Chapter 9

AMPLIFYING UNIT TYPE 7435

(Speech Clipping Modulator fitted to Power and Radio Unit Type 4192)

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INTRODUCTION

1. The introduction of the speech clipping modulator (amplifying unit Type 7435—10U/16659) to the power and radio unit Type 4192 is brought about by Modification No. 2980 which, although retrospective will, at first, result in the power and radio units being fitted with either one of two types of amplifying unit. The alternatives are as follows:—

(a) Amplifying unit Type 7435—10U/16659 (Speech clipping modulator).

(b) Amplifying unit Type 4209—10U/16683 (Modulator without speech clipping).

2. A slight modification is made to the power and radio unit when the new amplifying unit Type 7435 is fitted. This involves the fitting of a new cover plate to the potentiometer access holes on the front panel. Since there is no change in the Type No. of a modified power and radio unit the presence of the new cover plate on the front panel will be the first indication that the power and radio unit incorporates the speech clipping modulator.

3. Amplifying unit Type 4209 is described in Chapter 5. The modified power and radio unit Type 4192 and the speech clipping modulator are described in the following paragraphs.

Power and radio unit

4. The power unit of the power and radio unit gives outputs of 300V and 600V HT; the former output is applied to the audio amplifier and both outputs to the transmitter circuits. Input power to the motor of the rotary transformer is from the aircraft 28V supply.

5. The signal input to the amplifying unit Type 7435 is from the intercommunications circuits of the equipment (microphone and key). A tone oscillator provides 1,000 c/s modulation on MCW and a parallel push-pull amplifier modulates the HT to the transmitter.

CONSTRUCTION

6. The complete power and radio unit consists of a main chassis to which is attached the front panel which consists almost entirely of an air intake dust filter (*fig.* 1). A removable dust cover fits over the whole chassis and is fixed at the rear of the unit by means of a quick release fastener. The dimensions of the unit are 8×10 in. (front panel) and chassis length $12\frac{1}{2}$ in.

7. The whole base of the unit consists of a chassis $2\frac{1}{2}$ inches deep and open on the underside. On the top surface of the chassis is mounted the rotary transformer (left) and the amplifying unit Type 7435 (right). The modulating transformer (T3) is mounted to the rear of the amplifying unit.

8. A special bracket covers the HT brushes at the rear of the rotary transformer; this carries the P.A. valves heater dropping resistor R41 and can be swung clear for access to the brushes.

9. The remainder of the chassis incorporates a motor start relay and components of the HT smoothing circuits.

10. Cooling air for the power and radio unit is drawn through the air filter box on the front panel (*fig.* 1) by a fan on the LT or front end of the rotary transformer.

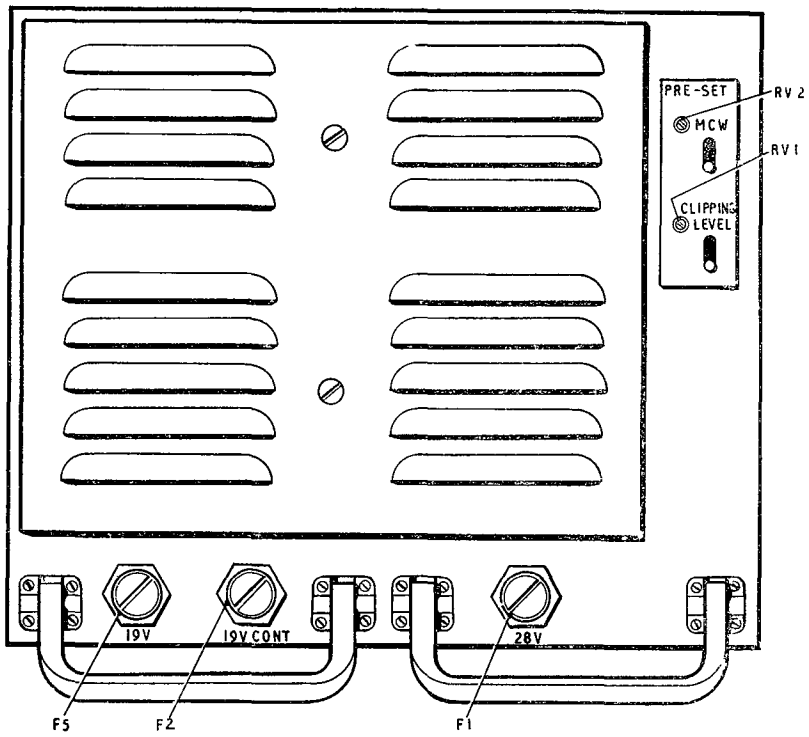


Fig. 1. Front panel of modified power and radio unit Type 4192

11. Some of the air intake is passed through the rotary transformer and some is taken directly from the fan through a slot in the cowl and directed across the output valves of the amplifying unit Type 7435 by a duct-deflector. The air exhaust is through louvres in the rear top of the dust cover.

12. Two quick release fasteners enable the dust cover over the two air filters to be removed and the air filters freed. A further four fasteners allow removal of the baffle plate behind the filters. This permits the fan cowl of the rotary transformer to be withdrawn for inspection of the LT brushes.

13. A sliding cover beside the air filter on the front panel provides access to two pre-set adjustments on the audio amplifier. These are:—

(1) MCW gain adjusting potentiometer RV2 (Engraved MCW).

