

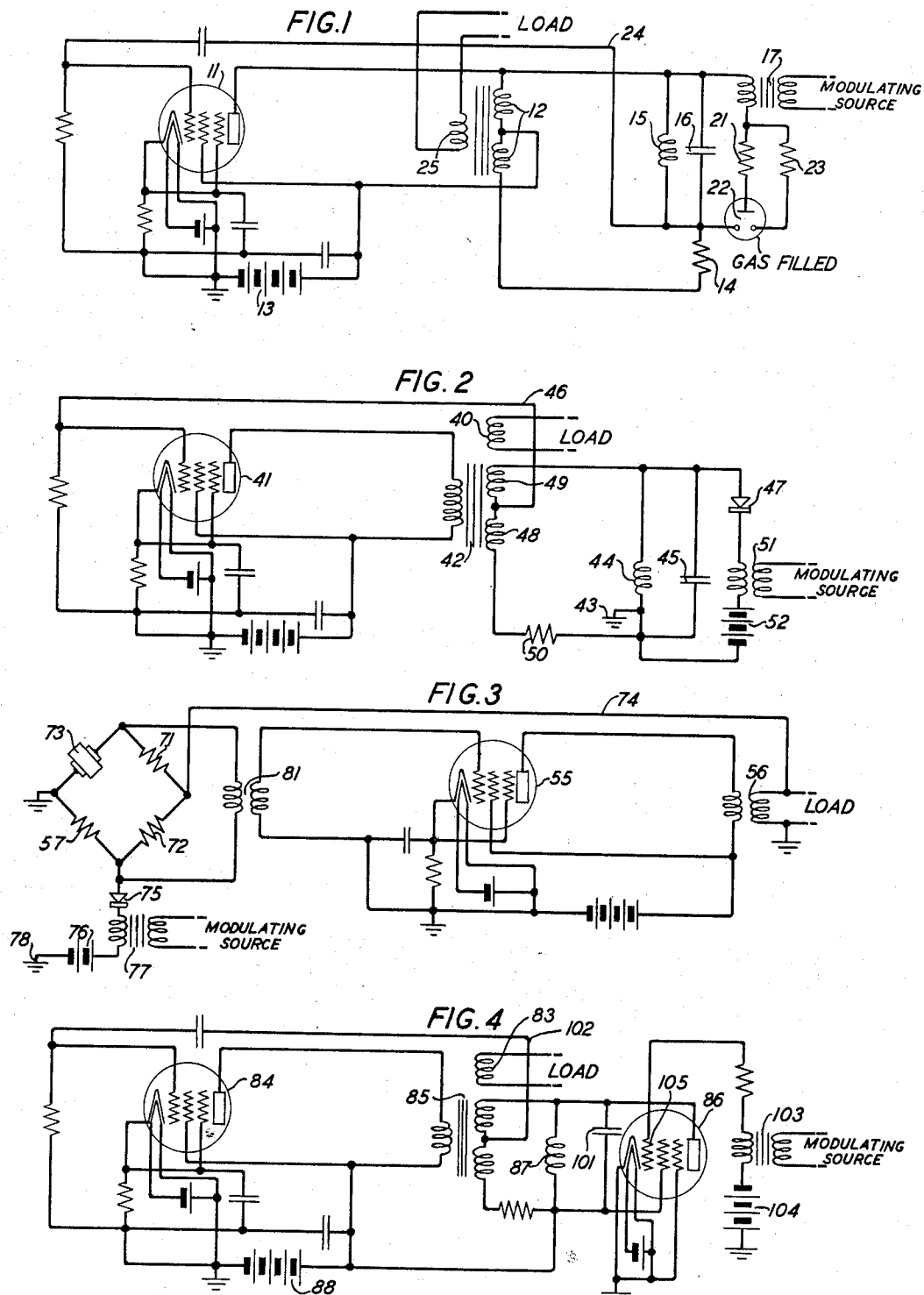
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OSCILLATION MODULATOR

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OSCILLATION MODULATOR

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This invention relates to an oscillation modulator and particularly to an amplitude modulator.

An object of the invention is to improve the over-all efficiency of a modulator without sacrifice of quality and fidelity of the resulting signals.

A more specific object of the invention is the effective amplitude modulation of a carrier frequency with a minimum expenditure of modulating energy.

A feature of the invention resides in means for effectively applying modulating voltages to an element of the oscillation circuit which normally would serve as an amplitude stabilizer of the oscillations.

There has previously been described (Patent 2,163,403, issued June 20, 1939, to L. A. Meacham) a stabilized oscillator circuit wherein means for stabilizing the amplitude of the oscillations is included in one arm of the stabilizing bridge circuit; this means in one embodiment is a non-linear resistance, e. g., a resistance having a positive temperature coefficient whereby the resistance value rises upon increase of current flow.

