quality, and curve *B* (Fig. 8) shows the acoustic run made in the 26th row center of the main floor. This curve is $^1/_6$ longer than curve *A*, due to the fact that the recording meter motor was operated on 50-cycle supply for curve *A* and 60-cycle for curve *B*. An integrating condenser of 50 μf was used in each case.

These runs are not intended to prove or disprove any theory about the characteristic of headphones, microphones, or theaters, but are intended as means of making routine checks of equipment and to correlate listening tests with actual measurements.

A CURVE-PLOTTING TRANSMISSION METER*

L. D. GRIGNON**

The need for a curve-plotting transmission meter has frequently been felt by every engineer in acoustics and transmission work, but up to the present the available meters have had very definite limitations as to characteristics or price. Following is a description of a meter constructed at a reasonable cost and having certain desirable characteristics.

One great advantage of a curve-plotting transmission meter is the saving of time effected when a great many measurements are to be made, such as tests of various circuits or circuit combinations, acoustic runs at various points in a room, or routine tests of many individual pieces of equipment. In deciding upon the requirements of such a meter it is apparent that a linear decibel scale should be used, and, further, the frequency coördinate should be logarithmic; in other words, coördinates similar to those of the semi-log plotting paper used by engineers for plotting transmission characteristics. Having such a set of coördinates, preliminary inspection of curves may be made without resorting to a transparent calibrating scale. This practice would not be strictly necessary if paper rolls having a frequency scale printed thereon were readily available, and provided that some such scale could satisfactorily be made standard by the users of similar meters.

Oscillator Drive.—A Western Electric *13-A* oscillator being the only one available at the moment, a design was produced wherein a small motor of $^1/_{70}$ hp. drives the oscillator condenser through a gear reduction system, a friction wheel, and an odd-shaped cam to convert the angular frequency scale of the oscillator to a frequency scale that is logarithmic with respect to time. The gear ratio and chart speeds were selected to obtain a scale the length of a piece of Codex No. *3115* semi-log plotting paper. The gear reduction system consists of one set of worm gears and one set of bevel gears having ratios of 80:1 and 4:1, respectively, or a total reduction of 320:1, placed in a duralumin housing. A long spring provides a minimum of pressure against the cam where pressure is least needed and increases the pressure as the friction wheel arrives at the smaller cam radii. The approximate cam design was obtained by computation and graphical methods, and the cam was then cut slightly larger than the calculated dimensions. By

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running the meter and oscillator drive, and marking the chart at appropriate frequencies as the oscillator passed them, the corrections to the cam were determined and the cam trimmed down to the final shape by the cut-and-try process. This non-technical method was used because of unavoidable inaccuracy in the graphical solution over parts of the frequency scale where the change is very great. Computation is difficult because of the necessity of considering the arc or point of contact of the friction wheel. After the final cam shape was obtained a checkering file was used on the edge to give a better grip for the friction wheel. The friction wheel is a medium-hard rubber hub between two metal washers which act as positive guides. The greatest tendency to slip occurs at frequencies from 5000 to 9500 cps., which is the highest frequency used; but except when the wear of the friction wheel is excessive, the reproducibility of the frequency

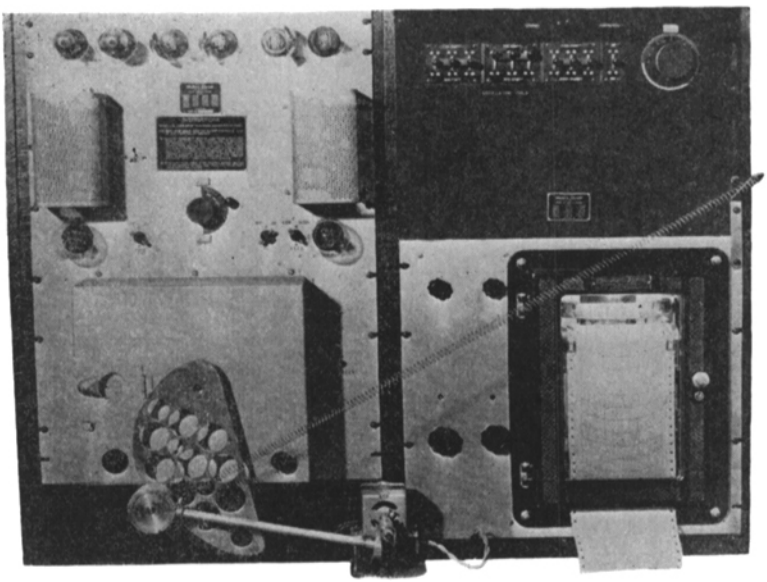

FIG. 1. Curve-plotting meter and oscillator drive, on Western Electric *13-A* oscillator, for frequency scale.

