Western Electric

PROGRAM AMPLIFIER

●

110A

FOREWORD

The part played by Bell Telephone Laboratories and by Western Electric in radio telephone broadcasting is the history of the radio art.

In 1922 a Western Electric radio transmitter was selected for use in a commercial broadcasting station. Other commercial broadcasting stations, in their selection of transmitting equipment, followed the example of this station, and—wherever Western Electric equipment was installed, efficient and dependable service was experienced. And so, the name Western Electric came to stand for leadership in radio broadcasting equipment as it had stood for many years in the telephone and associated apparatus field.

Among the pioneer efforts which have developed into incalculable advantage for the broadcaster, is equipment which extends effective coverage without increasing license power. Between the years 1922 and 1927, Western Electric succeeded in doubling the degree of modulation in broadcasting transmitters, thereby increasing the effective signal by 6 db. By 1931 Bell Telephone Laboratories and Western Electric introduced the half-wave radiator and thus added 3 more db to the signal.

Now with the Western Electric 110A Program Amplifier, another major step has been taken in increasing the effective signal. This unit increases the previous 9 db by 3 db. Within the short span of approximately ten years there have been 12 additional db increase in signal level. Another way to express this progress is by stating that a Western Electric 1 kilowatt transmitter produced in 1925 becomes, in effect, a 16 kilowatt transmitter in 1937—a remarkable improvement in radio art.

This is but one accomplishment of the world's two foremost organizations in the field of sound transmission. There are many others as outstanding in the sound transmission field for which Bell Telephone Laboratories and Western Electric are justly entitled to their positions of leadership.

The purchaser of sound transmission equipment has every reason to select a product bearing the Western Electric name, including the 110A Program Amplifier described in this bulletin.

Western Electric

110A PROGRAM AMPLIFIER

A development of Bell Telephone Laboratories — the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

PROVIDES THESE ADVANTAGES:

1. 3 db increase in average audio signal level or an increase in primary service area equivalent to that which would be obtained by doubling the carrier power.

2. Continuous visual indication of the correctness of operating levels.

3. Automatic graduated compression of excessive program peaks.

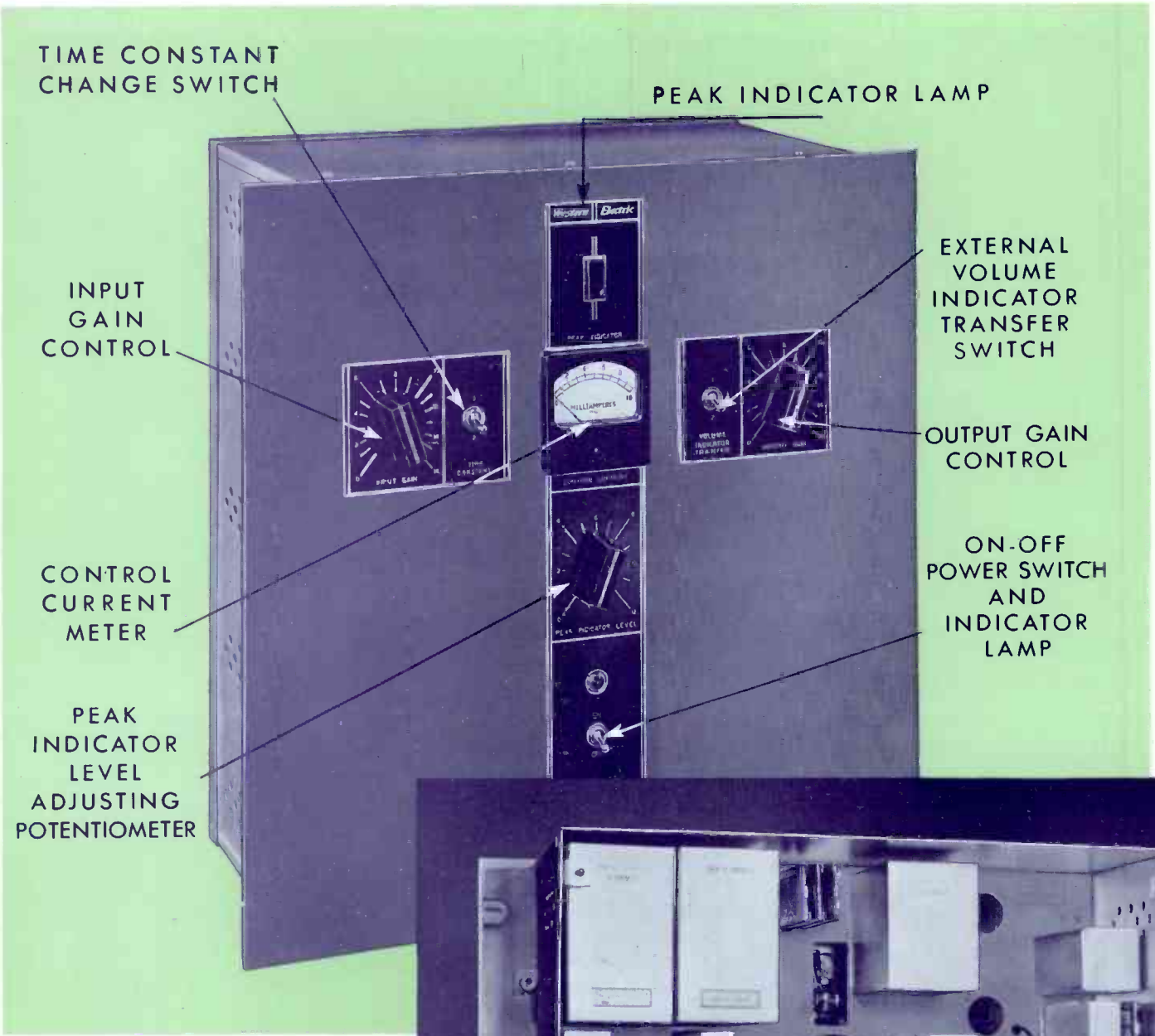
4. Protection against over-modulation—in event of accidental changes in program level.

