SECTION 3

LIMITERS: LIM/6 SERIES

3.1 Introduction

The LIM/6 series originated as equipment for v.h.f. sound-service transmitting installations but the latest type-variant is equally suited to use with transmitters employing amplitude modulation. The limiter is essentially a modification of the LIM/5 type (Instruction S.3, Section 19). Like that type it is intended to work with zero-volume input and output, but has a much higher input impedance to permit the parallel-feeding of several units from a conventional 600-ohm source.

Features for the initial purpose include (a) pre-emphasis of the side-chain input signal, of similar degree (50μs) to that in the modulator-drives of v.h.f. sound transmitters, (b) elimination of timing control by adoption of fixed, instead of switch-adjustable, time constants in the rectifier circuit providing control bias for the variable-gain stage, and (c) a relay facility for externally signalling the onset of limiting. The latest version is readily adaptable to work without feature (a) for application with amplitude-modulated transmitters.

The limiter was first issued in LIM/6 and LIM/6A versions which, as size counterparts of the LIM/5 and LIM/5A, have rack-mounting panel dimensions of $22\frac{1}{8}$ in. ($4\frac{1}{2}$ in. deep) and 19 in. ($5\frac{1}{4}$ in. deep) respectively. Both are not now in production as they have been superseded by the LIM/6B which has a link panel in connection with the pre-emphasis network. This addition and some component-type variation of no special significance are the only differences between the three versions.

3.2 General

The LIM/6 basic arrangement differs from that of the LIM/5 because inclusion of pre-emphasis necessitated a minor change which is of some operational importance. The LIM/6 block diagram, Fig. 3.1, shows that the side chain is fed from the main-chain output, instead of from intermediate point X as in the LIM/5 and earlier types. Although compensating loss in the pre-emphasis network, indicated by the general filter symbol, this transfer makes the side-chain input (and therefore limiting level) liable to alteration by the output-level control preceding the output amplifier (Fig. 3.1). For that reason the equipment needs a special line-up procedure whereby output level is determined under the non-limiting condition.

By incorporating a pre-emphasis network the side chain is given a response which rises with frequency and consequently its control of the variable-gain stage takes into account the programme-signal pre-emphasis which is part of the frequency-modulation process. Alternatively the convertible LIM/6B allows for working with only the resistive element of the network, the condition appropriate to amplitude modulation.

Apart from these qualifications the principle of operation is essentially as outlined in the corresponding sub-section of LIM/5 description; see previous reference. That description also gives useful information about the effects of different time constants, although in this respect the LIM/6 series is incapable of variation and has a fixed recovery time equalling the shortest of periods available with the LIM/5 type.

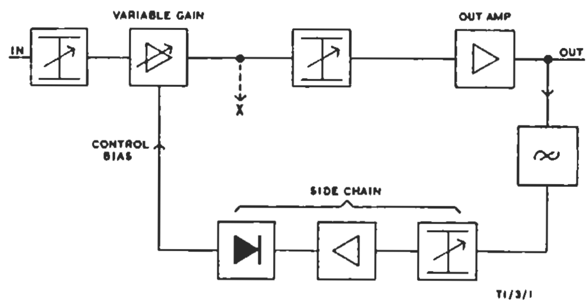


Fig. 3.1 Schematic of LIM/6 Arrangement

The equipment is operated with externally-derived supplies, nominally at 300 volts (45 mA) and 6·3 volts (1·7 A). Additionally the relay circuit is suited to a supply from the 50-volt positive-earthed sources generally employed for control and indication purposes. All three supplies and programme-circuit connections are made through a single multi-way plug at one end of the main panel. Controls unlikely to need frequent adjustment are adjacent to this connector and the remainder are immediately accessible at a cut-away in the front cover of the unit.

3.3 Circuit Description Fig. 3

The circuit diagram in Fig. 3 refers to the three versions of the equipment. Information about components is given as a complete table for the

LIM/6B and a note about the few component-type differences in the other versions.

3.3.1 Main Chain

The initial stage is a push-pull variable-gain amplifier employing variable-mu pentodes, V1 and V2, as means of obtaining the progressive change of incremental gain that is essential for satisfactory limiting action. The push-pull arrangement is preferred to a single-sided circuit not only to minimise even-harmonic components of distortion but also to allow use of a technique for suppressing plops which otherwise would be imposed on programme when control bias is applied from the side chain.

