RADIO ENGINEERING

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Space-charge-grid Tubes.—In space-charge-grid tubes there is an auxiliary grid called the space-charge grid located between the cathode and the control grid and operated at a low positive potential. The effect of the space-charge grid is to increase the number of electrons drawn out of the space charge near the cathode. Some of these electrons are immediately attracted to the space-charge grid, but many of them pass through its meshes into the space in front of the control grid, where they are slowed down by the retarding field and form a second space charge as shown in Fig. 77. This represents a virtual cathode which serves as the actual cathode for the remainder of the tube, which may be a triode, screen-grid tube, etc. The characteristic curves that result are similar to those for conventional tubes, as is apparent from Fig. 78.

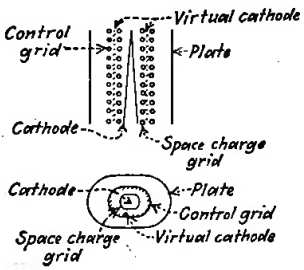

FIG. 77.—Details of space-charge grid tube. The inner grid is the space-charge grid and is operated at a moderate positive potential.

The advantages of the space-charge-grid arrangement arise from the fact that the virtual cathode has a large area and is located very close to the control grid. This gives a very high mutual conductance in proportion to the plate potential. The disadvantages of the arrangement are that the characteristic curves tend to have excessive curvature when considered over an appreciable range of voltages and that the space-charge grid draws a very heavy current, usually more than half of the total space current.

Any tube with more than one grid can ordinarily be arranged to function as a space-charge-grid tube. Thus the curves of Fig. 78 were obtained by using a conventional screen-grid tube with the ordinary control grid functioning as the space-charge grid and with the ordinary screen grid serving as the control grid. The result is then a space-charge-grid triode tube. A pentode tube can be likewise rearranged to serve as a space-charge-grid screen-grid tube, as in Fig. 79.

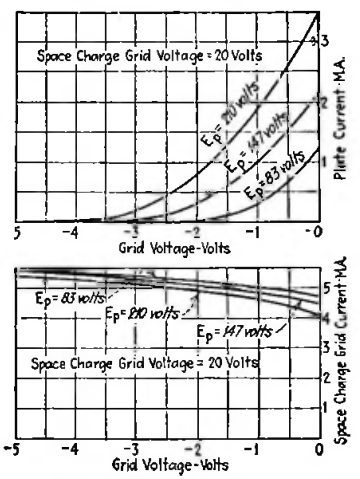

FIG. 78.—Characteristic curves of space-charge grid tube. The plate current varies with control-grid and plate voltages in much the same way as in a triode, while the space-charge grid current is much larger than the plate current and decreases as the plate current increases.

Special Connections for Conventional Tubes.—It is possible to operate conventional tubes to give special characteristics either by employing special connections or by using the proper combination of electrode

voltages. Several such examples have already been considered. Thus the dual-grid tube can be arranged as a triode having either a moderate or a high amplification factor, depending upon the way in which the grids are connected. Likewise, it was seen that any tube with two or more concentric grids could be made to operate as a space-charge-grid tube. The number of such arrangements is very great, particularly when the

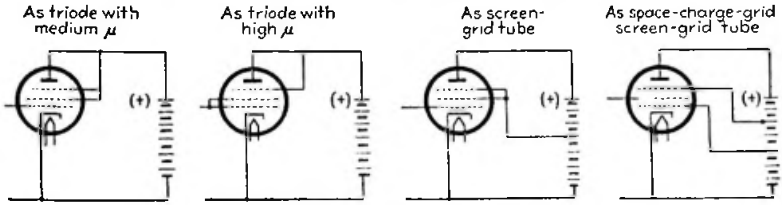

FIG. 79.—Pentode tube arranged in various ways.

number of electrodes at one's disposal becomes large. Thus an ordinary pentode tube can be connected as a triode having either a very high or a moderate amplification factor, as a screen-grid tube, or as a space-charge-grid screen-grid tube, as shown in Fig. 79.

Another way in which an ordinary tube can be rearranged is to interchange the functions of the grid and plate by making the grid the anode electrode and by using the plate as the negative control electrode, as shown in Fig. 80.[1] The operation of such an *inverted tube* rests on the fundamental fact that the space current flowing to the anode, which in this case is the positive grid, depends almost solely upon the electrostatic field in the vicinity of the cathode and is substantially independent of how this field is produced. Since both plate and grid potentials affect the intensity of this electrostatic field, it is possible to use a negative plate as a control electrode to serve the same purpose as the negative grid in the usual triode. The principal differences in the result are that the amplification factor is low, being approximately $1/\mu$, where μ is the amplification factor of the tube operated in the normal manner, and that the dynamic anode resistance is much lower than in the corresponding tube operated in the normal manner because changes in grid, *i.e.*, anode, voltage produce large changes in the electrostatic field near the cathode and hence large changes in anode, *i.e.*, grid, current. The inverted vacuum tube is a useful laboratory tool when it is necessary to control a current by a very high voltage without at the same time consuming any energy from the high potential source.

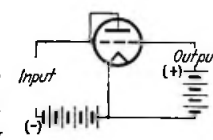

FIG. 80.—Circuit of inverted vacuum tube. The tube is an ordinary triode in which the plate is the control electrode and is operated at a negative potential, while the grid acts as the positive anode.

[1] See F. E. Terman, The Inverted Vacuum Tube, a Voltage-reducing Power Amplifier, *Proc. I.R.E.*, vol. 16, p. 447, April, 1928.