SECTION 9

LIMITER LIM/2

Function

The function of the Limiter LIM/2 is to prevent the accidental overloading of a transmitter or recording apparatus. The chief advantage gained from the use of the limiter is the ability to maintain the mean programme level at a higher value than is possible with manual control. In other words, transmitters can be modulated to a greater mean percentage and recordings made with a higher signal-to-noise ratio without the risk of distortion on peak levels. Maximum permissible peak volume is normally 8 dB above programme line-up level. Under working conditions, the controls of the limiter are so adjusted that this maximum peak volume cannot be exceeded. In the case of transmitters—which are normally lined up so that normal programme volume produces 40 per cent, modulation—the effect of limitation is to prevent maximum modulation from exceeding 100 per cent. (See Engineering Training Manual, p. 212.)

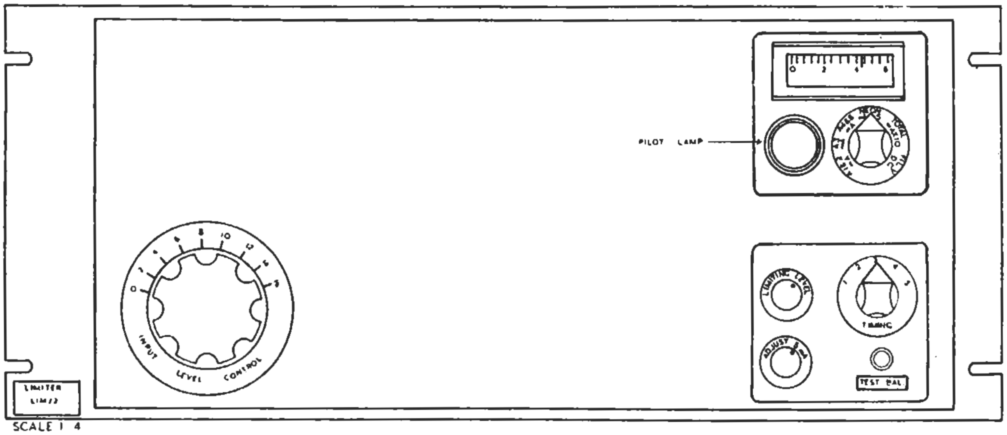

Fig. 9.1. Face Panel LIM/2

General Description

The LIM/2 was the first limiter to be put into general service and was developed from the experimental limiter, LIM/1.

It consists of a straightforward variable gain push-pull amplifier, preceded by a variable attenuator, and an associated side chain to provide the bias voltage for reducing the gain of the amplifier at excessive peak volume. When the variable attenuator is set at maximum loss, i.e., at zero position, the amplifier has zero gain. Variable-mu pentodes are used in the amplifier because the mutual conductance of this type of valve decreases smoothly (approximately exponentially) with increased bias and vice versa. The gain of the stage can be controlled by means of a d.c. bias potential. This potential is provided by the side-chain amplifier and is arranged to be proportional to the amount by which the output volume of the amplifier exceeds a predetermined maximum.

The action of the limiter may be described as follows :—

Referring to Fig. 9.2., when a signal e_s is applied to the input of the amplifier, a voltage V/n proportional to the input voltage, is developed across a tertiary winding on the output transformer T2. This voltage is applied to the side chain comprising an amplifier, control stage and rectifying stage. The control stage is normally biased back beyond cut-off point. If the signal e_s does not produce an output voltage greater than the permissible maximum value, the voltage V/n will not be great enough to counteract the cut-off bias of the control stage, and there will be no output from the side chain. If, however, the input signal causes the output voltage to rise above the permissible maximum, the value of V/n will be sufficiently high to operate the control stage, and a voltage proportional to the excess voltage will be passed through to the rectifier. This rectified voltage $-$ e,

