B.R. 575(2)A

AUDIO FREQUENCY EQUIPMENT

A.F.100 SERIES

BROADCAST SYSTEMS

THE 50-WATT AMPLIFIER

A.P. 12647*1*

1953

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Director of Electrical Engineering
ADMIRALTY, S.W. 1

A

CHANGES

~~AMENDMENTS~~

~~Amendment~~ No. CHANGES	A.F.O. " P " No.	Date of insertion in this copy	Initials
1	203/62	14-3-66	
2	RNBAS P42/68	15-1-69.	
3	RNBAS P365/69	3-4-70	J. Daly.
4	RNBAS P 1226/70	2-2-71	

Admiralty, S.W. 1

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B.R. 575(2)A, *Audio Frequency Equipment—A.F.* 100 *series, Broadcast Systems, The* 50 *watt Amplifier*, A.P. 12647, 1952, having been approved by My Lords Commissioners of the Admiralty, is hereby promulgated for information and guidance.

This pamphlet should be inserted in B.R. 575, guard cover for this series. Attention is directed to the notice printed below.

By Command of Their Lordships,

J. S. Long

To Flag Officers and Commanding Officers of H.M. Ships and Vessels concerned.

Suggestions for improvement of the text or illustrations which can be incorporated by way of amendment or in any future revision of the book, will be welcomed and will receive careful consideration; they should be forwarded to the Secretary of the Admiralty through the usual channels.

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At end of Text

Figure 1. 50 watt Amplifier, A.P. 12647. Circuit diagram
Figure 2. 50 watt Amplifier, A.P. 12647. Arrangement drawing (structural details)
Figure 3. 50 watt Amplifier, A.P. 12647. Pictorial wiring diagram

FIGURE 1. 50 WATT AMPLIFIER PAT. 0528/12647. CIRCUIT DIAGRAM.

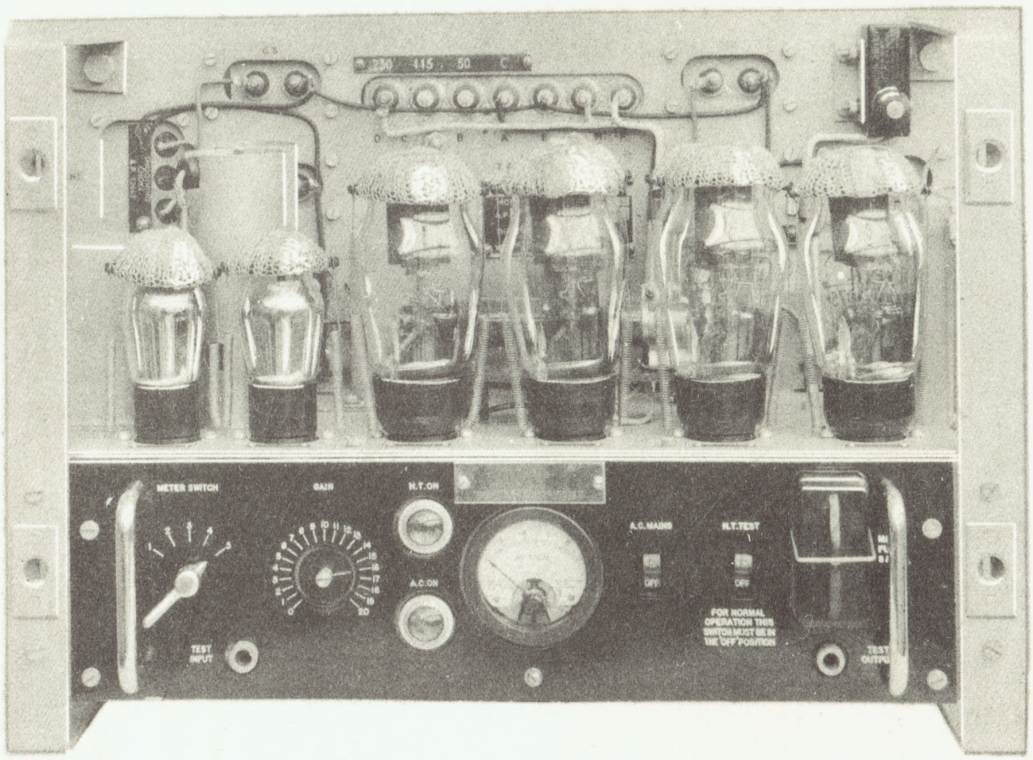


PLATE I. 50 WATT AMPLIFIER. A.P.12647/
GENERAL VIEW. COVER REMOVED

SAFETY WARNING

1. The voltages employed in the amplifier are sufficiently high to endanger human life. Every reasonable precaution has been taken in the design to safeguard the operating personnel. All the bare terminations of the amplifier are protected by the main cover, the removal of which opens a safety switch in the A.C. power supply, thereby cutting off power from all exposed parts except those on the control plug and socket. Power should be completely cut off before changing valves or making any internal adjustments.

2. Certain tests which at times need to be made in connection with repair or maintenance work require that the amplifier should be energised when the protective cover is removed and the safety switch therefore open. This necessitates the temporary closing of the safety switch by other means. Work under these conditions is to be undertaken only by personnel who are fully aware of the dangerous conditions and who also have taken adequate steps to avoid direct contact with high voltages.

INTRODUCTION

3. The 50 watt audio amplifier A.P. 12647 is the second largest in the range of amplifiers in four sizes of the A.F.100 series equipment. It is used in broadcast and intercom systems where output power is required in excess of 16 watts, but which does not justify the use of a 300 watt amplifier. The amplifier can be used singly or, two or three with paralleled inputs may share a load provided that the outputs are kept electrically separate.

4. The amplifier is designed to operate from any one of four different types of input device as is explained later. The output will supply audio power to a group of loudspeakers or, alternatively, will act as an input signal for one or more 300 watt amplifiers.

5. The structural design is such as to make the unit suitable for accommodation in a standard rack or for housing in a bulkhead mounting. Its weight is 98 pounds. Dimensions:—height 12¼ inches, depth (back to front) 17 inches, width overall 19 inches.

CIRCUIT DESCRIPTION

(*Figure* 1)

6. The amplifier circuit comprises three stages, namely, voltage amplification, driver, and output.

Power Supply

7. Power is from the C.W.S. or other source, usually at 230V, 50 cycles, single phase. An alternative supply is provided. The H.T. and heater transformers have primary windings with tappings which makes a supply at 115V or 50V also acceptable. The supply frequency is nominally 50 cycles but variations from this figure between the limits of 45 c.p.s. and 65 c.p.s. will have no appreciable adverse effect provided that the supply voltage is maintained.

8. One pole of the incoming A.C. supply is taken through a safety switch SW4 which opens the circuit by spring action when the amplifier front cover is removed, thus ensuring that all H.T. and heater circuits are dead under these circumstances. Before closing this switch by extraneous means for any purpose the safety warning on this page should be read.

H.T. Supplies

9. The H.T. supply is rectified by two C.V. 1071 valves, V9 and V10, in parallel bi-phase operation, fed from the H.T. transformer TR5. The rectified H.T. supply is smoothed by the choke L2 and the capacitors C11 and C12. Additional smoothing and de-coupling is provided in the H.T. for the first two stages by the choke L1, the resistors R9 and R38 and the capacitors C5 and C6. A 6-volt H.T. pilot lamp is fed by a pilot winding on the transformer TR5.

Heater Supplies

10. The heater transformer TR4 supplies power for:—

(*a*) Heaters of rectifying valves at 5 volts.

(*b*) Heaters of other valves at 6·3 volts.

(*c*) A 6-volt pilot lamp (LP2).

(*d*) Rectified current for the operation of the relay $\frac{H}{2}$ at 50 (nominal) volts.

Cathode Bias

11. Automatic cathode bias is provided in the valves of all three stages, the resistors being R4 for stage one, V1 and V2; R11 for stage two, V3 and V4; R25 for V5 and V7, and R28 for V6 and V8, of stage three. The value of the cathode bias in the valves of each stage is given in Appendix 2, in the table of voltage readings.

Input

12. The amplifier is designed for operation by an input from any one of the following:—

(*a*) An 8 ohms impedance group of paralleled microphones.

(*b*) A microphone of 25 ohms impedance or the output of the alarm unit.

(*c*) A gramophone pick up or similar source, for example, a broadcast receiver or a tape type recorder.

(*d*) A high impedance source.

13. An input transformer TR1 has two windings, and a loading resistor R3 which is connected across the terminals of the primary. The primary winding is tapped to permit the acceptance of an input from the lower impedance source. Details of the transformer windings are given in Appendix 1.

14. The normal input when the amplifier is in use in an A.F.100 series system, is from a single microphone having an impedance of 25 ohms. This input is connected across the whole of the primary winding of

the input transformer, which under these circumstances has a step up turns ratio of 1 : 40.

15. When the input is from the alarm unit it enters by the same connections and is applied to the input transformer in the same manner as an input from a 25 ohms impedance microphone.

16. An input test jack (TJI) is provided and connected across the terminals of the primary winding for the reception of a test input signal from a portable 25 ohms impedance microphone.

17. The input from paralleled microphones having an impedance of 8 ohms is connected to the tappings of the primary winding, and under these input conditions the transformer has a step up turns ratio of 1 : 70.

18. The stepped up microphone voltage variations from the secondary of TR1 are applied to the control grids of the first stage valves.

19. The input from a gramophone or similar source is connected to the control grids of the valves of the second stage, the input transformer and the first stage valves being by-passed. The connection to the valve grids is made through the gain control RV1, enabling adjustment to be made to the strength of the applied input signal. The gain control is described further in paragraph 26.

20. When the input is from a high impedance source it is applied direct to the control grids of the valves of the first stage, the input transformer in this case being by-passed.

The First Stage

21. The two valves of the first stage, V1 and V2, are C.V. 1056 connected in parallel. The output from this stage is resistance capacity coupled by R6 and C3 to the second or driver stage, the input circuit being completed through the gain control potentiometer RV1.

The Second Stage

22. The second stage comprises valves V3 and V4, which are C.V. 1067, also connected in parallel. The output from this stage is transformer coupled to the output stage by a 1 ; 1½ + 1½ phase splitting transformer TR2.

23. Transformer TR2 has four windings, two of them being in series to make up the primary. Loading resistors R14 and R15 are connected across the secondary windings. Details of the windings are given in Appendix 1.