(2) Speech clipping level potentiometer RV1 (Engraved CLIPPING LEVEL).

14. The rotary transformer is held in position by means of two clamp bands on a saddle. When these and the air duct are released and the electrical quick release connections freed, the rotary transformer can be removed.

15. The amplifying unit Type 7435 is fastened to the main chassis by means of four captive screws. Input connections are made by plug and socket (PL3, SK6—*fig.* 4). The output connections are made from the top caps of the output valves V9 to V12; plug PL4 connected to socket SK7 is not in use.

Interconnection in ARI.5874

16. The interconnection of the power and radio unit within the installation is made by plugs and sockets fixed to the rear face of the chassis. In common with other units of the installation these plugs and sockets (seven in all) plug directly into a back-plate at the rear of the power and radio unit mounting assembly (*Chap.* 10).

17. The back-plate is interconnected to the remainder of the installation by means of connectors permanently wired to the back-plates of other units of the installation. Some details of the plugs and sockets at the rear of the power and radio unit are given below; a more complete account is given in Chap. 10.

PL1 20-way plug	Power supply input
PL2 Coaxial plug	600V HT modulated output to transmitter.
SK1 20-way socket	Control and power supplies to transmitter.
SK2 20-way socket	Control and power supplies to control and drive unit.
SK3 4-way socket	Transmitter interlock
SK3 4-way socket	Receiver connections
SK5 8-way socket	Connections to intercommunications equipment (sidetone, key, mic. circuit and 1/6 power circuit).

Note . . .

PL2 and SK3 are mounted on a bracket above the chassis

CIRCUIT DESCRIPTION

Theory of speech clipping

18. A normal speech waveform as illustrated in fig. 2, contains very high peaks produced by vowel sounds which do not add considerably to the intelligence contained in the waveform. In order not to over-modulate a transmitter with a waveform such as this, the gain of the modulator must be adjusted so that the peaks give 100 per cent. modulation.

19. This is achieved by adjusting the gain control of the modulating amplifier to give 100 per cent. modulation with a standard input, i.e. 10mV open circuit voltage from a 200-ohm source at 1,000 c/s, which represents the average output from the microphone.

20. It can be seen from fig. 2A that the average level of modulation under R/T conditions is approximately 30 per cent. The object of speech

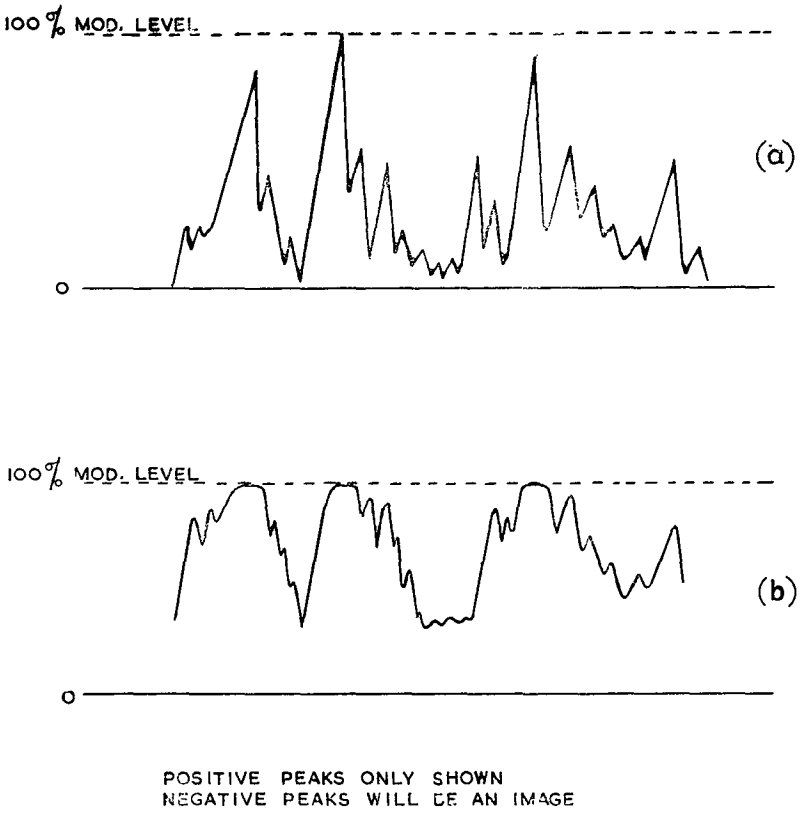


Fig. 2. Speech waveform with and without "speech clipping"

clipping is to raise the average level of modulation, thereby increasing the power output in the transmitted sidebands without over-modulation taking place.

21. Speech clipping in a modulating amplifier is achieved by increasing the gain of the amplifier and squaring off or "clipping" the peaks of the input waveform as shown in fig. 2b. Diodes are used to square or "clip" both positive and negative peaks and are so biased that they operate at a signal level which gives 100 per cent. modulation.

22. The limiting factor to the amount of extra gain available in the modulating amplifier is the amount of distortion of the waveform which can be tolerated, although up to a point the intelligibility is increased owing to the raising of the consonant levels.

