TRIMAX LIMITING AMPLIFIER - TYPE A.30

1.0 DESCRIPTION:

1.1 Application: The Trimax limiting amplifier type A.30 has been designed for use in any A.M. or F.M. installation where it is desired to control the amplitude of audio frequency peaks. Its application for use with transmitters is mainly in the interest of preventing over-modulation on loud passages, thus avoiding the accompanying distortion and "splutter". The result of this correctly applied limiting action is the effective increase of power, due to the higher average modulation level.

The A.30 is also capable of providing equal satisfaction in recording equipment, and in high quality P.A. systems. In recording it regulates the cutting level, prevents inter-groove cutting, and improves the signal to noise ratio by raising the average power. In public address work, a limiting amplifier of this type is particularly suitable in overcoming the change of level caused by the speaker changing the position of his head with respect to the microphone. This, of course, also applies to broadcast use.

1.2 Characteristics: The limiting amplifier has been designed to perform with the utmost efficiency under all normal conditions of operation, and is rugged enough to withstand considerable abuse. It easily meets the most important requirements of any production: firstly, performance to comply with the specifications laid down for the instrument, secondly, reliability, and thirdly, ease of maintenance. These features are accompanied by wide frequency response, high controllable gain, instantaneous "attack" time, and automatically variable recovery time. Although an adequate compression ratio, or limiting control characteristic is essential, it is also necessary that the limiting characteristic is such that the change from "limiting" to "no limiting" conditions is very rapid and should preferably be accomplished with the programme level changes by 0.5 db or less. This result has been achieved in this instrument.

When considering signals or pulses, which are applied to an amplifier, and which require limiting, it should be noted that they may be of either positive or negative polarity, and since the primary aim of this instrument is to reduce the attack time to negligible portions, it is necessary that either positive-going or negative-going signals should actuate the limiter. For this reason push-pull control circuits and control pulse rectification are essential.

The circuit has also been designed in such a manner that elaborate power supplies are unnecessary with a consequent saving in both initial cost and complexity of operation and maintenance.

1.3 Specification:

Frequency response:	30 - 10,000 cycles ± 1.0 db.
Input impedance:	600 ohms.
Source impedance:	600 ohms.
Output impedance:	600 ohms.
Load impedance:	600 ohms.

Input level at commencement of limiting:	Less than - 28 dbm.
Input level:	- 12 db max.
Output level:	+ 24 db max.
Distortion:	Less than 4% at + 24 dbm.
Overall gain:	56 db + 4/-2 db.
Gain control:	11 steps each 2 db.
Attack time:	Less than 100 micro-seconds.
Recovery Time:	Variable - see paragraph 2.4
Limiting rise:	Output does not increase by more than 3 db for 16 db of limiting, and the variation for 12 db of limiting is approximately 1 db.
Noise:	More than 55 db, below + 24 db.
Controls - front panel:	Metering switch, gain control, and limiter check switch; inside chassis, R.46 limiter calibration control.
Metering circuits:	All tube cathodes, limiting action, and limiting check are selected by means of S.1 metering switch.

Tube Complement:

V1	6J7G/1620	First amplifier tube.
V2	6SN7GT	Limiter Tube
(V3 & (V4	6SJ7GT	Push-pull voltage amplifiers
V5	6SN7GT	Push-pull output tube.
V6	6SN7GT	Push-pull control amplifier tube.
V7	6SN7GT	Push-pull cathode follower control driver tube.
V8	6X5GT	Control Rectifier.
V9	0D3/VR.150	Regulator tube.
	5V4G	Power supply rectifier.

Rack dimensions: The limiter unit A.30 occupies 6 rack units (10½")
The power supply type S.26 occupies 3 rack units (5¼")

2.0 PRINCIPLES OF OPERATION:

2.1 Time delay circuit: Since all limiter devices depend on the charging of a condenser, some time must elapse before limiting can take place. This is because the time constant, T = CR, cannot be zero unless R is zero when C has a finite value. Since it is impossible to obtain this condition of R = zero, and only to approach it with considerable difficulty, some other means must be utilized to achieve the desired result. We will consider the amplifier in two parts, firstly the control circuits and secondly the signal channel. The signal after being fed through the screened and balanced input transformer is amplified by V1 and passed to these two channels.