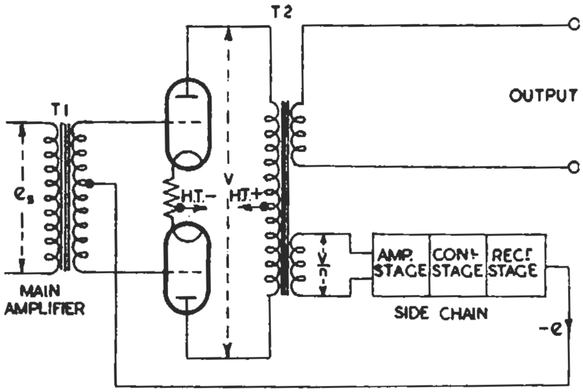

Fig. 9.2. Theoretical Circuit

will then be applied to the grids of the main amplifier valves in the form of negative bias, and the gain of that amplifier will be reduced, until the output falls below the maximum predetermined level.

If the output then remains below maximum for a considerable time (i.e., if no other excess voltage is applied to the input), the gain of the main amplifier is arranged to return slowly to normal. The speed at which the gain is restored after cut-back is adjustable by means of a timing switch, and it is upon the adjustment of this control that the behaviour of the limiter chiefly depends.

If the restoration time is very slow, the effect is that of an automatic maximum-level-setting device. If, however, the restoration time is comparatively quick, the effect is that of a compressor, cutting back the peak levels, and restoring the gain rapidly for the low-level intervals between the peaks. In certain circumstances, particularly when used on transmission channels subject to fading, the limiter is in fact used for compression. The degree of compression may be increased after line-up by adjusting the calibrated *Input Level Control* to a higher setting. This explains why in the earlier models of the LIM/2, this control is labelled *Compression Decibels.*

Unlike other types of compressor, the limiter does not introduce any noticeable harmonic distortion, except perhaps during the very short periods whilst the gain is being cut back. It should however, be understood that the rapidity with which the gain is cut back has been deliberately curtailed in the design, so that very sharp peaks in the programme will be passed on by the limiter at a level exceeding the predetermined maximum. These peaks will be of such a transient nature that the distortion produced will not be detected

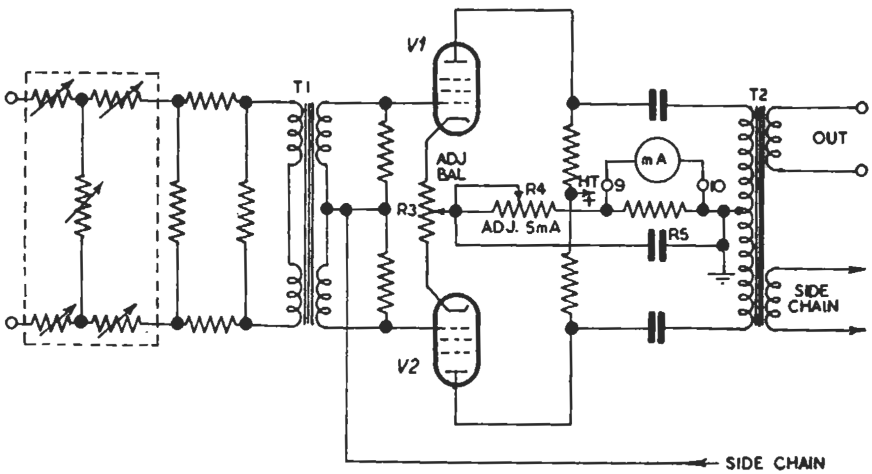

Fig. 9.3. Main Channel

aurally, and by allowing this condition, mean modulation can be maintained at a higher level than if the cut-back were instantaneous. In the case of certain transmitters, where it is highly undesirable that modulation should ever exceed the permissible maximum percentage, some form of peak limiter or chopper is included in the transmitter circuit.

Circuit Description (Fig. 25)

The circuit of the LIM/2 comprises two sections, viz. the amplifier proper, or *main channel*, and the *side chain*. These will be dealt with under separate headings.

(a) Main Channel (Fig. 9.3)

The main channel is designed to work between 600-ohm terminations and consists essentially of a balanced input attenuator, an input transformer, T1, two variable-mu pentodes, V1, V2, of the AC/VP2 type, connected in push-pull, and an output transformer, T2, having two secondary windings.

