

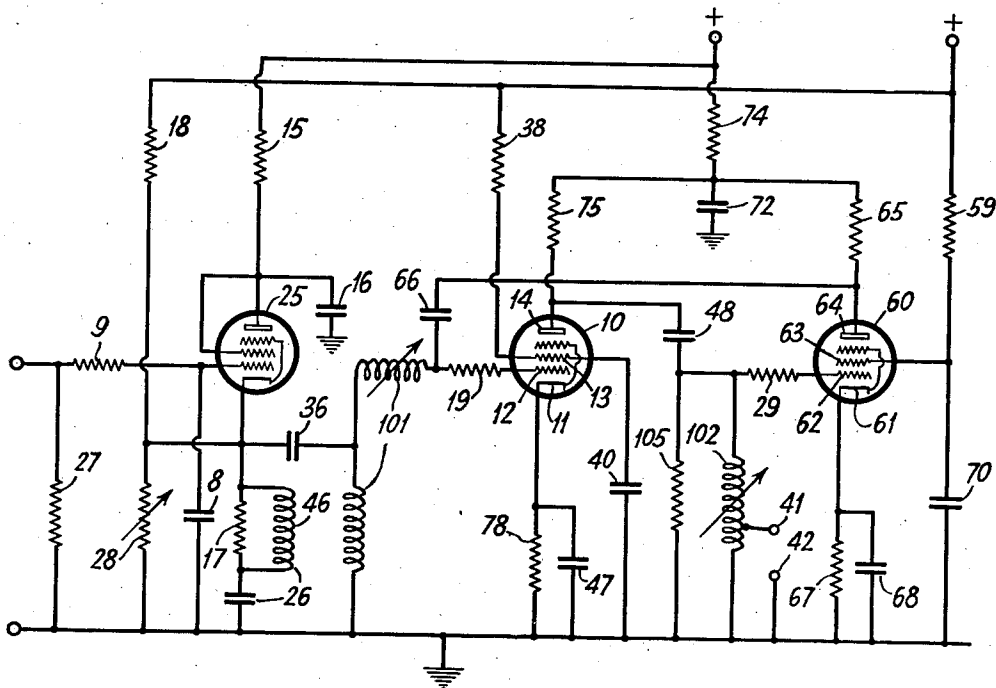
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FREQUENCY MODULATION

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FREQUENCY MODULATION

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4 Claims. (Cl. 179—171.5)

This invention relates to thermionic valve circuits and has particular, but not exclusive, reference to circuits for transmitting frequency modulated signals of high frequency deviation, the invention being applicable also for other purposes for which it is desired to obtain oscillations of varying frequencies as, for example, for automatic frequency correction in radio receivers and transmitters. This application is a division of my United States application #258,141 filed February 24, 1939, now Patent No. 2,231,854, dated February 11, 1941.

In the field of radio communication by means of carrier waves there are three fundamental methods of modulation of a carrier wave, namely, amplitude, phase and frequency modulation. At the present time the most commonly employed method of modulation is amplitude modulation, wherein the amplitude of the carrier wave is varied in sympathy with the modulation frequencies. Now it is known that by using frequency modulation instead of amplitude modulation a more efficient transmission can be effected, thus resulting in economy, especially in the operation of large transmitting stations. In addition, it is also known that frequency modulation, whereby the frequency of the carrier wave is altered in response to modulation frequencies, provides an improvement over amplitude modulation in the signal-to-noise ratio of reception, and this is of great importance in the transmission of television and other signals which occupy wide frequency bands.

