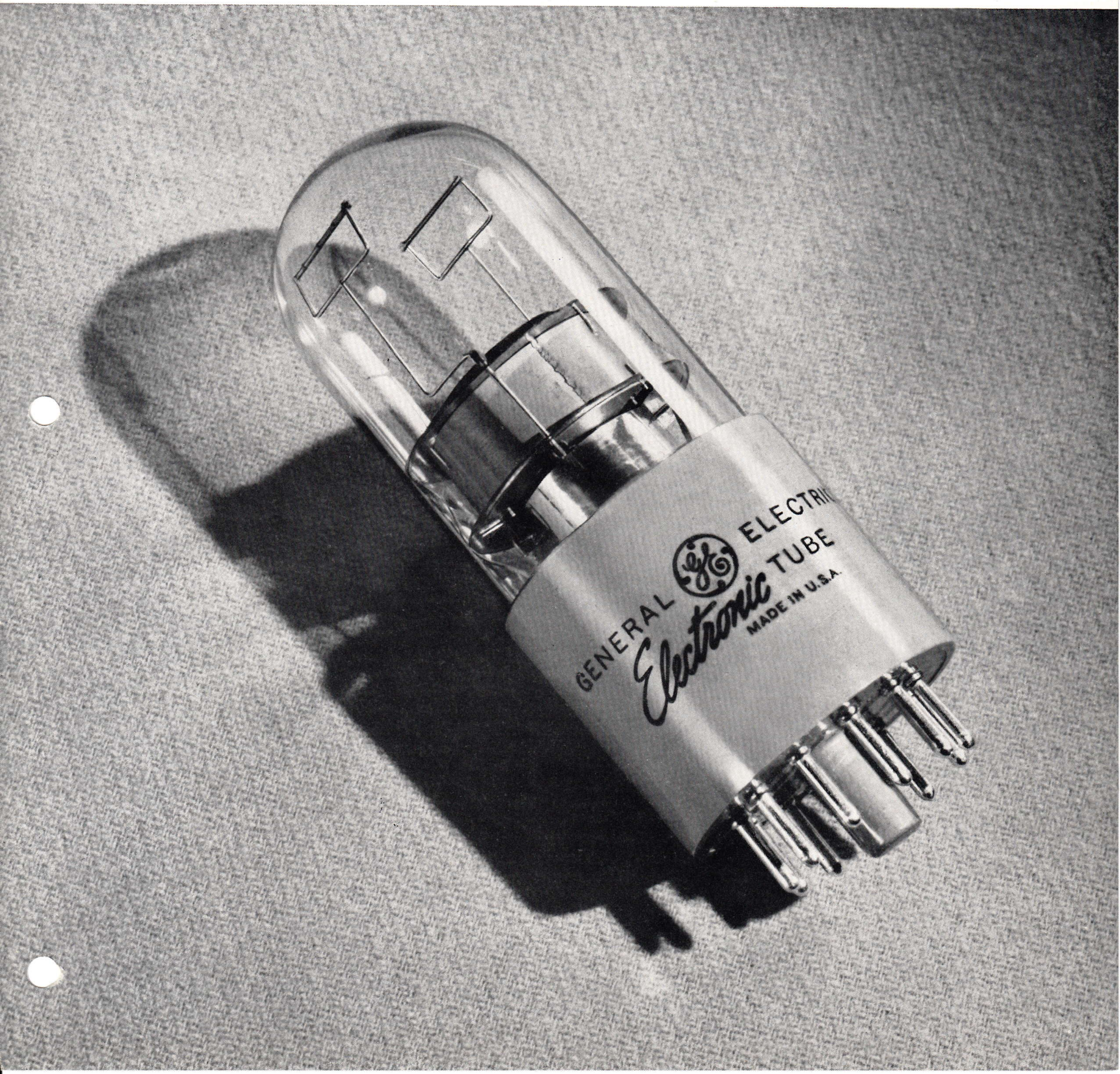
GENERAL ELECTRIC

PHASITRON



DESCRIPTION

The GL-2H21 is a phase-modulator tube for use in FM transmitters. It is intended for operation up to 500 kilocycles.

As a modulator tube, the GL-2H21 makes possible the introduction of comparatively wide-phase excursions at audio-frequency rates in a crystal-controlled, radio-frequency carrier. The modulating circuit audio response is such that the tube has a wide-swing, frequency-modulated output. The outstanding features which this tube contributes to FM transmission are:

1. Direct crystal control using a single crystal.
2. Modulation independent of frequency control.
3. Low distortion.
4. Low noise level.
5. Simplicity of circuit and circuit alignment.

