AIR MINISTRY

INSTRUMENT LANDING SYSTEM (ILS) AIRBORNE EQUIPMENT (ARI.18011)

This is A.L. No. 5 to A.P.2534E, Vol. 1

Part 1. List of Chapters: *delete* "*(to be issued later)*" after the title of Chapter 3 and *write* "(A.L.5)" in the outer margin against the deletion.
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SIGNALS

Chapter 3

TECHNICAL INFORMATION

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Localizer receiver

Glidepath receiver

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LIST OF ILLUSTRATIONS

Fig.

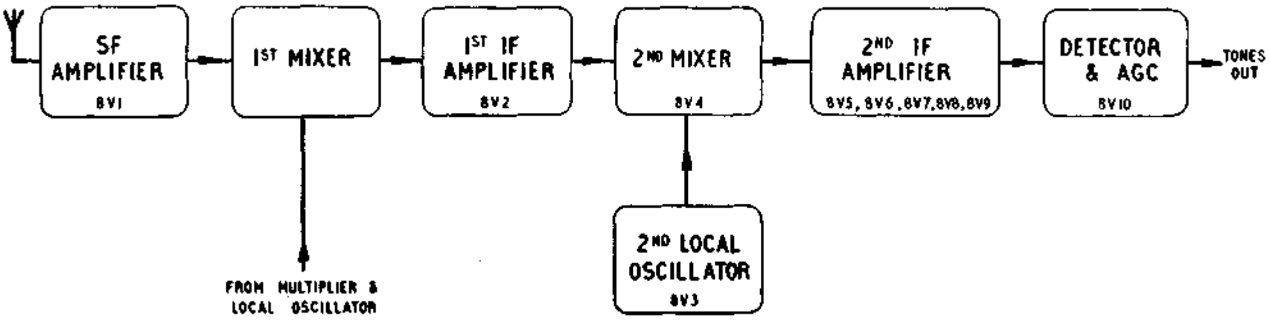


Fig. 5. Block diagram of receiver unit Type 119

Detailed circuit description

13. The circuit is described in detail under the four headings of localizer receiver, glidepath receiver, marker receiver, and power supplies. The description of each receiver is based first on a block diagram and then on a separate circuit diagram. The power supplies are described with reference to separate drawings of the HT and LT circuits.

14. Each receiver has been considered as an electrical whole, and, in general, attention has not been paid to the physical positions of the different circuit elements. Thus, for example, the circuits responsible for producing the localizer information have been treated as an entity and the path from aerial to indicator has been drawn on a single diagram. As a result the circuits can be seen functionally, and this despite the fact that the components concerned are distributed in up to eight units and sub-assemblies linked, in some instances, by aircraft connectors, and associated physically with the components of the other receivers.

15. To permit the circuits to be presented in this way, use has been made of the detached-contact system of drawing plug and socket connections. Each plug and socket point has therefore:—a prefix number identifying the particular unit on which the plug or socket is to be found: a "P" or "J" reference indicating the particular plug or socket in the unit: and a number or letter indicating the particular point on the plug or socket concerned.

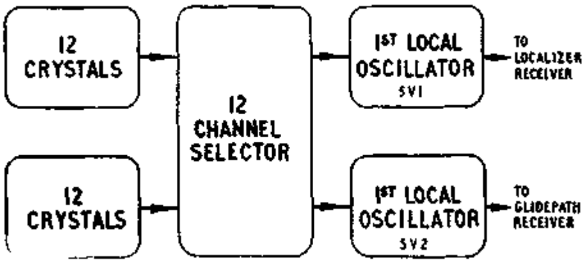


Fig. 8. Block diagram of control unit Type 705

Fig. 6. Block diagram of RF unit Type 74

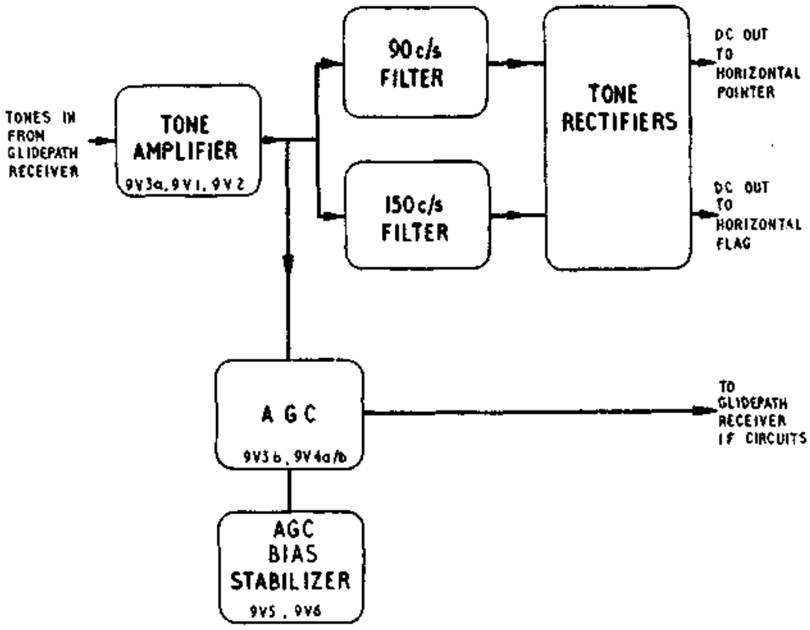


Fig. 7. Block diagram of LF unit Type 5

16. The position of the plugs and sockets on the units are identified in fig. 9. The alternative installations, "side-by-side" using a combined junction box and "separate" using two separate junction boxes, as shown. The differences between the two installations, as far as the circuit is concerned, are that first, the plug and socket nomenclature of the junction boxes is different (i.e. the plug carrying the DC input to the R.1964 is 12P1 in the "side-by-side" installation and 6P5 in the "separate" installation) and second, that an additional connector is used in the "separate" installation so that additional plug and socket points must be shown.

17. Separate circuit diagrams to show these differences have not been provided, but, instead, all relevant details have been incorporated on each of the main circuit drawings. In practice this merely means that certain plug and socket points and a few components are annotated twice, with, to avoid confusion, references for items in the " side-by-side " installation shown normally and for items in the "separate" installation shown bracketed. For the extra plug and socket points found only in the "separate" installation the bracketed references only are given.

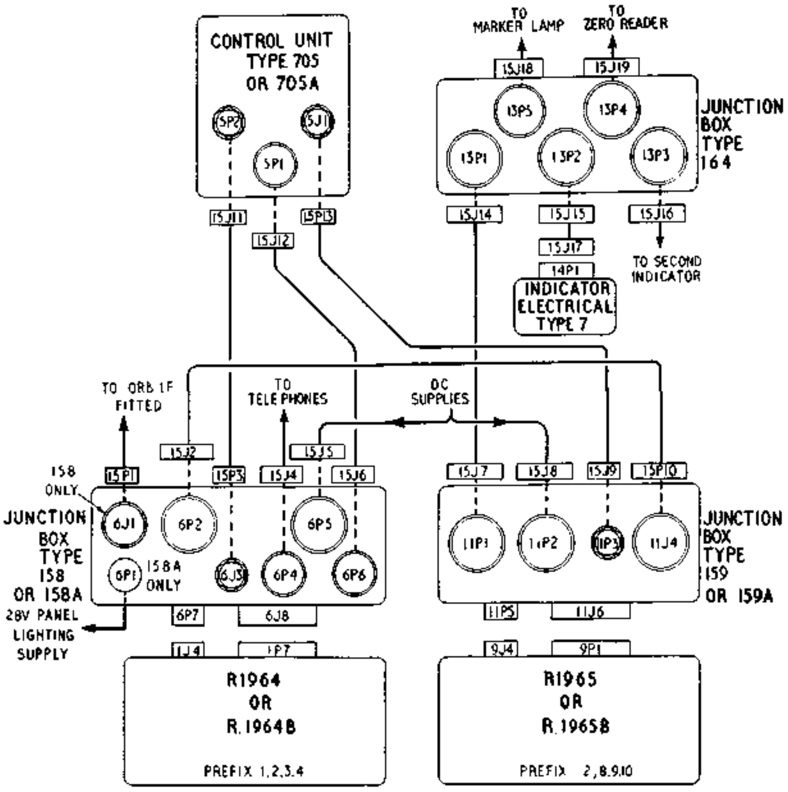
18. Thus, as shown in fig. 14, the output point of the localizer audio circuit feeds through a socket which is identified as "12J10/2" to show its reference in the junction box Type 157 of the " side-by-side " installation, and as " (6J8/2)" to show its reference in the junction box Type 158 of the " separate " installation. As an example of single referencing, the output to the indicator vertical pointer in the localizer circuit goes through a plug identified as " (6P2/B) " which is therefore to be found only in the junction box Type 158 of the " separate " installation.

LOCALIZER RECEIVER

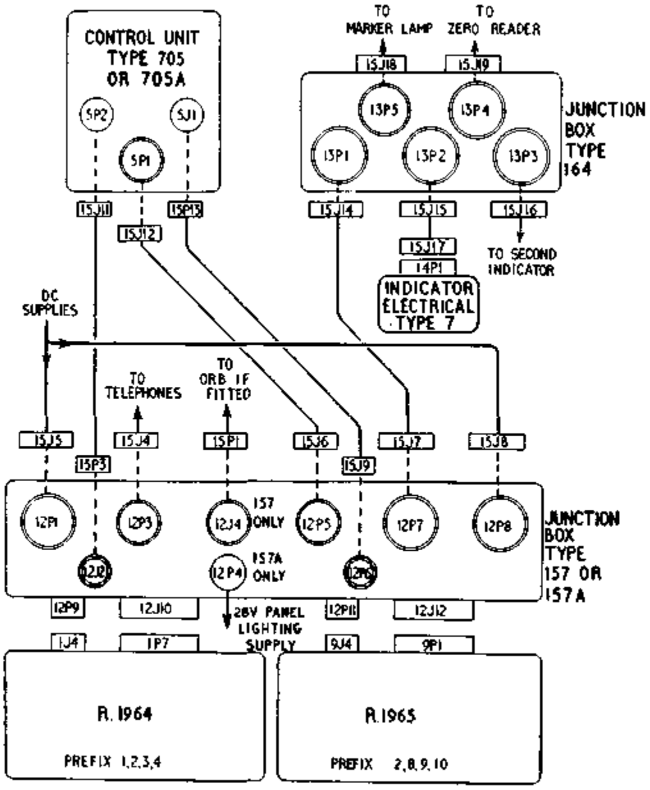
Nature of signals

19. Localizer transmitters operate in 100 kc/s-spaced channels in the VHF band from 108 Mc/s to 111·9 Mc/s. A localizer transmission consists of two lobes overlapping about the line of approach, one lobe consisting of carrier with 90 c/s modulation, the other of carrier (at the same frequency) and 150 c/s modulation. As transmitted, each modulation is at a depth of 40 per cent, but, because the carriers of the two lobes combine in the overlap zone, the effective modulation depths of the two modulations vary in this region.

