Chapter 1

INTRODUCTION

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LIST OF ILLUSTRATIONS

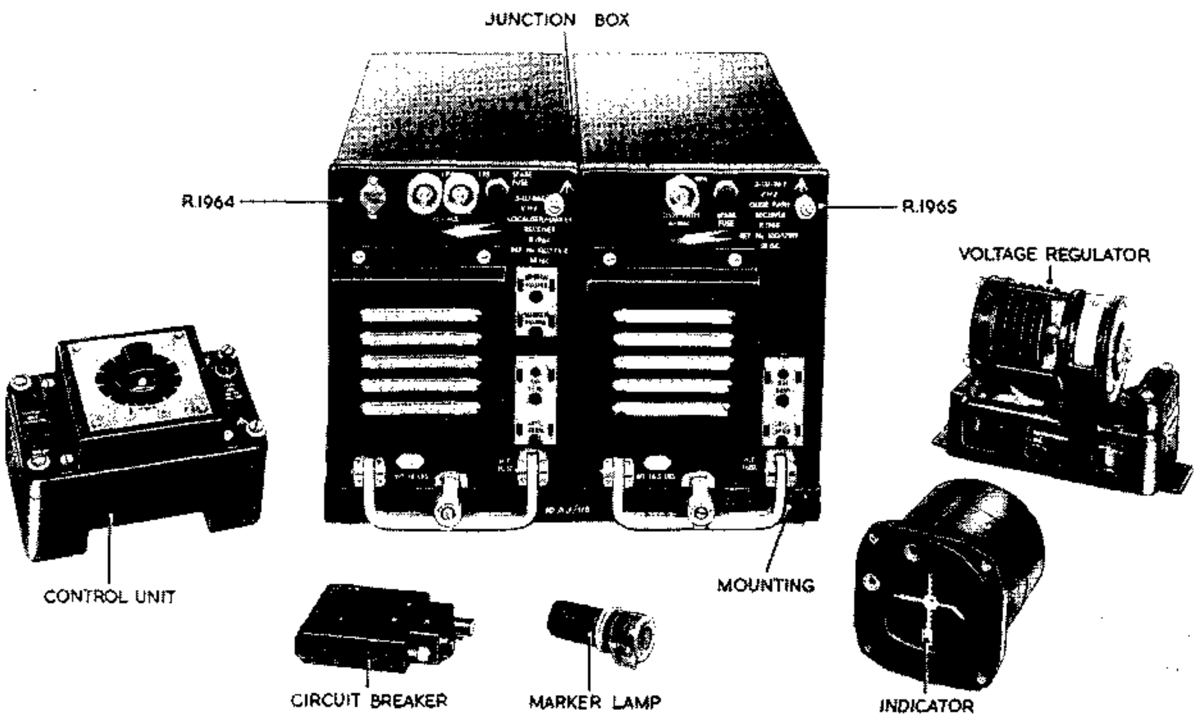

Fig. 1. Major items of ILS airborne equipment

Outline of ILS airborne

1. The receiving equipment described in this publication is a landing approach aid installed in aircraft as ARI.18011. It operates on transmissions from ground beacons and provides the pilot of an equipped aircraft with visual indications of the aircraft's position relative to the runway touch-down point.

2. The complete system (that is the ground beacons and the airborne equipment considered together) is known as the Instrument Landing System, or shortly as ILS. It is a Service version of the system as used in Civil Aviation, and both Service and Civil systems are developments of the American SCS-51 system. The differences between the Service and Civil versions are differences in detail only, which do not preclude the use of Service airborne equipments on Civil beacons or Civil airborne equipments on Service beacons.

3. Three receivers are used in the airborne equipment. A localizer receiver provides indications of lateral deviations from the approach path; that is, it shows the aircraft's position in the horizontal plane relative to the line of the runway. A glide-path receiver provides indications of deviations from the vertical path to the runway; that is, it shows the aircraft's position relative to the correct angle of approach to the runway. A marker beacon receiver indicates aurally or on a flashing lamp the approximate distance to the touchdown point at two fixed positions along the approach.

