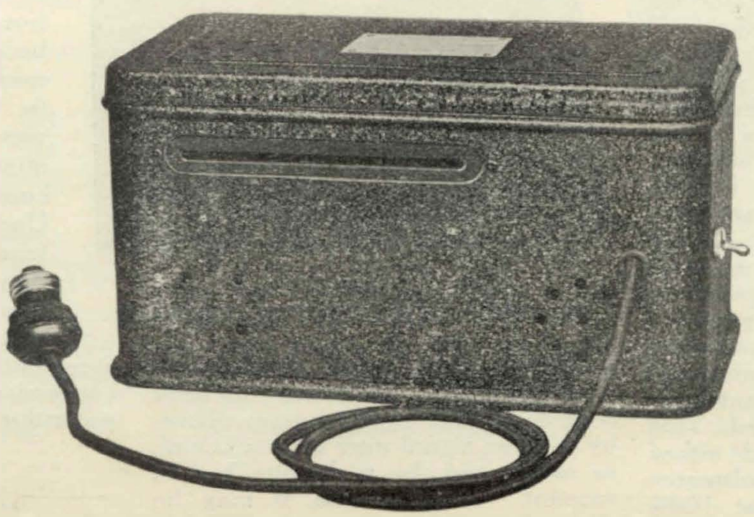
The GENERAL RADIO
EXPERIMENTER

VOL. 2 NO. 4 SEPTEMBER, 1927

Unique Method of Voltage Control Adapts Unit to Any Standard Type of Receiver

By P. K. McELROY, Engineering Department



THE NEW GENERAL RADIO TYPE 445 PLATE SUPPLY AND GRID BIASING UNIT

The design of plate supply devices for the coming season has been sensibly affected by several factors which were not in existence a year ago, in addition to the ever-present desire to make improvements upon the product itself. Chief among these newer influences are the code of Fire Underwriters' rules just formulated and approved, the body of standards adopted by the Radio Manufacturers Association and the National Electrical Manufacturers Association, and the freedom or restrictions, depending upon the point of view, brought about by the Radio Corporation's enforcement of their patent rights and licensing of power unit manufacturers. All these considerations have had a bearing on the design of this season's plate supply unit, the Type 445.

The standardization so much needed in the radio industry and simultaneously sought by committees of both the Radio Manufacturers Association and the National Electrical Manufacturers Association has caused two changes in design. The engraving on the binding posts now conforms to the similar recommendations of both committees. The B— terminal of the unit is no longer tied directly to the case, but connection is made through a 1 M.F. condenser to the case and the ground terminal. This protects the A battery from accidental short circuit with some battery connections, should the metallic case be pushed against a radiator or otherwise grounded (e.g., when B— and A+ are connected to one another, and A— is grounded).

The most important changes dictated by the Underwriters' Rules are for the purpose of protecting the user from the high voltages necessary to operate present-day power tubes at such a point as to give maximum audio output of true fidelity. While the voltages necessary for any but a 210 tube are too low to be dangerous, especially in a secondary circuit whose power output is so limited, they are high enough to be decidedly unpleasant when encountered unexpectedly. Accordingly, the binding post terminals have all been placed within the case. The connecting wires may be introduced through a slotted bakelite protecting panel parallel and adjacent to the binding posts. The slot is large enough to admit wires and terminals, but too small to allow the fingers to reach live parts. In order to afford protection when the case is opened, an automatic switch is inserted in the primary (110-volt) circuit in such a way that the circuit is made only when the cover is in place and is broken as soon as the cover is removed.

The new plate supply has been designed to use the UX-280 or CX-380 tube, which is capable of higher voltage and current output, better voltage regulation and longer life than the 213 type of tube. The voltage available under all but the most severe load conditions is sufficient to supply both maximum B and C voltages for a UX-171 or CX-371 tube.

Materials have been improved on account of the larger power supplied by the unit. The factor of safety for the paper condensers has been increased so as to obviate any danger of damage or inconvenience due to condenser puncture. The design of the choke coils in the filter has been improved so as to maintain the inductance at a high value to insure good filtering, even when a large current is being drawn from the unit so that the direct current flux tends to saturate the iron cores and decrease the inductance of the coils. The improvement can be noted from the fact that the ripple in the output of the new plate supply unit is considerably less at a larger current drain than the ripple from the old unit.