20. Graph A of fig. 10 shows the modulation characteristics of a typical localizer transmission. The horizontal axis shows angular deviation in degrees from the line of approach, and the vertical axis shows the depth of modulation represented by the two sets of sidebands at the stated angles of deviation. As the angle varies from 6¼ deg. right to 6¼ deg. left, the 150 c/s level falls from about 40 per cent to zero, and the 90 c/s level rises from zero to about 40 per cent. Along the line of the runway the modulation depth represented by each set of sidebands is the same at 20 per cent.



(a) SEPARATE INSTALLATION



(b) SIDE-BY-SIDE INSTALLATION

Fig. 9. Plug and socket identification on installation

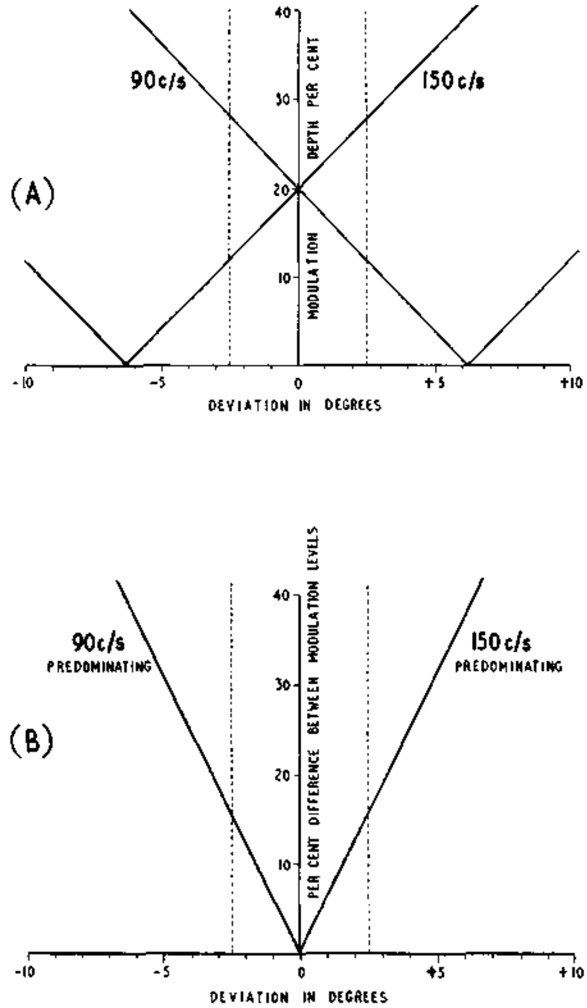


Fig. 10. Modulation characteristics of localizer

21. When the differences between the modulation depths are plotted we get graph B of fig. 10. Over the angle representing deviations from the line of approach of 2½ deg. each side, as shown by the dotted lines, the difference falls from 15½ per cent to zero and then rises again to 15½ per cent, with on the one side the 90 c/s predominating and on the other side the 150 c/s predominating.

22. A secondary modulation, radiated omni-directionally, is also transmitted by the localizer beacons. Normally it consists of an identification signal made up of a Morse-keyed modulation tone at 1,000 c/s, and repeated at regular intervals, but provision is made for this signal to be substituted by voice modulation for communication purposes in emergency.

AGC requirements

23. The localizer receiver is required to translate the differences in depth of the 90 c/s and 150 c/s modulations into deviations of a centre-zero vertical pointer. For a modulation difference of greater than 15½ per cent with the 150 c/s modulation predominating the pointer shows full-scale-deflection to the left, and for a similar difference with the 90 c/s modulation predominating the pointer shows f.s.d. to the right. For modulation differences between the two extremes the pointer deflection is proportional to the modulation difference, that is to the deviation from the line of approach.

24. In order to satisfy these conditions, the receiver output must be dependent only upon the relative modulation depths of the two sideband tones and must be independent of the strength of the received signal. A high level of AGC is therefore necessary in order to reduce the gain of the receiver once the input signal strength is above a predetermined level, and in practice the receiver output for a given modulation difference is sensibly constant for all input levels of greater than about 10μV.

25. Thus, within the operating range of a localizer transmission, the receiver output tends to be independent of the received signal strength, and therefore of the range, and dependent only upon the differences between the modulation depths of the two sideband tones, and therefore the deviation from the line of approach.

Selectivity

26. The receiver is designed to operate over the frequency range from 108 Mc/s to 118 Mc/s, but only the localizer transmitter range is actually used. The narrow spacing of the localizer channels (100 kc/s) demands a high order of adjacent channel selectivity, and to prevent interference from other bands second channel rejection must also be high.

27. These considerations are best satisfied by a double-superhet type of receiver which confers the following advantages:—

(1) A low intermediate frequency can be used in the second-IF amplifier, making it comparatively easy to produce a narrow bandwidth and thus satisfy the requirements of adjacent channel selectivity.

(2) A high intermediate frequency can be used in the first-IF stage, making for a high order of second channel rejection.

(3) The input circuit can be preset tuned to cover the whole required band (because selectivity considerations are satisfied by the IF circuits), and channel selection can thus be carried out by control of the first local oscillator only.

(4) The gain of the receiver is spread over three stages at different frequencies, and the gain at any one frequency is thereby reduced; the danger of oscillatory feedbacks is thus lessened and the receiver is highly stable.

Outline of localizer circuit

28. The outline of the localizer circuit is shown in the block diagram of fig. 11. The first stage is a signal-frequency amplifier fixed-tuned to cover the complete localizer band; its output together with a local oscillator signal is fed to a mixer stage in which the first-IF at 28·6 Mc/s is produced. The local oscillator signal is produced in a crystal oscillator which operates at one-eighth of the final mixing frequency, and which is controlled by a channel selector switch to provide any of twelve spot frequencies; frequency multiplication takes place in steps of times-two in the oscillator stage itself and in two multiplier valves.

29. The first-IF amplifier is a single valve feeding, together with the output from a second local oscillator, into a second mixer stage. The second

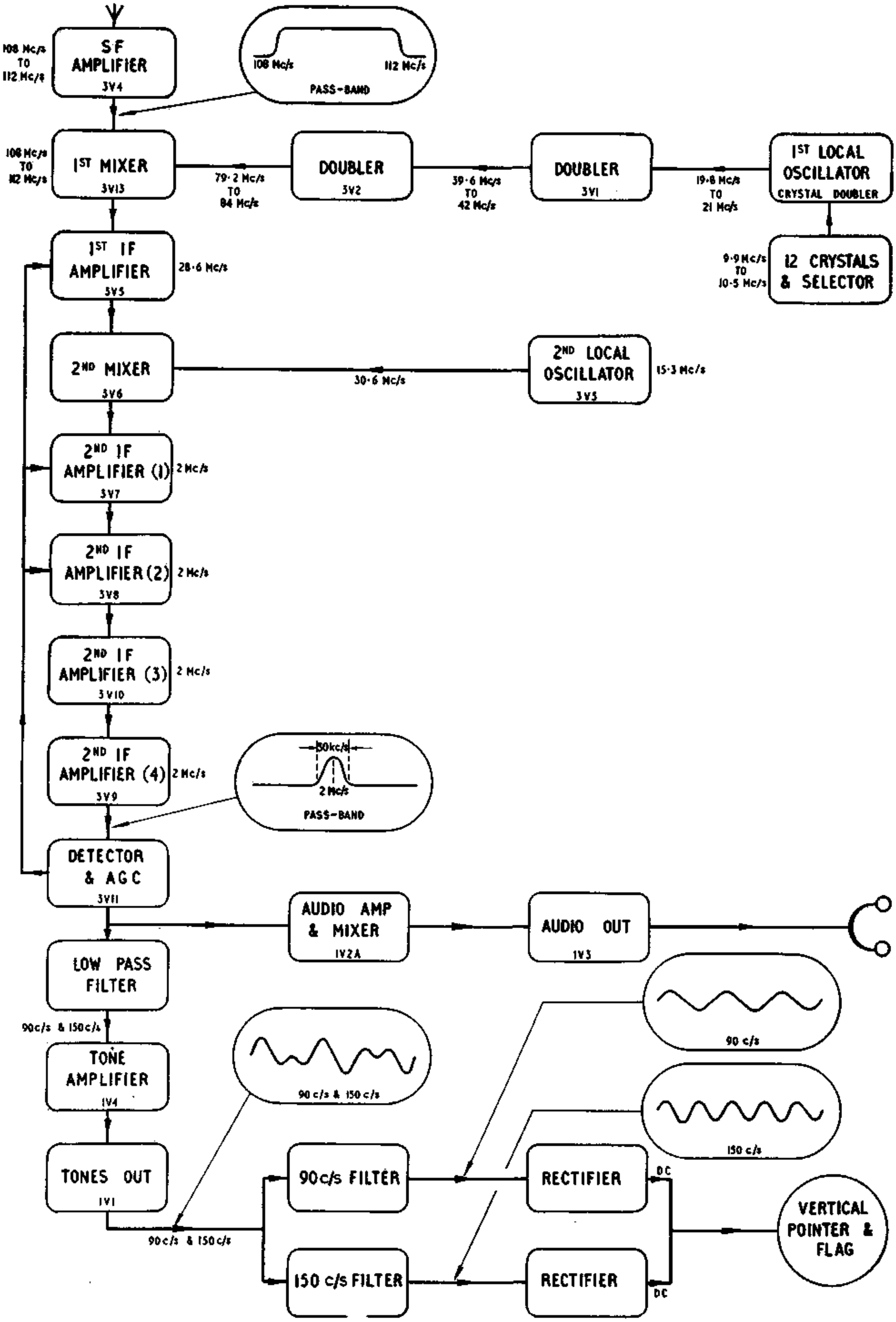


Fig. 11. Block diagram of localizer receiver

local oscillator is crystal controlled at 15·3 Mc/s and its output is frequency doubled to 30·6 Mc/s, so that the output of the mixer is at the difference frequency of 2 Mc/s. The second-IF amplifier includes five stages; the overall bandwidth is 50 kc/s at 6 dB down.

30. The second-IF is detected and is also used to produce an AGC potential which is fed back into the IF stages. The detected output consists of 90 c/s and 150 c/s tones derived from the localizer modulation sidebands, together with a Morse-coded 1,000 c/s tone representing the identification signals. The localizer tones are separated from the 1,000 c/s tone in a low-pass filter and are then amplified and separated from one another in two separate peak-tuned filters. The separated 90 c/s and 150 c/s tones are then rectified and combined to produce DC signals for operating the localizer pointer and alarm flag in the indicator.

31. An audio amplifier, including a mixer stage in which marker signals are introduced, amplifies the 1,000 c/s tone and feeds it as an audio output to the aircraft telephone circuits.