4. The localizer receiver operates at any one of twelve spot frequencies in the range from 108 Mc/s to 112 Mc/s; the tuning range of the receiver actually extends 6 Mc/s beyond this upper limit to 118 Mc/s, but no application for this extended range is at present foreseen. The glidepath receiver operates at any one of twelve spot frequencies in the range from 329 Mc/s to 335 Mc/s. The marker receiver is fixed tuned at 75 Mc/s.

5. The separation between adjacent localizer channels is 100 kc/s, and that between the glide-path channels is 300 kc/s; a total of 40 localizer channels and 20 glidepath channels are thus available. A single twelve-position switch on a pilot's control unit fitted remotely from the receivers controls selection of both the glidepath and localizer channels.

6. A common audio circuit provides a telephone output from the localizer and marker receivers. The audio signals consist of coded identification signals or emergency voice signals from the localizer receiver, and the characteristic marker beacon tones from the marker receiver.

7. The signals produced by the localizer and glidepath receivers are particularly suited for operating automatic following devices, and when applied to an auto-pilot they enable an automatic let-down to be carried out to within about 150 ft of the ground. Auto-pilots Mk. 10 and 12 are provided with the necessary coupling units which make them suitable for operating off ILS.

8. The major items in the airborne equipment are shown in fig. 1. One main unit (receiver Type R.1964) contains the localizer and marker receivers, the other (receiver Type R.1965) contains the glide-path receiver. The control unit (Type 705) carries the channel selector control and the local oscillator circuits for the localizer and glidepath receivers. Vertical and horizontal pointers displaying the localizer and glidepath receiver output are combined in a cross-pointer movement in the indicator unit.

9. Other parts of the installation include junction boxes, three separate aerials, and a marker indicating lamp. The separate aerials are of different