It was felt that no complication would be introduced by the addition of one C-voltage tap to supply bias for the power tube. This is of considerable value, since the C battery needed in that position is often almost as much as 45 volts. It was, however, necessary to conduct considerable investigation to determine the best arrangement of by-pass condensers in the output circuit, taking into consideration the amount and distribution of the ripple voltage and the fidelity of reproduction. As a result a circuit was developed which both keeps low the hum due to voltage ripple and makes very uniform the amplification at all audio frequencies.

The success which attended the use last year of fixed wire-wound resistances in the output voltage divider, a practice more generally followed by plate supply manufacturers this season, has prompted the retention of that method of voltage division. However, as it was desired to provide even closer voltage adjustment than was possible by the use of fixed taps on the output resistance, movable clamps have been provided for the C-voltage tap and for all B-voltage taps but the maximum. These clamps are not variable in the sense of variable resistances with knobs outside the case where they can be continually tampered with. The clamps may be moved back and forth, with the radio set in operation, until the correct positions are reached. This condition may be indicated either by using a high-resistance voltmeter with a resistance of at least 1000 ohms per volt or by ear in conjunction with the adjacent scale of approximate voltages. Each clamp is then fixed permanently in place by tightening the thumbscrew. With the tubes in use at present there is never any need to keep adjusting the plate voltages every few minutes, as one is tempted to do when there are control knobs outside the case. Line voltage variations seldom cause changes in output voltage sufficient to affect the set's performance. Accordingly, once the clamps have been set they need never be moved unless the plate supply is to power another set requiring different currents or voltages.

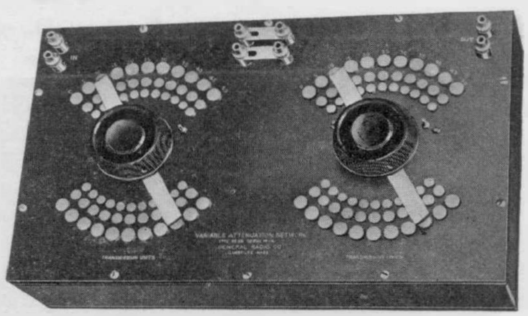
A further advantage of the clamps is that they permit a saving of output voltage taps, with a consequent lowering of price. While receiving sets rarely require over four different plate voltages, those four may be any of seven or more, namely, 22½, 45, 67½, 90, 135, 157½, 180, or choose your own. The price is materially reduced by replacing seven or more fixed voltage taps, which would inevitably vary slightly about their nominal values as current loads change, by four adjustable voltage taps, which can be set exactly as desired. Likewise, the single adjustable C-voltage tap takes the place of three or more fixed taps. When it is remembered that each tap must be bypassed by a condenser of at least 1 M.F. capacity, the saving is obvious.

The positive B-voltage taps provided are B+ DET, B+ AMP, B+ PWR1, and B+ PWR2, and the C-voltage tap is C— PWR. B+ DET supplies detector or intermediate frequency amplifier tubes, B+ AMP supplies radio, intermediate or audio amplifier tubes, B+ PWR1 supplies radio or audio amplifier or power tubes, and B+ PWR2 supplies power tubes. If it is preferred not to use on the power tube the full voltage available at B+ PWR2 any desired lesser voltage may be obtained at B+ PWR1 by adjusting the clamp. Grid bias for the power tube is obtained from C— PWR whether its plate is supplied from B+ PWR1 or B+ PWR2.

Type 445 unit is licensed by the Radio Corporation of America for radio amateur, experimental and broadcast reception only, and under terms of the R. C. A. license the unit may be sold only with tube. The price, including a UX-280 or CX-380 tube is $60.00

Design and Use of Attenuation Networks

By HORATIO W. LAMSON, Engineering Department



GENERAL RADIO TYPE 329
VARIABLE ATTENUATION NETWORK

In the laboratory devoted to communication engineering the need is often felt for an instrument whereby a given signal may be weakened, or attenuated, by a definite known amount. For instance, it may be convenient to measure one signal in terms of another by decreasing the louder until both are of the same intensity, a procedure frequently used in measuring the gain in amplifiers or the attenuation in line circuits.

