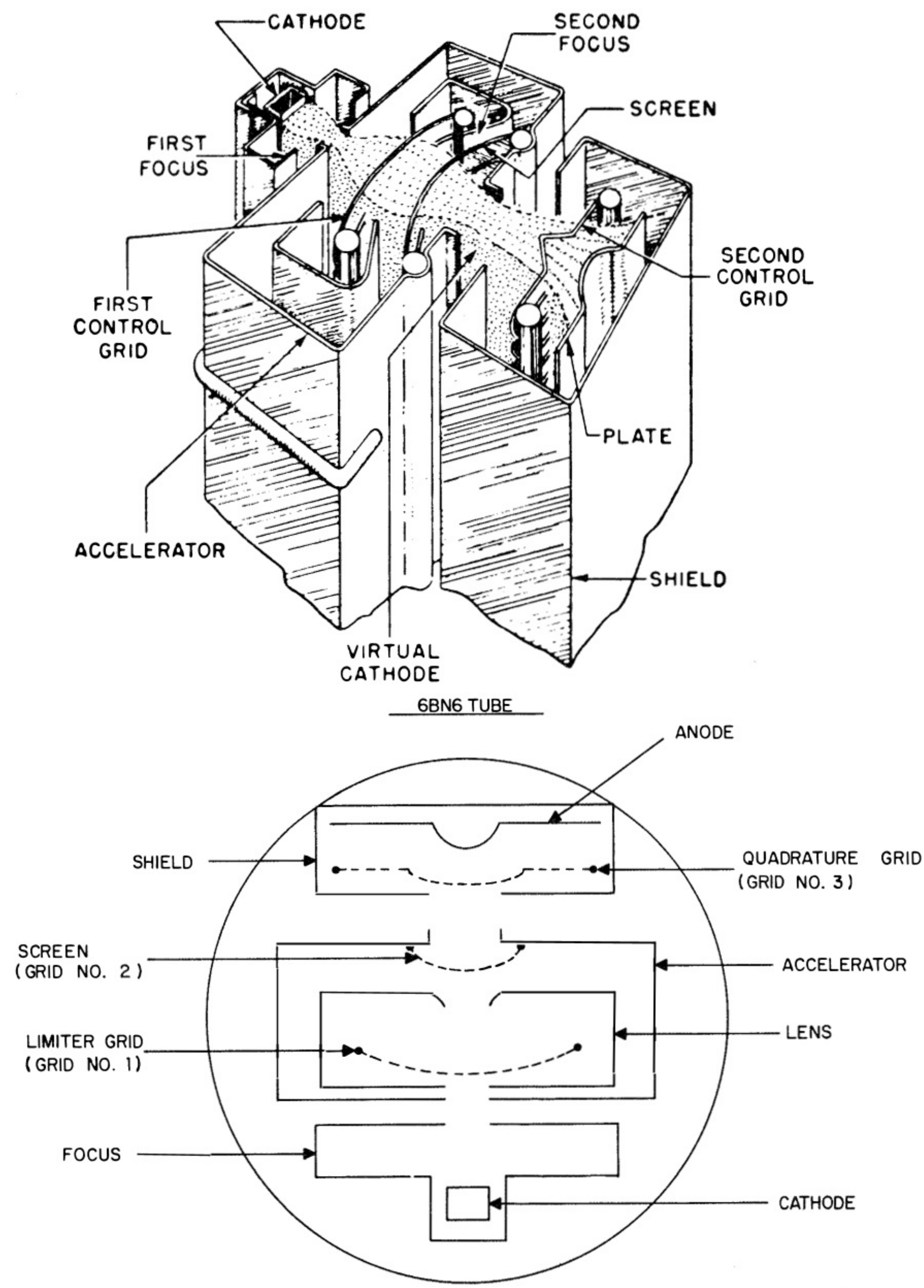

FIGURE 6-22. Gated-Beam Discriminator Tube and Schematic Diagram.

Gated-Beam Discriminator

Another approach to a combined limiter-discriminator combination, one that differs considerably from any of the previous circuits, is provided by the 6BN6 gated-beam tube. This tube, designed by Dr. Robert Adler of the Zenith Radio Corporation, possesses a characteristic such that, when the grid voltage changes from negative to positive values, the plate current rises rapidly from zero to a sharply defined maximum level. This same maximum value of plate current remains, no matter how positive the grid voltage is made. Current cutoff is achieved when the grid voltage goes about 2 volts negative.

