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Technological Report No. L-063

(1965/47)

D. Maurice

D.W. Stebbings, B.A.

for Head of Research Department

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SUMMARY

The 'Volumax' limiter is an automatic gain regulating device for controlling the programme input to a transmitter; it is claimed that it will maintain a high average programme level while preventing overmodulation.

The limiter has a slower attack time and a faster recovery time than the corresponding Corporation equipment, and relies on a built-in peak clipper to prevent momentary overmodulation. The performance of the 'Volumax' limiter shows no advantage over that obtainable from a limiter and clipper of the present type.

1. INTRODUCTION

The 'Volumax' limiter is manufactured by C.B.S. of America, who describe the design as a fresh approach to the problem of controlling programme signals to a specified crest value without unnecessarily lowering the average signal level. A special feature claimed for the instrument is that the effective attack time can be either long or short according to the duration of the signal peak to be suppressed. To this end, the attack time of the limiter proper is made rather longer than usual to avoid gain reduction being produced by peaks of very short duration. As these peaks, if allowed to pass, could overload the transmitter, a clipper is provided to restrict the crest value of the outgoing signal, and the references in the manufacturer's instructions to high speed operation on short peaks evidently relate to the action of this part of the circuit. The components of the clipper are encapsulated in a plug-in unit, internal details of which are not disclosed. Provision is made for clipping on both halves of the signal wave or on one half only, the latter condition being sometimes required at A.M. transmitters; this facility may account for the plug-in unit being described by the manufacturers, not as a clipper, but as a 'Polarity Sensor'.

2. DESCRIPTION

Fig. 1 shows the circuit of the 'Volumax' limiter. Transistors Q2 and Q3 form a push-pull input amplifier, whilst diodes D7, D8, D9 and D10, whose impedance varies with applied bias current, provide the variable-loss elements and transistors Q4 and Q5 constitute the push-pull stage following them. The output amplifier consists of transistors Q6, Q7, Q8 and Q9.