Signal-frequency stage (*fig. 14*)

32. The localizer aerial connects through a coaxial plug (1P5) and a short coaxial lead to 3J1 in the input tuned circuit. It feeds a bandpass filter made up of two series-resonant circuits in parallel across the input, and a third series-resonant circuit in series with a final parallel-tuned circuit. A resistor (3R37) is shunted across the aerial input to provide a DC return path and thus prevents the build-up of static on the aerial system.

33. The first series-resonant circuit (3C29, 3L30) is tuned to about 103 Mc/s to set the lower cut-off limit of the passband; the second (3C30, 3L31) sets the upper limit at about 123 Mc/s. The third series-resonant circuit (3L32, 3C31) and the grid tuned circuit are both tuned to the mid-band frequency at about 113 Mc/s. The input to the grid circuit is tapped on 3L10 in order to provide a correct terminating impedance to the external aerial circuit and reduce the damping effect of the aerial impedance.

34. The first valve 3V4 (pentode, CV138), is a conventional signal-frequency amplifier with a bandpass transformer in its anode circuit providing coupling to the following first mixer stage. The transformer covers the SF range from 108 Mc/s to 118 Mc/s. The preset tuning adjustments (3C37, 3C38) act as variable capacitances over part of their ranges and as variable inductances otherwise; a large frequency variation is thus possible with only a relatively small circuit capacitance.

First mixer

35. The first mixer is a diode detector 3V13 (part of double diode CV140: second diode not used). The SF signal is fed from a tap on the secondary of 3L12 to the diode anode, and the mixing signal is fed in series through 3L12. The earth return of the diode anode is through the coupling coil (3L6) which feeds the mixing signal from the local oscillator multiplier.

36. A series-resonant circuit comprising 3L33 and 3C118 is connected from one end of 3L12 to earth. It is tuned to approximately 132 Mc/s to prevent breakthrough of signals at and around this frequency. Strong signals of this order, in the absence of the rejector circuit, are capable of passing through the SF stage and beating with the second harmonic of the output of the local oscillator multiplier, to produce an interfering signal on certain channels.

First local oscillator

37. The local oscillator valve 5V1 (pentode, CV138) is a crystal oscillator and doubler. The oscillator action takes place between the cathode, grid, and screen electrodes, and electron coupling is used into the anode doubling circuit.

38. The crystal is connected between grid and earth, and the screen is earthed through 5C4; the crystal is therefore effectively connected between grid and screen; the cathode is taken to a capacitive tap across the crystal. The circuit can be compared to that of a Colpitt's-type oscillator, and in fact its action is similar to that of such a circuit.

39. The cathode resistor (5R3) provides a small standing bias between grid and cathode; further bias is developed from the flow of grid current through 5R1. The second cathode resistor (5R4) does not provide bias, but it isolates the cathode from earth at RF whilst, at the same time, permitting the flow of anode current.

40. Twelve crystals can be selected by the channel switch; they will be at 12·5 kc/s intervals in the range 9·9375 Mc/s to 10·4125 Mc/s. The act of selecting a particular channel is accomplished entirely by switching-in the appropriate crystal. The channel selected by any crystal is at a frequency of eight times the crystal frequency plus the first intermediate frequency; that is:—

$$f_c = (8 \times f_x) + 28{\cdot}6$$

where f_c = channel frequency in Mc/s
f_x = crystal frequency in Mc/s

41. The anode circuit of 5V1 is preset tuned by the primary of 5T1 to select the second harmonic of the crystal frequency. The output at the secondary of the transformer is thus in the range from 19·875 Mc/s to 20·825 Mc/s, depending upon the crystal in use.

Multiplier

42. A coaxial line between the control unit and the junction box and a short coaxial lead in the LF unit connect the local oscillator output from 5P2 to the input of a two stage multiplier at 3J2. The input circuit to the first stage is a bandpass filter (3L1, 3L2); the input point is tapped down the primary (3L1) to provide a matched termination to the line.

43. The first valve 3V1 (pentode, CV138) is biased normally by 3R3 in the cathode circuit, but the input signal is sufficient to run the valve to grid current; the negative potential developed across 3R1 biases the grid back to create the non-linear working conditions necessary for the production of harmonics.

44. A bandpass filter (3L3, 3L4) in the anode circuit of 3V1, is broadly tuned at about 40 Mc/s, so that second harmonics of the input signal in the range from 39·75 Mc/s to 41·65 Mc/s are selected. This signal is fed to the grid of 3V2 (CV138), which, in a similar circuit to that of the first doubler, produces a further frequency doubling. The output at four times the frequency of the input is selected in a bandpass transformer (3L5, 3L6) tuning over the range from 79·5 Mc/s to 83·3 Mc/s. The capacitor 3C17 connected across taps on the windings of the transformer increases the coupling between the windings, and controls the width of the passband.

First-IF amplifier

45. The output of the first mixer appears in a bandpass filter (3T1) in the cathode circuit of the diode. This transformer is tuned to 28·6 Mc/s and it selects that SF channel whose frequency is 28·6 Mc/s greater than the frequency of the local oscillator signal. The passband of the subsequent circuits is 50 kc/s (plus and minus 25 kc/s for response to be 6 dB down), so that if other channels are being received through the wide passband of the SF circuits they do not generate an IF signal.

46. The output of 3T1 is fed to the grid of the first-IF amplifier 3V5 (pentode, CV454). This valve is connected in a conventional amplifying circuit with cathode bias and an AGC feed to the grid; it is the only amplifier at the frequency of the first-IF. The anode circuit of 3V5 contains a further first-IF tuned transformer (3T2) feeding into the second mixer stage.

Second mixer

47. The second mixer 3V6 (pentode, CV131) operates as a leaky-grid detector with two parallel inputs on its grid. A cathode resistor (3R32) provides a small standing bias to prevent the valve overheating in the event of failure of the second local oscillator.

48. The first-IF input at 28·6 Mc/s is taken from a tap on 3L16; the use of the tap instead of the full winding prevents excessive damping of the tuned circuit by the low input impedance of the grid. The mixing input, from the second local oscillator, is at a fixed frequency of 30·6 Mc/s; the amplitude of this signal is sufficient to drive the valve to grid current, and the resulting flow through 3R60 biases the valve back to the non-linear working condition required for detection. The mixed output at the anode is at the difference frequency of 2 Mc/s.

Second local oscillator

49. The second local oscillator is 3V3 (pentode, CV138) in a crystal-doubler circuit. A 15·3 Mc/s crystal is used in a Colpitt's-type circuit of similar design to the first local oscillator (*para.* 37). The anode circuit is preset tuned to 30·6 Mc/s (the second harmonic of the crystal frequency) and an output at this frequency is taken to the grid of the second mixer through 3C23.

Second-IF amplifier

50. The 2 Mc/s output of the second mixer is amplified in a cascade circuit of three almost identical stages using 3V7, 3V8, and 3V10 (pentodes, CV131), in which bandpass transformers (3T3, 3T4, 3T5) are used for intervalve coupling, and a fourth RC-coupled stage uses 3V9 (pentode, CV138). The 50 kc/s receiver passband is shaped mainly in the second-IF transformers, which are designed to attenuate by 60 dB signals from adjacent localizer channels (spaced 100 kc/s either side of the wanted channel at the second-IF of 2 Mc/s).

51. The input to the final IF amplifier is untuned because the stage is required to produce gain only and not to contribute to the shape of the IF response. Outputs from the anode circuit are taken from a final IF transformer (3T6) consisting of a single peak-tuned circuit. An output to the detector stage is taken from a tap on the tuning coil (3L23) and an output to the AGC circuit is taken direct from the anode.

Detector and AGC

52. The final detector is a diode valve 3V11b (part of double diode, CV140). Its input is taken from a tap on the second-IF output coil to reduce damping that would otherwise be reflected into the tuned circuit. The detected output signals appear across a diode load consisting of two parallel resistance chains. The first chain (3R74, 3R70) feeds a low-pass filter (3L25, 3C100) which discriminates against all frequencies above 300 c/s and thus passes only the lower-frequency localizer tones at 90 c/s and 150 c/s. The second chain (3R51, 3R66, 3R76, 3R59) produces an output at the slider of 3R66 which contains the complete AF content of the received signal, including both localizer tones and the identification signals.

53. The AGC diode 3V11a is fed with the full output of the second-IF amplifier. It is cathode biased to about 25V to prevent operation on weak signals. The bias voltage is derived from a potential divider across the HT supply consisting of a diode 3V12 (gas-filled cold-cathode sub-miniature diode, CV2213) in series with 3R64, and the potential across the diode is further divided in 3R65 and 3R57; the presence of the diode stabilizes the bias potential and ensures that changes in the level of the HT supply do not affect the point at which AGC operation begins. (AL 27

54. The AGC diode load is 3R62, and the AGC feed is taken through a smoothing circuit (3R61, 3C98). AGC is applied to control 3V5 in the first-IF stage, 3V7 and 3V8 in the second-IF amplifier, and an AF amplifier (1V4) in the tone output circuit.

55. The delay potential on the AGC valve holds off AGC operation until the IF output signal is of at least 25V peak amplitude; this condition arises when the input signal at the aerial is between 10 μV and 20 μV. For aerial signals of greater amplitude the AGC operates, and because of the (AL 27) high degree of AGC feedback and the use of post-detector control (on 1V4) the tone output tends to remain constant despite wide variations in signal strength at the aerial. Thus the proportions of the two tones making up the tone output will not depend on the input signal strength but only on the relative levels of the modulation sidebands in the input signal, and the course sensitivity (change in indicator pointer reading for given deviation from line of approach) will remain constant at all useful ranges.

Audio output channel

56. The audio output from the slider of 3R66 is taken to the grid of a triode amplifier 1V2a (part of double triode, CV455). The anode of this valve is connected in parallel with the anode of the associated valve 1V2b, which receives an input on its grid from the audio output stage of the marker receiver; localizer and marker signals (if any) will thus appear together in the common load resistor 1R14. Both the localizer tones and the identification signals are fed from 3R66, but the input coupling components to 1V2a (1C4, 1R11) and the further coupling circuit (1C9, 1R19) to the audio output stage are chosen to ensure little gain at frequencies below 250 c/s, so that the localizer tones are attenuated, and only the identification (or emergency voice) signals are amplified and fed to the output stage.

57. The audio output valve is 1V3 (pentode, CV138) connected as a cathode-follower, and with a high degree of feedback coupling between the anode and cathode circuits through a transformer (1T1) which forms the cathode load. The feedback regulates the output impedance to provide a low-impedance source to the external circuit; the maximum output of about 450 mW is developed with an external load of 33 ohms, but the normal working level is less than 225 mW.