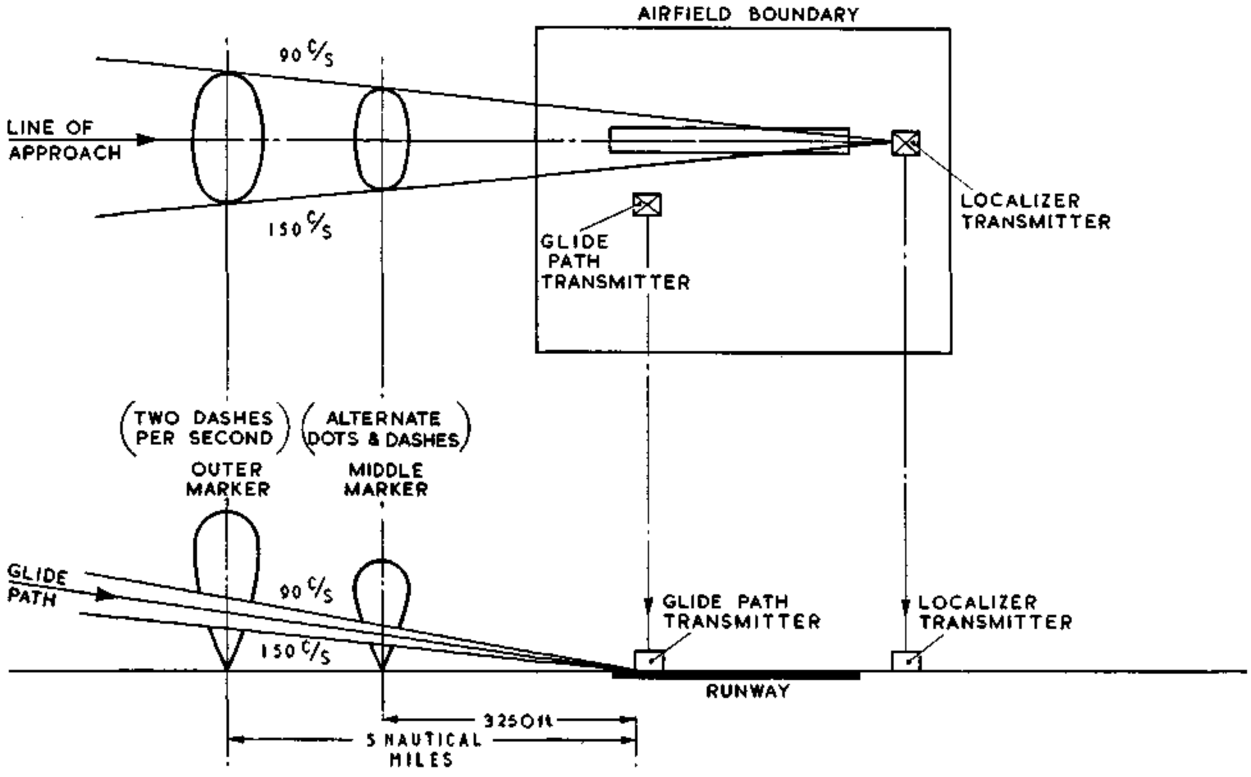

Fig. 2. Layout of ILS ground system

types to accommodate the different frequency ranges involved and the needs of different aircraft. In some slow flying aircraft traditional types of rod, sword and wire aerials are used; in other aircraft, including all high-speed types, suppressed aerials are used in which the external surfaces of the aircraft's structure form important parts of the reception system.

10. The equipment operates from aircraft DC supplies of 26·5V nominal. A direct input from the DC source operates a rotary transformer (motor-generator) in each unit to provide HT. A second input is taken through a voltage regulator to provide a stabilized source at between 18V and 20V, nominally 19V, to supply the valve heaters. The direct power consumption is about 140 watts, and the stabilized consumption is about 90 watts, making a total of 230 watts.

11. The ambient temperature range in which the equipment is designed to operate is from minus 35 deg. Celsius to plus 55 deg. Celsius (about minus 30 deg. F. to plus 130 deg. F.). A forced air cooling system is used in the two receiver units to allow the upper limit to be maintained. All units are fully tropicalized, but, because operational requirements limit the use of the equipment to low altitudes, they are not pressurized.

Summary of Instrument Landing System

12. The Instrument Landing System provides a radio guide along a prescribed approach path to a runway, and enables a fitted aircraft to descend to a low altitude without sight of the ground. Thus, in conditions of bad visibility, a successful approach can be made to a point at which sight of the ground or landing lights will permit a landing to be made.

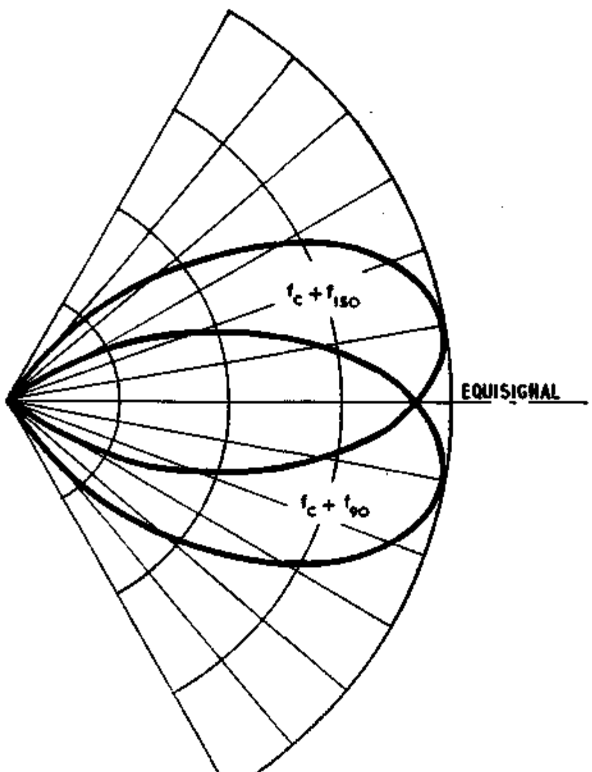

Fig. 3. Radiation pattern of localizer transmission

The layout of an airfield with ILS radio paths is shown in fig. 2.