In accordance with a specific embodiment of the present invention, a non-linear amplitude stabilizer, in the form of a cold cathode gas-filled tube, contact rectifier, vacuum tube or the like, is connected in one bridge arm of a bridge stabilized oscillator circuit. The modulating voltages are applied to this amplitude stabilizing element whereby the characteristics of said element are varied at a rate which is slow compared to that of the oscillator frequency. The result is effective amplitude modulation of the oscillations with a minimum expenditure of modulating energy.

A complete understanding of the operation of the various arrangements contemplated by the invention as well as appreciation of the various advantageous features thereof may be gained by consideration of the following detailed description and the attached drawing, in which:

Fig. 1 illustrates a bridge stabilized oscillator circuit with an amplitude stabilizer in the form of a cold cathode gas-filled tube connected in one bridge arm, the modulating voltages being applied to the gas-filled tube;

Fig. 2 illustrates a circuit similar to that of Fig. 1 except for the fact that the amplitude stabilizer is in the form of a contact rectifier;

Fig. 3 illustrates a bridge stabilized oscillator circuit of the type in which a piezoelectric crystal is included in one bridge arm and in which a biased rectifier is utilized as an amplitude stabilizer and modulating means; and

Fig. 4 illustrates a circuit similar generally to that of Fig. 2 but utilizing the plate characteristics of a pentode type vacuum tube for stabilization and modulation.

Referring now to Fig. 1, there is illustrated a bridge type oscillator circuit including a vacuum tube 11 which is preferably of the screen grid high amplification type and which is provided with the usual electrode energizing sources as illustrated. The bridge network comprises four arms, two of which are formed by a closely coupled inductance coil, or transformer, 12 having a center tap which divides the coil into two equal sections. The positive terminal of battery 13 is connected to this center tap. The other two arms of the bridge comprise, respectively, resistance 14 and a network which includes a tuned circuit, comprising inductance 15 and capacitance 16 connected in parallel, and a third parallel arm comprising the secondary winding of transformer 17, resistance 21 and gas-filled tube 22. The value of resistance 23 is high compared to that of resistance 21.

The tuned circuit, comprising inductance 15 and capacitance 16, controls the frequency of the oscillations produced by oscillator tube 11 in the general manner set forth in the Meacham patent referred to above while gas-filled tube 22, acting in a manner to be described subsequently, controls the amplitude of the oscillations. The bridge is in balance when the combined impedance of the three parallel paths (tuned circuit and path through gas-filled tube 22) is exactly equal to that of resistance 14. Feedback to the control grid of oscillator tube 11 is applied over feedback path 24 and, as this path is taken off the junction point of resistance 14 and the tuned circuit arm, it follows that any unbalance in the bridge is translated into grid potential swing of oscillator tube 11.

Oscillations produced by the circuit are applied to the load through coil 25 which is inductively related to coil 12. The modulating voltages are applied, as described subsequently, to the circuit through transformer 17.

Neglecting for the moment the modulating function of the circuit, let us see first how gas-filled tube 22 acts to stabilize the amplitude of the oscillations at the preselected value. At low amplitudes gas-filled tube 22 is essentially an open circuit being in deionized or non-conductive condition. Under such conditions the impedance of the tuned circuit is substantially higher than the resistance value of resistance 14; in other words, the bridge is unbalanced. When the plate circuit of oscillator tube 11 is closed, therefore, oscillations of a frequency determined by the characteristics of the tuned circuit will start and will build up in amplitude, this building-up continuing until something occurs to halt it.

As the oscillations continue to increase in amplitude a point is reached at which the peak voltage across the tuned circuit (inductance 15 and capacitance 16), is equal to the ionizing potential of gas-filled tube 22. Tube 22 will ionize, or

"break down" at this point and become conductive. A conductive path through the secondary winding of transformer 17, resistance 21 and main gap of gas-filled tube 22 is established (resistance 23 being, as set forth above, of high value compared to resistance 21) the result being that the combined impedance of the three-section arm (inductance 15, capacitance 16 and tube 22) is now brought down to a point only slightly higher than that of resistance 14 whereby the bridge is brought into approximate (but not exact) balance and the feedback over path 24 is reduced.

Under stable operating conditions gas-filled tube 22 will ionize, i. e., become conductive, on the voltage peaks of each half cycle and will deionize on each half cycle. The amplitude of the oscillations is, therefore, stabilized at the selected point as any increase of the peak voltage across the tuned circuit above this point would be absorbed by the path through the ionized tube while a decrease of the peak voltage below the point would prevent ionization of tube 22, with its consequent stabilizing action, and the building up of the amplitude of the oscillations would immediately recommence.

