TEST EQUIPMENT REQUIRED

	Stores Ref.
Microammeter, 0-250 mA	5Q/14427
Oscilloscope Type 13	10S/825
Signal generator Type 106	10SB/6086
Test set Type 210	10S/16002
Attenuator unit Type 70	10A/16129
Trimming tool (detachable fitting in each receiver)	

BENCH SETTING-UP AND TESTING

Indicator

1. The pre-set controls in the indicator provide for adjustments to the presentation ; no special test equipment is required. The controls involved are pre-set potentiometers situated on the left-hand top and side of the upper chassis immediately behind the front panel brightness and gain control, as shown in fig. 1.

2. To adjust the indicator pre-sets :—

(1) Remove the dust cover from the indicator.

(2) Connect the indicator into a bench installation.

(3) Switch on the equipment and leave for at least five minutes to warm up.

(4) Set the front panel controls as follows :—
   (a) Gain control fully counter-clockwise (minimum).
   (b) RF selector to channel number of local chain.
   (c) PRF selector to channel letter of local chain.
   (d) Xtal knob "in" for manual control.
   (e) Timebase selector to M.
   (f) Calibration switch for normal (non-calibrate) operation.

(5) Adjust the brilliance control for a clearly visible trace.

(6) Adjust the focus control (front panel pre-set) for a sharply focused trace.

(7) Loosen the locking screw on the astigmatism pre-set (RV4) and adjust, in conjunction with re-adjustments to the focus control, for optimum focus ; tighten the locking screw.

(8) Loosen the locking screw on the main timebase amplitude control (RV1) ; adjust for trace lengths of approximately two inches ; tighten the locking screw.

(9) Loosen the locking screw on the X-shift control (RV2); adjust to centre the traces; tighten the locking screw.

(10) Switch the timebase selector to S.

(11) Loosen the locking screw on the strobe timebase amplitude control (RV3) ; adjust for strobe trace lengths of approximately two inches ; tighten the locking screw.

3. To check the overall operation of the indicator :—

(1) Switch the timebase selector to M.

(2) Set the calibration switch to the calibrate position and check that calibration markers appear.

(3) Turn the p.r.f. control to each position in turn; check that after an initial period of jitter, steady calibration markers appear in each position.

(4) Check that a strobe well appears on each trace and that calibration markers appear inverted on the wells.

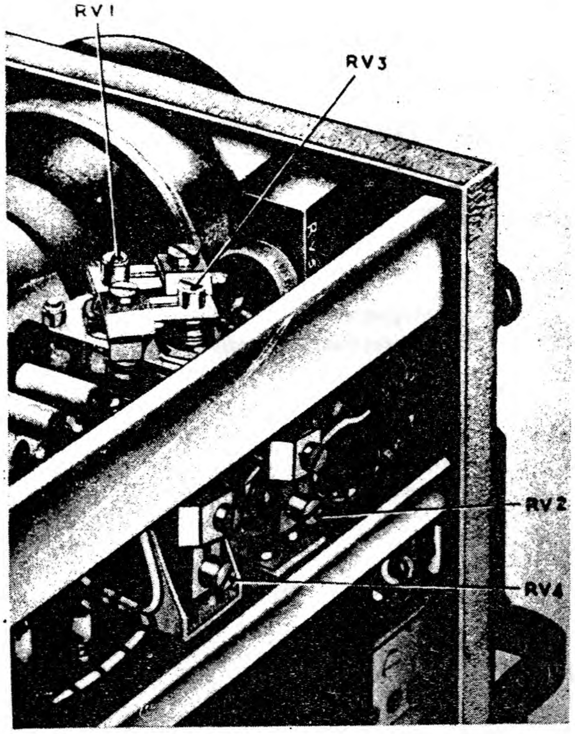


Fig. 1. Pre-set controls on indicator

(5) Turn the *B*-strobe coarse control through its full range ; note that the strobe well on the top trace moves in even steps from one end of the trace to the other and that the tens and units indicator dials move in steps of one from a lower limit of 01 to an upper limit of 25. Note : the upper limit of movement of the strobe well will come at a dial reading of about 23.

(6) Turn the *C*-strobe coarse control, through its full range ; note that the strobe well on the lower trace moves in even steps from one end of the trace to the other and that the tens and units indicator dials move in steps of one from a lower limit at 31 to an upper limit at 55. Note : the upper limit of movement of the strobe well will come at a dial reading of about 53.

(7) Switch the timebase selector to S ; check that the calibration markers appear inverted on the *B*- and *C*-strobe traces.

(8) Turn the *B*-strobe fine control through at least ten revolutions ; check that the *B*-strobe trace moves in steps and that the tenths and hundredths indicator dials move in steps of one over the range from 00 to 99 and that the units dial moves over one step as the tenths and hundredths dials pass from 99 through to 00.

(9) Turn the *C*-strobe fine control through at least ten revolutions ; check that the *C*-strobe trace moves in steps and that the tenths and hundredths indicator dials move in steps of one over the range from 00 to 99 and that the units dial moves over one step as the tenths and hundredths dials pass from 99 through to 00.

(10) Switch the timebase selector to M.

(11) Set the calibration switch for normal operation.

(12) Set the RF selector and the p.r.f. selector for reception of the local channel.

(13) Adjust the receiver gain control for optimum signals.

(14) Adjust the Xtal control to bring the single *A*-pulse to a point at the beginning of the top trace.

(15) Switch the timebase selector to S.

(16) Adjust the Xtal control for the *A*-pulse to drift slowly across the centre of the trace.

(17) Pull the Xtal control knob to the "out" (*A*-lock) position ; check that the *A*-lock comes into operation and the pulses become steady at the centre of the trace.

(18) Turn the illumination control through its full range ; check that the illumination of all the strobe indicator dials varies.

Waveform generator

4. The pre-set controls for second-line adjustment of the waveform generator are in the calibration and strobe timing circuits. No special test equipment is required. A further pre-set (RV4), which was introduced into the equipment by modification for the purpose of adjusting the anti-jitter circuit, is not now fitted.

5. The calibration controls (DIV 1, RV1, and DIV 2, RV2) are found behind a detachable cover at the bottom left-hand corner o the front panel (Part 1, Chap. 4, Fig. 1). Two of the timing controls (C77 and C78) are pre-set capacitors found behind a cover on the inside of the rear plate of the chassis (Part 1, Chap. 4, Fig. 1 and 2) ; screwdriver access holes are provided so that adjustments can be carried out without removing the cover. A third pre-set timing control (RV3) is found at the rear of the left-hand (from the front) section of the chassis, and is accessible from the top (Part 1, Chap. 4, Fig. 3).

6. To calibrate :—

(1) Remove the cover at the bottom left-hand corner of the front panel to give access to the timer controls DIV 1 and DIV 2.

(2) Set up the indicator to display calibration markers on the strobe traces.

(3) Adjust the *B*-strobe fine control for a 1 Gee unit marker to appear at each end of the *B*-strobe trace.

(4) Loosen the locking screw on the first divider pre-set DIV 1 and adjust as follows :—

(a) Turn DIV 1 for a division ratio of four-to-one — three 0·2 Gee unit markers between the two 1 Gee unit markers—and note the position of the control.

(b) Turn DIV 1 for a division ratio of six-to-one — five 0·2 Gee unit markers between the 1 Gee unit markers—and note the position of the control.

(c) Set DIV 1 centrally between the positions found in (a) and (b) for a division ratio of five-to-one—four 0·2 Gee unit markers between the 1 Gee unit markers.

(d) Tighten the locking screw.

(5) Turn the p.r.f. selector through each position in turn ; check that the division ratio remains the same in each position.

(6) Switch the indicator to display the main timebase traces.

(7) Loosen the locking screw on the second divider pre-set DIV 2 and adjust as follows :—

(a) Turn DIV 2 for a division ratio of four-to-one — three 1 Gee unit marker between each pair of 5 Gee unit markers—and note the position of the control.

(b) Turn DIV 1 for a division ratio of six-to-one—five 1 Gee unit markers between each pair of 5 Gee unit markers—and note the position of the control.

(c) Set DIV 1 centrally between the positions found in (a) and (b) for a division ratio of five-to-one—four 1 Gee unit markers between each pair of 5 Gee unit markers.

(d) Tighten the locking screw.

(8) Turn the p.r.f. selector through each position in turn; check that the division ratio remains the same and that a total of five 5 Gee unit markers appear on each trace in each switch position.

7. To adjust the *A*-strobe timing :—

(1) Adjust the indicator for calibration markers on the strobe timebases, and for a *B*-strobe setting of 12·00 and a *C*-strobe setting of 42·00.

(2) Loosen the locking screw on the *A*-strobe delay control RV3 ; adjust the control to line up the markers on the *A* and *B* traces; the alignment should be carried out on the 0·2 Gee unit markers and not on the slightly wider 1 Gee unit markers ; tighten the locking screw.

8. To adjust the *B*- and *C*-strobe timing :—

(1) Set the *B*- and *C*-strobe controls for readings of 11·99 and 41·99 respectively.

(2) Turn the *B*-strobe fine control two steps for a reading of 12·01 ; compare the movement of the markers on the *B*-strobe trace in each step.

(3) Adjust the *B*-strobe timer C77, as necessary, to equalise the distances moved at each step.

(4) Turn the *C*-strobe fine control two steps for a reading of 42·01 ; compare the movement of the markers on the *C*-strobe in each step.

(5) Adjust the *C*-strobe timer C78, as necessary, to equalise the distances moved at each step.

9. To check the overall operation of the waveform generator :—

(1) Check that strobe wells appear on both main timebase traces and that signals and/or calibration markers appearing in the wells are inverted.

(2) Turn the *B*-strobe coarse control on the indicator through its full range ; check that the strobe well on the top trace moves in even steps from the left-hand end of the trace to the right-hand end, the limit of movement (of the well but not the switch) occurring at a dial reading of about 23·00, and that one 1 Gee unit marker is moved through at each step.

(3) Turn the *C*-strobe coarse control on the indicator through its full range ; check that the strobe well on the bottom trace moves in even steps from the left-hand end of the trace to the right-hand end, the limit of movement (of the well but not the switch) occurring at a dial reading of about 53·00, and that one 1 Gee unit marker is moved through at each step.

(4) Switch the indicator to display calibration markers on the strobe timebases.

(5) Turn the *B*-strobe fine control through at least ten revolutions ; check that the *B*-strobe trace moves in even steps over the whole range.

(6) Turn the *C*-strobe fine control through at least ten revolutions ; check that the *C*-strobe trace moves in even steps over the whole range.

Receiver

10. Second line adjustments in the receiver comprise RF alignment, strobe-well presentation, and *A*-lock setting. The controls involved in RF alignment are adjustable cores to the tuning coils on the RF unit, a pre-set potentiometer on the IF unit, and a pre-set potentiometer on the synchronizing unit.

11. A test set Type 210 together with the attenuator unit Type 70 and a trimming tool are required for RF alignment ; no special equipment is required for the other adjustments.

12. As a preliminary to aligning the RF channels, check the alignment of the RF switches as follows :—

(1) Remove the dust cover from the receiver.

(2) Turn the receiver upside-down.

(3) Remove the IF unit and detach the cover from the RF switch mechanism.

(4) Connect the receiver, still upside-down, into the bench installation and switch on the DC supply.

(5) Note the channel selected by the wiper of the visible switch on the underside of the RF unit and check that it corresponds with the channel number shown on the drum indicator at the front of the receiver and also with the position of the channel selector on the indicator.

(6) Set the channel selector on the indicator to each position in turn and note that the switch wiper and indicator follow the movement and that in each position the wiper of the RF switch makes connection with one switch contact only.

(7) If the wiper does not position properly, adjust the setting of the contacts on the control switch S4A as described in Part 2, Chap. 1.

(8) Replace the IF unit and the cover on the switch mechanism.

13. To align the RF channels :—

(1) Re-fit the receiver the correct way up into the bench installation.

(2) Switch on all power supplies and allow at least five minutes for warming-up.

(3) Connect up the test set Type 210 and the attenuator unit Type 70 and leave for at least five minutes for warming-up.

(4) Refer to local orders for the spot frequencies specified for the RF channels.

(5) Set up the test set for a pulsed output at the frequency of channel 1.

(6) Set the RF selector switch on the indicator to channel 1.

(7) Remove the trimming tool from the clip at the top rear of the receiver front panel.

(8) Use the spanner on the trimming tool to loosen the locking nuts on the three channel 1 core adjustments.

(9) Adjust the three channel 1 cores, using the screwdriver on the trimming tool, in the order, oscillator, mixer, aerial, for maximum output as viewed on the indicator ; use the attenuator as necessary to prevent overloading as the cores are brought into tune.

(10) Lock the nuts on the channel 1 spindles.

(11) Set the RF selector switch to each channel in turn ; tune the test set to the appropriate frequency for each channel ; repeat operations 8, 9 and 10 on the cores appropriate to each channel. Note that channels 4, 5 and 6 will not be wired up in most equipments.

14. The strobe well presentation on the indicator display is controlled by the setting of the video bias control RV1 in the receiver. This control is found at the rear of the IF unit. To allow access for a screwdriver to the adjusting slot in the control spindle it will be necessary to loosen the captive screws on the IF unit and free the unit from the main framework without removing the plugs and wiring.

15. To adjust RV1 :—

(1) Set up the indicator for strobe timebase display without signals or calibration markers on the traces.

(2) Set the strobe controls to some central position, say 12·00 for the *B*-strobe and 42·00 for the *C*-strobe.

(3) Drop the IF strip to allow access to the control.

(4) Loosen the locking screw on RV1 ; adjust for a displacement of approximately one tenth of an inch between the *A* and the *B* traces and the *A* and the *C* traces ; tighten the locking screw.

(5) Replace the IF unit.

16. The pre-set control RV2 is used to adjust the setting of the *A*-lock circuit. It controls the time at which the received *A*-pulses will be stabilized within the period of the *A*-strobe. Adjustment of the control is carried out to bring the stabilized pulses central in the strobe traces. The control is found on the top deck of the synchronizing unit.

17. A received signal must be available for adjusting the *A*-lock setting ; if an actual transmission cannot be received, the test set Type 210 must be set up to provide the required input.

18. To adjust the *A*-lock setting :—

(1) Set up the indicator to display received pulses on the main timebase.

(2) Adjust the Xtal control for the *A*-pulses to appear stationary at the left-hand end of the traces.

(3) Switch to strobe timebase.

(4) Adjust the Xtal control further for the *A*-pulses to appear stationary near the centre of the strobe traces.

(5) Pull the Xtal control knob " out " to the *A*-lock position.

(6) Loosen the locking screw on RV2 ; adjust the control to centre the *A*-pulses in the traces ; tighten the locking screw.

19. To check the overall operation of the receiver :—

(1) Check the action of the gain control.

(2) Check that signals or noise are visible on each wired-up channel.

(3) Check that calibration markers appear in the calibrate position of the control on the indicator.

(4) Check that the strobe traces are parallel and that the strobe wells on the main timebases are not distorted.

(5) Set up the test set Type 210 to act as a source of interfering signal and note, that for levels of interference equal to that of the wanted signal, the *A*-lock is not broken except for slight jitter as the interfering pulses pass through the *A*-pulses ; note also the operation of the echo suppressor by checking that the amplitude of the interfering pulses is appreciably reduced as they pass through the trailing edges of the wanted signals.

THIRD LINE SERVICING ADJUSTMENTS

Indicator

Crystal oscillator adjustment

20. The anode coil L1 of the crystal oscillator V4A is pre-set to a point that allows the oscillator to operate satisfactorily over the full frequency range covered by the six crystals. In normal service the coil should not require adjusting, and, in general, adjustment should only be necessary when a faulty coil is renewed.

21. The coil is found behind the crystal bank on the underside of the right-hand chassis section. The adjusting spindle of the coil is accessible on the removal of a screw-type dust cover on the underside of the coil ; a locking nut must be unscrewed before the spindle can be turned. A special tool is required to turn the spindle ; it can be made up locally by making a cut with a hacksaw in a ¼ in. diameter rod of insulating material.

22. To adjust L1 :—

(1) Remove the cover from the indicator and connect the unit into a bench installation.

(2) Set up the oscilloscope Type 13 to display the crystal oscillator output by connecting the input of the oscilloscope to the grid of V6 (junction of C21, R29 and R28)

(3) Turn the p.r.f. selector on the indicator through each position in turn and note that a stable oscillation is displayed on the monitor, after a short settling down period, in each position.

(4) If the oscillations disappear, are unsteady, or take too long to settle down in any position of the p.r.f. selector, remove the dust cap from L1, loosen the locking nut and adjust the core in steps until a position is found in which stability and settling down time is satisfactory on all p.r.f. channels.

(5) Tighten the locking nut and replace the cap.

75 kc/s oscillator adjustment

23. The tuning coil and output winding on the transformer L2 in the circuit of the 75 kc/s oscillator V6 is adjustable to allow the oscillator to work satisfactorily and divide-by-two correctly over the full range of frequencies determined by the six crystals. In normal service the transformer should not require adjusting, and, in general, adjustment should only be necessary when the transformer is renewed.

24. The adjusting spindle of L2 is similar to that of L1. It is found adjacent to L1 on right-hand chassis section.

25. To adjust L2 :—

(1) Remove the cover from the indicator and connect the unit into a bench installation.

(2) Set up the oscilloscope Type 13 to display the 75 kc/s oscillator output by connecting the input circuit of the oscilloscope to pin 11 on the Jones plug E on the rear of the indicator.

(3) Turn the p.r.f. selector to A.

(4) Remove the dust cap from the core of L2, loosen the locking nut, and adjust the core for maximum output as viewed on the oscilloscope.

(5) Turn the p.r.f. selector through each position in turn and note that in each position a stable oscillation is displayed after a short settling down period.

(6) If the oscillations disappear, are unsteady, or take a long settling-down period in any one position of the p.r.f. selector, further adjust the core in small steps until a satisfactory stable oscillation with short settling-down time is apparent in all positions.

(7) Tighten the locking nut and replace the dust cap.

Waveform generator

75 kc/s input transformer adjustment

26. The input transformer L1 to the phase splitter in the waveform generator is adjustable to provide a suitable match to the output of the 75 kc/s oscillator in the indicator over the whole range of frequencies involved in the six p.r.f.s for which provision is made. In normal service the transformer should not require adjusting, and, in general, adjustment should only be necessary when a faulty transformer is replaced.

27. The transformer is found at the front left-hand section of the chassis ; the adjustable core is found beneath a screw type dust cover on the underside. The adjusting spindle is fitted with a lock nut and is similar to that on L1 and L2 in the indicator.

28. To adjust L1 :—

(1) Remove the dust cover from the waveform generator and connect the unit into a bench installation.

(2) Set up the oscilloscope Type 13 to display the 75 kc/s input to the grid of V1 (junction of C5 and R2).

(3) Turn the p.r.f. selector on the indicator to A.

(4) Remove the dust cap from the core of L1, loosen the locking nut, and adjust the

core for maximum output as viewed on the oscilloscope.

(5) Turn the p.r.f. selector through each position in turn and note that no appreciable change in output results in any one position.

(6) Tighten the locking nut and replace the dust cap.

29. In some equipments the range of adjustment provided by the core of L1 is inadequate and additional range is provided by a trimmer capacitor (C2) connected across the secondary winding. Where this trimmer is fitted the core is set to its central position and the necessary adjustments carried out with the trimmer.

Receiver

IF alignment

30. A signal generator Type 106 and a 0-to-250 microammeter are required for IF alignment. The procedure is as follows:—

(1) Remove the dust cover from the receiver and connect the unit upside-down into a bench installation.

(2) Loosen the fixing screws on the IF unit.

(3) Lift the IF unit away from the main chassis without removing the wiring, and position the unit on the chassis so that access is possible to the IF coil core adjustments.

(4) Remove the IF input plug P and connect the output of the signal generator to socket P.

(5) Remove the bottom cover of the IF unit.

(6) Connect a shorting link across the anode and cathode of V9B (across C37) to render the anti-echo circuit inoperative.

(7) Disconnect the lead to pin 12 on Jones plug L and insert the microammeter between the open lead and pin 12, with the positive side of the meter to pin 12. The meter reads detector current and is used as an output meter.

(8) Set the gain control for a bias of three volts as measured with a testmeter from pin 7 on the Jones plug L to chassis.

(9) Tune the signal generator to 7·5 Mc/s and set the output level for a visible reading on the output meter.

(10) Loosen the locking nuts on the spindles of the tuning cores of the IF coils ; adjust the cores in the order L31, L32, L33, L34, L35 and L36, for a maximum output on the meter ; reduce the output from the signal generator, as necessary, as the coils are brought into tune, to avoid overloading ; tighten the locking nuts.

(11) Remove the microammeter and reconnect the lead to pin 12 ; remove the shorting link from across C37.

(12) Replace the IF input plug and return the chassis to its normal fixed position.

(13) Carry out the RF alignment procedure of para. 12 in its entirety.

RF channel trimming

31. The limits of the tuning ranges of the RF coils are set by the pre-set capacitors C1, C9 and C13 across the aerial, RF, and oscillator circuits respectively. These pre-sets do not require adjusting as a normal RF channel setting-up procedure but may require adjusting when component changes are made. A test set Type 210 and an attenuator unit Type 70 are required.

32. The alignment procedure is :—

(1) Remove the dust cover from the receiver and connect into the bench installation.

(2) Switch on the equipment and leave for at least five minutes to warm up.

(3) Connect up the test set Type 210 and leave for at least five minutes to warm up.

(4) Assemble the attenuator unit Type 70 on the top of the test set and connect its input Pye socket to the RF OUTPUT plug on the test set.

(5) Connect the output plug of the attenuator unit, through the lead provided, to the aerial input point on the receiver junction box.

(6) Set up the test set as follows :—

- (a) Waveband switch to range 4.
- (b) RF-NOISE switch to RF.
- (c) MOD switch to ON.
- (d) CX CHECK switch to OFF.
- (e) RF TUNING control for an output at 86·5 Mc/s.

(7) Set the RF channel selector control on the indicator unit to channel 8.

(8) Use the spanner on the trimming tool provided with the receiver to loosen the locking nuts on the three channel 8 adjusting screws.

(9) Use the screwdriver on the trimming tool to turn the channel 8 adjusting screws fully counter-clockwise ; that is to set the coils for minimum inductance by turning the cores until the screws are fully visible.

(10) Check that no pulses are visible on the indicator display, and turn the gain control for noise to be just visible.

(11) Adjust the trimmers C13, C9, C1 in that order, for pulses (from the test set) to appear.

(12) Adjust the attenuator Type 70 for the pulses to be just visible.

(13) Repeat the adjustments to the trimmers, reducing the output of the attenuator as necessary to prevent overloading, to produce maximum amplitude of the pulses without saturation.

(14) Seal the trimmers.

(15) Carry out the complete RF channel alignment procedure, as detailed in para. 13, starting with channel 8 and following the sequence 9, 10, 1, 2, 3, 7.

