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POLYPHASE RELAXATION CIRCUIT OSCILLATOR

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FIG. 1

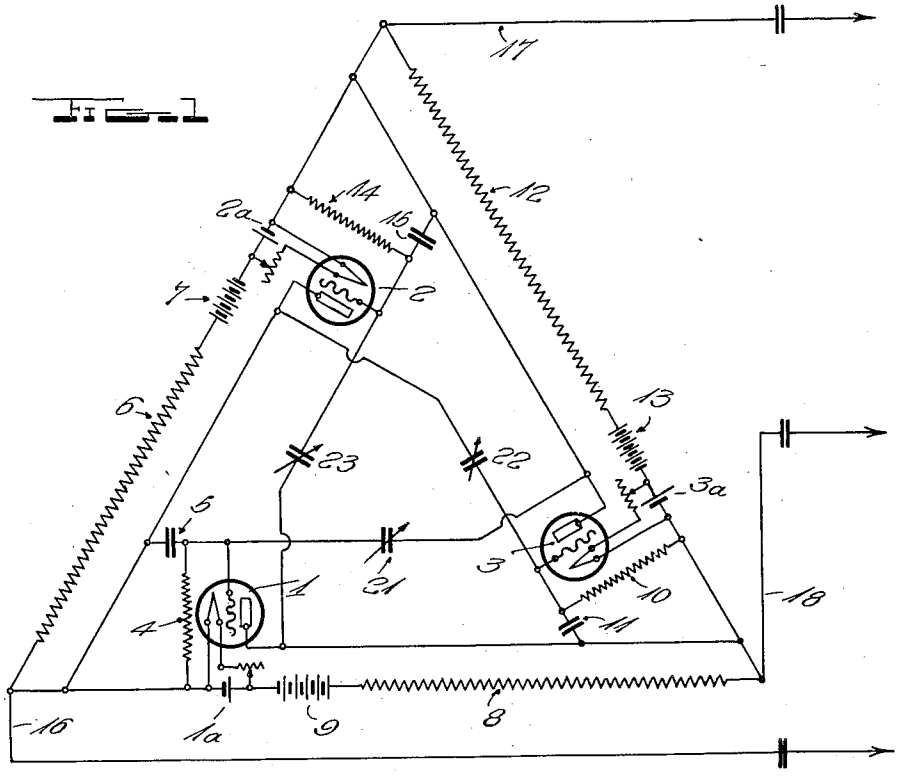
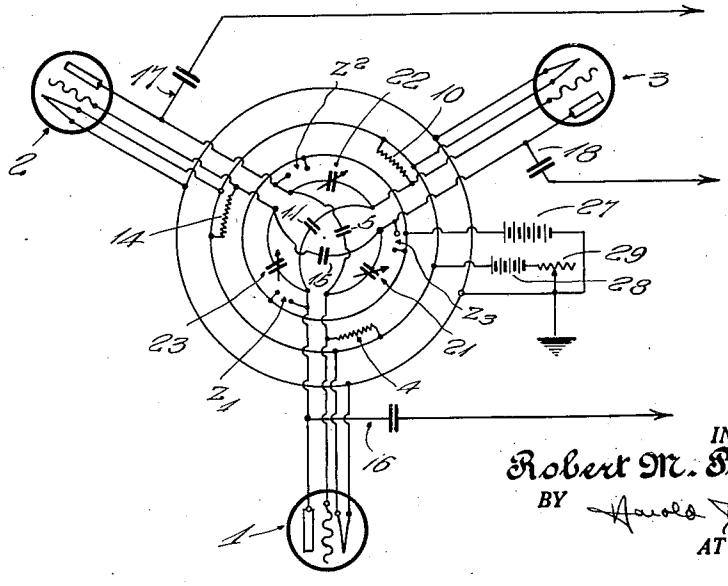