The Output Stage

24. The output stage comprises four valves C.V. 1075 (V5, V7; V6, V8), arranged in parallel push-pull class A.B.1. This stage employs negative feed back; approximately 10 per cent. of the amplified voltage variations from C7, R12 and R18 being applied to the input of valves V5/7 via TR2 and R17/R24, and from C8, R13 and R19 to valves V6/8 via TR2 and R16/R29.

The Output Transformer

25. This transformer, TR3, couples the output of the third stage to the loudspeaker or other load. It has five windings. Two of these form the halves of the split primary, each half being connected to one parallel pair of the output valves. The three secondary windings provide:—

(*a*) G–H. An output at 180 (nominal) volts for connection as an input to a 300 watt amplifier.

(*b*) F–D. An output at 31·6 (nominal) volts for direct connection to a loudspeaker load line.

(*c*) K–J. A supply for the meter registering the amplifier output.

Gain Control

26. Output level or overall gain is controlled by the potentiometer RV1 between the first and second stages. The potentiometer is of the rotary switch arm type. Adjustment is made by a screwdriver blade in a slot at the end of a stainless steel spindle which projects through a hole in the amplifier escutcheon plate. A scale around the spindle is graduated 0–20. The switch arm makes contact on studs disposed 13½ degrees apart over an arc of 270 degrees, the stud positions being located by detent action.

The Meter

27. The meter M1 is a milliammeter connected through the meter switch SW1. The instrument resistance is 100 ohms and one milliampere through it gives full scale deflection. The scale is graduated 0 to 10 in equal divisions, figure marking being by even numbered figures only. Each division is graduated in five equal subdivisions. The meter is mounted centrally on the front panel and its selector switch placed at the extreme left.

28. The meter and its switch enables:—

(*a*) The cathode currents of pairs of parallel valves in each stage to be measured in milliamperes.

(*b*) The amplifier output to be measured in terms of volts.

Note that in the push-pull stage, the two valves of which the cathode currents are measured collectively are valves which are in parallel, and not two which are normally considered to be a " pair ".

29. A feature of the amplifier being that no one valve works singly, normal meter readings indicate the cathode current of two valves collectively. By regular metering as laid down in the maintenance routines and comparison of the readings with those known to be normal it may be possible, especially in the output stage, to detect the failure of one valve of a pair before such an event becomes evident by other symptoms.

30. Cathode currents are metered by connecting the meter by means of the meter switch across a low value resistor inserted in the cathode circuit for metering purposes. The values chosen for the meter shunts, and

for the meter scale reading, are such as to cause the meter to read direct in milliamperes for the first two stages, and to read a value equal to 1/50th in the output stage; thus the reading 2·5 in switch positions 3 and 4 represents 2·5 × 50 = 125 milliamperes. The switch positions and the valves connected to each are:—

SWITCH POSITION	VALVES
1 . .	V1 and V2 combined.
2 . .	V3 and V4 combined.
3 . .	V6 and V8 combined.
4 . .	V5 and V7 combined.

Position 5 of the switch connects the meter for measurement of the amplifier output. The readings for each switch position which should be considered as normal are given in Appendix 2.

31. The output of the amplifier is metered by means of a meter winding on the output transformer TR3. A network comprising crystal rectifiers MR2 and MR3, with high value resistors R36 and R37, is in the output meter circuit. The resistor values are such that when the amplifier full output of 31·6 volts is reached the meter pointer registers 3·16, *i.e.*, a multiplying factor of 10 must be applied to the reading to ascertain the actual output voltage. A red line is inscribed on the meter dial at 3·16.

Controls (*Plate* 1)

32. The controls are mounted on the front panel and escutcheon plate. The lettered statement below shows their order when viewed from the front, left to right and from top to bottom. The condition or position in which each control should be for normal working is shewn opposite each.

CONTROL	NORMAL CONDITION OR POSITION
(*a*) Meter switch (SW1) .	Position 5.
(*b*) Microphone input test jack (TJI) . . .	Vacant.
(*c*) Gain control adjustment	As found by experience to be best.
(*d*) "H.T. on" pilot lamp (LP1)	Amplifier not in use—not glowing. Amplifier in use—alight.
(*e*) "A.C. on" pilot lamp (LP2)	Alight.
(*f*) Meter (M1) . . .	Amplifier not in use—pointer on zero; in use—registering output.
(*g*) A.C. supply switch (SW3)	To "on".
(*h*) H.T. test switch (SW2) .	To "off".
(*j*) Fuses (FS1, FS2) . .	In place.
(*k*) Output test jack (TJO)	Vacant.

Cable Connections

33. Three multi-pin type plugs and sockets, PLI and SKI, PLO and SKO and PLC and SKC, are employed for making all the connections to the amplifier. PLI and SKI connect the input cables, PLO and SKO the output connections, and PLC with SKC the control wiring and power supply. The connections to both plugs and sockets are shewn in Figure 1. It will be noticed that all the "live" cable terminals such as the A.C. supply leads are connected to the sockets so that they shall be shrouded when disconnected.

H.T. and Heater Current Switching

34. When the amplifier is ready for use, with the A.C. switch SW3 closed, the valve cathodes are heated and maintained at emission temperature. All that is now required to bring the amplifier into action is the closing of the supply to the transformer TR5 and the application of an input signal. For test purposes the H.T. can be switched on by closing the H.T. test switch SW2, but for normal use the supply to TR5 is closed by the contacts H1 and H2 by the operation of the relay H/2. The only action required for this relay energisation is to connect the outgoing line 8 from the control socket to the line 3 of the same socket. The Bc. or other system to which the amplifier is connected has switching arranged so that the relay operates when any "press to speak" switch is closed or one of the alarm or warning pushes is pressed.

34A

35. Use of Patt. F20/12647A Amplifier. Where amplifier A.P. F20/12647A is used in lieu of A.P. F20/12647 and an external pilot lamp is connected, a change in the external wiring becomes necessary. The external pilot lamp connection of the new panel is wired to tags JC4 and JC7 and when replacing an A.P. F20/12647 panel an extra wire will need to be run from the new tag JC7 to a spare terminal on the rack A.P. F1C/12643 or F1C/12644, or bulkhead mounting A.P. F1C/12646.

(Change No. 1.)

Table 1. List of Circuit Components and their Functions

Capacitors

C1	Cathode bias by-pass capacitor for valves V1 and V2.
C2	Screen grid de-coupling capacitor for valves V1 and V2.
C3	Coupling capacitor, valves V1 and V2 to valves V3 and V4.
C4	Cathode bias by-pass capacitor for valves V3 and V4.
C5	H.T. de-coupling capacitor, valves V3 and V4.
C6	H.T. de-coupling capacitor, valves V1 and V2.
C7	Blocking capacitor for feed back circuit, valves V5 and V7.
C8	Blocking capacitor for feed back circuit, valves V6 and V8.
C9	Cathode bias by-pass capacitor for valves V5 and V7.
C10	Cathode bias by-pass capacitor for valves V6 and V8.
C11	H.T. smoothing capacitor.
C12	H.T. smoothing capacitor.
C13	Screen grid de-coupling capacitor for output stage valves.

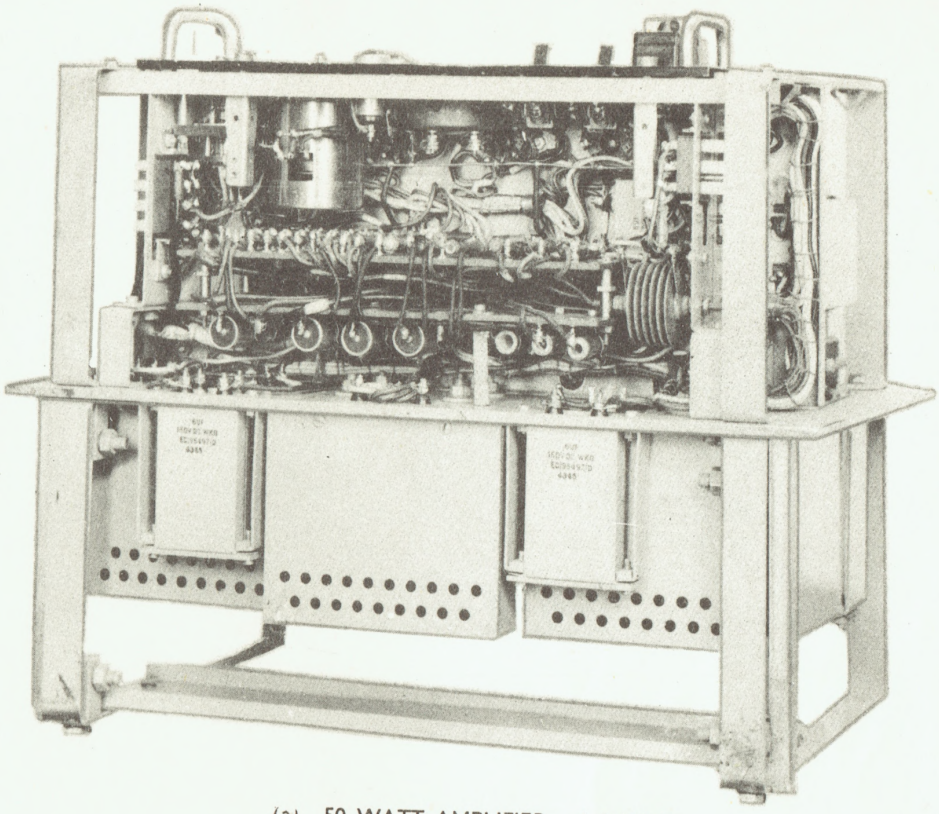
Resistors

*R1	Steadying or smoothing resistor for the operation of relay H/2.
†R2	De-coupling resistor. Amplifiers working with inputs paralleled.
R3	Input transformer primary loading resistor.
R4	Cathode bias resistor for valves V1 and V2.
R5	Cathode current meter shunt resistor, valves V1 and V2.
R6	Anode load resistor for valves V1 and V2.
R7	Screen grid de-coupling resistor for valves V1 and V2.
R8	
R9	De-coupling resistor, first and second stages.
R10	Cathode current meter shunt resistor, valves V3 and V4.
R11	Cathode bias resistor, valves V3 and V4.
R12	With R18 forms a potential divider for feed back circuit for valves V5 and V7.
R13	As for R12, but with R19 for valves V6 and V8.
R14 & R15	Secondary loading resistors for coupling transformer TR.2.
R16	Anti-parasitic or grid stopper resistor for valve V6.
R17	Anti-parasitic or grid stopper resistor for valve V5.
R18	With R12 forms a potential divider for feed back circuit for valves V5 and V7.
R19	As for R18 but with R13 for valves V6 and V8.
R20	Anti-parasitic or anode stopper resistor for valve V5.
R21	Anti-parasitic or anode stopper resistor for valve V6.
R22	Anti-parasitic or screen stopper resistor for valve V5.
R23	Anti-parasitic or screen stopper resistor for valve V6.
R24	Anti-parasitic or grid stopper resistor for valve V7.
R25	Cathode bias resistor for valves V5 and V7.
R26	Cathode current meter shunt resistor, valves V5 and V7.
R27	Cathode current meter shunt resistor, valves V6 and V8.
R28	Cathode bias resistor for valves V6 and V8.
R29	Anti-parasitic or grid stopper resistor for valve V8.
R30	Anti-parasitic or anode stopper resistor for valve V7.
R31	Anti-parasitic or anode stopper resistor for valve V8.
R32	Anti-parasitic or screen stopper resistor for valve V7.
R33	Anti-parasitic or screen stopper resistor for valve V8.
R34 & R35	Screen grid potential divider for output stage valves.
R36	Meter current limiting resistor, output load.
R37	Meter current limiting resistor, output load.
R38	Anode supply de-coupling resistor for valves V1 and V2.
RV1	Gain control potentiometer, grid resistor, valves V3 and V4.