23. The optimum gain figure is 15dB, so that 100 per cent. modulation will be obtained with an input of −15dB on the original 10mV input, that is 2·7 mV and all inputs up to 10mV will not therefore exceed 100 per cent. modulation.

24. The effect of distorting the input signal to something approaching a square-wave produces predominantly third order harmonics which are transmitted in the form of very wide sidebands. This is overcome by introducing a low pass filter to follow the clipping stage which offers a high impedance to all frequencies above 4,000 c/s, a figure which represents the normal bandwidth required for intelligible speech transmission.

25. The voice operated gain adjustment device (V.O.G.A.D.) is included in the modulating amplifier to prevent overloading of the first stage when input levels in excess of 10mV are applied (such as shouting into the microphone).

26. A portion of the signal is again applied to a diode biased so that it will conduct on input levels above the order of the 10mV, the voltage appearing across the diode load is applied as negative bias to the first stage.

Audio frequency circuits

27. The audio frequency circuits consist of (1) the amplifying unit Type 7435, which includes an audio amplifier and modulating unit and (2) the modulating transformer T3.

28. A block diagram is given in fig. 3 and a complete circuit diagram of the power and radio unit is given in fig. 7, the audio frequency circuits are shown at the left of the diagram. Illustrations of the amplifying unit Type 7435 are given in fig. 4, 5 and 6.

Microphone amplifier

29. The balanced microphone input enters the power and radio unit at pins 3 and 4 of SK5 and is taken through screened leads via socket SK6 and plug PL3 (pins 1 and 2) to the primary winding of the transformer T1. The secondary winding of T1 is connected to the input stage V1 and V2 operating in push-pull.

30. The anode supply to these valves is switched by the relay contacts RL4A and HT is applied in the R/T conditions only. HT is from the 300V KEY terminal 17 on the 28-way socket SK1 via pin 11 on SK6 and PL3. The screen connections to the valves is from the 300V supply via the potential divider R4/R5. These valves (CV2135) act as the microphone amplifier and also as the controlled stage in the voice operated gain adjusting device. (V.O.G.A.D.).

1st audio amplifier

31. With zero input signal the valves V1 and V2 are biased by the cathode resistor R69. The anodes of the valves are coupled by C17, R62 and C18, R63 to the grids of the push-pull double-triode V3; this is the 1st audio amplifier stage using a CV455.

32. Cathode-bias to the two triodes is provided by the resistor R9. The output from the anode loads

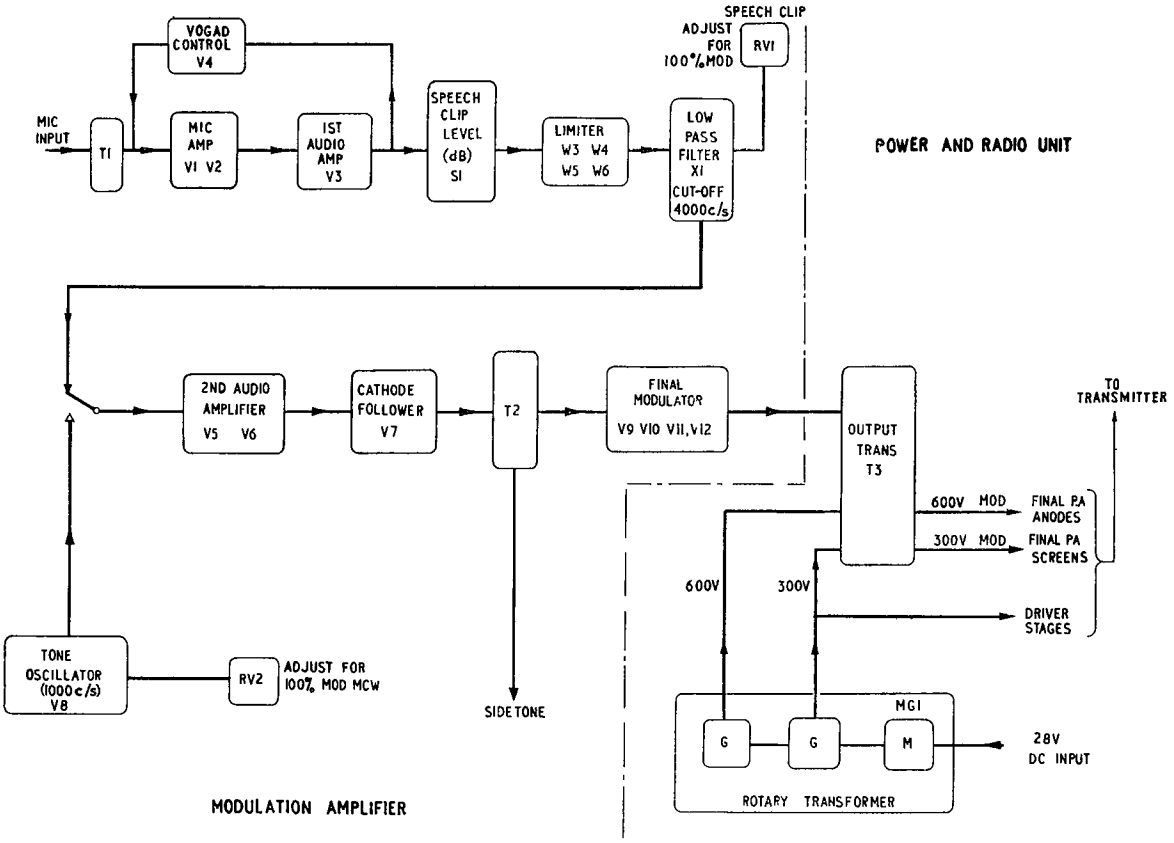


Fig. 3. Block schematic of amplifying unit Type 7435

R10 and R11 of V3a and V3b is coupled via C3 and C4, respectively, to the cathodes of V4a and V4b. This is a double-diode rectifier CV140 (V4) employed as the control source for the V.O.G.A.D.

