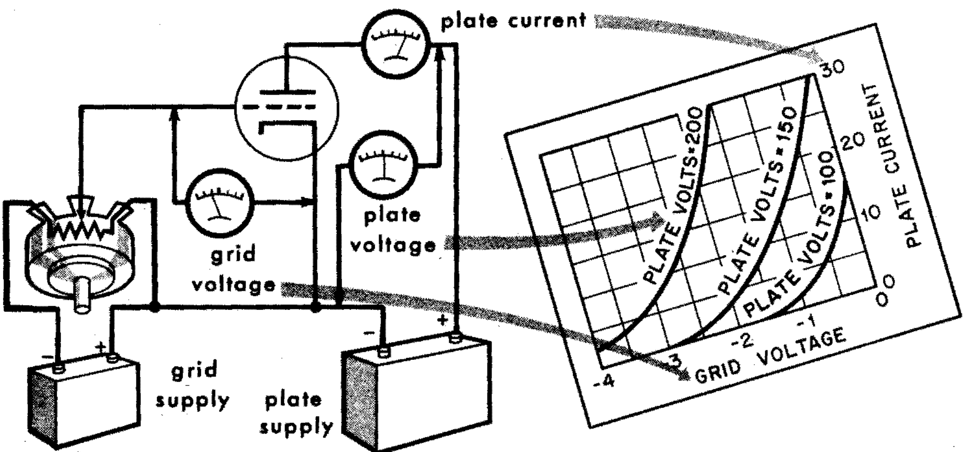
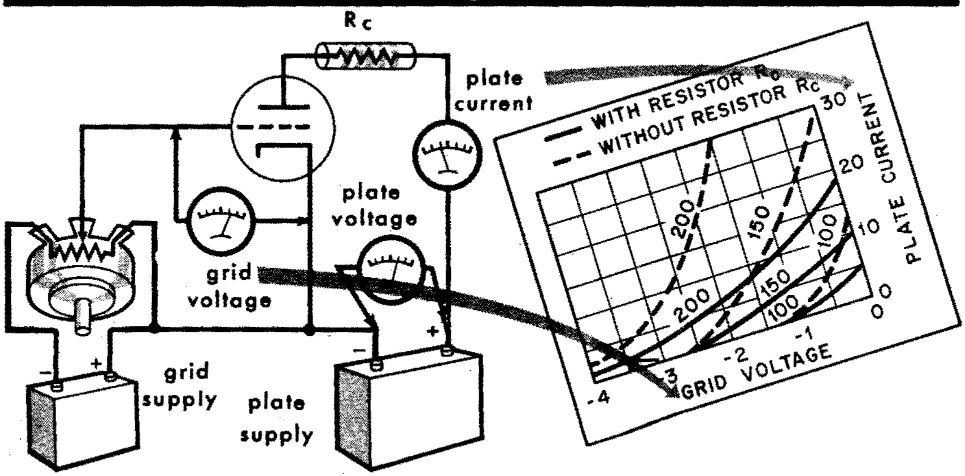
Load-Line Construction

We can find out more about amplification by plotting the curves of plate current and grid voltage with resistance connected in the plate circuit. However, we have to plot a new curve for each value of resistance with which we want to experiment. If, for some reason, we are not satisfied with any of the resistance values that we have already tried, the only thing to do is get the equipment out and plot some more curves.

Obtaining Plate Current versus Grid Voltage Curves for various values of plate voltage, Without Plate Load Resistor

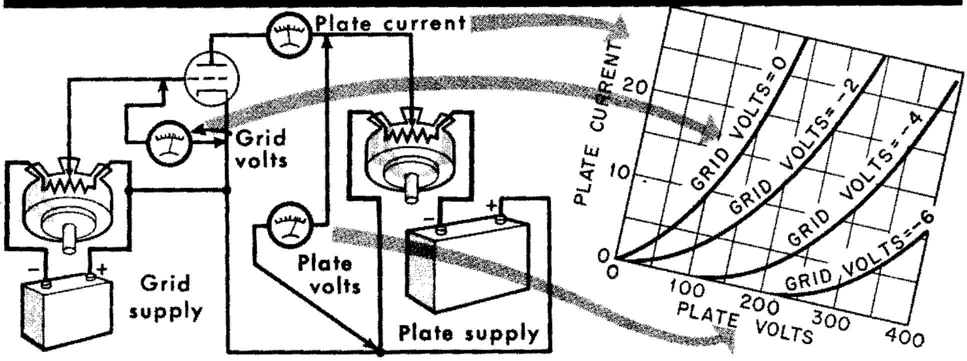


Obtaining Plate Current-Grid Voltage Curves With Plate Coupling Resistor R c in Circuit



Load-Line Construction (contd.)