Indicator circuit

58. The low-pass filter in the detector diode load circuit passes only the 90 c/s and 150 c/s tones to the input of a tone amplifier consisting of 1V4 (pentode, CV131) and 1V1 (pentode, CV138). Both valves are triode connected. The response of the circuit is maintained constant, so that both tone frequencies are amplified equally, by the omission of decoupling capacitors from the cathode biasing resistors (1R4, 1R6).

59. The anode load of the output valve contains two filter networks in series. Each filter consists of a tuned transformer, an RC filter, and a further tuned transformer. The lower filter (nearest the anode) is tuned to pass 150 c/s and its response falls sharply at lower frequencies; the second filter is tuned to 90 c/s and its response falls sharply at the higher frequencies. The localizer tones are thus separated to appear as 150 c/s and 90 c/s sine-waves at the output terminals of the two filters respectively.

60. The filters shown in the main circuit diagram (*fig.* 14) are simplified to show only the outline details of their electrical construction. Their actual circuit is shown in fig. 12. The filters are built into a hermetically-sealed container and in practice can not be serviced other than by complete renewal. The transformer windings are tapped to provide for tuning adjustments in manufacture, and links between the filters and transformers are also used for a similar purpose.

61. The separated tone outputs of the filters are next fed into a further hermetically-sealed unit containing two metal-rectifier bridge circuits. Each bridge rectifies its tone input and produces a DC output which is fed into a resistive network, shown in outline in fig. 13a, to feed the meter movements of the vertical pointer and alarm flag in the indicator, electrical, Type 7.

62. The two load resistors (1R24, 1R25) of the rectifier circuits form a bridge circuit with the DC sources represented by the rectifiers; the pointer and flag movements are connected across the network (*fig.* 13b *and* 13d). If the circuit feeding the pointer is considered alone, as in fig. 13b, it will be seen that the rectifiers are connected in such a way that currents from the two sources tend to pass in opposition through the movement. In consequence, if identical DC levels are produced at the rectifiers (because the 90 c/s and 150 c/s

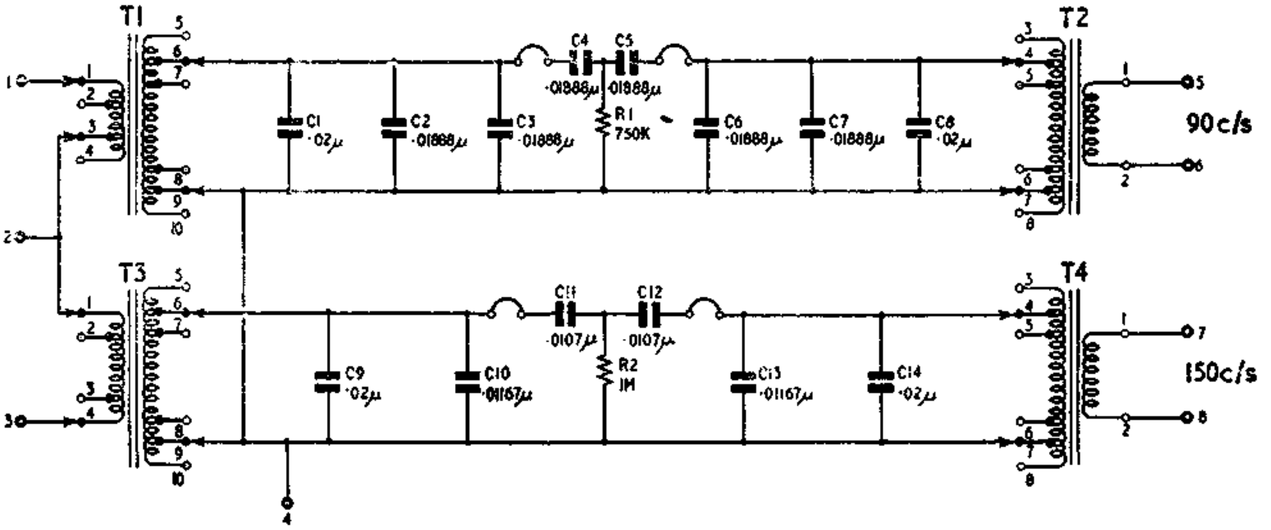


Fig. 12. Circuit of tone filters

tones are of equal amplitude) equal and opposite currents tend to be passed through the movement, and in practice no current flows and the pointer is undeflected. For other than identical levels an unbalance current flows in the movement whose direction is governed by the greater of the two levels and whose magnitude is dependent upon their relative amplitudes; the pointer is thus deflected to a degree dependent upon the difference between the levels of the received 90 c/s and 150 c/s tones, that is upon the aircraft's deviation from the line of approach.

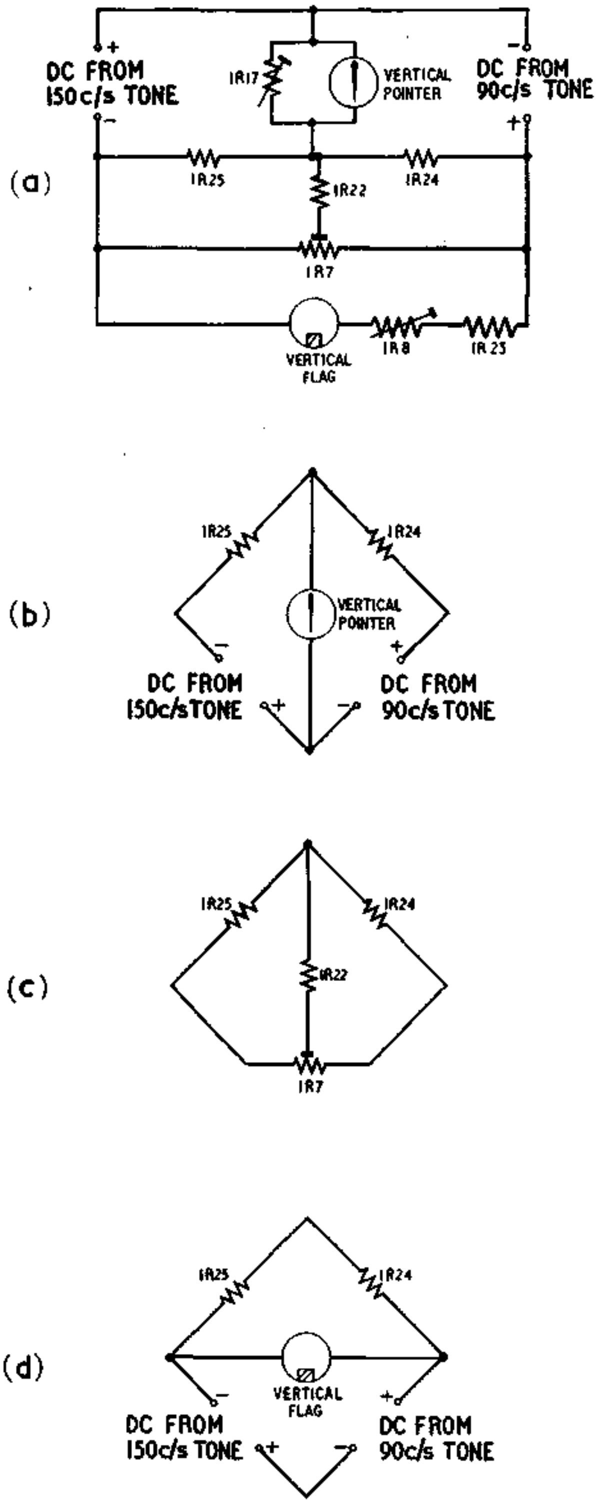


Fig. 13. Simplified diagrams of indicator circuit

63. A subsidiary bridge (*fig.* 13c) is formed with the two fixed resistors 1R24, 1R25, by a preset control 1R7. The slider is adjusted in practice for the condition whereby equal tone levels at the receiver input produce a zero deflection of the pointer, and it does this by altering the relative values of 1R24, 1R25. It should be noted that this balanced condition is not necessarily the same as the condition of equal outputs from the two rectifiers, because of the possibility of unequal amplification in the receiver of the two tone frequencies. A further preset (1R17) is shunted across the pointer movement to regulate the proportion of unbalance current that passes through; it is used to control deflection sensitivity.

64. The two DC sources are effectively in series to feed the movement of the alarm flag (*fig.* 13d). The flag is pulled completely out of sight when 400 μA passes through its movement, and this condition will not arise until the received signal is sufficiently strong to operate the AGC (that is the tone output level is no longer dependent upon the received signal strength) and both tones are present. A preset resistor (1R8) provides control of the sensitivity of the flag movement.

Duplicate indicators

65. Three indicators can be supplied from the output circuit. In practice these might consist of two ILS indicators and a zero reader. The pointer movements of the indicators are parallel connected, and the series movements are series connected. When less than the maximum number are being used, dummy loads are introduced into the circuit; thus once the presets have been set up for use with the maximum number, re-adjustments will not be necessary should the receiver be used with less.

66. Two shunt resistors are included in the pointer circuit, and these (6R1 or 12R5, and 6R2 or 12R6) are both out of circuit when three indicators are in use; the second (6R2 or 12R6) is in circuit with two indicators, and the first (6R1 or 12R5) is in circuit with only one indicator. The flag circuit is unloaded with three indicators, has 6R4 or 12R7 in series with two indicators, and has 6R4 of 12R7 together with 6R3 or 12R6 when only one is used. If less than the maximum number of indicators is being used, shorting links are connected across the unused plug points on the indicator junction box to maintain the flag circuit to the other indicators.

GLIDEPATH RECEIVER

Nature of signals

67. The glidepath transmitters operate in 300 kc/s-spaced channels in the UHF band from 329·3 Mc/s to 335 Mc/s. They radiate a double field pattern made up of a series of lobes bearing 150 c/s modulation and a second series of lobes bearing 90 c/s modulation. The main lobes of both patterns intersect along the required glidepath angle which

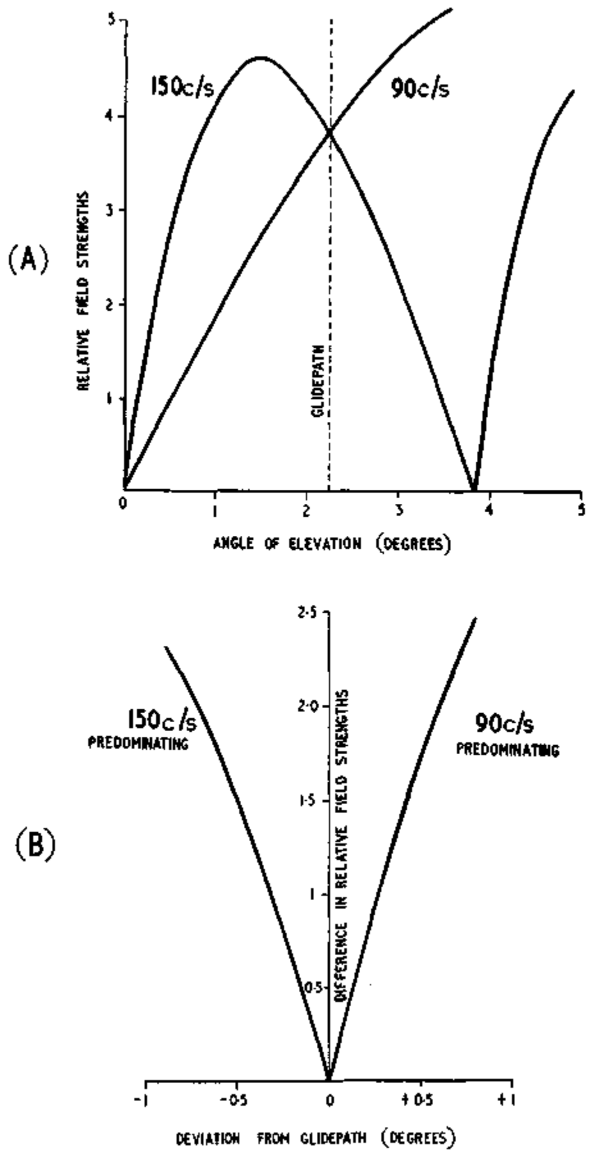


Fig. 16.