PART 3

FAULT DIAGNOSIS

This leaf issued with AL No 16, October, 1953

PART 3

LIST OF CHAPTERS

Note - A list of contents appears at the beginning of each chapter

AIR MINISTRY

GEE Mk. 3 AIRBORNE EQUIPMENT (ARI.5816)

This is Amendment List No. 9 to Air Publication 2557M, Volume 1

Part 3. List of Chapters: *delete* " *(to be issued later)* " after the title of Chapter 1 and *write* "(A.L. 9)" in the outer margin against the deletion. *Insert* this Chapter 1 to follow the List of Chapters. *Record* the incorporation of this A.L. in the Amendment Record Sheet.

SIGNALS

Chapter 1

FAULT FINDING IN THE AIRCRAFT

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

General procedure

1. Fault finding in the aircraft is limited to the diagnosis of faulty units, including junction boxes, and the investigation of inter-unit circuits. Table 1 provides a guide for action in localizing the fault to a particular unit. Where substitution of a new unit does not clear the trouble the inter-unit wiring can be suspected, and Table 2 and the illustrations have been provided to allow step-by-step checks to be undertaken in order to further isolate the defect.

Circuit tracing

2. Each separate circuit between any two main units includes at least eight plug and socket connections and each of these connections must be recognised as being a potential source of trouble. If the inter-unit circuits cannot be tested by the substitution of junction boxes and connectors known to be in good working order, it will be necessary to test the individual circuits between the units in order to isolate the fault. The illustrations will allow such circuit tracing to be carried out with the minimum of difficulty.

3. In the illustrations the inter-unit circuits are broken down into their separate sections, so that if a particular fault suggests a defect in a given circuit, the details of that circuit alone can be studied to provide a guide to testing action. The association between faults and the individual circuits is shown in Table 2.

4. To further ease the problem of following a circuit, the illustrations give the circuits in two forms. In the first form the true electrical circuits are shown with the plugs and sockets appearing as detached contacts, and in the second form the circuits are shown against the background of the actual appearance of the plugs and sockets on the units and junction boxes; the views of the plugs and sockets are as they would appear when seen from the outsides of the units and junction boxes.

5. The designations of the detached contact plugs and sockets are made up as follows :—

Pre-fix number, 1 to 6

SK or PL for socket or plug

Letter showing particular socket or plug

Number or letter—preceded by a stroke mark (/)—showing the particular point on the plug or socket

6. The pre-fix numbers indicate the unit concerned by the following code :—

No number—Connector

1—Waveform generator

2—Receiver

3—Indicator

4—Receiver junction box Type 361A

5—Waveform generator junction box Type 360A

6—Indicator junction box Type 359A

7. The final identification is a letter in the instance of the Mk. 4 plug and socket points and a number in the instance of the Jones plug and socket points.

8. To use the illustrations :—

(1) Study Table 2 to determine, from the symptoms of the fault, which circuit is involved.

(2) Refer to the particular circuit and note the plug and socket points concerned.

(3) Refer from (2) to the simplified wiring diagram to note the physical positions of the plug and socket points.

TABLE 1

Location of faulty units

Symptom	Action
No display.	(1) Check for illumination of strobe counters on indicator—if no illumination check AC input supply. (2) Replace indicator.
No traces, spot only.	(1) Replace waveform generator. (2) Replace receiver. (3) Replace indicator. (4) Replace waveform generator junction box. (5) Replace receiver junction box. (6) Replace indicator junction box.
No main timebase traces.	(1) Replace waveform generator. (2) Replace indicator. (3) Replace waveform generator junction box. (4) Replace indicator junction box.
No strobe wells or strobe timebase traces, main timebase traces otherwise normal.	(1) Replace waveform generator. (2) Replace indicator. (3) Replace waveform generator junction box. (4) Replace indicator junction box.

No spacing between traces.	(1) Replace waveform generator. (2) Replace indicator. (3) Replace waveform generator junction box. (4) Replace indicator junction box.
No calibration markers, signals and noise normal.	(1) Replace waveform generator. (2) Replace receiver. (3) Replace indicator. (4) Replace waveform generator junction box. (5) Replace receiver junction box. (6) Replace indicator junction box.
No calibration markers, signals or noise.	(1) Replace receiver. (2) Replace indicator. (3) Replace receiver junction box. (4) Replace indicator junction box.
No main timebase traces and A-strobe traces, B- and C-strobe traces normal.	(1) Replace waveform generator. (2) Replace indicator. (3) Replace waveform generator junction box. (4) Replace indicator junction box.
No signals or noise, calibration markers normal.	(1) Check aerial connection to receiver junction box. (2) Replace receiver. (3) Replace receiver junction box.
No A-lock.	(1) Replace receiver. (2) Replace indicator. (3) Replace receiver junction box. (4) Replace indicator junction box.
No control of signal drift (timebase speed) with XTAL control.	(1) Replace indicator. (2) Replace indicator junction box.

TABLE 2

Circuit associations of faults

Symptom	Circuit	Fig.
No display.	AC supplies.	1
Blowers and/or RF selector motor not working.	DC supplies.	2
No signals or grass; calibration markers normal.	Gain control circuit.	3
No signals; grass and calibration markers normal.	RF selector circuit.	2
No calibration markers; signals and grass normal.	Calibration marker circuit.	4
No signals, calibration markers, or grass	Receiver output circuit.	3
No traces; spot only.	HT circuit.	3
No main timebase traces ; strobe timebase traces normal.	500 p.p.s. sync. circuit.	4
No strobe timebase traces or strobe wells; main timebase traces normal.	Strobe pulse circuit.	4
Two strobe wells on each main timebase trace, only two strobe timebase traces.	Negative A-strobe circuit.	4
Single trace only on main timebase, two traces only on strobe timebase.	250 p.p.s. square wave.	4
Signal inversion on all traces.	Bias supply.	3
No A-lock, manual control normal.	(1) A-lock control circuit. (2) 210V HT circuit. (3) Negative A-strobe circuit. (4) Strobe pulse circuit.	3 3 4 4
No A-lock or manual control.	75 kc/s circuit.	4
Weak signals.	Control circuit to matching unit.	2

PREFIX No.	UNIT
1	WAVEFORM GENERATOR
2	RECEIVER
3	INDICATOR
4	JUNCTION BOX TYPE 361A
5	JUNCTION BOX TYPE 360A
6	JUNCTION BOX TYPE 359A

CONNECTORS HAVE NO PREFIX NUMBER

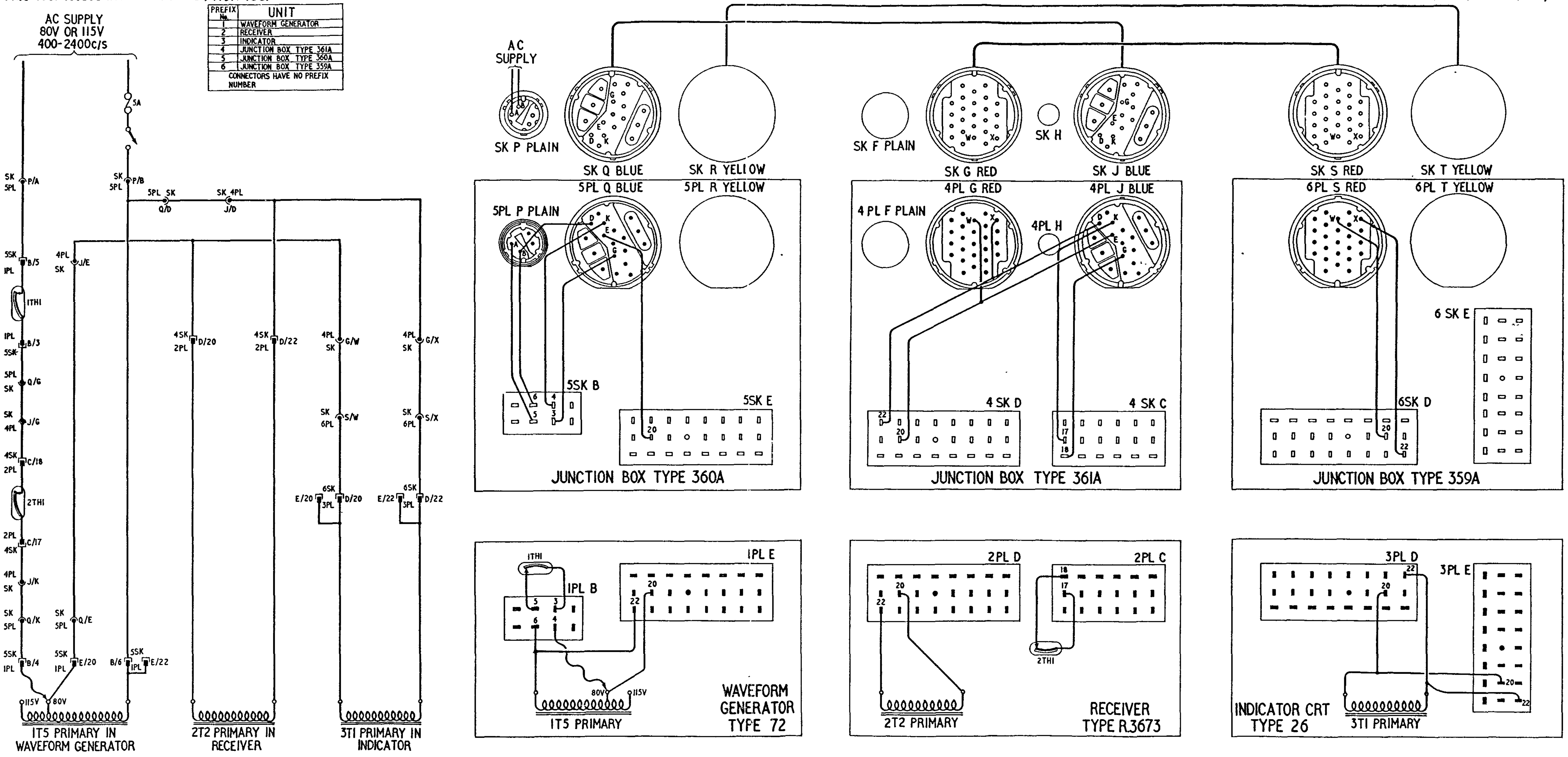
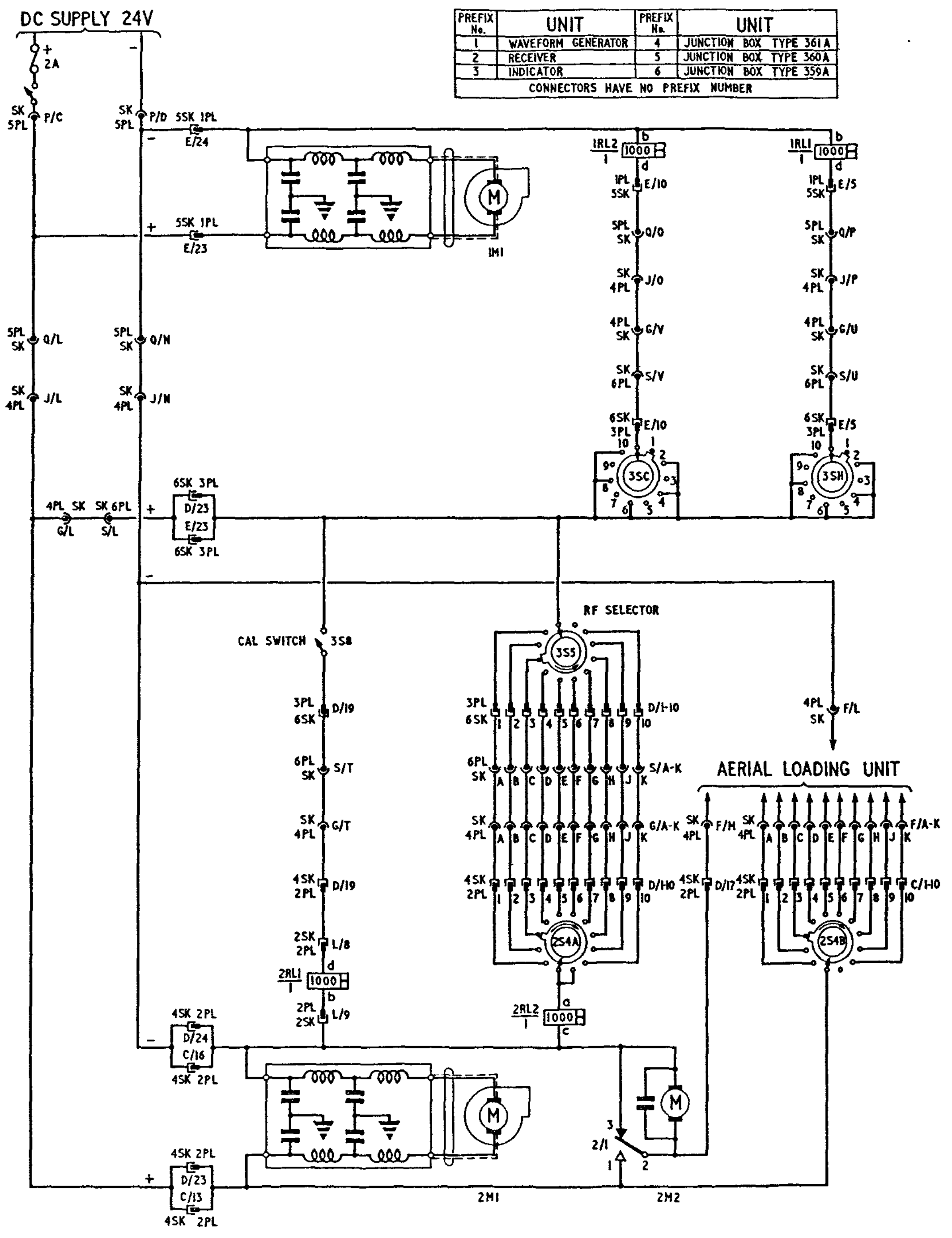


Fig. 1 — A C supply - circuit and simplified wiring — Fig. 1

PREFIX No.	UNIT	PREFIX No.	UNIT
1	WAVEFORM GENERATOR	4	JUNCTION BOX TYPE 361A
2	RECEIVER	5	JUNCTION BOX TYPE 360A
3	INDICATOR	6	JUNCTION BOX TYPE 359A
CONNECTORS HAVE NO PREFIX NUMBER			



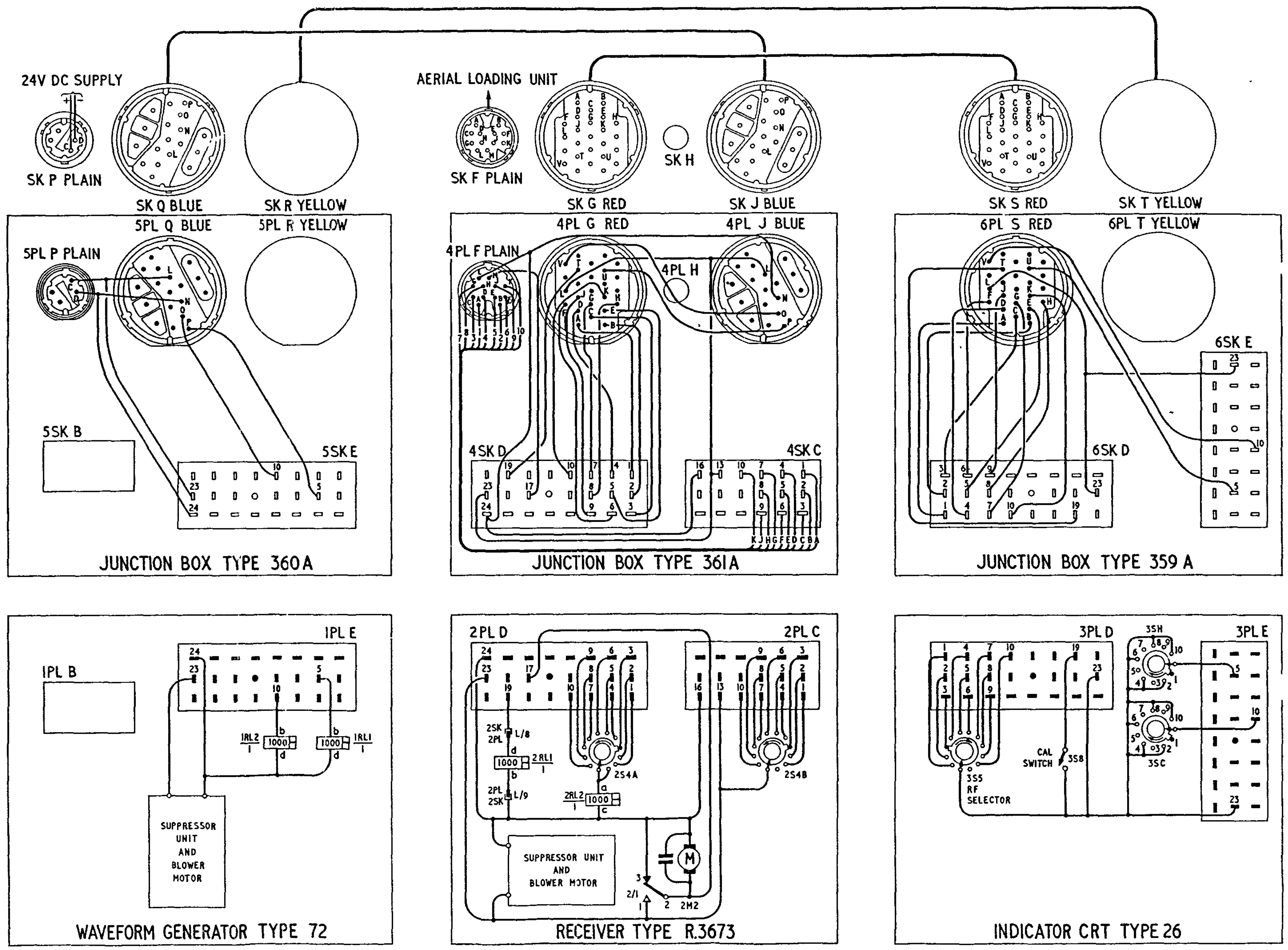


Fig.2 DC supply — circuit and simplified wiring Fig.2

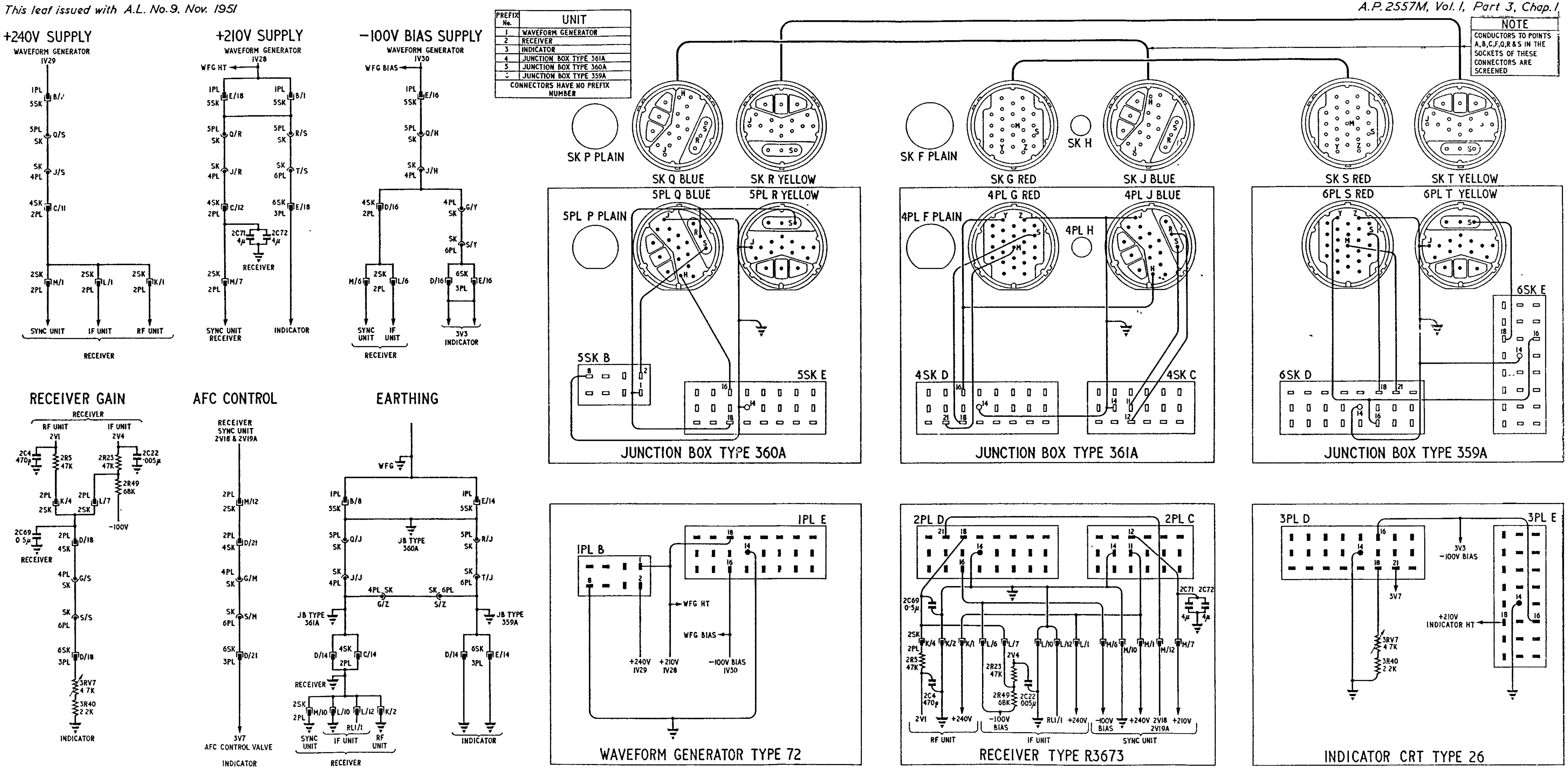


Fig. 3 HT and bias supplies — circuits and simplified wiring Fig. 3

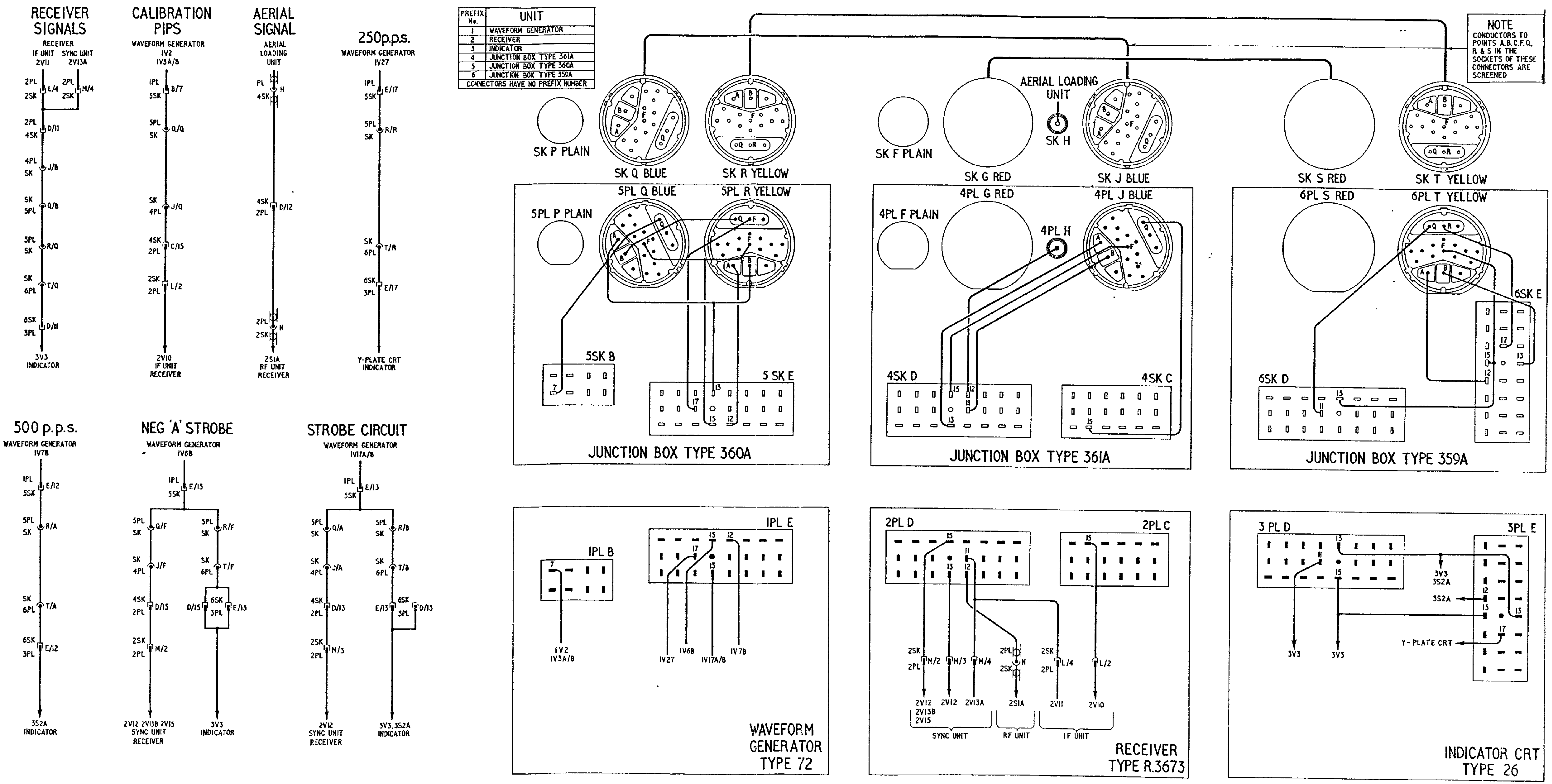


Fig. 4

Pulse and signal supplies - circuits and simplified wiring

Fig. 4

Chapter 2

BAY FAULT FINDING

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LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF EQUIPMENT REQUIRED

	Stores Ref.		Stores Ref.
Testmeter Type V	10S/821	Synchronizing unit Type 28	10D/18331
IF unit Type 125	10D/18330	Strobe switch unit Type 298	10F/16143
RF unit Type 148	10D/18329	Set of standard valves	

Procedure

1. The fault finding information in this chapter is limited to cover defects which may be rectified by the renewal of valves, the adjustment of pre-set controls, and the renewal of sub-assemblies. The pre-set adjustments involved are those described in the bench setting-up procedures of Part 2, Chap. 2, and do not extend to the third line servicing instructions provided in the same chapter.