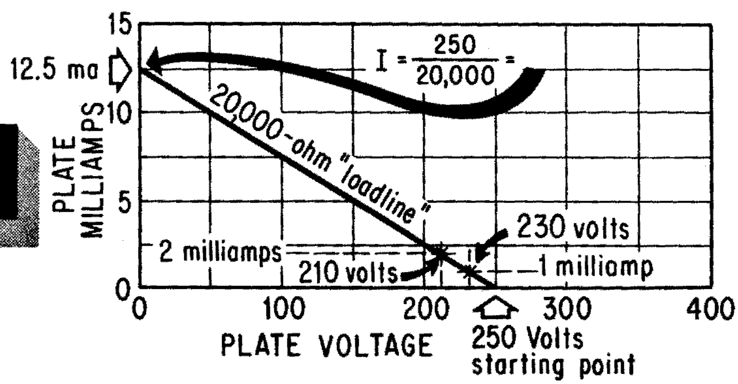
Setup for taking plate voltage-plate current curves, at different grid voltages



Fortunately there is a more direct way of obtaining all these curves. To start with we plot quite a different set of curves. Each of these curves shows all the possible combinations of plate current and voltage that can occur for one fixed potential on the grid. If we can draw, on the same graph, another line we can find all the possible relationships in the plate circuit, corresponding to whatever resistance or other circuit component is connected. Then these curves can be used to find how the circuit—any circuit—will work.

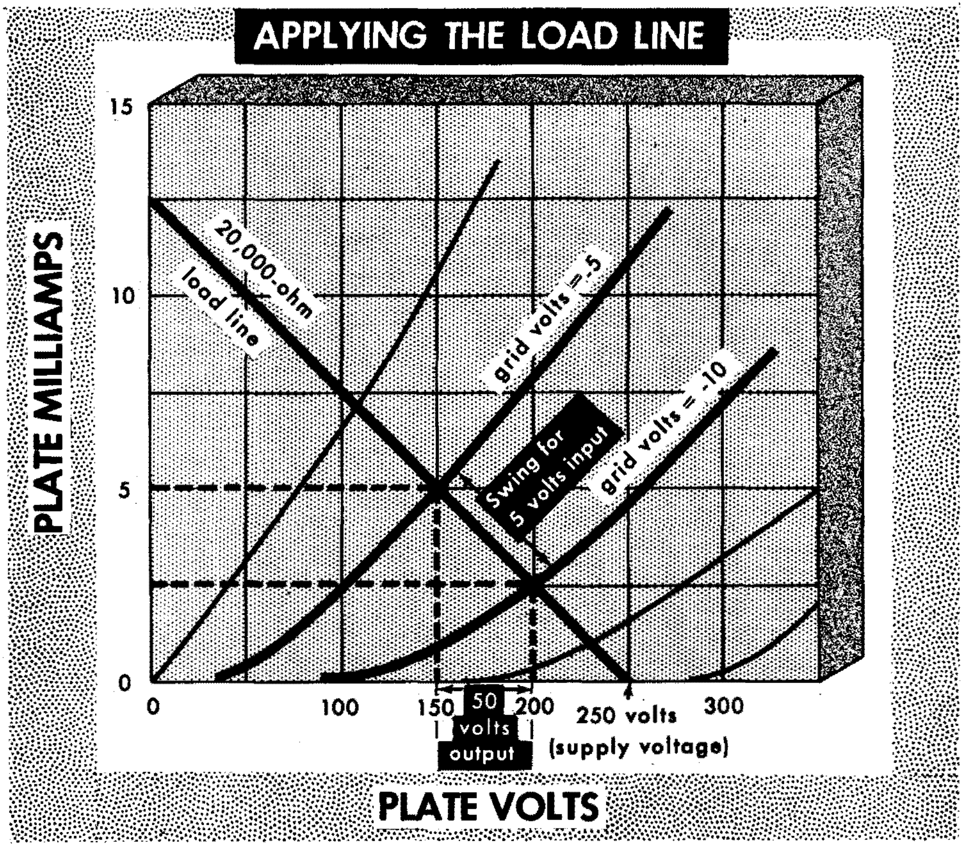
For example, if the supply voltage used is 250 volts, and the resistance used is 20,000 ohms, without any plate current flowing, the plate potential will be the same at both ends of the resistor—250 volts. If 1 milliampere of plate current flows, the drop across the resistor will be 20 volts, leaving 230 volts at the plate. With a plate current of 2 milliamperes, the drop will be 40 volts, leaving 210 volts at the plate, and so on. With 12.5 milliamperes flowing, the whole 250 volts will drop in the resistor, leaving 0 at the plate. These possibilities are shown by drawing a straight line through all these points.