Field characteristics of glidepath transmitter

may be at any angle between 2deg. and 4deg. The modulation depths in both patterns are constant at about 45 per cent.

68. The graph A of fig. 16 shows the field characteristics of a typical glidepath transmission at either side of the glidepath angle, in this case of 2¼deg. The horizontal axis shows the angle of elevation, and the vertical axis shows the relative strengths of the two fields at the given angles. As the angle varies from about 1¾deg. to about 2¾deg. the strength of the 150c/s-modulated field falls almost linearly, and the strength of the 90c/s-modulated field increases almost linearly. At the glidepath angle of 2¼deg. the field strengths are equal.

69. When differences between the strengths of the fields are plotted we get the graph B of fig. 16. Over the angle from 1¾deg. to 2¾deg. the difference falls from a value of 1·6 to zero and then rises to 1·8, with first the 150c/s predominating and then the 90c/s. The glidepath receiver is required to measure these differences in field strength and display them as deflections of a centre-zero horizontal pointer; a centre reading corresponds to reception at elevations equal to that of the glidepath angle; readings above centre will depend upon deviations below the required angle, and readings below centre will depend upon deviations above the required angle.

AGC requirements

70. For satisfactory operation it is necessary that a particular angle shall produce a particular pointer deflection at all useful ranges. This requirement is satisfied if the output depends on the relative field strengths of the two signals instead of their absolute strengths, and the necessary conditions can be established if a high order of AGC is applied. In practice the AGC operates to keep the sum of the detected- and amplified-output of the modulation tones constant for a wide range of inputs, and the difference between the tones making up this standard level is then constant for a given angle at all ranges.

Selectivity

71. The selectivity requirements of the glidepath receiver, as with the localizer receiver, are for adequate adjacent channel rejection, and a minimum of spurious signals due to second channel interference. The first condition is satisfied by a bandwidth that is narrow in comparison with the 300kc/s spacing of the glidepath channels, and the second by the use of a high intermediate frequency. The conflicting needs of narrow bandwidth and high IF can not readily be met by a normal superhet, and, as with the localizer, a double superhet is used.

Outline of glidepath circuit

72. The outline of the glidepath receiver circuit is shown in the block diagram of fig. 17. The first stage is a signal-frequency amplifier fixed-tuned to cover the complete glidepath band; its output together with that of a local oscillator signal is fed to a mixer stage in which the first-IF at 54Mc/s is produced. The local oscillator signal is generated at one-eighteenth of the final frequency in a crystal trebler circuit which is controlled by a channel switch (common to that operating on the localizer) to provide any of twelve spot frequencies; the local oscillator circuit includes an amplifier, a trebler, and doubler stages.

73. The first-IF amplifier is a single stage feeding, together with the output of a second local oscillator, into a second mixer. The local oscillator is crystal controlled at 15·8Mc/s and its output is frequency trebled to 47·4Mc/s. The mixer output is thus at the difference frequency of 6·6Mc/s. The second-IF amplifier includes five valves and has a response giving an overall bandwidth of 270kc/s at 6dB down.

74. The detected signals consist of 90c/s and 150c/s waveforms representing the glidepath tones. They are amplified together and then separated in two sharply tuned filters. The separate 90c/s and 150c/s outputs are then rectified and mixed to produce DC signals for operating the glidepath pointer and alarm flag.

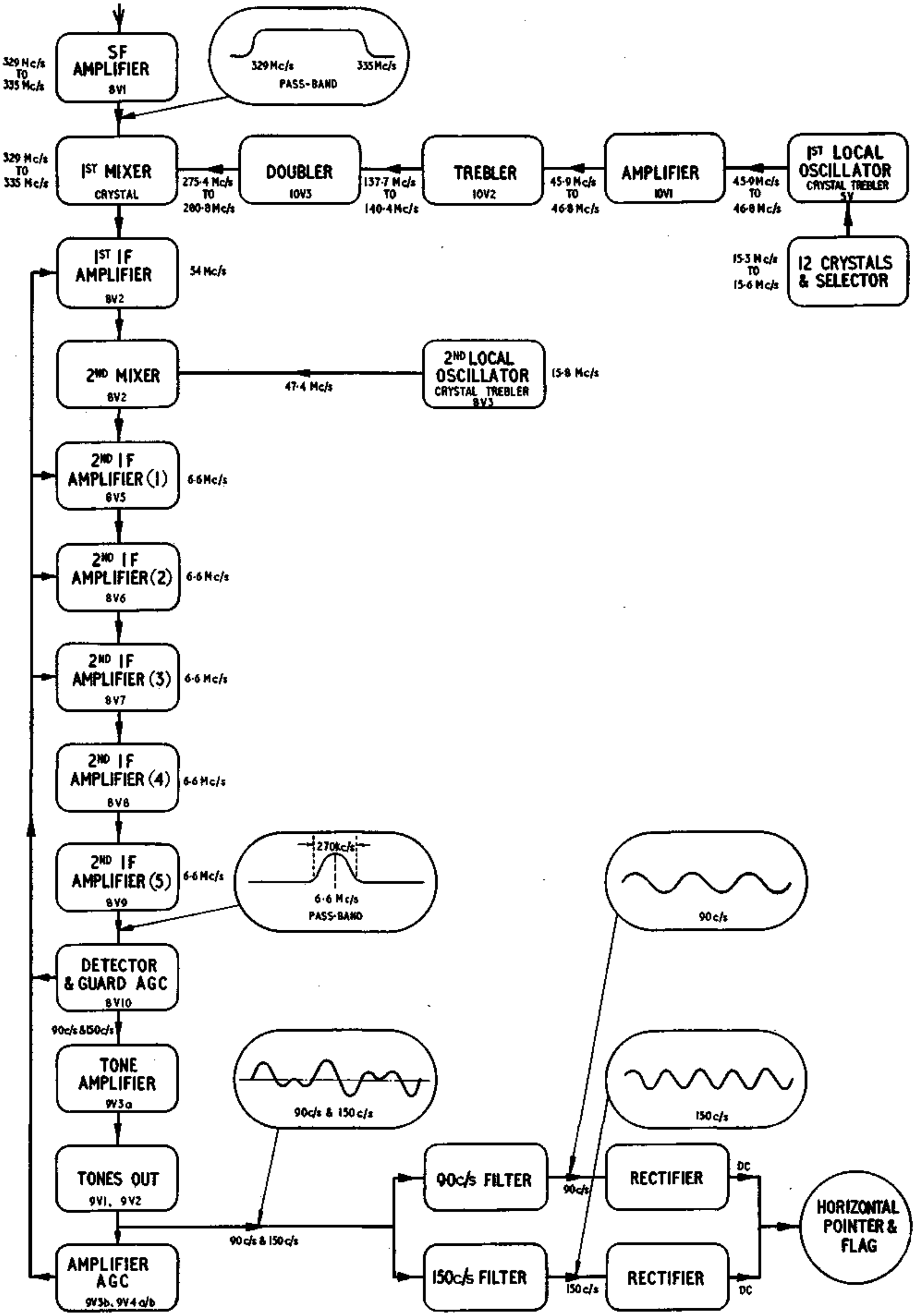


Fig. 17. Block diagram of glidepath receiver

RESTRICTED

feeding the localizer flag and pointer (*fig.* 13). The preset 9R8 balances the bridge formed between 9R23, 9R24 and the two DC sources, and enables the pointer to be set at the centre-zero when the tones are of equal amplitude. The second preset 9R1 is a shunt across the coil of the pointer movement; it allows the deflection sensitivity (deflection for a given difference in level between the tones) to be adjusted. A third preset 9R2 controls the current in the alarm flag and sets the minimum level at which the combined output will completely withdraw the flag.

104. Series dummy load resistors are connected into the flag circuit and parallel resistors in the pointer circuit. As with the localizer, these resistors are disconnected or shorted out in accordance with the number of indicators in use (*para.* 65).

Main AGC

105. The signal at the anodes of the tone output valves is rectified in the triple-diode circuit of diode 9V3b and double-diode 9V4 (CV140) to provide the main AGC potential. Onset of the rectifying action is retarded by a delay potential so that AGC is not produced until the peak level of the tone output reaches about 40V; for higher output levels an increasing level of bias is fed into the AGC line to control the gain of IF valves.

106. The first diode (9V3b) is connected in a normal type of delayed AGC circuit in which the signal is fed to the anode and the delay is provided by a voltage at the cathode. The other diodes (in 9V4) form a voltage doubler on the tone signal and control the voltage at the cathode of 9V3b.

107. When a signal is not being received the cathode capacitor 9C3 is charged through 9R20 and 9R9 to the potential of about 120V existing at the junction of 9R14 and 9V5 (gas diode, CV2213) and all the diodes are non-conductive. When a signal is received the tone signal applied through 9C6 to the common anode-cathode connection of 9V4 is rectified, and the charge of 9C3 is reduced until the potential across it falls by twice the peak value of the input signal.

108. If the signal has a peak value of say 41V the voltage at the cathode is reduced from 120V by 82V to 38V, so that at the peaks of the input through 9C5 to the anode of 9V3b, the anode tends to rise to 3V above the cathode. The diode therefore conducts and a negative potential develops across the load resistor 9R10. If the signal is less than 40V the combination of fall in cathode potential and peak rise at the anode is insufficient to cause the diode to conduct, and no current flows through 9R10, so that the potential across it remains zero.

109. For all signals of greater peak amplitude than 40V a negative potential is produced at the AGC line; its value is equal to three times the peak level of the tone signal minus 120V. The AGC therefore increases at three times the rate of increase of signal and results in the output being stabilized to approximately the level of 40V.