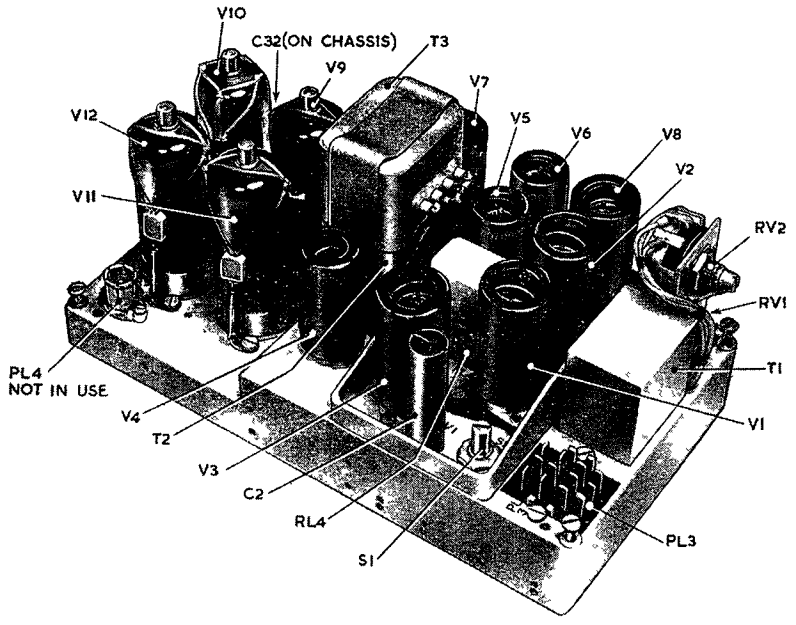


Fig. 4. Amplifying unit sub-chassis

Voice operated gain adjusting circuit

33. The double-diode V4a and V4b acts as a normal push-pull rectifier coupled by C3 and C4, the load being R1 and R2 in the input of the microphone amplifier stage.

34. A delay bias from the network R16, R24 and RV1 is applied from the 300V line at plug PL3 pin 12 from the source at socket SK1 pin 25. The delayed bias is applied to the cathodes of V4a and V4b so that when an audio level greater than this delay is applied, the negative potential from the anodes is applied to the junction of the resistors R1 and R2.

35. The V.O.G.A.D. action on the gain of the microphone amplifiers V1 and V2 is effected by two related circuits. The rectified negative potential at the junction of the resistors R1 and R2 is applied to the grids of V1 and V2; at the same time a current dependent on this potential will flow from earth through the selenium rectifiers W1 and W2.