scale is within 1/8 inch out of 7/8. The complete meter is shown is Fig. 1, wherein the oscillator drive is easily seen.

Conversion Amplifier.—The available chart-plotting meter being a current-operated device, it was necessary to have an amplifier that would produce equal increments of current at its output for each decibel change of input. In such a conversion amplifier practicable limits of linearity normally exist. In the amplifier to be described, linearity within ±0.1 db. is maintained over a range of 12 db. Over a 20-db. range there is a deviation from linearity of approximately 1 db. at each end.

Fig. 2 is the schematic circuit of the amplifier, which consists of a type *76* tube used as amplifier, another *76* used as half-wave rectifier, and a *6D6* as a d-c. relay tube. The filter network connecting the diode to the *6D6* grid may be arranged for various amounts of time delay, the values of which depend upon the measurements being made. The operating point of the relay tube is selected by means of P_2. P_3 is a shunt around the meter to reduce the current increment through the meter per decibel to conform to 1 db. per division on the chart being used. P_4 controls the mid-range position on the chart. In this particular instrument zero level (0.066 watt) is adjusted to mid-scale of the chart. Both P_3 and P_4 have switches incorporated for opening the potentiometers to facilitate calibration. As can be seen, the amplifier contains a power supply for all voltages. The various controls for the amplifier and motors are to the left of the meter in Fig. 1.

Warble Frequency Device.—This device is used to vary continuously the frequency being measured above and below its nominal value, to decrease the stand-

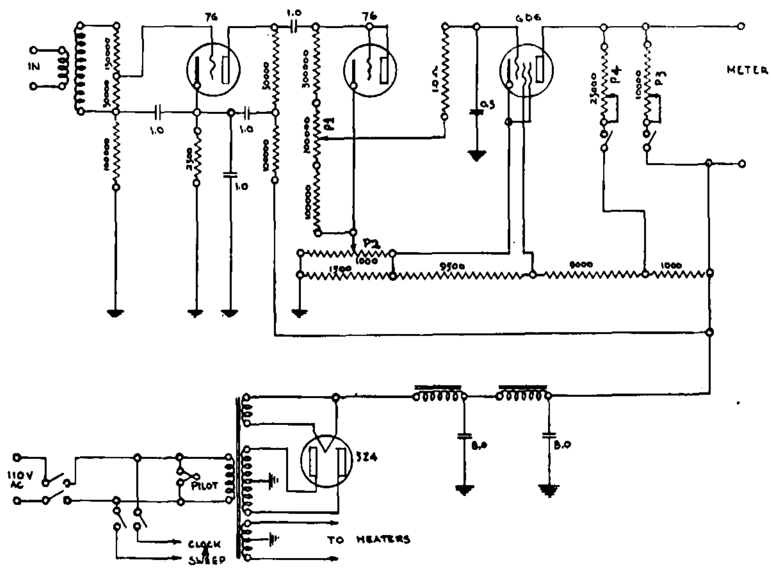

FIG. 2.—Schematic diagram of the amplifier.

ing-wave pattern when making acoustic measurements. This warble is produced by a separate motor driving a balanced variable condenser, through a reduction gear, at about 400 rpm. Another condenser, variable from the front panel, is connected in series with the motor-driven capacity for adjusting the amount of warble, and the combination is connected into the fixed section of the Western Electric *13-A* oscillator.

For acoustic measurements, the transmission meter described is used for comparative work only, since no facilities for calibrating a microphone are readily available. For routine transmission measurements, where the frequency characteristic is within the linear limits of the amplifier, and for studies of the characteristic for various circuit changes, the meter is a great time-saver. The record produced, being an inked line, is durable and may readily be filed for future reference.