FIG. 3



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FIG. 2

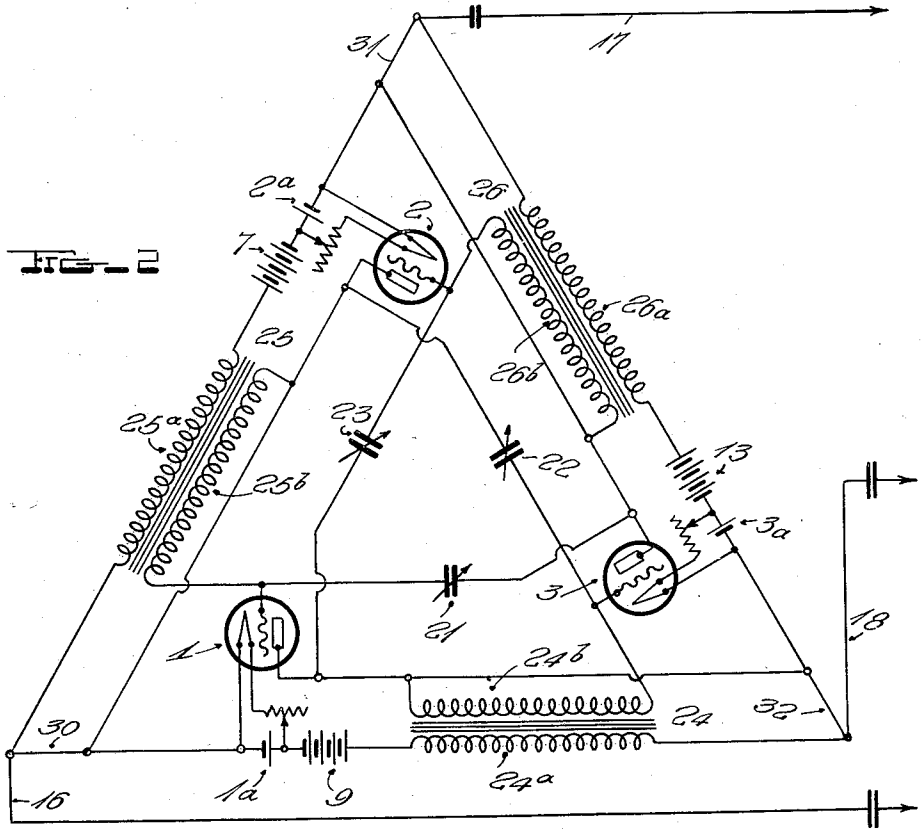
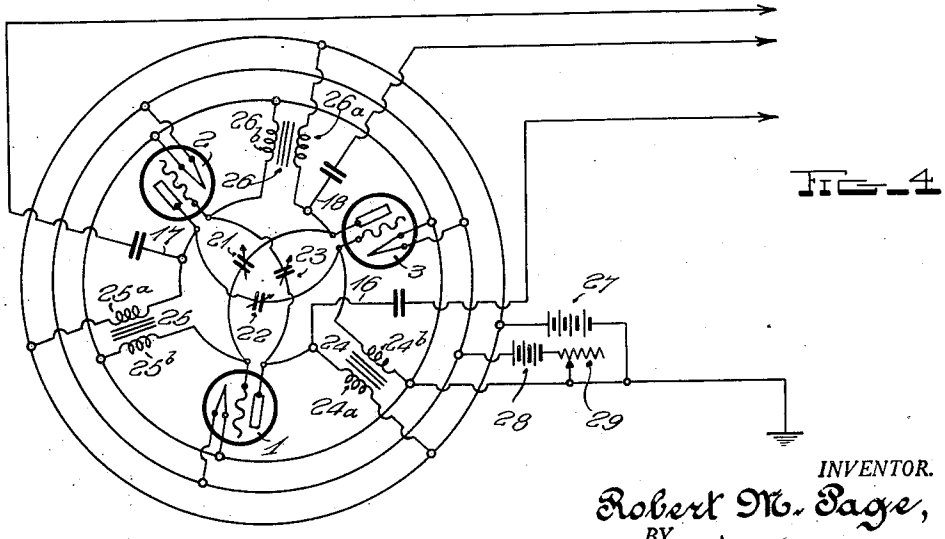


FIG. 4



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POLYPHASE RELAXATION CIRCUIT OSCILLATOR

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Application May 14, 1930, Serial No. 452,499

5 Claims. (Cl. 250—36)

My invention relates broadly to multi-phase relaxation circuit oscillators and more particularly to a phase adjusting circuit for multi-phase oscillators.

