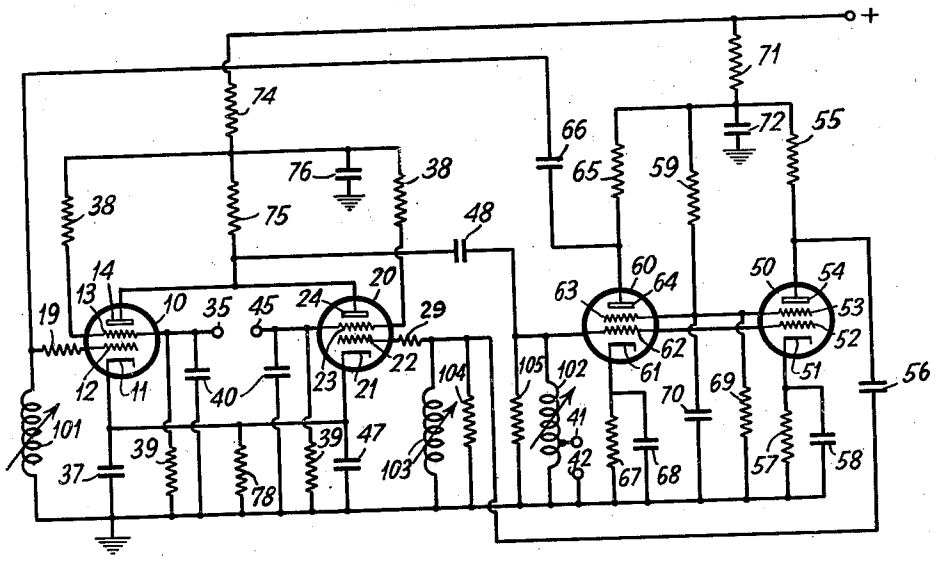
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FREQUENCY MODULATION

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FREQUENCY MODULATION

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This invention relates to thermionic valve circuits and has particular, but not exclusive, reference to circuits for transmitting wide band frequency modulated signals, 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.

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 vary 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.

According to a further feature of the invention a thermionic valve circuit is provided for generating varying frequency oscillations comprising a thermionic valve oscillator including at least two valves each associated with a frequency determining circuit tuned to a different frequency, the outputs of said valves being effectively connected to the input of a thermionic valve phase-inverting circuit having separate outputs which are arranged to feed back energy independently to the input circuits of said valves in such a manner as to tend to cause said valves to generate oscillations at the different frequencies, said valves being so connected that they are forced to produce oscillations of a resultant frequency, and means for applying controlling potentials to said valves so as to determine the resultant 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 single figure of the drawing the screen grid valve **10** is provided in its grid circuit with an inductance **101** which, in conjunction with the stray capacities of the circuit, forms a frequency determining circuit. Similarly, the valve **20** has an inductance **103** connected to its grid **22**, the resonant frequencies of the two frequency determining circuits being arranged at or beyond the opposite ends of the band of frequencies over which it is desired to vary the frequency of oscillation. The anodes **14** and **24** of the two valves **10** and **20** are arranged in parallel with a common anode impedance **75** and a suitable de-coupling resistance **74** in conjunction with a de-coupling condenser **76**. The anode circuit is coupled by means of a condenser **48** to the two grids **52** and

62 of the two valves 50 and 60, the grids of which are arranged in parallel. A broadly tuned circuit 102, which is suitably damped by a resistance 105, is connected effectively in the anode circuit of valves 10 and 20 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 50 and 60 are provided with suitable cathode biasing circuits, namely, resistances 57 and 67 and condensers 58 and 68 respectively. The screening grids 53 and 63 of valves 50 and 60 are de-coupled by means of the resistances 59 and 69 in conjunction with a condenser 70. Each of the valves 50 and 60 are provided with load resistances, the load resistance 55 in the anode of valve 50 being de-coupled from the source of positive potential by means of resistance 71 and condenser 72. The same de-coupling circuit is also used to de-couple the anode impedance 65 of valve 60. The anode 54 of valve 50 is connected by means of condenser 56 to the grid circuit of valve 20 whilst the anode 64 of valve 60 is similarly coupled by means of condenser 66 to the grid 12 of valve 10. The screening grids of valves 10 and 20 are supplied with suitable positive potentials by means of resistances 38 and 39, while condensers 40 are for the purpose of providing a low impedance at carrier frequencies between the screening grids and earth. The modulation potentials are applied between the terminals 35 and 45 in phase opposition. The control grids of valves 10 and 20 are biased by using a common cathode impedance 78 whilst condensers 37 and 47 are for the purpose of by-passing the impedance 78 at carrier frequencies.