The signal input is fed through a transformer, T1, with a turns ratio of 4.08 : 1 and its centre-tapped secondary loaded by a balanced variable attenuator AT1. This *Limiting dB* control has a range of 16 dB, covered in 2-dB steps as indicated by numerical calibration with reference to the maximum-loss setting marked *0*. The total resistance of the attenuator is 528 ohms, which corresponds to a primary-referred value of about 9 kilohms.

V1 and V2 draw their screen-grid supplies from a stabiliser used also in connection with the side chain. Their cathode-derived bias is developed mainly across two variable resistors. One (R6 : *Bias*) is the common main control for both valves and the other (R5 : *Balance*) is connected between the cathodes to permit a limited differential variation of the individual bias voltages. To compensate slight differences between valves the *Balance* resistor is set to equalise the mutual conductances and so ensure equal anode-current change when the augmenting bias from the side chain is applied to the grids via the mid-point junction of the attenuator and transformer secondary. The two impulsive signals from such abrupt change are applied to inter-stage transformer T2 in the phase-opposed sense and would cancel each other completely given a perfect balance condition.

Practically only an inexact balance is possible but that is adequate to ensure virtual removal of audible interference. An optimum setting for R5 is found with the aid of a *Set Bal.* switch in the side chain; see subsequent reference to SC.

The cathode circuit includes R7, to measure total V1/V2 feed with the aid of switched meter M1, and one winding of twin-coil relay RLA. The relay is a miniature moving-coil type incorporating permanent-magnet polarising and fitted with a single moving contact between two fixed contacts. Functionally it resembles the telegraph relay (Carpenter principle) illustrated and described in Appendix K.1 of Instruction L.1.

The relay is used with only one of two fixed contacts in circuit and the coils arranged for energising to magnetically-opposed states. Current through the cathode-circuit winding is fixed at the value specified for the V1/V2 feed. Current through the other winding is measured with meter M1 switched to R57 and adjusted by R55 (*Rel. Bias*) to a value either equalling or slightly less than that in the cathode circuit. This pre-setting operation aims at resting the moving relay-contact lightly against the unwired fixed contact. Essentially this is a sensitivity adjustment as it determines the extent to which cathode current must fall, owing to limiting, before the moving contact transfers to provide an earth on terminal 8. The working setting has to be a compromise taking into account consistent operation by the relay. The signalling circuit is intended to control an external relay, such as that in an IP/1 equipment (Limiter Indicator Panel) for drawing attention to excessive limiting; see Instruction T.10. Another application is the muting of an automatic monitor in circumstances where the limiter is within the monitored section.

The output of the variable-gain stage has a hum content originating from the heaters of the valves. For the following stage this hum can be reduced considerably by the arrangement to inject a phase-opposed voltage of suitable magnitude from the heater circuit. Across that circuit is a variable potential-divider (R41: *Hum Bal.*) with the slider connected through a high-value resistor (R42) to the secondary of shunt-fed transformer T2. Note that this hum-suppressing feature depends for its effectiveness of adjustment on the use of a heater-supply source which has an earthed centre-point connection. This requirement must be met, by supply-unit modification where necessary, as otherwise R41 will not operate properly and any hum reduction by its adjustment is likely only as a fortuitous result.

The output amplifier is fed through transformer T2, with a turns ratio of 1:2·83 and the secondary partly loaded by the series combination of a gain control (R10: *Output Level*) placed between R50 and R60 to restrict the range of adjustment. In the first stage is triode V3a, followed by double-triode V4 with the halves working as a cathode-coupled pair in a push-pull output stage. Output transformer T3 has a tertiary winding from which 15 dB of negative voltage feedback is applied to the V3a cathode; the inter-stage coupling includes C4 to ensure stability at high frequencies. The T3 secondary alone would present too low an output impedance and the required value (600 ohms) is obtained with R21 in series with the winding. A side-chain input is taken through C16 from the anode of one output triode.

The object of the unconventional cathode-coupling circuit in the push-pull stage is to minimise polarising of the output-transformer core, as the arrangement is suited to a self-balancing technique for maintaining equality of the two anode currents. The a.c. condition is such that the valves work with the equivalent of a common cathode-load resistor, because the individual load resistors (R17 and R15) are effectively paralleled owing to the very low impedance of C5 at all signal frequencies. Thus, with V4b grid decoupled to earth by C6, the operation is similar to that with the usual form of cathode-coupled pair.

The path separation at d.c. is utilised to provide current-equalising through mutual cross-connection whereby the grid of each valve is biased from a suitable point on the cathode load of the other valve. To outline the restoring operation, assume an increase in V4a anode current. That increases the voltages at V4a cathode, V4b grid and V4b cathode. The last change occurs by cathode-following action and, because the cathode load has a high value, nearly equals that at the V4b grid. This alteration necessarily results from V4b anode current having increased by almost the same amount as the original increase in V4a current.