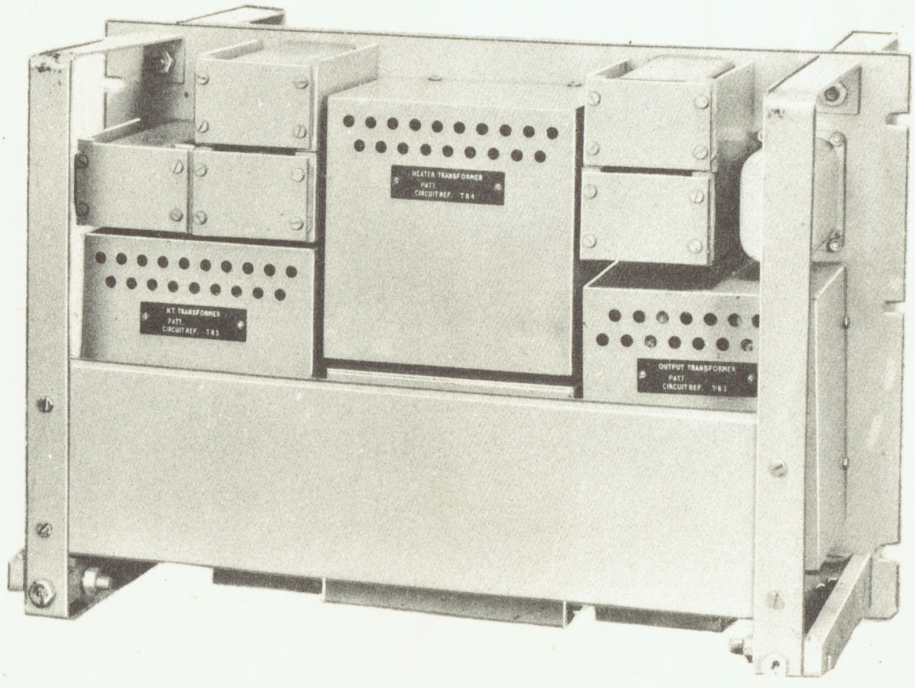
Miscellaneous

LP1	H.T. " on " pilot lamp.
LP2	A.C. " on " pilot lamp.
PLI	Input plug 8 way.
PLO	Output plug 6 way.
PLC	Control plug 10 way.
TJI	Input test jack.
TJO	Output test jack.
SW1	Meter selector switch, 5 position.
SW2	H.T. test switch.
SW3	A.C. " on " switch.
SW4	Cover safety switch.
MR1	Rectifier for relay operating current.
MR2	Rectifier for output meter current.
MR3	Rectifier for output meter current.
H/2	H.T. supply relay.
FS1	Fuse, 5 amp.
FS2	Fuse, 5 amp.
TR1	Input transformer.
TR2	Intervalve coupling and phase inverting transformer.
TR3	Output transformer.
TR4	Heater circuit supply transformer.
TR5	H.T. supply transformer.
M1	Milliammeter.
L1	Smoothing choke.
L2	Input choke.

* Fitted only in earlier amplifiers of the series.
† R2 is not fitted in the earlier amplifiers of the series. should be fitted if found to be necessary.



(a) 50 WATT AMPLIFIER. A.P.12647
UNDER DECK VIEW



(b) 50 WATT AMPLIFIER. A.P.12647
REAR VIEW

PLATE 2.

MAINTENANCE

35. Attention is drawn to the safety warning given on page 1 of this book.

Ready Use Maintenance Box (A.P. 12685)

36. Certain portable testing apparatus and maintenance stores are provided for the testing of and maintenance work on the amplifier. The Ready Use Maintenance Box A.P. 12685 provides portable stowage for the gear and for the appropriate handbook. The gear is listed and described in book (2)E of this series and includes for this amplifier:—

(*a*) Portable test microphone.
(*b*) Headset.
(*c*) Test load for amplifier.
(*d*) Fuses.
(*e*) Fuse wire.
(*f*) Valves and pilot lamps.

General Maintenance

37. The maintenance of the amplifier in good working order is very largely dependent upon frequent inspections and a constant and alert watch for incipient defects. A series of maintenance routine inspections and examinations, given in paragraphs 49–50 will ensure as far as is possible that minor defects cannot develop into major breakdowns.

38. The maintenance items which require periodical attention may be grouped into three classes, viz.:—

(*a*) Those which may be attended to without interference with the normal working of the amplifier:—
(i) Meter the valve cathode currents.
(ii) Meter the output and if necessary adjust the gain control.
(iii) See that the pilot lamps are working correctly.
(iv) Listen carefully to the output in order to detect excessive hum or output distortion in its early stages.
(v) Make a visible inspection of the valves from the outside to ensure that the power stage valve anodes are not running too hot. (A dull red is permissible in certain types.)

(*b*) Those for which the amplifier must temporarily be put out of use:—
(i) Renewal or exchange of valves.
(ii) Removal of dust from the terminals and surfaces generally in the valve compartment.
(iii) Audio tests such as that detailed in paragraph 54.

(*c*) Those for which the amplifier must be removed from its rack:—
(i) Inspect for visible signs of overheating of any component.
(ii) Cleaning and adjustment of switch contacts.
(iii) Cleaning and adjustment of relay contacts (*see paragraph* 47).
(iv) Renewal of components.
(v) Removal of accumulated dust from the interior.
(vi) Testing for location of defects.

39. Each amplifier should have a complete examination and test yearly.

40. Where several amplifiers of one pattern are fitted in any one ship it is inevitable that some should get more work than others. Each amplifier has a serial number shewn on its identity plate, and an outline history of its employment should be recorded.

Valves

41. Factors which contribute to the shortening of valve life are (*a*) vibration, (*b*) shock, (*c*) overruning of the heaters and, (*d*) (most important of all) the application of an input signal with the H.T. switched on when the output is open circuited or short circuited. Vibration and shock should not be serious unless local conditions are abnormal or some mounting component is defective. Heater overrunning is unlikely if the supply voltage does not vary greatly from its specified value. The effect named at (*d*) *must* be guarded against by making a rule always to disconnect the connection SKC before breaking the SKO connection.

Metering of Valve Cathode Currents (paragraphs reference 27-31)

42. Meter readings can be taken without interference with the normal operation of the amplifier. If the amplifier is in use the fact will be indicated by glowing of the " H.T. on " lamp during the test. Under these conditions the cathode currents may vary slightly from those of the static condition. If the cathode current of any stage is noticeably below normal the cause may be either the failure of one valve and the overloading of the other or, deterioration of both valves; which is the case can be determined by the process of substitution. If the meter readings generally are either above or below normal the fault is almost certainly due to variation in the voltage of the power supply. When any valve has been exchanged, or removed and replaced, time should be allowed for it to reach emission temperature and the cathode current then metered to ensure correct replacement.

Gain Control Adjustment and Metering of Output

43. The output does not necessarily require to be the full line voltage of 31·6 volts. Adjustment of the gain control should be made by listening to the output, and the setting made as found by experience to be best.

Cleanliness. Dust

44. The accumulation of dust leads to unsatisfactory working and it must be removed at frequent intervals. The areas most likely to be affected by dust are the transformer terminals and the surfaces generally in the valve compartment. These should be dusted at least monthly and more often if found to be necessary. Dusting of the space named can be done without removing the amplifier from the rack. The most effective methods are by suction cleaner, blowing and the use of a small stiff bristle brush lightly applied. Relay covers must not be removed during this dusting

work. The protecting covers or screens of individual components should be replaced immediately upon the completion of the work for which they were removed.

Ventilation

45. The design of the framework, racks, and covers of rack units has taken into account the need for a flow of air around the valves, resistors, chokes and transformers. Nothing should be allowed to impede the normal ventilation, either of the racks and their contents, or of the compartments in which they are situated.

Switch Contacts

46. Contacts of *switches* can be cleaned when necessary with "Solution, switch, cleaning and lubricating", A.P. 55945. The solution should be applied sparingly by means of a "dropper". A thin film of lubricant remains on the switch contacts after each application; any accumulation of dirty lubricant should be cleaned away during the annual examination and test of the amplifier.

Relay Contacts

47. Relay contacts should be treated with the greatest discretion. On no account should they be touched so long as they are working correctly. Special tools are available for adjustments of relay springs and contacts. Relay contacts should always remain dry and never be lubricated. The exclusion of dust from the relays is of the first importance. Further information on relays can be obtained from book (2)G of this series.

Maintenance Routines

RECORDED ROUTINES	PARAGRAPH REFERENCE
48. *Monthly.* All amplifiers.	
(*a*) Remove all accumulated dust from the the valve compartment	44
(*b*) Examine and if necessary clean switch contacts	46
49. *Annually.* All amplifiers.	
(*a*) Carry out a complete examination and test of the amplifier in the workshop	56–59 and App. 2
(*b*) Obtain test figures from all the lettered test points and compare with those given in App. 2	
NON-RECORDED ROUTINES	
50. *Occasional.* As frequently as convenient and as found necessary:—	
(*a*) Amplifiers in constant use:—	
(i) External visual inspection, looking particularly for overheating, ventilation obstruction and pilot lamps working.	
(ii) Meter the cathode currents of the valves of each stage	42
(iii) Meter the output and if necessary adjust the gain control	43
(iv) Listen carefully to the output for the detection of excessive hum or distortion.	
(*b*) Amplifiers not in constant or regular use:—	
(i) As for (*a*) (i) to (iv) as far as is applicable	31 (a)
(ii) If and when practicable, a complete audio test using the microphones and loudspeakers of the connected system.	
(iii) Alternative to (ii). Test the amplifier by means of the testing gear from the maintenance box, that is, the microphone plugged into TJI, the test output load connected to PLO, and the headset plugged into TJO.	