5. Freedom from distortion and extra-band radiation due to over-modulation; thus eliminating "monkey chatter."

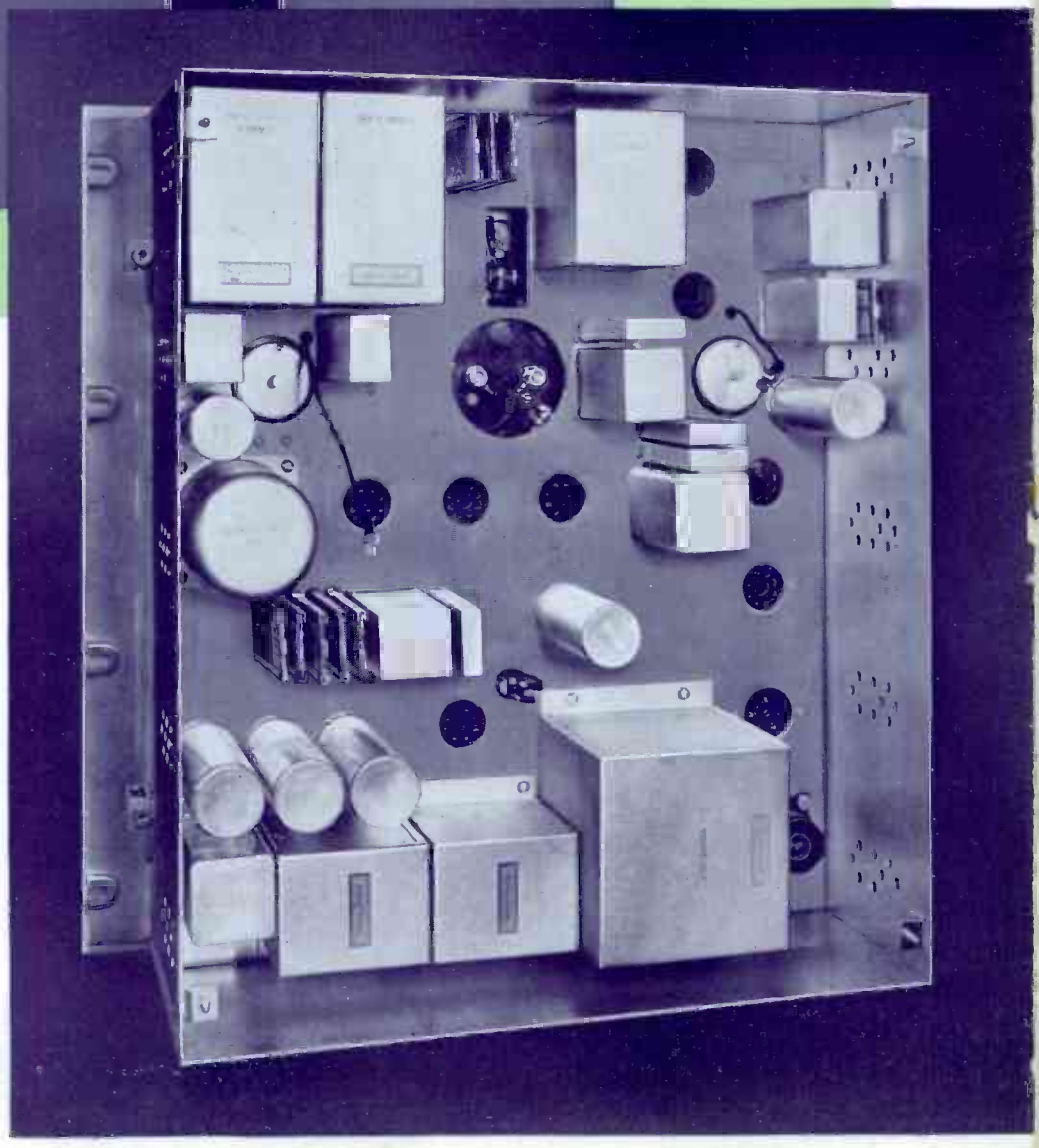
6. Program amplification of line output for feeding the transmitter at proper level.

