June 1, 1937. A. W. BARBER 2,082,317

ELECTRICAL APPARATUS

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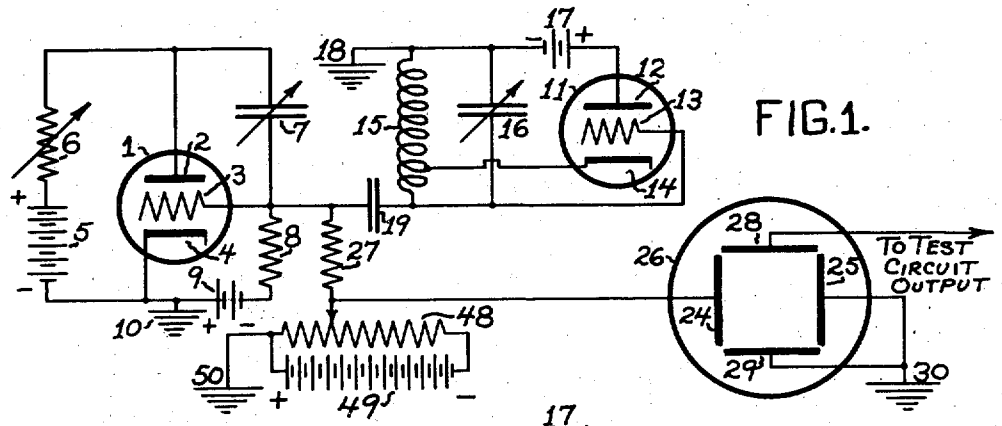


FIG.1.

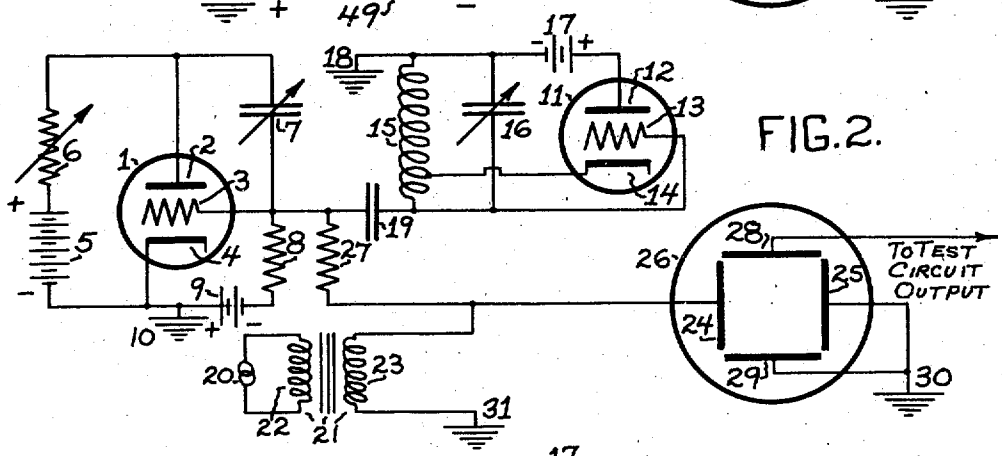


FIG.2.

