

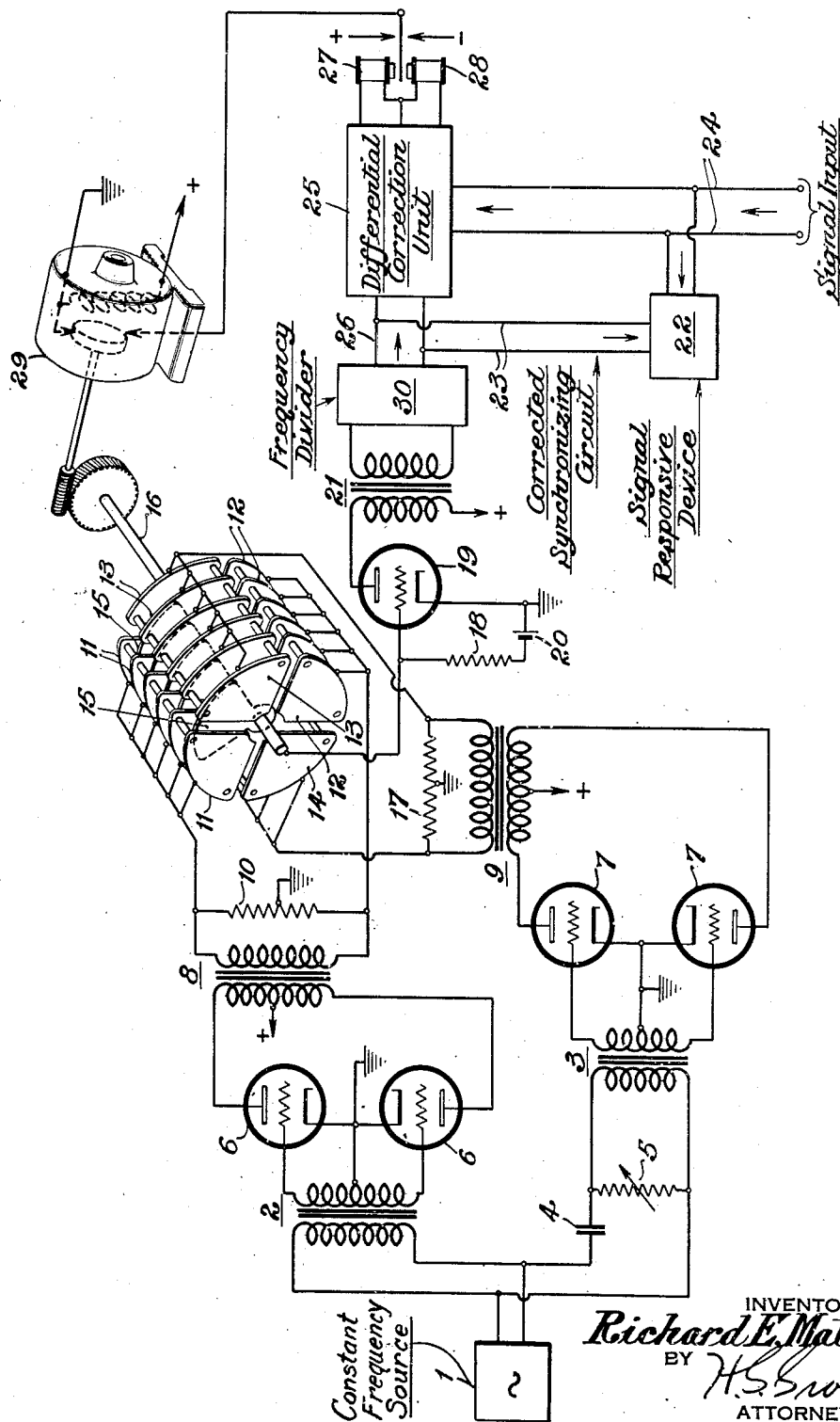
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PHASE SHIFTING SYSTEM

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PHASE SHIFTING SYSTEM

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This invention relates to phase shifting apparatus and has special application to systems of telegraphy, more particularly to provide means for utilizing a frequency standard and to vary the phase of its output as a means of correcting the frequency of a synchronizing circuit for receiving apparatus so that the latter may be maintained in synchronism with incoming signals from a remote transmitter.