2. The fault finding procedure will be generally the same for all units and should be undertaken as follows:—

(1) Remove the cover from the faulty unit and inspect the valves, components and wiring for obvious defects; look out particularly for broken or loose valves, damaged components, dry joints and loose connections.

(2) Substitute the unit in the bench installation and switch on power supplies.

(3) Note the nature of the display on the indicator and adjust the indicator front panel controls; note the effects of the controls on the display.

(4) Refer to Table 1, Table 2 or Table 3 for the waveform generator, indicator or receiver, respectively; check the first two columns for a listed symptom and display appearance corresponding with the observed symptoms and display.

(5) Carry out the action recommended in the third column of the table; refer to the appropriate illustration to find the circuit function and location of the suspected valve or component.

Notes on Tables

3. Unless otherwise stated, the displays shown in the tables are found under the following working conditions:—

(1) X'TAL control "in" for manual operation.

(2) PRF control set to A or the p.r.f. of the local chain.

(3) RF selector set to 1 or the channel number of the local chain.

(4) Calibration switch set for normal (non-calibrate) operation.

(5) Timebase switch set for MTB (main time-base) operation.

(6) Gain control fully counter-clockwise (minimum).

(7) Strobe controls fully counter-clockwise (minimum).

4. When working conditions other than the ones stated above are involved in the production of the displays, the different conditions are shown by the addition of the following abbreviations in the displays :—

(1) STB—strobe timebase operation.

(2) CAL—calibration switch set for calibrate.

(3) GAIN—gain control turned to the normal working level.

(4) GAIN M—gain control turned up to maximum.

TABLE I

Waveform Generator

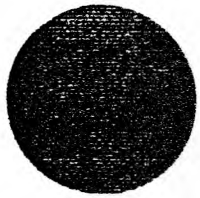
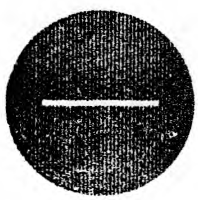
Symptom	Appearance of display	Action
No display		**(1) Check continuity of thermostat TH1; renew if open-circuit (as the mains input circuit is completed through the inter-unit connections and a thermostat in the receiver, the seating of all units must not be in doubt).** **(2) Check continuity of AC circuit from Jones plug point B6 to points B4 and E20.**
No traces; spot on display controllable		**Check HT at Jones plug point E18; if HT is low or zero disconnect AC supply and check HT line for short-circuits and check by renewal the rectifier valve V29 and the anti-jitter valve V28.**
No MTB and A-strobe traces; B and C-strobe traces appear normal on STB		**Check by renewal V7 and V5.**
No STB traces; MTB traces normal		**Check by renewal V16, V17, V15**
No A-strobe traces; MTB traces and B and C-strobe traces normal		**Check by renewal V18**
No trace separation; strobe wells normal		**Check by renewal V27**
No trace separation or strobe wells		**Check by renewal V8 and V19**

TABLE I (Continued)

Waveform Generator

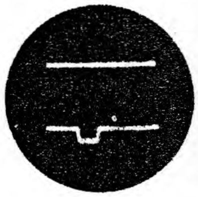
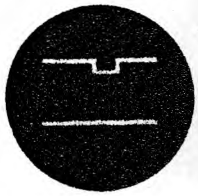
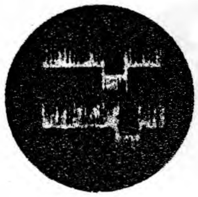
Symptom	Appearance of display	Action
No B-strobe well on MTB or B-strobe trace on STB		Check by renewal V9, V10, V11, V12, V13, V14, V15
No C-strobe well on MTB or C-strobe trace on STB		Check by renewal V20, V21, V22, V23, V24, V25, V26
Uncontrollable grass on all traces		Check bias at Jones plug point E16; if volts are zero or low disconnect AC supply and check bias line for short-circuits; check by renewal V30
No control of timebase speed with Xtal control; no 0·2-Gee unit markers on Calibrate		Check by renewal V2
No control of timebase speed; no 1-Gee unit markers on Calibrate; 0·2-Gee markers are non-synchronous		Check by renewal V3 (V3A)
No control of timebase speed; no 5-Gee unit markers on Calibrate; other markers non-synchronous		Check by renewal V3 (V3B)
No control of timebase speed; no MTB; all markers appear on STB but are non-synchronous		Check by renewal V4 (V4B), V6 (V6A)

TABLE 1 (Continued)

Waveform Generator		
Symptom	Appearance of display	Action
Traces normal; strobe wells jump in an erratic and uncontrolled manner	——	Check by renewal V28
Traces normal; strobes move unevenly on 0·1-Gee unit steps	——	Check by renewal V1
Traces normal; strobes move unevenly on 1-Gee unit steps	——	Check by renewal V26 (V26B)
Traces normal; strobes move unevenly on 5-Gee unit steps	——	Check by renewal V4 (V4A)
B-strobe moves unevenly in 0·01-Gee unit steps	——	Check by renewal V15 (V15A); check the adjustment of the B-strobe timer trimmer C77
B-strobe moves unevenly in 0·1-Gee unit steps	——	Check by renewal V13, V14
B-strobe moves unevenly in 1-Gee unit steps	——	Check by renewal V11, V12

TABLE I (Continued)

Waveform Generator

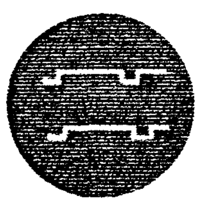
Symptom	Appearance of display	Action
B-strobe moves unevenly in 5-Gee unit steps		Check by renewal V9, V10
C-strobe moves unevenly in 0·01-Gee unit steps		Check by renewal V26 (V26A) ; check the adjustment of the C-strobe timer trimmer C78
C-strobe moves unevenly in 0·1-Gee unit steps		Check by renewal V24, V25
C-strobe moves unevenly in 1-Gee unit steps		Check by renewal V22, V23
C-strobe moves unevenly in 5-Gee unit steps		Check by renewal V20. V21
A-lock inoperative ; four strobe wells appear on MTB, no separation between A and B and A and C traces on STB		Check by renewal V6 (V6B)

TABLE 2

Indicator

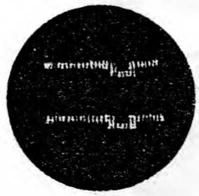
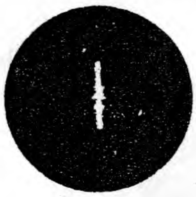
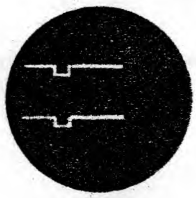
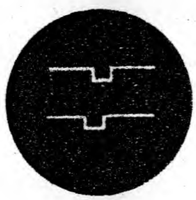
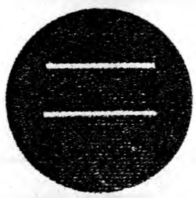
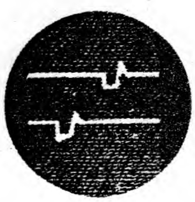
Symptom	Appearance of display	Action
No display		Check by renewal V9, V11
Poor brightness and focusing		Check by renewal V8, V11
No traces; vertical line at centre of display		Check by renewal V1
Short traces; no control of shift		Check by renewal V2
Short traces; shift control operates		Check by renewal V1
No strobe wells; signals normal		Check by renewal V3
Strobe wells not square		Check by renewal V4 (V4B)

TABLE 2 (Continued)

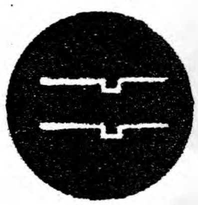
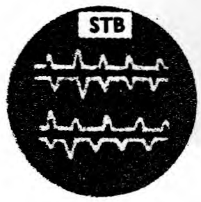
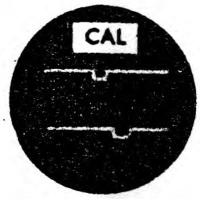
Indicator		
Symptom	**Appearance of display**	**Action**
Varying brightness level over traces		Check by renewal V10
No control of timebase speed ; no 0·2-Gee unit markers		Check by renewal V6
No control of timebase speed ; 0·2-Gee unit markers normal		Check by renewal V4 (V4A), V5
Timebase jitters on one or more, but not all, PRF's	—	Check by renewal crystals concerned ; check adjustment of L1, L2
A-lock does not operate	—	Check by renewal V7

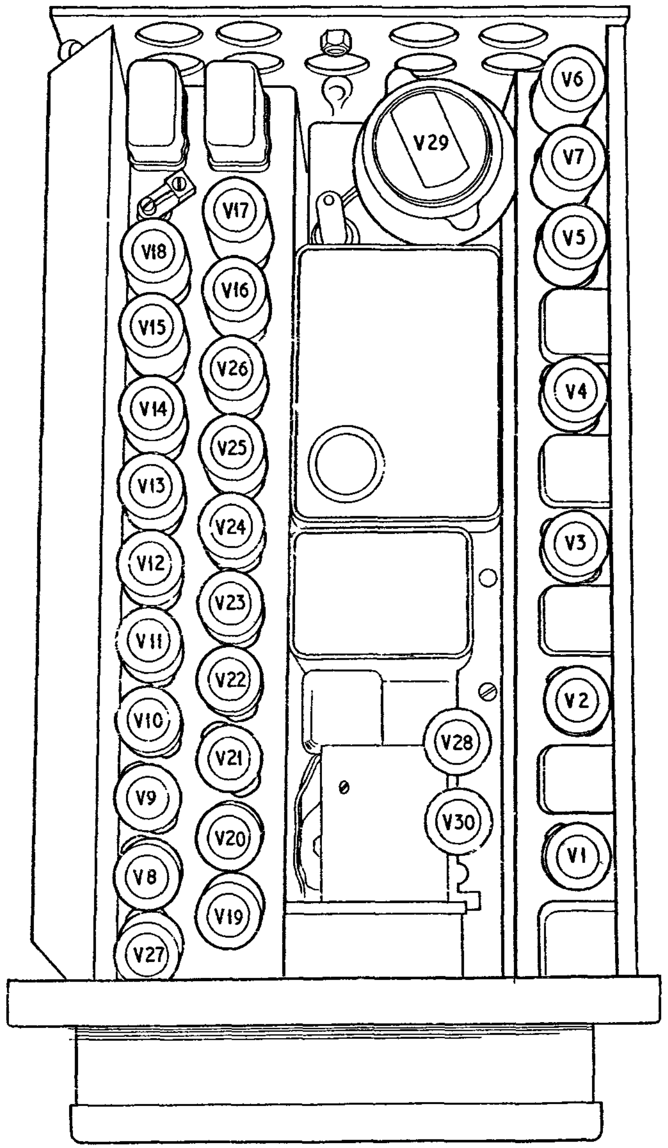
TABLE 3

Receiver		
Symptom	**Appearance of display**	**Action**
No display		Check continuity of thermostat T1 ; renew if open-circuit

TABLE 3 (Continued)

Receiver

Symptom	Appearance of display	Action
No signal pulses, grass or calibration markers; strobe wells normal		Check by renewal V10
No signal pulses, grass, calibration markers, or strobe wells		Check by renewal V11
No signal pulses or grass; calibration markers and strobe wells normal		Check by renewal V4, V5, V6, V7, V8, V9, and the IF unit
No signal pulses; calibration markers and strobe wells normal; some grass		Check by renewal V1, V2, V3; check mechanical alignment of RF switches; check electrical alignment of RF channels; check by renewal RF unit
Weak signals; calibration markers normal		Check RF channel alignment; check by renewal all RF and IF valves
Low amplitude of signals and calibration markers		Check by renewal V10, V11
A-lock inoperative	—	Check by renewal all valves on synchronising unit; check by renewal synchronising unit



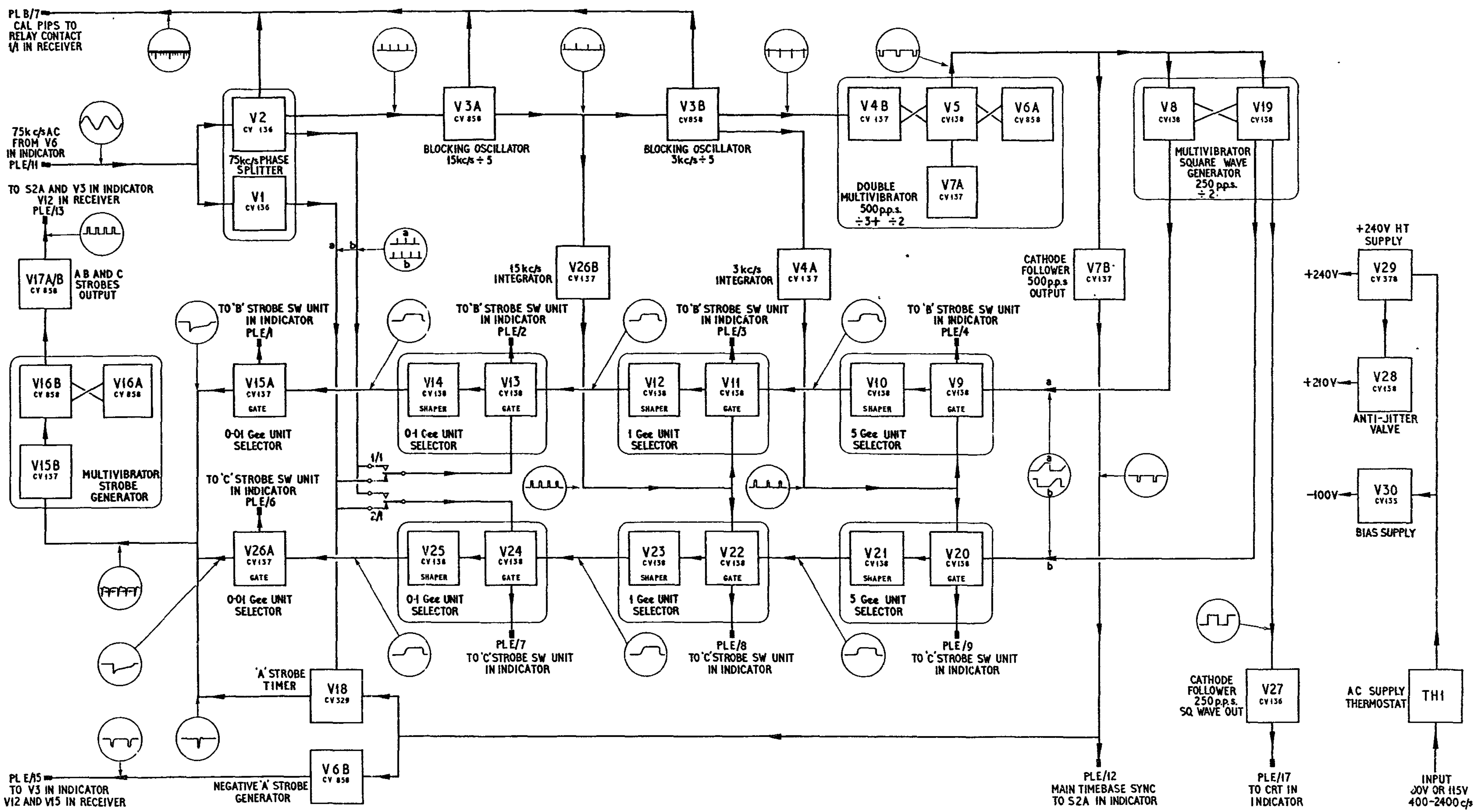


Fig. 1 Waveform generator Type 72, valve locations and block diagram Fig. 1

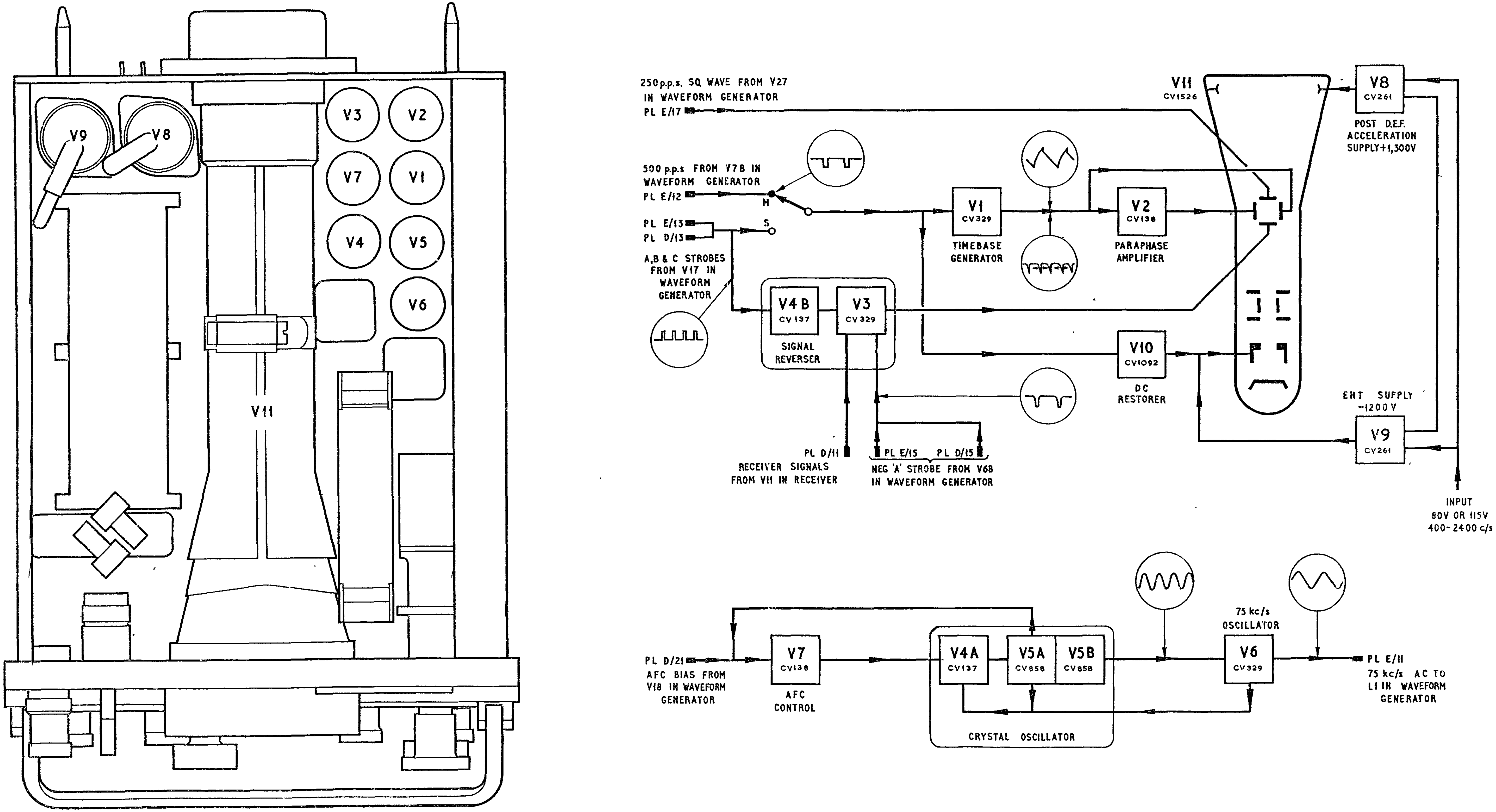
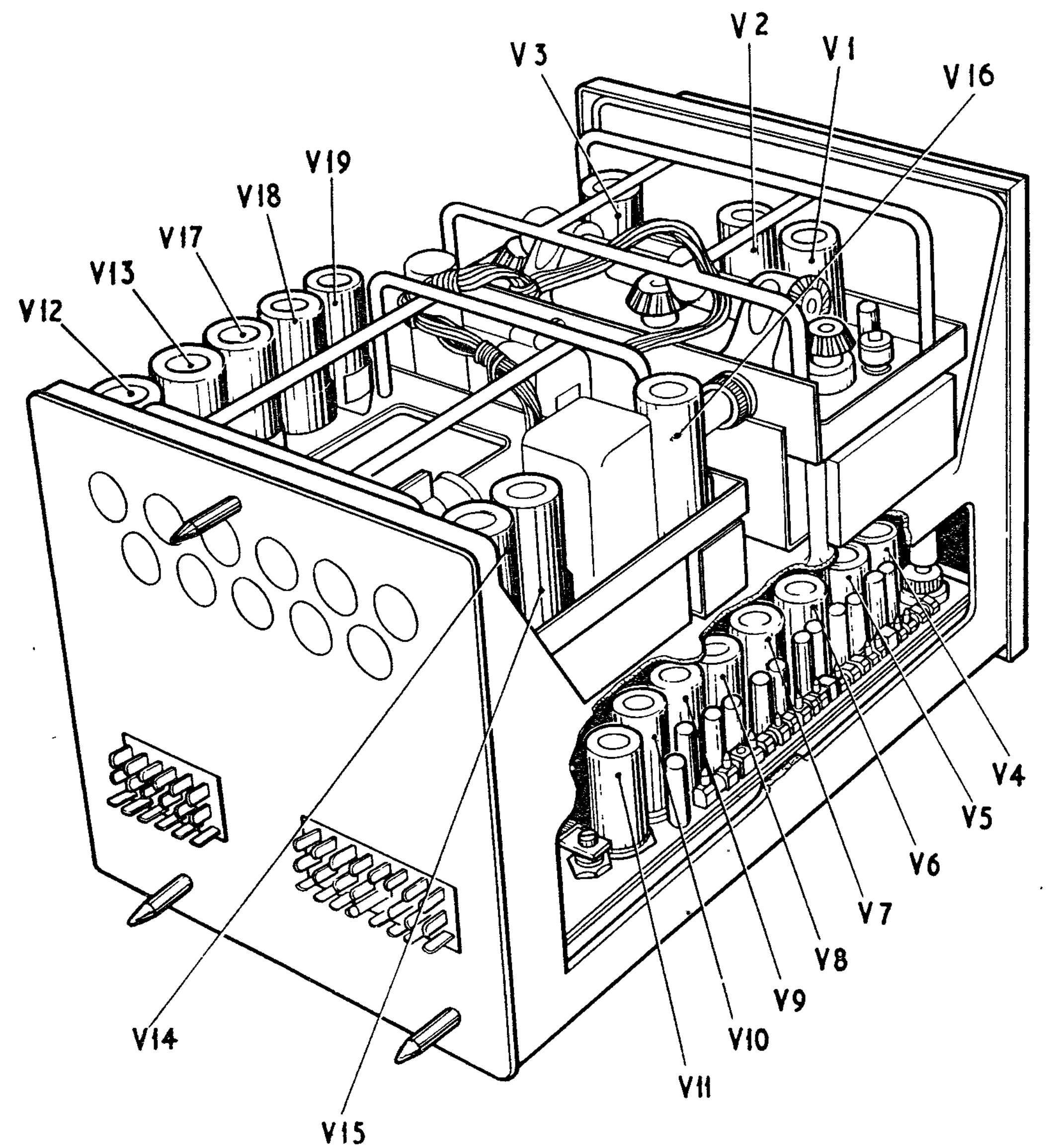


