LIMITING AMPLIFIER AM6/3

Introduction

The AM6/3 is a peak programme limiter which performs similar functions to those of the LIM/5 and LIM/6 and their sub-types. Its limiting characteristics and method of use are similar to those of the LIM/5 and LIM/6 series, but the general performance is improved, particularly in respect of stability, and other advantages are obtained by the use of semiconductors instead of valves.

Fig. 1. An attenuator and a buffer stage precede a limiting amplifier, and this is following by an output amplifier. Within the limiting amplifier is a control circuit which reduces the amplifier gain in proportion to the amplitude of a control voltage. This control voltage is derived from the output of the limiting amplifier by way of a side-chain, a rectifier and an amplitude gate so that a d.c. control signal is produced only when a peak in the programme signal exceeds a predetermined level. When

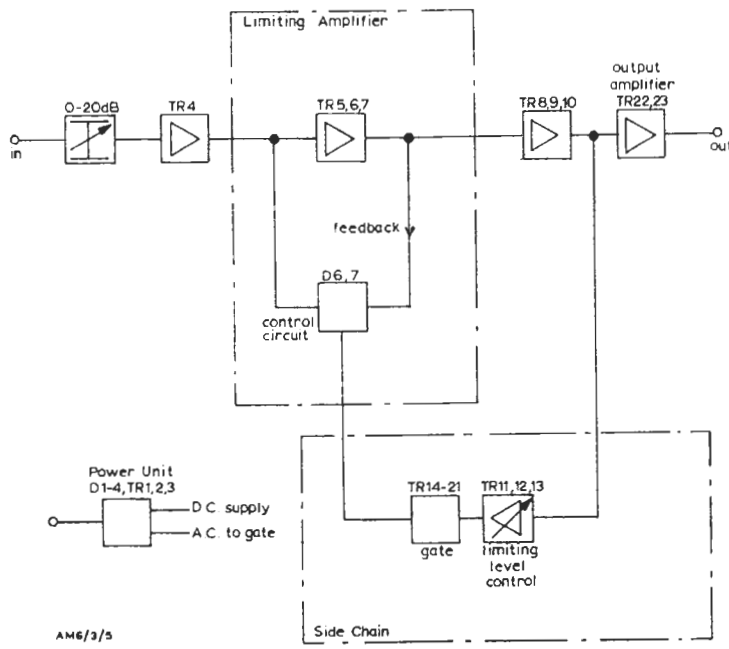


Fig. 1. Amplifier AM6/3: Block Diagram

The AM6/3 is constructed in two units for mounting on a panel PN3/23. Unit 1 (on a chassis CH1/18E) contains the limiting amplifier and the side-chain; unit 2 (on a CH1/18C) contains the output amplifier and the power supply section, which operates from a 190-260 volt 50-Hz mains supply. The index pegs on unit 1 are in positions 5 and 30, and those on unit 2 in positions 4 and 7.

Principle of Operation

The general arrangement of the AM6/3 is similar to that of the valve limiters and is illustrated in such a programme peak occurs, the gain of the limiting amplifier is reduced to a value which permits the programme peak to exceed the predetermined level only to the extent necessary to maintain the appropriate d.c. control signal. The rate at which the limiting action occurs, the *attack time*, is determined by the exponential time-constant of an *RC* circuit embodied in the side-chain and by the law relating gain reduction in the limiting amplifier with the amplitude of the control signal. The rate at which the gain is restored, the *restoration time*, is controlled similarly.

Circuit Description (Figs. 1 to 4)

General

The complete circuit is shown in Figs. 3 and 4; the latter contains only the details of the power supply section. Reference to the transistor numbers in Fig. 1 will assist identification of the various parts of the circuit diagram.