In various systems of telegraphy and facsimile transmission attempts have been made to maintain the receiving apparatus in step with the remote transmitter by the use of oscillators whose frequency could be directly corrected by means of a reactance tube thereby to provide a corrected synchronizing circuit for the receiving apparatus. These attempts, however, have not been entirely successful due to the difficulty of obtaining sufficient inherent stability in the reactance tube which functions to control the frequency of the oscillator. It is, therefore, a principal object of my invention to provide a phase shifting device which does not react upon the stability of the standard frequency source at the receiving station.

Another object of my invention is to provide a source of alternating potential which is constant in frequency and amplitude and to associate with this source a device for rotating the phase of its effective output throughout an unlimited angular range.

Another object of my invention is to provide a simple phase shifting apparatus which may be useful in numerous applications such as might suggest themselves to those skilled in the art.

A feature of my invention is the provision of a special form of variable capacitor having four sets of stator plates and one set of rotor plates arranged to deliver in an output circuit potentials which have any desired phase relation to the two-phase potentials which are delivered to the several stator plates.

The foregoing and other objects of my invention will be brought out more clearly in the description to follow, reference being made to the accompanying drawing in which the sole figure thereof represents diagrammatically a preferred embodiment of the invention, together with its application to a specific type of utilization device. It should be understood, however, that the invention itself may have other applications without departing from the scope of the claims.

Any desired standard frequency source may be employed as represented by the block 1. In the preferred embodiment such a standard may be of

the temperature-controlled tuning-fork type but other sources of fixed frequency oscillations may be employed, if desired. Such sources are available which are constant to within one cycle per 100,000 cycles.

The output from the standard frequency oscillator 1 is fed to the primaries of two transformers 2 and 3, but in the case of transformer 3 the potentials at the terminals of its primary are phase rotated through an angle of 90° by means of the combination of shunt resistor 5 and series capacitor 4. Any other arrangement of phase displacement network may, however, be utilized, if desired, provided the displacement angle is maintained at 90°.

The secondaries of the transformers 2 and 3 are center-tapped and grounded, while their terminals are fed respectively to individual grids in the two sets of push-pull discharge tubes 6 and 7 respectively.

The cathodes of the tubes 6 and 7 are grounded, while their anodes are fed through primary windings of different transformers 8 and 9 from a suitable source of direct current. The center taps on these transformer primaries are, of course, connected to the positive side of the direct current source, the negative side being grounded.

The secondary of transformer 8 has its terminals connected across a load resistor 10 having a grounded center tap. These terminals are also connected, one with a set of stator plates 11, and the other with a set of stator plates 12 on a variable capacitor having four sets of stator plates arranged in quadrature. The other sets of stator plates in this arrangement are numbered 13 and 14 respectively.

A set of rotor plates 15 is mounted on a shaft 16 so that it can be continuously rotated through any angle greater or less than 360°.

The secondary winding of transformer 3, like that of transformer 2, has a grounded center tap and its terminals feed to the grids of the discharge tubes 7. The anodes of these tubes are also fed with positive direct current potential through the center-tapped primary winding of transformer 9. The secondary of this transformer feeds to a load resistor 17 having a grounded center tap and the terminals of this resistor connect respectively with the sets of stator plates 13 and 14.

Since the resistors 10 and 17 have grounded mid-taps and since potentials are developed across these resistors which have a quadrature phase relation to one another, it will be seen that

the electrostatic field within the variable capacitor unit having the quadrature-disposed stator plates 11, 12, 13 and 14, will produce a rotation of electrostatic potentials about the axis of the shaft 16. Accordingly the position in which the rotor plates 15 happen to stand will determine the phase relation of output energy taken off the rotor plates with respect to the phase of the output energy from the frequency standard source 1.

The rotor plates 15 are connected to a load resistor 18 and to the control grid of a discharge tube 19. The cathode of this tube is grounded and connects with the cathode end of the resistor 18 preferably through a grid biasing source 20. The anode of tube 19 is fed with positive direct current potential from any suitable source, the negative side of which may be grounded. In the output circuit of the tube 19 is the primary winding of a transformer 21 the secondary of which delivers output energy having the desired phase adjustment with respect to the frequency standard.