Fig. 2 Indicator CRT Type 26, valve locations and block diagram Fig. 2



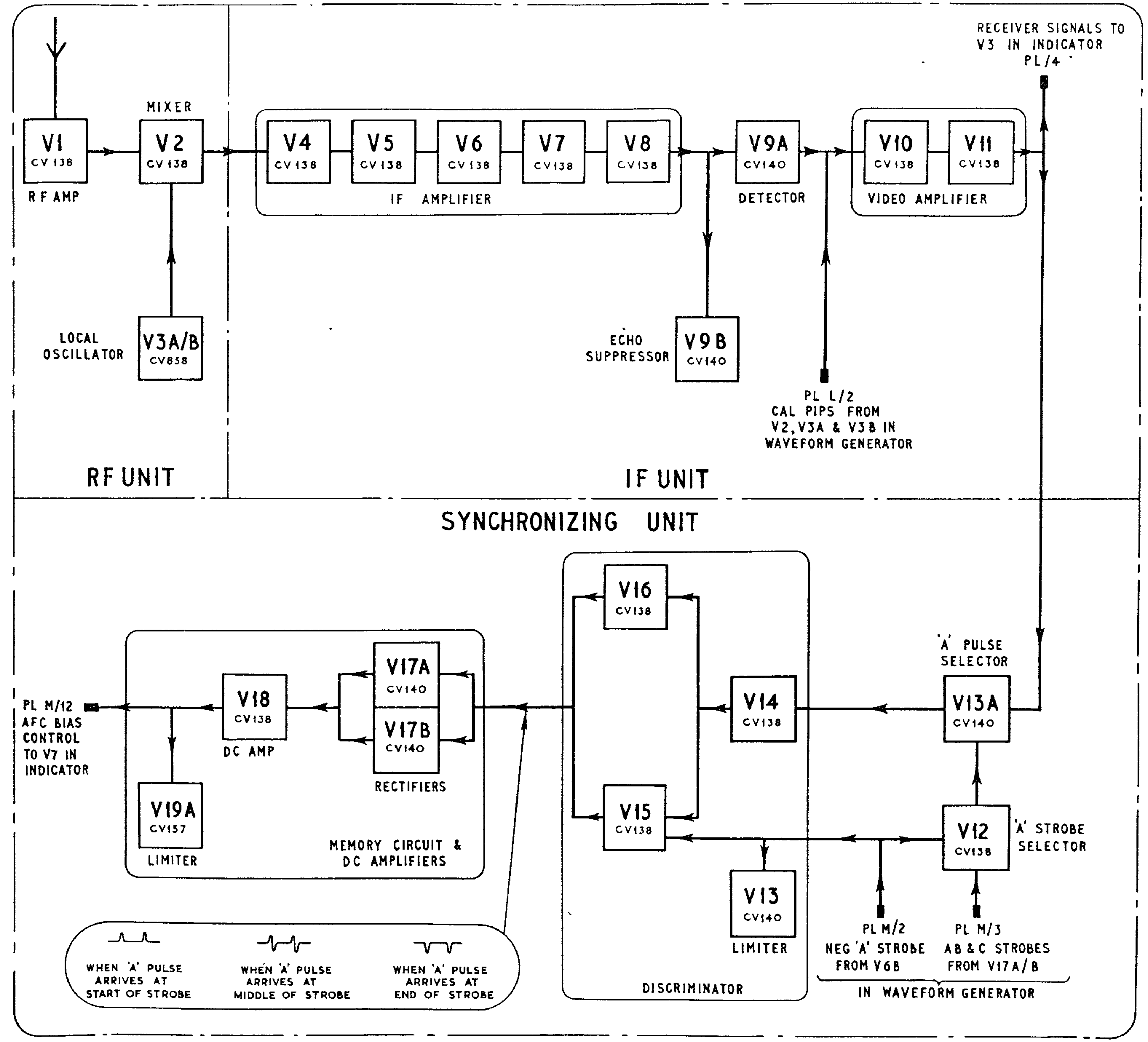


Fig. 3 Receiver Type R.3673, valve locations and block diagram Fig. 3

Chapter 3—ADVANCED FAULT FINDING

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

* To be issued later

LIST OF TEST EQUIPMENT REQUIRED

	Stores Ref.
Testmeter Type X, or	10S/16309
Tester, set Type 856G	110S/62
Oscilloscope Type 13, or	10S/825
Oscilloscope Type 10	10SB/180
Test set Type 210, or	10S/16002
Test set Type 253	10S/16049
Tester, insulation resistance	5G/1621
Voltmeter, electrostatic, 0-5KV	5Q/163
Voltmeter, thermo-couple, 0-100V	5Q/704
Microammeter, 0-250 μA	5Q/14427
Attenuator unit Type 70	10A/16129
Signal generator Type 106	10SB/6086

Scope of this chapter

1. A tabular guide to advanced fault finding is not provided herein because of the difficulty of presenting such matter in a form which is both useful and readable. As an alternative the chapter includes large-scale circuits, with voltages and waveforms added, together with diagrams of component positions and tables of component locations. This information should assist a fault-finder in applying his own reasoning to the location of a fault.

General procedure

2. Advanced fault finding will be carried out on individual units which have previously passed through first and second lines of servicing, and which, in consequence, should have their faults defined and localized to particular stages and sections. A faulty unit will be tested in a bench installation in which the associated units are in known good working condition ; in such an installation the circuits external to the faulty unit are free from suspicion thereby ensuring that all symptoms must necessarily relate to the faulty unit.

3. The method of fault finding will be generally the same for all units, and will be carried out on the following lines :—

(1) Note the reports on the equipment which have been provided by previous lines of servicing ; if the complaint is one of smoking, burning, overheating, etc., investigate the power circuits for shorts, using the test-meter and insulation tester, before connecting the unit under working conditions.

(2) With the unit connected into a working installation, study the display on the indicator and note the effect of handling controls.

(3) Decide in which stage the fault is most likely to lie, or, if the evidence drawn from (2) together with the reports from other lines of servicing is inadequate to allow a conclusion to be drawn, refer to the fault tables in Chapter 2 for guidance as to which stage might be responsible.

(4) Investigate the suspected circuit against the operation standards of voltage and waveform provided in the following illustrations.

Notes on testing

4. The voltages quoted in the illustrations were taken with a tester Type 856G ; they will not necessarily be obtained if other meters, particularly if of differing sensitivity, are used. In all instances, unless otherwise stated, the tests were made with the positive lead of the meter taken to the stated test point and the negative taken to chassis.

5. It should be noted that the quoted figures for all measurements are typical values which will not be repeatable exactly with other equipments. In general, the variations due to tolerances in power supplies equipments, valves and test gear should not exceed plus or minus 20 per cent, and in the special instance of the voltages at the HT and bias line tolerances should not exceed plus or minus 5 per cent ; results coming within these limits can normally be considered satisfactory.

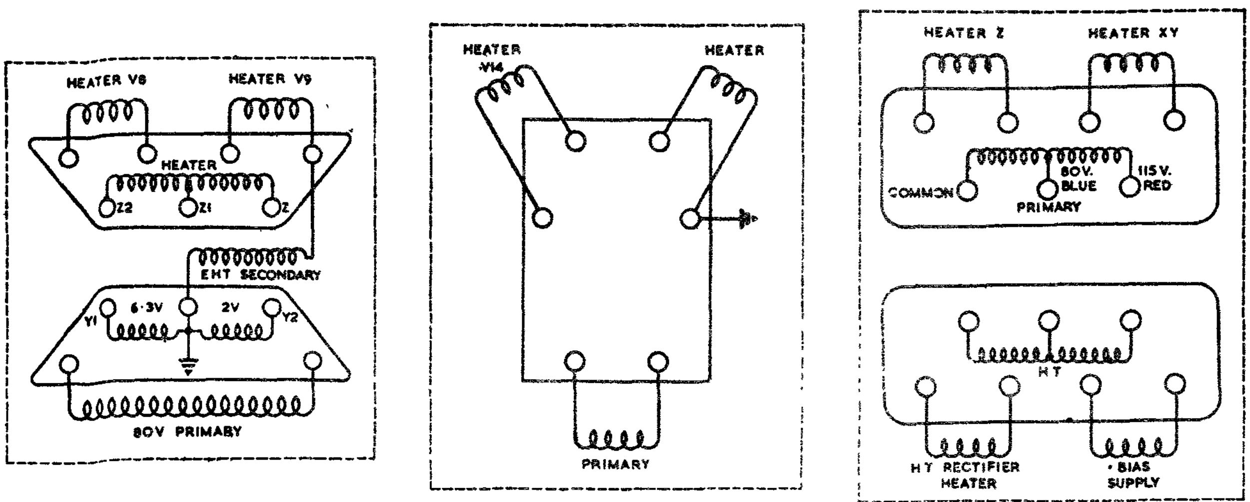
Soldering precautions

6. The greater part of the wiring in the units of the Gee Mk. 3 is insulated with PVC (polyvinyl-chloride) sleeving which is liable to damage if subjected to excessive heat. Such heat can be applied by the careless use of a soldering iron, particularly if a standard type of iron is used. Low-wattage irons are available for use with miniature equipments such as the Gee Mk. 3, and in order to reduce the possibility of damage to sleeving to the minimum these irons must always be used.

7. The recommended iron is the "Adcola" which is described as follows : Iron, soldering, electric, extra light, instrument type 230-250 volts, 25 watts, Stores Ref. 1L/143.

Component locations

8. The illustrations showing component positions are provided with reference lines at the top and right-hand sides. The position of each component is defined by reference to the numbered section of the top line which lies immediately above it, and the lettered section of the side line which lies immediately to the right. The references are recorded in the tables of component locations together with the fig. number of the illustration on which the component can most readily be seen.



T1 — INDICATOR T2 — RECEIVER T5—WAVEFORM GENERATOR

Fig. 1. Mains transformer connections

TABLE 1

Waveform generator—location of resistors

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location Fig. No.	Location Grid Ref.
R1	1·5 meg.	¼	10	10	2c
R2	1·5 meg.	¼	10	10	1c
R3	4,700	3	5	10	2c
R4	15,000	¼	10	10	2c
R5	15,000	¼	10	10	5d
R6	56,000	¼	10	10	5c
R7	390,000	¼	5	10	5c
R8	39,000	¼	10	10	5c
R9	8,200	¼	10	10	6d
R10	680,000	¼	5	10	6c
R11	22,000	¼	10	10	5d
R12	1,500	¼	10	10	5d
R13	3,300	3	5	10	4c
R14	15,000	3	5	10	4c
R15	15,000	3	5	10	4c
R16	330,000	¼	10	10	6d
R17	100,000	¼	10	10	6d
R18	100,000	¼	10	9	5c
R19	100,000	¼	10	10	7d
R20					
R21	1·5 meg.	¼	10	10	6d
R22	1·5 meg.	½	2	10	7c
R23	22,000	½	10	10	6c
R24	68,000	¼	10	10	7d
R25	33,000	¼	10	10	8d
R26	2·2 meg.	½	2	10	7c
R27	47,000	¼	10	10	7d
R28					
R29	1 meg.	¼	10	10	7d
R30	3·3 meg.	¼	10	10	7c
R31	1 meg.	¼	10	10	7d
R32	6,800	½	10	10	8c
R33	100	¼	10	10	8d
R34	47,000	¼	10	9	7c
R35	47,000	¼	10	9	7c
R36	6·8 meg.	¼	10	9	7c
R37	200,000	½	2	9	6b
R38	220,000	¼	10	9	6c
R39	18,000	¼	10	9	6b
R40	1·5 meg.	¼	10	9	7e
R41	1 meg.	¼	10	9	5a
R42	1 meg.	¼	10	9	6c
R43	22,000	¼	10	9	5b
R44	200,000	½	2	9	5b
R45	100,000	¼	10	10	6d
R46	220,000	¼	10	9	5c
R47	47,000	¼	10	9	5b
R48	1·5 meg.	¼	10	9	6e
R49	1 meg.	¼	10	9	4a
R50	22,000	¼	10	9	4b
R51	1 meg.	¼	10	9	5c
R52	200,000	½	2	9	4b
R53	150,000	¼	10	9	4c
R54	47,000	¼	10	9	4b
R55	3·3 meg.	¼	10	9	3b
R56	330,000	¼	10	9	3a
R57	1 meg.	¼	10	9	3b
R58	22,000	¼	10	9	2b
R59	100,000	½	2	9	3b
R60	47,000	¼	10	9	2b
R61	330,000	¼	10	9	2e

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location Fig. No.	Grid Ref.
R62	47,000	¼	10	9	1b
R63	100,000	¼	10	9	2e
R64	47,000	¼	10	9	2c
R65	220,000	¼	10	9	2d
R66	820,000	¼	10	9	2c
R67	22,000	¼	10	9	2e
R68	100	¼	10	9	1e
R69					
R70	47,000	¼	10	9	1b
R71	100,000	¼	10	9	2b
R72	470,000	¼	10	9	1e
R73	220,000	¼	10	9	1b
R74	47,000	¼	10	10	7d
R75	100,000	¼	10	10	8b
R76	27,000	¼	10	10	8d
R77	27,000	¼	10	10	3c
R78	6,800	¼	10	10	3c
R79	6,800	¼	10	10	3c
R80	6·8 meg.	¼	10	8	1d
R81	200,000	½	2	9	7d
R82	220,000	¼	10	9	7d
R83	18,000	¼	10	9	7e
R84	1·5 meg.	¼	10	9	7e
R85	1 meg.	¼	10	9	6e
R86	1 meg.	¼	10	9	6c
R87	22,000	¼	10	9	6e
R88	200,000	½	2	9	6d
R89	1 meg.	¼	10	9	7c
R90	220,000	¼	10	9	5d
R91	47,000	¼	10	9	5e
R92	1·5 meg.	¼	10	9	5e
R93	1 meg.	¼	10	9	5e
R94	1 meg.	¼	10	9	5c
R95	22,000	¼	10	9	5e
R96	200,000	½	2	9	5d
R97	150,000	¼	10	9	4d
R98	47,000	¼	10	9	4e
R99	3·3 meg.	¼	10	9	4e
R100	330,000	¼	10	9	4e
R101	1 meg.	¼	10	9	3d
R102	22,000	¼	10	9	3e
R103	100,000	½	2	9	3d
R104	47,000	¼	10	9	3e
R105	330,000	¼	10	9	2e
R106					
R107	1 meg.	¼	10	9	7b
R108	100	¼	10	9	7b
R109					
R110	10,000	¼	10	9	7b
R111	1 meg.	¼	10	8	2b
R112	4,700	¼	10	8	2b
R113	470	¼	10	8	3b
R114	180	5	5	8	3a
R115	150,000	¼	10	8	2b
R116	2,200	¼	10	8	2b
R117					
R118					
R119	8,200	¼	10	9	2e
R120	6,800	¼	10	10	3d
R121	82,000	¼	10	9	2d
R122	100	¼	10	9	2c
R123	6,800	¼	10	10	3b
R124	100,000	¼	10	9	3c
R125	1,000	¼	10	10	6b
R126	180,000	¼	10	8	5a

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
R127	22,000	¼	10	8	5a
R128	1,000	¼	10	10	8b
R129	470	¼	10	8	1d
R130	100	¼	10	8	2b
R131	12,000	¼	10	9	2c
R132	10,000	¼	10	8	6d
R133	6,800	¼	10	8	7d
R134	6,800	¼	10	8	7d
R135					
R136					
R137					
R138					
RV1	50,000			8	1d
RV2	50,000			8	1d
RV3	50,000			8	6d
RV4	5,000			8	4c

Notes.

(1) Before RMC Mod. No. 2415/2:—

(a) R53 and R97 were 220,000 ohms.

(b) R57 and R101 were 5 6 meg.

(c) R133 and R134 were not fitted.

(2) Before RMC Mod. No. 2428/4:—

(a) R116 was 4,700 ohms.

(b) RV4 was not fitted.

TABLE 2
Waveform generator—location of capacitors

Circuit Ref.	Value	Rating wkg. volts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
C1	100 pF	350	2	10	2c
C2					
C3	0·05 μF	350	20	10	2c
C4	100 pF	350	5	10	2c
C5	100 pF	350	5	10	1c
C6	0·05 μF	350	20	10	2c
C7	220 pF	350	5	10	5c
C8	820 pF	350	5	10	6c
C9	0·01 μF	350	20	10	5c
C10	0·25 μF	350	25	10	4c
C11	1,200 pF	350	5	10	6c
C12	2,200 pF	350	10	10	6c
C13	1,500 pF	350	5	10	7c
C14	0·05 μF	350	20	10	7c
C15	0·02 μF	350	20	10	7c
C16	47 pF	350	5	9	7b
C17	1,000 pF	350	5	9	7b
C18	0·01 μF	350	2	9	7d
C19	470 pF	350	10	9	7d
C20	0·2 μF	350	20	9	6b
C21	1,500 pF	350	5	9	6b
C22	0·01 μF	350	20	9	6b
C23	0·05 μF	350	20	9	5b
C24	2,000 pF	350	2	9	6d
C25	470 pF	350	10	9	5d
C26	0·005 μF	350	20	9	5b
C27	330 pF	350	5	9	5b
C28	0·01 μF	350	20	9	5b
C29	0·005 μF	350	20	9	4b
C30	390 pF	350	2	9	4b
C31	470 pF	350	10	9	3b
C32	0·005 μF	350	20	9	4b
C33	0·01 μF	350	20	9	3b
C34	68 pF	350	5	9	3b
C35	33 pF	350	10	9	2b
C36	0·005 μF	350	20	9	2b
C37	100 pF	350	10	9	2d
C38	100 pF	350	10	9	2d
C39	120 pF	350	5	9	2d
C40	0·05 μF	350	20	9	2d
C41	100 pF	350	5	9	2b
C42	470 pF	350	10	9	1b
C43	1,500 pF	350	2	10	8c
C44	0·1 μF	350	25	10	8c
C45	0·25 μF	150	25	10	3c
C46	47 pF	350	5	9	7b
C47	1,000 pF	350	5	9	7b
C48	0·01 μF	350	2	9	7d
C49	470 pF	350	10	9	7d
C50	0·02 μF	350	20	9	7d
C51	1,500 pF	350	5	9	7d
C52	0·01 μF	350	20	9	6d
C53	0·05 μF	350	20	9	6d
C54	2,000 pF	350	2	9	6d
C55	470 pF	350	10	9	5d
C56	330 pF	350	5	9	5d
C57	0·005 μF	350	20	9	5d
C58	0·01 μF	350	20	9	5d
C59	0·005 μF	350	20	9	5d
C60	390 pF	350	2	9	4d
C61	470 pF	350	10	9	4d
C62	68 pF	350	5	9	4d
C63	0·01 μF	350	20	9	3d

Circuit Ref.	Value	Rating wkg. volts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
C64	0·005 μF	350	20	9	4d
C65	0·005 μF	350	20	9	3d
C66	33 pF	350	10	9	3d
C67	0·005 μF	350	20	9	3d
C68	0·05 μF	350	20	9	7b
C69	0·005 μF	350	20	9	2b
C70	0·25 μF	350	20	8	3b
C71	0·5 μF	350	20	8	1b
C72	0·5 μF	350	20	8	2c
C73	1·0 μF	250	20	8	1b
C74	0·5 μF	500	20	8	1c
C75	0·5 μF	500	20	8	1c
C76	0·5 μF	500	20	8	1b
C77	30 pF			9	1d
C78	30 pF			9	1d
C79					
C80					
C81	0·05 μF	350	20	10	6c
C82	220 pF	350	5	9	7b
C83	47 pF	350	10	9	4c
C84	0·02 μF	350	20	9	2d
C85	39 pF	350	10	9	1c
C86					
C87					
C88	1·0 μF	250	20	8	1b
C89	0·5 μF	500	20	8	6c
C90	27 pF	350	10	9	1b

Notes.

(1) Before RMC Mod. No. 2417/3:—
C43 was 1,200 pF.