The operation of the circuit can be explained as follows:

Assume that the valve 20 has a large negative potential applied to its screning grid 23 so that the anode current of the valve is reduced substantially to zero and that the screening grid 13 has a large positive potential applied to it. Should the grid of valve 10 become slightly positive, then the potential applied to the grid of valve 60 is changed in phase by 180° by means of valve 10 and is consequently negative. The valve 60 then changes the phase of its input signal by 180°, or, in other words, the anode 64 becomes positive. This positive signal is fed back to the grid of valve 10 and since the change of phase of the fed back signals is exactly 360° the circuit 101 will oscillate at its resonant frequency, that is, at a frequency which is at one end of the band of frequencies over which it is desired to modulate the oscillator. Similarly, if the screening grid 23 of the valve 20 has a large positive potential applied to it and the anode current of valve 10 is reduced to zero, then the circuit 103 will oscillate owing to the feedback produced by valves 20 and 50 at a frequency at the other end of the frequency band. If both valves are passing current and the ratio of the extreme frequencies of the two circuits 101 and 103 is not too great, then oscillation will occur at an intermediate frequency. Thus, the effect of modulation applied to the terminals 35 and 40 is to make the frequency vary in sympathy between the extreme limits determined by the frequency determining circuits 101 and 103.

It is desirable that the valves 10 and 20 be matched. This is not so necessary when a common cathode impedance 78 is employed which is large at modulation frequencies but is small at the frequencies of the carrier and sidebands. Such an impedance causes the sum of the currents through the valves to vary only slightly at modulation frequencies and the effect of the mis-matching between the valves is reduced to a second order.

The purpose of resistances 19 and 29 is to prevent the circuit oscillating at very high frequencies although any other suitable means may be employed for this purpose.

I claim:

1. A thermionic valve circuit for generating varying frequency oscillations comprising a thermionic valve oscillator at least two valves each associated with a frequency determining circuit tuned to a different frequency, the outputs of said valves being effectively connected to the input of a thermionic valve phase-inverting circuit having separate outputs which are arranged to feed back energy independently to the input circuits of said first two valves in such a manner as to tend to cause said valves to generate oscillations at the different frequencies, said valves being so connected that they are forced to produce oscillations of a resultant frequency, and means for applying controlling potentials to said valves so as to determine the resultant frequency of the generated oscillations.

2. A thermionic valve circuit according to claim 1, wherein each frequency determining circuit is associated with a pair of cascade-coupled therminonic valves, the output circuit of each pair of cascade valves being effectively connected to their respective input circuits.

3. A thermionic valve circuit according to claim 1, wherein the controlling potentials are applied to a plurality of valves, said valves having a common cathode impedance which is high at the frequency of the controlling potential or potentials but which is low at the frequency of the generated oscillations.

4. In a frequency modulation system a pair of electron discharge valves each having a cathode, a control electrode and an anode, a circuit broadly tuned to the frequency of the oscillations to be generated coupled to the anodes of said valves, a tuned circuit connected between the control electrode and cathode of each of said valves, an additional valve coupling said first named tuned circuit to the control grid of one of said first named valves, a further valve coupling said first named tuned circuit to the control grid of the other of said first valves, said additional and further valves serving to reverse the phase of voltages supplied thereto and apply the same to said control grids, and means for modulating the impedances of said first two valves in phase opposition at signal frequency.

5. A system as recited in claim 4 wherein the cathodes of said first pair of valves are tied directly together and connected to a source of direct current by means for maintaining the direct-current supply to said cathodes substantially constant.

6. In a frequency modulation system a pair of electron discharge valves each having a cathode, a control grid and an anode, a circuit broadly tuned to the frequency of the oscillations to be generated coupled to the anodes of said valves, circuits tuned to frequencies on opposite sides of the mean frequency to which said first circuit is tuned connected between the control grids and cathodes of said valves, a third valve coupling

said first named tuned circuit to the control grid of one of said first named valves, a fourth valve coupling said first named tuned circuit to the control grid of the other of said first valves, said third and fourth valves serving to apply voltage from said first circuit to said control grids, and means for modulating the impedances of said first two valves in phase opposition at signal frequency.

7. A system as recited in claim 6, wherein the cathodes of said first pair of valves are tied directly together and connected to a source of direct current by means for maintaining the direct-current supply to said cathodes substantially constant.

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CERTIFICATE OF CORRECTION.

Patent No. 2,231,854. February 11, 1941.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 16, claim 1, after "oscillator" insert --including--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of May, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)