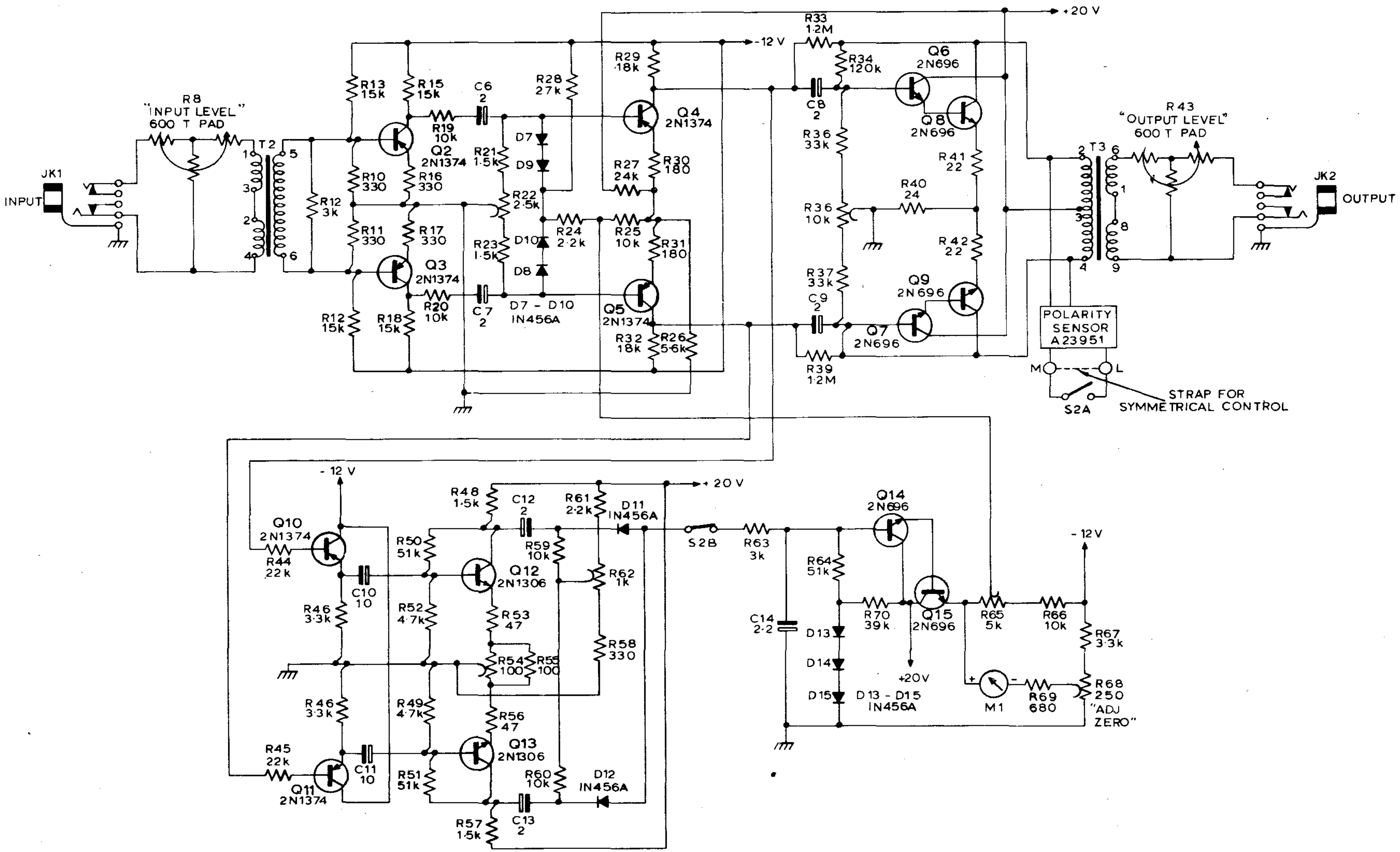

Fig. 1 - 'Volumax' limiter circuit

The control chain is supplied with signals taken from the output of Q4 and Q5. It consists of a push-pull amplifier made up of transistors Q10, Q11, Q12 and Q13, whose output is rectified by diodes D11 and D12, followed by a low output impedance d.c. amplifier stage Q14 and Q15 which produces the control bias for the variable-loss diodes. Balance adjustments for the transistor pairs Q4, Q5 and Q6, Q7 are effected by R22 and R36 respectively.

The meter M1 gives an indication proportional to the control current applied to the variable-loss diodes and thus indicates the amount of gain reduction produced by the limiter. The scale is divided into two equal parts, coloured green and red, indicating respectively 'normal' and 'excessive' gain reduction. According to the manufacturer's instructions the indication of the gain reduction meter on programme should lie in the green area for most of the time with only occasional excursions into the red area.

For level control on recording systems or F.M. transmitters, points M and L are connected together giving both positive and negative peak clipping; with these two points disconnected clipping takes place only on one polarity of the signal. To facilitate adjustment of the clipping level, the control chain of the limiter can be disconnected by operating switch S2B.

3. STATIC CHARACTERISTICS

3.1. Input/Output Characteristic

In accordance with the manufacturer's instructions, the limiter was lined up by applying a 1 kc/s input signal at a level of +8 dBm, the push-pull amplifier stages being individually balanced by adjusting R22, R36 and R54 for minimum distortion. With the same signal level, the input attenuator R8 was adjusted to the point at which clipping of the output signal waveform was just apparent on a C.R.O.; finally the output signal level was adjusted by attenuator R43 to +8 dBm.

After the lining up process, the static input/output characteristic of the limiter was measured with the clipper circuit temporarily disconnected. The result is shown in Fig. 2, on which are also marked the signal levels at which clipping commences; it will be seen that there is a slight disparity between the clipping levels for the two halves of the wave, but there is no adjustment by which this could be corrected.