36. As the magnitude of the current is increased, the selenium

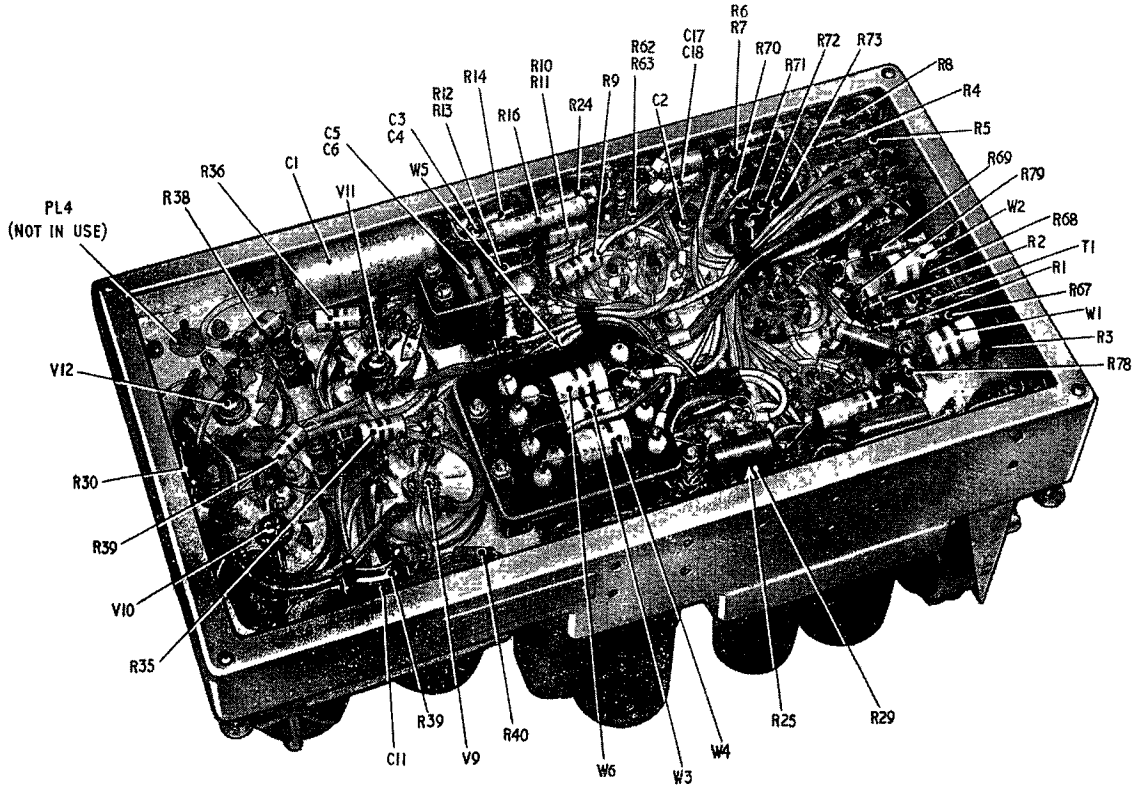


Fig. 5. Underside view of amplifying unit (1)

rectifiers in series across the secondary of the transformer T1 will behave as a decreasing load resistor and thus reduces the audio signal voltage on the rids of V1 and V2.

37. The potential developed across resistor R3 will also increase the negative grid bias and the combination of the two effects will provide a relatively constant audio level on the cathodes of V4a and V4b.

38. Attenuation of the controlled signal is available in six steps by a balanced network formed by R12 and one of the five resistors R80, R70, R71, R72 and R73 together with R13 and one of the five resistors R81, R74, R75, R76 and R77. These resistors are selected by the switch S1 as shown in fig. 7.

"Speech clipping" circuit

39. The selected audio level is coupled by the capacitors C5 and C6 to a push-pull series limiter which provides "speech clipping". This in effect "squares off" the tops of the modulation to enable a higher average level of modulation to be achieved with the resulting improved intelligibility under weak signal conditions, particularly in the presence of noise.

40. The limiter consists of the selenium rectifiers W3, W4 and W5, W6 together with the resistors R17, R19, R21 and R18, R20, R22, respectively. The rectifiers are biased positively through the junction of R19, R20 from the potential divider RV1 off the 300V supply.

41. Consider one half of the limiter circuit and assume that the bias from RV1 is E volts and that W3 and W4 behave as "perfect" diodes. Assume that the value of R19 is R ohms, R17 is R/2 ohms and R21 is R ohms.

42. With these assumed values and with a current flowing through W3 and W4, the voltage across R17 and R21 will be E/4 volts. approx.

43. Under operating conditions the incoming audio signal voltages across C5 will be superimposed on this value of E/4 volts. When the positive swing of the incoming signal takes the potential across R17 above E/2 volts the rectifier W3 ceases to conduct thus leaving a potential of E/2 across R21.

44. On the negative swing, W3 conducts continuously and the potential appears across R21. If, however, the negative swing falls below zero, W4 ceases to conduct and the potential across R21 cannot fall below zero. Thus no matter what the input to the limiter, the potential across R21 is limited to E/2 volts on positive swings and zero on the negative.

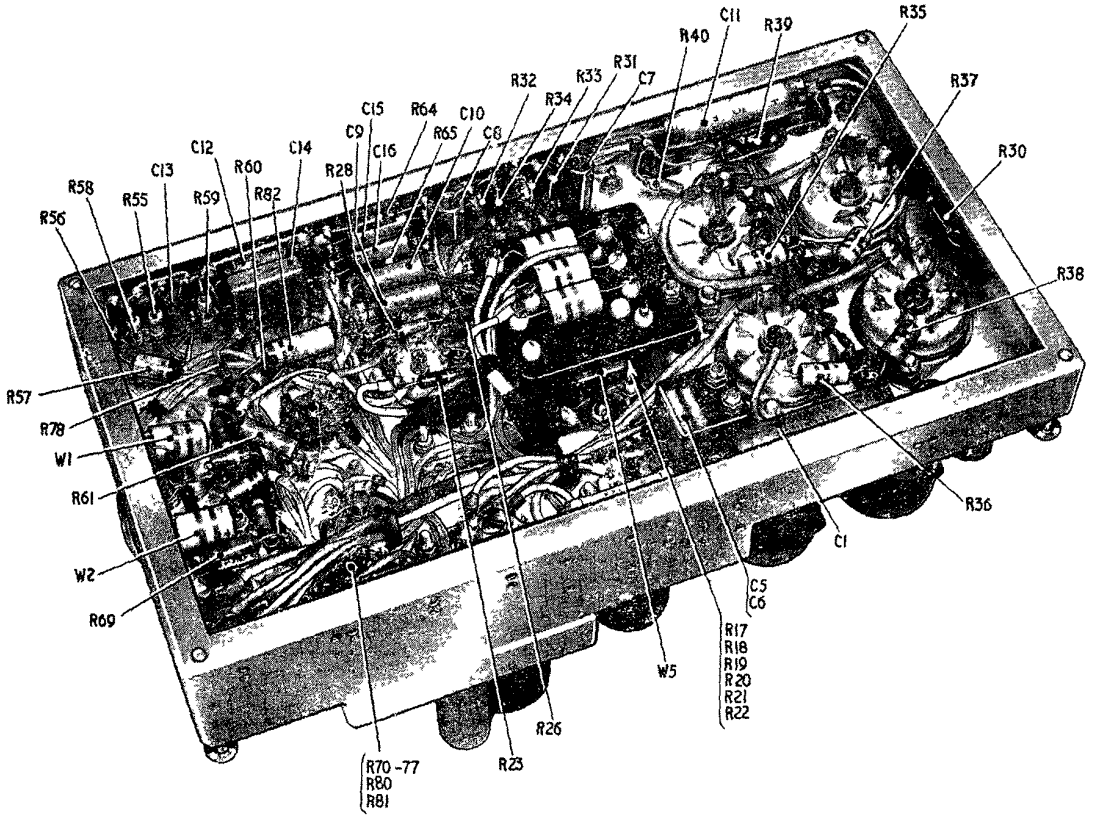


Fig. 6. Underside view of amplifying unit (2)