Known methods of frequency modulation have been found difficult to apply to the wide pass band required for television, and there are two main reasons for this. In the first place, it is not easy to deviate the carrier frequency over a sufficiently wide band, and secondly, it is not a simple matter to maintain a wide pass band for the side bands, it can be shown that theoretically frequency modulation produces an infinite number of side bands. For example, let it be required to vary the frequency of a carrier between 42 megacycles per second and 48 megacycles per second at a low periodicity to represent a low frequency component of the modulation signal. At the same time let there be superimposed a high modulation frequency component of say 3 megacycles per second, but of a very small amplitude. The minimum side bands required for the higher frequency component will be 42—3 megacycles/second and 48+3 megacycles/second depending on the instantaneous amplitude of the low frequency component. From this it will be seen that for television a very wide pass band is required in the radio-frequency circuits even if the higher sidebands are neglected.

It is the object of the present invention to provide improved means for frequency modulation of a carrier frequency which is especially suitable where the modulation frequencies comprise television or other wide band signals.

According to a feature of the invention a thermionic valve circuit is provided for generating varying frequency oscillations comprising a thermionic valve oscillator including a frequency determining circuit, a plurality of valves in cascade the output circuit of the cascade valves being effectively connected to the input circuit of the cascade valves for the generation of oscillations, and means for applying a controlling potential for determining the frequency of the generated oscillations.

In order that the said invention may be clearly understood and readily carried into effect the same will now be more fully described with reference to the accompanying drawing in which the single figure illustrates a thermionic valve circuit arranged in accordance with the invention.

In the drawing, the screen grid valve 10 has its grid 12 connected in a grid circuit with an inductance 101 which, in conjunction with the stray capacities of the circuit, forms a frequency determining circuit. The anode 14 of valve 10 is coupled by condenser 48 and resistance 29 to the grid 62 of a valve 60. The anodes 14 and 64 of the two valves 10 and 60 are arranged in parallel with anode impedances 65 and 75 and a suitable de-coupling resistance 74 in conjunction with a de-coupling condenser 72. A broadly tuned circuit 102, which is suitable (heavily) damped by a resistance 105, is connected effectively in the anode circuit of valve 10 and is designed so that its resonant frequency is preferably situated in the middle of the frequency band over which modulation is to be carried out. The output of the oscillator is taken from terminals 41 and 42 which are connected across a part of the inductance 102. Valves 10 and 60 are provided with suitable cathode biasing circuits, namely, resistances 78 and bypass 67 and condensers 47 and 68 respectively. The anode 64 of valve 60 is coupled by means of condenser 66 to the grid 12 of valve 10. The screening grids 13 and 63 of valves 10 and 60 are supplied with suitable positive potentials by means of decoupling resistances 38 and 59, in conjunction with condensers 40 and 70, which provide low impedance paths for voltages of carrier frequencies between the screening grids and earth. The circuit will normally oscillate at a frequency determined by the tuned circuit 101.

For the purpose of controlling the frequency of oscillations, a portion of the circuit 101 is damped by means of the cathode impedance of

valve 25 to the control grid of which the modulation or control potentials are applied via resistance 9 and the grid leak 27. A small value condenser 8 is connected between the grid of valve 25 and earth in order to effectively earth the grid of valve 25 at carrier frequencies but not at modulation frequencies. Resistances 18 and 28 provide grid bias for valve 25 and resistance 15 in conjunction with condenser 16 form an anode de-coupling circuit. The screening grid of valve 25 is connected to the anode of that valve and the suppressor grid is connected to the cathode. The cathode of valve 25 is connected by means of condenser 36 to a tapping on the inductance 101. For the purpose of providing a low cathode impedance to modulation frequencies with a high impedance to carrier frequencies a circuit comprising resistance 17, condenser 26 and high frequency choke 46 is provided in shunt with resistance 28. On applying modulation potentials to the grid of valve 25 the slope of the valve is changed and consequently the damping which valve 25 imposes on the circuit 101 is varied and this varies the effective reactance between the grid of valve 10 and the earth line. Thus, the frequency at which the oscillator comprising valves 10 and 60 oscillates is varied.

By the use of suitable components it is found possible to obtain a frequency variation of from 10 to 20 megacycles per second. Instead of taking the output from circuit 102 it is also possible to derive the output from across the circuit 101.

