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RADIO TRANSMITTING SYSTEM

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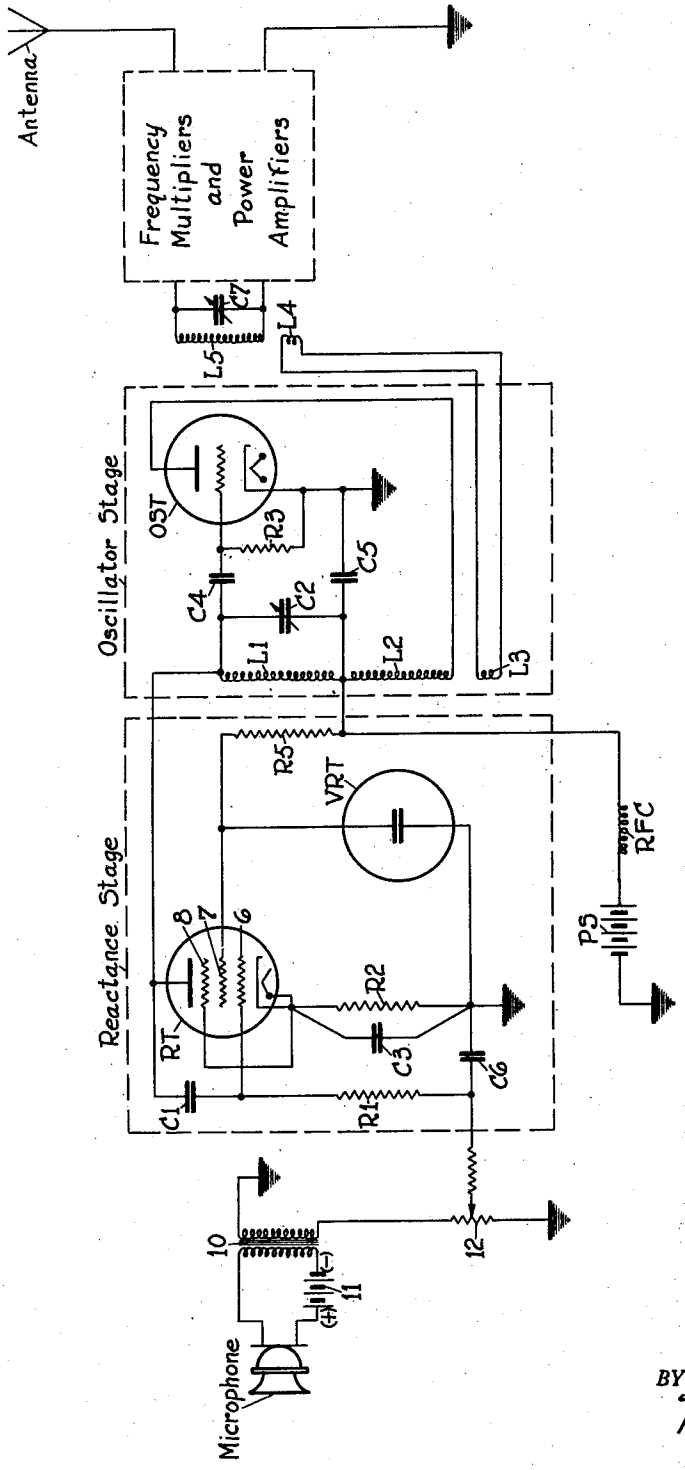

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RADIO TRANSMITTING SYSTEM

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This invention relates to radio transmitting systems, and more particularly pertains to the provision of means to prevent over-modulation in a frequency modulation type transmitting system.

In the transmission of messages by the modulation of a carrier frequency in accordance with the principles of frequency modulation, the deviation of the carrier frequency from the center frequency of such carrier is in accordance with the amplitude of the modulating audio frequency signal. If the amplitude of the modulating audio frequency signal becomes too great, then the carrier frequency will have a deviation exceeding the carrier band of frequencies allotted to the transmitter, which may cause numerous objectionable results in the transmission including interference with other stations having adjacent carrier frequency bands, and possible poor demodulation, and the like. For this reason it is desirable to provide means to limit the extent of frequency deviation regardless of the wide variations in the amplitude of the modulating audio frequency signals.