The input attenuator AT1 has ten 2-dB steps and is normally set at maximum attenuation. It is labelled *Limiting* to indicate that, when the equipment is correctly set up, deliberate limiting to the indicated amount can be introduced by this control. Following AT1 and the buffer amplifier TR4 is the limiting amplifier (TR5, 6, 7) which has feedback through the control circuit containing elements (D6, D7) sensitive to the control signal.

from the gate circuit, the resistances of the diodes are high compared with the shunting resistors (R28, R29 in Fig. 3) and the bridge is near its balance point. It is sensitive to a small change in any of its arms but, because of the high gain of the amplifier, there is sufficient negative feedback to stabilise the amplifier in the usual way. When a control signal flows through the diodes, R_a falls in value, thus unbalancing the bridge and applying additional negative feedback to the amplifier, which reduces the gain. Also, as R_a and R19 are in series across the input to TR5, the level of signal applied to this transistor falls. With low amplitudes of control signal the feedback effect predominates; with higher control current the input shunting effect becomes more significant. The diodes are selected to be well

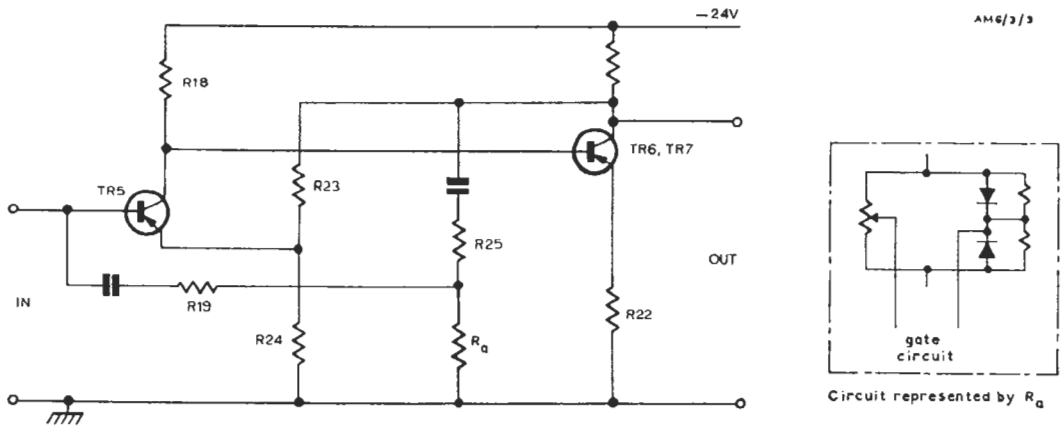


Fig. 2. Amplifier AM6/3: Simplified Circuit

Limiting Amplifier

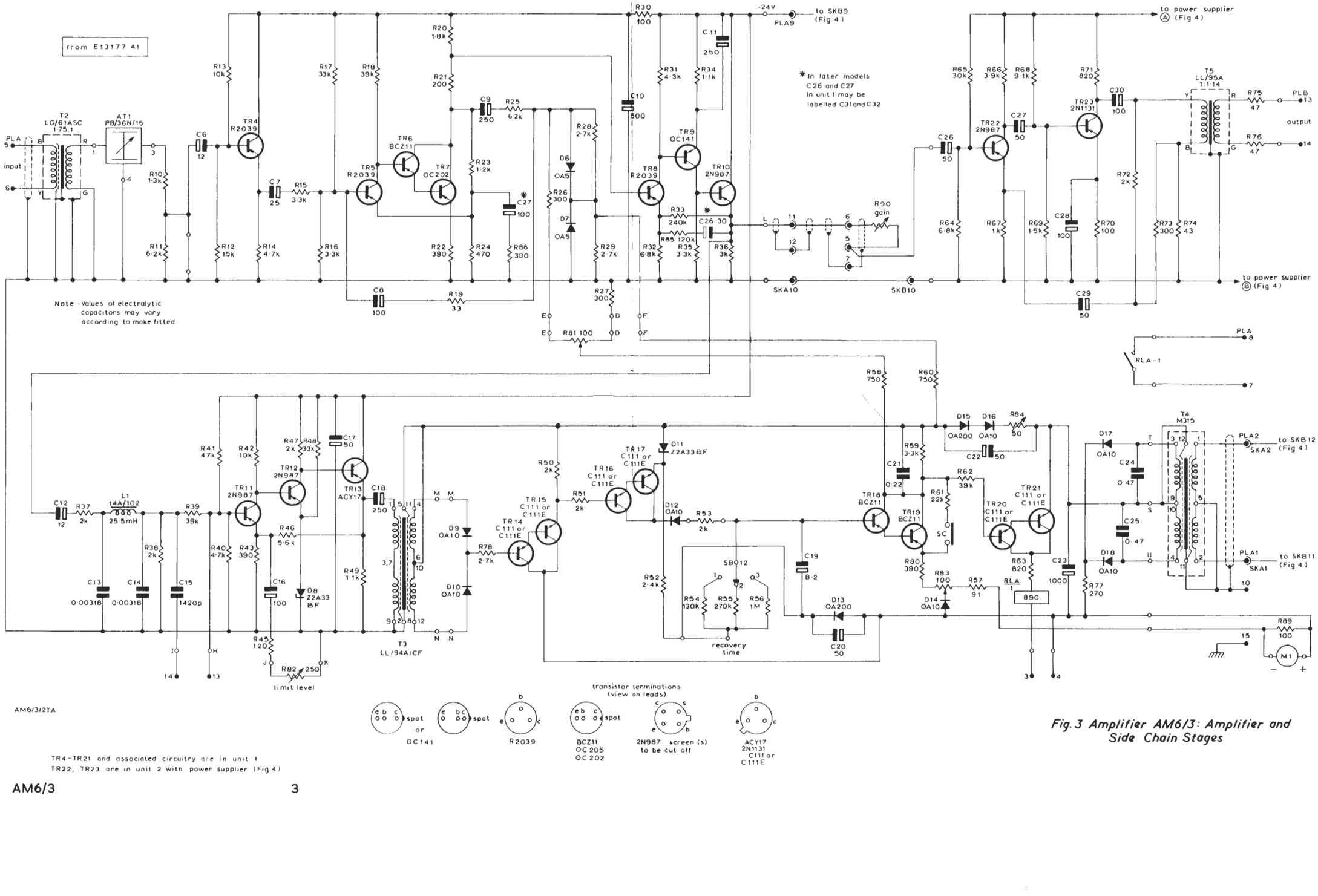
Fig. 2 is a simplified circuit diagram of the limiting amplifier, with the Darlington pair TR6, 7 represented by a single transistor. The stages are d.c.-coupled and a large degree of d.c. negative feedback is applied by the potential divider R23, R24. In parallel with this divider across the amplifier output is another divider consisting of R25 and R_a. (R_a represents R26, R27 and R81, together with the two diodes (D6, D7) and their shunting resistors, and is effectively varied by the d.c. control signal from the gate circuit described later.)