Considering now, in particular, the modulating action of the circuit, when no modulating voltages are being applied through transformer 17, gas-filled tube 22, operating as above described, will maintain the peak voltage across the parallel combination of inductance 15 and capacitance 16 at a value just slightly higher than the sustaining voltage of the tube. As modulating voltages are applied through transformer 17 they are applied to gas-filled tube 22 in series with the voltage applied across the tuned circuit by oscillator tube 11. The modulating voltages, therefore, effectively add to and subtract from the peak voltage applied by oscillator tube 11, thereby causing gas-filled tube 22 to ionize (and restore) at a higher (or lower) point with respect to the output of oscillator tube 11 than when subjected to the oscillator output alone. That is, the point at which the increase in amplitude of the oscillations is halted by ionization of gas-filled tube 22 is changed from moment to moment (increased or decreased) by addition (or subtraction) of the modulating voltages to the peak voltage applied by oscillator tube 11. This means, of course, that the alternating voltages fed back over path 24 to the control grid of tube 11 are varied in both directions from the stabilized value in accordance with the variations in the modulating voltages; the net result is that the oscillations supplied to the load by oscillator tube 11 through coils 12 and 25 are modulated directly in accordance with the fluctuations in the modulating voltage applied through transformer 17. It will be understood that the rate at which the ionization and deionization points of tube 22 are changed is slow compared to the oscillator frequency.

It will be evident from the above description that, in accordance with the novel arrangement contemplated by the invention, effective modulation may be achieved through relatively low power expenditure in the modulating source.

Considering now Fig. 2, the circuit illustrated is similar generally to that of Fig. 1 described above. Oscillations produced by oscillator tube 41 are supplied to the load through coil 40 which is inductively related to the primary winding of transformer 42. In the circuit of Fig. 2, however, a ground 43 is connected to the tuned circuit,

which includes inductance 44 and capacitance 45, thereby making possible a grounded bias supply and low alternating current impedance to control grid of oscillator tube 41 over feedback path 46. The bridge includes as the four arms, respectively, coil 48, coil 49, resistance 50 and the three branch arm, i. e., inductance 44, capacitance 45 and rectifier 47. Rectifier 47 in this instance acts as the stabilizing and modulating element. When no modulating voltages are supplied from the modulating source through transformer 51, the alternating current peak voltage supplied across the parallel combination of inductance 44 and capacitance 45 by oscillator tube 41 is held at a value just slightly greater than the voltage of battery 52 and the amplitude of the oscillations produced by tube 41 is stabilized at this point. Now as modulating voltages are applied through transformer 51, they effectively add to and subtract from, depending upon their instantaneous polarity, the voltage of battery 52, thereby causing corresponding changes in the voltage supplied across inductance 44 and capacitance 45 thereby resulting in corresponding changes in the alternating voltage supplied over feedback path 46, to the control grid of oscillator tube 41. The amplitude of the oscillations supplied to the load by oscillator tube 41 is thereby modulated in accordance with the modulating voltage applied through transformer 51.

Considering now Fig. 3, the circuit illustrated is of a type in accordance with which the oscillations supplied by oscillator tube 55 to the load through output transformer 56 are normally stabilized by a bridge which includes in three arms respective resistances 57, 71 and 72 and in the fourth arm a piezoelectric crystal 73. Alternating voltage is fed back to the bridge over feedback path 74. In this instance rectifier 75, biased by battery 76, serves as an amplitude stabilizer and modulating element. The path through rectifier 75 to ground 78 is in effect a shunt across bridge arm 57, decreasing the effective resistance of that arm and bringing the bridge closer to an exact balance.

When no modulating voltages are being applied through transformer 77, the bridge, together with the biased rectifier, holds the oscillations at the point of stabilization. When modulating voltages are applied to transformer 77, however, they effectively add to and subtract from, depending upon their instantaneous polarity, the voltage of battery 76, thereby varying the bridge unbalance and causing corresponding variations in the alternating voltage supplied through transformer 81 to the control grid of oscillator tube 55. The amplitude of the oscillations supplied to the load by oscillator tube 55 is thereby effectively modulated in accordance with the modulating voltage applied through transformer 77.