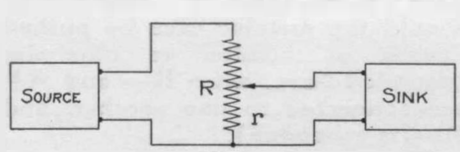


FIG. 1

One method of doing this is illustrated in Figure 1, which shows the familiar form of potentiometer. A fixed resistance, R, is connected across the terminals of the source, while a variable portion, r, of this resistance is connected across the sink into which the attenuated signal is fed. If this sink is a voltage-operated device, drawing no current, the potential at its input terminals will be equal to the output voltage of the source multiplied by the simple ratio r/R. The impedance of the potentiometer, viewed from the source, will, of course, be equal to R, and should be made equal to the characteristic impedance of the source, viewed from its output terminals, if optimum working conditions are to be attained. Under these conditions the attenuation of the potentiometer may readily be calibrated in terms of T. U. (transmission units). If, however, the sink is a current-consuming device, then the expression for the attenuation of the potentiometer becomes more complicated, involving the characteristic impedance of the sink. Furthermore, the impedance of the potentiometer, viewed from either end, is a variable, changing with each setting of the adjustable contact. This will give rise to electrical reflections which will tend to produce wave distortion and kindred troubles.

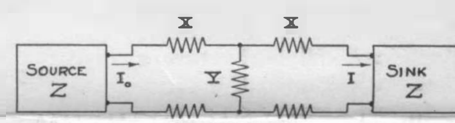


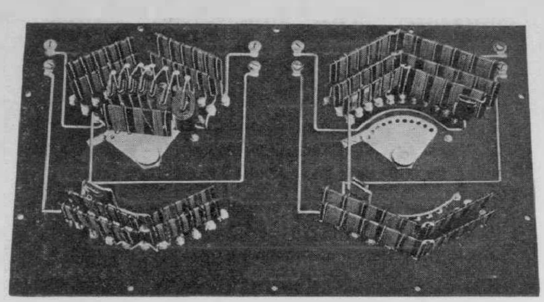
FIG. 2

If, however, we wish to produce a distortionless and easily computable attenuation between a source and sink, each having the same characteristic impedance Z, we may make use of the attenuation network shown in Figure 2. This so-called H-type network comprises four equal series resistances X, and an additional shunt resistance element Y, connected between the source and sink in the symmetrical manner indicated. If such a network is intended to introduce a definite number, N, of transmission units of attenuation, then, the values of X and Y may be computed from the equations:

$$X = \frac{Z}{2}\left(\frac{k-1}{k+1}\right)$$

$$Y = 2Z\left(\frac{k}{k^2-1}\right)$$

$$\text{where } k = \frac{I_o}{I} > 1$$



INSIDE VIEW OF TYPE 329 VARIABLE ATTENUATION NETWORK

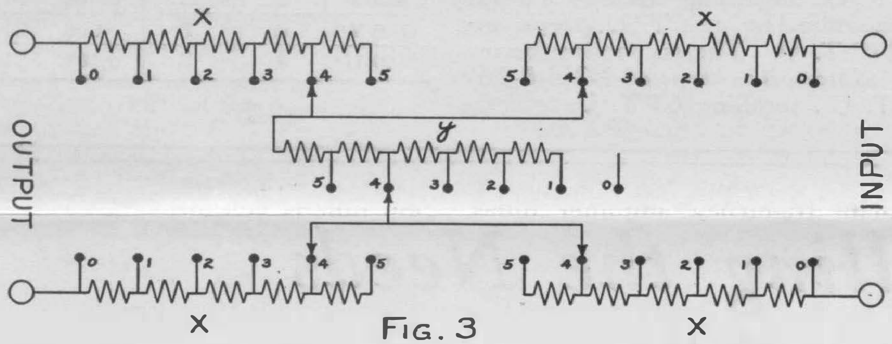


FIG. 3

the ratio of the current, Io, leaving the source to the current, I, entering the sink.

Expressed in terms of transmission units:

$$k = 10^{N/20} = \text{antilog}\ \frac{N}{20}$$

where N equals the number of T. U.'s attenuation.