The two potential dividers form an a.c. bridge, the output diagonal of which is taken through R19 to the first transistor base/emitter junction, thus applying a.c. feedback over two stages; this feedback is always negative. When there is no control signal

matched over the operating range of control current and R81 is used to effect a precise balance so that a negligible control signal voltage appears across R_a.

Side-chain Amplifiers

The limiting amplifier is followed by the feedback triplet TR8, 9, 10 having a low output impedance from the emitter-follower TR10 which feeds both the side-chain amplifier TR11, 12, 13 and the output amplifier. TR11, 12, 13 also form a feedback triplet with the emitter-follower TR13 designed to deliver a high peak voltage output, in order to pass to the gate circuit, without clipping, the very short high-level peaks which initiate the limiting action on a large sudden overload. In the feedback circuit of TR11, 12, 13 is the pre-set *Limiting Level* control R82, which sets the side-chain gain.



transistor terminations (view on leads)

Fig. 3 Amplifier AM6/3: Amplifier and Side Chain Stages

TR4–TR21 and associated circuitry are in unit 1
TR22, TR23 are in unit 2 with power supplier (Fig 4)

F.M. Pre-emphasis

When the AM6/3 is used in the programme input chain to an f.m. transmitter, the side-chain of the limiter must have the same pre-emphasis characteristics as the transmitter, in order to ensure the same maximum deviation of the transmitter at all frequencies. This is effected by strapping sockets 13 and 14 on the mounting panel, to place C15 in shunt with R39 and introduce pre-emphasis with the usual time-constant of 50 μs.