Localizer

13. The line of approach to the runway in the horizontal plane is marked by a localizer beacon sited at the far end of the runway. The radiation pattern of this beacon in the horizontal plane is characterized by two major lobes which overlap along a line passing through the centre and along the length of the runway, as shown in fig. 3. The right-hand lobe (looking towards the transmitter from the touch-down end of the runway) carries a modulation at 150 c/s, and the left-hand lobe carries a modulation at 90 c/s. At the centre of intersection of the two lobes, along the equisignal, there are equal amplitudes of the modulation sidebands, and the carriers of the two lobes are equal and in phase.

14. An aircraft in the range of the beacon receives a signal with a predominant modulation of either 150 c/s or 90 c/s when flying to the right or left respectively of the correct line of approach, and a signal with equal levels of the two modulations when flying exactly along the approach path. For angles of deviation from the line of approach of up to 4 deg. the difference between the levels of the two modulations is proportional to the angle.

15. The airborne receiver of the localizer transmissions produces two DC outputs whose levels are dependent upon the modulation levels of the received signals. These outputs are connected in opposition to provide a single DC source which is positive or negative according to which modulation level is the greater, and zero when the levels are equal. The deviation from the line of approach is therefore indicated by the magnitude and polarity of this DC output.

16. The final output is fed to a moving-coil meter unit in the indicator to control the position of a vertical pointer. Left deflections of the pointer result when the aircraft is to the right of the approach path, right deflections when to the left, and centre-zero shows when the aircraft is on the path. A warning flag is also controlled by the output to appear over the end of the pointer when weak, zero, or faulty reception (one modulation signal missing) makes the pointer reading misleading.

17. An identification signal is transmitted by the localizer beacon to provide identification of the complete ILS ground installation. It takes the form of a 1,000 c/s note keyed in accordance with a prearranged code to distinguish each separate installation, and it is radiated in both lobes as an additional modulation on the localizer carrier. The 1,000 c/s tone which appears in the output stages of the localizer receiver is separated from the 150 c/s and 90 c/s localizer tones and is amplified in an audio circuit for presentation on the aircraft's inter-com system. In emergency the identification tone is switched out at the beacon and voice signals substituted, thus providing a ground-to-air channel of communication at the frequency of the localizer channel.

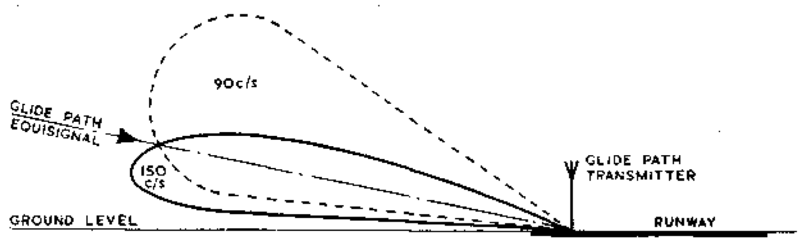

Fig. 4. Radiation pattern of glidepath transmission

18. The localizer beacon has a range of about 25 miles at a height of 2,000 ft.; and at distances within this range, deviations of 2½ deg. from the line of approach produce full-scale deflection of the indicator pointer independently of the actual range.

Glidepath

19. The approach path in the vertical plane, that is the angle of approach to the touch-down point, is marked by a glidepath beacon whose aerials are sited at the side of the runway at the approach end. The radiation pattern in the vertical plane has two major lobes overlapping along the descent path and meeting the ground at the approximate touch-down point as shown in fig. 4. Measures are taken in the design of the aerial system to correct the radiation pattern to ensure that the descent path is a straight line down to the runway.

20. The upper lobe of the glidepath transmission carries a 90 c/s modulation and the lower lobe carries a 150 c/s modulation; the modulation depths in both lobes are the same at about 45 per cent. At points along the glidepath the field strengths of the two lobes are the same, and at points above and below the glidepath the field strength of one or the other of the lobes predominates.