Consider now what happens in the control channel. The signal is further amplified, and converted to push-pull, by

means of the amplifier tubes V6A and B, and passed to the rectifier. This develops the limiting pulse, which is "positive going".

Now return to the signal channel. This signal is passed through the transformer T2 on its way to the limiter tube. The control pulse, having been delayed by the time constant of the rectifier circuit, could not actuate the limiter tube by the time the pulse, through the signal channel, has reached the limiter. Thus, portion of the signal, which should have been limited, breaks through before the limiting action commences. The resultant over-modulation or over-cutting as the case may be, although of short duration, is still serious. However, by inserting a time delay network between T2 and the control tube V2, the signal may be sufficiently delayed so that the limiting takes place simultaneously with the arrival of the signal. For an ideal case the attack time is thus zero, but in the practical case, due to the complexity of a time delay of sufficient length, the attack time will have a small value, which in this limiter is kept to 50 micro-seconds or less. Thus, no pulse except one having a very steep "front" can break through the limiter, and being of such short duration, should not be of consequence.

2.2 Cathode follower limiter: Limiters usually have three general methods of operation. These are (a) use of variable-mu tubes, (b) variable negative feed-back, and (c) bridged networks. The first method results in severe distortion, and even more serious inter-modulation, due to the curvature of the valve characteristics. The second suffers from the difficulty that the frequency response and the amount of distortion in the output may vary with the changing of the feed-back. In the third case, it is difficult to achieve quick changeover from limiting to non-limiting conditions, and also keep distortion low.

Perhaps the most linear use of a vacuum tube, is as a cathode follower. In the A.30 this application has been used. A valve acting as a cathode follower presents an output impedance of approximately $R = \frac{1}{Gm.}$. The mutual conductance, G_m, is a function of the grid-cathode voltage, hence the controlling pulse effectively alters the impedance presented by the tube, by changing the static grid cathode voltage. The tube V2 is so operated that up to the limiting point it is drawing only a very slight current and thus has relatively high resistance. Consider now a fixed resistance (R21,R27) in series with the variable impedance offered by this tube (V2 in the circuit). By potentiometer action, the output voltage between R21 and R27 will change according to the variation in output resistance of V2 caused by the control voltage. Since both R21 and R27 and the output impedance of the tube are of low resistance, this voltage deviation will not be accompanied by frequency distortion, a common fault in potentiometers. For this reason, a cathode follower is used in preference to the anode resistance variation of a triode. Since only a linear device is used, this system is virtually distortionless.

2.3 Control Circuits: As was emphasised in paragraph 2.1, R in the formula T = CR should be kept as small as possible in order to keep T small, C being assumed fixed. The anode impedance of a triode is in the vicinity of

10,000 ohms and C usually of the magnitude of 0.01 mfd. This gives a time constant of 100 micro-seconds. Since it is necessary to use push-pull control drivers, the charging impedance becomes 20,000 ohms, plus resistances in the rectifier. In the A.30, to keep these charging resistances to a minimum, push-pull cathode-followers V7A and B are used after the control amplifiers V6A and B, in order to keep the charging resistance in the region of 1000 ohms total. By the use of a low impedance rectifier, V8, a very quick attack is achieved, and when combined with the time delay circuit of paragraph 2.1, operation times of less than 100 micro-seconds occur at all frequencies between 20 cycles and 13.5Kc. Since this attack time is negligible, it is unnecessary to incorporate in the instrument a variable method of controlling the attack time, thus simplifying the controls.

2.4 Automatic recovery time: One adjustment, perhaps the least satisfactory, of most limiters, is that of recovery time. A control, or sometimes two controls, are usually incorporated which must be manually adjusted to suit the programme being presented. This entails considerable supervision, and results, at the best, in a compromise, since programme material is rarely constant for any length of time. In this limiter, a system has been incorporated whereby the recovery time varies automatically with the programme material. The recovery from a single short limited peak is instantaneous, but where a number of peaks of considerable amplitude occur in succession, recovery time is considerably increased. With heavily limited programmes, delays of up to 5 seconds may occur, but this will not affect operation after the programme has temporarily ceased, or dropped below the limiting level. This feature allows programme material such as strings, tympani and piano to be reproduced with startling realism, an extremely difficult achievement when manual adjustments of the recovery time are made. Speech is also reproduced with maximum intelligibility.