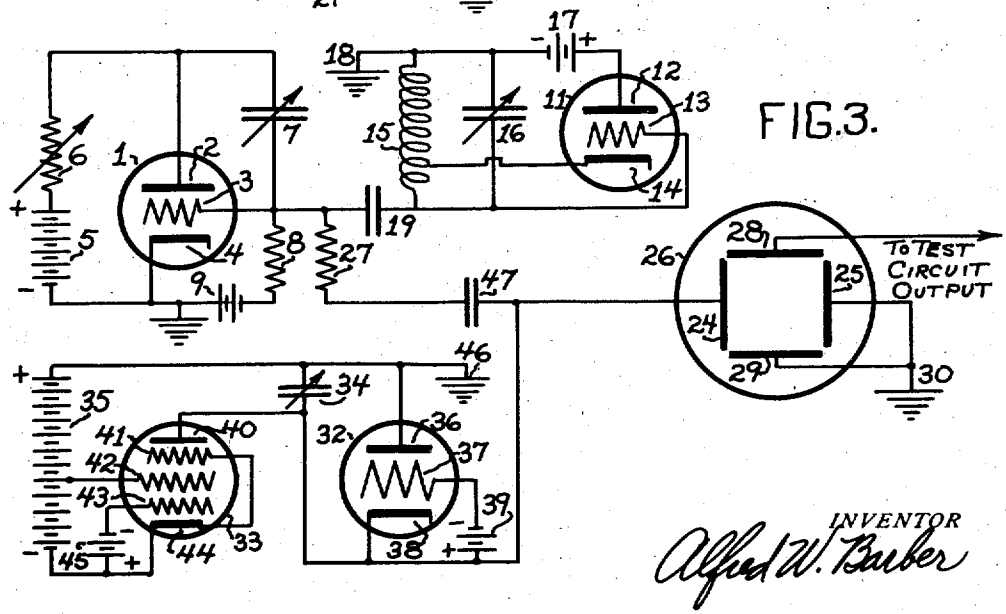


FIG.3.

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ELECTRICAL APPARATUS

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18 Claims. (Cl. 250—20)

My present invention relates to an electronic variable capacity, and, more particularly, to a method of, and means for, electronically varying the frequency of an oscillator in point by point synchronism with the position of the beam of a cathode ray tube.

One of the objects of my invention is to provide an electronic variable capacity varying as a function of a voltage, which voltage also controls the position of the beam of a cathode ray tube. A further object is to provide a cyclic variation of a capacity and a completely synchronized cathode ray tube beam excursion such that for every value of capacity over a cycle of change, the position of a cathode ray tube beam in one direction of its motion is relatively positioned, bearing a point by point correspondence to the capacity values. Another object is to provide in conjunction with a sweeping cathode ray tube beam, a varying oscillator frequency synchronized in such a manner as to yield identical frequencies for each beam position at each cyclic repetition of the sweeping voltage.

These and other objects of my invention will be apparent from the following specification when taken with the accompanying drawing.

Fig. 1 shows one method of controlling a capacity and oscillator frequency in complete synchronism with the motion of the beam of a cathode ray tube by electronic means.

Fig. 2 embodies a periodic control voltage in the control of a synchronized capacity, oscillator and cathode ray tube beam position.

Fig. 3 is similar to Fig. 2 but embodying a sawtooth control voltage.

It is well known that the effective input, that is grid to cathode capacity of a thermionic vacuum tube is a function of the physical plate to grid capacity and the tube gain. The physical capacity may be the capacity of the tube elements and wiring alone or an external capacity may be added. Since the gain of a thermionic vacuum tube is a function of the mutual conductance of the tube, it is possible to vary the effective input capacity electronically simply by varying the tube grid bias. I have now invented a system in which by applying the same voltage or a fraction of it to the grid of a tube which is applied to the control electrode of a cathode ray tube, I make the electronic tube capacity vary in continuous synchronism with the cathode ray tube beam or spot position. I have found this procedure very useful in many test and measurement systems where a continuous observation of physical or electrical phenomenon is desired.

In Fig. 1 of the drawing I have shown a thermionic vacuum tube 1 with plate 2, control grid 3, and cathode 4. The battery 5 is provided to energize the plate circuit. Cathode heating means will be understood and is not shown for sake of simplicity. Variable resistor 6 acts as a plate-circuit load, but may be replaced by other impedances in some cases. Variable condenser 7 is provided in order to supplement the capacity between the tube elements and wiring. Resistor 8 serves to bias the tube grid 3 from battery 9 although I have found that in most applications a cathode dropping resistor may be used to provide the grid bias. For convenience of illustration a ground 10 is shown and is intended to indicate a common circuit with other grounds of the system. With this circuit an effective capacity between grid 3 and ground 10 will appear which is greater than the sum of capacity 7 and the tube and wiring capacity. This excess capacity depends on the tube characteristics, operating conditions and load resistor 6 or other plate impedance if used.