Gate Circuit

This consists of the parts of the circuit between the transformers T3 and T4. The second transformer is not part of the gate circuit proper; its function is to handle the mains-frequency input to the separate rectifying circuit using D17 and D18, in order to supply the gate circuit with a power supply which is floating and balanced about earth. This is necessary because the d.c. control signal to the limiting amplifier is applied at points which are above earth potential. T3 and T4 isolate the gate circuit from the amplifiers and power supply respectively; their double screening also ensures that no disturbing signal or power-supply pulses are injected longitudinally into the limiting amplifier.

In the gate circuit following T3, the incoming signal is rectified by D9, D10 and applied to the gate proper TR16, 17 by way of the Darlington pair emitter-follower TR14, 15. The gate transistors TR16, 17 have back-bias of 3·3 volts from the zener diode D11 so that no collector current flows until the peak of the rectified signal pulses exceeds that value. When this occurs, current flows by way of D12 and R53 into C19. The Darlington pair TR16, 17 bottoms on any except very small excess peaks and acts as a switch, applying slightly less than the voltage across R52 (about 10 volts) to R53, C19, so that C19 charges with a time-constant of about 8·2 ms. This, in conjunction with the characteristics of the control circuit, results in an attack time of 0·8 ms. When the excess peak is removed, C19 discharges in a time determined by the setting of switch SB, which is one of the front panel controls. Recovery times of about 0·5, 1·0 and 2·0 seconds are provided.

The voltage pulse across C19 drives the Darlington pair TR18, 19, which has the control diodes of the limiting amplifier in the collector circuit. D13 forward-biases the base of TR18 to overcome part of the base/emitter voltage drop of the transistors and thus to avoid the time delay which would occur if the limiting action did not start immediately C19 began to charge. This would allow an excessive overshoot and a tendency to instability.

In the emitter circuit of TR18, 19 is the meter M1, calibrated to indicate approximately the degree of limiting. R83 enables the shunting effect of D14 to be adjusted to match the meter scale to the characteristics of the particular unit.

The pushbutton SC enables an artificial control pulse to be applied to the control diodes when adjusting the balance control R81 and is also used in setting up the relay circuit described below.

Relay Circuit

The relay RLA is brought into use by strapping sockets 3 and 4 on the mounting panel and is normally adjusted to operate whenever limiting of 1 dB or more occurs. The relay contacts are used primarily to prevent unnecessary alarms by automatic monitors.

The relay circuit is set up by operating SC while adjusting R84 to set the forward bias developed across D15, D16, R84 to cause the relay to operate at the required limiting level.

Output Amplifier

This is a conventional two-stage amplifier with current and voltage feedback proportioned by R72, R73, R74 to give an output impedance of 600 ohms. It delivers a maximum output programme volume of 0 dB and its voltage gain, adjustable by R85 which is a screwdriver control on the front panel, has a maximum value of 12·5 dB.

Continued overleaf

Power Supply (Fig. 4)

The d.c. supply, except to the gate circuit, is at 24 volts, stabilised against mains-input variations between 190 and 260 volts r.m.s. There are two fuses: F2 is inside the unit and is quick-acting, to protect against accidental short circuits during test or adjustment; F1 is a delay fuse, accessible at the front panel.

The mains transformer T1 also supplies a.c. at about 26 volts r.m.s., from which is derived the independent d.c. supply in the gate circuit.

Gain and Limiting Level

1. Set the *Limiting* control AT1 and the *Limiting Level* control R82 fully anticlockwise.
2. Apply 1-kHz tone to the input at a level of +8 dB.
3. Load the output with 600 ohms.
4. Adjust the *Gain* control R90 for an output level of +8 dB.
5. Adjust the *Limiting Level* control to depress the output level by 0·1 dB.