TABLE 3

Receiver—location of resistors

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location Fig. No.	Location Grid Ref.
R1	47,000	¼	10	13	9b
R2	56	¼	20	13	8b
R3	4,700	¼	10	13	8b
R4	22,000	¼	10	13	8b
R5	47,000	¼	10	13	9b
R6	470,000	¼	10	13	8c
R7	56	¼	20	13	8c
R8	22,000	¼	10	13	8d
R9	2,200	¼	10	13	8c
R10	10,000	¼	10	13	9e
R11	10,000	¼	10	13	9e
R12	470	¼	10	13	8e
R13	10,000	¼	10	13	7b (on L1)
R14	10,000	¼	10	13	7b (on L2)
R15	10,000	¼	10	13	7b (on L3)
R16					
R17					
R18					
R19					
R20	47,000	¼	10	16	6c
R21	56	¼	10	16	6d
R22	3,300	¼	10	16	6d
R23	47,000	¼	10	16	6c
R24	47,000		10	16	6c
R25	2,200	¼	10	16	5c
R26	3,300	¼	10	16	5d
R27	47,000		10	16	5c
R28	4,700	¼	10	16	5c
R29	3,300	¼	10	16	4d
R30	47,000		10	16	4c
R31	4,700	¼	10	16	4c
R32	3,300	¼	10	16	4d
R33	47,000		10	16	4c
R34	4,700	¼	10	16	3c
R35	4,700	¼	10	16	3d
R36	1 meg.	¼	10	16	3c
R37	10,000	¼	10	16	2d
R38	100,000	¼	10	16	2c
R39	220	¼	10	16	2d
R40	470,000	¼	10	16	2d
R41	10,000	½	10	16	2d
R42	100,000	¼	10	16	2c
R43	1,500	¼	10	16	2d
R44	220	¼	10	16	1d
R45					
R46	680	¼	10	16	1c
R47	10,000	¼	10	16	1c
R48	220,000	¼	10	16	1c
R49	68,000	¼	10	16	3c
R50	6,800	¼		16	2d
R51	6,800	¼	10	19	5b
R52	33,000	¼	10	19	5c
R53	100,000	¼	10	19	5c
R54	100,000	¼	10	19	5c
R55	3,300	¼	10	19	5c
R56	22,000	¼	10	19	6a
R57	330,000	¼	10	19	6a
R58	33,000	¼	10	19	5a
R59	33,000	¼	10	19	5b
R60					
R61	4,700	¼	10	19	5a
R62					

Circuit Ref.	Value	Rating in watts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
R63	1,000	¼	10	19	5a
R64	47,000	¼	10	19	6b
R65	1,200	¼	10	19	6c
R66	1,500	¼	10	19	6d
R67					
R68					
R69					
R70	68,000	¼	10	19	6c
R71	1·8 meg.	¼	10	19	7c
R72	47,000	¼	10	19	7d
R73	47,000	¼	10	19	7c
R74	1 meg.	¼	5	19	7c
R75	1 meg.	¼	5	19	7c
R76	1 meg.	¼	10	19	7c
R77	3,300	¼	10	19	5b
R78	100,000	¼	10	19	6d
R79	4,700	¼	10	19	6d
R80	39,000	¼	10	19	6c
R81	4,700	¼	10	19	5b
R82					
R83					
R84					
R85	15	¼	10	13	8e
RV1	100,000			16	1b
RV2	50,000			17	1b

Notes.

(1) Before RMC Mod. No. 2416/1:—

(a) R50 was not fitted.

TABLE 4

Receiver—location of capacitors

Circuit Ref.	Value	Rating wkg. volts	Tolerance ± per cent	Location Fig. No.	Location Grid Ref.
C1	3·3 pF			13	2a
C2	470 pF		10	13	8b
C3	47 pF	500	10	13	9b
C4	470 pF	500	10	13	9b
C5	0·005 μF	350		13	1a
C6	470 pF	500	10	13	8c
C7	470 pF	500	10	13	8c
C8	10 pF	500	10	13	8d
C9	3·3 pF			13	2d
C10	0·005 μF	350	25	13	1c
C11	1·0 pF	500	0·5 pF	13	8e
C12	3·3 pF	500	0·5 pF	13	9e
C13	3·3 pF			13	1f
C14	4·7 pF	500	10	13	8f
C15	470 pF	500	10	13	9e
C16					
C17					
C18					
C19					
C20	470 pF	500	20	16	6c
C21	47 pF	500	10	16	6d
C22	0·005 μF	350		16	6b
C23	0·005 μF	350		16	5b
C24	470 pF	500	20	16	6d
C25	0·005 μF	350		16	5b
C26	470 pF	500	20	16	5d
C27	0·005 μF	350		16	4b
C28	0·005 μF	350		16	5b
C29	470 pF	500	20	16	4d
C30	0·005 μF	350		16	4b
C31	0·005 μF	350		16	4b
C32	470 pF	500	20	16	4d
C33	0·005 μF	350		16	3b
C34	0·005 μF	350		16	4b
C35	470 pF	500	20	16	3d
C36	470 pF	500	20	16	3c
C37	0·001 μF	500		16	3b
C38	10 pF			16	2d
C39	10 pF			16	2d
C40	470 pF	500	20	16	2d
C41	10 pF	500	10	16	2d
C42	0·001 μF	500		16	1d
C43	0·005 μF	350		16	2b
C44	470 pF	500	20	16	2d
C45					
C46	0·005 μF	350		16	3b
C47					
C48					
C49					
C50					
C51	0·01 μF	350	20	19	6c
C52	0·005 μF	350	20	19	5b
C53	0·05 μF	350	20	19	5c
C54	220 pF	350	5	19	6b
C55	0·5 μF	350		19	3b
C56	0·25 μF	150	25	19	5c
C57	0·25 μF	150	25	19	5b
C58					
C59	0·25 μF	150	25	19	6b
C60	0·25 μF	150	25	19	6c
C61	0·1 μF	350	25	19	6c
C62	0·1 μF	350	25	19	5b

Circuit Ref.	Value	Rating wkg. volts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
C63					
C64					
C65	0·001 μF	350	10	Blower suppressor	
C66	0·001 μF	350	10	Blower suppressor	
C67	0·001 μF	350	10	Blower suppressor	
C68	0·001 μF	350	10	Blower suppressor	
C69	0·5 μF	150	25	Main chassis	
C70	0·1 μF	150	25	RF selector motor	
C71	4 μF	400	20	Main chassis	
C72	4 μF	400	20	Main chassis	

TABLE 5

Indicator—location of resistors

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location Fig. No.	Location Grid Ref.
R1	1 meg.	$\frac{1}{4}$	10	25	5a
R2	2·2 meg.	$\frac{1}{4}$	10	27	6a
R3	820,000	$\frac{1}{4}$	5	26	4d
R4	820,000	$\frac{1}{4}$	5	26	4d
R5	68,000	$\frac{1}{4}$	10	26	5b
R6	33,000	$\frac{1}{4}$	10	26	5a
R7	2·2 meg.	$\frac{1}{4}$	10	27	6a
R8	47,000	$\frac{1}{4}$	10	26	3d
R9	68,000	$\frac{1}{4}$	10	26	6b
R10	22,000	$\frac{1}{4}$	10	25	2a
R11					
R12	6,800	$\frac{1}{4}$	10	26	4c
R13	6,800	$\frac{1}{4}$	10	26	3d
R14	4·7 meg.	$\frac{1}{4}$	10	27	5a
R15	27,000	$\frac{1}{4}$	10	26	4c
R16	100,000	$\frac{1}{4}$	10	27	6b
R17	22,000	$\frac{1}{4}$	10	27	6a
R18	220,000	$\frac{1}{4}$	10	26	5d
R19	15,000	$\frac{1}{4}$	10	26	5d
R20	27,000	$\frac{1}{4}$	10	26	5d
R21	1 meg.	$\frac{1}{4}$	10	25	5a
R22	470	$\frac{1}{4}$	10	27	5b
R23	1 meg.	$\frac{1}{4}$	10	26	4b
R24					
R25	560	$\frac{1}{4}$	10	27	5a
R26	820	$\frac{1}{4}$	5	26	5b
R27	33,000	$\frac{1}{4}$	10	27	6a
R28	220,000	$\frac{1}{4}$	10	26	4b
R29	1 meg.	$\frac{1}{4}$	10	27	4a
R30	47,000	$\frac{1}{4}$	10	27	4a
R31	100,000	$\frac{1}{4}$	10	27	4a
R32	2,700	$\frac{1}{4}$	10	27	5b
R33	820	$\frac{1}{4}$	5	27	4b
R34	1 meg.	$\frac{1}{4}$	10	27	5b
R35	18,000	$\frac{1}{4}$	10	25	4a
R36	330,000	$\frac{1}{4}$	10	26	5d
R37					
R38	120	$\frac{1}{4}$	10	26	3b
R39	82,000	$\frac{1}{4}$	10	25	2a
R40	2,200	$\frac{1}{4}$	10	25	1a
R41	2·2 meg.	$\frac{1}{4}$	10	25	4a
R42	560,000	$\frac{1}{2}$	10	25	3a
R43	560,000	$\frac{1}{2}$	10	25	3a
R44	560,000	$\frac{1}{2}$	10	25	4a
R45	47,000	$\frac{1}{4}$	10	25	4a
R46	270,000	$\frac{1}{2}$	10	27	5d
R47	47,000	$\frac{1}{4}$	10		
R48	390,000	$\frac{1}{2}$	10	25	3a
R49	390,000	$\frac{1}{2}$	10	25	3a
R50	390,000	$\frac{1}{2}$	10	25	3a
R51	13,750 }			Strobe switch unit	
R52	13,750 }				
R53	1,330 }			Strobe switch unit	
R54	1,330 }				
R55	1,330 }			Strobe switch unit	
R56	1,330 }				
R57	1,330 }			Strobe switch unit	
R58	1,750 }				
R59	1,330 }			Strobe switch unit	
R60	1,750 }				
R61	1,750 }			Strobe switch unit	
R62	1,750 }				

Circuit Ref.	Value in ohms	Rating in watts	Tolerance ± per cent	Location	
				Fig. No.	Grid Ref.
R63	1,750 }			Strobe unit switch	
R64	1,750 }				
R65	2,200 }			Strobe unit switch	
R66	2,200 }				
R67	2,200 }			Strobe unit switch	
R68	2,200 }				
R69	2,200 }			Strobe unit switch	
R70	3,800 }				
R71	2,200 }			Strobe unit switch	
R72	3,800 }				
R73	10,000	$\frac{1}{4}$	10	27	5a
R74	390,000	$\frac{1}{4}$	10	26	3d
R75	6,800	$\frac{1}{4}$	10	27	6b
R76	27,000	$\frac{1}{4}$	10	26	4b
R77	5,600	$\frac{1}{4}$	10	26	5b
R78	5,600	$\frac{1}{4}$	10	27	4a
R79	47,000	$\frac{1}{4}$	10	26	4d
R80	1,000	$\frac{1}{4}$	10	27	6a
R81	1,000	$\frac{1}{4}$	10	27	6a
R82					
R83	1,000	$\frac{1}{4}$	10	27	6b
RV1	50,000			25	2b
RV2	25,000			25	2a
RV3	50,000			25	2a
RV4	220,000			25	3a
RV5	100,000			25	2a
RV6	100,000			25	2b
RV7	4,700			25	1a
RV8	6			Front panel	

Notes.

(1) Before RMC Mod. No. 2396/1:—

(a) R45 was 100,000 ohms.

(b) R47 was not fitted.

TABLE 6

Indicator—location of capacitors

Circuit Ref.	Value	Rating wkg. volts	Tolerance ± per cent	Location Fig. No.	Location Grid Ref.
C1	0·1 μF	150	25	25	5a
C2	0·02 μF	350	20	26	4d
C3	33 pF	350	5	26	5b
C4	820 pF	350	5	26	5b
C5	0·05 μF	350	20	26	5b
C6	47 pF	350	5	26	5b
C7	47 pF	350	5	26	6b
C8	0·25 μF	150	25	26	6b
C9					
C10					
C11	0·1 μF	350	25	26	3d
C12	0·1 μF	350	25	26	3d
C13	0·05 μF	200	20	25	4a
C14	0·01 μF	350	20	26	5d
C15	0·05μF	200	20	26	4d
C16					
C17					
C18	75 pF	Variable		25	2d
C19	8·2 pF	500	10	25	3d
C20	560 pF	350	10	26	4b
C21	100 pF	350	10	26	4b
C22	0·001 μF	500	20	26	4b
C23	0·001 μF	500	20	26	4b
C24	470 pF	350	5	26	4b
C25	0·05 μF	200	20	26	5d
C26	100 pF	350	10	26	5d
C27					
C28	0·03 μF	2,500	20	27	4c
C29	0·03 μF	2,500	20	27	5c
C30	0·03 μF	2,500	20	27	5c
C31	0·03 μF	2,500	20	27	5d
C32	0·05 μF	200	20	26	4d
C33	0·25 μF	350	25	26	6c
C34	10 pF	500	10	27	5b
C35	25 pF	Variable		25	3d
C36	680 pF	350	10	26	3b

