

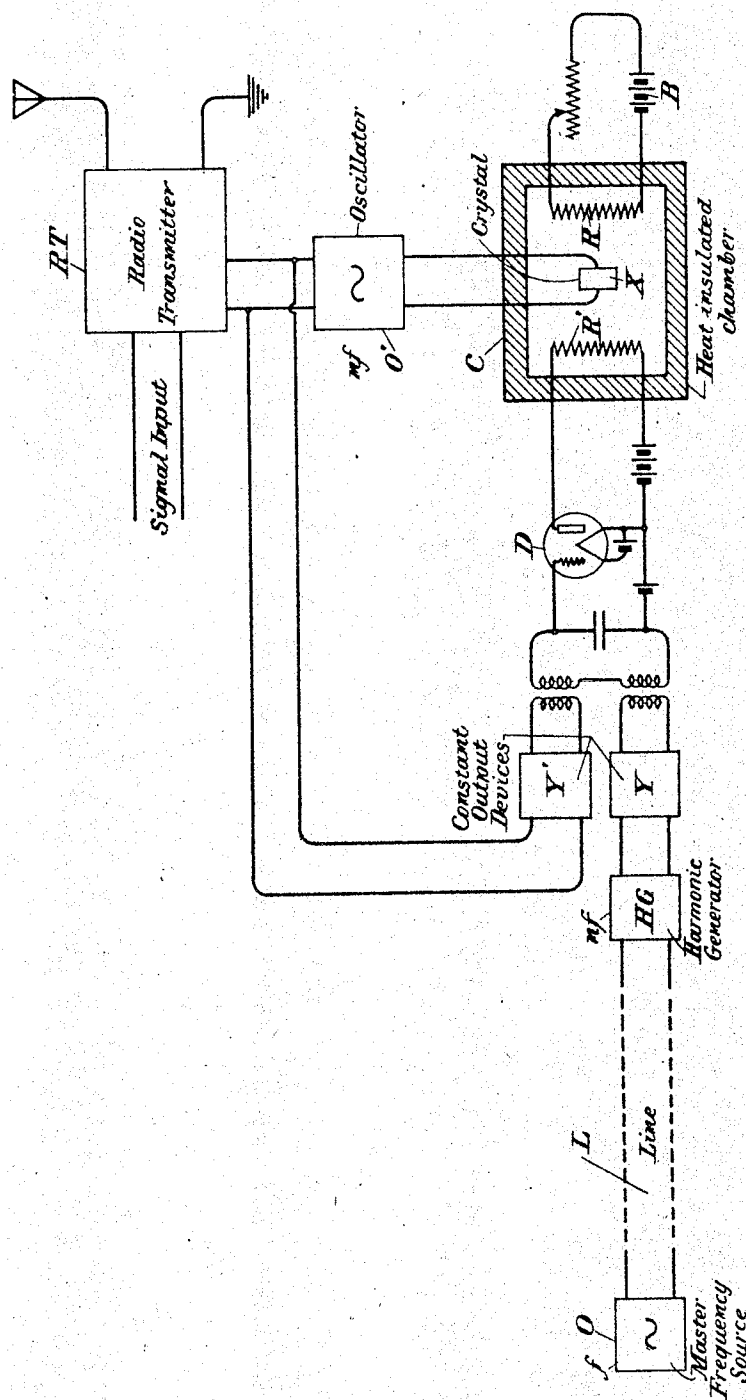
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FREQUENCY CONTROL

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FREQUENCY CONTROL

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This invention relates to an arrangement for determining the phase and frequency of a local source of current by means of a master source, the wave from which may be transmitted over a line. Such an arrangement has application in connection with the synchronism of distant radio stations and like uses.

In accordance with the present invention it is proposed to control the frequency of a local source of alternating current by transmitting a control frequency over a line circuit, using the control frequency as a constant check on the frequency generated by the local source. Such an arrangement is particularly advantageous because in case of failure of the line circuit which transmits the control frequency, the local generator will still function although its frequency may not be accurately held. An arrangement of this sort also makes it more readily possible to minimize the effect of noise received from the line circuit and to control the rate at which the incidental line changes are impressed on the local source.

In accordance with one embodiment of the invention, the source of current whose frequency is to be controlled may embody an oscillator whose frequency is stabilized by means of a crystal mounted in the usual heat insulated chamber. Alternating current from a master frequency source may be transmitted over a line and after being stepped up to the frequency assigned to the local oscillator may be applied to a detector together with some of the output from the local oscillator. If the two applied waves are of the same amplitude, the output current will be dependent upon their phase relation and by using this output current to heat a resistance in the heat insulated chamber, the frequency of the local oscillator may be changed, due to the action of the crystal, in such a manner as to maintain the oscillator in step with the master frequency source. Constant frequency sources based on the use of tuning-forks or magnetostriction devices would obviously also lend themselves to temperature control of the same kind.

The invention will now be more fully understood from the following description when read in connection with the accompanying

drawing the figure of which illustrates schematically a preferred embodiment of the invention.

Referring to the drawing, O' designates an oscillator for supplying the carrier wave to a radio transmitter RT. The oscillator may be of the vacuum tube type whose frequency is controlled by means of a crystal X which is mounted within a heat insulating chamber C. A resistance R in circuit with a source of current B may be used for maintaining the interior of the chamber C at a desired normal temperature.