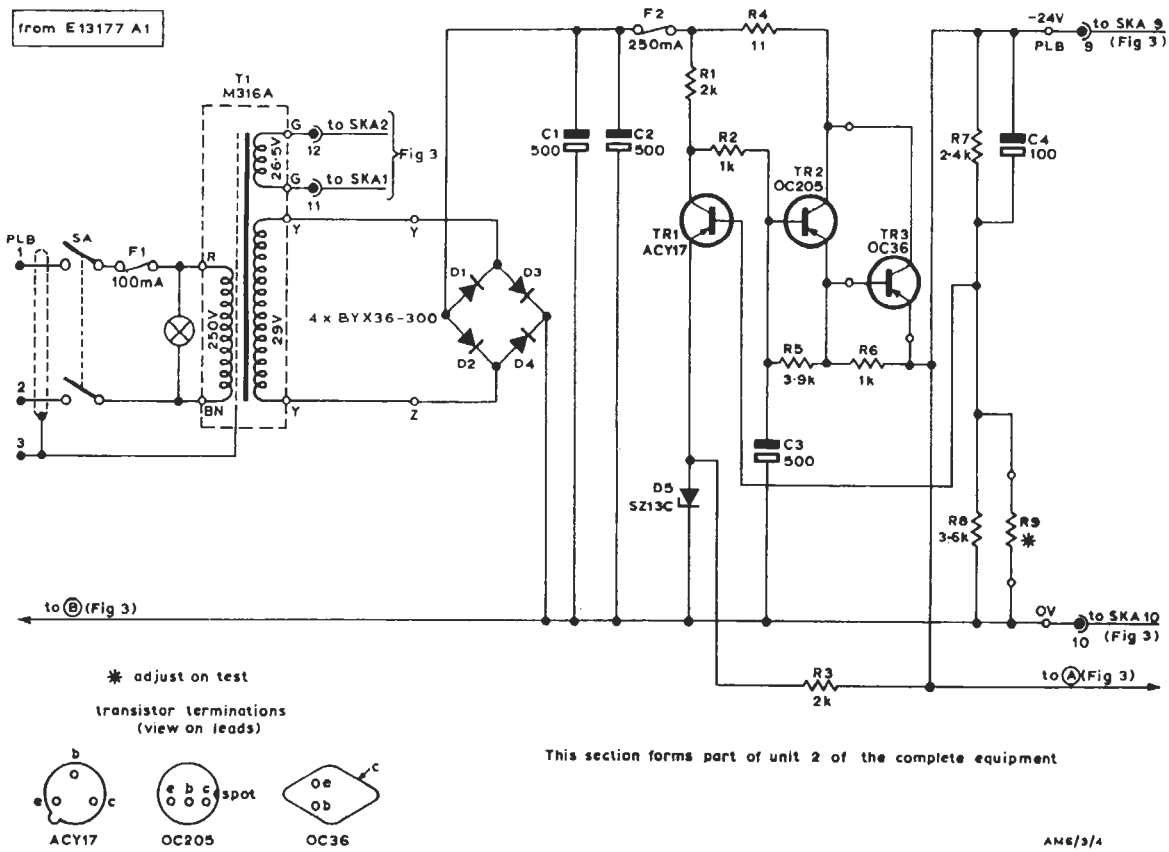


Fig. 4. Amplifier AM6/3: Power Supply Section

Adjustment and Operating Instructions

The full adjustment and lining-up procedure is carried out during acceptance tests, and the stability of the AM6/3 is such that only the *Gain* and *Limiting Level* controls, both of which are mounted on the front panel, are needed for operational use.

General Data

Impedances

Normal source impedance	300 ohms
Input impedance	13·5 kilohms
Output impedance	600 ohms
Normal load impedance	600 ohms

Input and Output Levels

Normal input at onset of limiting: +8 dB voltage level, equivalent to 0 dB programme volume.

Maximum output: as above.

Test Data

Frequency Response

Relative to level at 1 kHz.

(a) Below limiting level:

60 Hz to 15 kHz	+0·3 −0·4 dB.
40 Hz to 20 kHz	+0·3 −1·0 dB.

(b) At input level at which limiting begins, without side-chain pre-emphasis:

60 Hz to 15 kHz	±0·3 dB.
40 Hz to 20 kHz	+2·0 −1·0 dB.

(c) At input level at which limiting begins, *with* side-chain pre-emphasis:

Follows the required 50-μs curve to within ±0·5 dB up to 10 kHz. At 15 kHz, within +2 −0 dB.

Limiting Characteristic

At any frequency in the range between 40 Hz and 20 kHz, a rise of input level of 10 dB relative to that giving 0·1 dB of limiting should give a change in output level of about 0·1 dB. Similarly, a 20-dB rise in input level should give a change in output level of about 0·2 dB.

