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ELECTRON CAPACITY AND ELECTRON CAPACITY MODULATOR

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Fig. 1.

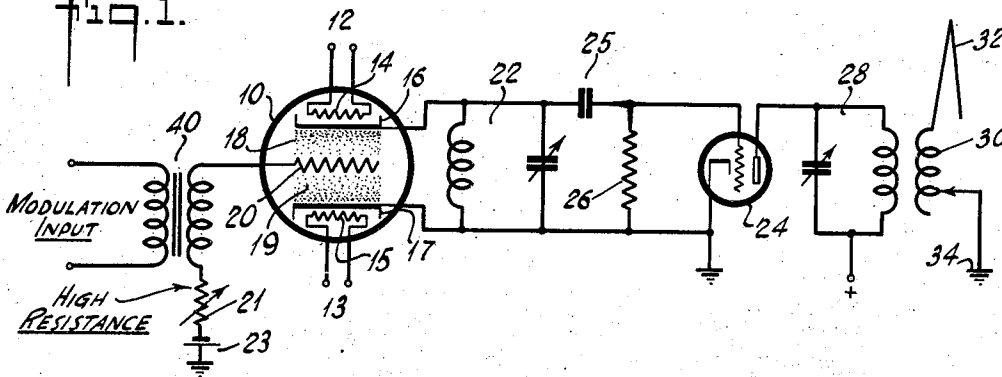


Fig. 2.

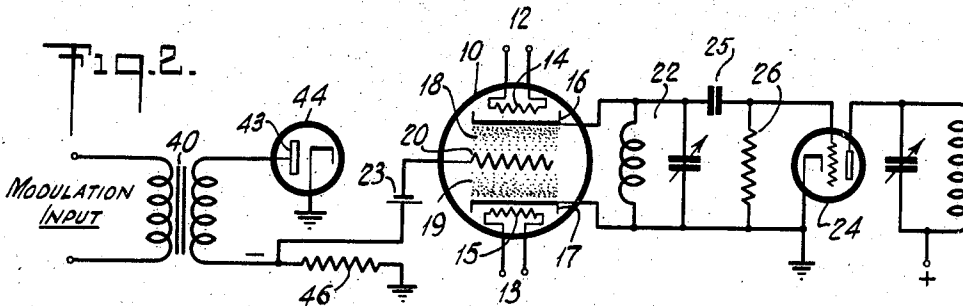


Fig. 3.

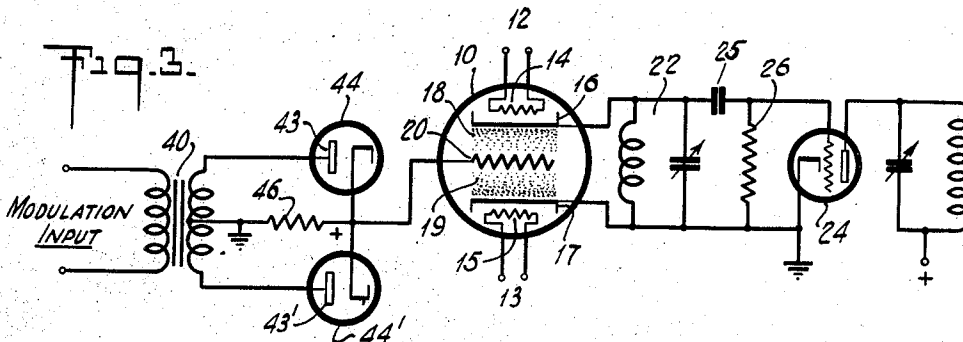
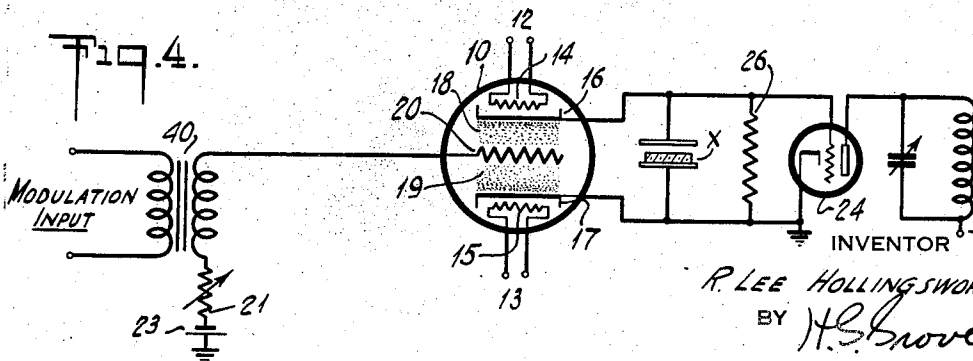