Further, the rise at V4b cathode increases the voltage on V4a grid and there the change is inevitably less than has occurred at V4a cathode. Thus the net result of the two changes is to make V4a grid more negative to V4a cathode than at the start of restoring action and this to some extent counteracts the anode-current increase which initiated the process.

These events illustrate the interdependence underlying the anode-current equalising, but note that satisfactory correction of unbalance necessitates use of close-tolerance resistors to provide cathode circuits which are substantially identical. They include shunts, R19 and R20, for checking the individual currents with switched meter M1.

3.3.2 Side Chain

The side-chain input is given 50-μs pre-emphasis by the parallel combination of R51 and C18 preceding the pre-setting control R43 (*Limiting Level*). Alternatively to suit the a.m. application a fixed value of attenuation at all frequencies is obtainable in the LIM/6B, by shifting a link to disconnect the capacitor; see inset in Fig. 3.

The signal is first amplified by triode V3b, coupled to the following stage by shunt-fed transformer T4 with a turns ratio of 1:2·83. The T4 secondary is used with a full-wave rectifier (MR1 and MR2) to derive a direct voltage applied positively from load resistor R24 to the grid of V5a. The rectifier circuit lacks a reservoir capacitor and therefore its output corresponds to the input signal subject to polarity reversal of the negative-going portions.

Bias to make V5a ordinarily non-conductive is developed in the cathode circuit as a voltage drop on R27 owing to current flowing in V5b. This valve serves as a current-setting device only, with its grid maintained suitably positive to earth by connection to the junction of R28 and R29 across the stabilised h.t. supply from V6. By this means the V5a grid is biased to approximately —30 volts and, as that is several times the voltage needed for cut-off, the direct voltage applied from the rectifier must reach a considerable fraction of that value to drive the valve into conduction. While the amplitude of the side-chain input is large enough for this current flow there is a V5a output of negative-going pulses developed on load resistor R45; the other anode-circuit components, R26 and C14, are a safeguard against instability under certain unbalance conditions.

Pulse signals from V5a are rectified by diode V7, arranged with an output polarity suited to the purpose of controlling V1 and V2 in the variable-gain stage. The V7 cathode is biased positively, about 2 volts, from a voltage-divider formed by R33 and R35 in series across the V5 cathode resistor. During no-signal periods this voltage is sufficient to prevent random arrival of electrons at V7 anode and so diode-load capacitor C9 is incapable of charging to the small voltage, considerably influenced by minor heater-voltage variations, that otherwise would be applied to the variable-gain valves.

The diode biasing also ensures that the condition for start of limiting action is more closely determined than by conduction in V5a. The disadvantage of relying on V5a is that individual valves differ in their cut-off voltages and so the instantaneous grid voltage giving conduction is liable to some variation. Owing to its bias V7 will not conduct until the cathode-applied signal exceeds 1 volt approximately, for which reason the start of limiting action is less dependent on the particular operating condition of the previous stage.

The charging time-constant of the rectifier circuit, determined by the values of R34, R35, C8, C9 and V7 forward-resistance, is chosen to make C9 acquire relatively little charge from transient pulses. Under working conditions therefore the reduction of V1/V2 gain is negligible for occasional programme peaks of very short duration. With R36 and C9 a discharge time-constant of about 0·5 seconds is obtained and this recovery time is sufficiently rapid for the limiter to be used as means of programme compression if required.

Switch SC, a spring-loaded type, is between grid and cathode of V5a to facilitate adjustment of the *Balance* control associated with V1 and V2. Closing this *Set Bal.* switch has the effect of a severe transient signal-overload, as it causes V5a to change rapidly from non-conduction to full conduction and consequently the control bias rises quickly from zero to a high maximum value. This rigorous action is repeated at intervals long enough to permit recovery, while the optimum *Balance* setting is found as explained earlier with reference to R5.

3.4 Operating Instructions

3.4.1 Supplies

These, and also programme-circuit connections, are made through a 12-way miniature socket (Painton No. 500841) wired to apply:

300-volt h.t. supply to pins 10 (+) and 7 (— and earth).

6·3-volt a.c. supply to pins 9 and 12; *this supply must have an earthed centre-point connection.*

50-volt d.c. supply to pins 2 (—) and 5 (+ and earth).

Supplies must be on for at least one minute before valve-operating conditions (see under 3.5.1) are checked.