It will be noted from Fig. 2 that gain reduction begins at an output level some 4 dB below that at the prescribed maximum set by the clipper, and that the upper part of the characteristic has a slope corresponding to a compression ratio of about 1 to 4 (compared with 1 to 20 or more for limiters in current use by the Corporation). This form of characteristic is not advantageous when the highest possible average modulation is required.

The gain reduction meter was found to give a mid-scale reading when the input to the limiter was +4 dBm; it will be seen from Fig. 2 that in these circumstances the gain reduction was about 4 dB. The meter, however, is not of the fast-acting type, and the degree of gain reduction on programme is likely to be greater than that indicated.

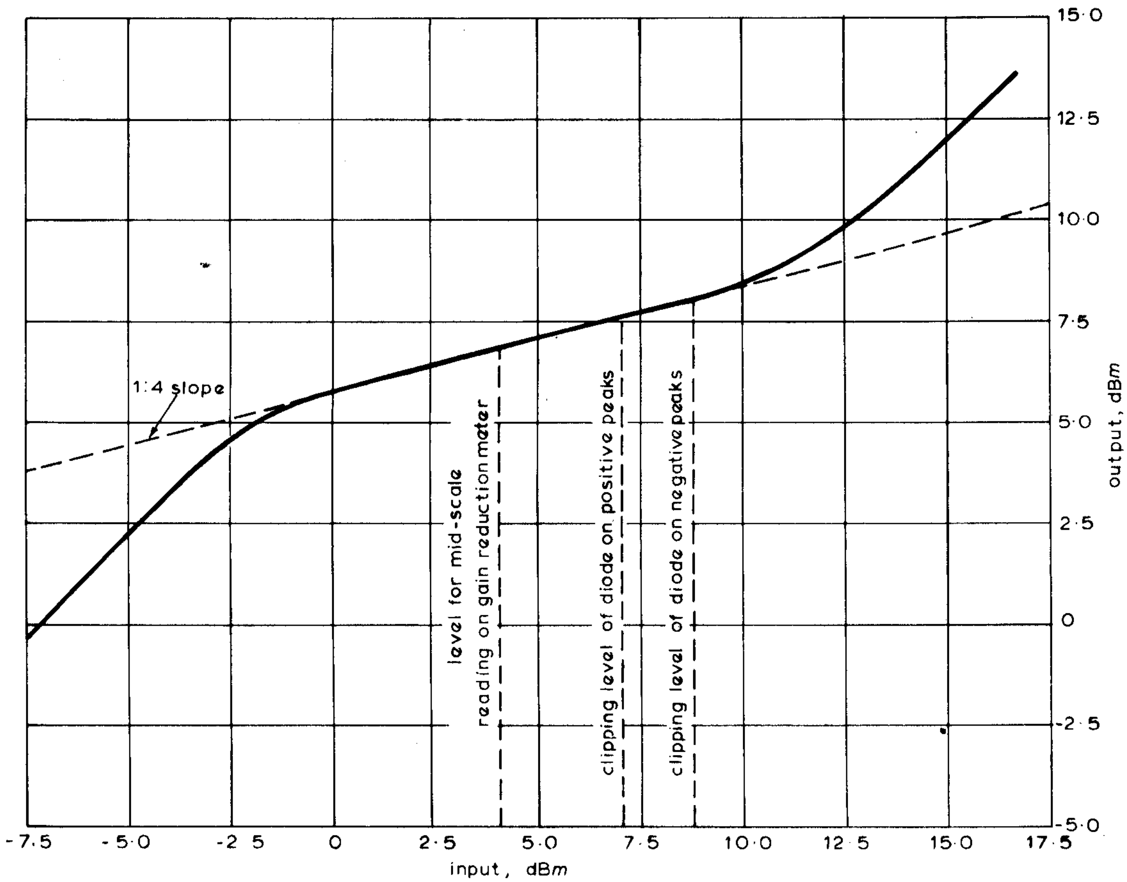

Fig. 2 - 'Volumax' limiter input/output characteristic

3.2. Input and Output Impedances

The moduli of the input and output impedances varied by some ± 10% from 600Ω with associated attenuator setting, but were substantially independent of frequency.