APPLICATION AND OPERATION

The basic circuit in which the GL-2H21 is used is shown in Fig. 1. The functions of the circuit are:

1. To supply 3-phase, crystal-controlled voltages to the deflection electrodes of the tube.
2. To supply a magnetic field in the direction of the axis of the tube, which varies with time at the audio-frequency rate.
3. To extract the frequency-modulated signal which requires only amplification and frequency multiplication from this stage on.

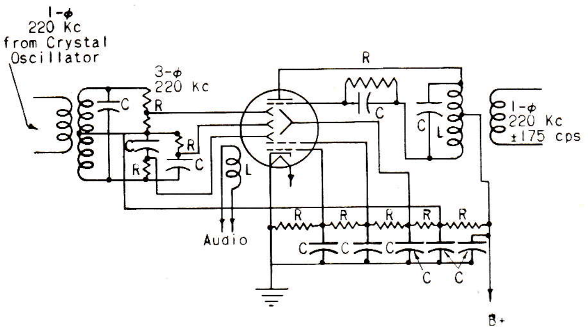


Fig. 1—Basic GL-2H21 Phasitron Modulator Circuit
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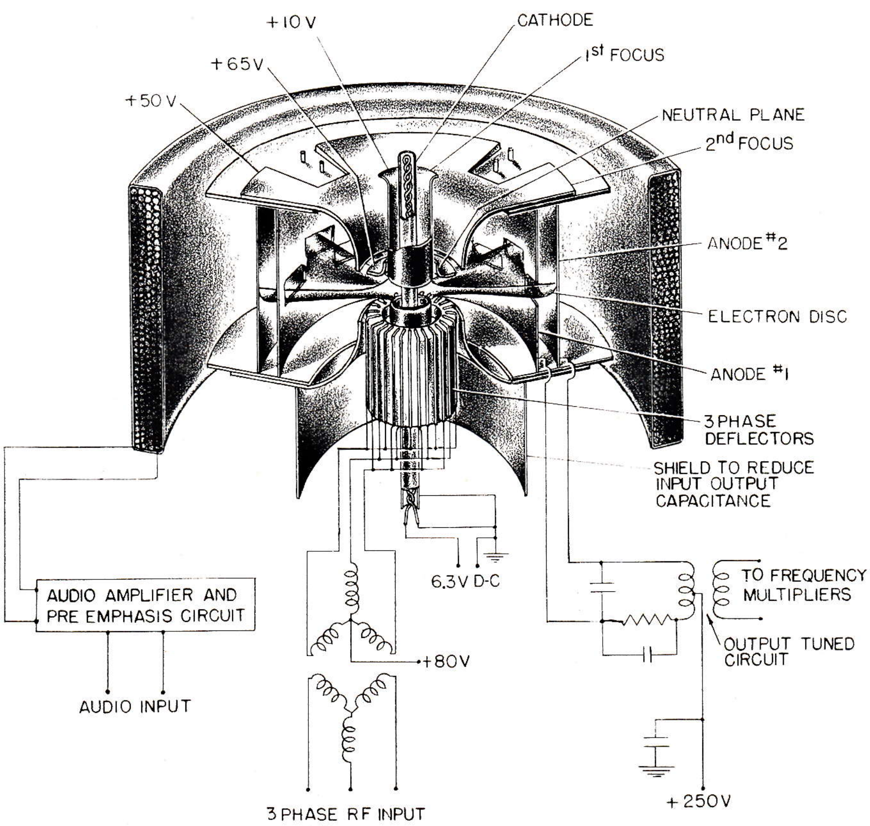

Fig. 2—Cut-away View of GL-2H21 with Companion Circuit Connections

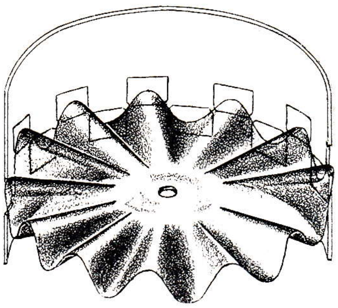

Fig. 3—Perspective View of the Undulate Disk

APPLICATION AND OPERATION (CONT'D)

The tube, when receiving a 220-kilocycle, radio-frequency signal, will deliver to subsequent stages at low distortion a frequency-modulated signal having a frequency deviation of 175 cycles per second from 220 kilocycles. Frequency multiplication of 432 yields an output frequency of 95 megacycles with a frequency deviation of 75 kilocycles. The maximum audio-frequency power required to perform this modulation is approximately 50 milliwatts.

