BELL LABORATORIES RECORD

DIALING FOR RADIO CHANNELS
J. B. BISHOP

A VACUUM TUBE FOR HIGH FREQUENCIES
J. O. McNALLY

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New telephone which is being installed on a trial basis

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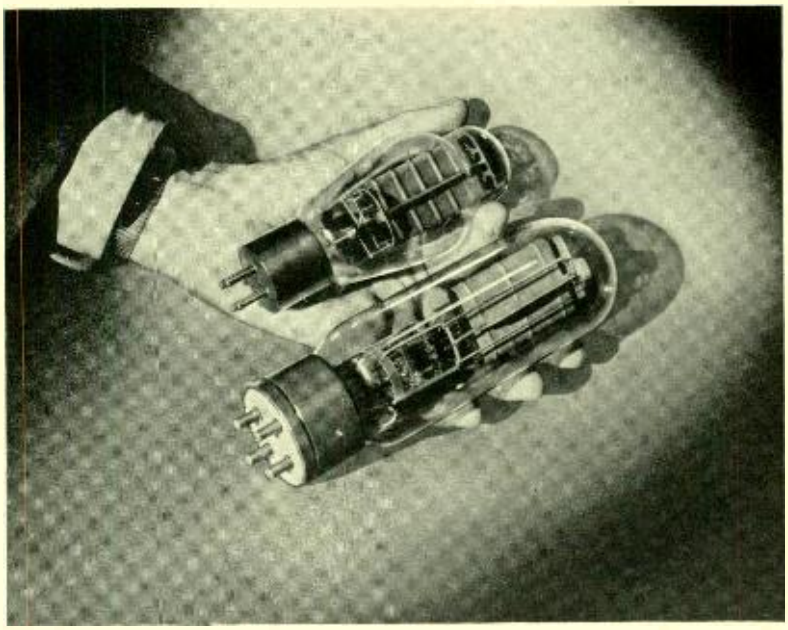

The 300A Vacuum Tube

By J. O. McNALLY
Vacuum Tube Development

THROUGH the development of a new power vacuum tube—the 300A—improved amplifiers for sound-picture and public-address systems are now available at lower costs. One of the factors contributing to this cost reduction is a decrease in the operating plate voltage, which has made savings possible in the rectifier equipment contained in the amplifiers. This lower plate voltage has also made possible economies in the construction of the tube. This results in a lower maintenance cost due to the lower cost of tube replacements.

Improvements in the electrical behavior of the 300A tube are indicated by comparing its operating characteristics with those of the 242A tube. This latter tube is employed in the 43A amplifier, which is used at present in the majority of theatres equipped with Western Electric Sound Systems, while the 300A tube is employed in the 86A amplifier, which is designed for similar purposes. The comparison is given in Table I. The 242A tube requires a plate voltage of 800 volts, or over twice that of the 300A tube. The power output of the 43A amplifier is 12 watts whereas 15 watts is obtained from the 86A amplifier. The filament power required for the

TABLE I

Type Tube	242A	300A
Operating plate voltage	800	325
Operating plate current—milliamperes per tube	67.5	60
Power output in watts of two tubes in push-pull	12	15
Filament power in watts—per tube	32.5	6

Fig. 1—Disassembled elements of the 300A tube against a background of the same tubes on life test

242A tubes is five times that for the 300A tube. The comparative sizes of the two tubes may be seen in the photograph at the head of this article.

Like the previous tubes, the 300A is a triode. It has an oxide-coated filament which may be operated on five volts alternating current, normal filament current being 1.2 amperes. The plate is formed from sheet nickel, blackened by a carbonizing process to increase its heat radiating ability. Molybdenum wire, wound flat and welded to two nickel support wires, forms the grid. The general appearance and construction of the tube are shown in Figure 1, where the base with filament and grid structure are in the left hand, and the plate structure in the right. With a plate potential of 350 volts and a plate current of 60 milliamperes, the normal grid bias is −74 volts. A single frequency input of 74 peak volts will deliver 8.5 watts to a 3000-ohm resistance load in the plate circuit.

The ability to obtain large power outputs from the 300A tube with low plate voltages is made possible by the low plate resistance. This reduction in plate resistance has been accomplished by decreasing the amplification factor, by decreasing the spacing between elements—particularly that between filament and grid—and by increasing the area of the elements. The amplification factor has been reduced to the lowest practical limit, which is set by

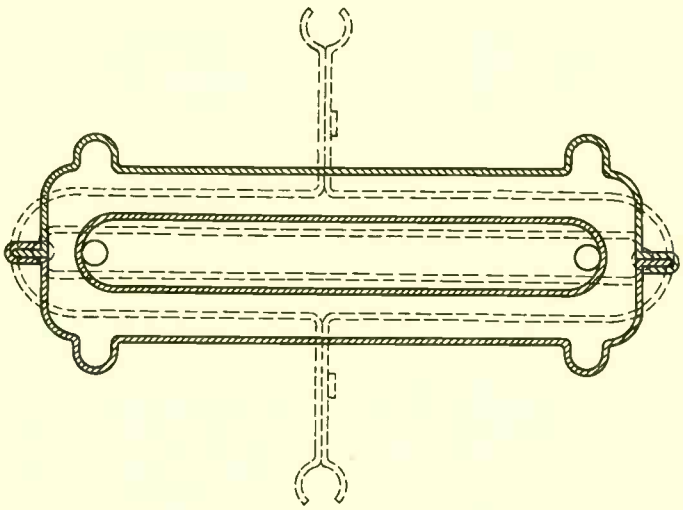

Fig. 2—A cross-section of the elements of the 300A tube, shown in dashed lines, superimposed on a similar cross-section of the 252A in solid lines, indicates one of the methods that were employed to decrease plate resistance

the point at which the varying current in the plate circuit ceases to be sufficiently linear with the input voltage, and causes distortion in the output.