7. Increase in the effective area of coverage without increasing the power consumption of the transmitter.

8. Safety from overloading of amplifiers and loud speakers in public address and program distribution systems.



CONTROL ARRANGEMENT OF THE 110A PROGRAM AMPLIFIER



INTERIOR VIEW OF THE 110A PROGRAM AMPLIFIER FROM THE REAR, WITHOUT TUBES

MECHANICAL DESCRIPTION

The 110A Program Amplifier is assembled on a recessed metal panel, 19¼″ high and 7½″ deep, and is intended for rack or equipment cabinet mounting.

The major components such as vacuum tubes, condensers and pads are on the rear of the panel while the terminals and wiring are in the recessed portion of the front which is covered by a face mat. All controls are on the front of the panel. They consist of input and output gain controls; peak indicator lamp and peak indicator level adjusting potentiometer; control current meter; on-off power switch and indicator; and a volume indicator transfer switch for transferring an external volume indicator from the input to the output circuit of the amplifier (and vice-versa). This indicator permits reading output levels corresponding to a series of input levels for the purpose of determining the proper operating adjustment of the amplifier circuit.

FUNCTION OF AMPLIFIER

The audio signal produced in a radio receiver by a carrier is directly proportional to the degree of modulation of that carrier. It is apparent then that the useful audio signal, and consequently, the coverage of a given transmitter's output, can be increased by raising the average level of modulation. Where the dynamic range of a program is less than the full range of which the transmitter is capable, it is obviously desirable to use the higher level portion of the transmitter's capability and thereby deliver stronger audio signals at receiver locations. But, as the upper limit of the transmitter capability is approached, the hazard of over-modulation by sudden instantaneous program peaks is increased.

Because it is impossible for the operator to make the correct gain variations—as to magnitude, time or duration—with precision, the present method of minimizing over-modulation by manual control is inherently too slow to compress the sudden program peaks. So, it is common practice in order to prevent overloads by an adequate margin of safety to lower the general program level.

A realization of this inherent weakness in present-day operating technique has resulted in the development of the Western Electric 110A Program Amplifier.

This Program Amplifier incorporates a network which, above a certain level, increases its loss as the output level from the network increases. As long as the level at the input remains within a predetermined limit the loss is small and fixed, but as the program level rises above a preselected value, the loss inserted becomes increasingly great. Therefore, although the level at the input to the network may rise steadily the level at its output will taper off above some preselected point. The result is that the product at the output of the amplifier is held within the desired limit. The amplifier may be adjusted so that the peaks of the program cannot cause modulation of the transmitter in excess of 100%.