3.4.2 Alignment

(*a*) *Bias Controls*

1. With no audio input to the limiter, set *Meter* switch to *V1 and V2÷2* position and adjust *Bias* control for a current of 16mA.
2. Shift *Meter* switch to *Rel. Bias* setting and adjust *Rel. Bias* control so that the traveller and unconnected fixed contact of relay RLA are barely touching each other. The current should be about 15 mA.

This unequal-current condition is preferable to give a greater margin against the effect of mains-voltage variation. With equal currents the relay normally operates for a tone input-level increase of less than 1 dB from the value needed to start limiting. Limiting indication for an even smaller increase would result if, subsequent to the setting-up operation, a mains change caused the relay traveller to shift towards the connected fixed contact. The high sensitivity of the system is slightly reduced by working as specified, which avoids too-frequent indication of limiting.

(*b*) *Balance Controls*

1. Provide the limiter with 600-ohm input and output terminations; connect a Test Programme Meter to measure audio output.
2. Set the *Output Level* control for maximum gain.
3. Adjust *Hum Bal.* control for minimum deflection of the programme meter. Note: The need for centre-point earthing of the heater supply has been mentioned previously.
4. Turn *Limiting Level* control fully counter-clockwise.
5. Press *Set Bal.* push-button switch repeatedly at intervals of not less than one second while adjusting *Balance* control for minimum deflection on the test programme meter.
6. Set *Meter* switch to *V1 and V2÷2* position and, if necessary, readjust *Bias* control to obtain 16-mA reading.

(*c*) *Level Controls*

The letter X is used below as a generalised reference to the numerically-marked settings of the *Limiting dB* control. Thus in any given instance it is necessary only to replace X with the number appropriate to the limiting level desired for the particular operational purpose.

1. Retain limiter-terminating condition as under item 1 of (*b*), but substitute a high-impedance amplifier-detector for the test programme meter.
2. Apply 1,000-c/s tone at zero level to the limiter.
3. With *Limiting Level* control fully counter-clockwise and *Limiting dB* control at *O*, adjust *Output Level* control to give zero-level output.
4. Use switched meter to check that V1/V2 feed is still 16 mA.
5. Turn *Limiting dB* control to X dB and use amplifier-detector to check that output level is +X dB.
6. Slowly rotate *Limiting Level* control clockwise

until the onset of limiting becomes evident from a slight reduction of V1/V2 current indicated by switched meter.

This threshold condition should be achieved without any apparent change in the amplifier-detector reading. Leaving the *Limiting Level* control at the position obtained, and the Limiting dB control also at the X dB setting:

7. Check that relay RLA is not operated with the input at 0 dB but operates consistently for the particular input-level increase determined by the relay biasing-current adjustment; see information relevant to sensitivity, under heading 3.4.2 (*a*).
8. Restore *Limiting dB* control to *O* position.

3.5 Maintenance Data

3.5.1 D.C. Measurements

Measuring with an Avometer Model 40, the voltage across various resistors should be:

Resistor	*Voltage*	*Meter Range*
R11 (V3a cathode)	0·85 v.	12 v.
R44 (V3b cathode)	1·70 v.	12 v.
R27 (V5 cathode)	30·0 v.	120 v.
R31 (V6 anode)	50·0 v.	120 v.

Tolerance on these readings is ±20 per cent although for CV455 valves, especially V3b, there is a possibility that figures will marginally exceed the specified maxima. The few instances are more likely in later-produced equipments because the CV455 category now includes a valve type tending to slightly higher anode current than those which preceded it.

This comment applies also to the V4a and V4b. Their cathode currents, measurable with the switched meter, should be 6·8 mA ± 20 per cent and not mutually differ by more than 0·3 mA.

3.5.2 A.F. Test Conditions

These are:

Limiter input terminated with 600 ohms.

Output level measured into 600 ohms, using amplifier-detector.

Limiter gain of 0 dB.

Limiting Level control set so that limiting just occurs at +12 dB.

Note that test procedures refer to an equipment limiting at one level only, as above, but they are readily adaptable to circumstances where limiting is at other levels and the tabulated results sufficiently indicate the figures to be expected in that event.

3.5.3 Limiting Characteristics

Measure output levels while applying 1,000-c/s tone at different input levels and using various settings of the *Limiting dB* control, as follows:

Table 1

Tone Input Level (dB)	*Limiting dB Control at:*	*Output Level (dB)*
+4	0	+ 4
+12	0	+12
+12	2	+12 (−0 (+1
+12	8	+12 (−0 (+1·5
+12	16	+12 (−0 (+2

3.5.4 Frequency-response Characteristic

With *Limiting dB* control at *O* and using 1,000-c/s tone, check that the unit has a gain of 0 dB and just begins to limit with a +12 dB input.