45. The potentiometer RV1 is used to adjust this value of E/2 volts to correspond to approximately 100 per cent. modulation. The selector switch S1 then allows, by control of the input, a choice of amount of clipping as follows; 3, 8, 11, 14, 16 or 19bD nominally.

Low-pass filter

46. The clipped audio signal is then coupled to the 2nd audio amplifier via a low-pass filter X1 which is designed to cut off at 4,000 c/s.

2nd audio amplifier

47. The second audio amplifier consists of two CV136 valves connected in push-pull (V5 and V6). The anode and screen supplies are from the 300V line at pin 25 of SK1. The screen voltage is dropped by the resistor R25.

48. Across the anodes of V5 and V6 is connected a phase correction network R26, R28, C9, R27, R29 and C10 which partly compensates for distortion that occurs in the output transformer T3.

49. The anodes of V5 and V6 are resistance-capacitance coupled by C7, R31, and C8, R32 to the grids of the push-pull cathode-follower drive stage V7 (CV491—V7a and V7b), the anodes of which are connected to the 300V line through R30.

50. The cathode load of this stage is provided by the iron cored choke formed by the primary of T2; the voltages across this are applied to the grids o the final modulator stage.

51. A secondary winding on the transformer T2 provides sidetone to pin 10 of PL3/SK6 which is then connected via the relay contact 2A to either the receiver telephones SK4/1 or the intercom. telephone (SK5/1).

Final modulator stage

52. The final modulator stage employs four tetrode valves (CV428) connected in parallel push-pull and working in Class AB. The bias is obtained partly from the cathode resistor R39 decoupled by C11, but the main part of the bias is from the positive 28V supply at SK2 pin 3 via PL3 pin 8 or 9 and relay contacts 4B, 2B, 1B and 3A.

53. When the 28V bias is removed by the relay contacts the resistor R40 behaves as an extra cathode-bias resistor and biases the stage to cut-off. The capacitor C19 across R40 limits the transients appearing across the output valves when relay contact 4B opens.

54. The anodes of the four tetrodes are joined to the primary of the output transformer T3, the anode supply being obtained at the centre tap

from the 600V supply at PL2 (600V+MOD). The transformer is not a part of the amplifying unit sub-chassis but is mounted at the rear of the main power and radio unit chassis.

55. There are two secondary windings to the transformer. The winding marked 5–6 is the main secondary supplying the 600V modulated supply to the transmitter unit power amplifier valves via PL2 (*Chap.* 4). Winding 7–8 provides the 300V modulated supply to the transmitter power amplifier valve screen grids via SK1 pin 22 (300V MOD).

Tone oscillator

56. The tone oscillator circuit employs a double-triode CV455. The triode V8a is used as a type of phase shift oscillator operating at approximately 1,000 c/s. It is a cathode-follower with a "twin Tee" network consisting of C12, R59, C14 and R55, C13, R58.

57. The cathode-follower has a gain of slightly less than unity, but since the network to which it is connected has a corresponding gain of slightly greater than unity, oscillation will take place.

58. A proportion of the output from the relatively high cathode load (potentiometer RV2) is directly coupled by means of the slider of RV2 to the second triode V8b. This is a conventional phase-splitter stage and gives a symmetrical output across its anode and cathode.

59. This output is taken through C15, R64 and C16, R65 to the grids of the second audio amplifier stage V5 and V6. The coupling is of a relatively high impedance and has no effect on the operation of the speech clipping circuit.

60. The potentiometer RV2 is used as a MCW level control of modulation.

Heater circuits

61. All the valves on the amplifying unit chassis are connected in series-parallel to the 19V stabilized supply via PL3/SK6 pin 4, fuse F2 and pin 14 of SK2 on the main power and radio unit chassis.

Relay function in audio circuits

62. The following paragraphs describe the function of the relays in the audio amplifier with relation to the selected position of the services switch on the remote control unit.

CW

63. During operation on CW an earth is applied to the connection at pin 13 of SK2 (MCW/CW); relay RL4/2 is energized from the 28V supply at pin 11 of SK1.

64. The 300V HT supply from pin 11 of PL3 (the keyed supply from pin 17 of SK1—"300 KEY") is connected via relay contact 4A to the anode of the tone oscillator triode V8a which will thus be in operation. (The anode of V8b is connected to the 300V supply at pin 25 of SK1.)