Fault Location

51. The internal wiring of the amplifier should never be altered in an attempt to locate a fault. The fact that it has worked satisfactorily is proof that the wiring scheme is correct. Broken or dry joints are the only defects likely to be found in the wiring.

52. Bear in mind the possibility of the existence of two or more defects which may give rise to misleading symptoms and lead to a mistaken diagnosis.

53. In order to safeguard the valves from damage due to possible excessive voltage in the output stage, the H.T. test switch should not be put to "on" for any test unless and until either the normal load or the test load is connected to the output of the amplifier. Excessive peak voltage may be expected in the output stage if an input signal is applied with the H.T. on and the output open circuited.

TESTING FOR FAULTS WITH THE AMPLIFIER IN PLACE

54. See that the earth connections are good and the power supply pilot lamps glowing. To make sure that the fault lies in the amplifier and not in some connected component or cable proceed as follows:—

(*a*) Disconnect the input socket SKI.

(*b*) Plug the portable testing microphone into TJI.

(*c*) Plug a headset, portable loudspeaker or Avometer set to the appropriate range into TJO.

(*d*) Set the meter selector switch SW1 to position 5.

(*e*) Close the H.T. test switch.

Speech into the microphone will now enable the output to be:—

(*f*) Indicated by the meter.

(*g*) Heard in the plugged in headset or loudspeaker, or indicated by the Avometer.

It must be remembered that under these conditions all speech into the test microphone will be broadcast over the connected loudspeakers.

55. If this method does not give satisfactory reproduction of speech the fault may still lie outside the amplifier in the output circuit. Open the H.T. test switch, disconnect the socket SKO and connect the test output load in its place. Close the H.T. test switch, repeat the test and observe the results. If still not satisfactory the fault lies in the amplifier or in the testing apparatus. Check the condition of the testing apparatus by testing it in an amplifier known to be in working order; if satisfactory the suspected amplifier is at fault and must be removed to the workshop for further examination.

Tests of the Amplifier in a Workshop

56. When preparing to carry out the tests bear in mind the safety warning given on page 1. When testing for high voltage readings, particular attention must be paid to the insulation conditions of the testing apparatus, especially the insulation of flexible test leads and prods. In most cases it will be advisable to make temporary clip-on connections with the H.T. test switch open, and make the test by switching on.

57. When using an Avometer for voltage readings other than those of the test points, select a range which will give the clearest indication without danger of overloading the instrument.

Amplifier Test Data. (*Appendix 2 and 3*)

58. Appendix 2 gives tables shewing:—

(*a*) Voltage values which should exist at various points in the circuit.

(*b*) Meter readings for the five positions of the meter switch.

(*c*) Total current and power consumption.

(*d*) Transformer terminal voltages.

The voltage values given in Table (*a*) were measured with an Avometer A.P. 47A, and are the averages for a number of amplifiers tested; the readings from a single amplifier may therefore be expected to deviate by small amounts from the values shewn. The differences in the readings which may be expected as normal in the valve circuits are those due to the acceptable manufacturing tolerances allowed in the valves and the resistors or other components. Care must be taken to use the Avometer on the range shewn against each reading, this being the range used to obtain the figures.

Tests

59. The tests which follow (in Table 2) are suggested for testing the amplifier. Where applicable the tests should be made with a headset, a portable loudspeaker, or an Avometer plugged into TJO, with the testing microphone and test output load plugged respectively into TJI and PLO.

Table 2. Amplifier Testing

Abbreviations used in the text:—

OC = Open circuited.
SC = Short circuited.
D = Defective (*e.g.*, Low insulation resistance).

PROCEDURE	POSSIBLE DEFECT	ACTION
(*a*) *No hum or noise*		
(i) See valves and pilot lamps are on.	(i) No supply	Provide.
	(ii) Not switched on	Switch on.
	(iii) Fuses OC	Renew.
	(iv) Valves or lamps not firmly in socket	Refit.
	(v) TR4 D	Renew.
(ii) Check main H.T. voltage (Test point M).	*If zero:*—	
	(i) H/2 (or SW2) not closed	Close.
	(ii) Rectifier valves D	Renew.
	(iii) L2 OC	Renew.
	(iv) TR4 or TR5 D	Renew.
	If low:—	
	(v) Rectifier valves D	Renew.
	(vi) C11 or C12 OC	Renew.
(*b*) *Excessive hum*		
(i) Connect a similar capacitor across C11.	(i) Capacitors may be OC or otherwise D	Renew.
(ii) Replace rectifier valves.	(i) Valve may be working half wave	Renew.
(*c*) *No output signal*		
(i) Check position of gain control.	May be at zero.	Adjust.
(ii) Short the grids of each pair of valves or each stage to earth in turn, starting from the power stage.	Noise and hum will get progressively greater until faulty stage is isolated when no difference will be observed	Check faulty stage.
(iii) Check voltages at all points.	*If no anode volts:*—	
	(i) Anode or decoupling resistors OC	Renew.
	(ii) TR2 or TR3 primary OC	Renew.
	If no bias volts:—	
	(i) Bias or meter shunt resistors OC	Renew.
	(ii) C1, C4, C9, C10 SC	Renew.
	If low anode volts:—	
	(i) Low bias on valve	Correct.
	(ii) C3 SC	Renew.
	If low screen volts:—	
	(i) C2 or C13 D	Renew.
	If low bias volts:—	
	(i) Bias resistor D	Renew.
	(ii) C1, C4, C9, or C10 D	Renew.
(iv) Check TR1 windings for continuity.	May be OC	Renew transformer.
(v) Check TR3 secondary windings for continuity.	May be OC	Renew transformer.
(vi) Check TR2 secondary windings for continuity.	May be OC	Renew transformer.
(*d*) *Output signal distorted*		
(i) Check anode voltage of output valves.	(i) *If low*	Check as in (*a*) (ii).
	(ii) *If high:*— Valve may have low emission	Renew
	(iii) *If unequal in push pull pairs:*—	
	(i) Valves unmatched	Renew in pairs as necessary.
	(ii) Split primary winding of TR3 D	Renew.
(ii) Renew output valves.	Characteristics may be mismatched	—
(iii) Check voltages of other valves.	One may be D	Renew.
(iv) Check all audio frequency transformer windings in turn for inductance, working from output to input.	S.C. turns in windings	Renew.

PROCEDURE	POSSIBLE DEFECT	ACTION
	If no screen volts:—	
	(i) R7, R22, R23, R32, R33 or R34 OC . . .	Renew.
	(ii) C2, C13 or R35 SC . . .	Renew.
(e) *Noise:—*		
Scratching		
Check carbon type resistors (usually in grid circuits).	May be D . .	Renew.
Ringing		
Tap valves, especially in early stages.	Microphonic valves	Renew or prevent vibration in mounting.
Oscillation		
(i) Check earth connection in internal wiring.	Earth connection may be disconnected from capacitor, transformer base, screened wire or circuit wiring	Remake.
(ii) See all valve screens in place.	Screens omitted .	Refit.
Intermittent clicks		
Check:—		
(i) Switch contacts	May be dirty . .	Clean.
(ii) Valve pin sockets.	May be dirty . .	Clean.
(iii) Potentiometer slides.	Stud contacts dirty.	Clean.
(iv) Capacitors	May be D . .	Renew.
Motor boating		
Check anode decoupling capacitors and resistors.	Capacitors may be OC. Resistors may be altered in value .	Renew.

APPENDIX 1

TRANSFORMER AND CHOKE WINDING DATA

Notes on re-winding Transformers and Chokes

1. It is not intended that transformers or chokes should be re-wound in ships except in cases of necessity.

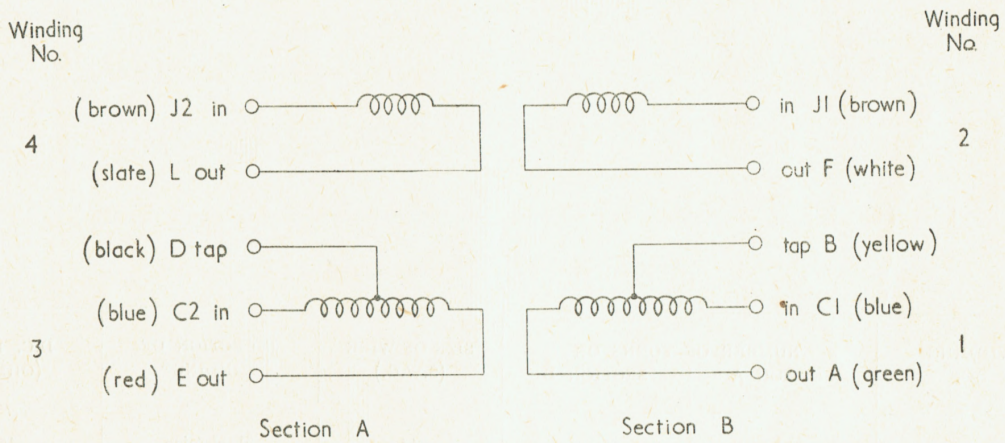
2. In connection with the winding data given in the following pages it is assumed that the defective article will be available for study as to the manner of leading the ends of windings in and out, it being impracticable to give full winding directions in this book.

3. Particular care must be taken when re-winding transformers which have screens, to ensure that any overlap of the single turn is well insulated.

4. Chokes and certain transformers have a spacer of insulating material inserted in the iron circuit, usually in the centre leg. Its purpose is to prevent the D.C. flowing from causing saturation of the iron and therefore to preserve the inductive properties of the choke or transformer under load. In re-winding care must be taken to ensure correct replacement. Details are given in the winding data sheets.

APPENDIX 1

Transformer TR1 A.P. 12659



WINDING NO.	NO. OF TURNS	WIRE SIZE (S.W.G.)	TAPPED AT TURN NO.	DIRECTION OF WINDING*	D.C. RES. (OHMS)
1	20	38	11	clockwise	1·1
2	800	46	—	clockwise	308
3	20	38	11	anti-clockwise	1·1
4	800	46	—	anti-clockwise	308

* Direction of winding. As viewed from the end of the former where the ends of that particular winding are brought out.