(669) Wt. 43688/3684 1625 2/64 T.T.P. Ltd. 3334-2

This leaf issued with A.L. No. 12, April, 1952

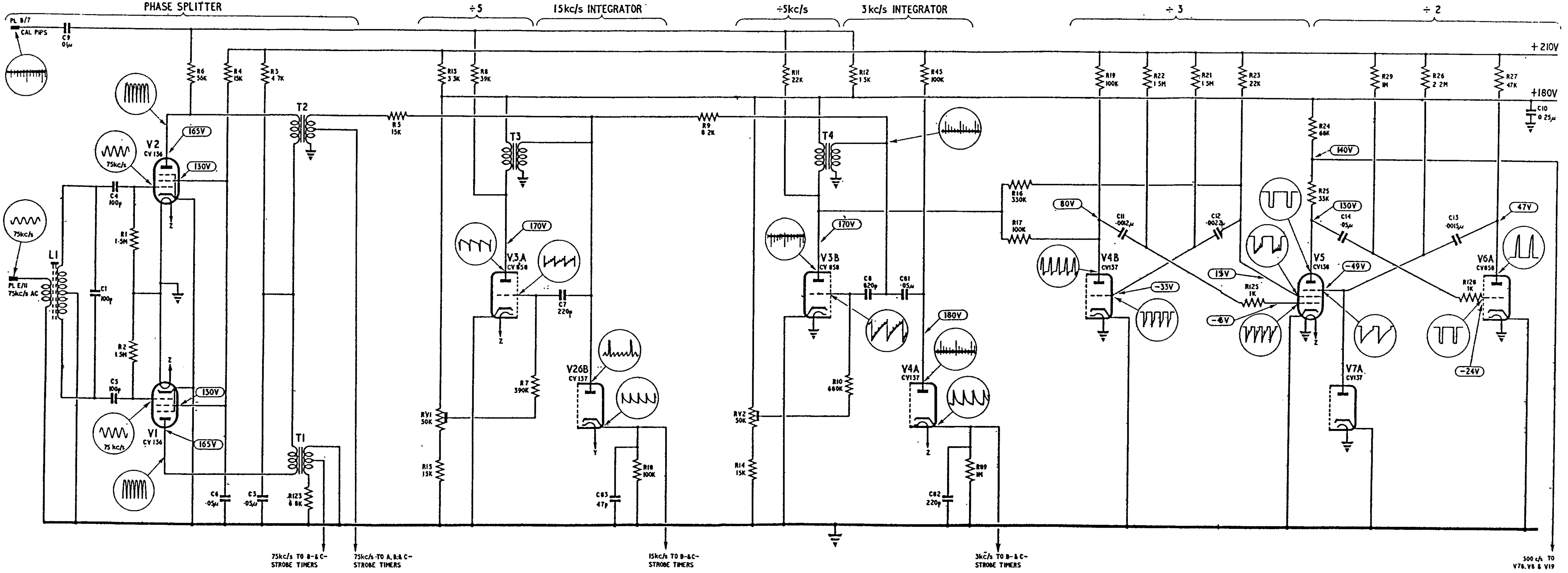


Fig. 2

Waveform generator – divider circuit

Fig. 2

455596 / 6758 375 10/54 BR Ltd Gp 979

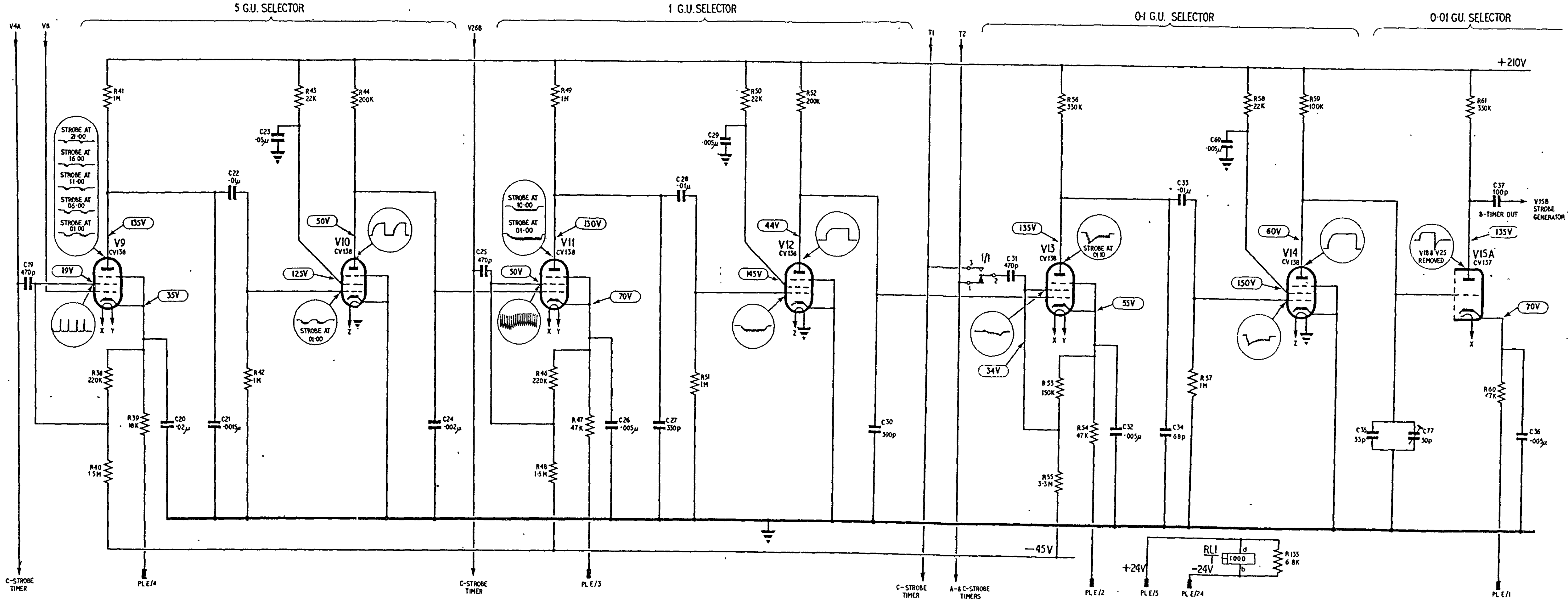


Fig. 3

Waveform generator — B-strobe circuit

RESTRICTED

Fig. 3

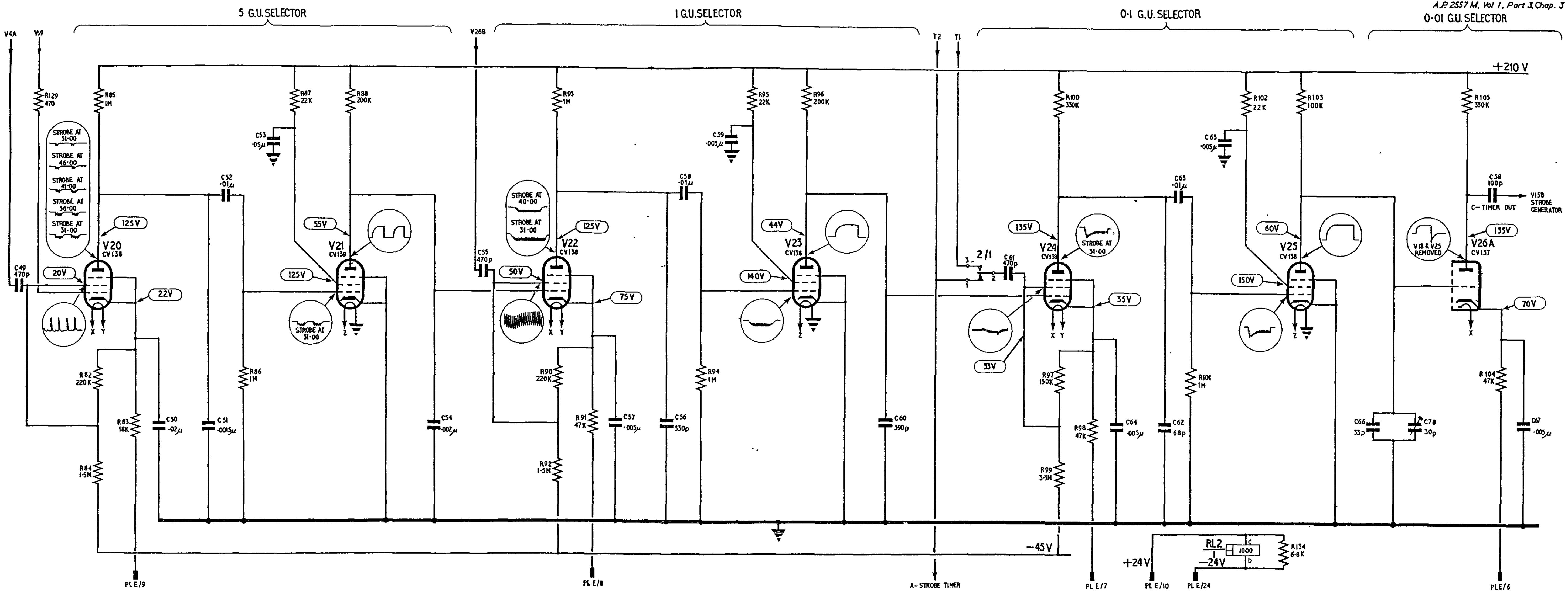


Fig. 4 Waveform generator—C-strobe circuit Fig. 4

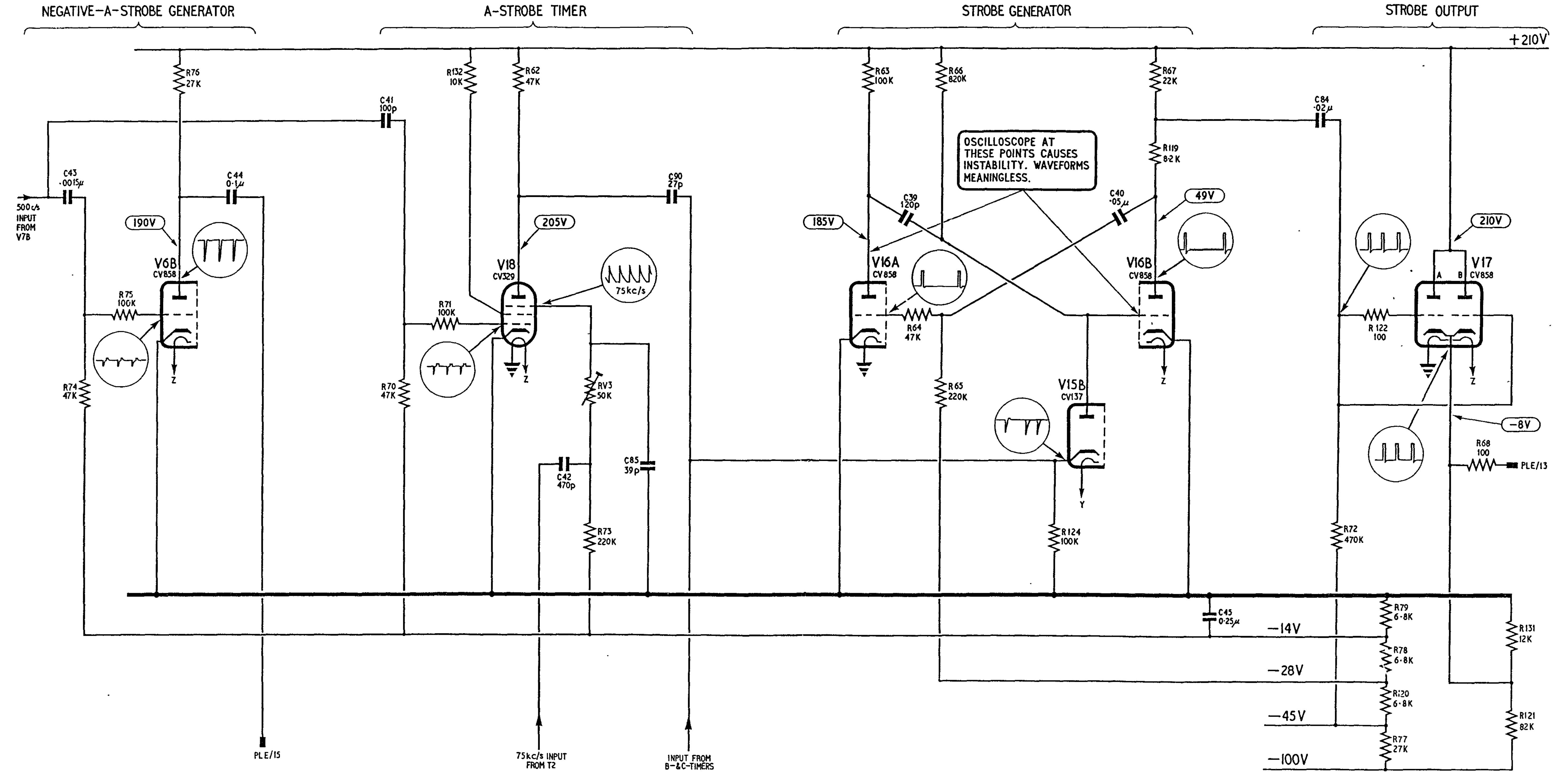


Fig. 5 Waveform generator — A-strobes and strobe generator circuit Fig. 5

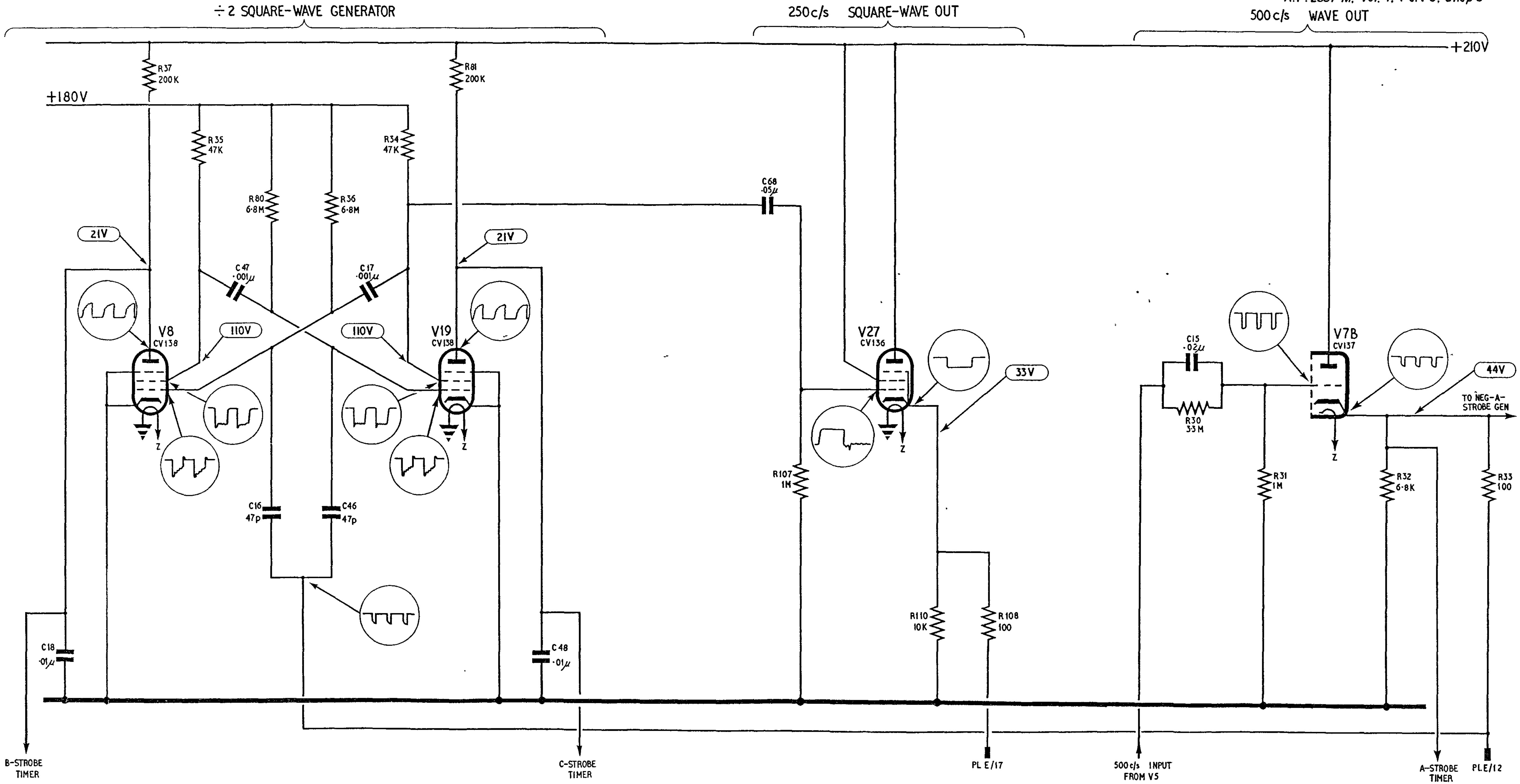


Fig. 6 Waveform generator—square-wave and 500 c/s output circuit Fig. 6

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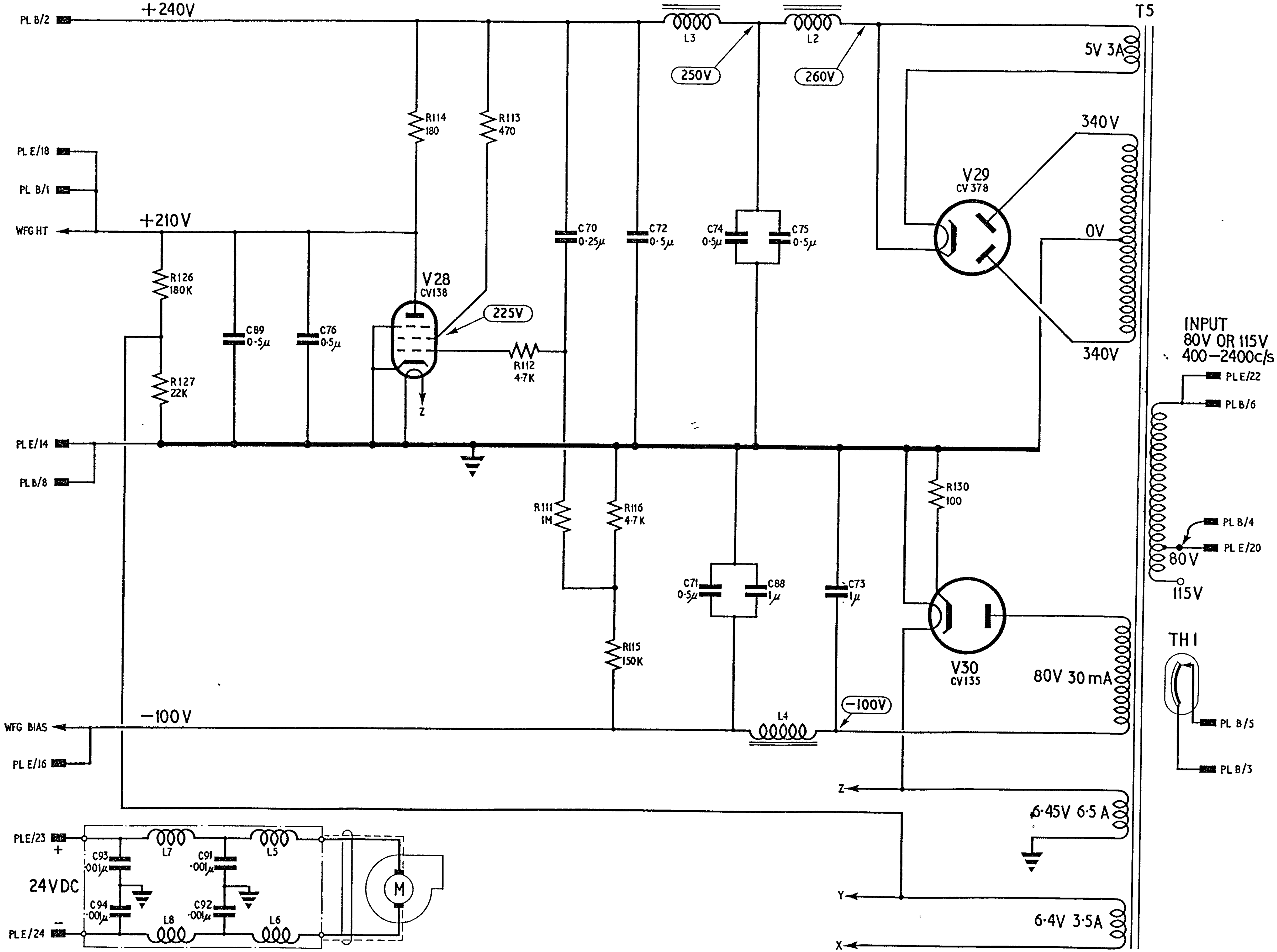

Fig. 7 Waveform generator – power supply circuit Fig. 7

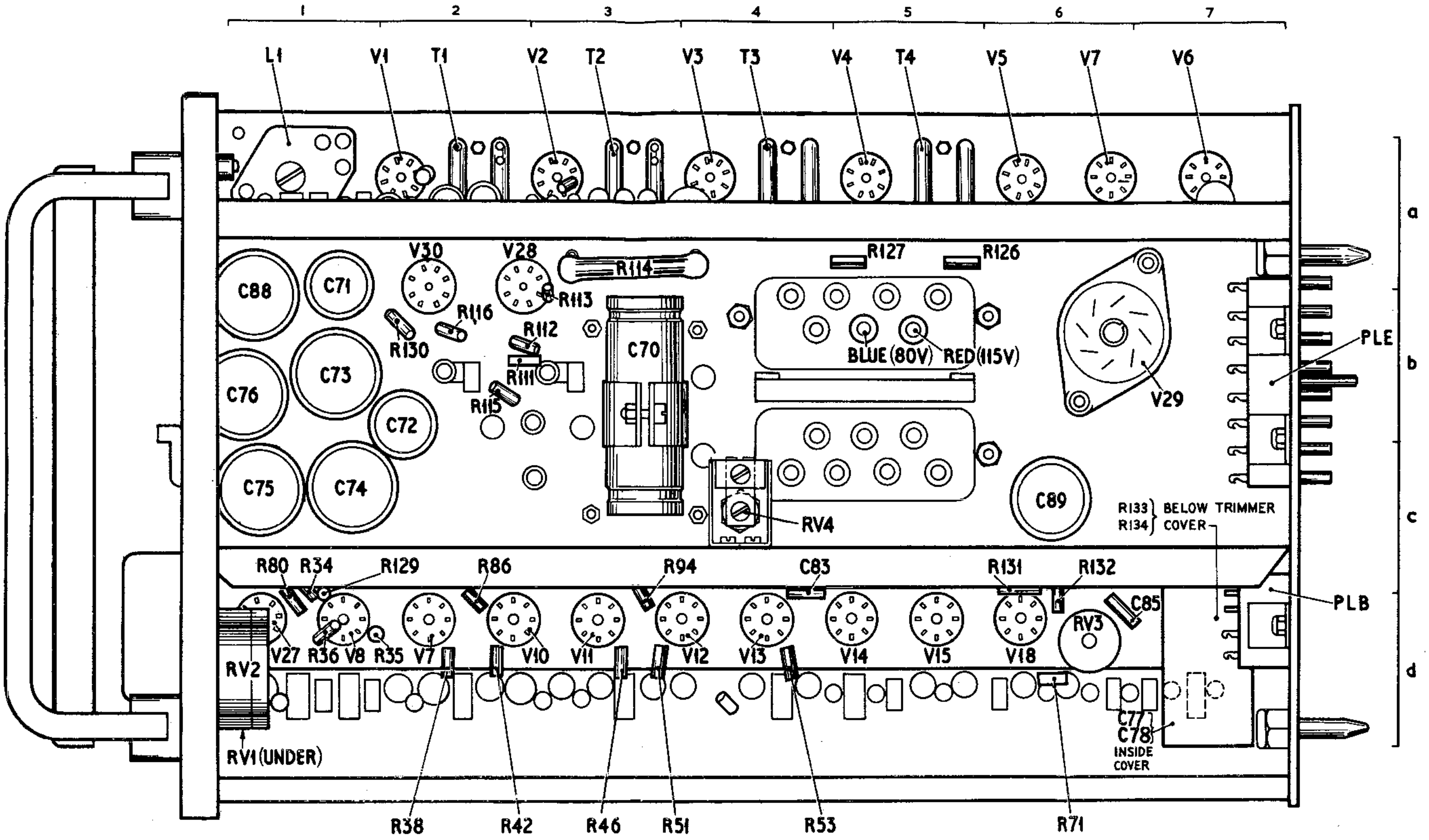

Fig. 8 Waveform generator—component positions, underside Fig. 8

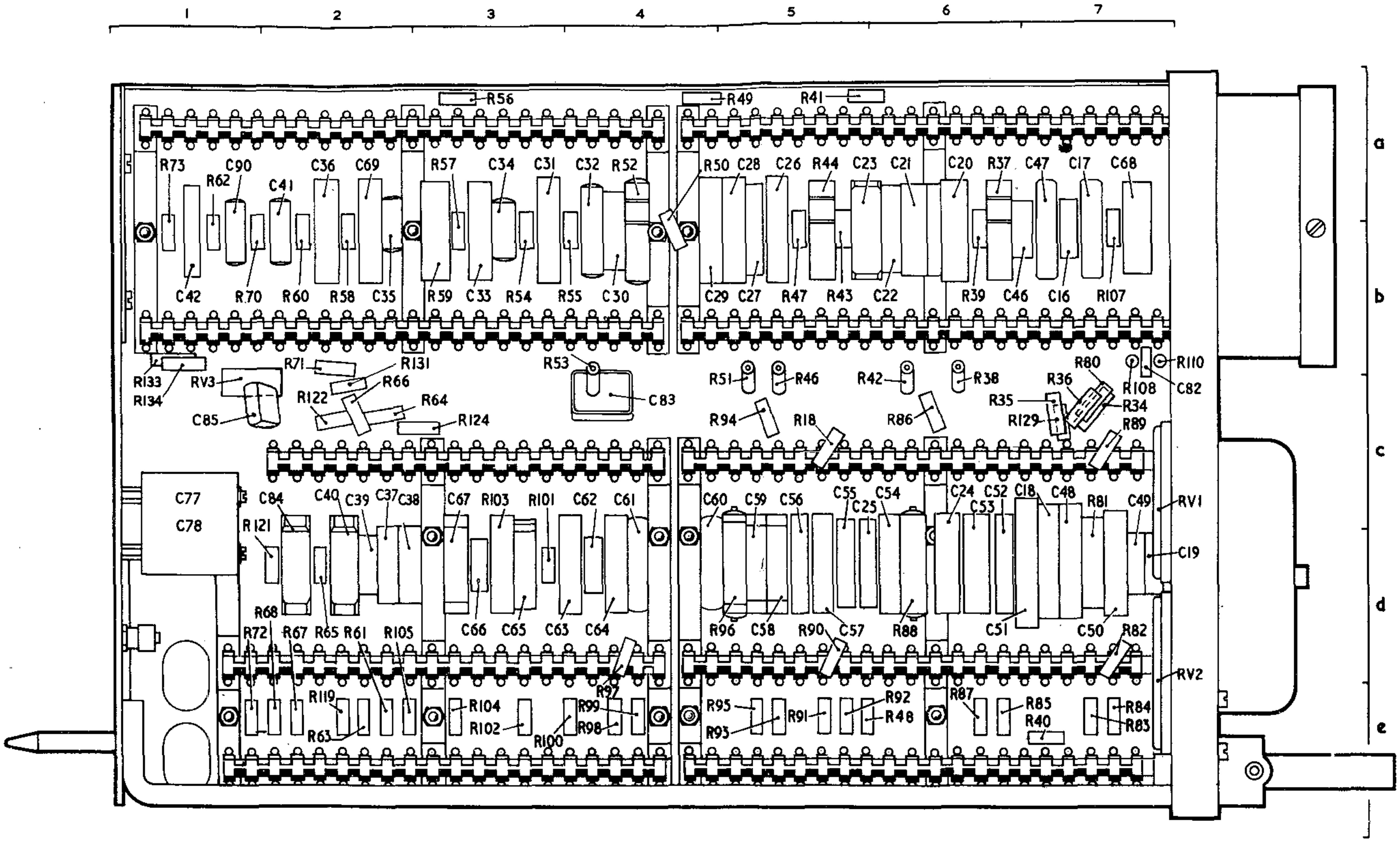

Fig. 9 Waveform generator — component positions, left-hand side Fig. 9

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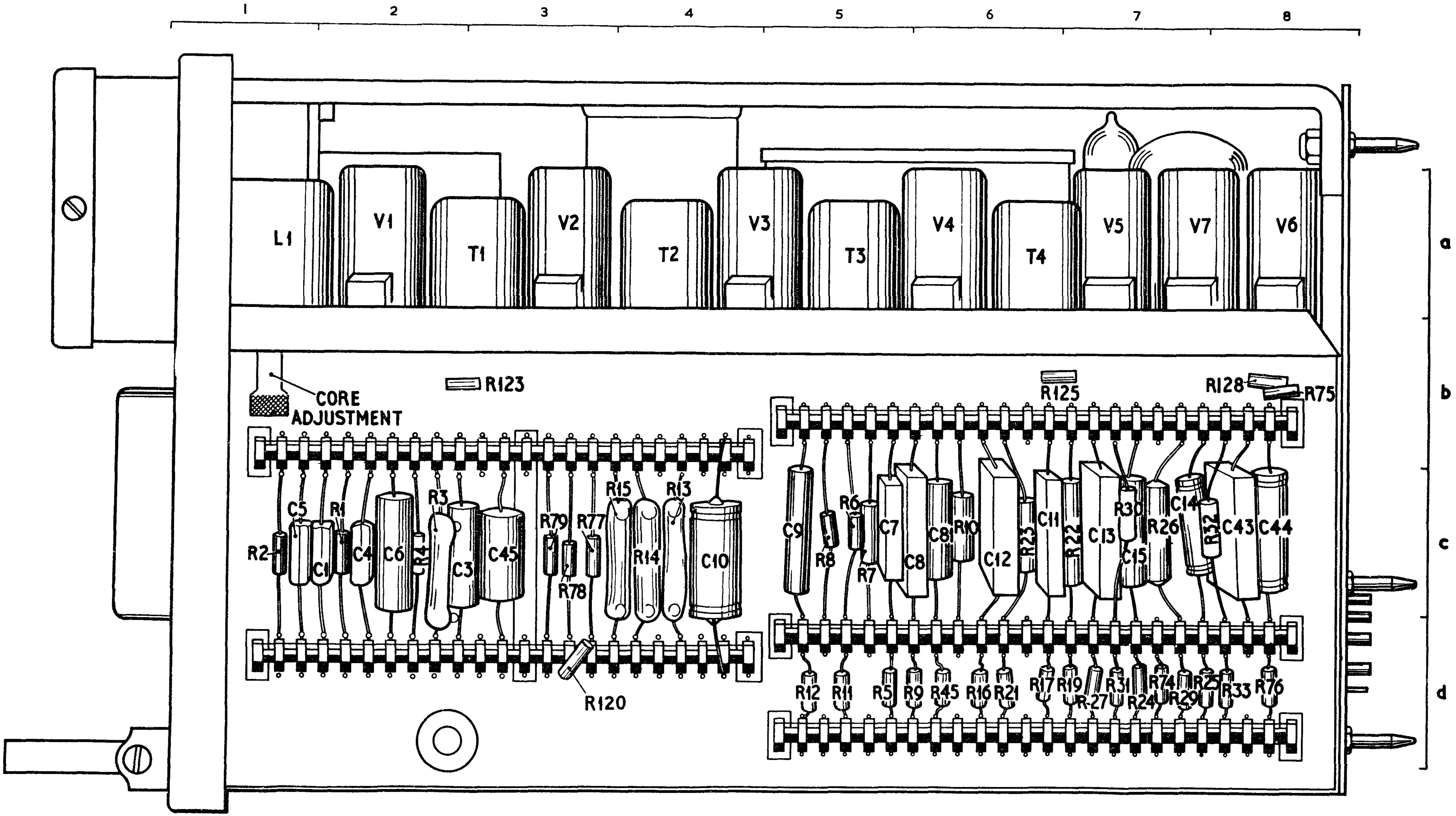