3.0 OPERATION:

3.1 Metering of Cathodes: The cathode current of each valve is metered by means of the direct reading meter on the front panel, and selection is by switch S.1. Where dual valves are used, both cathodes are metered where practicable. This is useful in keeping the tube balanced, which, though not strictly necessary, greatly assists in operation by cancelling even harmonic distortion, and is specially beneficial in the case of V3 and V4, whereby "thump" is also minimised.

This does not mean that "thump" will become audible, if V3 and V4 are unbalanced. In fact, limiter tubes, having twice the thump output mentioned in paragraph 3.4 below could be used without producing audible thump, but where tubes are unbalanced, examination with a synchronized, low-speed, single-stroke-time-base oscilloscope will show thump by displacement of the trace.

3.2 Metering of Limiter tubes: In position marked "LIM" the meter reads the cathode current of the limiting tube, V2, and has been calibrated to give an indication of the amount of limiting taking place at any instant. Degrees of limiting from 0 to 16 db are indicated on the top of the scale. This more than covers all

usual requirements. It is emphasised that the meter is not dynamically stabilised, and should not be used as a volume indicator in this function, but merely to indicate, when and by how much, limiting is taking place.

3.3 Gain Control: A balanced gain cortrol having 11 steps of 2 db each is incorporated in the instrument and allows the output to be set at the desired figure (from +2 to +24 dbm).

3.4 Selection of limiter tubes: All limiters suffer from the necessity of overcoming "thump" introduced by the control tubes. With most limiters a complete balancing procedure is often necessary, both for static and dynamic conditions. In the A.30 the circuit has been so designed that this balancing procedure has been largely eliminated. However, in order to maintain "thump" at a minimum, a method of selecting limiter tubes has been incorporated in the A.30. Should the limiter valve require replacing, it is necessary to check the setting of the zero position on the limiting scale of the meter. To do this, set the meter switch to "LIM" while operating the unit with NO signal, and adjust the potentiometer R.46, until the meter reading shows exactly zero on the limiting scale. Access to R.46 is obtained by opening the hinged panel. The limiting calibration will now be correct for the new tube.

Next turn the switch S.1 to position marked "CHK" and press the white button on the front panel. If the meter does not pass the red mark on the lower scale, the tube is acceptable but tubes which give an output greater than this value should be rejected. It is found in production that more than 75% of valves type 6SN7GT satisfy this requirement. This test should only be carried out when the limiter is disconnected from the programme equipment, for otherwise up to 5 volts of 50 cycles a.c. may be injected into the output line, when the limiter check button is pressed. Noise may be caused by heater cathode leakage in the 6X5GT and this should be checked before replacing limiter tube.

3.5 Maintenance: The Trimax A.30 has been constructed with carefully selected and tested parts, and close tolerances have been employed wherever advantageous. A long trouble free life can be expected, but should faults occur, the unique construction (incorporating as it does a hinged front panel, and vertical strips) makes maintenance less arduous. All strip mounted components are marked with their circuit number, and major components have numbers fixed to them or placed close by. Should a condenser have to be replaced, care should be exercised to see that the "earth" or "negative end" is connected as in the original construction.

3.6 Cathode currents: Average cathode currents for the valves in the limiter are as follows:

V1	2.0
V3 and V4	1.7
V5	5.5
V6	1.0
V7	1.0

4.0 POWER SUPPLY:

4.1 Performance of power supply: The power supply provided with this amplifier is a separate unit and is equipped with a pilot light. It has the following output voltages and currents. 300 volts, 100 milliamp d.c., 6.3 volts 4 amps a.c. It is designed to operate from 200 to 250 volts 40-60 cycles supplies, and incorporates the "Trimax" tap-changing fuse-holder. Consumption is 74V.A., 64W.

4.2 Purpose of power supply: The power supply type S.26 which is used with this limiting amplifier is a standard type which is also supplied for use with type "F" amplifiers. Since the number of the latter may vary, being either 4, 8 or 12 amplifiers, three taps are provided in the power supply output to adjust the voltage to the correct figure. When used with the A.30 the supply is taken from the terminal marked "12".