Fig. 4.



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ELECTRON CAPACITY AND ELECTRON
CAPACITY MODULATOR

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Application December 8, 1943, Serial No. 513,448

10 Claims. (Cl. 179—171.5)

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In this application I disclose an improved capacity of the electron type which is variable, and the same in a circuit tuning arrangement, and a timing or angular velocity modulation system wherein the electron capacity which is inertialess in operation is used to timing or angular velocity modulate oscillatory energy.

In my U. S. Patent #2,243,423, dated May 27, 1941, I disclose extensive use of electron stream and electron cloud capacities produced in electron discharge tubes of the evacuated type and use thereof in various radio circuits. In my U. S. application Serial #471,946, filed January 11, 1943, I also show extensive usage of the electron stream capacity and of the electron cloud capacity contained within electron discharge tubes of the evacuated type and the same in numerous radio applications.

In the present application I disclose a new and improved electron system or electron cloud capacity within an evacuated electron discharge device and the use of the same in improved signalling systems.

An object of the present invention is improvement in electron system or electron cloud capacities in electron discharge devices. In the inertialess capacity of the present invention at least two electron clouds or streams or grouping of electrons are provided symmetrically related to a control electrode and to at least two plates in such a manner that variation of the control electrode potential causes displacement of the electron stream or cloud or groups of electrons to thereby simulate movement of two plates of a condenser.

Another object of the present invention is improvement in circuit tuning. This is accomplished by arrangement of the inertialess capacity described immediately above in circuits and control of the capacity to effect tuning of the circuit.

A particular object of the invention is the use of my improved inertialess electron capacity in an angular velocity modulation system. If the system is of the frequency modulation type, the tuning of an oscillatory circuit is controlled by the electron capacity to frequency modulate the generated oscillations.

Where the oscillatory energy is to be modulated in phase the inertialess electron capacity is included in a tuned circuit wherein the oscillatory energy is set up, for example, a circuit coupling two tube stages.

It is intended that the improved electron system or cloud or capacity of the present applica-

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tion is to be used in any of the circuits shown in my pending application U. S. Serial #471,946, filed January 11, 1943, and furthermore that the voltage potential variable inertialess capacity of the present disclosure is applicable to increase or decrease the capacity as desired when connected directly or indirectly to any electrical circuit with which the capacity is associated.

In describing my invention in detail, reference will be made to the attached drawing wherein

Fig. 1 illustrates my improved electron system or electron cloud capacity and the manner in which the same operates, and the use of the same in a tuned circuit of an oscillation generator for modulating the timing of the generated oscillations.

Figs. 2 and 3 are modifications of the arrangement of Fig. 1. In Fig. 2 the modulating potentials are rectified and applied to the control electrode in such a way that the potential thereon is of a selected value with no modulation and becomes more negative as the modulation level increases. In Fig. 3 the arrangement is such that the potential on the control electrodes becomes more positive with respect to a selected value as the modulation level grows.

Fig. 4 is a modification of the arrangement of Fig. 1.