The bias is controlled by the side chain, as shown in Fig. 9.2, and it is important to realise that the bias control voltage may be many times greater than the input signal voltage. When a sudden application of control voltage is fed to the grids of V1, V2, a sudden change of anode current is produced and, unless the anode currents of the two push-pull valves are properly balanced, the sudden changes will give rise to considerable " plops " in the output. The setting of the adjust balance potentiometer R3 is therefore critical. The method of adjusting this balance is described under the heading Operating Instructions.

The two terminals, 9 and 10, shown in the circuit diagram are the limiter meter terminations on the main terminal block. In some cases a high speed limiter extension meter is inserted at this point, in series with the normal meter. It is important to remember that the normal limiter

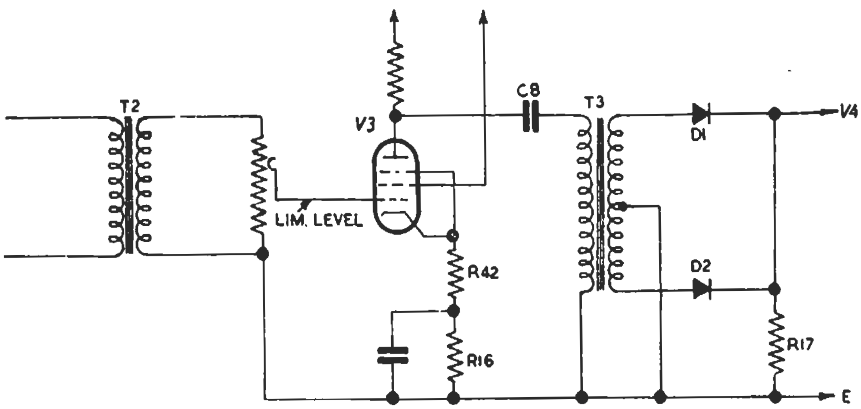

Fig. 9.4. Side Chain. Amplifier Stage

The input attenuator is divided into two sections, the first of which is the *Input Level* control and takes the form of a variable H-network. The second section is in the form of a fixed square-network and is included because the normal gain of the amplifier is greater than that required for working conditions. With the input level control set at zero (maximum loss) and no limiting taking place, the amplifier as a whole has zero gain.

Steady bias for V1, V2 is obtained from the resistor R3, the tapping point on which is made variable to obtain accurate balance, and also from the common cathode resistors, R4, R5 in series. Total cathode current is controlled by the adjustment of R4 and measured across R5.

meter also functions as the feed meter for other stages. When the limiter is in use, therefore, the meter switch must always be set at position 1 (or A1, A2) so that the meter will give an indication of the operation of the limiter.

(b) The Side Chain (Figs. 9.4, 9.5, 9.6)

The first part of the side chain consists of a single-stage amplifier, V3 (Fig. 9.4), the gain of which is controlled by the potentiometer labelled *Limiting Level*.

A small amount of current feedback is obtained from R42. This stage is followed by a full-wave rectifier, D1, D2, comprising two copper-oxide rectifiers Type WX6. The rectified output produces a ripple voltage across R17, which is applied unsmoothed and in a positive sense to the grid of V4 (Fig. 9.5).

This valve is already biased beyond cut-off point

When V4 operates, the amplified ripple voltage developed across R17 is passed through R24, C11 to V6 and charges up the 0·2-μF capacitor, C12 (Fig. 9.6).