In view of the above considerations, it is proposed in accordance with the present invention to provide a system of frequency modulation having such characteristics as to substantially eliminate the possibility of over-modulation. It is proposed to accomplish this purpose by simple but effective means.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawing which illustrates a transmitting organization in a simplified diagrammatic manner as one form of embodiment of the present invention.

For the purpose of simplifying the illustration and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown digrammatically and certain conventional illustrations have been employed, the drawing having been made more with the purpose of making it easy to understand the principles and mode of operation than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various devices are illustrated in a conventional manner, and various conventional symbols are used to indicate the devices,

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wiring connections, batteries or other sources of electric current and the like.

With reference to the drawing, a transmitting organization is illustrated as comprising in general a microphone, a reactance stage, an oscillator stage, frequency multiplier and power amplifier stages, and an antenna-ground system.

The microphone is shown connected to the primary of an audio transformer 10 having in its circuit a suitable source of energy such as battery 11. The secondary of the audio transformer 10 is connected through a potentiometer 12 to ground, so that the variable point of the potentiometer can be used to supply a manually selected potential drop across the potentiometer for normal volume of messages as the input of the reactance stage.

The reactance stage (see dotted rectangle with corresponding legend) includes a reactance tube RT of the pentode type having a control grid 6 of the super-control type. This super-control or remote cut-off is effected by winding the grid 6 with wide spacing at the middle and close spacing at the ends. In other words, the tube RT with respect to the control grid 6 may be considered as a tube having a variable-mu characteristic. The tube RT is also provided with a screen grid 7, and a suppressor grid 8 directly connected to the usual heater type cathode. The energy for operating the heater of this tube has not been shown, since for the purpose of the present disclosure it can be assumed that the cathode is continuously heated. The cathode is connected to ground through resistor R2 which has a by-pass condenser C3.

The plate of the reactance tube RT is connected to one terminal of condenser C1, which condenser C1 has its other terminal connected through resistor R1 and by-pass condenser C6 to ground to constitute a phase splitting network. The intermediate connection between the condenser C1 and the resistor R1 is connected to the control grid 6; while the intermediate connection between the resistor R1 and the by-pass condenser C6 is connected to the movable point of the potentiometer 12. The suppressor grid 7 of the reactance tube RT is connected through a series resistor R5 and a radio frequency choke RFC to the plate supply PS which of course has its negative terminal connected to ground.

In accordance with the present invention, a glow-discharge tube VRT is employed, as a voltage regulator tube connected between the screen grid 7 and ground. This voltage regulator tube VRT with such a connection acts to provide a con-

stant voltage on the screen grid 7 regardless of variation in the current flow through the screen grid-cathode circuit, to thereby cause the circuit organization of the reactance stage to function, as will later be described.

The oscillator stage (see dotted rectangle with corresponding legend) may be any conventional oscillator but has been shown as including a triode oscillator tube OST having its control grid-cathode circuit resonated by the usual tank circuit including the inductance L1 and the condenser C2. The tank circuit is connected to the control grid through the by-pass condenser C4 and the other terminal of the tank circuit is connected to ground through the by-pass condenser C5. The plate circuit of the oscillator tube OST includes an inductance L2 coupled with the inductance L1 to provide the feed back for the oscillator organization. The plate circuit of the oscillator is provided with energy from the plate source PS through the radio frequency choke RFC connected to the midpoint between the inductance L1 and the inductance L2. The upper terminal of the tank circuit (L1+C2) is connected to the plate and phase splitting circuit of the reactance stage.

The oscillator stage may be connected to the frequency multipliers and power amplifier in any suitable way but has been shown inductively coupled thereto by the inductance L3 being associated with the inductances L1 and L2, which inductance L3 is connected to the inductance L4 coupled with the inductance L5 tuned by a variable condenser C7. The frequency multipliers will probably include in practice a buffer stage for reasons well understood in the art.