How the inter-electrode spacing has been decreased and the areas increased is indicated by Figure 2, which shows a cross-section plan of the 300A tube in dotted lines, superimposed on that of the 252A tube, which is an earlier tube of approximately the same bulb size and developed for plate potentials up to 500 volts. It is capable of delivering only about one-half of the power of the 300A tube under similar operating conditions. The plate of the 300A tube has been widened in the direction of the plane of the filament, and the transverse spacing made less. To obtain the increased width of the plate without using a larger bulb, the plate construction has been changed. The two halves of the plate of the 252A tube are joined by flanges at the ends, and four support wires are fastened to the plate near the corners. In the 300A tube, the two halves are joined by wide flanges on the sides, to which the support wires are secured. This allows the plate to occupy the entire distance in width occupied by the plate and flanges in the 252A tubes, and has the additional advantage of stiffening the middle portion of the plate. The grid has been correspondingly widened in one direction and narrowed in the other to decrease the distance between the grid and filament.

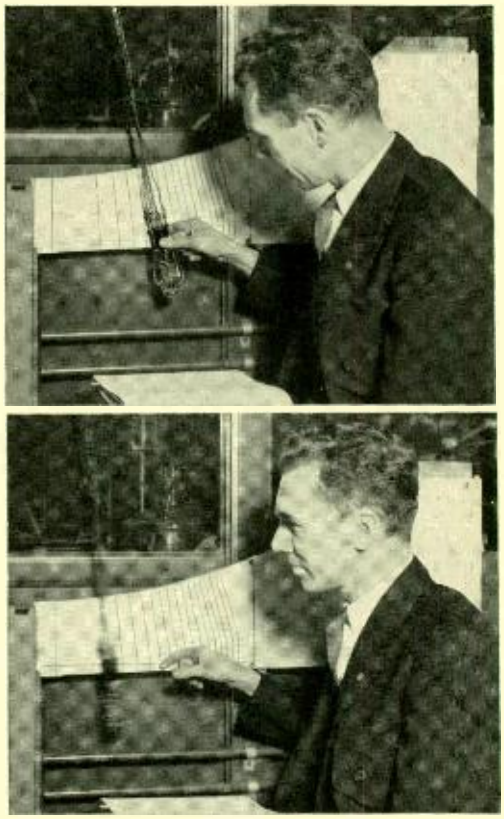

Fig. 3—C. Depew tests tube for shock

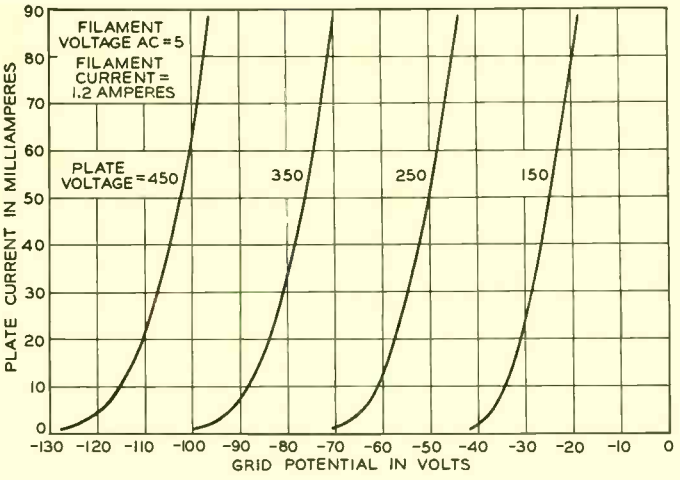

Fig. 4—Plate current and grid voltage characteristics

Beside these changes, it has been essential to have the filament extend the full length and width of the plate, so that the plate cur-

Fig. 5—L. G. Petrovich checking operating conditions of 300A vacuum tubes on life test

rent may be drawn as nearly as practicable over the entire plate area. This has been accomplished in the 300A tube by arranging the filament in a double M instead of the single M usually used. This is shown in Figure 1. The two M's are connected in parallel across the filament voltage supply.

In bringing the filament, grid, and plate closer together, the danger of short circuit from accidental physical contacts of the parts has been increased. Design features, such as the side ribs on the plates, and the rigid fastening of both ends of the support wires, however, improve the stiffness and offset this danger. The inherent stiffness of the tube elements is tested by attaching the tube to a cord and allowing it to swing as a pendulum against a stop in the center position. Such a test is shown in progress in Figure 3. The tube is drawn back to increasing angles and then released, and the angle at which failure occurs, as indicated by a relay circuit sensitive to short circuits of very short duration, is a measure of the stiffness of the elements.

Typical characteristics are shown in Figure 4. The output of the tube will depend, of course, on the plate and grid voltages selected. As the result of extensive life tests, it has recently been possible to raise the maximum operating plate voltage for the 300A tube from 350 volts to 450 volts. With 450 volts on the plate and a plate current of 60 milliamperes, a single tube will deliver 12.5 watts into a 4000-ohm load with second and third harmonics 26 db and 39 db, respectively, below the fundamental. Two tubes in push-pull may be expected to deliver 25 watts with harmonic levels of the order of 40 db below the fundamental.