110. The static bias for the circuit is provided by a potential divider consisting of 9R14, 9V5, and 9V6 across the HT line. The return of 9V6 is taken to the 19V stabilized heater supply. The stability of the potential provided by this circuit is of the greatest importance in maintaining a constant deflection sensitivity.

MARKER RECEIVER

General information

111. Marker beacons operate at a fixed frequency of 75 Mc/s and radiate keyed MCW signals in which the coding and frequency of the modulation identifies the position of each beacon relative to the runway. Modulation is in the form of audio tones keyed with Morse symbols.

112. In normal operation the maximum range at which reception is required is limited to the distance represented by the height of the aircraft when on or near the correct approach path and when passing over the beacons. This distance will not usually exceed about 5,000 ft., so that a simple TRF receiver satisfies all requirements.

113. A block diagram of the marker receiver is shown in fig. 18. It will be seen to consist of a two-stage signal-frequency amplifier, a detector, an AF amplifier feeding a telephone output through the common audio circuit of the localizer receiver, an audio detector, and a lamp-operating DC amplifier. The circuit of the complete marker receiver is given in fig. 19.

Signal-frequency circuits

114. The marker aerial connects through a coaxial plug (1P4) and a short coaxial lead to the receiver input point at 4J1. The input circuit is a single-winding circuit peak-tuned at 75 Mc/s, with the input taken to a tap on the coil 4L1. A second tap on the coil provides an output feed to the first signal-frequency amplifier 4V1 (CV138).

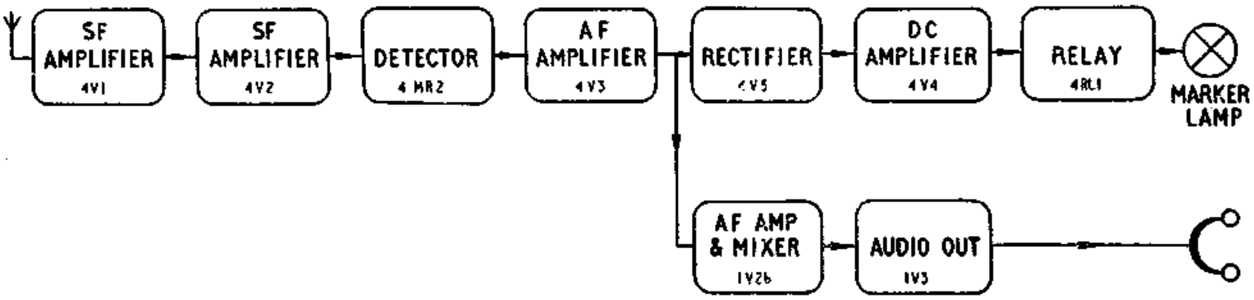


Fig. 18. Block diagram of marker receiver

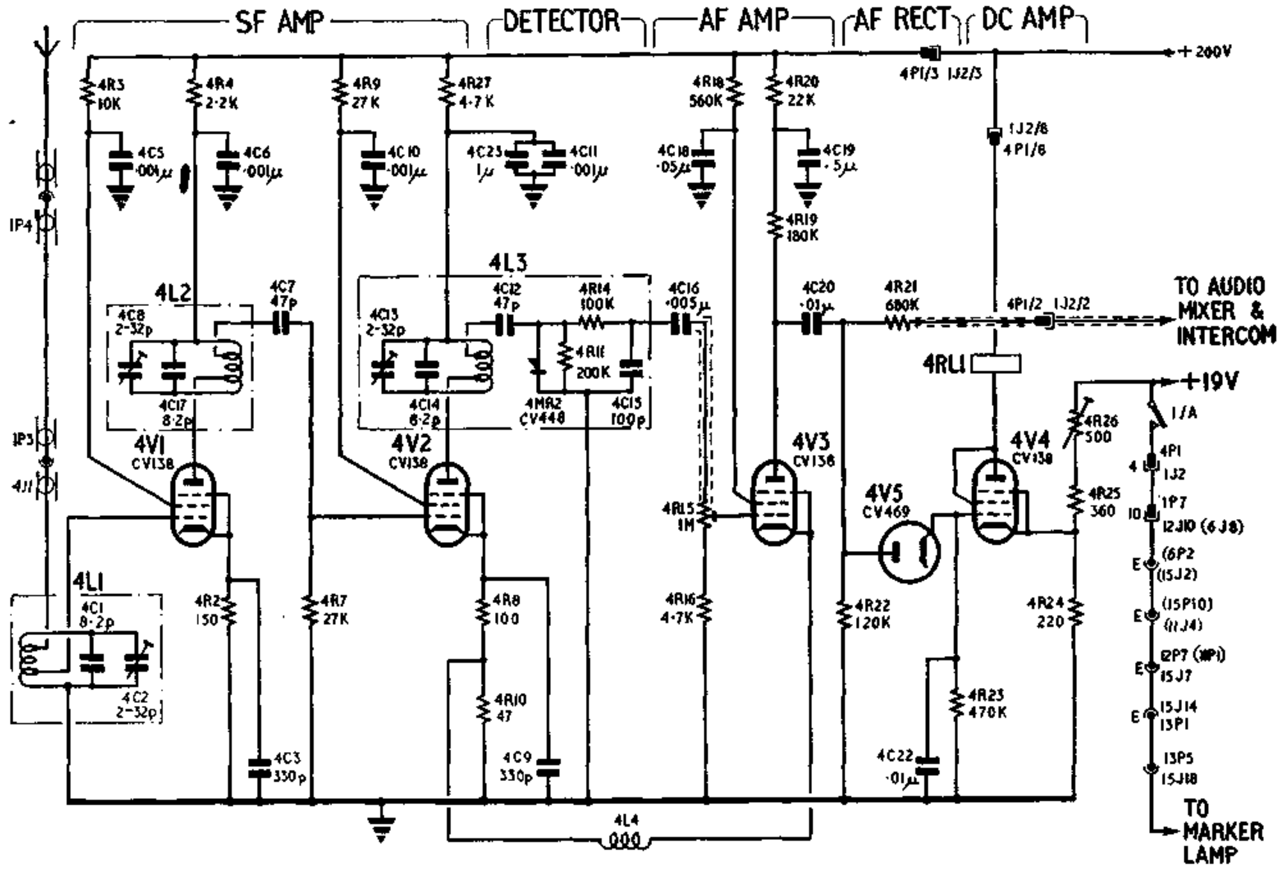


Fig. 19. Marker receiver—circuit

115. A second tuned circuit forms the anode load of 4V1. The anode connects to a tap on the coil (4L2) and a second tap provides the output through 4C7 to the second signal-frequency amplifier 4V2 (CV138). A third tuned circuit forms the anode load of 4V2 and provides the signal-frequency output to the detector.

116. The three tuned circuits are preset, by adjustable cores in the coils, to 75 Mc/s, and provide an overall bandwidth of 1 Mc/s for a response 8 dB down on the centre frequency. The input and output taps on the coils are arranged to provide correct matching between the several circuits in order to avoid damping and to maintain the bandwidth.

117. The bias for 4V1 is provided by a cathode resistor (4R2) and that for 4V2 is provided by two resistors in series (4R8 and 4R10); 4R10 is common to the cathode circuit of the AF amplifier valve 4V3. When the detected AF signal at the grid of 4V3 is passing through its positive half-cycles the potential across 4R10 due to the flow of current in 4V3 is increasing, and when the AF signal is passing through its negative half-cycles the potential across 4R10 decreases. The gain of 4V2 therefore decreases and increases as the audio rises and falls.

Detector and AF amplifiers

118. The 75 Mc/s output of the second SF-amplifier is applied to a germanium crystal diode (4MR2). The diode conducts during the positive periods of the carrier input so that an output in the diode load circuit (across 4C15) is a negative-going signal following the shape of the carrier modulation envelope.

119. The AF content of the detector output is fed to the grid of an amplifier valve 4V3 (CV138). The proportion of signal is controlled by a preset potentiometer (4R15), the marker gain control. The cathode bias for the valve is derived from the common cathode resistor with 4V2, 4R10.

120. Because the detector is connected to produce a negative-going output, the positive half-cycles of the audio signal applied to 4V3 are produced during the periods when the modulation envelope of the carrier is decreasing in amplitude, and the negative half-cycles are produced when the carrier envelope is increasing in amplitude. A rising potential is thus being introduced into the cathode circuit of 4V2 during envelope-decreasing periods of the carrier, so that the gain of the valve is reduced and the amplitude of the output is also reduced. A falling potential is introduced into the cathode circuit during envelope-increasing periods of the carrier, so that the gain of the stage is increased and the amplitude of the output is also increased. The resulting feedback action produces an effective increase in the apparent modulation depth of the input signals.

121. Amplified audio signals in the anode circuit of 4V3 are fed through 4C20 to the grid of a further amplifier 1V2b in the LF unit Type 4 (*fig.* 14). The level of input to 1V2b is controlled by 3R67 in the potentiometer formed by 4R21, 1R18, and 3R67. The anode load of 1V2b is common to the localizer audio amplifier 1V2a and so the marker AF signals appear in the input to the audio output valve 1V3, and are fed into the aircraft telephone circuits.

Lamp circuit

122. The marker AF signal is also fed to the anode of a rectifier 4V5 (diode, CV469), whose load circuit (4R23, 4C22) is of long time-constant. The rectified output appears at the grid of 4V4 (CV138) as positive DC pulses which follow the coding of the original marker signals.

123. 4V4 is a DC amplifier. It is normally non-conducting due to the bias voltage at the cathode derived from the 19V heater supply through 4R26 and 4R25. Each pulse at the grid causes anode current to flow and relay 4RL1 in the anode circuit to operate. The contacts of the relay therefore close for the duration of each input pulse and an external lamp connected in the heater supply circuit is switched on. The tripping level of the relay is controlled by the bias adjustment (4R26) on the valve.

POWER SUPPLIES

Control circuit (*fig. 20*)

124. The ILS receivers operate on aircraft battery supplies at the nominal level of 27V DC. A single feed is taken from an aircraft power point through a control circuit common to both receiver units; thereafter separate lines are used to feed the two units.

125. The positive line of the common feed includes a thermal circuit breaker and the pilot-operated ON/OFF switch. After the switch, two lines supply the 27V to the receiver units, and a third line feeds a voltage regulator. The output of the regulator at 19V supplies the heater circuits of both units.

Circuit breaker

126. The circuit breaker is a Type A thermally-operated switch rated to trip and open the circuit when more than a pre-determined current is passing through the switch. It consists of a single-pole switch manually closed in normal operation by a press button, and held in the operating position by a mechanical locking system; the internal connection to the switch contacts includes a bi-metal strip which expands and trips the locking mechanism on over-heating and so releases the switch; a second press button is provided to permit the switch to be tripped manually if desired. A preset adjustment on the tripping mechanism is set normally for tripping to take place when 15A is passing.