21. An aircraft in the range of the glidepath transmission will thus receive a strong 90 c/s modulated signal and a weak 150 c/s modulated signal when flying above the glidepath, equal strengths of the two signals when on the glidepath, and a strong 150 c/s modulated signal and a weak 90 c/s modulated signal when below the glidepath. For small deviations from the glidepath angle the difference between the strengths of the two signals at a particular deviation is proportional to the angle.

22. The glidepath receiver is generally similar to the localizer receiver, and its output is also a DC potential whose value depends upon deviations from the correct path. The horizontal pointer of the indicator is controlled by the output to indicate up-deflections when the aircraft is below the glidepath, down-deflections when the aircraft is above the glidepath, and centre-zero when the aircraft is on the glidepath. A warning flag is also controlled by the output to appear over the end of the pointer when weak or zero signals, or faulty reception, make the pointer reading misleading.

23. At an angle of elevation equal to a third of the glidepath angle the glidepath beacon has a range of about 15 miles, and within this range full-scale deflection of the pointer is produced by deviations of approximately ½ deg. up and ¾ deg. down from the glidepath angle. The glidepath angle will differ between installations, but will normally be about 3 deg.; the sensitivity of the glidepath indicator will also differ with differing glidepath angles.

Markers

24. Two marker beacons are placed along the approach path to the runway as shown in fig. 2. Each beacon transmits a fan-shaped vertical radiation pattern in a narrow beam. The beacons are referred to as outer marker and middle marker, and their siting positions are at five miles and 3,250 ft. respectively from the approach end of the runway. Provision is also made for an inner marker at the airfield boundary, but this beacon is not normally used.

25. Each marker is distinguished by a characteristic tone modulation on its carrier, and as a further distinction the tones are keyed. The outer marker is modulated at 400 c/s and keyed for two dashes per second; the middle marker is modulated at 1,300 c/s and keyed with alternate dots and dashes.

26. The marker transmissions are received on a marker receiver in the aircraft and displayed both aurally, over the aircraft's intercom system, and visually, as a coded blinking of the marker indicator lamp. The aural signals consist of the complete marker characteristic modulations of keyed tones, but the lamp is operated from the modulation keying only. The maximum altitude for reliable reception is about 3,000 ft. with suppressed aerials and a little greater with external aerials.

General description of ILS receivers

27. The basic requirements of the ILS receiving system is shown in fig. 5, and the outline of the receiving installation in fig. 6. The localizer receiver translates deviations from the horizontal approach path marked by the localizer beacon into right and left deflections of a vertical pointer; the glidepath receiver translates deviations from the vertical approach path marked by the glidepath beacon into up and down deflections of a horizontal pointer; and the marker receiver translates the distance indicating signals of the three marker beacons into the ordered blinking of a lamp.

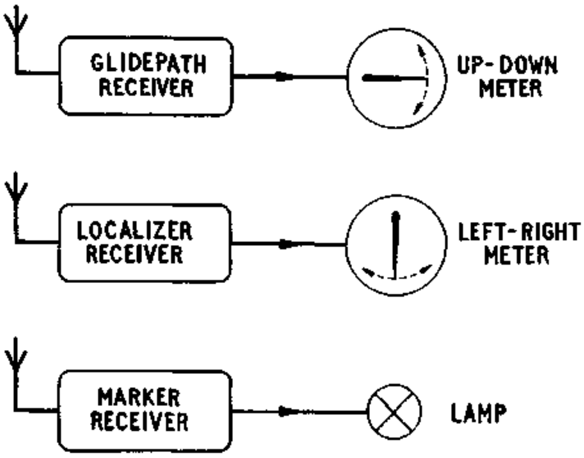

Fig. 5. Basic receiving system

Localizer

28. The localizer receiver is a double superhet operating over the VHF band from 108 Mc/s to 118 Mc/s. The first local oscillator (in the control unit Type 705) is crystal controlled; the channel switch in the control unit selects crystals which allow for operation at twelve spot frequencies. The first IF is at 28·6 Mc/s, and the second IF is at 2 Mc/s.