One of the objects of my invention is to provide a circuit arrangement for controlling the vector relation of the currents between the various phases of a multi-phase relaxation circuit oscillator.

Another object of my invention is to provide a circuit for balancing or adjusting the phases of a multi-phase relaxation circuit oscillator system independently of the character of the load to which the oscillator is connected.

Still another object of my invention is to provide circuits for correcting an unbalanced condition of a multi-phase relaxation circuit oscillator.

Other and further objects of my invention reside in the circuit arrangement for a multiphase relaxation circuit oscillator as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 illustrates a delta connected three phase oscillator embodying the principles of my invention; Fig. 2 is a diagrammatic circuit arrangement of a modified form of delta connected three phase oscillator including the improvements of my invention; Fig. 3 is a Y connected three phase oscillator employing the balancing means for using the correction circuits of my invention; and Fig. 4 is a diagrammatical illustration of a modified form of Y connected three phase oscillator showing the balancing circuits of my invention incorporated therein.

My invention contemplates the accurate balancing of the circuits of a polyphase relaxation circuit oscillator for controlling the vector relationship of the currents in the several phases for insuring the operation of the circuits independent of the load. Heretofore in a multi-phase relaxation oscillator system, a non-reactive load has so influenced the operation of the oscillator system that a condition of unbalance has been produced resulting in relatively poor efficiency in the operation of the oscillator and destroying the stability of the oscillations which the circuits tend to establish. I provide corrective measures whereby the stability of the oscillations in the relaxation circuit oscillator is insured and the vector relationship of the currents in the various phases accurately controlled independently of the character of the load.

Referring to the drawings in more detail, Fig. 1 shows a plurality of electron tubes indicated at 1, 2 and 3. Each of the tubes has independent input and output circuits. Tube 1 has an input circuit included between the grid and cathode thereof including the shunt impedance 4 and the coupling capacity 5. The output circuit of electron tube 2 includes the impedance 6 and high potential source 7, and there is a connection between a point in the output circuit of tube 2 and a point in the input circuit of tube 1. The output circuit of electron tube 1 includes impedance 8 and high potential source 9. There is a connection between the output circuit of tube 1 with the input circuit of tube 3 the connection being taken to one side of the shunt impedance 10 and coupling condenser 11 which connects in shunt thereto. The output circuit of electron tube 3 includes the impedance 12 and high potential source 13. The input circuit of electron tube 2 including shunt impedance 14 and parallel connecting coupling condenser 15 is connected to a point in the output circuit of electron tube 3. The cathodes of the electron tubes have been shown excited by independent potential sources indicated at 1*a*, 2*a* and 3*a*. The circuit connections for the oscillator in Fig. 1 are shown arranged in delta, that is, the tubes all have a portion of their input and output circuit extending in a series path closed upon itself. At the junctures of the input and output circuits of the several tubes, terminal connections are provided as illustrated at 16, 17 and 18 for taking off the polyphase current generated in the several circuits. In order to balance the oscillator circuits and provide an even distribution of current in the several circuits, I provide cross coupling capacities which I have designated at 21, 22 and 23. For balancing the operation of the circuit connected with the electron tube 1, the coupling condenser 23 is connected between the plate electrode of electron tube 1 and the grid electrode of electron tube 2. For balancing the operation of electron tube 3, a coupling condenser 21 is connected between the grid electrode of electron tube 1 and the plate electrode of electron tube 3. For balancing the operation of electron tube 2, I provide a cross coupling condenser 22 disposed between the plate electrode of electron tube 2 and the grid electrode of electron tube 3. In other words, a cross coupling condenser is disposed between the grid and plate electrodes of those tubes which have their output and input circuits coupled respectively.