Reduce tone-input level to −10 dB at various frequencies and measure output levels relative to that at 1,000 c/s. Results should be within the following limits:

Table 2

Frequency (c/s)	*Output Level (dB relative to 1,000-c/s level)*
40	−1·0 ±1·0
60	−0·4 ±0·4
10,000	−0·5 ±0·5
15,000	−1·0 ±1·0

Increase input level to +12 dB and set the *Limiting dB* control to *4* for a further check which should give values within the following limits:

Table 3

Frequency (c/s)	*Output Level (dB relative to 1,000-c/s level)*
40	+1·0 ±1·0
60	+1·0 ±1·0
5,000	−5·0 ±1·0
10,000	−10·0 ±1·5
15,000	−13·0 ±2·0

This table applies to equipments working with pre-emphasis of the side-chain input. Operating a LIM/6B without this feature, by shifting a link to the *AM* position, the measured values for the upper frequencies should be as for 40 c/s and 60 c/s.

3.5.5 Harmonic Distortion

Check with 1,000-c/s tone that the limiter is still balanced, that the gain is 0 dB and that limiting starts at +12 dB when the *Limiting dB* control is at *O*.

The following table specifies various conditions for measurements of total harmonic distortion and figures obtained should be better than those in Table 4.

3.5.6 Noise

Apply 1,000-c/s tone at zero level, and, with the *Limiting dB* control at *O*, measure the audio output across 600 ohms by means of a Test Programme Meter. With the TPM controls at *O* the reading should be 4.

Disconnect the tone input and adjust the TPM controls until the meter peaks to 6, and check that the *Hum Bal.* control is correctly adjusted. As read from the level controls of the TPM the signal-noise ratio should be better than 55 dB.

3.5.7 Relay Operation

For the reason given under 3.4.2(*a*) this check involves taking account of working with relay sensitivity either at maximum, requiring equal currents in both windings, or slightly reduced by having a smaller current in the winding associated with the *Rel. Bias* control.

Apply tone as for 3.5.6. Check with the switched meter successively at the *V1 and V2 ÷2* and *Rel. Bias* settings for readings of 16 mA and the value appropriate to the sensitivity condition, respectively.

Increase the tone-input level until limiting just occurs. With the maximum-sensitivity condition of relay RLA there should be consistent operation for a further input-level increase of 1 dB. Otherwise the larger increment required should correspond to a predetermined value relevant to the normal-working adjustment that has been adopted.

3.5.8 Listening Test

Inject programme at zero volume into the limiter and set the *Limiting dB* control to 8 dB. Spurious noises owing to limiting action should not be audible.

Table 4

Tone Input Level (dB)	*Limiting dB Control at:*	*Harmonic Distortion (dB) at*	
		90 c/s	*1,000 c/s*
0	0	−40	−55
+12	0	−40	−50
+12	+12	−40	−50
+12	+16	−35	−45

JR/0663.

COMPONENT TABLE: FIG. 3

N.B. Table refers to LIM/6B unit; see supplementary note.