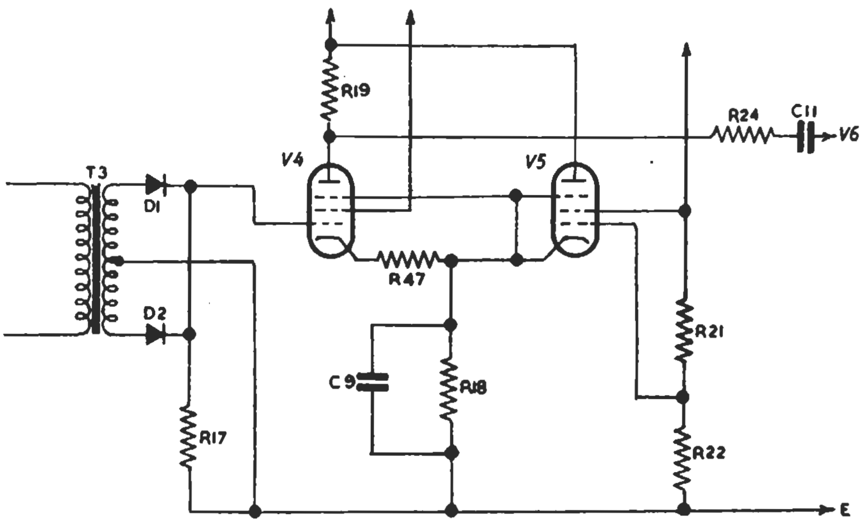

Fig. 9.5. Side Chain. Control Stage

by the voltage (approximately 20 volts) developed across R18, through which is passed the cathode current of V5. V4 passes no anode current until the bias on its grid is approximately − 3 volts. It therefore remains inoperative until the rectified signal exceeds about 17 volts peak value.

The reason for the inclusion of V5 in the circuit can be explained as follows :—

It has been stated that limiting does not take place until the signal voltage applied to V4 is sufficiently high to counteract the cut-off voltage developed across R18. If the limiting level is to remain constant for a given setting of the *Limiting Level* control, the voltage across R18 must not vary.

In the absence of some form of stabiliser, the pulsating d.c. voltages applied to V4 would, under operating conditions, cause variations in the cathode current and hence in the biasing voltage. V5, therefore, acts in the same way as a neon stabiliser and is used in preference to a neon because of its greater reliability. The circuit is so arranged that V5 passes maximum cathode current when V4 is inoperative. When V4 operates, the cathode current of V5 falls as that in V4 rises, so that the mean cathode current and hence the cut-off bias voltage remains constant.

It should be pointed out here that R24 increases the time taken for C12 to charge fully. This delay permits the passage of transient peaks through the main amplifier as previously explained.

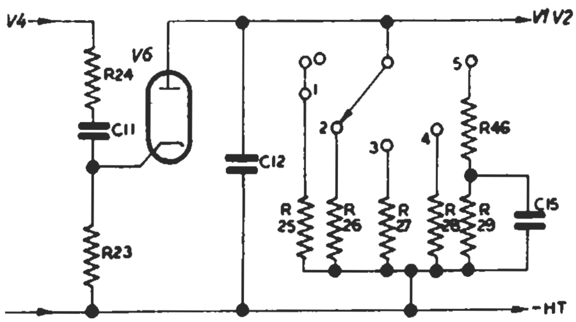

Fig. 9.6. Side Chain. Rectifier Stage

The resulting d.c. voltage obtained from C12 provides additional negative bias in the main amplifier valves V1 and V2, thereby reducing their gain. The capacitor discharges slowly through any one of the five resistors, R25 to R29, selected by the timing switch. Except in cases where compression is required, the timing switch is normally set to position 5. This position introduces a special discharge circuit designed to avoid the disastrous effect of, for example, a heavy drum beat occurring in the middle of a pianissimo orchestral passage. The effect of such a peak is to charge C12, which momentarily reduces the limiter gain but rapidly discharges via R46 into the large reservoir capacitor, C15. If a number of peaks occur in succession, C15, ultimately becomes charged and the limiter gain is therefore held down until this charge on C15 slowly leaks away through R29.

Stabilising Screen Grid Volts

A neon stabilising lamp is provided to maintain constant screen voltages of all valves irrespective of screen currents taken by V1, V2, V4 and V5. Difficulty may be experienced with the striking of the neon lamp, especially when the limiter is supplied from a mains unit and, to cover this, a special *Strike Neon* key is fitted. The operation of this key will cause the lamp to glow slightly, the lamp striking on the release of the key ; lamps which fail to strike should be rejected. When once struck, lamps will remain alight, provided their working voltage is sufficiently low, and will be practically unaffected by programme peaks.