Where the output circuit of one tube couples to the input circuit of the succeeding tube in the delta association, I provide a balancing auxiliary

condenser disposed between the grid of the first tube and the plate of the second tube, respectively. In Fig. 1, I have shown the impedances in the delta connection formed by resistances. I may employ inductance elements in lieu of resistance elements as shown in Fig. 2.

In Fig. 2 the input circuit of electron tube 1 connects with secondary winding 25*b* of transformer 25. Primary winding 25*a* is inductively related to the secondary winding 25*b* and is disposed in series in the output circuit of electron tube 2. Thus I provide an inductive coupling between the output circuit of electron tube 2 and the input circuit of electron tube 1. There is also however a conductive connection between the output circuit of electron tube 2 with the input circuit of electron tube 1 as indicated by conductor 30. That is, a portion of the output circuit of electron tube 2 is connected in common with the input circuit of electron tube 1. The output circuit of electron tube 2 is completed from the plate circuit of the tube through primary winding 25*a* and battery 7 to the cathode of the electron tube 2, which is heated from battery 2*a*. The electron tube 2 has its input circuit completed through secondary winding 26*b* which is coupled to primary winding 26*a* of the transformer 26. There is a conductive connection between the input circuit of electron tube 2 and the plate electrode of electron tube 3 as has been shown at 31. The output circuit of electron tube 3 is completed through battery 13 and the cathode of electron tube 3, which cathode is heated from battery 3*a*. The input circuit of electron tube 3 includes secondary winding 24*b* of transformer 24 which has primary winding 24*a* inductively coupled thereto. The output circuit of electron tube 1 includes the anode of electron tube 1, the primary winding 24*a* of transformer 24, the high potential source 9 and the cathode of the electron tube 1, which is heated from battery 1*a*. The output circuit of electron tube 1 is conductively connected with a point in the input circuit of electron tube 3 by means of conductor 32, as shown. The three phase oscillations which are established by the circuit arrangement shown in Fig. 2 are stabilized and the several circuits balanced by the connection of condensers 21, 22 and 23 in the cross coupling relationship shown. That is, condenser 21 connects between a point in the input circuit of electron tube 1 and a point in the output circuit of electron tube 3, it being observed that the output circuit of electron tube 1 is magnetically coupled with the input circuit of electron tube 3. The condenser 22 is disposed between the grid electrode of electron tube 3 and the plate electrode of electron tube 2, it being observed that the output circuit of electron tube 3 is coupled with the input circuit of electron tube 2. Similarly condenser 23 is disposed between the grid electrode of electron tube 2 and the plate electrode of electron tube 1, it being observed that the output circuit of electron tube 2 is coupled to the input circuit of electron tube 1. By the adjustment of the cross coupling relationship balanced operation of the oscillator system is obtained.

In each of the diagrams I have indicated that the condensers 21, 22 and 23 are variable. By varying these condensers balance is obtained in the circuit. One or more of the condensers may be adjusted in different capacity relationships for completing the balanced condition of the circuits with such precision that polyphase operation of the circuits may be maintained. In lieu of the delta connections in Figs. 1 and 2 I may arrange the parts of the circuit in a star or Y connection.

In Fig. 3 the parts of the circuit are shown arranged in star or Y with the resistance elements 4, 14 and 10 connected in shunt with the input circuits of tubes 1, 2 and 3, respectively. The coupling condensers are shown at 5, 11 and 15 disposed between the input and output circuits of adjoining tubes in the star connection. The balancing condensers are shown at 21, 22 and 23 connected between the plate and grid electrodes of adjoining tubes. Impedances which may be either resistance or inductance are connected in the circuits in the positions Z_1, Z_2 and Z_3. All of the plate circuits are supplied with potential from battery 27. The cathodes of the several tubes are brought up to electron emitting temperature by means of battery 28 under control of rheostat 29.