4.3 Location of power supply: The power supply should preferably be located at a distance of two feet or more from the limiter in the equipment rack. Should this not be readily possible mounting adjacent to the limiter will cause only a slight increase in the noise output.

PARTS LISTS - LIMITING AMPLIFIER - TYPE A.30

R1	100 K	ohm	1/2 watt	I.R.C.	10%
R2	1 K	"	"	"	"
R3	1 K	"	"	"	"
R4	11.1	"	"	"	5%
R5	300 K	"	"	"	10%
R6	100 K	"	"	"	"
R7	25 K	"	"	"	"
R8	250 K	"	"	"	"
R9	1 meg	"	"	"	5%
* R10	120 K	"	"	"	"
R11	11.1	"	"	"	"
R12	25 K	"	"	"	10%
R13	3 K	"	"	"	"
R14	25 K	"	"	"	"
R15	11.1	"	"	"	5%
R16	1 meg	"	"	"	10%
R17	100 K	"	"	"	"
R18	1 meg	"	"	"	"
R19	2.5K	"	"	"	"
R20	100 K	"	"	"	"
R21	5 K	"	"	"	5%
R22	300	"	"	"	"
R23A	11.1	"	"	"	"
R23B	11.1	"	"	"	"
R24	33	"	"	"	"
R25	2.5K	"	"	"	10%
R26	100 K	"	"	"	"
R27	5 K	"	"	"	5%
R28	300	"	"	"	"
R29	1 meg	"	"	"	10%
R30	10 meg	"	"	"	"
R31	50 K	"	"	"	"
R32)	Attenuator, Trimax type Y25P				
R33)					
R34	10 meg	ohm	1/2 watt	I.R.C.	10%
R35	15 K	"	1 watt	"	"
R36	50 K	"	1/2 watt	"	"
R37	11.1	"	"	"	5%
R38	11.1	"	"	"	"
R39	200 K	"	"	"	10%
R40	500 K	"	"	"	"
R41	100 K	"	"	"	"
R42	100 K	"	"	"	"
R43	5 K	"	20 watt	"	5% Type D.G.
R44	15 K	"	"	"	" " "
R45	5 K	"	"	"	" " "
R46	500	"	Marquis potentiometer		
R47	500 K	"	1/2 watt	I.R.C.	10%
R48	11.1	"	"	"	5%
R49	1 K	"	1 watt	"	10%
R50	11.1	"	1/2 watt	"	5%
R51	500 K	"	"	"	10%
R52	75	"	1 watt	"	5%
R53	4 K	"	1/2 watt	"	"
R54	25	"	"	"	10%
R55	25	"	"	"	"
R56	750	"	"	"	"
R57	1,000	"	"	"	"

T1	Trimax Type	MS82
T2	" "	TA82
T3	" "	TZ286
T4	" "	TA931

PARTS LIST (Contd.)

* C1	.008	uf	400	volt	Mica T.C.C. 5%	
C2	100	"	40	"	Electrolytic	
C3	.25	"	400	"	Paper Technico	
C4	8	"	525	"	Electrolytic	
C5	.25	"	400	"	Paper Technico	
C6	.01	"	"	"	"	"
C7	.05	"	"	"	"	"
C8	.05	"	"	"	"	"
C9	2	"	200	"	"	Ducon 10% type PST.60
C10	2	"	"	"	"	" 10%
C11	.05	"	400	"	Technico	
C12	.05	"	"	"	"	
C13	.5	"	200	"		
C14	.01	"	400	"	Paper Technico	
C15	.05	"	"	"	"	"
C16	.05	"	"	"	"	"
C17	.1	"	"	"	"	"
C18	.5	"	200	"	"	"
C19	.5	"	400	"	"	"
C20	.002	"	"	"	"	"
C21	.05	"	"	"	"	"
C22	.05	"	"	"	"	"
C23	24 mfd. 350 V.W. Electrolytic.					

SW1 2 Bank 11 position single pole Oak switch
SW2 Push button - Federal.

M1 .0 - 1 ma meter scaled 0 - 10 ma and 0 - 16 db. lim. Radio Equip. 100 ohm.

X1 1 ma 1/2 wave metal rectifier to stand 10V.

VALVES:

V1 6J7/1620
V2 6SN7GT
V3 6SJ7GT
V4 6SJ7GT
V5 6SN7GT
V6 6SN7GT
V7 6SN7GT
V8 6X5GT
V9 0D3/VR150

* NOTE: R10 and C1 may vary from values stated, to suit individual amplifiers.