Depression of the *Test Balance* key will reduce the lamp current and may extinguish a lamp whose working voltage is unduly high ; any lamps which behave in this way should be changed, as balancing cannot be carried out properly unless the lamps stays alight during the operation. In order to see whether the neon lamp remains alight, two view holes are provided through the main panel and one through the lower sub-panel. Provided the back cover is in position it is easy to see the lamp glow.

The type of neon originally fitted in the LIM/2 is being replaced by an alternative type (Cossor S130) which should overcome the troubles outlined above.

Operating Instructions

1. *Adjusting Amplifier Feed*

Switch on mains unit and allow one or two minutes for working conditions to become stabilised. Set the meter switch to position 1 and adjust the total cathode current for valves V1 and V2 to read 5 mA. Make this adjustment with no incoming signal and the *Timing* switch at the setting it is intended to use for the programme.

2. *Balancing*

This operation should only be necessary when (*a*) the equipment is first installed, (*b*) either V1 or V2 is changed, or (*c*) it is suspected that the characteristics of the valves have changed through ageing or other causes.

To obtain correct balance conditions, proceed as follows :—

(*a*) Adjust for *5 mA* as indicated under 1, and remove front cover.

(*b*) Set the *Limiting Level* control fully anticlockwise. (In this position the side chain is at maximum gain and full limiting action obtains.)

(*c*) Set the *Timing* switch to 1. (Minimum recovery time.)

(*d*) Plug headphones into *Check Balance* jack.

(*e*) Depress and release the *Test Balance* key repeatedly, at the same time adjusting the *Adj. Balance* potentiometer, R3, until the ' plops ' produced by the operation of the *Test Balance* key are reduced to minimum loudness. The correct condition will only be obtained by a process of elimination. Between successive depressions of the *Test Balance* key sufficient time should elapse for the feedmeter to be restored to 5 mA. When carrying out this operation, attention should be concentrated on the low-frequency component of the ' plop,' the residual high-frequency ' click ' being relatively unimportant.

3. *Lining Up*

Although the limiter can be arranged to operate over wide limits of programme level, the optimum level for operation is -23 dB. This condition is obtained, in the case of transmitting stations by the insertion of attenuators and a listener correction unit between the D-amplifier output and the limiter input. In the case of recording channels, the limiter is preceded by a fixed attenuator, the value of which is conditioned by the incoming programme level.

Since the circuits with which the limiter is associated vary considerably at different centres, it is not desirable that a standard line-up instruction should be given here. Detailed information is issued in the Station Instructions at those centres where limiters are employed.

Valve Data

Valve	*Anode Current mA*	*Screen Current mA*	*Fil. Volts*	*Fil. Amps.*
Stage 1, AC/VP2	2·0	0·5	4	1
Side Chain				
V 3, AC/SP3B RH	4·5	1·6	4	1
V 4, AC/SP3B RH	—	—	4	1
V 5, AC/SP3B RH	3·4	0·9	4	1
V 6, D/42	—	—	4	0·6

Total Feed, 26 mA, including neon.
H.T. Supply, 250 or 300 V.
L.T. Supply, 4 V a.c. or 6 V d.c.

General Data

Input Level Control

Type	*No. of Studs*	*Loss per Stud*
Painton PH/2G1	8	2 dB.

Meter. Elliott Miniature Edgewise. No. ED 1456.
Meter Switch. Yaxley Type A. 2-bank, 9-position.
Timing Switch. Yaxley Type B12. No. 5168.

Potentiometers

Adjust Balance.
Type : Morganite Stackpole MNAP 40150.
Resistance : 400 Ω.

Adjust 5 mA.
Type : Morganite Stackpole MNAP 10250.
Resistance : 1,000 Ω.

Limiting Level.
Type : Morganite Stackpole MNAP 10410.
Resistance : 100,000 Ω.