Fig. 1 also shows a second thermionic vacuum tube 11 having plate 12, grid 13 and cathode 14 connected in a conventional oscillator circuit. Inductance 15 and variable condenser 16 form the oscillatory circuit. Tube 11 is energized by plate battery 17 and a cathode heater not shown. The common negative plate battery terminal and junction with inductance 15 and capacity 16 are connected to common ground point 18. Grid 3 of tube 1 is connected to inductance 15 by means of blocking condenser 19. Since with these connections the effective grid to ground capacity of tube 1 is across oscillator inductance 15, it serves to control the frequency of oscillation of tube 11 by modifying the LC product of the oscillatory circuit.

In order to vary the grid 3 to ground 10 capacity of tube 1, a battery 49 is shown bridged by potentiometer 48. Grid 3 is connected to the slider of potentiometer 48 thru resistor 27. This connection serves to vary the bias of grid 3 and hence the capacity of grid 3 to ground 10 which, as explained above, is connected so as to vary the frequency of oscillation of tube 11. Battery 49 and potentiometer 48 are tied together and to ground point 50. While the positive terminal of battery 49 is shown grounded, the negative end might have been chosen or a mid-point, depending on the net bias it is desired to supply to grid 3 and the cathode ray tube deflecting plates.

A cathode ray tube 26 is shown with vertical deflecting plates 28 and 29 and horizontal deflecting plates 24 and 25. For convenience of illustration plates 24 and 29 are connected to ground 30. By connecting plate 24 to the same point on potentiometer 48 as bias resistor 27 the horizontal deflection of the cathode ray tube beam will have a point by point correspondence to the change of capacity of tube 1 and hence also the frequency of oscillation of tube 11. The vertical deflecting plate 28 may then be con-

nected to the output of a test circuit, the input of which is or is controlled by a voltage from oscillator tube 11. These connections result in a system capable of making point by point analysis since for every horizontal cathode ray tube deflection point, the test system response will be due to a corresponding and predetermined value of oscillator 11 frequency.

I have found it usually desirable to use a large ratio of inductance to capacity in the controlled oscillator 11 circuit since the control tube 1 operates most efficiently over a limited capacity variation range. While the available effective capacity of tube 1 may be varied over wide limits by varying its grid bias, the useful range of capacity variation is determined by the tolerable resistance component introduced across the oscillator circuit as determined by its effect on amplitude.

The oscillator voltage across coil 15 may be used in many ways and any conventional coupling to the oscillator circuit may be used. Tube 11 may for instance be one tube of a beat oscillator or it may be used as a generator of a readily variable frequency in any one of numerous ways. A beat oscillator system is especially useful in audio response studies while a single varying frequency is particularly useful in radio frequency response analysis such as in the case of selectivity curve tracing.

In Fig. 2 I have shown my electronic system for synchronous oscillator variation and cathode ray tube beam deflection by means of a periodic or harmonic control voltage. In place of the battery and potentiometer of Fig. 1 I use a source of harmonic voltage 20 coupled thru a transformer 21, primary 22 being connected to source 20 and secondary 23 being connected to the deflecting means 24 and 25 of cathode ray tube 26 and to the electronic variable capacity tube grid 3 thru resistor 27. I then connect the cathode ray tube deflecting means 28 and 29 to the circuit or system under test, the test circuit input being taken from or being controlled by the oscillations of tube 11. The circuits are shown interconnected by grounds 30 and 31. I have found that for most purposes the frequency of repetition, that is the frequency of voltage 20 should be of the order of from 5 to 100 cycles per second. Cathode ray tubes with slow decay screens may be used in cases where it is necessary to operate at very low frequencies to reduce flicker and in some tests it may be of advantage to operate above 100 cycles.