In a system of frequency modulation, the center frequency of the carrier is mainly determined by the characteristics of the oscillator tank circuit including the inductance L1 and the variable condenser C2, although it will be understood that the association of the reactance stage and other elements in the organization modify this resonant frequency of the tank circuit to a limited degree to determine the central frequency of the carrier. However, for practical purposes it will be considered that the carrier frequency is determined by the tank circuit of the oscillator stage, and that this frequency is applied to phase splitting network of the reactance stage including the condenser C1 and the resistor R1 as well as the by-pass condenser C6.

Although the radio frequency potentials of the oscillator tank circuit are also applied to the plate-cathode circuit of the reactance tube this has practically no effect on its operation. The radio frequency voltages placed across the phase splitting combination results in producing a current therein leading the potential of the tank circuit by substantially ninety degrees. Such current in the resistor R1 acts to produce a voltage drop causing the control grid 6 of the tube RT to be governed in accordance therewith so that the tube RT allows a plate-cathode current to flow leading the carrier frequency potential in the oscillator tank circuit by substantially ninety degrees. This in effect is the same as if a condenser were connected across the tank circuit. In other words, the reactance tube RT in effect acts upon the oscillator tank circuit the same as a capacity. If the positions of condenser C1 and resistor R1 are reversed, or if an inductance is used to replace the capacity, then the current in the phase splitting circuit will lag the potential of the tank circuit

by substantially ninety degrees. This causes the reactance tube RT to in effect act as an inductance upon the oscillator tank circuit. In either case, the general functioning of the organization is the same.

If the same bias were placed upon the control grid 6 at all times, then the effect of tube RT would be constant with respect to the tank circuit of the oscillator, but the control grid 6 has its normal bias (determined by the resistor R2) modified in accordance with the audio frequency signals produced by speaking into the microphone and generating audio frequency signals in the secondary of the audio transformer 10. The potentiometer 12 determines the normal amplitude of the audio signals supplied to the control grid, but the general effect is to cause the bias of the control grid 6 to vary with the audio signals.

The magnitude of the reactive plate current (i. e. alternating current component) of the tube RT depends on the mutual conductance of the tube, that is, on the sensitivity of the plate current to a change in grid voltage. Since the reactive current flow in the reactance tube RT is caused by the carrier frequency voltages supplied to the control grid 6 from the oscillator tank circuit, the resultant effect of the tube RT on the oscillator stage would always remain the same were it not for the fact that the degree of amplification can be changed in the reactance tube because this tube is of the variable-mu type.

In brief, the audio voltages applied to the control grid 6 of the tube RT act to determine the degree of amplification of the tube RT, so that the carrier voltages supplied by the oscillator tank circuit will cause a reactive current to flow with an amplitude dependent upon the audio voltage. This change in reactive current amplitude causes a change in the reactive effect upon the tank circuit of the oscillator in such a way that the frequency deviation of the oscillator from center frequency of the carrier is dependent upon the amplitude of the audio signal, whereas the frequency of recurrence of such deviation is dependent upon the frequency of the audio signal.

In view of the above, it will be apparent that the effectiveness of the reactance tube is because of its variable mutual conductance, and an operation of the tube beyond that portion of its mutual conductance curve where the rate of change is rapid, results in effect to cause the tube output to become constant so that extreme variations in amplitude of the audio signals become less effective for modulation purposes.

However, in a reactance-modulator organization of this type, the supply of the screen grid 7 with a potential through a series resistor R5 causes under the usual conventional conditions a voltage drop in the resistor R5 due to screen grid current which in turn decreases the amplification factor of the tube. This negative characteristic of the screen grid due to the series resistor tends to change considerably the mutual conductance curve of such a tube so as to extend its curvature over the entire range of operating values. At the same time, the rate of change of the mutual conductance curve is made considerably smaller.

