ductive or capacitive reactance predominates and the phase of the voltage V_a changes accordingly. At frequencies greater than resonance, inductive reactance is predominant in the tuned circuits and V_a leads V_1 by less than 90°. Conversely, for frequencies less than resonance, capacitive reactance is the greater and V_a leads V_1 by more than 90°. Since V_b is unchanged in phase, the alternations of V_a and V_b no longer coincide and the rectifier currents become unbalanced because a greater voltage results in one side of the secondary than the other. At higher frequencies than resonance diode 1 will have the greater current flow and vice versa for lower frequencies.

In Figure 1b we see just how the control voltage is developed. From this illustration it becomes evident that this control voltage may be either positive or negative and of various amplitudes. Electrons move from negative to positive so that all one must do to determine the polarity of the voltages E_1 and E_2 is to visualize the electron flow. Since these are in series E_c, the control voltage, equals E_1 plus E_2 added algebraically.

When suitably filtered, the control voltage is delivered to the control tube where the actual frequency control is accomplished. Two methods of utilizing vacuum tubes for frequency control are shown in Figures 2a and 2b. Figure 2a illustrates a typical type involving variation of effective capacity to change frequency, while Figure 2b depicts the inductance variation type.

A triode with a choke in its plate circuit reflects capacity into its grid circuit. Degeneration resulting from the condenser C_1 increases this effect. The actual amount of reflected "capacity" depends upon the gain of the tube and it is this fact which is used to affect frequency control by varying the effective bias on the grid of the tube. R and C are filter components. In actual practice this circuit is not commonly used because it has several disadvantages. The tube acts as a poor condenser and hence introduces losses into the oscillator tank. The amount of control varies considerably with frequency and is unsymmetrical about resonance.

A better system involves inductive control as shown in Figure 2b. In this circuit a pentode is used to control the oscillator frequency. Screen grid, suppressor and cathode connections are made in the standard manner. The gain of the tube is controlled by means of the additional bias supplied by the discriminator.

A small amount of the voltage developed across the oscillator tank is fed into the control grid of the pentode (this same grid is biased by the control voltage) and amplified. This exciting signal voltage undergoes a 90° phase shift across condenser C, and hence causes the plate current of the tube to lag its plate voltage by approximately 90°. The result is apparent shunt inductance across the oscillator tank. Therefore, frequency change is readily accomplished by varying the gain of the tube and hence the amplitude of its output.

Essentially these are the basic principles underlying automatic frequency control. And now that they are understood, let's go looking for trouble.

Probably the first thing to be done is