In Fig. 4 I have shown a star or Y connection for the several circuits wherein the input and output circuits of adjacent tubes are coupled through transformer 24, 25 and 26. The output circuit of tube 1 includes primary winding 24*a* of transformer 24 which is inductively coupled to secondary winding 24*b* which connects across the input circuit of electron tube 3. The output circuit of electron tube 3 includes primary winding 26*a* of transformer 26 which is inductively coupled to the secondary winding 26*b*, which is included in the input circuit of electron tube 2. Transformer 25 has its primary winding 25*a* connected in the output circuit of electron tube 2 and its secondary winding 25*b* connected in the input circuit of electron tube 1. The balancing condensers are shown at 21, 22 and 23 connected between the input and output circuits of adjacent tubes and adjustable to equalize the distribution of current in several parts of the circuit for balancing the operation of the polyphase system. The supply of plate potential and filament heating potential is obtained in a manner similar to the provisions of Fig. 3. The taps constituting the take-off circuit for the polyphase system connect at 16, 17 and 18 in a manner similar to the connections provided in the circuit arrangements heretofore illustrated. In all the figures it will be noted that the anode of each tube is coupled to the grid of each other tube but is electrically isolated from the grid of its own tube. In a polyphase system employing more than three tubes, this condition will also obtain. The connections from each anode to the grids of the other tubes form part of the oscillating circuit.

I have found that the polyphase circuits of my invention are stable in operation at any frequency within the range for which the circuits are desired to be operated and that the circuits may be readily balanced or adjusted to meet the exigencies of the particular conditions under which the circuits must operate.

While I have described my invention in one of its preferred embodiments I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a polyphase oscillator, a plurality of electron tubes each having cathode, anode and grid, circuits interconnecting said tubes in electrical rotation, the anode of each tube being electrically isolated from the grid of said tube, a circuit comprising an impedance connecting the anode of

each tube to the grid of the tube adjacent thereto in one sense of rotation, and a phase adjusting variable condenser connected between the anode of each tube and the grid of the tube adjacent thereto in the opposite sense of rotation.

2. A polyphase oscillation generator comprising a plurality of electron tubes exceeding two in number connected in endless tandem for amplification in one direction of rotation and means including capacitive couplings between the output circuit of each tube and the input circuit of the tube in the opposite direction of rotation for adjusting the phase displacement of the currents supplied by said oscillation generator to a polyphase load.

3. A polyphase oscillation generator comprising a plurality of at least three discharge tubes each provided with a cathode, a control electrode and an anode, means for applying suitable differences of potential between said control electrodes and said cathodes also between the latter and said anodes, means intercoupling the output circuit of each tube with the input circuit of another tube rotatively in one direction, and balancing means intercoupling the output circuit of each tube with the input circuit of another tube rotatively in the opposite direction whereby said generator may be caused to feed to a load polyphase oscillatory energy having equal displacement between phases.

4. A multistage generator of polyphase alternating current comprising a plurality of at least three electron discharge devices, appropriate input and output circuits interconnecting said devices in endless tandem stages whereby said devices are caused to amplify from stage to stage rotatively in one direction, a polyphase load symmetrically connected to the output circuits of said devices and balancing means intercoupling the output circuit of each device with the input circuit of another device rotatively in the opposite direction whereby the phase angles of the currents supplied by said generator to said load may be equalized.

5. A polyphase generator comprising a plurality of electron tubes having input and output circuits, coupling means interposed between the output of one tube and the input of the following tube, said means tending to amplify said currents from tube to tube rotatively in one direction whereby said tubes interdependently operate to produce polyphase oscillations, means including a load for taking off current from the output circuits of the several tubes and means including variable couplings between said tubes operating rotatively in the opposite direction for compensating for an unbalanced condition of said load which would otherwise distort the normal displacement between phases.

ROBERT M. PAGE.