In Fig. 1, 10 is a tube the envelope of which encloses the electron discharge inertialess capacity device. The numerals 12 and 13 indicate connections to heater electrodes within the tube by means of which voltage is applied so that the current is supplied to indirect heater filaments 14 and 15. The cathodes 16 and 17 are heated by the filament resistances 14 and 15 to a point of electron emission. 18 and 19 indicate electron clouds or groups of electrons which hover in the vicinity of and/or around the cathodes 16 and 17. The cathodes 16 and 17 form the condenser plates. The control grid 20 is located as shown intermediate the cathodes 16 and 17. The capacity is dependent on positions of the electron clouds 18 and 19, and the latter are influenced by the potential on the electrode 20. Variation or adjustment of the potential on 20 changes the value of the capacity simulated by the tube.

It will be seen that I have provided an inertialess electron capacity having the two clouds 18 and 19 which simulate variable capacities in series across the tank circuit 22. The inductance of the tuned circuit 22 completes a direct current path between the two cathodes 16 and 17 and the grid 20. The tuned circuit 22 is coupled by

blocking condenser 25 to an oscillator tube 24, having its grid connected to its cathode by bias resistance 26. The output of the oscillator 24 is impedance matched through tuned circuit 28 to the antenna coupling coil 30, connected with the antenna radiating means 32 and to ground at 34.

40 is a transformer such as may be used in any high fidelity audio circuits in radio broadcasting work. Across the terminals of the primary winding of this transformer 40 I apply the modulation from a high fidelity microphone and associated equipment in a manner much used in the broadcasting art. The secondary winding of transformer 40 is connected to the control electrode 20 and connects the same through a high resistance 21 and source 23 to ground and to the winding of circuit 22. 23 is a biasing battery connected in a conventional manner to the grid 20.

The tube 24 is an oscillation generator of any type. For purposes of illustration I have shown an oscillation generator of the Miller tuned plate tuned grid type which is oscillating at a frequency determined by the capacity and inductance in tuned circuit 22, and by the capacity represented by the electron clouds 18 and 19 which are shown connected in parallel to the tuned circuit 22.

If we assume that the potential applied to the control grid 20 is steady, carrier current radiated from antenna 32 will be reasonably constant in frequency due to the inherent stability of the associated electrical circuit constants.

By adjusting the potential on the grid 20 of the tube 10 the capacity provided thereby is changed, thereby changing the tuning of circuit 22. For example, the values of 21 or 23, or both, may be varied to adjust the value of the capacity and the tuning of the circuit.

If now modulation potential is applied to grid 20, and if the applied potential be negative with respect to the potential on the cathodes 16 and 17 or to ground potential electron clouds 18 and 19 will be displaced away from grid 20 toward cathodes 16 and 17, thereby reducing the capacity between the said electron clouds 18 and 19, and, as a consequence, causing the frequency of the generated oscillations to be shifted to a higher value. With the progression of the modulating voltage cycle the frequency of the radiated energy returns to its original value as the modulation voltage passes through its zero axis. The modulation voltage then becomes positive with respect to the cathodes 16 and 17, at which time the electron clouds 18 and 19 are drawn closer together increasing the capacity across the oscillator tuned circuit 22, and causing the frequency of the radiated energy to be decreased. When positive potential is applied to the grid 20, grid current flows, thereby further increasing the capacity change. If the amount of current taken by the grid is allowed to be increased above a selected value, the modulation may become non-symmetrical. In practice, steps are taken to operate on the linear portion of the modulation characteristic of the tube. The characteristic curve of the tube may be made sufficiently linear above and below the crossover point for most purposes. By adding a high resistance in the direct current path, say in the grid return at 21, this increase in capacity due to grid current may be limited by the increase in potential drop in this resistance, thus increasing the linearity of the

characteristic above and below the crossover point.

During modulation the change in frequency or timing or angular velocity or phase of the radiated energy is governed by the amount of potential applied to the grid 20 of the electron discharge device 10.