Wire insulation. Enamel and single wound silk (natural or artificial) covered.

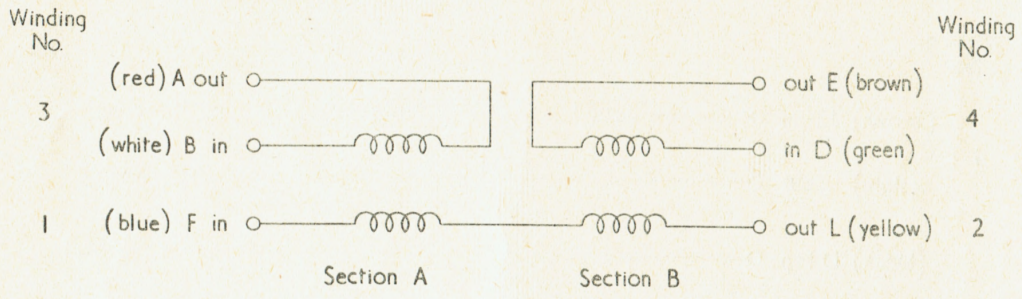
Insulation over each winding. Two turns of unimpregnated natural silk ribbon.

Wire material. Copper.

Inductance of secondary windings (Nos. 2 and 4 in series) 3·8H + 3·8H = 15H total.

APPENDIX 1

Transformer TR2 A.P. 12660



WINDING NO.	NUMBER OF TURNS ON SECTION A	NUMBER OF TURNS ON SECTION B	SIZE OF WIRE (S.W.G.)	DIRECTION OF WINDING*	D.C. RES. (OHMS)
1	2000	—	44	clockwise	452
2	—	2000	44	clockwise	452
3	6000	—	44	clockwise	2000
4	—	6000	44	anti-clockwise	2000

* Direction of winding. As viewed from the end of the former where the ends E, D and L are brought out.

Wire insulation. Enamel and single wound silk (natural or artificial) covered.

Insulation over windings Nos. 1 and 2. Two turns of insulating cloth.

Insulation over windings Nos. 3 and 4. Two turns of natural silk ribbon.

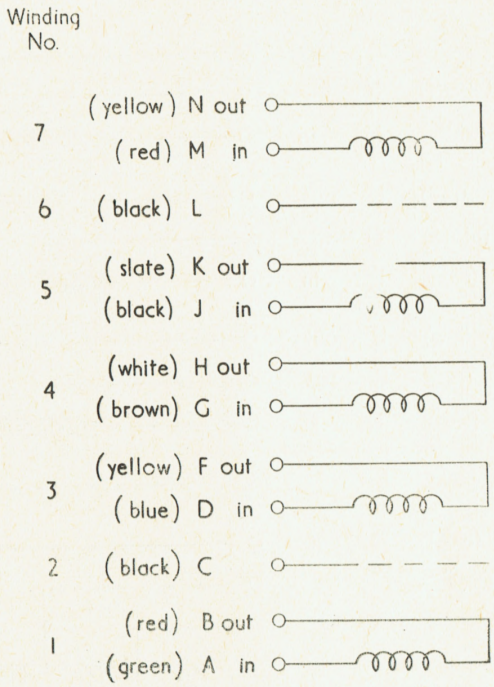
Wire material. Copper.

Iron circuit spacer. Bakelite sheet, 3 mils thick.

Inductance of primary windings (Nos. 1 and 2 in series). 20H at 10 mA.

APPENDIX 1

Transformer TR3 A.P. 12661



WINDING NO.	NO. OF TURNS	SIZE OF WIRE (S.W.G.)	WIRE INSULATION	D.C. RES. (OHMS)
1	863	26	A	12·6
2	1	(— screen		—)
3	120	18	B	0·53
4	715	26	A	16·4
5	120	26	A	3·6
6	1	(— screen		—)
7	863	26	A	21·5

Wire insulation. A. Enamel and single wound silk (natural or artificial) covered.
B. Enamel and D.C. covered.

All windings wound clockwise as viewed from the end of the former where the winding ends are brought out.

Adjacent layers of all windings are separated by one turn of manilla paper, 3 mils. thick.

Insulation over each winding and each screen. Two turns of insulating cloth.

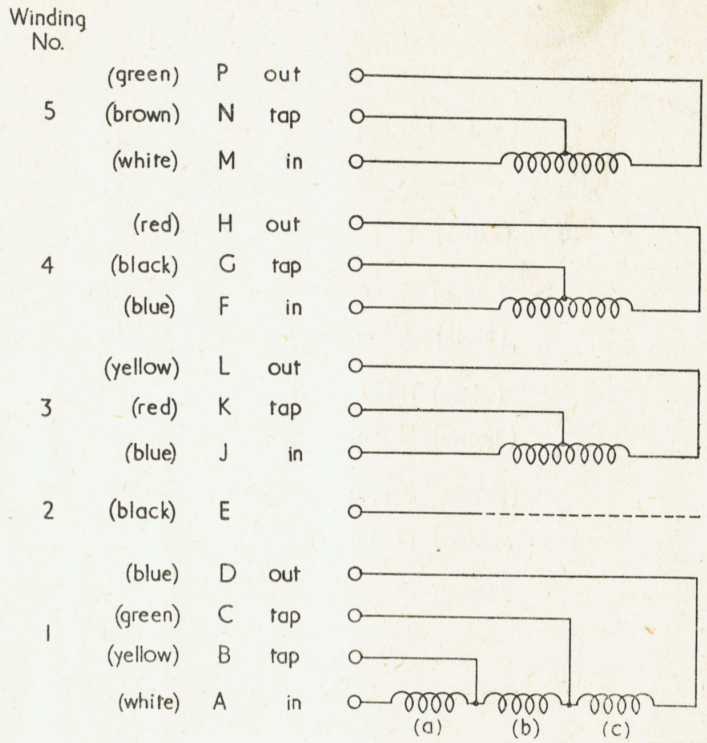
Wire material. Copper.

Screen material. Tinned copper foil, 2 to 3 mils. thick.

Inductance of primary windings (Nos. 1 and 7 in series.) 1·4H + 1·4H = 5·5H total.

APPENDIX 1

Transformer TR4 A.P. 12664

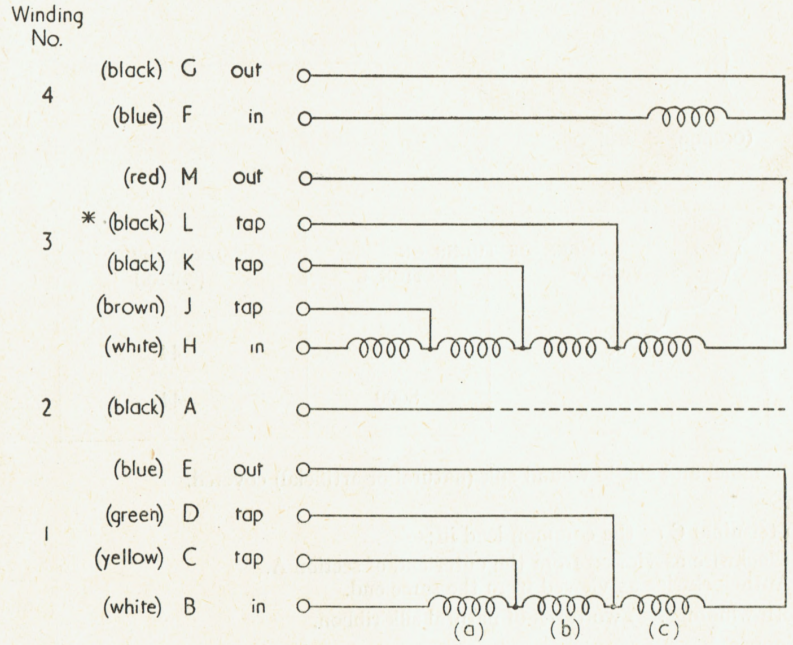


WINDING NO.	NO. OF TURNS	SIZE OF WIRE (S.W.G.)	TAPPED AT TURN NO.	D.C. RES. (OHMS)
1 (*a*)	203	18	—	0·49
(*b*)	234	22	—	2·14
(*c*)	413	24	—	7·3
2	1	(— screen —)		
3	20	14	10	0·04
4	25	14	12·5	0·05
5	193	24	176	0·13

Wire insulation. Enamel covered.
Winding direction. All windings clockwise as viewed from the end of the former where the winding ends are brought out.
Winding No. 1 (*a*), (*b*) and (*c*), and winding No. 5. All adjacent layers separated by one turn of manilla paper, 3 mils. thick.
Insulation over each winding and the screen. Two turns of insulating cloth.
Wire material. Copper.
Screen material. Tinned copper foil, 2 to 3 mils. thick.

APPENDIX 1

Transformer TR5 A.P. 12665



*.—In amplifiers of later serial numbers this tap lead is brown.

WINDING NO.	NO. OF TURNS	SIZE OF WIRE (S.W.G.)	TAPPED AT TURN NO.	D.C. RES. (OHMS)
1 (*a*)	95	16	—	0·27
(*b*)	123	18	—	0·57
(*c*)	219	22	—	4
2	1		(— screen —)	
3	2060	26	560, 1030, 1501	70·7
4	8·5	24	—	0·4

Wire insulation. Enamel covered.

All windings wound clockwise as viewed from the end of the former where the winding ends are brought out.

Insulation over windings:—

Nos. 1 and 4, two turns of insulating cloth.
Nos. 2 and 3, three turns of insulating cloth.

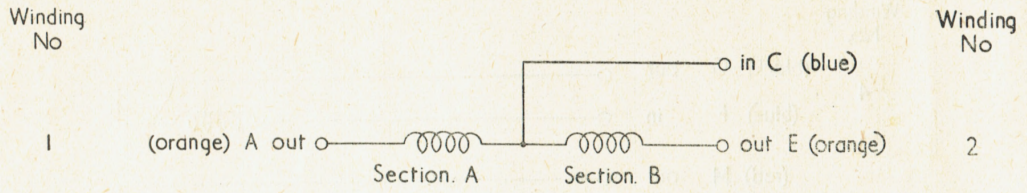
Windings Nos. 1 and 3. All adjacent layers separated by one turn of manilla paper, 3 mils. thick.

Wire material. Copper.