The operation of the circuit of Fig. 2 depends on the action described in connection with Fig. 1. Resistors 8 and 27 acting as a voltage divider apply a voltage to grid 3 which has the same frequency and form as voltage 20. The variable voltage serves to vary the grid 3 to ground 10 capacity as a predetermined function of voltage 20. Since the cathode ray tube in general requires a large deflecting voltage, an undivided voltage may be applied as shown directly from secondary 23. It will readily be seen that since a fixed relation exists between the voltage on grid 3 and the cathode ray tube deflection voltage on electrodes 24 and 25, each point on the cathode ray beam excursion will correspond to a definite tube 1 input capacity value and also oscillator frequency. The deflection then due to the test circuit output on electrodes 28 and 29 will occur at particular excursion points and will be due to the action of particular corresponding values of capacity and oscillator frequency.

While voltage 20 is shown transformer coupled to the cathode ray tube static field deflecting means, other means may be used as will be evident to one skilled in the art. One such other means is an amplifier feeding cathode ray tube magnetic deflecting coils. Also the coupling resistor 27 may be replaced by other means such as a choke coil or condenser or other impedance combinations. It will be considered as not departing from the spirit of the invention to use other coupling means.

Fig. 3 shows a form of my invention embodying a saw-tooth control voltage. A saw-tooth voltage generator is shown consisting of a gaseous discharge tube 32 and a current limiting tube 33 for discharging and charging condenser 34. High voltage is supplied by battery 35. Discharge tube 32 is of the conventional type having a plate 36, control grid 37 and cathode 38. Grid bias battery 39 serves to determine the amplitude of the generated voltage. Current limiting tube 33 is of the pentode, or constant current type having plate 40, suppressor grid 41, screen grid 42, control grid 43, and cathode 44. A tap on battery 35 supplies screen voltage and a bias battery 45 serves to maintain the control grid at the desired voltage. For electro-static deflection one end of condenser 34 is connected to electrode 24 and the other end to ground point 46. The action of this type of voltage generator is conventional and will not be described further. For the continuously synchronous timing feature of my invention grid 3 may be coupled to the saw-tooth control voltage by means of resistor 27 in series with condenser 47. Condenser 47 may, however, be omitted if a unidirectional pulse is desired on grid 3. With this system a linear variation of control voltage will move the cathode ray tube beam across the screen in step with the frequency variation of tube 11 as caused by the capacity variation of tube 1. At the end of the linear variation, tube 32 discharges condenser 34 quickly returning beam, capacity and frequency to the initial condition and the cycle is repeated. As with Fig. 2 other coupling networks may be used between control voltage, cathode ray tube and electronic variable capacity tube within the spirit of the invention.

While I have indicated and described one particular form for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. The method of controlling the position of a cathode ray tube beam and the frequency of a vacuum tube oscillator as a function of a common control voltage which comprises applying said common control voltage to beam control means of said cathode ray tube and applying said common control voltage to gain control means of a second vacuum tube and utilizing the effective input capacity of said second vacuum tube as at least a part of the frequency determining means of said vacuum tube oscillator.

2. The combination of a cathode ray tube, a variable capacity vacuum tube and a common control voltage at every instant the linear deflection of said cathode ray tube being a function of said common control voltage and further the input capacity of said vacuum tube also being a function of said common control voltage, in which

at least a part of said common control voltage is applied to beam deflection control means associated with said cathode ray tube and at least a part of said common control voltage is applied to a control element of said variable capacity vacuum tube.

3. The combination as set forth in claim 2 in which both of said functions are linear.

4. The combination as set forth in claim 2 and including an oscillator connected across said variable capacity vacuum tube.

5. In combination, a thermionic vacuum tube, a cathode ray tube including electro-static beam deflecting means, a source of periodic voltage, including passive coupling impedances between said periodic voltage source and said thermionic vacuum tube grid and further passive coupling impedances between said periodic voltage source and said cathode ray tube electro-static deflecting means wherein said vacuum tube grid is electrically connected to at least a portion of an electrical oscillation circuit.

6. In combination, a thermionic vacuum tube oscillator including a capacity tuned inductance, at least a part of said capacity being the dynamic input capacity of a second thermionic vacuum tube, a cathode ray tube, a variable voltage source, a passive electrical network coupling said variable voltage source to the grid of said second thermionic vacuum tube, a second passive electrical network coupling said variable voltage source to the beam deflecting means of said cathode ray tube.