Comp.	Loc.	Type	Tolerance per cent
AT1	D5	BBC PNN/4M3G	
C1	K4	T.C.C. SCE76PE/PVC	−20/+50
C2	K7	T.C.C. SCE76PE/PVC	−20/+50
C3	O4	T.C.C. CP35N/PVC	20
C4	P7	T.C.C. CM20N	20
C5	R7	T.C.C. CE180AAR/PVC	
C6	T7	T.C.C. CP35N/PVC	20
C7	C12	T.C.C. SCE77L/PVC	−20/+50
C8	M14	Hunt BM21KV	25
C9	P12	Hunt B501K	20
C11	N9	T.C.C. SM3N	5
C13	O3	Plessey CE809/1	−20/+50
C14	G12	Hunt BM1KV	20
C15	M8	Erie P100L	10
C16	Q3	Hunt BM21KV	20
C17	H2	Hunt B503K	20
C18	B11	T.C.C. CSM20N	5
C19	C14	Hunt BM15KV	20
LP1	T13	P.O. No. 2 (6V.)	
M1	V6	Turner Model 909, F.S.D. 1mA Scale 0/20 mA	
MR1	E12	Westinghouse W6	
MR2	E14	Westinghouse W6	
R5	F5	Colvern CLR1132/15S	10
R6	F4	Colvern CLR1132/15S	10
R7	H5	Painton P406A	1
R8	J4	Erie 100	2
R9	J6	Erie 100	2
R10	M6	Plessey CP.161101/213	20
R11	N8	Erie 109	2
R12	O3	Erie 9	2
R13	O7	Erie 109	2
R14	Q5	Erie 9	1
R15	R8	Erie 100	1
R16	R6	Erie 109	1
R17	Q8	Erie 100	1
R18	Q6	Erie 109	1
R19	Q8	Painton P406A	1
R20	R9	Painton P406A	1
R21	T2	Erie 109	2
R22	S5	Erie 9	10
R23	B11	Erie 8	10
R24	E14	Erie 9	10
R25	F11	Erie 9	10
R26	G11	Erie 9	10
R27	F14	Erie 9	10
R28	J13	Erie 9	10
R29	J10	Erie 9	10
R30	K11	Erie 9	10
R31	L11	Painton P306A	5
R32	L10	Painton P306A	5
R33	L15	Erie 9	10
R34	M14	Erie 9	10
R35	O14	Erie 9	10
R36	P12	Erie 9	10
R41	U12	Colvern CLR1132/15S	10
R42	M4	Erie 9	10
R43	A12	Plessey CP.161101/213	20
R44	B14	Erie 9	10
R45	G10	Erie 9	10
R46	J8	Erie 9	10
R47	N8	Erie 9	10
R48	P1	Erie 9	10
R49	N5	Erie 9	10
R50	M6	Erie 9	10
R51	A11	Erie 108	2
R52	A14	Erie 9	10
R53	M6	Erie 9	10
R54	D2	Erie 8	10
R55	E3	Plessey CP.161003/1380	20
R56	E2	Erie 8	10
R57	H2	Painton P406A	1
R58	G2	Erie 9	10
R59	H1	Erie 9	10
R60	M5	Erie 9	10
R61	T13	Painton MV1A	5
RLA	F3	Elliott R100B (Moving coil)	
SB	V6	N.S.F. DM 2p. 4 way (BBC Ref. EPA 8001)	
SC	F11	Painton No. 501404	
T1	B5	BBC LL/64SA	
T2	K5	BBC AGG/5SA	
T3	R2	BBC AAL/19-2P	
T4	D13	BBC AGG/5SA	