If the voltage applied from the signal source coupled to transformer 40 is rectified before application of the control potential to the grid 20, uni-directional or single side band frequency or wave length modulation results. This can be explained as follows: if control grid 20 is varied yet never becomes positive with respect to cathodes 16 and 17, the frequency variation of the transmitted waves takes place only on the high frequency side of the assigned frequency or carrier frequency, assuming that the proper negative bias value of the source 23 is originally chosen. Thus, by an arrangement as illustrated in Fig. 2, the modulation is applied from 40 to the anode 43 of a rectifier 44 having as a load the biasing resistance 46 connected at one end with the grid 20 of tube 10 and at the other end to the cathode of the rectifier and to ground and the cathodes 16 and 17 of tube 10 by way of the inductance of circuit 22.

Now the source 23 holds grid 20 slightly negative and modulation rectified in 44 increases the potential across resistance 46 thereby making the grid more negative with increase in modulation level. Thus the capacity simulated in tube 10 decreases from an initial value, at no modulation, i. e., carrier frequency, as the modulation level increases and the effect is uni-directional or single side band modulation of the carrier.

If it is desired to increase the voltage variation across resistance 46 a full wave rectifier is used at 44 in place of the half wave system. The manner of connecting this is too well known in the art to need illustration. The connections may be as shown in Fig. 3 if the cathode end of resistance 46 (Fig. 3) is disconnected from the control electrode 20 and grounded, and the anode end of the resistance 46 connected through the source 23 to the grid 20, instead of to ground as shown in Fig. 3.

If, on the other hand, positive potential only is applied to the control grid 20, which is sufficient to always produce an increase in the capacity between the electron clouds, the carrier frequency will always be lowered from its assigned value, so that this may be considered also single side band frequency modulation. This arrangement is shown in Fig. 3 and a full wave rectifier comprising tubes 44 and 44' is used. If the tube 10 characteristic is such that with no modulation, no current flows, then grid 20 is at zero potential. If the characteristic of tube 10 is such that some current flows with no modulation then the grid of tube 10 is slightly negative due to the drop in resistance 46. To operate on the linear portion of the tube 10 characteristic it may be desirable to have the tube 10 draw some current at this time. In any case increase in the modulation level makes the grid more positive to increase the capacity of tube 10 and decrease the frequency of the oscillations generated from no modulation frequency, i. e., carrier frequency.

In the prior systems the tuned circuit 22 may be in the input or output of a tube translating wave energy as, for example, amplifying it. In this case the phase of the wave energy rather than the frequency thereof will be modulated.

The tuned circuit 22 may be replaced by a piezo electric crystal X, as illustrated in Fig. 4, and the oscillation generator including said crystal will be frequency modulated during operation substantially as described in connection with Fig. 1.

As in my prior mentioned application, I use a plurality of electron cloud or stream capacities of the type shown herein when it is desired to simultaneously tune a number of associated electric or radio circuits in synchronism with applied modulating voltage. For example, by tuning each individual tuned circuit including the radiating system of an angular velocity modulated transmitter more linear radiation is produced. In systems where an extremely wide band of transmission is used, this arrangement is of particular value. The band may be of the order of several megacycles per second. Such a system would be arranged substantially as shown in Fig. 2a of my U. S. application #471,946, filed January 11, 1943, modified, however, to include the tube capacity of this disclosure.

Moreover, in my novel tube capacity one or more additional grids may be inserted to also have control of the electron stream or electron capacities within tube 19 as a means for shaping in accordance with an E. M. F. the characteristics of this electronic capacitor tube. It is within the scope of this invention that variable wave energy may also be applied to these additional control elements, if desired, to arrive at a desired result or objective such as signal mixing, and complex modulation.

I claim:

1. In combination a variable capacity comprising two electron emission elements in a container which emission elements serve as plates of the capacity, a control electrode in the field between said emission elements, connections for adjusting the potential between said control electrode and at least one of said emission elements to adjust the capacity between said emission elements, and a circuit connected to said emission elements to include said capacity as a tuning reactance in said circuit.

2. In combination a variable capacity comprising two electron emission elements in a container which emission elements serve as plates of the capacity, a control electrode in the field of said emission elements, connections for adjusting the potential between said control electrode and both of said emission elements to adjust the capacity between said emission elements, and a resonant circuit connected to said emission elements to include said adjustable capacity as a tuning element in the resonant circuit.