7. The method of controlling the instantaneous value of the input capacity of a thermionic vacuum tube as a function of the deflection of a cathode ray tube beam which comprises, controlling both said input capacity and said cathode ray tube beam deflection by means of a single voltage.

8. In combination, a variable frequency oscillator, a cathode ray tube having electro-static beam deflecting means, a source of periodic voltage, said periodic voltage exerting continuous control over the frequency of said variable frequency oscillator, said periodic voltage also controlling the instantaneous beam position of said cathode ray tube and including frequency control means connected between said source of periodic voltage and said oscillator and an electrical path between said source of periodic voltage and said beam deflecting means.

9. In combination, a thermionic vacuum tube exhibiting an input capacity having a value a function of grid bias voltage, a cathode ray tube including electro-static beam deflecting means, a saw-tooth voltage generator, a passive electrical circuit interconnecting said vacuum tube grid and said saw-tooth voltage generator, a second passive electrical circuit interconnecting said cathode ray tube electro-static beam deflecting means and said saw-tooth voltage generator, a thermionic vacuum tube oscillator with at least a part of its oscillatory circuit shunted by the effective input capacity of said first vacuum tube.

10. In combination, an electronic variable capacity thermionic vacuum tube, a cathode ray tube including electro-static beam deflecting means, a source of periodic voltage, passive electrical circuits interconnecting said source of voltage, said vacuum tube and said cathode ray tube and a thermionic vacuum tube oscillator at least partially tuned by the effective input capacity of said variable capacity tube.

11. In combination, a thermionic vacuum tube comprising an electron emitting cathode, a grid and an anode, an external impedance connected in series with said plate, a source of variable voltage, a passive electrical network connected between said source of variable voltage and said grid of said vacuum tube, a cathode ray tube including beam deflecting means, an electrical network between said source of variable voltage and said beam deflecting means and at least part of an oscillating circuit in shunt with said vacuum tube.

12. In combination, a cathode ray tube, cathode ray tube beam deflecting means, a thermionic vacuum tube oscillator, electronic vacuum tube oscillator frequency control means, and a common control voltage source and including an electrical path between said control voltage source and said beam deflecting means and an electrical path between said control voltage source and said frequency control means.

13. The combination as set forth in claim 12 wherein said electronic vacuum tube oscillator frequency control means comprises a thermionic vacuum tube including an electron emitting cathode, a grid and a plate, and means associated with said vacuum tube comprising an electrical condenser connected between said grid and said plate.

14. The combination as set forth in claim 12 wherein said electronic means for varying said oscillator frequency comprises a thermionic vacuum tube including an electron emitting cathode, a grid, and a plate, and means associated with said vacuum tube causing it to exhibit a dynamic grid to cathode capacity having a value a function of the bias on said grid wherein said means associated with said vacuum tube comprises a plate load resistor, a plate voltage supply and a physical plate to grid capacity.

15. In a resonance curve tracing apparatus, the combination of, a thermionic vacuum tube oscillator including tuning means, at least a part of said tuning means comprising an electronically variable capacity thermionic vacuum tube, a cathode ray tube indicating means including beam deflecting means, a periodic voltage source, passive electrical circuits interconnecting said periodic voltage, said variable capacity tube, and said beam deflecting means producing continuously controlled variable capacity and beam deflection as a function of said periodic voltage.

16. In an electrical response analyzing apparatus, the combination of, at least one tunable thermionic vacuum tube oscillator, a thermionic variable capacity tube electrically connected to at least a part of the frequency determining means of said oscillator, a cathode ray tube including beam deflecting means, a source of control voltage varying the input capacity of said variable capacity tube, an interconnecting electrical circuit between said cathode ray tube beam deflecting means and at least a part of said control voltage.

17. The combination as set forth in claim 16 in which said beam deflecting means is of the electro-magnetic type.

18. The combination as set forth in claim 16 in which said beam deflecting means includes a thermionic vacuum tube amplifier.

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