Screen material. Tinned copper foil, 2 to 3 mils. thick.

APPENDIX 1

Choke L1 A.P. 12662



WINDING NO.	NUMBER OF TURNS ON SECTION A	NUMBER OF TURNS ON SECTION B	SIZE OF WIRE (S.W.G.)	D.C. RES. (OHMS)
1	8000	—	44	2300
2	—	8000	44	2300

Wire insulation. Enamel and single wound silk (natural or artificial) covered.

Winding direction:—

Starting from terminal C as the common lead in:—

No. 1. Clockwise as viewed from the outer end of section A.

No. 2. Anti-clockwise as viewed from the same end.

Insulation over both windings. Two turns of natural silk ribbon.

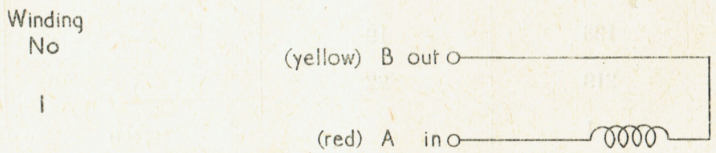
Wire material. Copper.

Iron circuit spacer. Bakelite sheet, 10 mils. thick.

Inductance of windings Nos. 1 and 2 in series. 70H at 10 mA.

APPENDIX 1

Choke L2 A.P. 12663



WINDING NO.	NO. OF TURNS	SIZE OF WIRE (S.W.G.)	D.C. RES. (OHMS)
1	3600	24	56

Wire insulation. Enamel covered.

Adjacent layers separated by one turn of manilla paper, 3 mils. thick.

Insulation over winding. Two turns of insulating cloth.

Wire material. Copper.

Iron circuit spacer. Bakelite sheet, $\frac{1}{16}$th inch thick.

Inductance 5H at 400 mA.

APPENDIX 2

Test Data

(a) **Voltage Readings.** (Paragraph reference 58.) Instrument used—Avometer A.P. 47A. Readings taken between test point and the chassis earth. Dynamic readings taken with the amplifier delivering 50 watts at 1 Kc.

LETTER	TEST POINT	METER READINGS STATIC (VOLTS)	METER READINGS DYNAMIC (VOLTS)	METER RANGE (FULL SCALE DEFLECTION) (VOLTS)	ACCEPTABLE TOLERANCE + OR −
A	Anodes V1 and V2	100	99	1200	†
B	Screens V1 and V2	34	34	1200*	†
C	Cathodes V1 and V2	1·28	1·25	12	†
D	Across C6	230	227	1200	†
E	Cathodes V3 and V4	7·2	7	12	25%
F	Anodes V3 and V4	240	240	1200	25%
G	Across C5	250	248	1200	25%
HA & HB, HC & HD	Anodes V5, V6, V7 and V8	403	395	1200	10%
KA & KB, KC & KD	Screens V5, V6, V7 and V8	337	283	1200	10%
LA & LB	Cathodes V5, V6, V7 and V8	27	33	120	10%
M	Across C11 and C12	410	403	1200	10%
N	Across C13	340	288	1200	10%
O	Unsmoothed H.T.	430	420	1200	10%
PA & PB	Anodes V9 and V10	518	512	1200	10% ÷

* Reading taken with the ÷ 2 button pressed.
† Tolerances undefinable due to valve and resistor wide limits.

(b) **Meter Readings**

SWITCH POSITION	METER INDICATION	METER READINGS	ACTUAL MEASUREMENT
1	Cathode current V1 and V2	1.4	1·4 × 1 = 1·4 mA.
2	Cathode current V3 and V4	8·0	8·0 × 1 = 8 mA.
3	Cathode current V6 and V8	2·5	2·5 × 50 = 125 mA.
4	Cathode current V5 and V7	2·5	2·5 × 50 = 125 mA.
5	Output voltage*	3·16	3·16 × 10 = 31·6 volts.

* Only when an input is present.

(c) **Current** = H.T. Total = 330 mA

Power Consumption 300 VA.

(d) **Transformer A.C. Voltages.** Avometer A.P. 47A. Instrument and conditions as for (*a*) above.

TRANSFORMER				METER READINGS STATIC (VOLTS)	METER READINGS DYNAMIC (VOLTS)	METER RANGE (FULL SCALE DEFLECTION) (VOLTS)
TR4	Heater	(i) Rectifier	J–K–L		2·5 + 2·5	12
		(ii) Pilot	P–N		4·3	12
		(iii) Rectifier	N–M		45·5	120
		(iv) Valve	H–G–F		3·1 + 3·1	12
TR5	H.T.	(i) Pilot	G–F		4·2	12
		(ii) H.T.	H–K–M	520 + 520	512 + 512	1200

APPENDIX 3

Sound Data

(*a*) *Distortion and Power Output*

INPUT	CHANNEL	OUTPUT (WATTS)	DISTORTION (PERCENTAGE)
0·35 ~~1·6~~ mV	25 ohm microphone	50	5
0·415 ~~1·9~~ mV	25 ohm microphone	54	10
0·22 ~~0·8~~ mV	8 ohm microphone group	50	5
0·295 ~~0·8~~ mV	8 ohm microphone group	54	10
1·8 volts	Line (grid of V3)	50	5
2 volts	Line (grid of V3)	54	10

(*b*) *Noise Level*

Decibels below 50 watts = 32

(*c*) *Frequency Response.*

(Ref. 25V into 20 ohms at 1 Kc/s.)

FREQUENCY CYCLES	DB. 25 OHMS INPUT	DB. 8 OHMS INPUT	DB. LINE INPUT
50	−10	− 8	− 8
100	− 6	− 3	− 3
200	− 3	− 1	− 2
300	− 1	− 0·5	− 1·5
500	0	0	0
600	0	0	0
800	0	0	0
Kc/s.			
1	0	0	0
2	− 1	0	0
3	− 2	− 0·5	− 0·5
5	− 3	0	− 0·5
6	− 3	+ 0·5	− 1
8	− 4	+ 1	− 2
10	− 5	+ 1	− 2
12	− 6		
15	− 8·5		
20	−14·5		

APPENDIX 4

Summary of Structural and Electrical Details

Structural

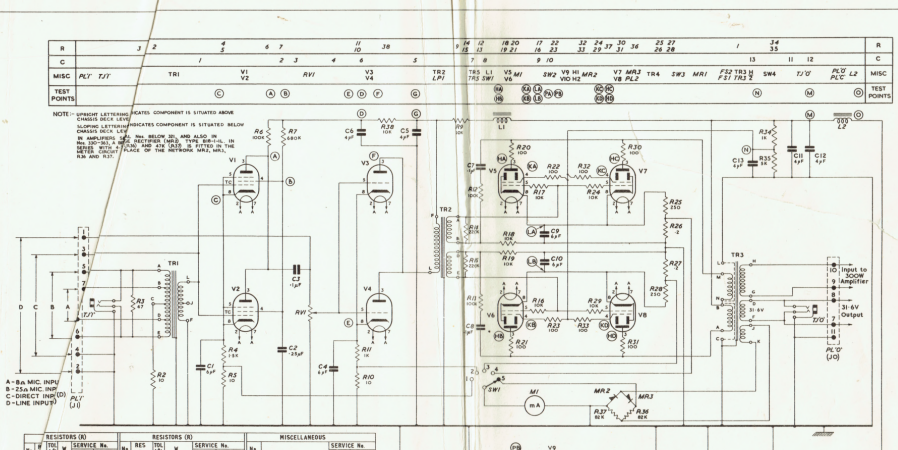
Dimensions:—	
Height	12¼ in. (7 E).
Width overall	19 in.
Depth, front to back	17 in.
Projection, front from mounting rack	9 in.
Withdrawal clearance	18 in.
Weight	98 lb.
Types of mounting	Rack and bulkhead.
Fixing particulars	Slide rails and clips.
Cable entry	Multi-pin sockets. 6, 8 and 10 way. One of each. I.S. Cat. Nos. Z 560115, Z 560117, Z 560119. With side entry covers.
Positions	At sides.
Casing material	Mild steel sheet.
Type of enclosure	Protected. Ventilated.

Electrical

Supply	A.C.
Voltage	230, 115 or 50V.
Frequency	50 to 60 c.p.s.
Power consumption	300 VA.
Fuses	2 A.P.19248.
Capacity	5 amperes.
Valves	2—C.V. 1056. 2—C.V. 1067. 4—C.V. 1075. 2—C.V. 1071.
Pilot lamps	2—X959101.
H.T. Voltage, maximum	530 V.
Power output. Audio	50 watts at 31·6 V.

(SO 3080) Wt. 32591—D7179 2000 6/53 H & S Ltd. **Gp. 399**

FIG. 1



RESISTORS (R)

No.	Ω	TOL ± %	W	SERVICE No. A.P.	I.S. CAT.
1	75	20	3/4	W8561	2220093
2	150	10	3/4	W3392	2220103
3	267	20	3/4	W8510	2220172
4	1·5K	10	3/4	W1559	2220227
5	1Ω	10	3/4	W3292	2220703
7	100R	20	3/4	W7328	2220402
8	680Ω	10	3/4	W8465	2220346
9					
10	10K	5	4½	52524	2244007
10	1Ω	10	3/4	W3292	2220103
11	1K	10	3/4	W1558	2220046
12	100K	10	3/4	W1587	2223030
13	100K	10	3/4	W1587	2223030
14	220R	10	3/4	W2650M	2220381
15	220K	10	3/4	W2650M	2220381
16	10K	20	3/4	W8563	2220153
19	10K	20	3/4	W8563	2220153
18	10K	10	3/4	W4607	2220152
19	10K	10	3/4	W4607	2220152
20	100	5	5	W7321	2243099
21	100	5	5	W7321	2243080
22	100	20	3/4	W8512	2220114
23	100	20	3/4	W8512	2220114
24	10K	20	3/4	W8563	2220153
25	250	5	6		2243134
26	2	5	3/4	12677	—
27	2	5	3/4	12677	—

RESISTORS (R)

No.	RES Ω	TOL ± %	W	SERVICE No. A.P.	I.S. CAT.
R1	1K	5	15		2245004
R2	1·5K	5	50		2242103
R3	82K	10	3/4		2223035
R4	82K	10	3/4		2223030
R5	10K	20	3/4	W8563	2220153
R6	100K				
R7	680K				
R8	10K				
R9	4µF				
R10	10K				
R11	1K				
R12	10K				
R13	10K				
R14	10K				
R15	10K				
R16	10K				
R17	10K				
R18	10K				
R19	10K				
R20	100				
R21	100				
R22	100				
R23	100				
R24	10K				
R25	330				
R26	2				
R27	10K				
R28	330				
R29	100				
R30	100				
R31	100				
R32	100				
R33	10K				
R34	10K				
R35	1K				
R36	82K				
R37	82K				
RVI	50K				
RV2	100K				