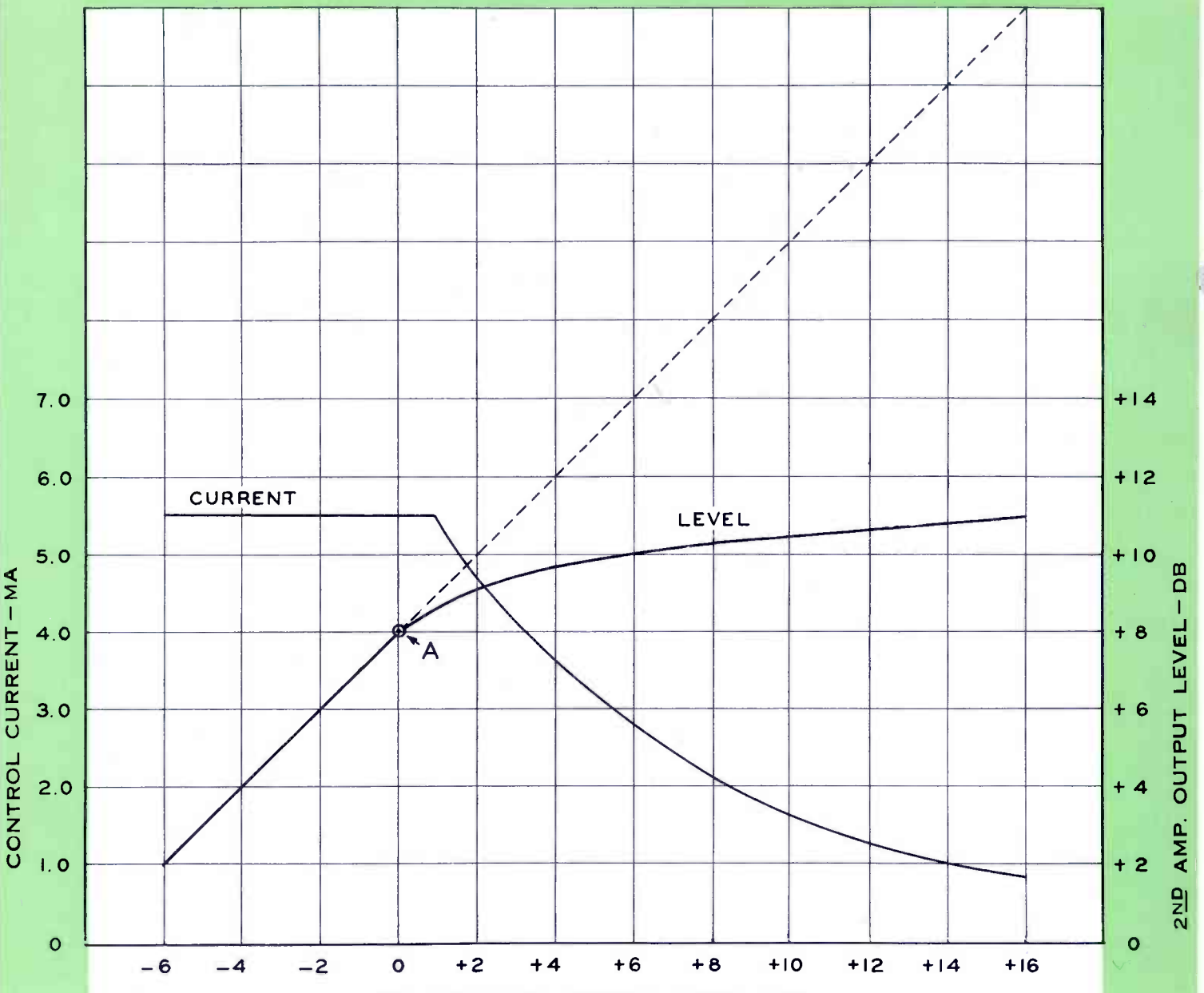


FIGURE 1—TYPICAL OPERATING CURVES

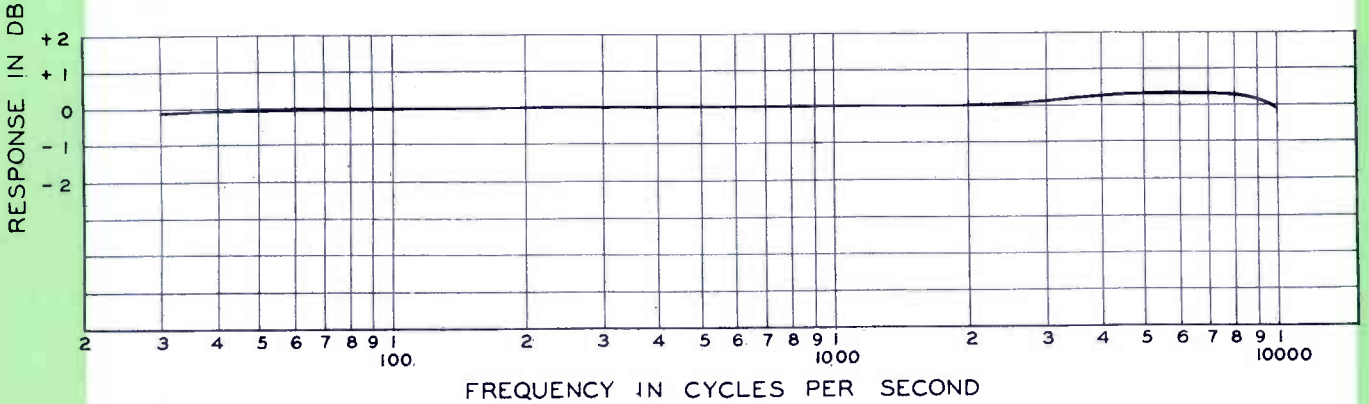


FIGURE 2—TYPICAL FREQUENCY RESPONSE CHARACTERISTIC

AMPLIFIER IN OPERATION

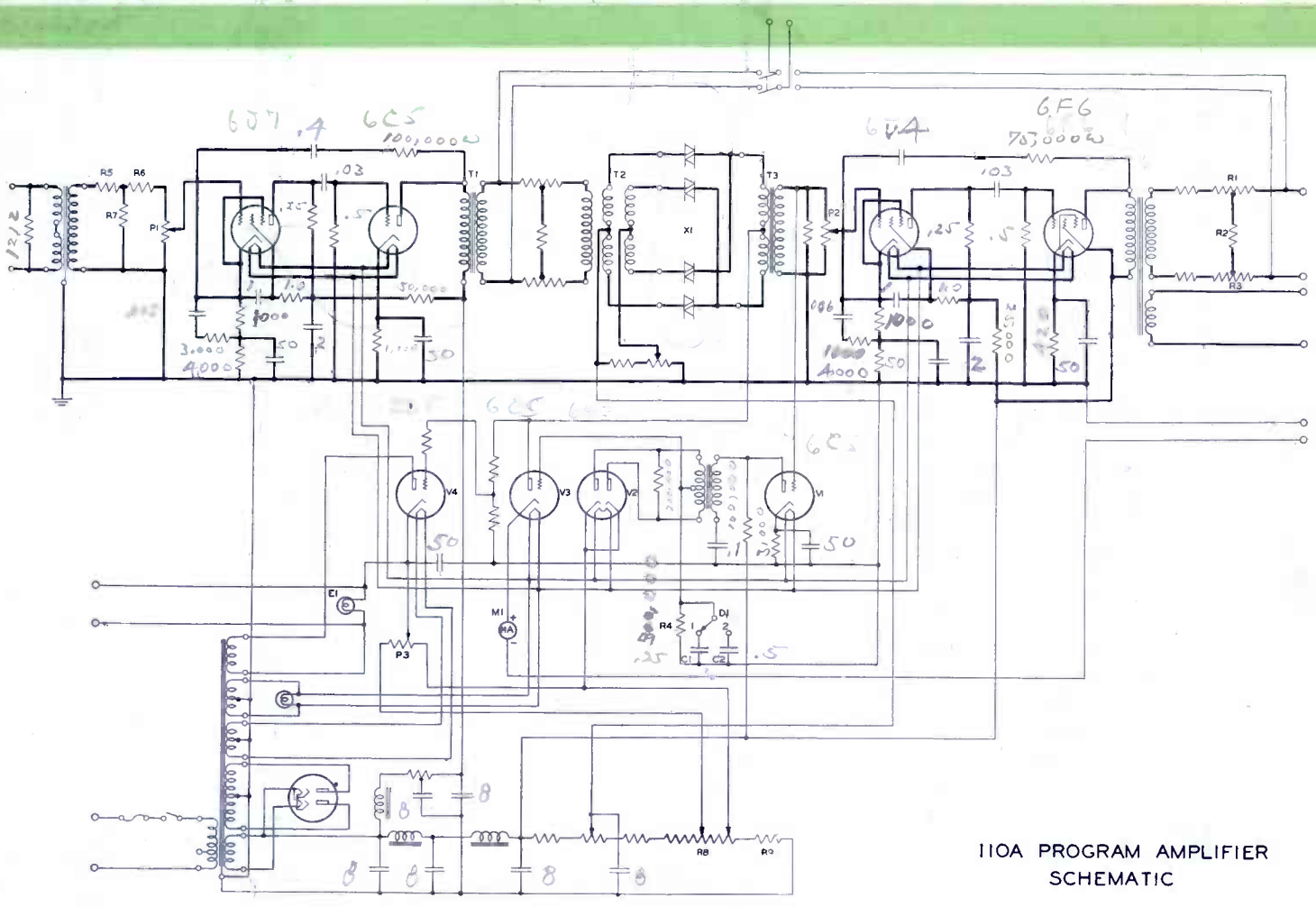
A characteristic of the amplifier network is shown in Figure 1. This graph indicates the relationship between the output and input levels for a steady-state single frequency. It will be seen that up to the level marked "A" the relationship is linear. For input levels less than "A" the network acts as though it were a small fixed loss and hence will not affect the character of the program. When the level "A" is exceeded the network inserts additional loss in an amount dependent upon the increase in program level, and the volume range beyond the level "A" will therefore be compressed.