Fig. 10 Waveform generator — component positions, right-hand side Fig. 10

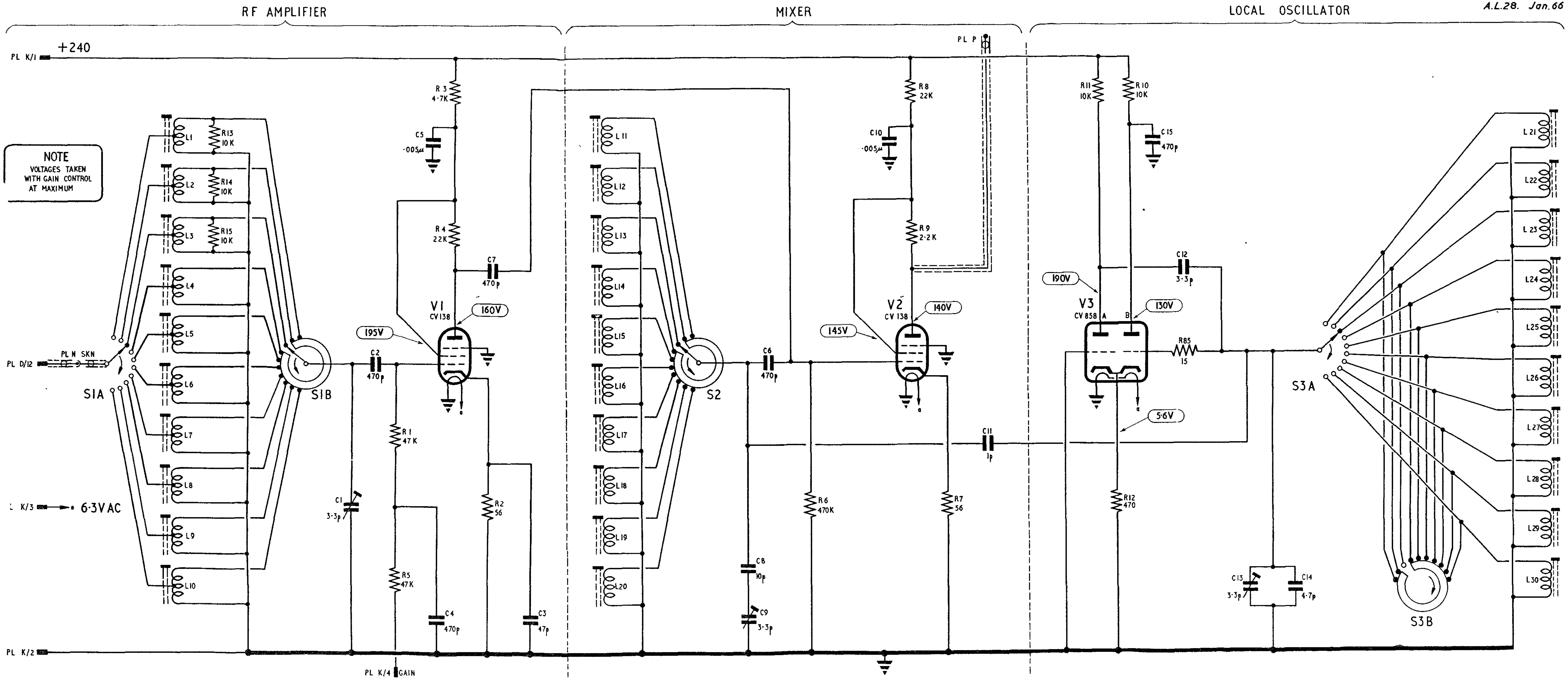

Fig. 12 Receiver-RF unit circuit Fig. 12

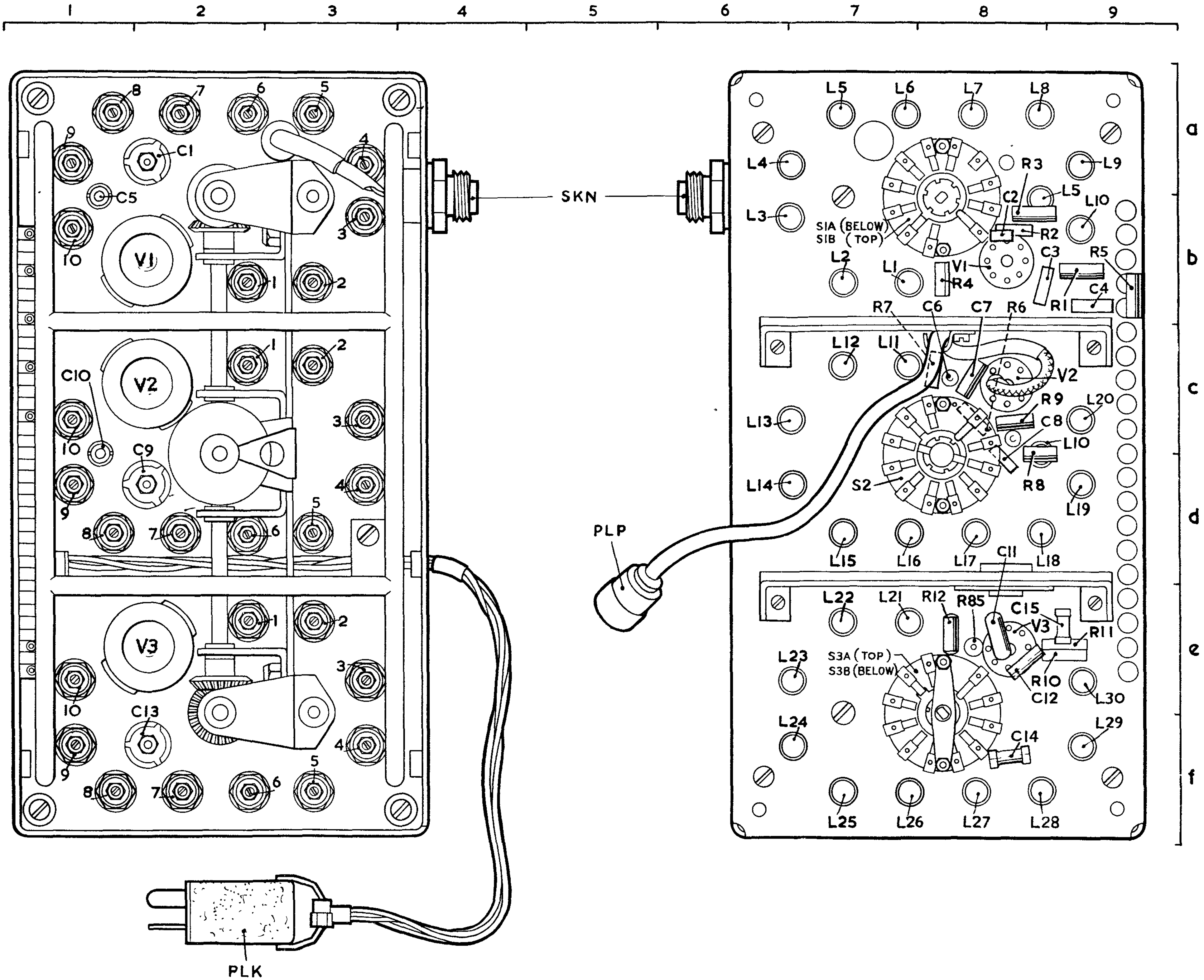

Fig. 13 **Receiver — RF unit component positions** Fig. 13

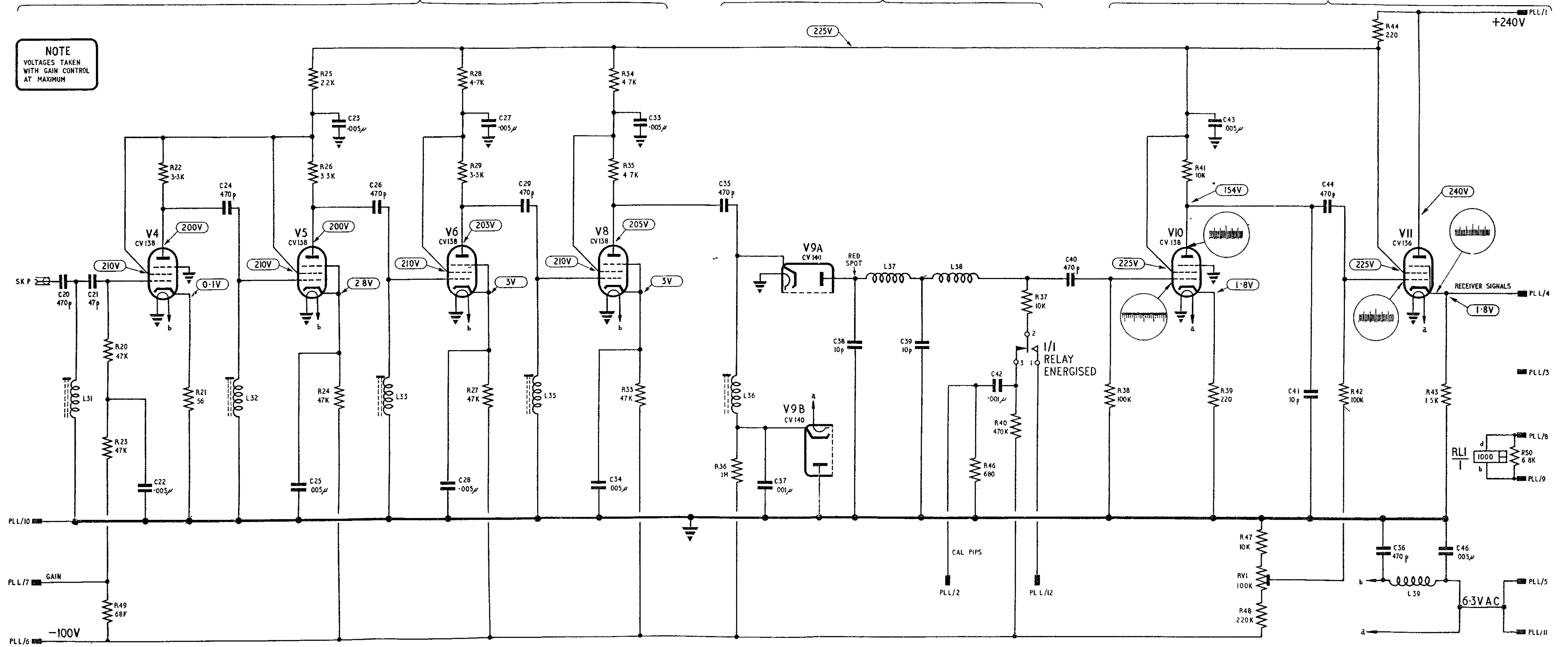

Fig. 15 Receiver – IF unit circuit

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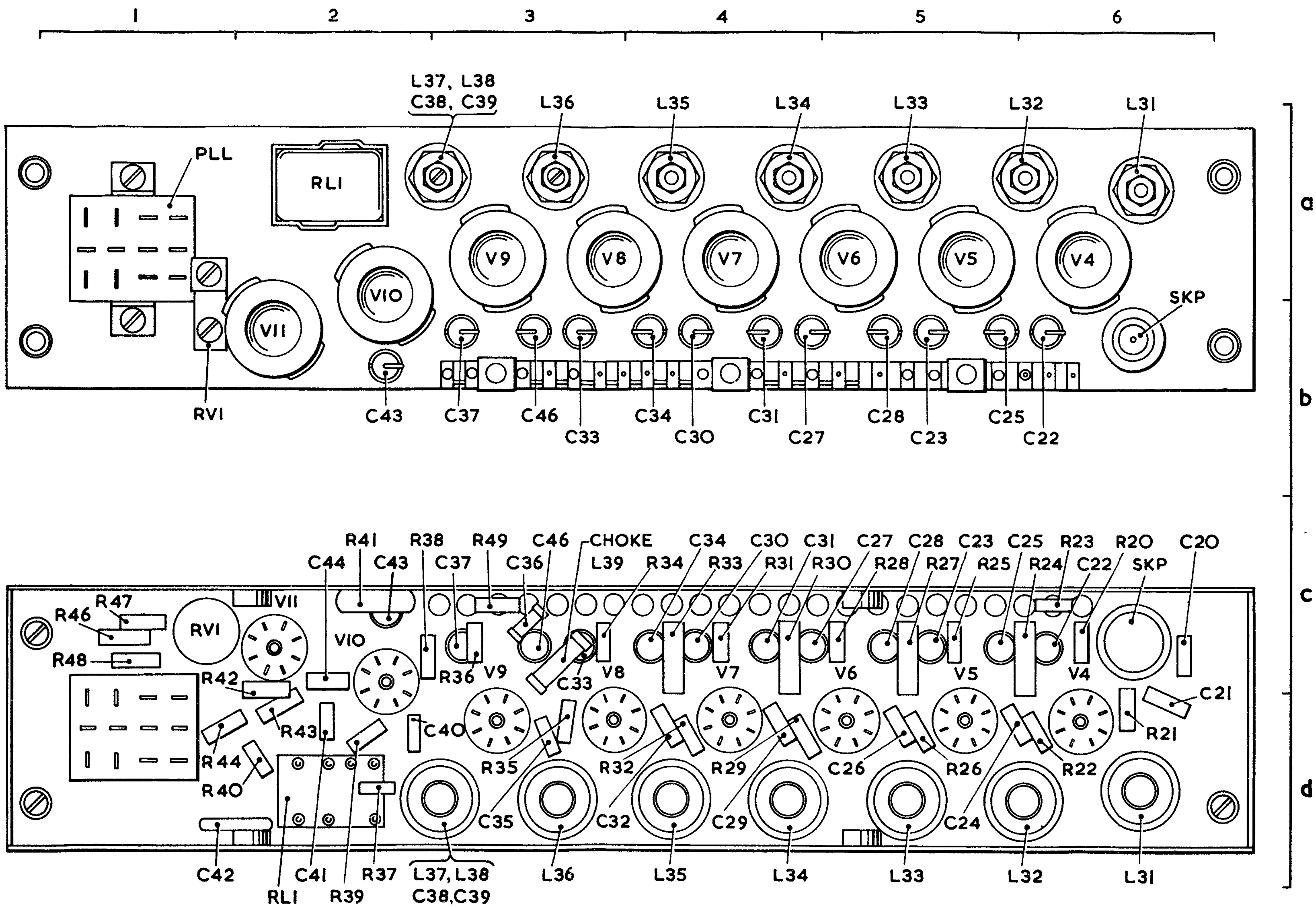

Fig. 16 Receiver — IF unit component positions Fig. 16

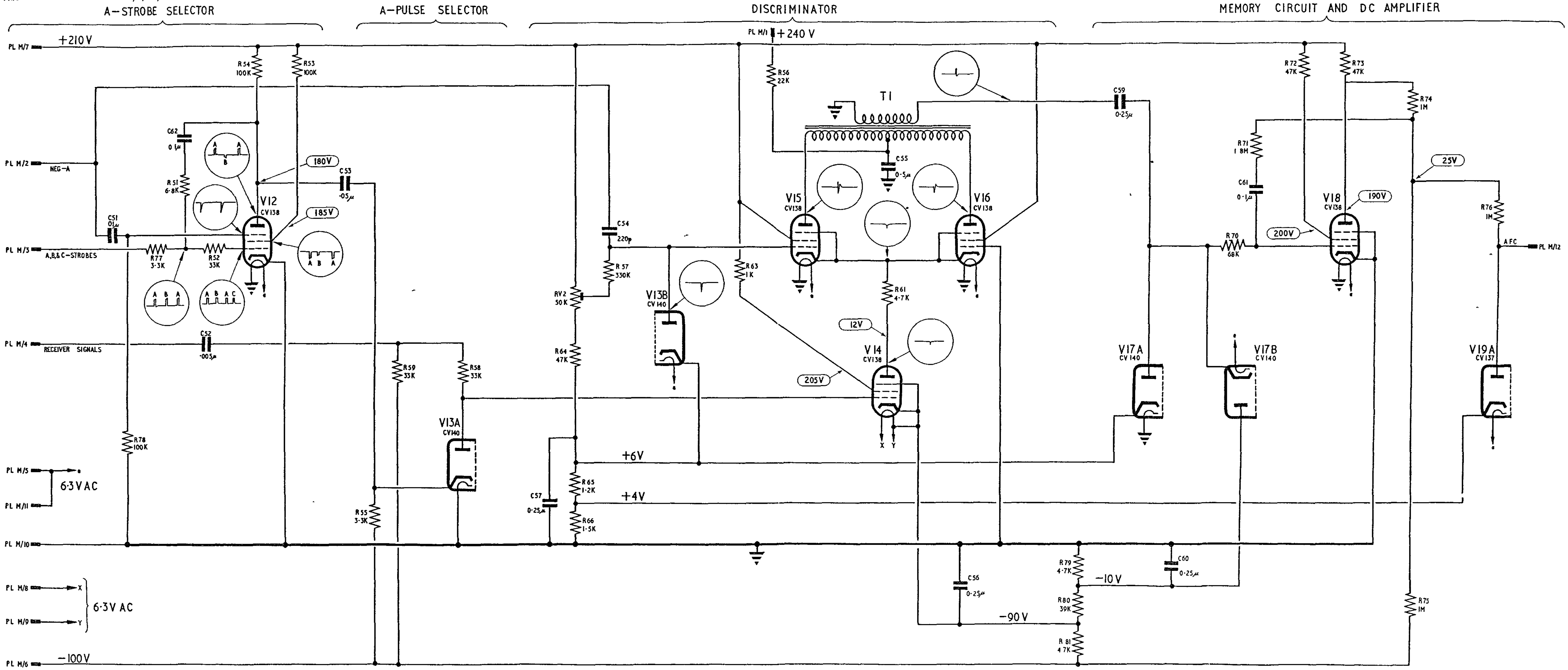

Fig. 18 Receiver—synchronizing unit circuit Fig. 18

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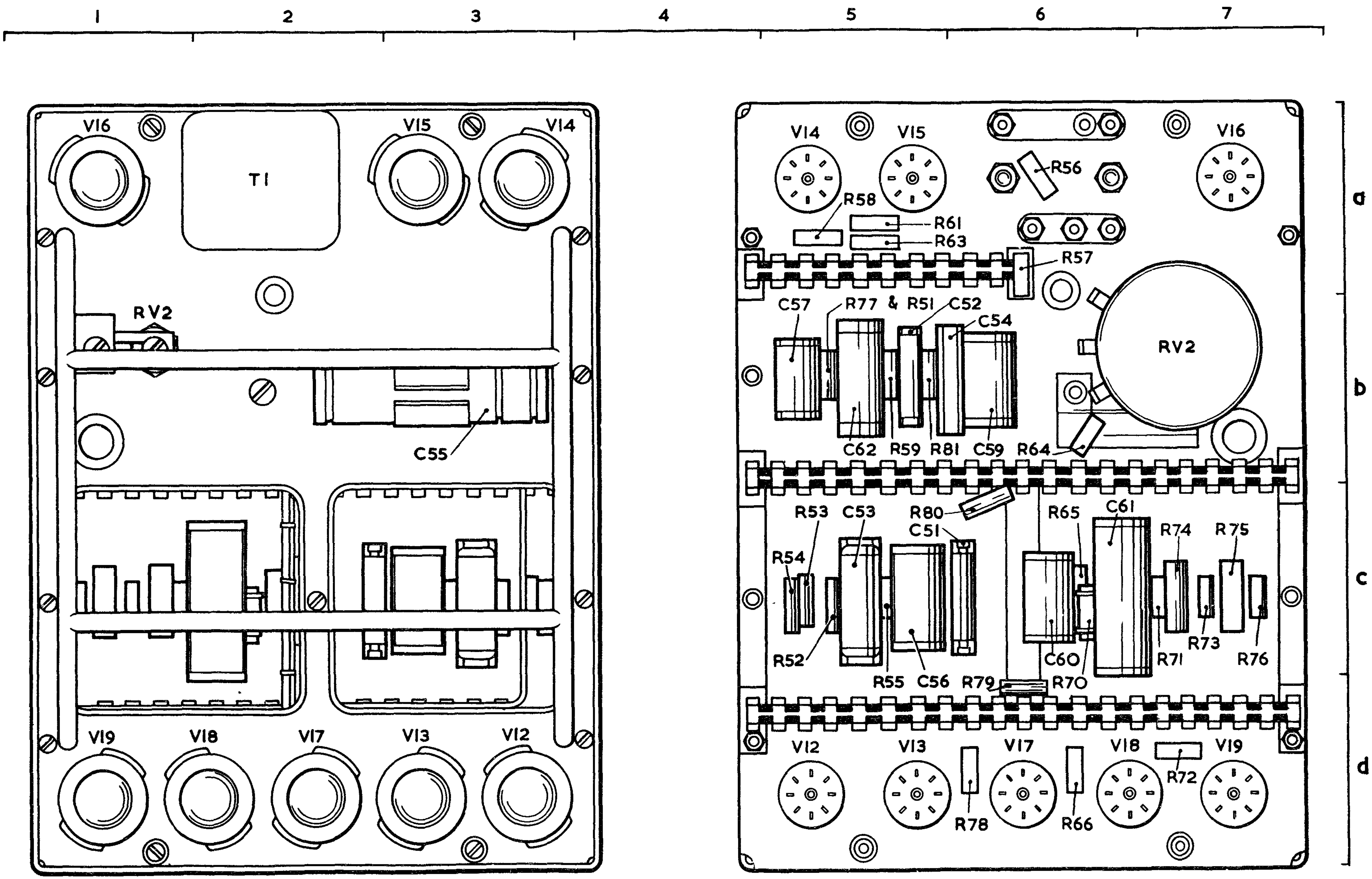