The reason for this particular behavior of the tube stems from its construction. See Fig. 6-22. The focus-electrode, together with the first accelerator slot, forms an electron gun which projects a thin-sheet electron stream upon grid 1. The curved screen-grid, together with the grounded lens slot and aided by the slight curvature of grid 1, refocuses the beam and projects it through the second accelerator slot upon the second control grid. This grid and the anode which follows are enclosed in a shield box. Internally, the focus, lens, and shield electrodes are connected to the cathode. The accelerator and the screen grid receive the same positive voltage because both are connected internally.

The foregoing design is such that the electrons approaching the first grid do so head-on. Hence, when grid 1 is at zero potential or slightly positive, all approaching electrons pass through the grid. Making the grid more positive, therefore, cannot increase the plate current further. When, however, grid 1 is made negative, those electrons that are stopped and repelled back toward the cathode do so along the same path followed in their approach to the grid.

Because of the narrowness of the electron beam and its path of travel, electrons repelled by the grid form a sufficiently large space charge directly in the path of other approaching electrons, thus causing an immediate cessation of current flow throughout the tube. In conventionally constructed tubes, the opposite is true.

These differences between tubes may be compared to the differences between the flow of traffic along narrow and along wide roads. Along the narrow road, failure of one car can slow down traffic considerably; along the wide road, more room is available and the breakdown of one car has less effect. The electron beam leaving the second slot of the accelerator approaches grid 3 also in the form of a thin sheet. Thus, this section of the tube may also serve as a gated-beam system. If this second grid is made strongly negative, the plate current of the tube is cutoff no matter how positive grid 1 may be. Over a narrow range of potentials in the vicinity of zero, the third grid can control the maximum amount of current flowing through the tube. However, if the third grid is made strongly positive, it also loses control over the plate current, which can never rise beyond a predetermined maximum level.

A typical gated-beam FM detector system is shown in Fig. 6-23, utilizing a 6BN6 gated-beam tube. The accelerator grid structures of the tube are in reality in the form of plates, which help shape the electrons into a narrow beam. The positive voltage of the accelerator grid structure increases the electron beam velocity and forces the beam through a narrow slot in the accelerator electrode. The electron beam then encounters the limiter grid, which, in conjunction with the quadrature grid, acts to control the electron flow. As with other tubes, the anode is made positive to attract the electrons emitted by the cathode.

The limiter grid has sufficient control over the electron beam to produce cutoff for any negative voltage. If the limiter grid has zero voltage or a positive voltage applied, however, it will permit current flow within the tube. The quadrature grid, if slightly negative, will also cause plate current cutoff. Thus, both grids are influential in preventing or permitting current flow within the tube.

With a small value of fixed bias, such as one volt, an incoming signal has sufficient amplitude to cause the tube to be operated at satura-