As an example of its use in connection with a broadcast transmitter, suppose that when the instantaneous program level reaches the level "A" the transmitter is modulated 80 per cent. To reach 100 per cent modulation of the transmitter, the level at the output of the amplifier must rise about 2 db, and to effect this increase the level, at its input, must rise about 5 db. The difference of 3 db represents the amount by which the average program level can be raised by the use of the Program Amplifier.

Due to the variable loss characteristic of the Amplifier, program peaks at the input to the Amplifier which greatly exceed the level "A" will not cause over-modulation. An occasional peak which might exceed the level "A" by as much as 10 db would attempt to drive the transmitter to 178 per cent modulation if the amplifier were not in circuit. But, with the amplifier, this excessive input would create only about 108 per cent modulation. Such extreme peaks are, of course, infrequent, but the example illustrates the enormous factor of safety which the amplifier provides.

When the system is adjusted in the prescribed manner, the average program level will be sufficiently below the level "A" to provide an ample margin of safety so as to prevent accidental shifts in the program level from placing it in the compression range.

In addition, because the relationship between the number and the duration of peaks and the average program level varies widely, a lamp is provided to flash whenever the peaks exceed some preselected level. This flashing indicator may be set to operate at any level equal to or greater than the level "A." If it has been decided to compress only the upper 5 db of the volume range, as in the example, then the indicator would be set to flash at an input level 5 db higher than the level "A." So long as the lamp flashes infrequently the operator can feel assured that the desired operating condition is being maintained. If the lamp flashes at frequent intervals, it is an indication that the normal peaks are being compressed more than the predetermined 5 db and adjustments in level should be made.



110A PROGRAM AMPLIFIER
SCHEMATIC

CIRCUIT DESCRIPTION

The heart of the 110A Program Amplifier is a network which compresses a definite portion of the program volume range. The units shown on the schematic as X1 are Varistors, the resistance of which is a function of the voltage to which they are subjected. As will be seen, each side of the balanced line contains one Varistor in series and one in shunt connection. This arrangement maintains the terminating impedances at fixed values while varying the loss through the network. The loss through the network is controlled by a DC potential applied in the manner described in the following paragraphs.

The transformers T2 and T3 are used to introduce the DC control potential as well as to obtain impedance matching between the units X1 and the preceding and following circuits. Connected across the program circuit, as the output of the transformer T3 is an amplifier V1, followed by a full wave rectifier V2. Across the load circuit of this rectifier (R4—C1—C2) a DC potential will be generated which is related to the program level at the output of the transformer T3. The return circuit from the filament of V2 includes a biasing potential obtained from R9—R8. Its function is to prevent rectifying action at all program levels below a preselected value, for which levels, therefore, the potential across R4 will remain zero. The

network (R4—C1—C2) is included in the grid circuit of the control tube V3, whose plate load is the Varistor network X1.