A single such network offers, of course, a definite amount of attenuation determined by the values of X and Y. If, however, all five branches of the network are made adjustable by steps, as indicated schematically in Figure 3, and if the five switch arms are moved in unison to the corresponding switch points, then, by a proper calibration of the X and Y branches, the characteristic impedance Z of the network may be maintained constant while its attenuation is varied by any desired steps.

In certain lines of work it may be desirable to ground the center point of the Y shunt branch. This can be accomplished by using a network with six adjustable switch arms, as indicated in Figure 4, wherein the shunt resistance Y is bisected into two equal parts.

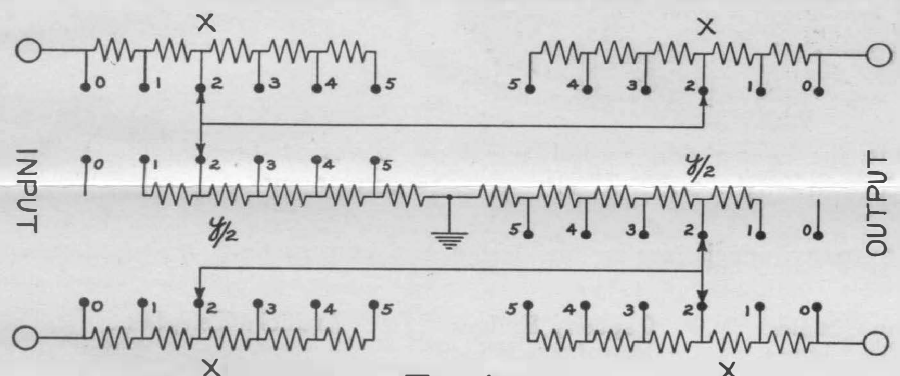
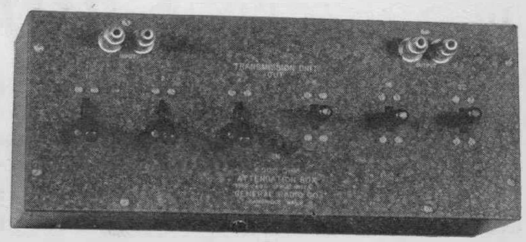


FIG. 4

TYPE	CHARACTERISTIC IMPEDANCE	TOTAL ATTENUATION	NET PRICE
329-H	600	55 TU	$220.00
329-J*	600	55 TU	$240.00
329-K	6000	55 TU	$235.00
329-L*	6000	55 TU	$255.00
329-M	600	22 TU	$230.00
329-N*	600	22 TU	$250.00
329-O	6000	22 TU	$240.00
329-P*	6000	22 TU	$260.00

The types marked * are provided with a center tap for the Y branch, as indicated in Figure 4. A limited number of certain of these types are carried in stock; others may be built to order.

The General Radio Company has developed a series of attenuation networks operating on these principles. Each instrument, as shown in the illustrations, contains two decade H type networks which may be used individually or joined in series. In one series of these instruments the decades are calibrated in steps of 5 T. U. and 0.5 T. U. respectively, giving a total attenuation of 55 T. U.; while in the second series, the decades are calibrated in steps of 2 T. U. and 0.2 T. U., giving a total attenuation of 22 transmission units. These instruments may be obtained calibrated for a characteristic impedance of either 600 ohms or 6000 ohms, as desired. The table on the bottom of this page gives pertinent data.



GENERAL RADIO TYPE 249 ATTENUATION BOX

Instead of varying attenuation by the adjustment of the five branches of a single network section, as hithertofore described, the same results may be obtained by adding two or more fixed sections in series. The method of doing this, with H type sections, is illustrated in Figure 5. A four-pole double-throw switch serves to insert or remove each particular section at will. Given the characteristic impedance and the desired attenuation in Transmission Units of such a section, the necessary values of the X and Y branches may be computed directly from the previous equations.

In place of the symmetrical H-type network, it is frequently permissible to utilize the simpler but unbalanced T-type networks for attenuation purposes after the manner indicated in Figure 6. Here a double-pole double-throw switch suffices to throw each section into or out of circuit. The resistance values are calculated in the same manner, except that each of the two X branches has, obviously, the value 2X in order to maintain the same total series resistance in the network.