In order to illustrate a useful application of the invention in receiving telegraph apparatus, I have shown, for example, a signal responsive device 22 which may be made subject to a corrected synchronizing circuit 23 which derives its energy from the sine wave current delivered by a frequency divider unit 30, which unit is controlled by output from the secondary of the transformer 21. The signal responsive device may be the combination of a printing telegraph instrument or recorder and a synchronous motor for driving the same. The power source for the motor, however, may be synchronized by the corrected synchronizing circuit 23. The details of construction of such an arrangement are not shown, but are to be understood as included in the block diagram 22 as a signal responsive device. It will be assumed, therefore, that this device is fed with signal input energy by the conductors 24 and is maintained in synchronism by the conductors of the circuit 23.

In order that the phase adjustment device may be rendered subject to control by the signal input, it is necessary to provide a differential correction unit of any well known type and to cause this unit to function in response to the application of both signal input pulses and pulses from the local synchronizing source 21 in such manner as to control a phase corrector.

As an illustration of differential phase correction units which may be used in this connection reference is made to my patent, also to Patent No. 2,359,649, granted October 3, 1944, to Alfred Kahn et al.

Such a correction unit is indicated at 25 and has input leads 26 from the frequency divider 30, as well as signal input leads 24. In the operation of the differential correction unit when synchronism is maintained between the local impulses and the peaks of the received marking signals, neither one of the windings 27 or 28 of the polar relay will be energized. Assuming, however, that in the reception of a train of cyclically timed signals there is a lag in the signal input behind the delivery of local impulses across the leads 26, then it is necessary to rotate the phase angle of the latter until synchronism is restored. For this purpose relay winding 27 may, for example, be energized, thereby causing a potential which is positive with respect to ground to be applied to the armature of a correction motor 29. This motor will then be driven in a suitable direction for turning the shaft 16 and hence the rotor plates

15 into a position for producing the same lag in the local pulses as is needed for the maintenance of synchronism with the signal input.

If, however, the phase of the local impulses is to be advanced because of an acceleration of the signal input frequency, then the differential correction unit will be actuated in such manner as to energize the relay winding 28 thereby to apply a negative potential with respect to ground across the armature of the rotor 29. In this case the motor will turn in the opposite direction from that aforesaid and will advance the rotor shaft 16 and the rotor plates 15 so as to produce a corresponding phase adjustment of the potentials applied across the leads 23 and 26.

It will be seen from the foregoing description that the phase angle of the output from the transformer 21 may be rotated through as many degrees as are necessary to restore synchronism between the synchronizing circuit and the frequency of the output energy from the remote source, such as the transmitter.

It is not necessary to adhere to the details of mechanical construction of the special variable capacitor represented by the stator plates 11, 12, 13 and 14 in combination with the rotor plates 15. In place of this construction it may be desirable to employ capacitive elements consisting of a metal drum or cylinder which is split into four insulated quadrants and to employ within this cylinder a quadrantal sector mounted with a relatively small air gap between itself and the inside walls of the cylinder. This sector will then be mounted on a shaft so as to rotate concentrically inside the cylinder and to maintain a uniform capacitive relation to the inside walls of the opposing stator plate or plates. This form of construction, however, appears to be less desirable than the one shown since its space factor in relation to the obtainable capacitance is unfavorable.

If the output from the standard frequency source 1 could be split into three-phase components, it would then be suitable to employ a variable capacitor arrangement having three sets of stator plates each comprehending an angle of substantially 120°. Phase rotation of the potentials applied electrostatically to these plates would then produce the same results as are obtained in the manner shown herein with the two phase potentials applied to quadrantly disposed stator plates.

As heretofore indicated I do not wish to be limited as to the precise details of construction herein shown and described, but the invention itself is to be understood as commensurate in scope with that of the claims.

I claim:

1. Apparatus for varying the phase of an alternating potential throughout an unlimited angular range, comprising a variable capacitor having an electrode member which is rotatable with respect to a plurality of opposed stator members, means for continuously applying phase-differentiated potentials from a common constant frequency source to said stator members thereby to produce an electrostatic field which rotates about the axis of said rotor member, a utilization circuit including a load resistor connected to said rotor member and branched to different ones of said stator members, an electron discharge tube having an input circuit which includes said load resistor, reversible means for shifting the angular relation of said rotor member to said stator members, and means responsive to varia-

tions in the phase of a train of cyclically timed signals with respect to said constant frequency source for actuating said reversible means.