Pilot Lamp. P.O. No. 2, 4 V.

Impedances

Input Z = 600 Ω.
Output Z = 600 ,,
Normal Load Z = 600 ,,

Normal Working Levels

Input – 23 dB.
Output – 23 dB.
Normal Limiting Output, – 15 dB.

Test Data

Maximum Working Voltage Gain and 600-ohm Test Gain

Test Conditions :
V1, V2 feeds tested for Balance.
Feeds for V1, V2 adjusted to 5 mA.
Input Level Control set to Stop 16.
Limiting Level Control fully clockwise (non-limiting).
Tone Source Sending Level, – 23 dB.
Gain at 1,000 c/s, G = 16 dB.

Frequency-response Test

Test Conditions :
V1, V2 feeds tested for Balance.
Feeds for V1, V2 adjusted to 5 mA.

(*a*) Input Level Control set at minimum gain.
Tone Source Level adjusted so that no limiting takes place.
Gain at 50-10,000 c/s, ±0·5 dB relative to gain at 1,000 c/s.

(*b*) Input Level Control set for 14-dB limitation.
Timing Switch set to 1.
Gain at 50-10,000 c/s, ± 0·5 dB relative to gain at 1,000 c/s.

Total Percentage Harmonic Content

8 dB above normal working input and output levels.

	Without limitation	*15-dB limitation*	*20-dB limitation*
1,000 c/s	0·26	< ·25	< ·2

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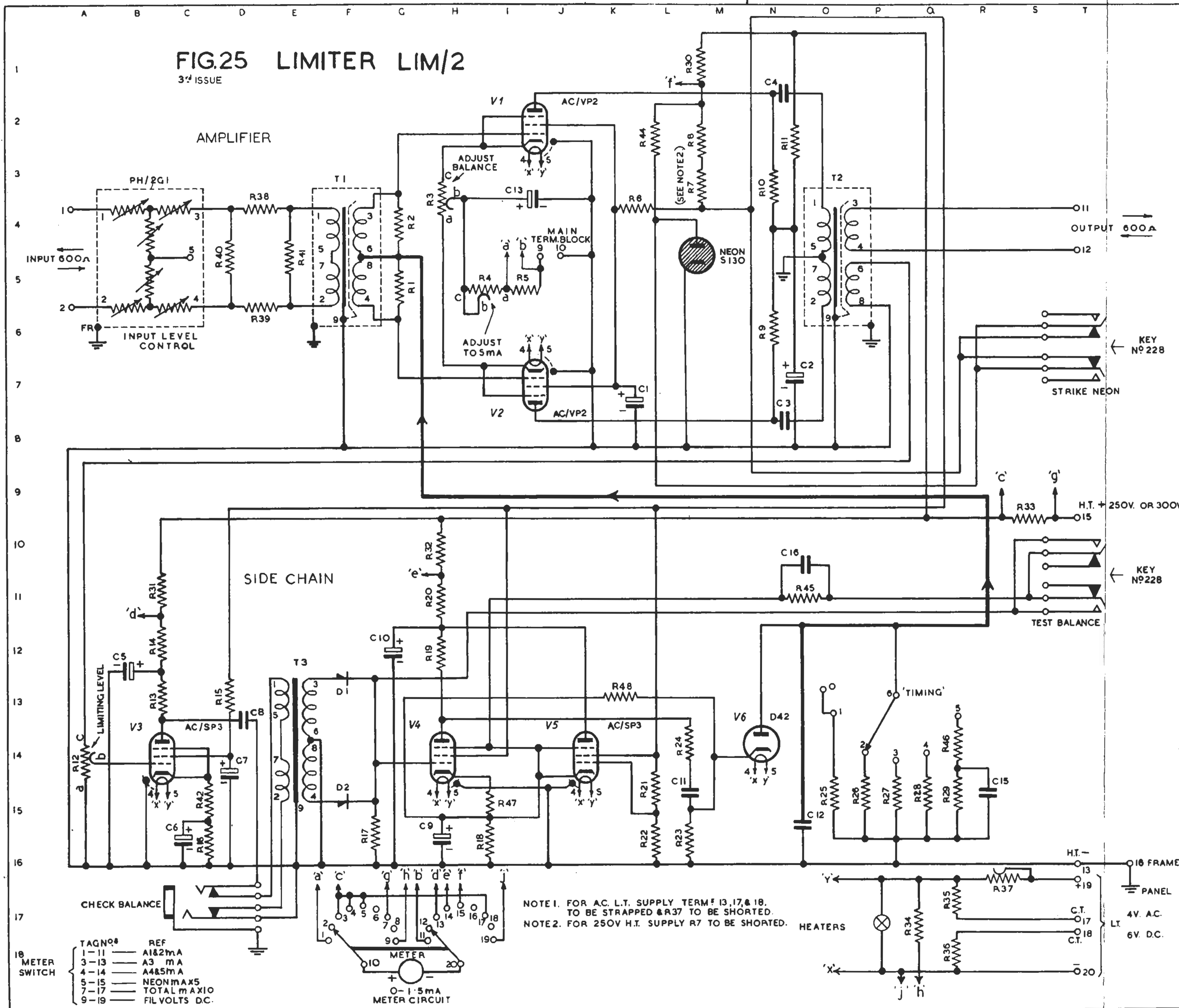
FIG.25 LIMITER LIM/2