The operation of the tube can best be studied by reference to its construction. Fig. 2, page 2, cut-away view, shows the entire cut-away structure of the tube and a companion circuit. Fig. 3 shows a perspective view of the electron disk.

Anodes No. 1 and No. 2 are at positive d-c potential and draw electrons from the cathode. The two focus electrodes form the electron stream into a tapered thin-edge disk. This disk with the cathode as its axis lies between the neutral plane and the deflector structure and extends out to anode No. 1.

The deflectors consist of 36 separate wires, the active portions of which are radially disposed with respect to the cathode. These wires are labeled A, B and C in Fig. 4. All of the A wires are connected together, all of the B wires are connected together, and all of the C wires are connected together. These three combinations of A, B, and C wires are brought out to the base of the tube and constitute the three deflectors; No. 1, 2, and 3, shown on the basing diagram (see ETX-125). The neutral plane is connected to a pin on the base of the tube and constitutes the deflector No. 4, on the basing diagram shown on ETX-125. Fig. 4 shows a developed view of this grid structure and the neutral plane.

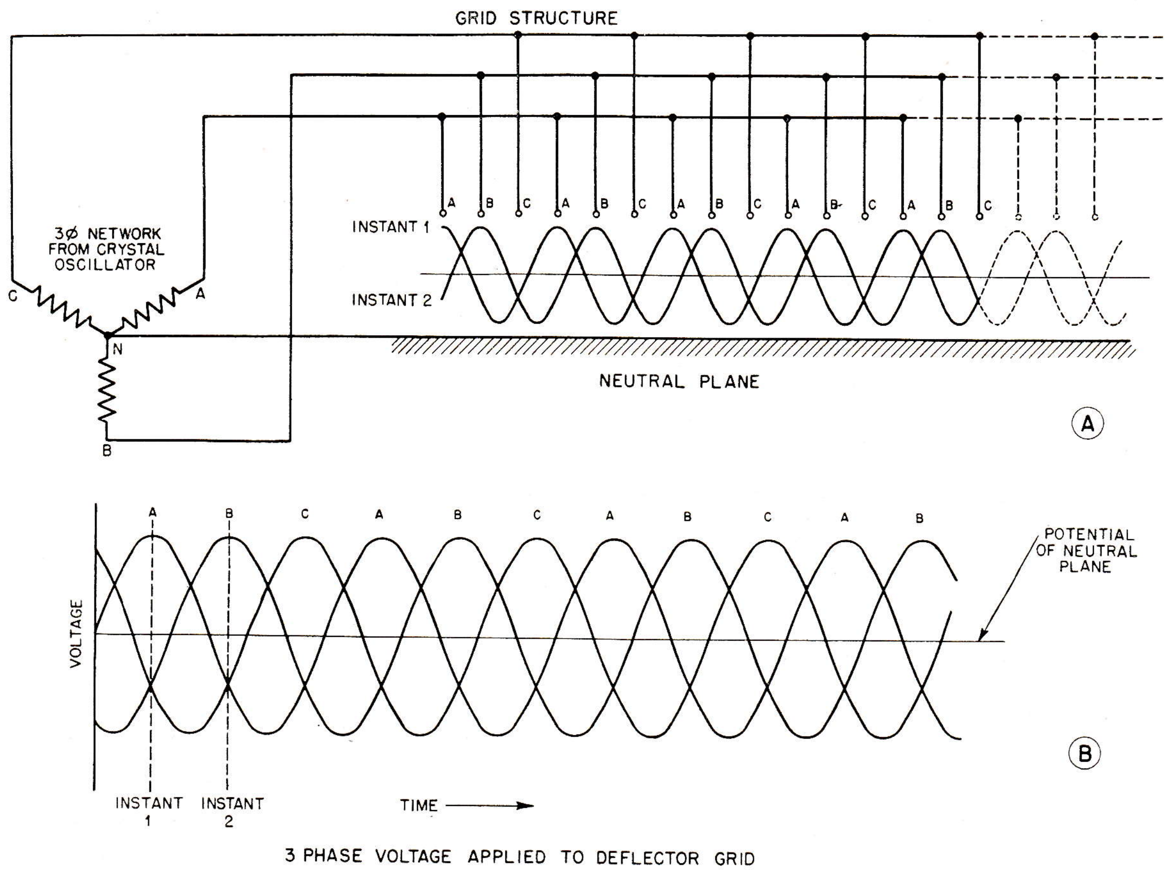

Fig. 4—View of Grid Structure and Neutral Plane

Three-phase, crystal-controlled radio frequency is applied to the deflectors. Phases A, B, and C are each connected to the similarly marked deflector wires; and the neutral of the 3-phase-Y system is by-passed to ground. The deflecting action of these 3-phase voltages on the disk of electrons passing between the neutral plane and the deflector grids can now be seen; at instant 1 the grid wires A are positive with respect to the neutral plane while grid wires B

APPLICATION AND OPERATION (CONT'D)

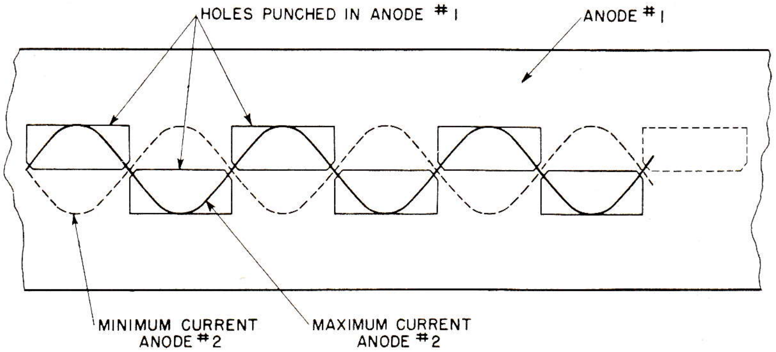

Fig. 5—Developed View of Portion of Anode No. 1 Showing Current Variation

and C are negative. This results in deflection of the electron disk as shown at instant 1, in Fig. 4. At instant 2, 1/3 of a cycle later, deflector wire B is positive and A and C are negative. The undulate disk would then appear to have moved the space of one grid wire during the time interval between instant 1 and instant 2. It can be seen that with the 3-phase voltages applied the undulate electron disk appears to rotate at a rate determined by the applied frequency and the number of deflector wires.