3. In combination an inertialess electron capacity of the discharge tube type including at least two cathodes each having an electron emitting surface area with the emitting areas facing each other, said cathodes forming the plates of the capacity connections for heating said cathodes to a point at which electron emission takes place in the area between said cathodes, a control element in the electron field equi-distant between said cathodes, connections for applying a variable potential to said control element for varying the position of the electrons emitted by each of the cathodes and consequently correspondingly varying the electrical capacity between said cathodes, and a parallel tuned circuit connected to said cathodes to include said capacity in said circuit as a tuning reactance.

4. In apparatus of the class described, an elec-

tron capacity of the discharge tube type including within an envelope at least two cathodes each having an electron emitting surface area, which cathodes serve as the plates of said capacity, connections for heating the two cathodes to a point at which electron emission takes place, a control element in the electron paths of said two cathodes, a source of control potentials, and a rectifier system coupling said source to said control element for applying rectified control potential voltage to said control element which potential varies with respect to the potential on at least one of said cathodes to move the electrons with respect to said cathode surface and simultaneously to change the electrical capacity between said cathodes.

5. In apparatus of the class described, an electron capacity of the discharge tube type including at least two cathodes of a desired electron emitting surface area, which cathodes serve as the plates of said capacity connections for heating the cathodes to a point at which electron emission takes place, a source of control potentials, a control element in the electron paths of said two cathodes, and a rectifier system coupling said source to said control element for applying a rectified control potential to said control element in positive potential relation with respect to the potential on at least one of said cathodes to move the electrons further away from the said cathode surface and simultaneously increase the number of electrons within said electron clouds to increase the electrical capacity between said cathodes.

6. In a signalling system a circuit to be tuned and an inertialess capacity for tuning the same including a tube having within its envelope two cathodes electronically separated by a control element and serving as plates of a capacity, connections for heating the cathodes, connections for applying a controllable potential to the control element, and connections between the cathodes and said circuit.

7. In a signalling system an oscillation generating circuit and an inertialess capacity for tuning the same including a tube having within a container, two cathodes between which said capacity appears and a control element therebetween, connections for heating said cathodes, connections coupling said cathodes with said circuit, a source of control potentials and connections for coupling said source to the control element of said tube to change the frequency of operation of said circuit.

8. In apparatus of the class described, a piezo electric crystal oscillator, a tube having two electron emitting surfaces between which a capacitive effect is produced, a control grid interposed between said cathodes, connections coupling said cathodes in parallel with said crystal, and connections for applying an electrical potential to the control grid of said discharge tube to control the frequency of operation of said crystal oscillator.

9. In a signalling system, a tube having two cathodes between which a capacitive effect is produced, a control element between said cathodes, a circuit coupled to said cathodes to be tuned by the capacitive effect developed therebetween, a source of control potential coupled between said cathodes and said control element, and means for varying said control potential in accordance with signals.

10. In a signalling system a tuned circuit wherein oscillatory energy flows the timing of

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which is determined in part at least by the reactance in said circuit, and means for modulating the timing of the oscillatory energy flowing in said tuned circuit comprising, an electron discharge device having two cathodes spaced one from the other, means for producing electron emission from each of said cathodes, a control electrode mounted in the field of emission from said cathodes, said control electrode being substantially equal distance from each of the cathodes, a direct current biasing circuit connecting said control electrode to both of said cathodes to supply to said control electrode the desired bias with respect to said cathodes, a coupling

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to said control electrode for applying modulating potentials thereto to thereby vary the potential of said control electrode relative to the potentials on said cathodes to vary the electron fields of said cathodes and produce between said cathodes a capacitive effect which varies in accordance with the modulating potentials, and connections between said cathodes and said tuned circuit to include as reactance in said tuned circuit the capacitive effect between said cathodes to thereby modulate the timing of the oscillatory energy flowing in said tuned circuit in accordance with the modulating potentials.

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