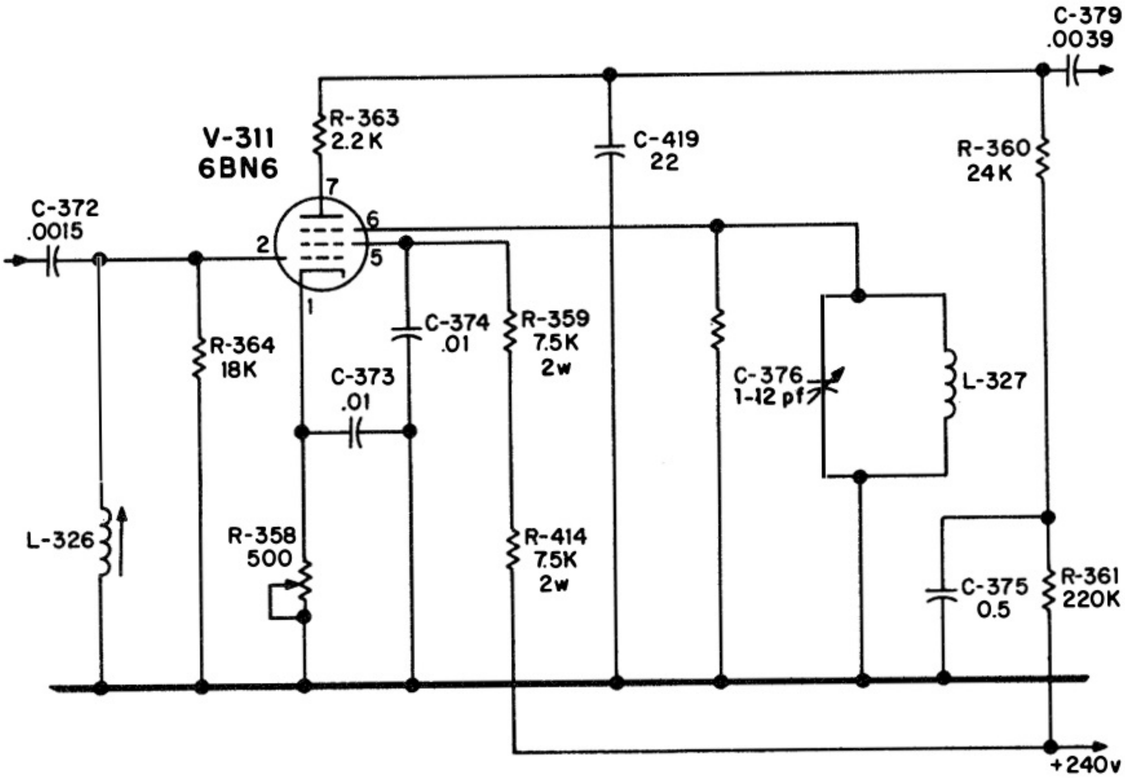

FIGURE 6-23. Typical Gated-Beam FM Detector System.

tion for the positive peaks of the grid signal, or at cutoff for the negative peaks of the incoming signal. Because the grid structure releases current flow rather suddenly, and also stops current flow quickly, a square wave of beam current occurs within the tube in the region beyond the input grid. Thus, the tube acts as a self limiting device, and will eliminate AM variations of incoming signal. A parallel resonant circuit is connected to the quadrature grid. The quadrature resonant circuit is tuned to the center carrier frequency of the incoming FM signal. During signal input, the cloud of electrons (space-charge) around the cathode varies and the quadrature grid is also affected by the electron beam because of space-charge coupling. Hence, the square wave type of signal generated within the tube is also present at the quadrature grid, and will pulse the quadrature circuit into a resonant flywheel condition.

The signal voltage which appears across the quadrature circuit, however, lags the input signal by approximately 90 degrees. The phase lag occurs because of the nature of the space-charge coupling. With a 90 degree lag between the signal at the quadrature grid and that at the limiter grid, the plate current of the tube is cutoff for a greater period of time than would otherwise be the case.

This can be seen from an inspection of Fig. 6-24, which shows that the plate current can only flow when neither the limiter grid nor the quadrature grid is negative. Thus, only about one-half of each square-wave alternation reaches the anode during the time the carrier is at center frequency. When the incoming FM carrier shifts to a higher frequency, the quadrature circuit will be off resonance with respect to the shifted carrier frequency. The quadrature circuit becomes predominantly capacitive, because the higher frequency impressed on it increases the inductive reactance and decreases the capacitive reactance. Since the capacitive reactance is low, the current through the capacitive reactance is higher than that in the inductive reactance. Because a parallel resonant circuit with the resonant frequency impressed on it, exhibits a high imped-