3.3. Signal-to-Noise Ratio

The r.m.s. unweighted noise was 75 dB below peak signal.

3.4. Frequency Characteristic

The frequency characteristic was uniform within ± ½ dB from 50 c/s to 15 kc/s which is within the manufacturer's specification.

3.5. Harmonic Distortion

The total harmonic distortion of a 1 kc/s tone at an output amplitude of +7 dBm, was 0·2%.

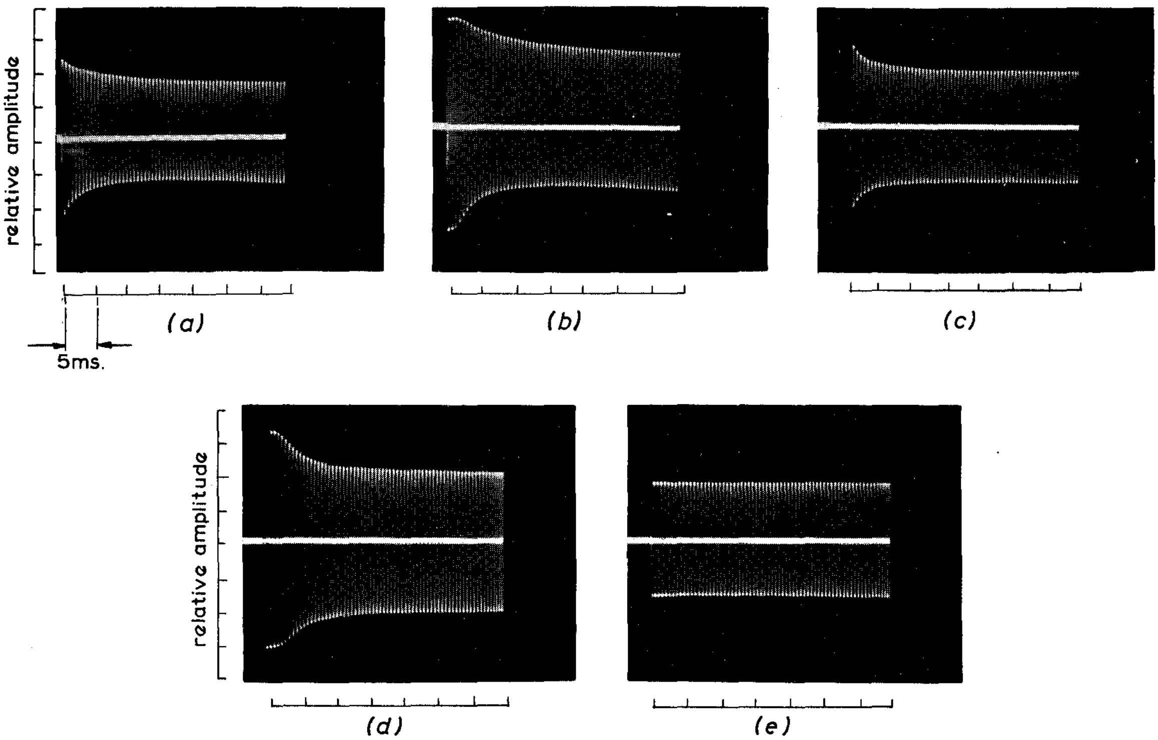

Fig. 3 - 'Volumax' limiter, transient response with suddenly applied 2 kc/s signal:

(*a*) 4½ dB gain reduction
(*b*) 9 dB gain reduction
(*c*) 4½ dB gain reduction after re-adjustment of R22
(*d*) 9 dB gain reduction after re-adjustment of R22
} Clipper temporarily disconnected
(*e*) 9 dB gain reduction after re-adjustment of R22 - with clipper

4. DYNAMIC CHARACTERISTICS

Pulsed tones were used to investigate the transient response of the limiter. To ascertain the attack characteristic, a switched 2 kc/s tone was employed.