29. The detected output is filtered to remove all but the localizer 150 c/s and 90 c/s tones, and the output of tones only is amplified. The two tones are then separated in sharply tuned filters, and rectified to produce two DC outputs. The levels of the DC outputs are directly proportional to the modulation depths of the original received tones.

30. The localizer pointer is operated from a parallel combination of the two levels which gives an output proportional to the difference between them; the localizer flag operates from a series combination in which the two outputs add together.

31. An audio channel which cuts out all frequencies below 300 c/s is also taken from the detector. This channel carries the output of identification or voice signals and is fed into the aircraft telephone system.

Glidepath

32. The glidepath receiver is also a double superhet; its operating range is from 329 Mc/s to 335 Mc/s. The first local oscillator is crystal controlled, and the channel switch (common with that of the localizer) selects crystals for operation at twelve spot frequencies. The first IF is at 54 Mc/s, and the second IF is at 6·6 Mc/s.

33. The detected output comprising 90 c/s and 150 c/s glidepath tones is amplified, and the tones are separated in sharply tuned filters, and rectified to produce two DC outputs. The output levels are proportional to the received strengths of the 90 c/s and 150 c/s input signals.

34. The glidepath pointer is operated from a parallel combination of the two DC levels, and the pointer is deflected in proportion to the difference between them. The glidepath flag operates from a series combination in which the two levels add together.