2. A system for deriving an alternating potential having an adjustable phase relation to a given source of constant frequency, said system comprising a capacitor having one set of rotor plates interleaved with four sets of stator plates, means for supporting the stator plate sets in quadrature relation to the axis of said rotor plates, means controlled by said source for causing said stator plates to produce an electrostatic field which constantly rotates about the axis of said rotor plates, a utilization circuit having an impedance connected between said rotor plates and a point of fixed potential, independent and substantially non-reactive impedance branches from said point of fixed potential to each set of stator plates, and synchronizing means including a reversibly operable motor the energy applied to which is controlled by the phase relation between the potentials in said utilization circuit and potentials from a periodic signal source for shifting the position of said rotor plates throughout an unlimited angular range.

3. In a variable phase shifter, a capacitor having rotor plates and four sets of stator plates, the stator plate sets being quadrantly disposed about the axis of said rotor plates, a source of constant frequency potential, means for applying said potential in opposite phase to two diametrically opposed sets of said stator plates, means for deriving quadrature phase displaced potentials from said source, means for applying said phase displaced potentials in opposite phase to the remaining sets of said stator plates, an output circuit including parallel resistive branches from each set of stator plates to a point of fixed potential and thence through a load resistor to said rotor plates, a utilization device under control of currents traversing said load resistor, the phase of said currents being rotatable as a function of the angular position of said rotor plates, a phase correction unit under joint control of said utilization device and a train of cyclically timed signals, and means subject to control by said phase correction unit for shifting the position of said rotor.

4. A system wherein a variable phase output is derived from a constant phase source, said system comprising a variable capacitor having a single set of rotor plates interleaved with stator plates which are disposed in four quadrantal sectors, a circuit arrangement so connected between said source and said stator plates and so constituted as to produce a continuously rotatable electrostatic field about the axis of said rotor plates, a load impedance connecting said rotor plates to ground, impedances individually in circuit between ground and each of the stator plate sectors, an electron discharge tube having a control circuit which includes said load impedance, a frequency divider under control of output potentials from said discharge tube, a utilization device adapted for cyclic operation at the output frequency of said frequency divider, said utilization device being subject to control by a train of received signals, a differential phase corrector jointly operable by output energy from said frequency divider and said signals, and means controlled by said phase corrector for shifting the angular position of said rotor plates thereby to

maintain a desired phase relation between the operation of said utilization device and said signals.

5. In a phase shifter, a capacitive device having four sets of stator plates and one set of rotor plates, the stator plate sets being quadrantly disposed about the rotational axis of the rotor plate set, an inductive impedance interconnecting two of the stator plate sets which are diametrically opposed one to the other, a second inductive impedance interconnecting the remaining stator plate sets, means for maintaining the mid-points of said impedances at a substantially fixed potential, a third impedance connected between the rotor plate set and a terminal which is maintained at said fixed potential, means for applying alternating current potentials to said stator plates in such manner as to develop an electrostatic field which rotates about said rotational axis, the last said means including a quadrature phase splitting device having branches interposed between a single-phase constant frequency source and the respective stator plate sets, a utilization device including a reversible motor for orienting said rotor plate set, and means including a relay for applying power to drive said motor to a limited extent and in a desired direction, the last said means being controlled by potentials developed across said third impedance, the phase relation of the last said potentials to the potentials of said source being a function of the orientation of said rotor plate set about its axis.

6. The combination according to claim 5 and including an electron discharge tube in said utilization device, said tube having an input circuit which extends through said third impedance.

7. The apparatus set forth in claim 5 in combination with a device responsive to periodic signals, a differential correction unit, and means operable in dependence upon the phase relation between the potentials derived from said utilization device and the periodic signal frequency for causing said differential correction unit to act upon said relay means, thereby to cause the orientation of said rotor plate set to be shifted and hence to maintain the last mentioned potentials in synchronism with said signal frequency.

8. In a phase shifting system wherein quadrature phase related potentials are derived from a single-phase fixed-frequency source, and said potentials are simultaneously applied respectively to different sets of quadrantly arranged capacitive stator plates, there being a single set of rotor plates inter-leaved with said stator plates, the method of producing single phase output potentials having any desired phase relation to the phase of said source, which method comprises producing a rotating capacitive field about the axis of said rotor plate set, obtaining potential differences between the rotor plates and corresponding areas of said stator plates which lie in dielectric relation to the rotor plate areas, said phase relation being a function of the orientation of said rotor plate set about its axis, and causing said phase relation to be automatically so varied as to maintain synchronism between said output potentials and alternating potentials derived from an independent source.

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