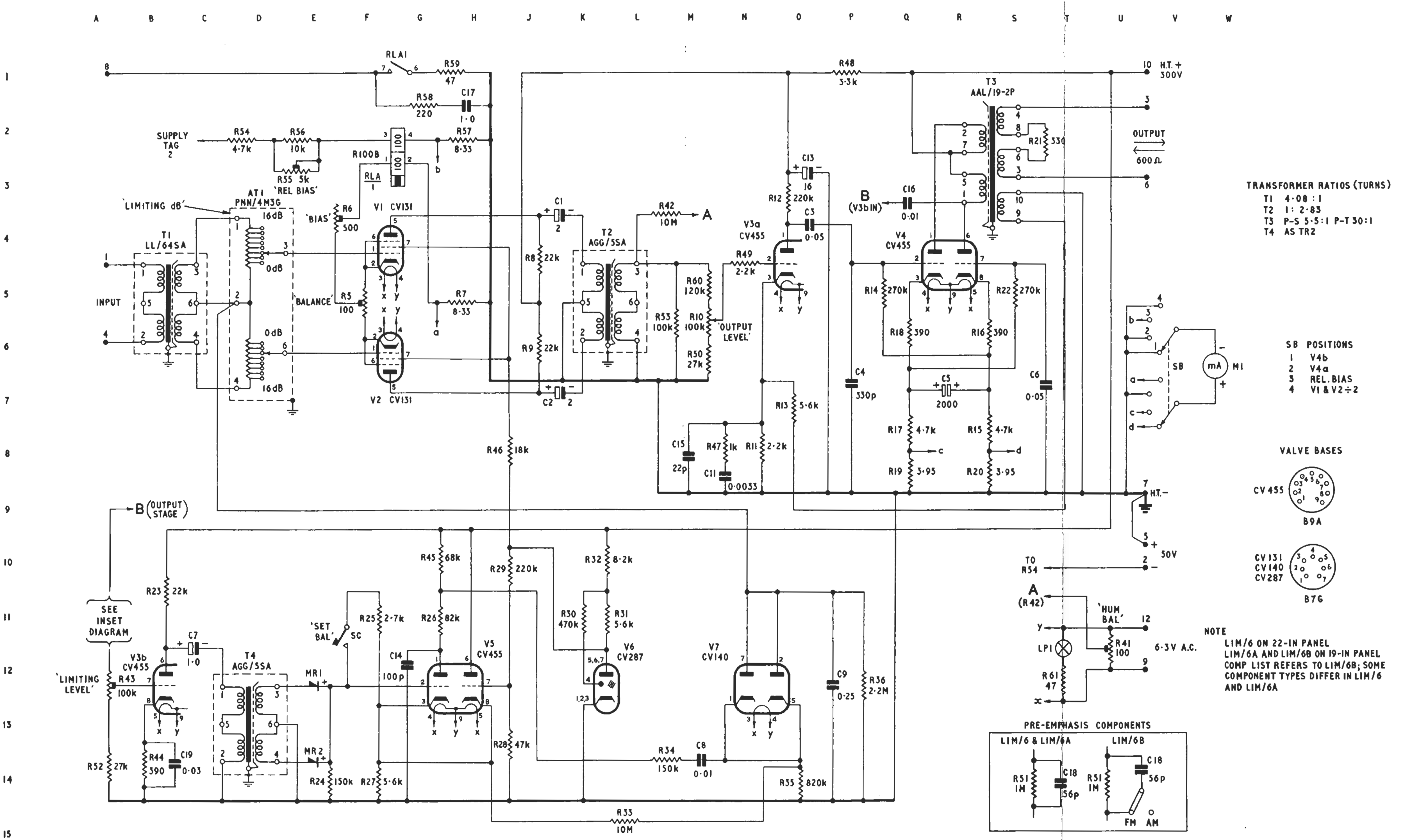
LIM/6 AND LIM/6A COMPONENTS

Installed equipments may incorporate a type-BBC/PNN/4M2 as the AT1 component. Additionally these earlier versions may contain a few capacitors and resistors that differ, owing to change in manufacture and/or type, from their counterparts in the preceding table.

62/JR/101/DJE
TTS 57/JR/108
(T10)

FIG 3

T1
SECTION 3



LIMITERS LIM/6 SERIES: CIRCUIT

LIM/6, 6A, 6B

APPENDIX A

OPERATING INSTRUCTIONS: LIMITERS LIM/6 AND LIM/6A

For their intended application at v.h.f. transmitting stations these equipments are normally set to limit at + 12 dB. Information below includes their adjustment for that condition and illustrates method if limiting at some other level is required. In this event the only change is substitution of the appropriate value for 12 in the itemised account of procedure.

(a) Supplies

These are connected to the unit through a 12-way miniature plug wired as follows:

Pins 10 (+) and 7 (– and earth) to 300-volt h.t. supply.

Pins 9 and 12 to 6·3-volt a.c. supply at 1·5 amperes (Centre-tap of this supply *must* be connected to earth).

Pins 2 (–) and 5 (+ and earth) to 50-volt d.c. supply.

(b) Alignment

(i) Bias Controls

With no audio input to limiter and switch SWB at setting marked V1 and V2 ÷ 2, adjust the Bias control so that meter reads 16 mA. Turn SWB to Rel. Bias position and note meter reading after Rel. Bias control has been adjusted so as to make the travelling contact of the moving-coil relay just touch the *unconnected* fixed contact. The indicated current should be 15 mA approximately. Note: This setting has been found preferable to one giving 16 mA through the relay-bias coil also, as it provides a greater margin against an effect of mains-voltage variation. With equal coil currents the operative contact should close for a tone input-level increase of less than 1 dB from the value at which limiting starts. An even smaller increase of input can result in limiting indication if subsequent to a setting-up operation a mains-voltage change causes the travelling contact to shift towards the connected fixed contact. Using unequal coil currents as above slightly reduces the high sensitivity of the system but also avoids a too-frequent signalling of limiting as the result of the effect described.

(ii) Balance Controls

Terminate the input and output circuits with 600 ohms, set Output Level control for maximum gain, and connect a Test Programme Meter to measure the audio output. Then adjust the Hum Bal. control for minimum deflection of the meter. N.B. This control will not operate correctly unless the heater supply centre-tap is earthed as noted above.

Leave test conditions as in previous paragraph, but also turn the Limiting Level control fully anti-clockwise, and measure output with a high-impedance amplifier-detector instead of the programme meter. Press the Set Bal. push-button repeatedly at intervals of not less than one second whilst adjusting the Balance control for minimum deflection on the amplifier-detector.

Set switch SWB to V1 and V2 ÷ 2 setting and, if necessary, readjust the Bias control so that meter reads 16 mA.

(c) Level Controls

Retaining the 600-ohm input and output terminations as above, and the high-impedance amplifier-detector for measurement, apply 1,000-c/s tone at zero level to the input. With the Limiting Level control fully anti-clockwise and the Limiting dB control at 0, adjust the Output Level control to give zero-level output.