AC POWER CONVERTED TYPE S.26 PARTS:

TP ABAC TP.1540 power transformer
T " TZ.3 filter choke
R1 10,000 ohm 1 watt metallised resistor
R2 10,000 ohm 1 " " "
R3 10,000 ohm 1 " " "
R4 10,000 ohm 1 " " "
R5 400 ohm 3 watt wire wound "
R6 2000 ohm 3 " " " "
C1 12 mfd Electrolytic 525 PV
C2 12 " " " "
F ABAC voltage tap and fuse holder
V 5V4G valve.

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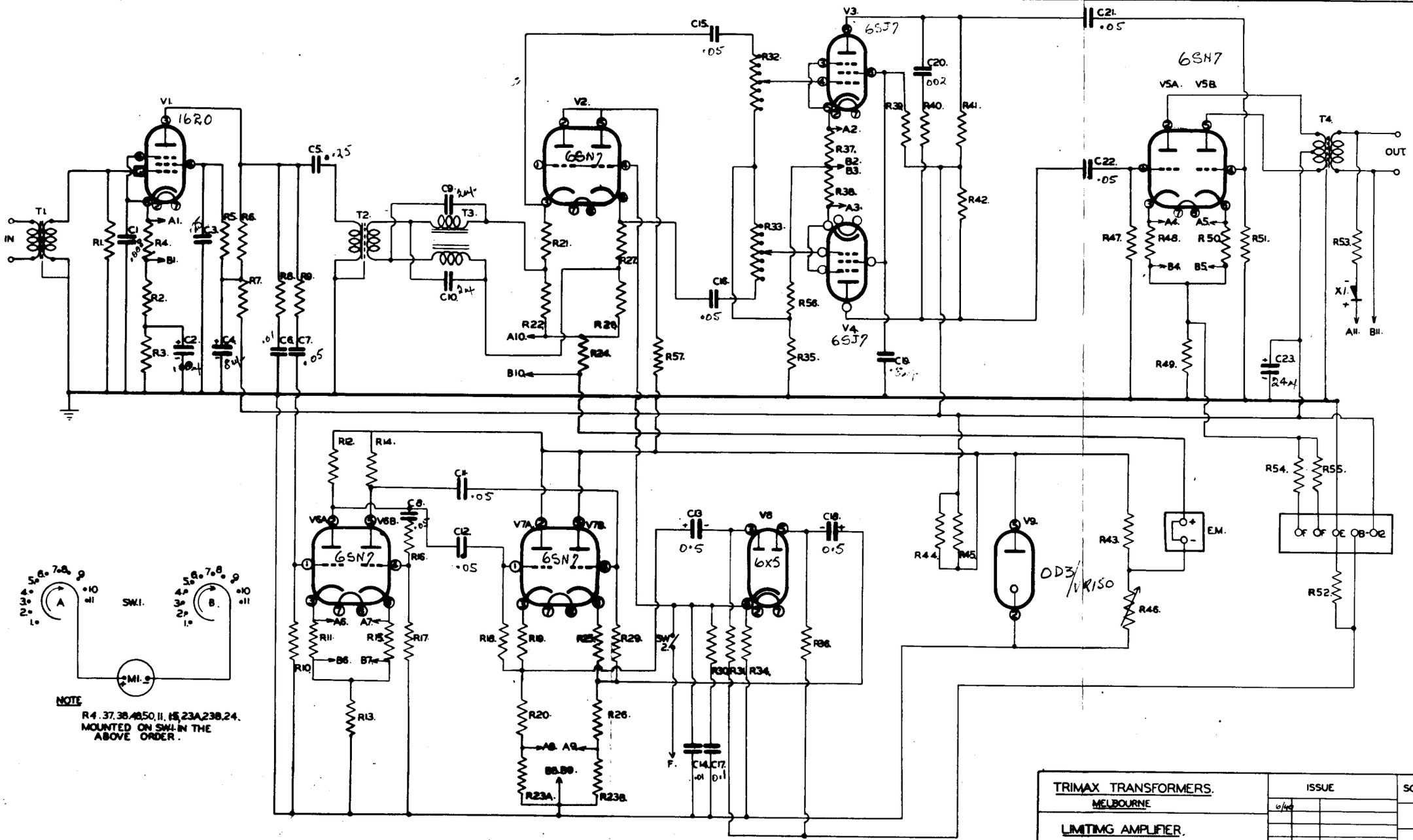
R1 R4. R2. R3. R5. R6. R7. R8. R9. R10. R11. R12. R14. R13. R15. R16. R17. R18. R19. R21. R20. R22. R23A. R24. R25. R27. R26. R28. R23B. R29. R57. R38. R31. R32. R33. R34. R35. R37. R56. R38. R36. R39. R40. R41. R42. R44. R45. R47. R43. R46. R48. R50. R51. R54. R55. R52. R53.