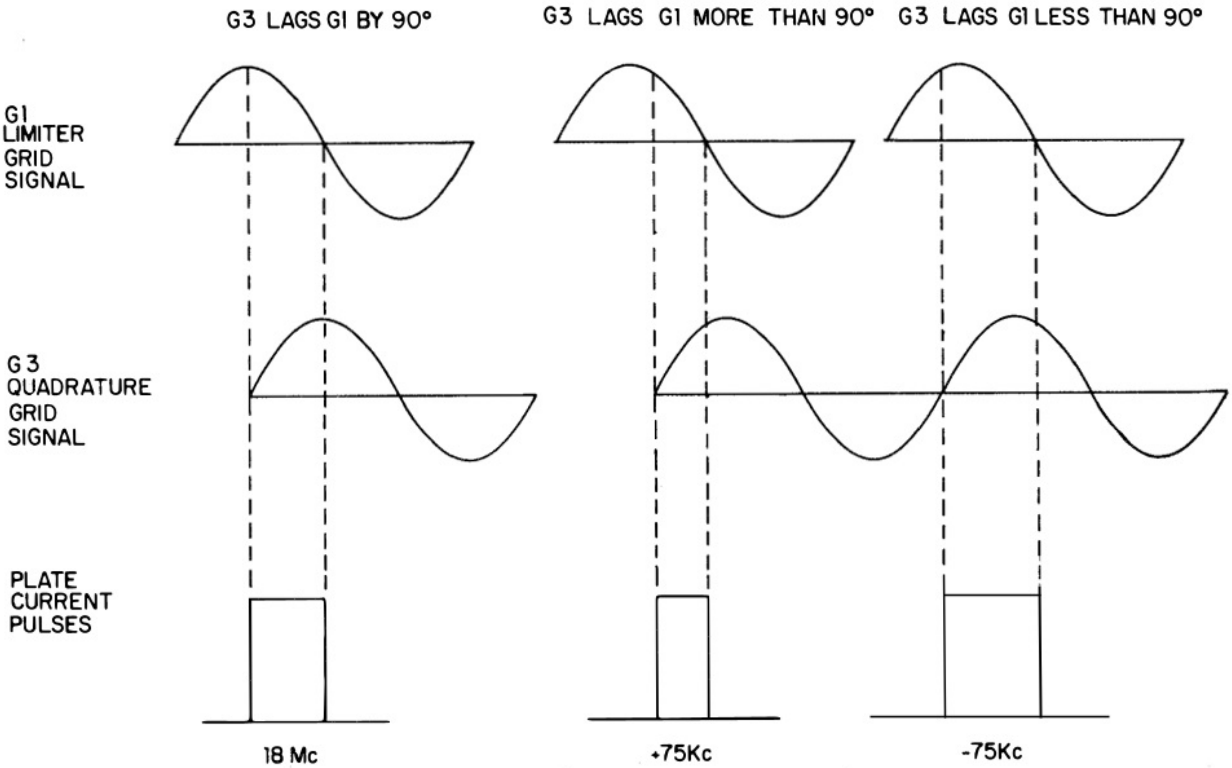

FIGURE 6-24. Gated-Beam Discriminator Waveforms.

ance, the reduction of such impedance through decreased capacitive reactance causes the circuit to be predominantly capacitive. The capacitive characteristics of the quadrature circuit will now cause the signal voltage at the quadrature grid to lag the signal at the limiter grid by more than 90 degrees, which is the lag at center carrier-frequency. Because of the increased phase difference between the two current-controlling voltages, less than one-half of each square-wave alternation arrives at the anode of the tube. Hence, the average value of plate current decreases. When the carrier signal at the limiter grid shifts lower in frequency, the quadrature circuit becomes predominantly inductive and the voltage tends to lead. As shown in Fig. 6-24, more than one-half of each square-wave alternation reaches the anode and thus the average value of plate current increases.

In the circuit of Fig. 6-23 a 2.2 K ohm resistor, R363 is inserted between the load R360 and the plate of the tube. By-passing of the IF voltage is accomplished by C419 but since this capacitor is placed beyond the 2.2 K ohm resistor, a small IF voltage appears at the anode of the tube. Through the interelectrode capacitance that exists between the anode and grid 3, the IF voltage developed across R363 is coupled into L327-C376. The phase relationship existing in this circuit is such that this feedback voltage aids in driving the tuned circuit. Capacitor C419 and resistor R363 in the anode circuit also form an integration circuit. An integration circuit has the ability to produce an average value from a series of pulses having various widths. Resistor R360 is the conventional load resistor across which the audio signal voltages develop. Capacitor 419 has a low shunt reactance for the high carrier frequency, and thus eliminates the latter from the output circuit. Bias for grids 1 and 3 is obtained by placing a resistor R358 in the cathode leg of the tube. Since AM rejection, especially at low input signals near the limiting level, is a function of the correct bias, the cathode resistor R358 is made variable. This permits adjustments to be made in the field in order to compensate for tube or component changes.