For program levels below that needed to overcome the rectifier bias, the grid bias for the tube V3 (potential across R4) is zero and the division of the plate supply voltage between X1 and the internal impedance of V3 remains fixed. For this condition, the loss through X1 amounts to about 4 db. As the program level at the output of T3 increases sufficiently to overcome the bias on V2 the grid of V3 will receive a bias which is a function of the excess program level. This bias increases the internal plate impedance of V3, thus decreasing the potential across X1 and increasing the loss in the program path. The relationship between the program level at the input to the transformer T2 and that at the output of T3 is shown in the schematic. The point "A" corresponds to that input level whose rectified component is just equal to the bias on V2.

As the overall frequency characteristics should be flat, within narrow limits, from 30 to 10,000 cycles, it is necessary to prevent the variable loss network from following the cyclic variation in level at low frequencies. This is accomplished by shunting the resistor R4 by means of a condenser of suitable size so that the action of the amplifier becomes more nearly syllabic. Too rapid insertion or removal of loss would also give an unpleasant effect on peaks of very short duration. The constants of R4 and its shunt condenser are selected as a compromise to give an insertion time of about 20 milliseconds and a removal time of 250 milliseconds for position 1 on the schematic or the normal position for the switch D1. To provide for those users who desire slightly faster operation, position 2 of the switch D1 will give operation intervals of about one-half those in position 1. To indicate the conditions of operation, a relay tube V4 is connected in parallel with the Varistors X1. This tube receives a variable bias through P3 and R8 which permits its breakdown potential to be adjusted to any level equal to or higher than that corresponding to the level "A." In the plate circuit of V4, the lamp E1 will light whenever the bias on V4 is exceeded. By observing the flashes of E1, the operator can determine how frequently and for how long periods the inserted loss acts at any level.

The characteristics of the Varistors X1 are controlled in their manufacture. Varistors are selected so that they will function in connection with a control tube V3 of reasonable size.

Due to the fact that the action of the network requires more or less fixed levels, the most logical place for its insertion in the program circuit is at the transmitter. Amplifiers are provided because the program levels required for transmitter input circuits vary widely from the levels needed for the operation of the varistor network, input and output. In the interest of proper impedance matches, proper gains and acceptable overall frequency characteristics, the necessary amplifiers and gain controls have been built into the 110A Program Amplifier. Both input and output amplifiers are two stage units employing feedback. The gain controls P1 and P2 each have 19 steps of 1 db each. On the input, the pad (R5—R6—R7) is selected to bring the input level A within the range of P1 and on the output the pad (R1—R2—R3) serves the same purpose for the control of P2. In spite of the high overall gain of the device and the manner of inserting loss, the distortion contribution, is in fact, negligible.

SPECIFICATIONS

Input and Output Impedances: 600 ohms.

Input and Output Levels: Input levels down to —35 db can be accommodated and output levels up to +20 db can be obtained. Resistances are furnished to accommodate inputs up to +5 db and outputs down to —14 db. The fixed input pads are supplied in steps of 10 db. The fixed output pads are supplied in steps of 5 db. Two potentiometers, each of which has 19 steps of 1 db each and an off position, are used to interpolate between the fixed levels furnished by the fixed pads. Adequate overlap is provided.

Maximum Overall Gain: 55 db.

Transmission Characteristic: Flat within 1 db from 30 to 10,000 cycles.

Distortion Contribution: Less than 1% under normal operating conditions.

Mounting: Relay rack mounting. Occupies approximately 19¼" of rack space.

Weight: Approx. 68 lbs. Shipping weight approx. 80 lbs.

Controls: All controls on front of panel.

Construction: All metal recessed panel construction. Tubes and other components on rear of panel; wiring in recessed portion at front protected by face mat.

Power Supply: Self-contained power supply, completely AC operated from 110 volt, 50-60 cycle supply.

Power Consumption: Less than 100 watts.

Vacuum Tubes: Standard, commercially available, octal base radio receiver tubes. Must be ordered separately.

2—6J7G	1—6H6G
3—6C5G	1—5V4G
1—6F6G	1—885

REAR VIEW, 110A PROGRAM AMPLIFIER WITH TUBES

FOR FURTHER INFORMATION

For further information regarding the Western Electric 110A Program Amplifier described in this bulletin you are requested to address any distributor listed below.

DISTRIBUTOR IN THE UNITED STATES

GraybaR
ELECTRIC COMPANY

Executive Offices: 420 Lexington Avenue, New York, N. Y.

DISTRIBUTOR FOR CANADA AND NEWFOUNDLAND

Northern Electric Company
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General Offices and Plant: 1261 Shearer Street, Montreal, P. Q.

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International Standard Electric Corporation

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