Voltage regulator

127. The voltage regulator Type 60 consists of a carbon pile assembly in series with an operating solenoid across the 27V supply. The nominal voltage drop across the pile is 8V, so that the voltage across the solenoid circuit is normally 19V; if the supply voltage rises, more current flows in the solenoid and the plunger in the carbon pile (which is controlled in position by the core of the solenoid) is moved in such a way as to reduce compression in the pile; the resistance of the pile is thus increased and the voltage drop across the pile increases. The rise in supply voltage tends therefore to appear mainly across the pile, and the potential across the solenoid circuit tends to remain constant at the required level of 19V.

128. The resistor in series with the solenoid is a preset adjustment on the current flow through the solenoid. It is used to set the stabilized level to the required 19V.

HT—R.1964

129. A rotary transformer Type 797 (prefix 2) provides HT in the R.1964. The 27V input circuit (*fig.* 21) includes an RF filter which prevents feed-back of commutation noise into the supplies; a further filter is included in the HT output line to prevent noise injection into the receiver circuits.

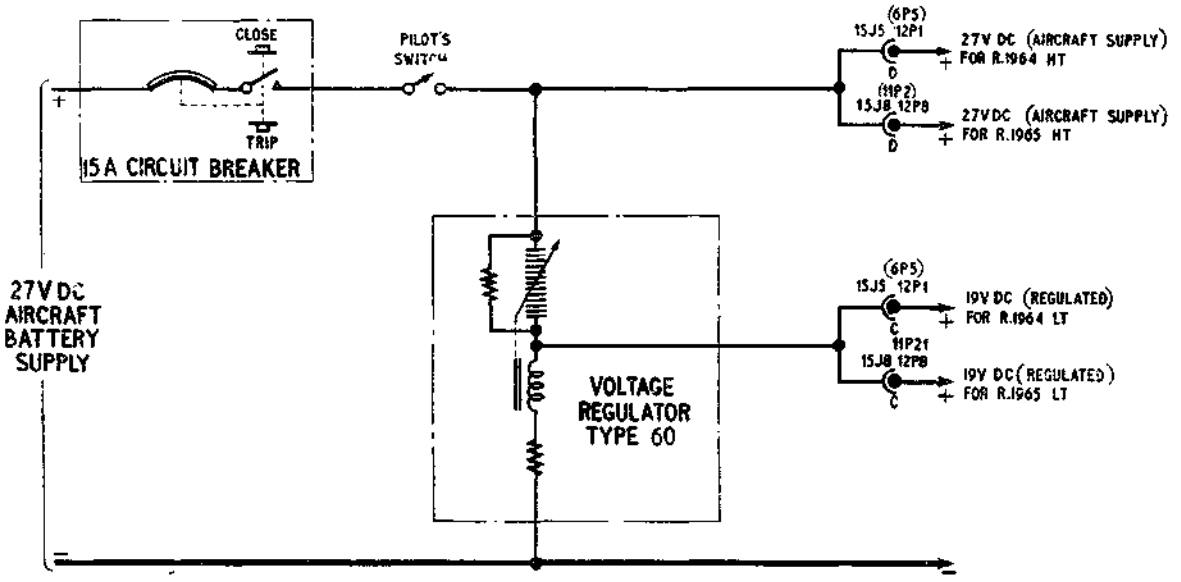


Fig. 20. Power control circuit

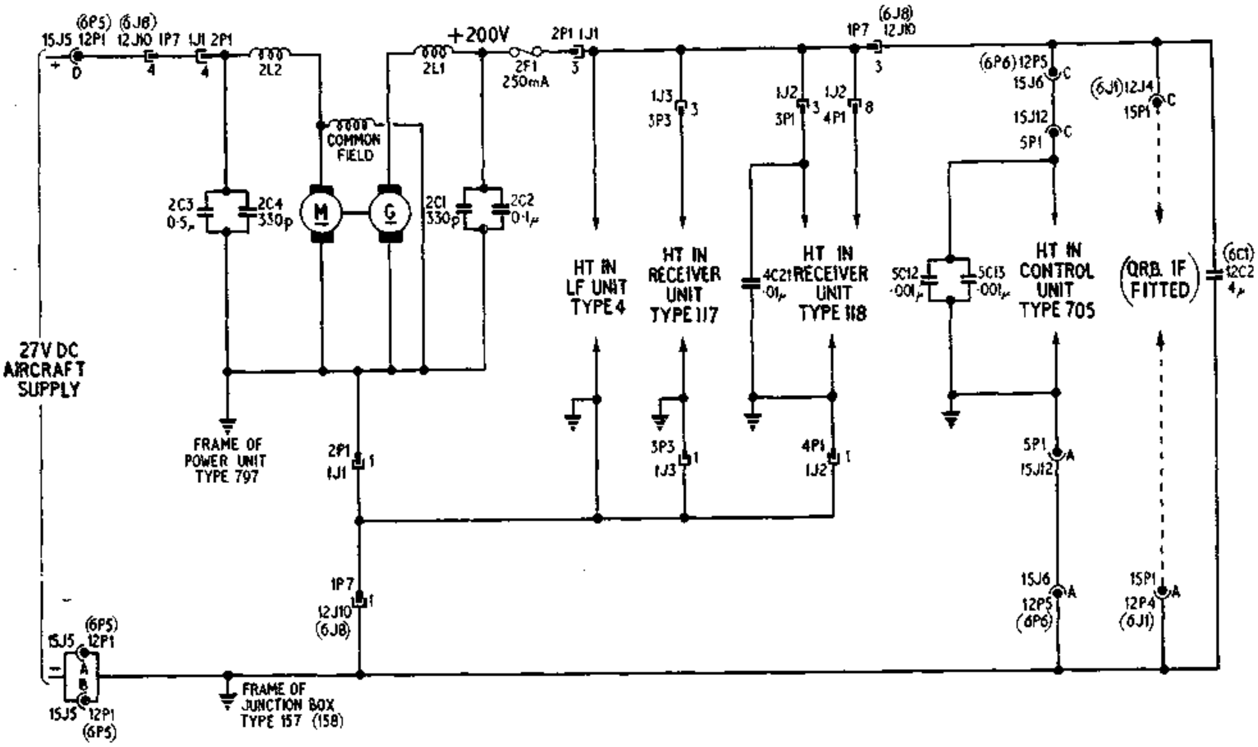


Fig. 21. R.1964 HT supplies

130. The transformer consists of a 27V DC motor and a 200V DC generator in which a single stator winding provides a common field, and the two rotor windings are on a common armature with separate commutators, one at each end. A fan is fitted on the LT commutator end of the armature to provide a forced draught for cooling the receiver unit as a whole.

131. The HT output appears on pin 3 of the plug 2P1, and it is coupled into the LF unit Type 4 through 1J1. The distribution of HT to the receiver units Type 117 and 118, as shown also on fig. 21, takes place through the plug and socket interconnections on the LF unit; and further distribution to the control unit Type 705 and to a possible, but unused, application in an O.R.B. unit, takes place through the junction box.