In accordance with the present invention, it is proposed to provide the glow discharge tube VRT acting as a voltage regulator to make the voltage on the screen grid constant irrespective of the current flow thereto. In this way, the mutual con-

ductance of the tube RT is not affected by varying screen grid current as it would be if the screen grid 7 were supplied through a series resistance only. This organization causes the reactance tube RT to maintain over a relatively limited portion of its mutual conductance curve a high rate of change in the mutual conductance with a low rate of change beyond the extent of this limited portion of the curve, so that the reactance tube RT with its opposite portions of constant slope relatively close together in effect acts to limit the degree of modulation which may be impressed upon the frequency produced by the oscillator. This is very desirable in order to maintain the frequency deviation of the modulated carrier within the frequency band allotted to the station. Such a simple expedient of modulation control is especially useful in a portable or mobile transmitter, and is practically indispensible in those cases where the transmitter is used by novices or by those who may at times be using the transmitter under conditions of mental stress, in which cases the voice messages may be unnecessarily loud and tend to cause over-modulation The modulating effect of the reactance tube should be adjusted so that the extent of modulation permitted before compression action begins is sufficient for the deviation desired in a particular transmitter. This can be done by selecting the proper proportion of reactance provided by the tube, to reactance in the tank circuit of the modulated oscillator.

Having thus described a radio transmitting organization having means for preventing over-modulation as one specific embodiment of the present invention, it is desired to be understood that this form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume, and, it is to be further understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of form without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What I claim is:

1. In a system of volume compression for use in connection with the frequency modulation of a carrier frequency through the control of an oscillator by a reactance stage comprising in combination, a multiple element tube having a screen grid and a control grid with variable-mu characteristics by reason of the variable pitch of the turns of such control grid, circuit means connecting the plate-cathode circuit of said tube to the tank circuit of an oscillator, a phase splitting network also connected across said tank circuit and having a mid-point connection to said control grid, a screen grid-cathode circuit including said screen grid in series with a resistor and a source of potential, a glow discharge tube connected in multiple with the screen grid-cathode circuit of said tube for maintaining the potential of such screen grid constant regardless of variations in the potential of said control grid, and audio input circuit means for supplying potentials of audio frequency to vary the bias of said control grid, whereby the constant potential of said screen grid causes said tube to maintain over a relatively limited portion of its mutual conductance curve a high rate of change in the mutual conductance with a low rate of change beyond the extent of this limited portion of the curve to thereby provide limits in the variation of the amplification of the tube to prevent over-modulation of the carrier signal produced by the associated oscillator.

2. In a system of volume compression for use in connection with the frequency modulation of a carrier frequency signal through the control of an oscillator by a reactance stage comprising in combination, a multiple element tube of the variable-mu type having a control grid normally biased to the knee of its mutual conductance curve and also having a screen grid supplied with potential through a series resistor, input circuit means supplying a radio frequency signal from the oscillator to the plate-cathode circuit of said multiple element tube, a phase splitting network also supplied with said radio frequency signal and connected to said control grid of said multiple element tube so as to supply potentials to it substantially ninety degrees out of phase with the radio frequency signal of the oscillator, a glow discharge tube connected to the screen grid of said multiple element tube to maintain the potential of that grid constant regardless of changes in the current flow through the screen grid to thereby maintain the basic variable-mu characteristics of the tube, and audio input circuit means for varying the bias on said control grid in accordance with an audio signal, whereby normal variations in amplitude of said audio signal causes variations in the reactive effect of said tube on the oscillator producing the radio frequency signal while abnormal variations in amplitude of the audio frequency signal causes the amplification factor of said multiple element tube to approach or reach a constant value thereby providing automatic volume compression.

3. In a system of volume compression for use in connection with the frequency modulation of a carrier frequency signal source including a tube having electrodes coupled regeneratively for the production of oscillations which appear in a resonated tank circuit, a reactance modulator for varying the frequency of the oscillations of said carrier frequency source by varying the effective reactance coupled to its tank circuit, said reactance modulator including a pentode tube having a variable-mu by reason of the variable pitch of its control grid, and a glow discharge tube connected to maintain constant potential on the screen grid of said pentode tube regardless of variations in potential on said control grid to cause said pentode tube to have limits in the variability of its mutual conductance under abnormal variations in bias potential on said control grid to prevent over-modulation of said carrier frequency signal source when audio signal potentials applied to the control grid exceed normal values of amplitude.

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