65. Relay contact 4A also disconnects the HT supply from the anodes of V1, V2 and V3, thus disabling the speech input stages. Relay contact 4B closes to connect the cathodes of the modulator valves (V9 to V12) through pin 8 of PL3/SK6 and the closed relay contact 1B to relay contact 3A which, however, remains open. The modulator valves then remain cut-off by the resistor R40.

66. When the key is "made" relay RL2/2 is energized and the tone signal from V8 is passed from V5 and V6 to V7 where the sidetone is routed from transformer T2 via pin 10 of PL3/SK6 and relay contact 2A to TEL+ at pin 1 of SK5. The closing of contact 2B is ineffective in the conditions obtaining.

MCW

67. With MCW facilities pins 4 and 13 of socket SK2 (MCW/R/T and MCW/CW) are earthed, thus energizing relays RL3/2 and RL4/2. Relay contact 3A closes and connects the modulator cathodes to the positive 28V supply at pin 3 of SK2 (relay contact 4B closed) thus allowing the modulator stage to operate. Relay contact 2B is inoperative since the modulator stage is not keyed on MCW; it is therefore shorted by contact 4B.

68. MCW is provided at 100 per cent. modulation with no clipping. Sidetone is again provided at pin 1 of SK5 as before.

R/T

69. For R/T operation pin 4 of SK2 (MCW/R/T) only is earthed and relay RL3/2 is energized. Relay contact 4A now disconnects the tone oscillator and connects the 300V HT to the anodes of the speech input valves V1, V2 and V3.

70. With relay contact 4B released, the cathodes of the modulator stage are now connected through pin 9 of PL3, relay contacts 2B, 1B and 3A to the positive 28V supply. The connection depends upon the closing of relay contact 2B which will only close when the key circuit is closed and relay RL2/2 thus energized.

71. Speech modulation is possible with the conditions described above and sidetone is taken from transformer T2 as before. When the key circuit is opened relay contact 2B is released and R40 cuts off the modulator valves as an economy measure. This also occurs when the TUNE relay RL1/2 is operated under TUNE conditions.

INT

72. When the equipment is being set up in the INTERTUNE condition, relay RL1/2 is energized from either contact pin 10 of SK1 or pin 10 of SK2. Contact 1B opens and effectively puts the modulator in the CW condition.

Power supplies circuit

73. The input power supplies to the whole of the transmitter equipment is applied via PL1; with 28V positive on pins 13–20, 19V positive stabilized on pins 11 and 12 and the common earth on pins 1–10.

74. When the equipment is switched to STANDBY the relay RL6/1 is energized from the 19V supply and closes contact 6A thus connecting the 28V supply through the 3-amp fuse F1 to a section of the control circuits. Contact 6A also completes the circuit of the energizing coil of RL7/1 which closes contact 7A and connects the 19V positive lines to another section of the control circuits and to the valve heater circuit of the equipment.

75. The following fuses are mounted on the front panel of the equipment:—

(1) Fuse F1, 3-amp. Protects the 28V control circuits.

(2) Fuse F2, 2-amp. Protects the 19V control circuits and the valve heaters in control unit Type 4190 or Type 4243.

(3) Fuse F5, 10-amp. Protects all the 19V supplies.

Rotary transformer

76. The rotary transformer is intended to operate at a nominal input of 28V as normally provided by the aircraft battery supplies. There are two secondary windings giving 300V and 600V HT respectively. These outputs supply 300V and 600V HT to the incorporated amplifying unit Type 7435, and 300V HT to the crystal-controlled oscillator in the control unit Type 4190; the 300V supply (modulated and unmodulated), and the 600V supply (modulated) is applied to the transmitter unit.

77. In the HT ON or TX condition of the equipment, relays RL8/1 and RL9/2 are energized from pin 2 of SK3. Contact 8A makes and connects the 28V supply from PL1 to the motor side of MG1 through the low value resistors R44 and R45. At rest, the armature approximates to a short-circuit, and most of the volts are dropped across R44 and R45 so that RL10/1 cannot operate. Relay RL12/1 is also energized from the 28V supply.

78. As the speed of the motor and the armature resistance increases, the back EMF builds up to approximately 20–24 volts and relay RL10/1 is energized through the closed contacts 9A. Relay contact 10A closes and short-circuits the starting resistors R44 and R45, thus allowing the motor to reach its maximum speed.

79. The relay contact 9B breaks the circuit between pins 3 and 4 of SK3 and can be used to interlock with the circuit of any other equipment in the aircraft which may be connected to SK3. When SK3 is not connected to other equipment pin 1 and 2 are shorted by a special link which is plugged into the back-plate.

80. After transmission the relays RL8/1 and RL9/2 are de-energized and the motor-generator switched off. Contact 9A breaks the circuit of RL10/1 and contact 10A reinserts the starting resistors in the motor circuit ready for any immediate restart.

81. The negative side of the motor winding is earthed via PL1. Noise suppression on the positive side is provided by the two-stage filter L6, C25 and L7, C26 mounted in a screened box.

82. Outputs from the generator side of the machine are provided by two armature windings giving, respectively, 300V HT and 600V HT. The 300V output is connected through the noise filter L5, C28 and L4, C27 and then through L8, C22 connected as a one-stage ripple filter.

83. The 600V output from the machine is taken through the noise filters L3, C30 and L2, C29 to the secondary winding of transformer T3 and C24 which gives some ripple suppression.