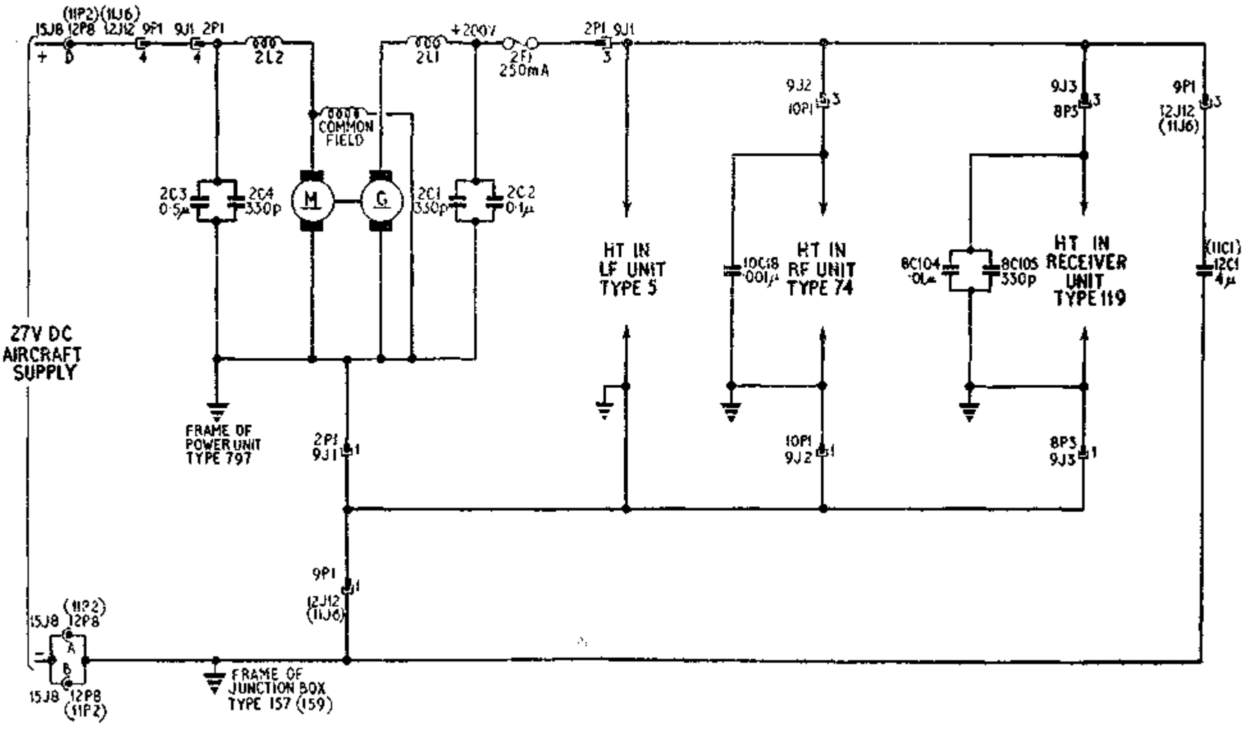


Fig. 22. R.1965 HT supplies

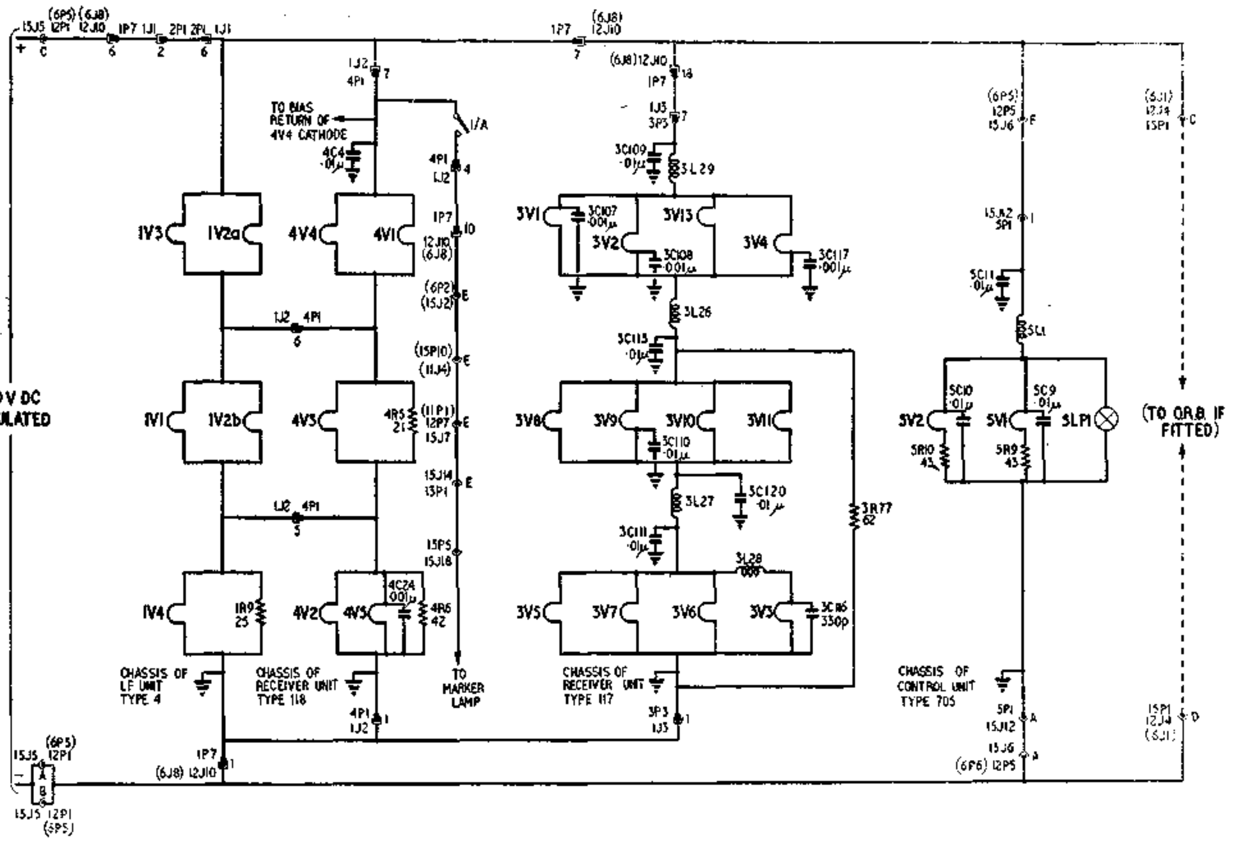


Fig. 23. R.1964 LT supplies

132. In general a decoupling circuit is provided separately in each unit taking HT, but a common smoothing circuit is provided by a 4 μF capacitor (12C2 or 6C1) fitted in the junction box.

HT—R.1965

133. The HT circuit of the R.1965 is shown in fig. 22. HT is generated as in the R.1964 by a rotary transformer Type 797. The output at 200V is distributed through the plug and socket interconnections on the LF unit Type 5, and a feed is also taken into the junction box to a capacitor, 12C1 or 11C1, which provides smoothing. No external circuits are provided with HT from the R.1965

LT—R.1964

134. The LT circuit of the R.1964 is shown in fig. 23. The 19V regulated supply is brought into the LF unit Type 4 through the junction box and is fed in a complex series-parallel arrangement to the valve heaters in the receiver units and the control unit. Provision is also made on the junction box for the 19V supply to be fed to an O.R.B. unit if fitted.

135. The heaters of the twelve valves in the receiver unit Type 117 are connected in three parallel groups of four, and the three groups are then connected in series; each heater requires 6·3V, so that the complete chain requires approximately 19V. The valves in the first group (3V1, 3V2, 3V13, 3V4) draw 0·3A each, so that the total required drain down the chain is 1·2A. The second and third groups each consist of two valves drawing 0·3A and two drawing 0·2A, a total of 1·0A, so that a bleeder (3R77) is connected across them to draw the excess 0·2A. Chokes and capacitors decouple the sets of heaters from one another, and the heater of the second local oscillator (3V3) is separately isolated by 3L28.

136. The heaters of four valves in the LF unit Type 4 and five in the receiver unit Type 118 are also connected in a chain of three 6·3V circuits. In the first parallel group of valves, three (1V3, 4V4, 4V1) each draw 0·3A and one section of the centre-tapped heater of 1V2 draws 0·15A; a total drain of 1·05A. In the next group 1V1 and 4V3 each draw 0·3A, the second half of the heater of 1V2 draws 0·15A, and a bleeder (4R5) draws 0·3A to make up the total to 1·05A. In the third group of heaters, 1V4 takes 0·2A, 4V2 takes 0·3A, 4V5 takes 0·15A, a bleeder (1R9) takes 0·25A, and a second bleeder (4R6) takes a further 0·15A to make up the total to 1·05A.

137. The heaters of the two valves (5V1, 5V2) in the control unit each requires 6·3V at 0·3A, and they are connected in parallel across the supply, each in series with a dropping resistor (5R10, 5R9). The pilot lamp (5LP1) is rated at 24V, but it is connected in parallel with the valve circuits across the 19V supply.

138. The LT supply for the marker indicating lamp is derived from the 19V source in the receiver unit Type 118. The feed includes the switch contacts of the marker relay. The same 19V source also provides cathode bias for the relay control valve 4V4.

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LT—R.1965

139. The LT circuit of the R.1965 is shown in fig. 24. The 19V regulated supply is brought into the LF unit Type 5 through the junction box, and connected in a complex series-parallel arrangement which brings all the valves in the LF unit Type 5, the receiver unit Type 119, and the RF unit Type 74 into three series groups. In the first group, the valves (10V3, 9V1, 8V2, 8V1, 8V10) each take 0·3A, and the bleeders 9R21 and 8R73 take 0·3A and 0·1A respectively; the total chain current is therefore 1·9A. The second chain is similar with 10V2, 9V2, 8V9, 8V8, and 8V7, each taking 0·3A, and the bleeders 9R22 and 8R74 taking 0·3A and 0·1A respectively. In the third chain 10V1, 9V3, 9V4, 8V4, and 8V3, each take 0·3A, and 8V6 and 8V5 each take 0·2A; making up the required total of 1·9A.

140. Each group of heaters in the receiver unit Type 119 is isolated by a choke, and the heaters of the RF valve, second detector, and second local oscillator are separately isolated. The three feeds to the valves in the RF unit Type 74 are also decoupled by separate chokes and capacitors.

141. The 19V supply in the LF unit Type 5 is also used to increase the bias potential in the AGC delay circuit. Two cold-cathode discharge valves are connected in series with a resistor 9R14 from the HT positive line to the LT line, so that the stabilized potential of just over 100V across the valves is added to the 19V heater supply to produce the required bias potential at about 120V.

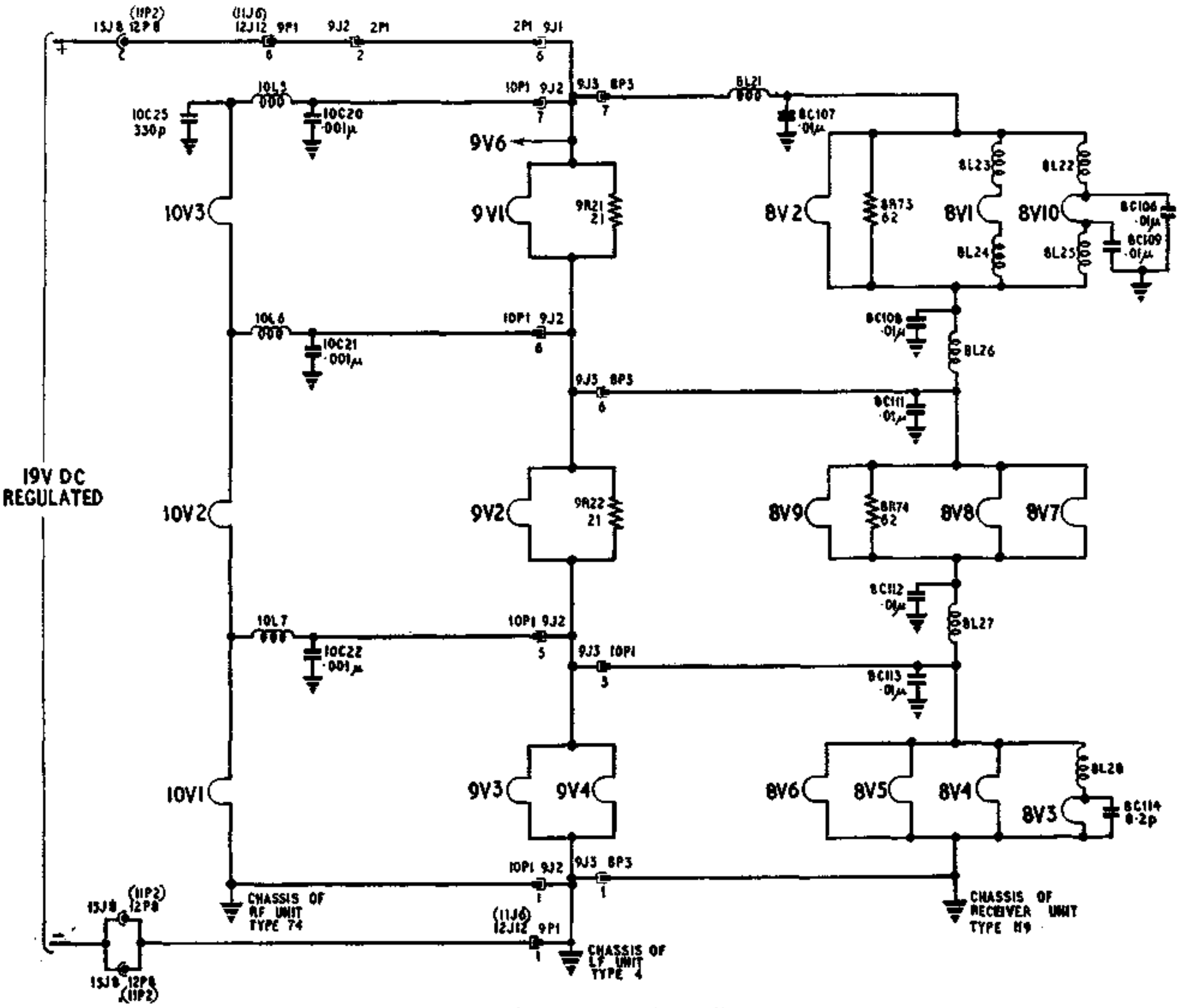

Fig. 24. R.1965 LT supplies

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