Set switch SWB to V1 and V2 ÷ 2 position and check that meter M1 still reads 16 mA. Turn Limiting dB control to 12 dB, and check that output-level reading on the amplifier-detector is + 12 dB. Slowly rotate the Limiting Level control clockwise until meter M1 shows a slight reduction of current, marking the onset of limiting. For this threshold condition the output-level reduction by limiting should not be apparent from the amplifier-detector reading. Leave the Limiting Level control at the position obtained, and the Limiting dB control at 12 dB.

Check that relay A in the limiter is not operated with the input at 0 dB but operates consistently for the particular input-level increase as determined by the Rel. Bias adjustment; see note under Bias Controls heading. Restore the Limiting dB control to 0.

(d) Maintenance Instructions

(i) Voltage and Current Measurements

Voltages measured with a Model 40 Avometer across various resistors should be:

Resistor	Voltage		Meter Range
R11 (V3A cathode)	0·85 v.	± 20%	12 v.
R44 (V3B cathode)	1·70 v.	± 20%	12 v.
R27 (V5 cathode)	30·0 v.	± 20%	120 v.
R31 (V6 anode)	50·0 v.	± 20%	120 v.

The V4A and V4B cathode currents, as read with internal meter M1, should be 6·8 mA ± 20 per cent and not differ from one another by more than 0·3 mA.

(ii) Test Conditions

Input of limiter terminated with 600 ohms.
Output level measured into 600 ohms.
Limiter gain of 0 dB.
Limiting Level control set so that limiting starts at + 12 dB.

(iii) Limiting Characteristics

Using 1,000-c/s tone and measuring with the amplifier-detector, the following output levels should be obtained:

Tone Input Level (dB)	*Limiting dB Control Setting*	*Output Level (dB)*
+ 4	0	+ 4
+ 8	0	+ 8
+ 12	0	+ 12
+ 12	2	+ 12 { − 0, + 1 }
+ 12	8	+ 12 { − 0, + 1·5 }
+ 12	16	+ 12 { − 0, + 2 }

(iv) Frequency Characteristic

With Limiting dB control at 0, check that the unit has a gain of 0 dB, and that limiting starts at + 12 dB. Alter tone input-level to − 10 dB for various frequencies and measure output levels which, relative to that at 1,000-c/s, should be within the following limits.

Frequency (c/s)	*Output Level (dB relative to level at 1,000 c/s)*
40	− 1·0 ± 1·0
60	− 0·4 ± 0·4
10,000	− 0·5 ± 0·5
15,000	− 1·0 ± 1·0

Increase input level to 12 dB and set Limiting dB control at 4 for a further check which should give values within the following limits.

Frequency (c/s)	*Output Level (dB relative to level at 1,000 c/s)*
40	− 1·0 ± 1·0
60	+ 1·0 ± 1·0
5,000	− 5·0 ± 1·0
10,000	− 10·0 ± 1·5
15,000	− 13·0 ± 2.0

(v) Harmonic Distortion

Check that the limiter is still balanced, that the gain is 0 dB, and that limiting starts at + 12 dB when the Limiting dB control is at 0.

Measurements of total harmonic distortion for various conditions should give figures better than those tabulated below.

Input Level (dB)	*Limiting dB Control Setting*	*Harmonic Distortion at: 90 c/s*	*1,000 c/s*
0	0	− 40 dB	− 55 dB
+ 12	0	− 40 dB	− 50 dB
+ 12	12	− 40 dB	− 50 dB
+ 12	16	− 35 dB	− 45 dB

(vi) Noise

Set Limiting dB control at 0 and inject 1,000-c/s tone at zero level. Measure audio ouput across 600 ohms, using a Test Programme Meter with the controls set at 0; a reading of 4 should be obtained. Disconnect tone input and adjust controls of TPM until meter peaks 6, also checking that the Hum Bal. control is correctly adjusted. Signal-noise ratio as read from the TPM controls should be better than 55 dB. Restore the 1,000-c/s tone input at zero level.

(vii) Relay Operation

Under the non-limiting condition check that M1 reads 16 mA at the V1 and V2 ÷ 2 setting of SWB, and that the appropriate current is indicated at the Rel. Bias setting of the meter switch; see explanation under heading (*b*). Increase input level until limiting just occurs. Then check relay A for consistency of operation by further increase of input level as described under heading (*c*).

(viii) Listening Test

Conduct this test with programme applied at zero volume to the input, and with the Limiting dB control at 12. Absence of spurious noises due to limiting action is indicative of satisfactory operation.