Anode No. 1 has twelve holes punched above the plane of the electron disk and twelve punched below. The rotating edge of the electron disk, therefore, impinges on this series of holes. At an instant when the disk edge is lined up as shown by the solid line of Fig. 5, page 4, most of the electrons pass on through the holes to anode No. 2. One-half cycle later the edge of the disk has moved on to the position shown by the dotted line of Fig. 5. At this instant few, if any, electrons get through to anode No. 2. Thus, the current flowing to anode No. 2 varies sinusoidally at the crystal frequency. Also, it can be seen that any variation in the angular velocity of rotation of the electron disk will result in phase and frequency variation in this output current.

A magnetic coil or solenoid is so placed around the tube that the magnetic field resulting from a current flowing in this coil is perpendicular to the plane of the electron disk. The electrons traveling radially out from the cathode toward the anodes through this field experience a force which is mutually perpendicular to their direction of motion and the direction of the magnetic field. Thus, an angular displacement is introduced in the rotation of the electron disk causing a phase shift in the output current.

Audio-frequency current flowing in this coil causes audio-frequency angular displacements to qualify the rotation of the electron disk and develops a phase-modulated radio-frequency voltage whose average frequency is that of the crystal. It can be seen that if a d-c voltage is applied to the coil the magnetic field causes a fixed angular displacement in the rotation of the electron disk which continues to rotate at the same rate, and causes no change in output frequency. Therefore, we have direct crystal-controlled phase modulation.

Phase modulation when performed at a sinusoidal rate is always accompanied by frequency modulation which bears the folllowing relationship to the phase displacement:

$$f_d = \phi \, f_a$$

Where: f_d = Maximum Frequency Deviation in Cyclces

and: ϕ = Maximum Phase Displacement in Radians

f_a = Audio Modulating Frequency.

From this equation it can be seen that, in order to hold the maximum frequency deviation constant, the maximum phase displacement must vary inversely as the modulating audio frequency. This can be accomplished if the audio-frequency current in the modulating coil is inversely proportional to the frequency. If the impedance of the coil is purely inductive reactance, the current in the coil will meet the required conditions when a constant audio-frequency voltage is applied—this voltage being independent of frequency. Thus, a driving tube which supplies a constant audio-frequency voltage to the coil will produce frequency modulation directly.

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