It will be understood that although the main object of the invention is to produce large variations of frequency for frequency modulation, the circuits described can be used for other purposes, such as automatic frequency correction, remote control of the oscillator frequency of a superheterodyne radio receiver, etc. One special application is to provide sawtooth frequency variations for the purpose of showing the response curves of filters and networks on the screen of a cathode ray oscillograph.

The circuits also have applications to so-called "resistance tuning." If the feed back is reduced to such an extent that the circuits are rendered just short of the oscillatory condition, then by applying signals to a point in the circuit it is possible to tune selectively the arrangement to a signal frequency by applying controlling potentials in the manner already described. For example, with my arrangement, signals from an antenna may be applied to the circuit 101 and the output from circuit 102 may be fed to the mixer stage of a superheterodyne receiver. By varying the potential on the grid of valve 25 the input circuit of the receiver is effectively tuned to a required signal frequency. One way of varying the potential of the grid is to connect the grid of valve 25 to earth and to vary the value of the resistance 28.

What is claimed is:

1. In a frequency modulation system, at least three electron discharge valves each having an anode, a control electrode and a cathode, a tuned circuit interconnecting the control electrode and cathode of one of said valves, a tuned circuit coupling the anode to the cathode of said one of said valves, a coupling between the control grid of another of said valves and said last named tuned circuit, a coupling between the anode of said other of said valves and said first named

tuned circuit, a source of modulating potentials connected with the control grid and cathode of a third of said valves, a circuit including reactance connected between the cathode of said third valve and ground and a coupling between said last named circuit and said first named tuned circuit.

2. In an electrical system, a plurality of electron discharge valves each having an anode, a control electrode and a cathode, a tuned circuit interconnecting the control electrode and cathode of one of said valves, a broadly tuned output circuit coupling the anode to the cathode of said one of said valves, a coupling between the control grid of another of said valves and said last named broadly tuned circuit, a regenerative feedback coupling between the anode of said other of said valves and said first named tuned circuit, said circuits, valves and feedback being arranged to generate wave energy in said valves and circuits, a source of control potentials, a damping impedance coupled in shunt to a portion of the reactance of said first tuned circuit, a third electron discharge valve means having electrodes coupled to said damping impedance, and means coupling said source of control potentials to said third valve means for controlling the impedance between the electrodes thereof to thereby control the effect of said damping impedance on the reactance of said first named tuned circuit and the frequency of the generated wave energy.

3. In a frequency modulation system, a plurality of electron discharge valves each having an anode, a control electrode and a cathode, a tuned circuit interconnecting the control electrode and cathode of one of said valves, a broadly tuned circuit coupling the anode to the cathode of said one of said valves, a damping resistance in said last named circuit, a coupling between the control grid of another of said valves and said last named broadly tuned circuit, a regenerative feedback coupling between the anode of said other of said valves and said first named tuned circuit, said circuits, valves and feedback being arranged to generate wave energy in said valves and circuits, a source of modulating potentials connected with the control grid and cathode of a third of said valves, and a circuit of low impedance to modulating potentials and high impedance to wave energy of the generated frequency coupling said third valve to said first named tuned circuit to control the reactance thereof in accordance with the modulating potentials supplied to the control grid and cathode of said third valve to thereby control the frequency of the generated wave energy.

4. In a frequency modulation system, a plurality of electron discharge valves each having an anode, a control electrode and a cathode, a tuned circuit interconnecting the control electrode and cathode of one of said valves, a tuned circuit coupling the anode to the cathode of said one of said valves, a coupling between the control grid of another of said valves and said last named tuned circuit, a feedback coupling between the anode of said other of said valves and said first named tuned circuit, a source of modulating potentials connected with the control grid and cathode of a third of said valves, a circuit including a damping impedance connected between the anode and cathode of said third valve, and connections coupling said damping impedance in shunt to a portion of said first named tuned circuit.

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