84. Fuses F3, 750mA and F4, 250mA, protect the HT circuits and the "noise" filters. They are mounted inside the unit to avoid bringing unfiltered leads and dangerous voltages to the front panel of the equipment. Spare fuses for F3 and F4 are mounted under the chassis.

Reduced power conditions

85. The resistor R43 in the 300V line to the secondary winding of transformer is brought into circuit by the breaking of relay contact 11A. Relay RL11/2 is energized when the equipment is in the SAFE condition (from pin 19 of SK2) and R43 limits the screen potential of the transmitter P.A. stage.

"SAFE"

86. The SAFE condition is provided primarily to reduce the output power of the transmitter to a safe level to prevent corona discharge which occurs at altitude in the event of a pressure leak in the suppressed aerial tuning unit (*Sect.* 2).

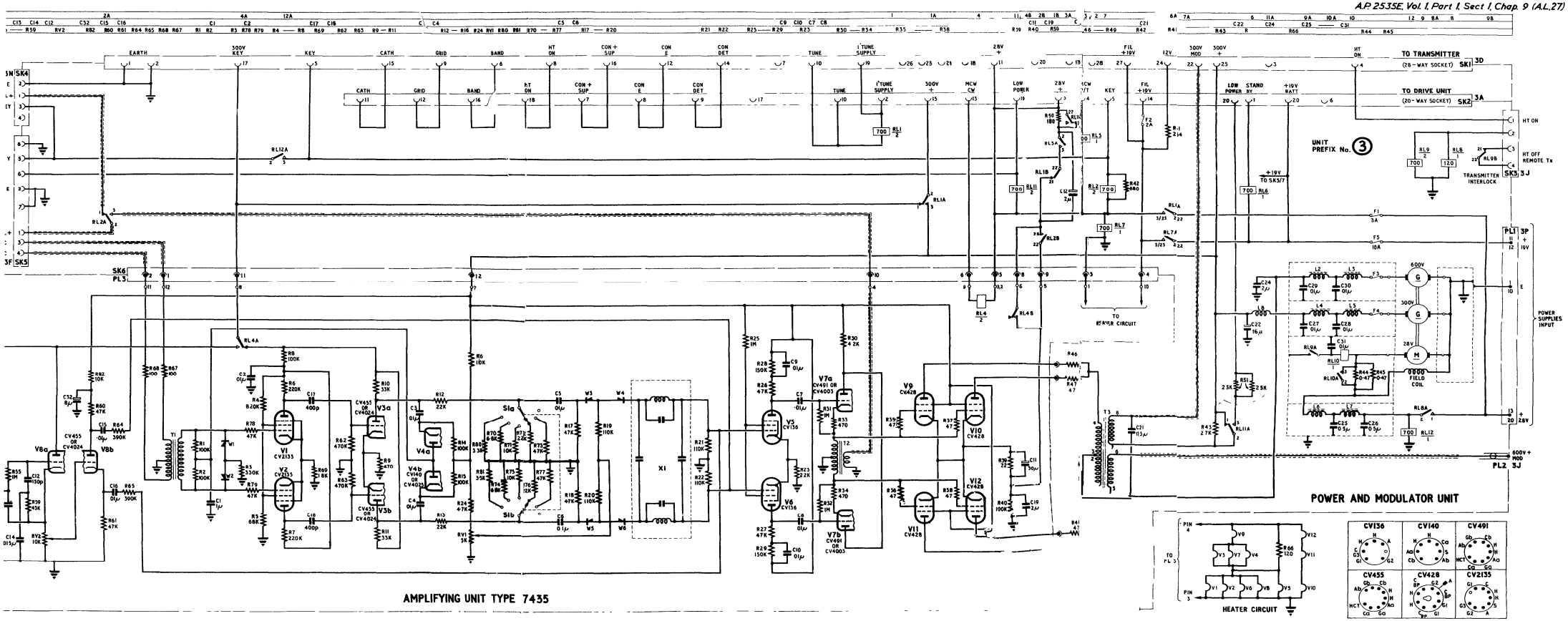
87. This low power facility is also provided under control of the operator in the form of a HIGH/LOW power switch connected between pin 6 of SK5 and earth on the "Intercom" output socket. (*Chap.* 10–*fig.* 8.)

88. "Safe" conditions occur when the LOW OUTPUT line is earthed by the LOW POWER switch or by the barometric pressure switch in the suppressed aerial tuning unit (*para.* 86). An immediate reduction in power is obtained since the screen potential of the transmitter P.A. stage is reduced by the potential divider formed by R43 and R51, the latter being taken to earth via pin 20 of SK2 and the control unit Type 4190 at 1RL7B (*Chap.* 3).

89. In addition to the reduced power obtained at the P.A. stage, relay contact 11B opens and inserts an extra cathode bias resistor R50 in the audio out put stage V5–V8.

"TUNE"

90. When the TEST TUNE KEY on the control and drive unit or the suppressed aerial selector unit is in the TUNE position, the resistor R51 is removed from its earth connection by 1RL7B in the control and drive unit (via pin 20 of SK2—*fig.* 7). Tuning can then take place at nearly full power since only R43 remains to limit the screen voltage.



ARI 5874 – Power and radio unit Type 4192 with speech clipping modul

RESTRICTED

Fig. 7

(A.L.27, Dec. 55)