Considering now Fig. 4, the circuit illustrated is similar generally to that of Fig. 2 except for the fact that the plate characteristic of a pentode type vacuum tube is utilized to stabilize and modulate the oscillator output. Oscillations produced by oscillator tube 84 are supplied to the load through coil 83 which is inductively coupled to transformer 85. Pentode type vacuum tube 86 has its cathode-anode space path connected in parallel with the elements of the tuned circuit, i. e., inductance 87 and capacitance 101, the alternating current impedance of battery 88 being negligibly small, and this tube functions as an amplitude stabilizer and as a modulating element. The characteristics of the elements of the

bridge circuit are so fixed that the alternating voltage feed-back over path 102 to the control grid of oscillator tube 84 is held at the stabilization value at such times as no modulating voltages are being supplied through transformer 103. At such times the plate current versus plate voltage relationship of pentode tube 86 is fixed by the biasing voltage supplied from battery 104 to control grid 105. Now as modulating voltages are applied through transformer 103, they are effectively added to and subtracted from the biasing voltage supplied to the control grid of tube 86 whereby the plate current versus plate voltage relationship of pentode tube 86 is varied in accordance with the variations of the modulating voltage. This variation of the characteristic of pentode tube 86 in turn causes corresponding variations in the peak voltage across inductance 87 and capacitance 101 thereby resulting in a corresponding variation in the alternating current feedback over path 102 to the control grid of oscillator tube 84. The oscillations supplied to the load through transformer 85 are, therefore, modulated directly in accordance with the modulating voltages applied through transformer 103.

While certain specific embodiments of the invention have been selected for disclosure and detailed description, the invention is not, of course, limited in its application to such embodiments. The embodiments disclosed should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a non-linear element connected effectively in shunt with elements of one arm of said bridge for stabilizing the amplitude of oscillations produced by said source, a source of modulating voltages and means for varying the characteristics of said non-linear element in accordance with variations in the modulating voltages.

2. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a non-linear device connected in one arm of said bridge for limiting the amplitude of the oscillations produced by said source, a source of modulating voltages and means for varying the characteristics of said non-linear device in accordance with variations in the modulating voltages.

3. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a gas-filled discharge device having a definite breakdown characteristic connected in one arm of said bridge for stabilizing the amplitude of oscillations produced by said source at a value determined by said breakdown characteristic, a source of modulating voltages and means for varying the breakdown characteristic of said device in accordance with variations in the modulating voltages.

4. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, one of the arms of said bridge comprising a tuned circuit and a gas-filled discharge device having a definite breakdown voltage characteristic connected in parallel, means for applying oscillations produced by said source across said tuned circuit, said gas-filled discharge device being adapted to ionize when the peak volt-

age of the waves applied across said tuned circuit exceeds the breakdown voltage characteristic thereof, ionization of said device being effective to stabilize the amplitude of the oscillations at the approximate value existent when said ionization took place, a source of modulating voltages, and means for varying the ionization point of said device with respect to said peak voltages in accordance with the variations in the modulating voltage.

5. An amplitude modulator comprising an oscillation device, a bridge connected in circuit with said oscillation device, one arm of said bridge including means for stabilizing the frequency of oscillations produced by said device and means for stabilizing the amplitude of said oscillations, said last mentioned means being connected in parallel with said first mentioned means and comprising a gas-filled discharge device having a predetermined breakdown voltage characteristic, the breakdown voltage characteristic of said device being a determining factor in the amplitude stabilization point, a source of modulating voltages and means for varying the breakdown point of said device with respect to the amplitude of said oscillations in accordance with variations in the modulating voltages.

6. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a rectifier, a biasing battery for said rectifier, said rectifier and biasing battery being connected in series with each other and in shunt with the elements of one arm of said bridge, a source of modulating voltages and means for superimposing voltages from said modulating source upon the voltage of said battery whereby the biasing voltage applied to said rectifier is fluctuated in accordance with the fluctuations of the modulating voltages.

7. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a multi-electrode vacuum tube, means for connecting certain electrodes of said tube in one of the arms of said bridge whereby the plate current versus plate voltage characteristic of the tube is applied effectively in shunt with elements of said one arm, a source of modulating voltages and means for varying said plate current versus plate voltage characteristic in accordance with variations in the modulating voltage.

8. An amplitude modulator comprising a source of oscillations, a bridge connected in circuit with said source, a vacuum tube having a cathode, anode, control grid, shield grid and suppressor grid, potential sources for the electrodes of said tube, the cathode-anode space path of said vacuum tube being so connected in one arm of said bridge that the plate current versus plate voltage characteristic of the tube is applied effectively in shunt with elements of said one arm, a battery, means for applying a biasing voltage from said battery to the control grid of said tube for stabilization of said plate current versus plate voltage characteristic of the tube, a source of modulating voltages and means for superimposing voltages from said modulating source upon the voltage applied to said control grid from said battery whereby the plate current versus plate voltage characteristic is varied in accordance with variations in the modulating voltages.

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