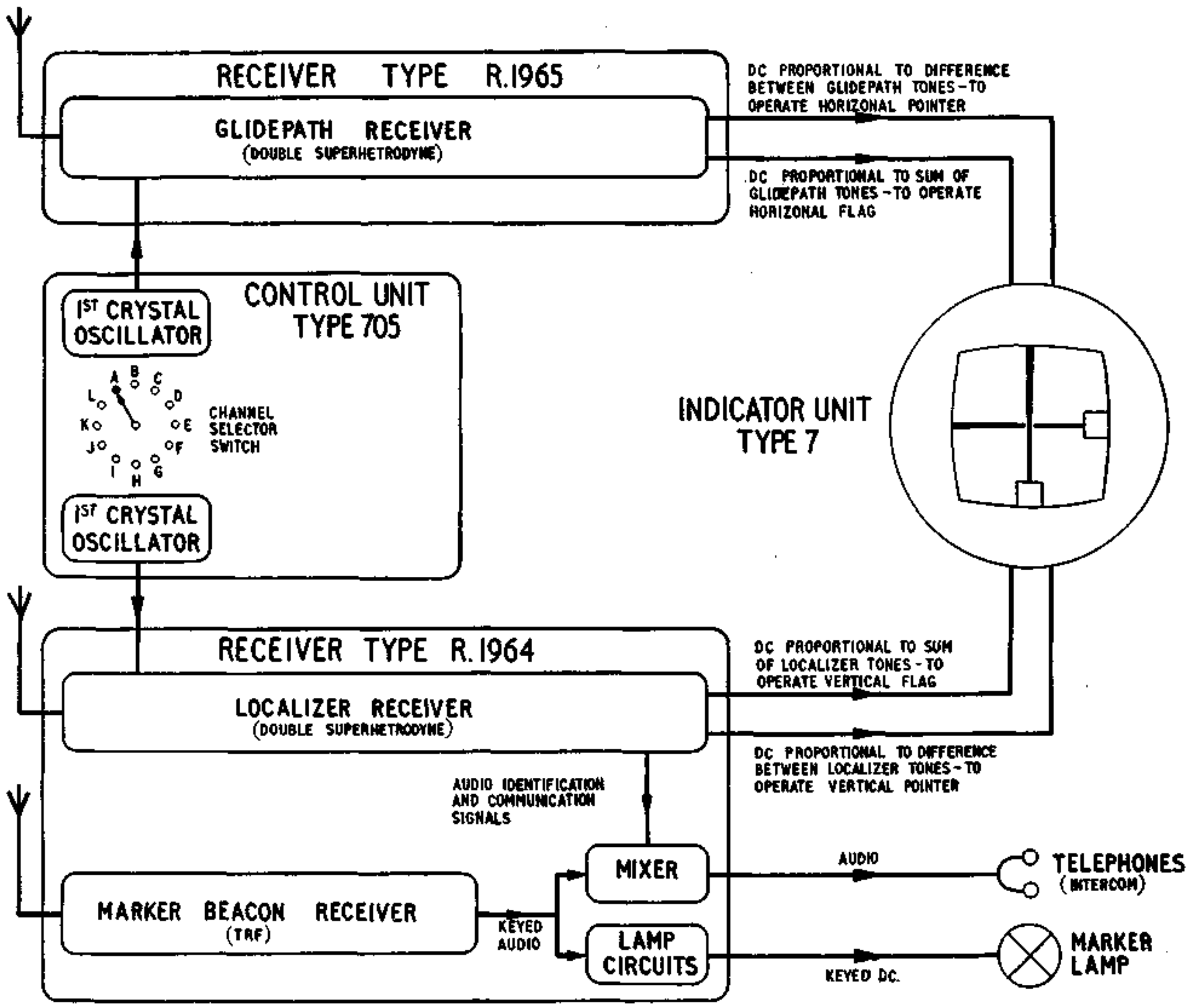

Fig. 6. Outline of receiving installation

Markers

35. The marker receiver is a TRF fixed tuned at 75 Mc/s. The detected signal of keyed tones is amplified and fed through two output circuits for aural and visual presentation. The aural channel includes a mixer in which the marker signals are introduced into the audio output circuit of the localizer receiver. For visual presentation the audio is rectified, and, after amplification, DC pulses representing the marker keying operate a blinker lamp through a relay.

Test equipment

36. Several items of test equipment are supplied exclusively for the purpose of servicing ILS airborne equipment. They are:—

(1) Test set Type 391

(2) Test rig (installation) Type 5

(3) Signal generator Type 69.

Test set Type 391

37. First line servicing requirements are satisfied by the test set Type 391 which is used for tests of ILS installations in the aircraft. The test set includes a signal generator (test oscillator Type 9), output control devices and extension connectors on a reel. A 24V DC power supply is required. In a normal set-up the test set and accumulators providing the operating power will be mounted on a trolley.

38. Signals at localizer, glidepath, and marker frequencies are provided by the test oscillator; they may be radiated directly from built-in aerials for tests of the installation including receiving aerials, or fed through the extension connectors for checking the receivers only. The order of modulation of the signals can be controlled to simulate actual beacon transmissions and permit the indicator circuits to be set up.

Test rig (installation) Type 5

39. For second and third lines of servicing a bench assembly is provided in the test installation Type 5. Mountings to carry receivers, control unit, and indicator are fitted in a case, together with items of test equipment, junction boxes and connectors. The case is opened on the bench and an equipment to be tested is fitted into the mountings. A 24V DC power supply is required.

40. Connectors supplied with the installation allow the sub-assemblies in the receiver units to be operated separately on the bench. The test equipment includes meters which are used for checking the power supply and the deflection sensitivity of the indicators, and a mixer unit Type 20 which is used to extend the range of the signal generator Type 62 to cover glidepath and marker frequencies.

Signal generators

41. Test signals at second and third lines of servicing are provided from a rack-mounted assembly of two signal generators and their separate power units. A signal generator Type 62 provides the VHF signals and a signal generator Type 69 provides the tone modulation. The signal generator Type 62 is a general purpose instrument, but the Type 69 is designed specifically for ILS use.

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Receivers R.1964A and R.1965A

42. Receivers Types R.1964A and R.1965A differ from the receivers R.1964 and R.1965 only by the embodiment of modifications Nos. 3488/2 and 3489/2 respectively. These modifications provide an extension of the internally developed a.g.c. voltages from the receivers to certain airborne calibration equipment. No actual circuit change is involved and the general appearance of the modified receivers is as shown in fig. 1.