CAPACITORS (C)

No.	CAP. µF	TOL ± %	WORKING VOLTS D.C.	SERVICE No. A.P.	I.S. CAT.
C1	6	20	150		2112558
C2	25	20	100	52170	2113510
C3	1	20	1000	52168	—
C4	4	10	150	—	2112558
C5	4	20	600	50856	2112528
C6	4	20	600	50856	2112528
C7	4	20	1000	52168	—
C8	4	20	1000	52168	—
C9	6	10	150	—	2112558
C10	6	10	150	—	2112558
C11	4	20	600	50856	2112528
C12	4	20	600	50856	2112528
C13	4	20	600	50856	2112528

VALVES (V)

No.	TYPE	CODE
V1	PENTODE	CV 1056
V2	TRIODE	CV 1067
V3 V4	TETRODE	CV 1075
V5 V6	RECTIFIER	CV 1071

MISCELLANEOUS

No.		SERVICE No. A.P.	I.S. CAT.
LP1	'LT. ON' LAMP	9	3093101
LP2	A.C. ON' LAMP	9	3093101
PL1	8 WAY INPUT PLUG	—	2560115
PL0	6 WAY OUTPUT PLUG	—	2560114
PLT	10 WAY CONTROL PLUG	—	2560118
TJT	INPUT TEST JACK	—	PD 01061
TJT	OUTPUT TEST JACK	—	PD 01061
SW1	5 POSITION SWITCH	12674	—
SW2	10 AMP SWITCH	W1367	—
SW3	10 AMP SWITCH	W1367	—
SW4	SAFETY SWITCH		A.M. SC/2126
MR1	HALF WAVE RECTIFIER	60516	—
MR2 MR3	RECTIFIERS	GEX 66/6	
RJ2	500Ω, RELAY	W538/20078	
FS1	5 AMP FUSE	19248	—
FS2	3 AMP FUSE	19248	—
TR1	INPUT TRANSFORMER	12659	—
TR2	INTER STAGE TRANSF.	12660	—
TR3	OUTPUT TRANSFORMER	12661	—
TR4	HEATER TRANSFORMER	12664	—
TR5	H.T. TRANSFORMER	12665	—
L1	CHOKE	12662	—
L2	CHOKE	12663	—
MI	MILLIAMMETER	12666	—
RV1	POTENTIOMETER 500 K	12673	—

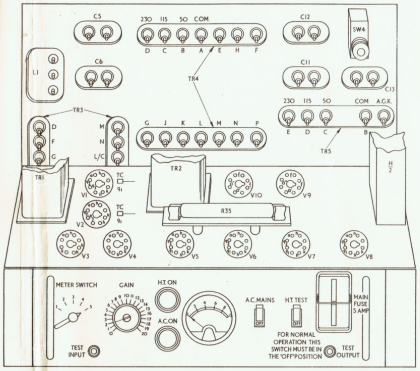
TED ONLY IN THE EARLIER AMPLIFIERS OF THE SERIES

G.E.C. CODE No.*

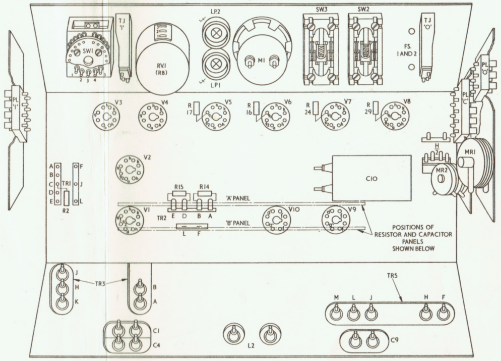
50 WATT AMPLIFIER A.P.12647 CIRCUIT DIAGRAM

H.M.S. COLLINGWOOD. DWG. No. H402
BASED ON D.E.E. DWG. No. 18711

FIG. 2

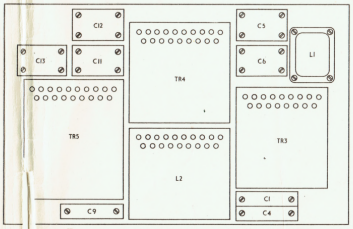


TOP LAYOUT SHOWING FRONT PANEL

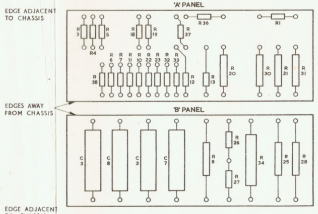


BOTTOM LAYOUT

✓ LAMPHOLDERS NOT SHOWN.
✓ TERMINAL CONNECTIONS ONLY.



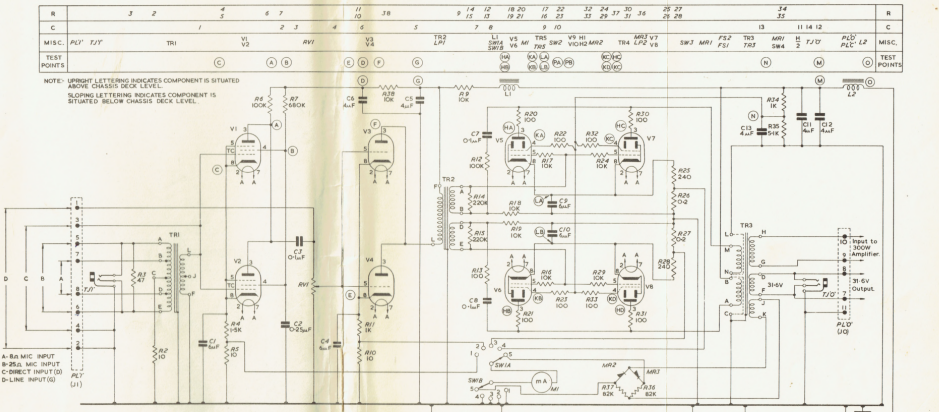
DISPOSITION OF APPARATUS AT BACK OF AMPLIFIER



H.M.S. COLLINGWOOD
DWG. No. 114/53

50 WATT AMPLIFIER A.P.12647. ARRANGEMENT DRAWING. (STRUCTURAL DETAILS)

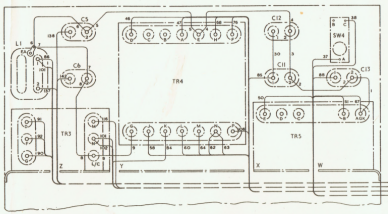
FIG. 4



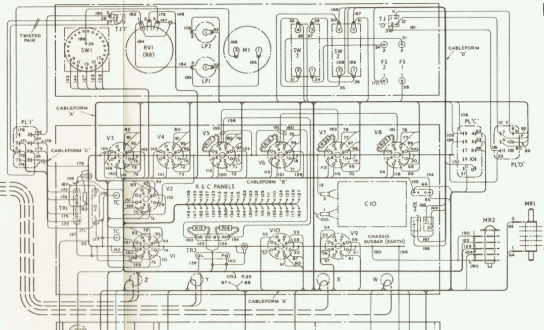
REGISTORS (R)						REGISTORS (R)						MISCELLANEOUS		
No.	RES Ω	TOL ± %	W	SERVICE No. I.S. REF. A.P.	No.	RES Ω	TOL ± %	W	SERVICE No. I.S. REF. A.P.	No.	ITEM	SERVICE No. I.S. REF.A.P.
1										LP1	HT. ON" LAMP 6V	6240-99-995-9101
2	10	10	1/2	5905-99-022-4003	33	100	10	1/2	5905-99-022-1111	LP2	AC. ON" LAMP 6V	6240-99-995-9101
3	47	10	1/2	5905-99-022-1069	34	1K	5	1.5	5905-99-011-3154	PL1'	8 MIC INPUT PLUG	5935-99-943-8332
4	1·5K	10	1/2	5905-99-022-2037	35	5K6	5	3Q	5905-99-011-7648	PL2'	5-WAY OUTPUT PLUG	5935-99-940-2267
5	1Ω	10	1/2	5905-99-022-1003	36	82K	10	1/2	5905-99-022-3030	PL3'	10 WAY CONTROL UNIT PLUG	5935-99-972-8280
6	100K	10	1/2	5905-99-022-3036	37	82K	10	1/2	5905-99-022-3030	TJ1'	INPUT TEST JACK	AB64985
7	180K	10	1/2	5905-99-022-3144	38	10K	10	1/2	5905-99-022-2132	TJ2'	OUTPUT TEST JACK	AB64986
9	10K	5	4·1/2	5905-99-011-3511						SWA/B	5-POSITION SWITCH	P302/205664
10	10	10	1/2	5905-99-022-1003	CAPACITORS(C)					SW2	10 AMP SWITCH	W1367
11	1K	10	1/2	5905-99-022-2006	No.	CAPS μF	TOL ± %	WORKING VOLTS DC	SERVICE No. I.S. REF. A.P.	SW3	10 AMP SWITCH	W1367
12	100K	10	1	5905-99-011-1495	1	6	10	150	5905-99-580-3521	SW4	SAFETY SWITCH	5930-99-943-8275
13	100K	10	1	5905-99-011-1495	1	6	10	150	5905-99-580-3521	MR1	BRIDGE RECTIFIER	P26/20-4127
14	220K	10	1/2	5905-99-022-3081	2	10-25	20	500	5960-99-011-5510	MR2/3	RECTIFIER	CV1102
15	390K	10	1/2	5905-99-022-3091	3	0·1	20	1000	5960-99-011-5508	H2	SCOOL RELAY	5945-99-920-1042
16	10K	10	1/2	5905-99-022-2132	4	6	10	150	5960-99-580-3521	FS1	5mAMP FUSE 220V	5920-99-053-0112
17	10K	10	1/2	5905-99-022-2132	5	4	20	800	5960-99-011-3529	FS2	5mAMP FUSE 220V	5920-99-053-0112
18	10K	10	1/2	5905-99-022-2132	6	4	20	800	5960-99-011-3529	FS1	10-AMP FUSE 115V	5920-99-011-9925
19	10K	10	1/2	5905-99-022-2132	7	0·1	20	1000	5960-99-011-5508	FS2	10-AMP FUSE 115V	5920-99-011-9925
20	100	5	4·1/2	5905-99-011-3463	8	0·1	20	1000	5960-99-011-5508	TR1	INPUT TRANSFORMER	AP.1659
21	100	5	4·1/2	5905-99-011-3463	9	6	10	150	5960-99-580-3521	TR2	INTER STAGE TRANSFR	AP.12660
22	100	10	1/2	5905-99-022-1111	10	6	10	150	5960-99-580-3521	TR3	OUTPUT TRANSFORMER	AP.12661
23	100	10	1/2	5905-99-022-1111	11	4	20	800	5960-99-011-2529	TR4	HEATER TRANSFORMER	AP.12664
24	10K	10	1/2	5905-99-022-2132	12	4	20	800	5960-99-011-2529	TR5	H.T. TRANSFORMER	AP.12665
25	240	5	6	5905-99-011-7898	13	4	20	800	5960-99-011-2529	L1	CHOKE	AP.12662
25	0·2	5	1/2	AP.12577	14	2	20	200	5960-99-011-2882	L2	CHOKE	AP.12663
27	0·2	5	1/2	AP.12677	VALVES(V)					MI	MILLIAMMETER	AP.12676
28	240	5	6	5905-99-011-7898	No.		TYPE		CODE	RV1	POTENTIOMETER 25K	5905-99972-2923
29	10K	10	1/2	5905-99-022-2132	1 & 2		PENTODE		CV1056 OR CV358			
30	100	5	4·5	5905-99-011-3463	3 & 4		TRIODE		CV1067			
31	100	5	4·5	5905-99-011-3463	5 TO 8		TETRODE		CV1075			
32	100	10	1/2	5905-99-022-1111	9 & 10		RECTIFIER		CV 717			

