USE OF CURVES

In general, curves are used to determine the proper operating point which will give a required characteristic. Audio amplifier tubes should be operated on the linear portion of the tube characteristic while detectors on the contrary should be operated on a non-linear portion. There are many curves which may be taken on tubes, but engineers have selected the following ones as being generally useful.

Plate Characteristic—This is the name given to the curve taken with plate current plotted along the vertical axis and plate voltage along the horizontal axis. A number of lines are generally shown, for different grid bias voltages at regular intervals over the range of probable use. In a screen grid tube there may be a number of plate families required, one for each recommended value of screen voltage.

On power tubes the plate characteristic may be used to determine the approximate power output for conditions not listed by the manufacturer. Let us take the type TA4 as an example. Power output of this tube is not normally required so is not included in the characteristics, but suppose that a small amount of power were required from a triode of this nature, the procedure would be as follows:—Since the tube, when operated at 250 volts on the plate and —8 volts bias, draws 9 ma. This would seem to be a safe operating current. (For other plate voltages the bias voltage is generally taken

as .68 x Eb. Make a mark on the —8 volt curve above 250

volts on the voltage scale. The next step is to get a load line. If the load impedance is known, a line is drawn through the selected operating point such that the ratio of the voltage as read at the point of intersection with the horizontal axis to the current at the point of intersection on the vertical axis gives the desired value of load resistance. This is best done by arbitrarily selecting a value of current, say 20 ma., and if 20,000 ohms load is required the voltage intercept which gives this

will be E = I x R = $\dfrac{20 \times 20,000}{1000}$ = 400

Then join 20 ma. with 400 volts. This does not give the desired load line because it does not pass through the required operating point. All lines parallel to this, however, have the same ratio of intercepts so the new load line is drawn parallel to it but passing through the selected operating point.

From this line we can now read the instantaneous value of current for any instantaneous value of signal applied to the grid. If operation is limited to the negative region the peak signal cannot exceed 8 volts and the tube current will swing from 15½ ma. at 0 grid volts to 3½ ma. at —16 grid volts. The voltages at these points are read if the value of power output is required. These read about 125 and 355 respectively and the power output is:—

$$\dfrac{\text{Change in current x Change in voltage}}{8} \text{ watts}$$

$$\dfrac{12}{1000} \times \dfrac{230}{8} = .345 \text{ watts or 345 milliwatts}$$

If more signal is available or if there is less signal, the end points selected may be different and the power correspondingly increased or decreased. If necessary to estimate the % 2nd. Harmonic Distortion, this is obtained from:

$$\frac{\text{Avg. Current} - \text{Current at Operating Point} \times 100}{\text{Change in Current}}$$

$$\frac{(9\frac{1}{2} - 9)}{12} \times 100 = 4.15\%$$

In cases where the best value of load is not known several lines may be drawn and the best one used.

Although a triode was selected as an example the procedure for use of a load line for a pentode is the same providing the distortion is kept to a reasonably low value.

The plate resistance for conditions not given in the rating or on other curves, may be taken approximately as the slope of the tangent to the plate current curve at the point required. The dynamic plate resistance is usually higher than that obtained in this way. It can be seen from the shape of the curves why the selectivity obtained with RF pentodes at 100 volts plate and screen is not as good as that obtained under the 250 volt condition. The plate resistance acts like a resistor shunted across the tuned plate circuit.

Transfer Characteristic—is the name given to the curve showing Mutual Conductance, Plate Current, Plate Resistance or Amplification Constant plotted on the vertical scale and grid bias on the horizontal axis. Its main uses are in determining the operating range for tubes used with AVC voltage, and the selection of the best point for operating a grid biased detector or a converter. Servicemen may need this in selecting a tube with the proper cut-off characteristic for use in a given circuit.

The instantaneous plate currents found by adding or subtracting a value of peak signal voltage from the operating center can also be used in those cases where the impedance of the plate load is negligible. Examples of such cases are pentode broad-band amplifiers and relay operation where the load impedance is low compared to the tube resistance.

Conversion Characteristic—These are given only for converter type tubes and are shown in two different ways: Characteristics vs. oscillator grid current, and characteristics vs. control grid volts. The first of these is important in selecting the oscillator strength for operation over a required frequency range. Since no practical circuit has the same oscillator grid current at all frequencies it is necessary to compromise for best overall performance. The other curve against control grid volts is used similarly to the transfer characteristic in showing the desired range of AVC voltage to be applied.

Diode Load Curve—This may be used in designing AVC systems or vacuum tube voltmeters. Taking the curves given under type 7B6 as an example, the load current may be found for any applied signal voltage and several values of DC load resistance. With 25 volts RMS applied signal and 0.1 meg. load resistance, for example the load current will be 270 ua. and the developed bias 26.8 volts.