Noise

With the apparatus normally adjusted for 0 dB gain, terminate the input by 300 ohms and measure the total output noise on the T.P.M. of an ATM/1 or other T.P.M. limited to a 20-kHz band, allowing the meter to peak to 6. The noise volume so measured should not be greater than −57 dB.

Balance of Control Diodes

The balance of control diodes D6, D7 should be checked about once a year, or if 'thumps' are produced in operation.

1. Connect a 600-ohm T.P.M. to the AM6/3 output.
2. Set *Recovery Time* Switch SB to position 1, giving the shortest recovery time.
3. With no input applied, measure the pulse produced when pushbutton SC is pressed. Ignore the pulse produced when SC is released.
4. Allowing several seconds between pulses, adjust *Balance* control R81 to make the pulses a minimum. With the best balance obtainable, the residual pulses should have an amplitude of about −45 dB when peaked to 6 on the T.P.M.
5. If a balance of this order cannot be obtained, either
   (a) replace the diodes with a better matched pair, obtainable from Equipment Department Test Laboratory, or
   (b) return the AM6/3 to Equipment Department Test Laboratory for rectification.

D.C. Tests: General

All readings are with reference to an Avometer Model 8 used on the lowest practicable range.

D.C. Tests: Unit 1

The total current entering tag 9 should be 50 ±5 mA. The voltage across C23 should be 15·1 ±0·3 volts with a mains input of 225 volts r.m.s.

Neither rail of this supply is at earth potential and the supply is not stabilised.

The following voltages should be present between the emitters of the transistors and the common positive line (for pnp) or common negative line (for npn).

TR4	TR5	TR7	TR8	TR9
12·9	1·7	2·0	7·0	3·5

TR10	TR11	TR12	TR13
12·2	1·6	3·2	14·0

	TR15	TR17	TR19
no signal input ..	0	2·9	0
limiting 10 dB ..	2·1	2·9	0·45

TR21 relay current, when limiting 10 dB, 4·5 to 6·0 mA.

Care must be taken that transistor emitters are not inadvertently earthed; if this happens to either TR10 or TR13, the transistor will be destroyed immediately. Note also that tag 11 of unit 1 and tag 6 of unit 2 are connected directly to TR10 emitter.

D.C. Tests: Unit 2

The voltage across C1/C2 should be 33 volts for a mains input of 225 volts r.m.s.

The current through fuse F2 should be 39 ±5 mA.

Transistor voltages, measured between emitters and the common positive line, should be as follows.

TR1	TR22	TR23
13	3·9	2·0

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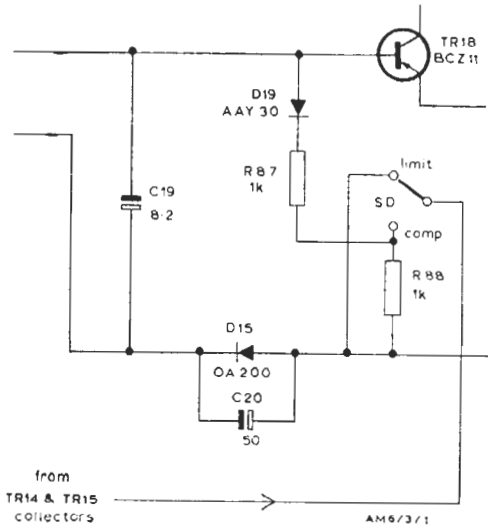

Fig. 5. Modification of AM6/3 to AM6/3A

Amplifier AM6/3A

A simple modification to the circuit of the AM6/3 enables the limiting effect over part of its range to be replaced by compression. The working of the modification is fully explained in Designs Department Technical Memorandum 3.92(67).

Fig. 5 shows the modification to the circuit of the AM6/3 which converts it to an AM6/3A. This modification takes place in the base circuit of TR18, and consists of the addition, in the positions shown, of diode D19, resistors R87 and R88 and a change-over switch SD, which enables the amplifier to be used either for limiting only or for compression as well.

The input level at which compression begins is +4 dB and, assuming zero gain in the non-limiting condition, the compression is such that when the input level is +10 dB the output level is +6 dB.

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