50 WATT AMPLIFIER PATT. 0558/126471. CIRCUIT DIAGRAM

FIG. 3



UPPER PART OF REAR PANEL



BOTTOM LAYOUT

STRAPPING WIRES			
LINE	FROM	TO	COLOUR
1	TR5-A6	C12-2	BLACK
2	C13-2	C12-2	-
3	C12-2	C12-1	-
4	C12-1	C11-1	-
5	C11-1	SW1-6	-
6	C6-2	C5-2	-
7	L1-E4	C4-2	-
8	C4-2	TR3-A5	-
9	TR3-A5	TR4-A6	-
10	PL12-B	PL12-J	-
11	PL12-C	PL12-J	-
12	C12-2	BUSBAR	-
13	C11-1	BUSBAR	-
14	V1-1	-	-
15	V3-1	-	-
16	V4-1	-	-
17	V5-1	-	-
18	V6-1	-	-
19	V7-1	-	-
20	V8-1	-	-
21	V9-1	-	-
22	V10-1	-	-
23	PL12-J	-	-
24	PL7-C	PL7-K	-
25	PL7-L	PL7-P	RED
26	PL7-S	PL7-U	WHITE
27	PL7-T	PL7-V	BLACK
28	C1-1	SW2-1	RED
29	C2-1	SW3-1	RED
30	FS1-2	SW3-3	YELLOW
31	C4-1	SW2-3	BLACK
32	C6-1	BUSBAR	-
33	C7-1	BUSBAR	-
34	FS2-2	SW3-1	GREEN
35	SW3-4	SW2-2	YELLOW
36	SW3-5	SW2-1	GREEN

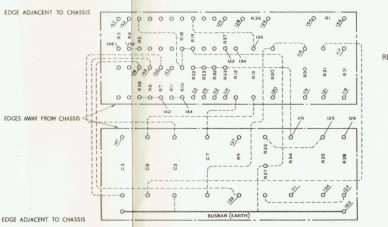
CABLEFORM 'A'			
LINE	FROM	TO	COLOUR
37	PL7-D	SW6-A	WHITE
38	SW6-B	SW5-2	YELLOW
39	SW5-4	TR6-2	-
40	SW5-2	C14-2	GREEN
41	SW5-1	C14-1	-
42	SW5-3	C15-2	-
43	C14-2	TR5-A4	-
44	C14-1	TR5-A3	-
45	C15-2	TR5-A2	-
46	C15-1	TR5-A1	-
47	SW3-2	TR6-A	GREEN
48	SW2-4	TR5-E	SLATE
49	SW2-5	TR5-B	BROWN
50	TR5-F	LP1-1	RED
51	TR5-F	PL7-E	-
52	TR5-H	PL7-F	-
53	TR5-F	PL7-C	-
54	TR5-H	PL7-K	-

CABLEFORM 'A'			
LINE	FROM	TO	COLOUR
55	V9-6	V10-5	RED
56	TR5-H	V9-4	YELLOW
57	V9-4	V10-4	-
58	V10-6	V9-5	SLATE
59	V10-4	V9-3	-
60	TR4-L	V10-2	BLUE
61	V10-2	V9-2	-
62	TR4-M	LP2-1	GREEN
63	TR4-N	PL7-A	-
64	TR4-M	MR1-1	WHITE
65	MR1-2	$^{TR}/_{PL}$-K	BLUE
66	$^{TR}/_{PL}$-J	PL7-B	BROWN
67	C9-2	TR5-A5	BLACK
68	TR5-G	V8-2	YELLOW
69	V8-1	V9-1	-
70	V7-2	V7-1	-
71	V8-2	V5-2	-
72	V5-2	V6-2	-
73	V6-2	V7-2	-
74	V7-2	V8-2	-
75	V2-2	V3-2	-
76	V3-2	V4-2	-
77	V4-2	V5-2	-
78	V7-7	V7-8	-
79	V8-7	V8-8	-
80	V9-7	V9-8	-
81	V6-7	V6-8	-
82	V5-7	V5-8	-
83	V4-7	V4-8	-
84	V3-7	V3-8	-
85	V2-7	V2-8	-
86	TR4-K	LP1-1	BROWN
87	TR5-K	PL7C-D	BLUE
88	R3B-D	C6-1	YELLOW
89	TR5-K	PL7C-D	BLUE
90	TR3-G	PL7-R	BROWN
91	TR3-F	PL7-Z	GREEN
92	TR3-G	PL7-Y	GREEN
93	C1-2	V1-9	BROWN
94	V1-9	V2-8	-
95	V3-8	V4-8	GREEN
96	V4-9	C4-2	-
97	V5-8	V7-8	BROWN
98	V7-9	C6-1	-

CABLEFORM 'A'			
LINE	FROM	TO	COLOUR
99	V6-9	V8-8	BROWN
100	V8-9	C10-1	-
101	LL1-1	TR3-N	RED
102	TR3-M	C10-2	-
103	TR3-K	MR1-4	GREEN
104	TR3-L	LP2-2	BLUE
105	PL7C-S	TR4-F	-
CABLEFORM 'B'			
106	R32-2	R34	YELLOW
107	TR3-P	R34	RED
108	R32	V7-4	BLUE
109	R32	V5-4	-
110	R33	V8-4	SLATE
111	R33	V6-4	BROWN
112	TR3-N	R30	BROWN
113	TR3-A	R31	YELLOW
114	R31	LR1-3	RED
115	R30	V7-3	SLATE
116	R30	V5-3	-
117	R31	V6-3	RED
118	R33	LR1-5	BROWN
119	R30	V7-3	SLATE
120	R30	V5-3	-
121	R31	V6-3	RED
122	R33	TR3-J	GREEN
123	R37	MR2-2	-
124	R32	LR1-8	BROWN
125	R35	SW1-15	BLACK
126	R35	LR1-1	-
127	R28	SW1-13	BROWN
128	SW1-17	R36	YELLOW
129	R36	MR2-3	WHITE
130	TR2-B	R12	GREEN*
131	TR3-H	R13	RED*
132	A9	LL1-2	SLATE
133	R38	C11-1	BLUE
134	TR2-B	R12	GREEN*
135	TR3-H	R13	RED*
136	A9	LL1-2	SLATE
137	R38	C11-1	BLUE
138	R9	TR2-L	RED
139	R9	TR2-L	RED
140	TR2-F	V2-3	BROWN*
141	V3-3	V4-3	RED
142	R11	V3-4	-
143	R11	V2-4	BROWN
144	R10	SW1-11	WHITE
145	V4-5	V3-5	GREEN
146	V3-5	RV1-1	GREEN*
147	C5	RV1-3	WHITE*
148	R6	V1-3	RED*
149	V1-3	V2-3	RED

CABLEFORM 'B'			
LINE	FROM	TO	COLOUR
150	R7	V1-4	BLUE
151	V1-4	V2-4	-
152	V2-4	R4	BROWN
153	R4	R5	YELLOW
154	$^{FS}/_{2}$-1	R1	BLUE
155	$^{FS}/_{2}$-2	R1	GREEN
156	TR1-A	R2	WHITE*
157	TR1-B	R3	RED*
158	PANEL CHASSIS BUSBAR	BUSBAR	BLACK
CABLEFORM 'D'			
159	SW3-1	$^{FS}/_{1}$-1	GREEN
160	SW3-3	$^{FS}/_{1}$-2	BROWN
161	$^{FS}/_{1}$-1	$^{FS}/_{2}$-1	SLATE
162	$^{FS}/_{1}$-2	$^{FS}/_{2}$-2	RED
163	PL7-C	TR1-L	YELLOW
164	PL7-S	TR1-A	WHITE
165	PL7-T	TR1-B	RED
166	PL7-T	TR1-B	SLATE
167	PL7-R	TR1-B	GREEN
168	PL7-A	BUSBAR	BLACK

STRAPPING WIRES			
LINE	FROM	TO	COLOUR
169	TR1-L	V1-10	GREY
170	TR1-L	V2-10	-
171	RV1-3	TR1-L	GREEN*
172	PL7-E	TR1-A	WHITE*
173	PL7-E	TR1-B	RED
174	PL7-J	TR1-B	SLATE
175	PL7-K	TR1-B	GREEN
176	PL7-A	BUSBAR	BLACK



EDGE ADJACENT TO CHASSIS

EDGES AWAY FROM CHASSIS

EDGE ADJACENT TO CHASSIS

BUSBAR (EARTH)

RESISTOR & CAPACITOR PANELS

STRAP WIRES SHOWN DOTTED (NOT NUMBERED OR LISTED)



* DENOTES SCREENED LEAD

50 WATT AMPLIFIER A.P.12647. PICTORIAL WIRING DIAGRAM

H.M.S. COLLINGWOOD
DWG. No. 11404

C.B.H. 22641 - Wt. 32591 - Dd. D.B179 - 2000 - 6/53