3rd ISSUE



S3

COMP.	LOC.	VALUES	RATINGS
R1	G5	50K	0·25 W
R2	G4	50K	0·25 "
R3	H4	400	TYPE MNAP
R4	I5	1K	" "
R5	J5	33·3	RES.CARD
R6	K4	20K	1·0 W
R7	M3	4K	1·0 "
R8	M2	10K	2·0 "
R9	N6	20K	0·5 "
R10	N3	20K	0·5 "
R11	N2	20K	1·0 "
R12	A14	100K	TYPE MNAP
R13	C13	20K	1·0W
R14	C12	20K	1·0 "
R15	D13	20K	0·5 "
R16	C16	100	0·25 "
R17	G15	100K	0·25 "
R18	I16	5K	0·5 "
R19	G12	250K	0·5 "
R20	C11	20K	1·0 "
R21	L15	250K	0·25 "
R22	L16	50K	0·25 "
R23	L16	250K	0·25 "
R24	L14	47K	0·25 "
R25	O15	500K	0·25 "
R26	P15	2M	0·25 "
R27	P15	10M	0·5 "
R28	Q15	40M	0·5 "
R29	R15	2M	1·0 "
R30	M1	5·26	RES.CARD
R31	B11	33·3	" "
R32	H10	33·3	" "
R33	S10	2·56	" "
R34	Q17	3·9K	PAINTON
R35	Q17	10	RES.CARD
R36	Q18	10	" "
R37	R16	2	PAINTON
R38	D4	225	0·25W
R39	D6	225	0·25 "
R40	D5	1·8K	0·25 "
R41	E5	1·8K	0·25 "
R42	C15	150	0·25 "
R44	L2	250K	0·25 "
R45	O11	0·5M	1·0 "
R46	R14	0·5M	0·25 "
R47	I15	4·7K	
R48	K13	1·0M	0·5 "
C1	K7	16	MA15129
C2	N7	16	" 15129
C3	N8	2	TYPE 87
C4	N2	2	" 87
C5	B12	16	MA15129
C6	C15	250	" 14680
C7	D14	16	" 15129
C8	D13	0·5	TYPE 87
C9	H15	25	" C
C10	G12	16	MA15129
C11	L15	0·01	TYPE 431
C12	N15	0·2	" 87
C13	J3	250	MA14680
C15	R15	4·0	TYPE 87
C16	O10	0·05	
T1	F5	1:12·9	LGG/9RB
T2	O5	7·83:11·96:1	AAL/10RA
T3	F14	1:3·17	AGG/3RC
D1, 2	F13 F15	WX6	