Receivers R.1964B and R.1965B

43. These receivers are electrically identical with the receivers R.1964 and R.1965 but a different rotary transformer is used to make the "B" versions suitable for vertical mounting in certain aircraft. The l.f. units of the "B" versions differ only in the identification markings on the receiver front panels. In appearance the R.1964B and R.1965B are similar to the R.1964 and R.1965 shown in fig. 1.

Composition of ILS receivers

44. The composition of the various airborne receivers is as follows:—

(1) Receiver R.1964 (10D/17818)
- (a) L.F. unit Type 4 (10D/17822)
- (b) Receiver unit Type 117 (10P/13184)
- (c) Receiver unit Type 118 (10P/13185)
- (d) Power unit Type 797 (10K/16691)

(2) Receiver R.1965 (10D/17819)
- ◀ (a) L.F. unit Type 5 (10D/17824) ▶
- (b) Receiver unit Type 119 (10P/13186)
- (c) R.F. unit Type 74 (10D/17823)
- (d) Power unit Type 797 (10K/16691)

(3) Receiver R.1964A (10D/19903)
- (a) L.F. unit Type 4 (10D/17822) modified
- ◀ (b) Receiver unit Type 117 (10P/13184) modified ▶
- (c) Receiver unit Type 118 (10P/13185)
- (d) Power unit Type 797 (10K/16691)

(4) Receiver R.1965A (10D/19904)
- ◀ (a) L.F. unit Type 5 (10D/17824) modified ▶
- (b) Receiver unit Type 119 (10P/13186) modified
- (c) R.F. unit Type 74 (10D/17823)
- (d) Power unit Type 797 (10K/16691)

(5) Receiver R.1964B (10D/21517)
- (a) L.F. unit Type 4A (10D/21528)
- (b) Receiver unit Type 117 (10P/13184)
- (c) Receiver unit Type 118 (10P/13185)
- (d) Power unit Type 11953 (10K/20718)

(6) Receiver R.1965B (10D/21518)
- (a) L.F. unit Type 5A (10D/21529)
- (b) Receiver unit Type 119 (10P/13186)
- (c) R.F. unit Type 74 (10D/17823)
- (d) Power unit Type 11953 (10K/20718)

◀ Boxes, junction Type 157A, 158A and 159A

45. These junction boxes differ from the types 157, 158 and 159 respectively, mainly by the embodiment of modification No. 5977. Circuits are given Part 3, Chap. 4, Fig. 5. This modification provides electrical damping on the indicator outputs by the use of 6 capacitors (750μF each) in series-parallel (3 in parallel, in series with another 3 in parallel) connected by their positive terminals across the indicator output terminals 6P2/A and 6P2/B in the case of box, junction Type 158A (10D/23722) and terminals 11P1/C and 11P1/D for box, junction Type 159A (10D/23723). A total of 12 capacitors consisting of 2 sets of 6, each set being connected in the manner described above, is connected across a pair of output terminals, either 12P7/A and B or 12P7/C and D in the combined junction box, junction Type 157A, (10D/23721).

Two of the above units, namely, boxes, junction Type 157A and Type 158A have been further modified by the embodiment of modification No. 6451, the purpose of which is to provide an input plug to carry power supplies for the lighting of the Plasteck type illuminated front panel of the control unit Type 705A.
Circuit diagram Fig. 5, Vol. 1, Part 3 Chap. 4, refers.

Control Unit Type 705A (10L/16749)

46. This unit was introduced by Draft Informatory Leaflet Mod. No. 5505 and has since been manufactured. Apart from the addition of 2 pairs of lamps to illuminate the new Plasteck type front panel which is incorporated, the unit is the same electrically as the control unit Type 705. The diagonally opposite lamps constitute a pair and each pair is separately fed.
Circuit diagram Fig. 3A, Vol. 1, Part 3, Chap. 4, refers.

Control, receiver Type M30 (10L/16834)

47. On Lightning aircraft Marks 1, 1A, 2 and 4, the control units Type 705 (10L/263) have been converted by Mod. No. 5945, to control, receiver Type M30 by changing the cap which is fitted to the power warning lamp, to an optical dimming type. The lamp is dimmed by turning the cap. ▶