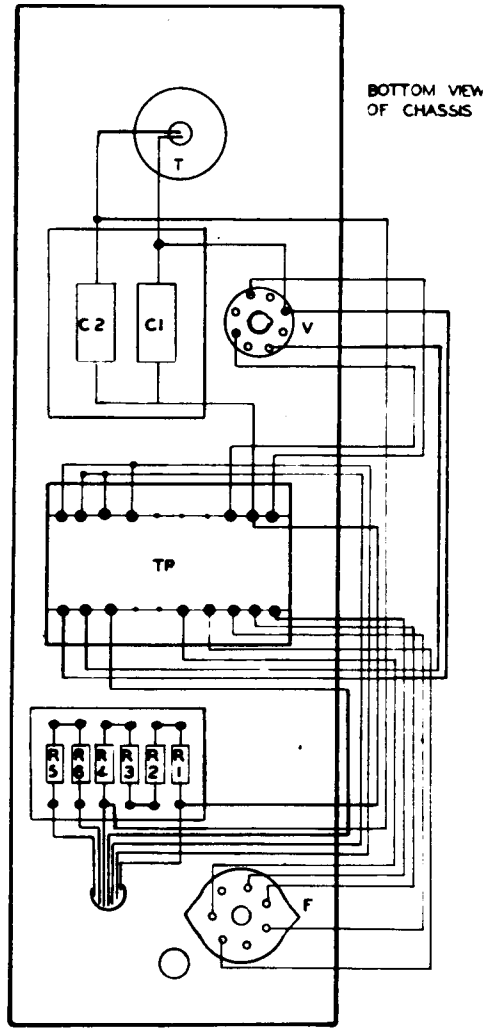
C1. C2. C3. C4. C6. C7. C5. C9. C10. C11. C12. C13. C14. C15. C16. C17. C18. C19. C20. C21. C22. C23.

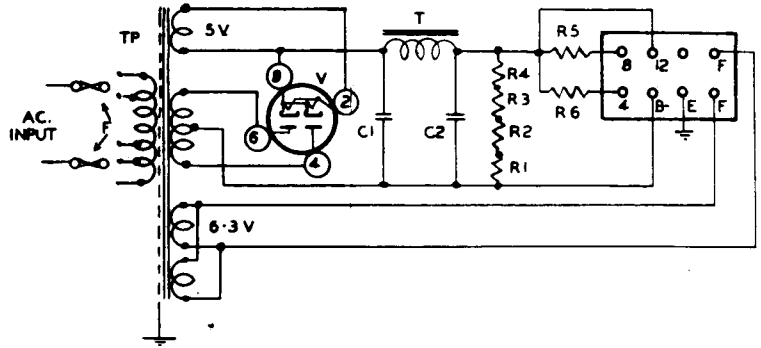


NOTE

R4. 37. 38. 48. 50. 11. 15. 23A. 23B. 24. MOUNTED ON SW1. IN THE ABOVE ORDER.

TRIMAX TRANSFORMERS. MELBOURNE	ISSUE	SCALE.	DRAWN. CHECKED.
LIMITIMG AMPLIFIER. TYPE. A.30.	6/48		K.W.
		DRAWNING NO. E63	
		SHEET. 1.	





R		R1-2-3-4	R5 R6
C	C1	C2	

TRIMAX TRANSFORMERS MELBOURNE	ISSUE		SCALE	DRAWN / CHECKED
TYPE 'F' AMP POWER CONVERTER — "ABAC" S26	2	10-48		K.W.
				DRAWING No. E53