Fig. 19 Receiver — synchronizing unit component positions Fig. 19

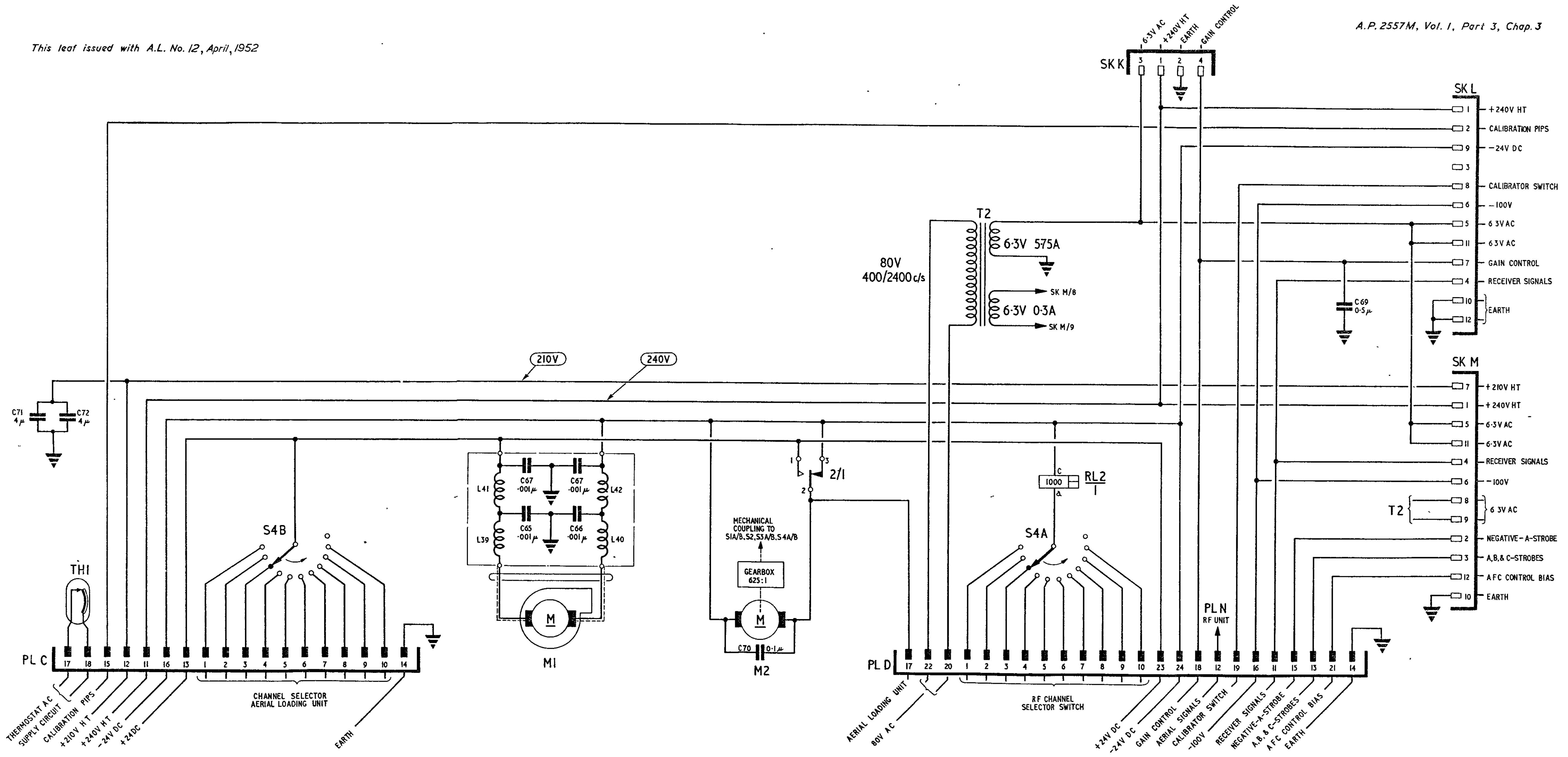

Fig. 21 Receiver–main chassis circuit Fig. 21

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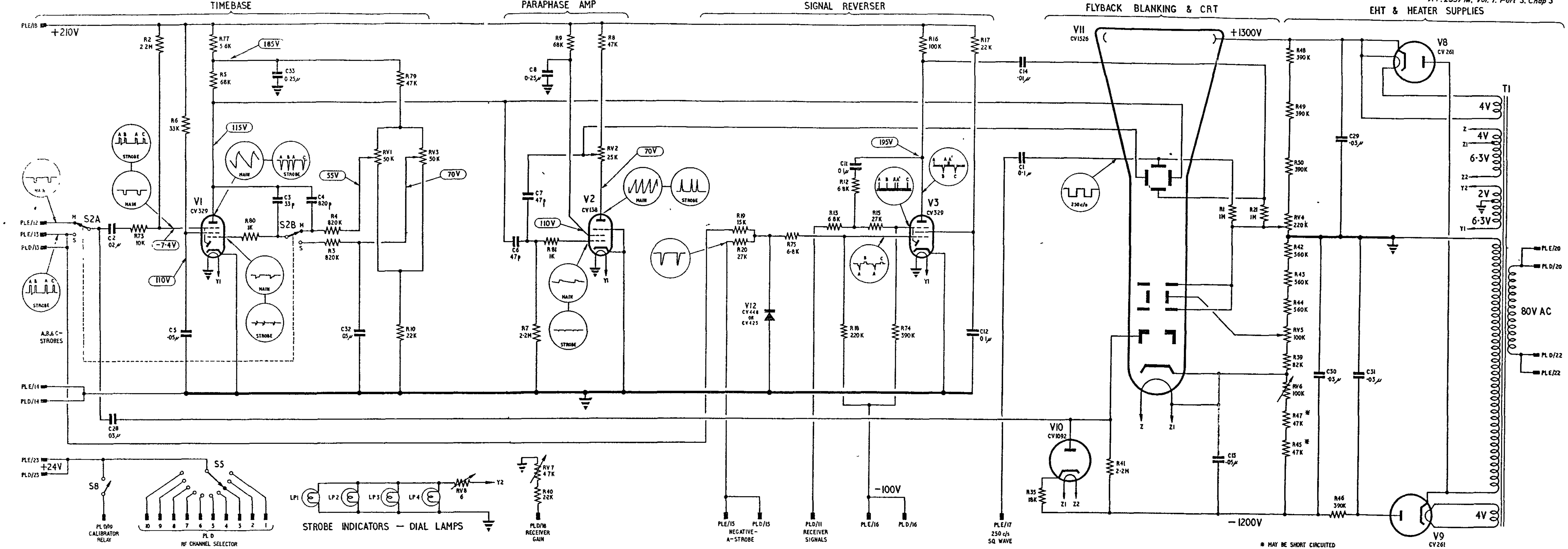

Fig. 23 Indicator-display circuit Fig. 23

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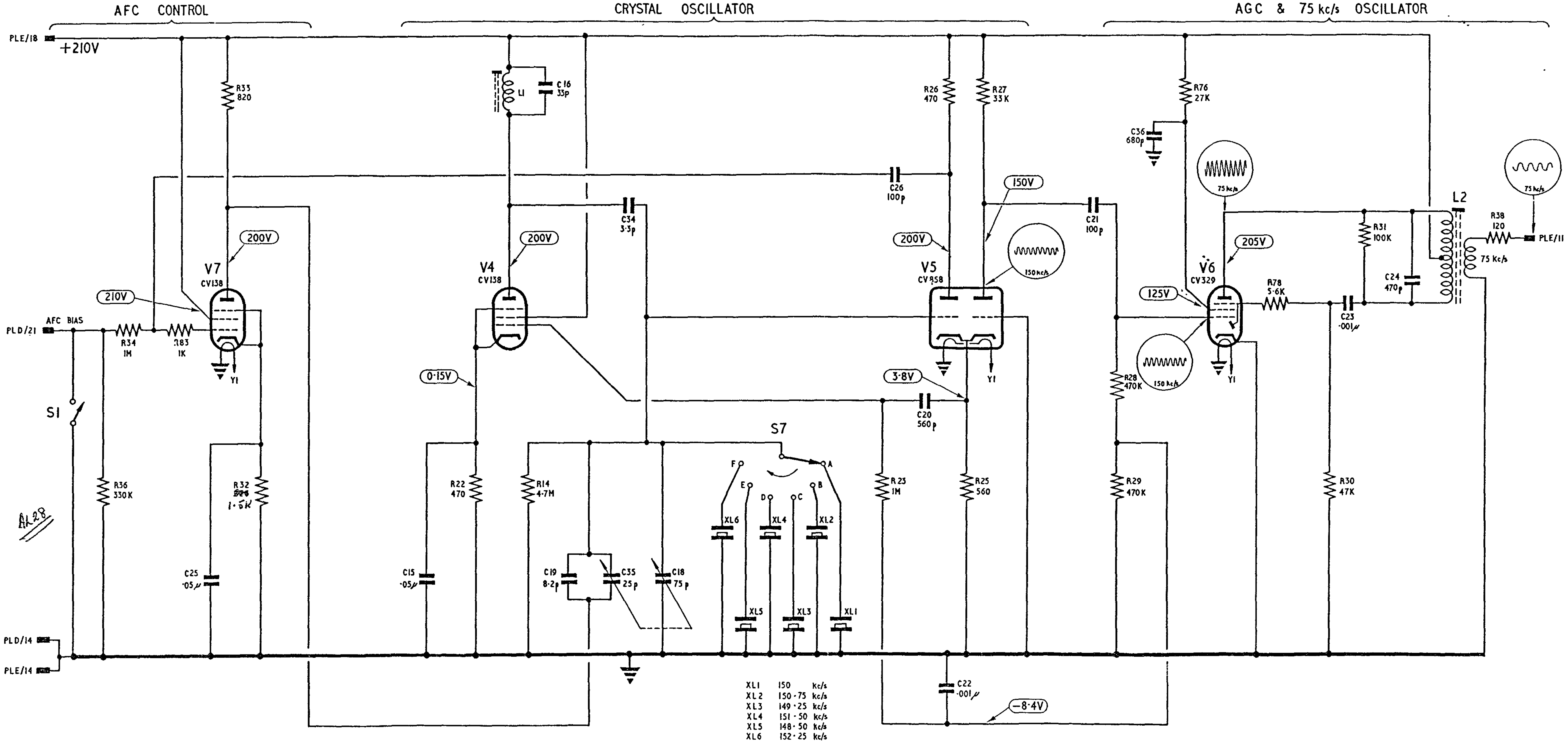

Fig. 24

Indicator – crystal oscillator circuit

Fig. 24

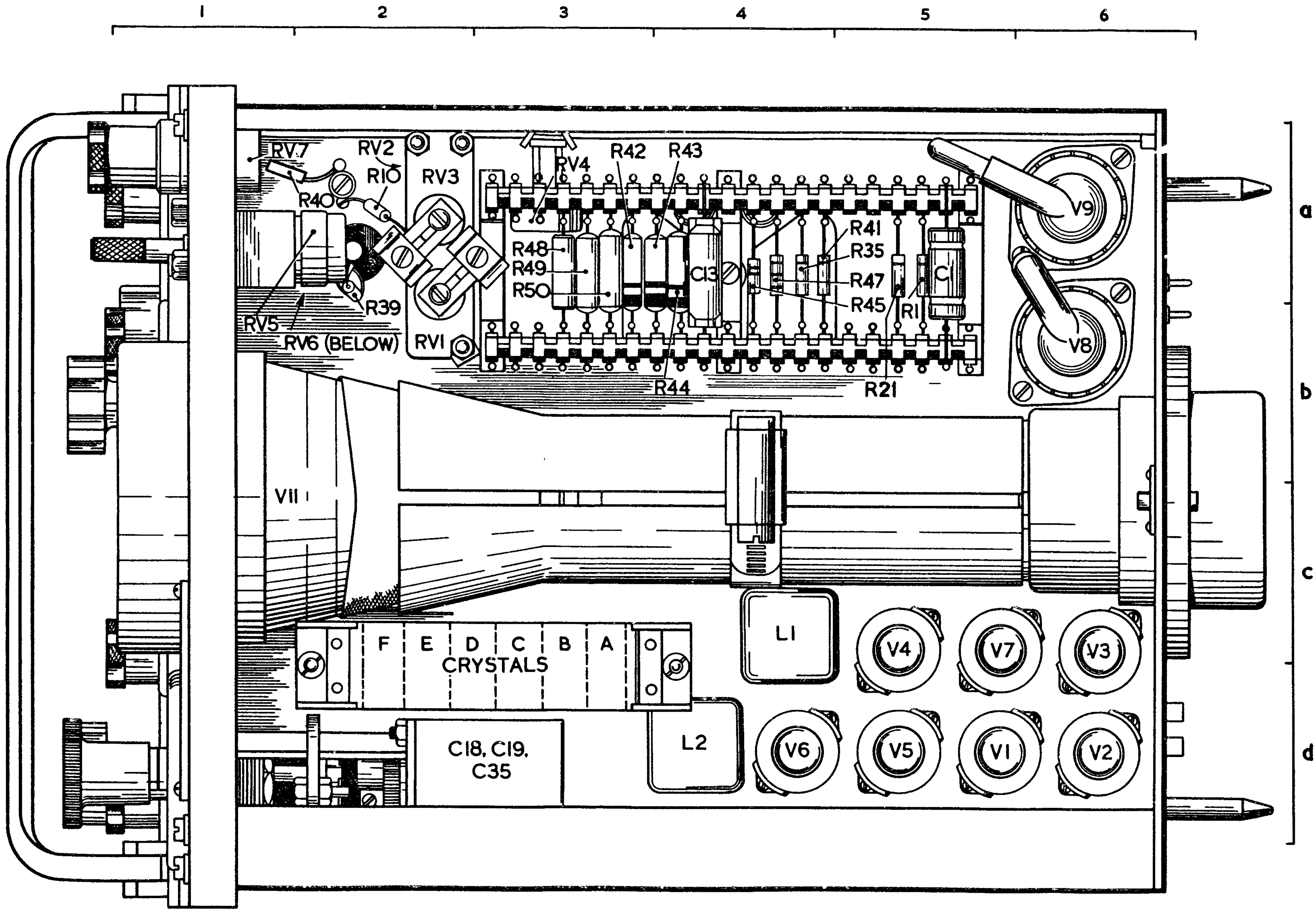

Fig. 25 Indicator — component positions, plan view Fig. 25

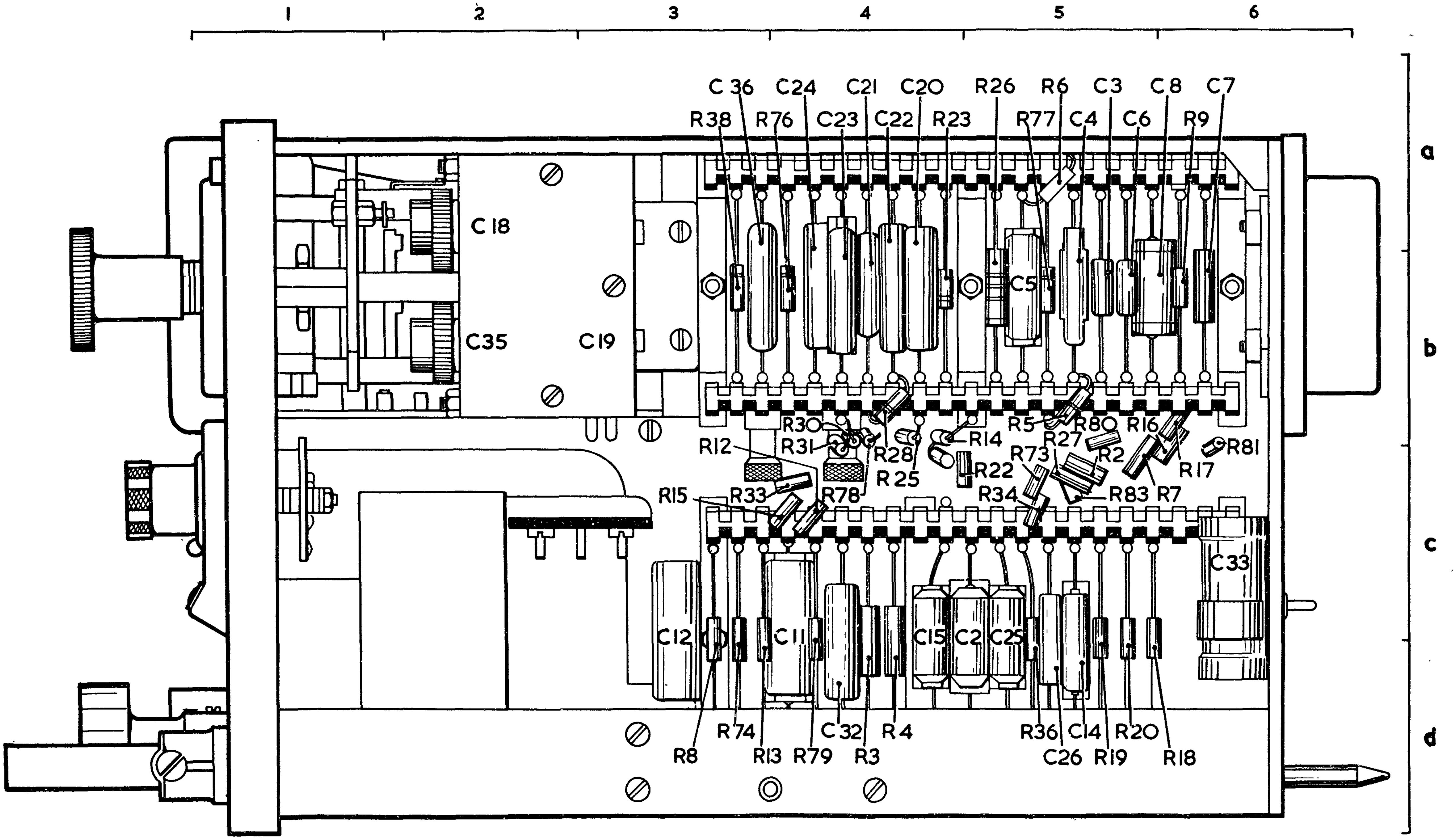

Fig. 26 Indicator — component positions, right-hand side Fig. 26

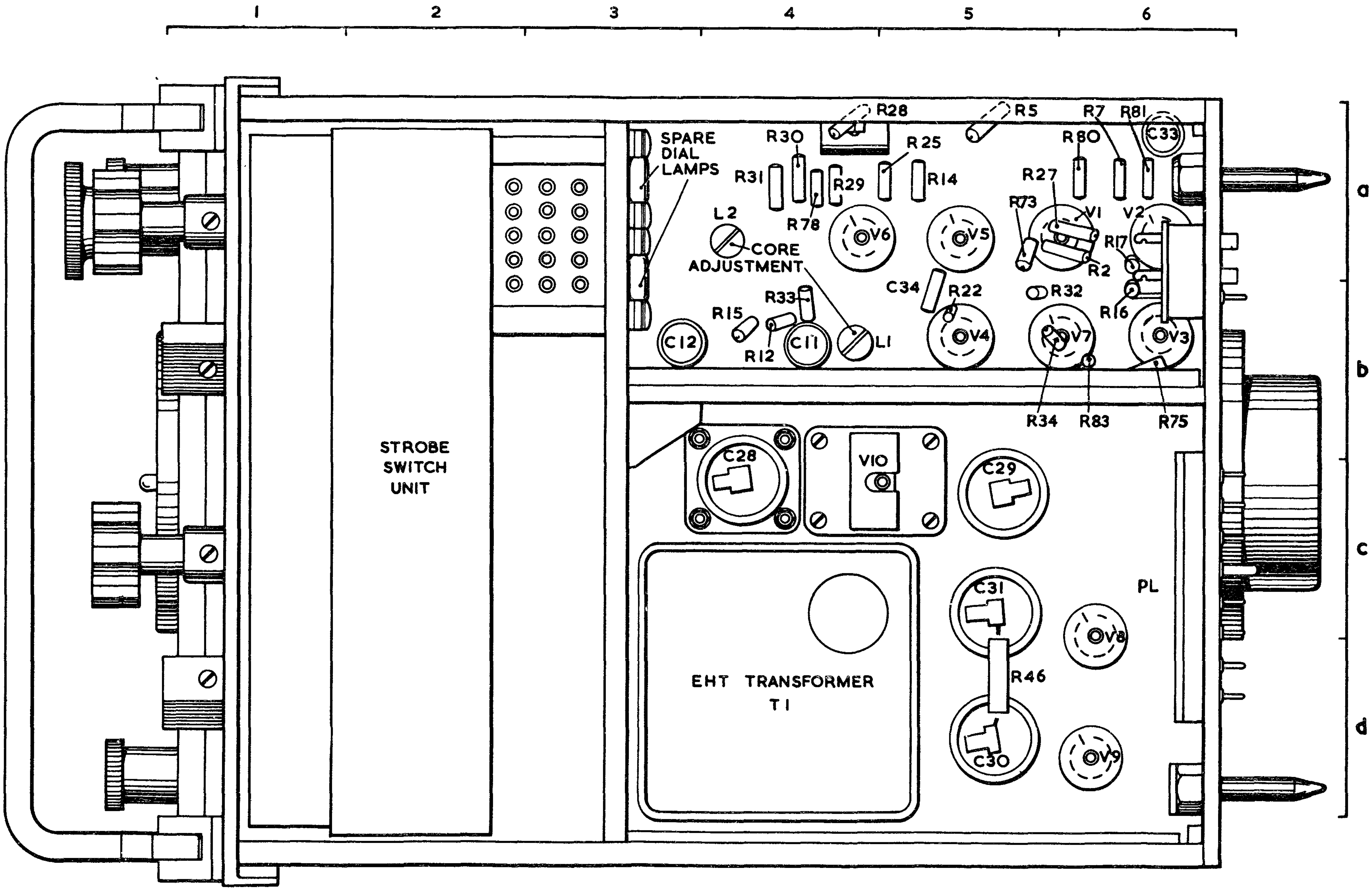

Fig. 27 Indicator—component positions, underside Fig. 27

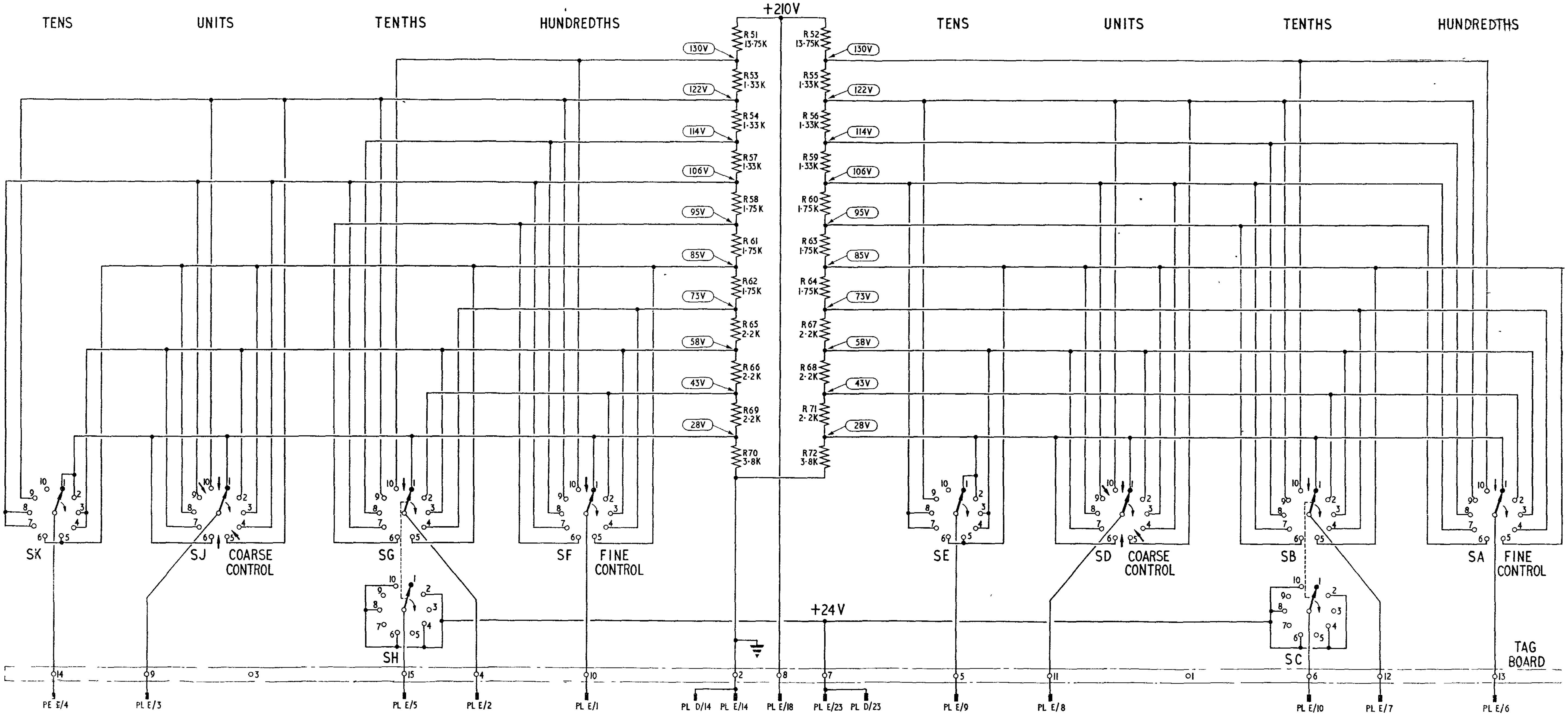

Fig. 29

Indicator-strobe switch unit circuit

Fig. 29

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