Tests were first carried out with the peak clipper disconnected. Figs. 3(*a*) and 3(*b*) show the form of the initial transient for inputs of +4 dBm and +10 dBm, corresponding respectively to levels 6 dB and 12 dB above the knee of the input/output characteristic, or to 4½ dB and 9 dB of gain reduction. It will be seen that the signal envelope is in each case asymmetrical, probably through imperfect matching of the variable-loss diodes. The effect of the asymmetry is to increase the effective operating time of the limiter; in Fig. 3(*b*), for example, although the peak-to-peak signal amplitude was reduced to within 2 dB of its final value in about 5 ms, approximately 30 ms were needed for the level of the positive peak of the signal to reach the corresponding value. It was found that by adjustment of R22, a symmetrical transient envelope could be obtained but the steady-state distortion of a 1 kc/s tone was then increased from 0·2% to 1·5%. This difficulty could have been avoided in the design of the limiter if separate adjustments had been provided for Q4, Q5 and for the diodes D7, D8, D9 and D10.

Figs. 3(*c*) and 3(*d*) illustrate the more symmetrical waveform obtained after readjustment of R22. In this case both the positive and negative halves of the signal are reduced to within 2 dB of their final amplitude in 4½ ms and 9 ms for inputs of +4 dBm and +10 dBm respectively. These times are about twice as long as those for the BBC limiter type LIM/6, so that distortion due to clipping of the excess signal will be correspondingly longer in duration.

The remainder of the tests were carried out with both halves of the peak clipper connected. Fig. 3(*e*) shows the initial transient with an input of +10 dBm. It will be seen that the waveform is clipped for the first 8 ms of the signal; distortion persisting for this length of time will in general be audible.

The recovery characteristic of the limiter was measured with an input of +6·5 dBm corresponding to 6 dB of gain reduction, by suddenly reducing the signal amplitude by 20 dB and observing the subsequent increase in output. The time taken for the signal level to return to within 2½ dB* of its final value was 75 ms, which is about one third of the recovery time of a typical limiter type LIM/6. This short recovery time has doubtless been adopted in order to minimise the proportion of programme time during which the circuit gain is depressed.

5. SUBJECTIVE ASSESSMENT

A variety of programme material transmitted through the limiter was listened to, both through a high quality loudspeaker type LS5/1, and, by means of a modulated oscillator, through a commercially available medium-wave receiver of limited audio-frequency bandwidth. With orchestral and choral works, distortion was heard on the high quality loudspeaker and was also audible, though less obvious, on the receiver; with piano music, however, distortion was noticed very frequently on both. This distortion disappeared when the peak clipper was disconnected, but there seemed to be no subjective difference between having the clipper operating on one or on both half-waves of the signal. As is to be expected with such a short recovery time, the gain fluctuations were rapid, and 'pumping' effects were evident on some types of programme. Subjective comparison between a 'Volumax' limiter and a standard limiter LIM/6 followed by a peak clipper showed no audible difference in modulation level.

6. CONCLUSIONS

The design of the 'Volumax' limiter embodies no novel principle and the performance is as expected. The distortion produced by the clipper is in the circumstances inevitable and it would be necessary, in order to avoid this, to allow a greater separation between limiting and clipping levels. Apart from having the convenience of a limiter and a clipper in one piece of apparatus, the device does nothing which could not be done as well or better by existing Corporation equipment.

* Following the principle of the C.C.I.T.T. specification for compressors, this level is chosen because on the linear scale of a C.R.O. it represents a point midway between the initial and final signal amplitudes, for a limiter having ideal static characteristics.

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