For certain types of experimental work an adjustable attenuation box having one T. U. as the smallest unit is sufficient. Accordingly the General Radio Company has devel-

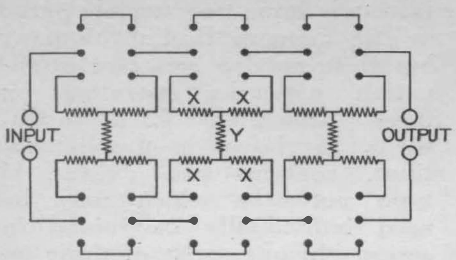


FIG. 5

oped a series of Type 249 Attenuation Boxes containing six or eight fixed sections which are controlled by individual switches. While this type does not permit as rapid manipulation as the Type 329 networks, it is, nevertheless, quite satisfactory. The illustration shows the appearance of one of these boxes.

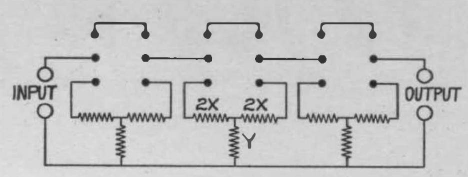


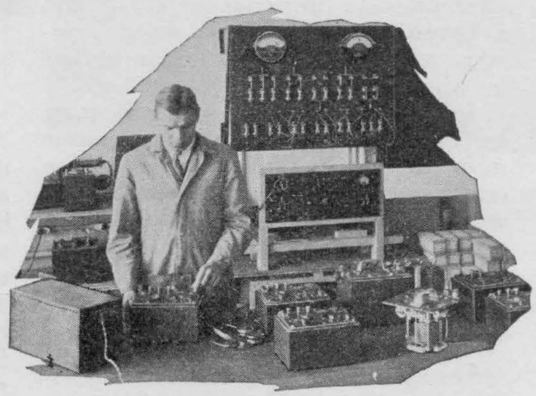
FIG. 6

The eight section boxes are calibrated in steps of 1-2-3-4-10-20-30-40 T. U., affording thereby a total attenuation, by one T. U. steps, up to 110 T. U. The six section boxes are calibrated in steps of 1-2-4-8-16-32 T. U., totalling 63 T. U.

The following types are built to order:

Type No.	No. of Sections	Type of Section	Characteristic Impedance	Price Net
249-A	6	H	600	$100
249-B	6	H	6,000	$110
349-C	6	T	600	$90
249-D	6	T	6,000	$100
249-H	8	H	600	$120
249-J	8	H	6,000	$150
249-T	8	T	600	$100
249-U	8	T	6,000	$130

Fullfilling the Needs of the Communications Laboratory



The laboratory devoted to the many and varied problems covering the broad field of communication engineering requires a large assortment of precision apparatus.

The General Radio Company specializes in the design and construction of such equipment as:

- Standards of Inductance
- Standards of Resistance
- Standard Condensers
- Precision Condensers and Wavemeters
- Variable Air Condensers
- Decade Resistance Boxes
- Telephone Transformers
- Vacuum Tube Oscillator
- Radio Frequency Oscillator
- Tuning Fork Oscillator
- Thermo-Couples
- Hot Wire Meters
- Galvanometers
- Galvanometer Shunt
- Vernier Condenser
- Audibility Meters
- Wavemeters
- Oscillograph
- Vibration Galvanometer
- Variometers
- Capacity Bridges
- Impedance Bridge
- Vacuum Tube Bridge
- Bridge Circuits for Cable Testing and Other Purposes
- Decade Condensers
- Miscellaneous Apparatus
- Piezo Oscillator
- Artificial Cable Units
- Artificial Telephone Lines
- Attenuation Networks
- Lab. Potentiometers
- Ohmmeters
- Amplification Test Set
- Beat Frequency Oscillator
- Laboratory Amplifier
- Transformers, Fixed and Adjustable

In addition to the standardized equipment listed above the Engineering Department of the General Radio Company designs and constructs equipment on special order.

WRITE FOR GENERAL RADIO LABORATORY CATALOG "X"