Construction of a Load Line



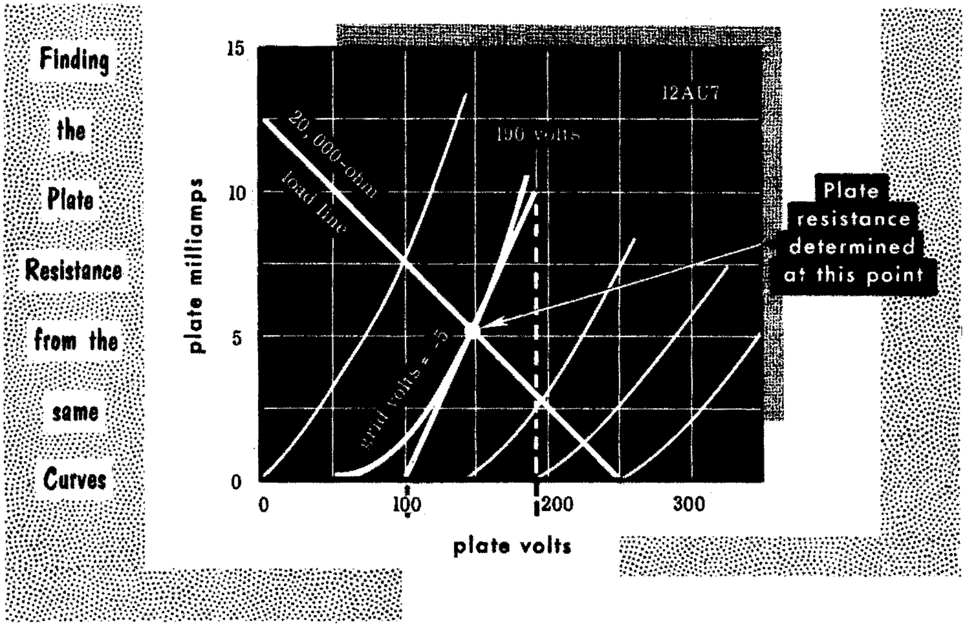
Finding the Plate Resistance

Now suppose the grid potential varies between —5 volts and —10 volts. These curves show that, when the grid potential is —5 volts, the plate current is 5 milliamps and the plate potential is 150 volts. This is where the —5-volt curve, showing possible combinations at this grid voltage, crosses the 20,000-ohm load line, showing the possible combinations with this resistor connected in series with the plate from a 250-volt supply.



When the grid potential is —10 volts, the plate current is 2.5 milliamperes, with a plate potential of 200 volts, where the load line crosses the —10-volt curve. Thus with this resistor, we can see quite easily that there is a swing between 150 and 200 volts on the plate. If a 5-volt input swing gives a 50-volt (200 — 150) swing at the output, the tube is working at a gain of 10, because the output swing is 10 times the input swing. These curves can also be used to find the plate resistance of the tube at different operating conditions (combinations of grid potential plate current and plate potential).

Finding the Plate Resistance (contd.)



By laying a straight-edge (ruler) along the curve at the point where the two lines cross, its slope *at this particular point* can be found. Extending the line drawn as tangent to the curve down to the zero current line and up to the 10-milliampere line, the corresponding voltages may be read off and the plate resistance calculated.

$$\text{PLATE (or A-C) RESISTANCE (in ohms)} = \frac{\text{Change in plate volts}}{\text{Change in plate current (In Amps)}} = \frac{90}{.01} = 9{,}000 \text{ ohms}$$

For example, using the 12AU7 curves and laying the ruler along the curve for —5 volts, where the 20,000-ohm load line crosses it, the line drawn as tangent goes through the zero current line at 100 volts and through the 10-milliamp line at 190 volts. This means, if the slope at the point we chose is extended, that a *change* of 10 milliamps causes a *change* of voltage of 90 volts. This is why the relationship is sometimes called an a-c resistance—because it deals with changes of fluctuations in current. The value of the resistance, in ohms, is given by Ohm's law. In this example, the plate resistance is 90/.01 or 9000 ohms.