The master controlling frequency may be generated by any suitable source at some distance station, such a source being conventionally illustrated in the drawing at O. The control wave derived from this source is then transmitted over a line L to the radio station and applied to a harmonic generator HG which steps the frequency up to that of the carrier wave assigned to the radio station. This high frequency current is then applied to the input of a detector D and some of the energy from the oscillator O' is also applied to the input of said detector D. If desired, both waves may be maintained at the same constant amplitude by means of constant output devices Y and Y'. The output of the detector D is connected to a heating resistance R' also mounted in the heat insulating chamber C.

With this arrangement it will be apparent that if the control wave and the controlled wave applied to the detector D are of equal amplitude, the detected current flowing through the resistance R' will depend upon the phase relation of the two waves, this current being a maximum when the two waves are in exact synchronism and being a minimum when they are 180 degrees out of phase. Therefore, if the two waves are normally so phased that an intermediate value of current flows through the resistance R', any tendency of the oscillator O' to step out of phase with respect to the control wave will be corrected by the change in current which flows through the resistance R'. This change in current changes the temperature of the

crystal, thereby tending to bring the oscillator back to normal.

This arrangement has the advantage that if there are any changes in the phase of the line control current due to temperature or other climatic variations of the line circuit, these will manifest themselves by corresponding action in the control circuit but the temperature lag of the crystal heater system will insure that these changes are imparted to the system very gradually so that they will be without serious effect on the operation of the system. In other words, the lag of the resistance R in translating change in current to change in temperature for the control of the crystal, will be sufficient to take up any small and rapid changes in the apparent phase of the control frequency.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

25 What is claimed is:

1. In a frequency control system, means to generate a wave whose frequency is to be controlled, temperature responsive means to vary the frequency of the wave generated, means to supply a control wave, means responsive to certain changes in the normal phase relation of the control and controlled wave to produce temperature variations to affect said temperature responsive means.

2. In a frequency control system, means to generate a wave whose frequency is to be controlled, temperature responsive means to vary the frequency of the wave generated, means to supply a control wave, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and controlled waves, and means to translate said current into heat to affect said temperature responsive means.

3. In a frequency control system, means to generate a wave whose frequency is to be controlled, temperature responsive means to vary the frequency of the wave generated, means to supply a control wave, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and controlled waves, and a heating element controlled by said current, said heating element being associated with said temperature responsive means.

4. In a frequency control system, means to generate a wave whose frequency is to be controlled, temperature responsive means to vary the frequency of the wave generated, means to supply a control wave, a detector to which said control and controlled waves may be applied said detector producing a

current varying with changes in the normal phase relation of the control and controlled waves, and a heating element controlled by said current, said heating element being associated with said temperature responsive means and said heating element being sufficiently sluggish in the production of temperature changes so as to be relatively unresponsive to minor variations in the phase relation of the control and controlled wave.

5. In a frequency control system, a crystal controlled oscillator at one station for generating a wave whose frequency is to be controlled, the crystal of said oscillator being responsive to temperature changes to vary the frequency of said oscillator, means to generate a control wave at another station, a line to transmit said wave to said first station, means at said first station responsive to certain changes in the normal phase relation of the control and controlled wave to produce temperature variations to affect said crystal.

6. In a frequency control system, a crystal controlled oscillator at one station for generating a wave whose frequency is to be controlled, the crystal of said oscillator being responsive to temperature changes to vary the frequency of said oscillator, means to generate a control wave at another station, a line to transmit said wave to said first station, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and controlled waves, and means to translate said current into heat to affect said crystal.

7. In a frequency control system, a crystal controlled oscillator at one station for generating a wave whose frequency is to be controlled, the crystal of said oscillator being responsive to temperature changes to vary the frequency of said oscillator, means to generate a control wave at another station, a line to transmit said wave to said first station, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and controlled waves, and a heating element controlled by said current, said heating element being associated with said crystal.

8. In a frequency control system, a crystal controlled oscillator at one station for generating a wave whose frequency is to be controlled, the crystal of said oscillator being responsive to temperature changes to vary the frequency of said oscillator, means to generate a control wave at another station, a line to transmit said wave to said first station, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and

controlled waves, and a heating element controlled by said current, said heating element being associated with said crystal and said heating element being sufficiently sluggish in the production of temperature changes so as to be relatively unresponsive to minor variations in the phase relations of the control and controlled wave.

9. In a frequency control system, a crystal controlled oscillator at one station for generating a wave whose frequency is to be controlled, the crystal of said oscillator being responsive to temperature changes to vary the frequency of said oscillator, means to generate a control wave at another station, a line to transmit said wave to said first station, a detector to which said control and controlled waves may be applied, said detector producing a current varying with changes in the normal phase relation of the control and controlled waves, and a heating element controlled by said current, said heating element being associated with said crystal, and a heat insulated chamber enclosing said heating element and said crystal.

10. In a frequency control system involving a crystal controlled oscillator for generating the wave whose frequency is to be controlled, the method which consists in supplying a control wave, producing temperature changes determined by variations from the normal phase relation of the control and controlled waves, and applying said temperature changes to the crystal of the oscillator so as to tend to bring the oscillator back into step with the control frequency.

11. In a frequency control system involving a crystal controlled oscillator for generating the wave whose frequency is to be controlled, the method which consists in supplying a control wave, producing a current determined by variations from the normal phase relation of the control and controlled waves, translating said current into corresponding temperature changes, and applying the temperature changes to the crystal of said oscillator so as to tend to bring the oscillator back into step with the control frequency.

In testimony whereof, I have signed my name to this specification this 20th day of February, 1931.

HERMAN A. AFFEL.