June 12, 1934. A. McL. NICOLSON 1,962,207

OSCILLATION CONTROL APPARATUS

Filed Aug. 2, 1930

Fig. 1

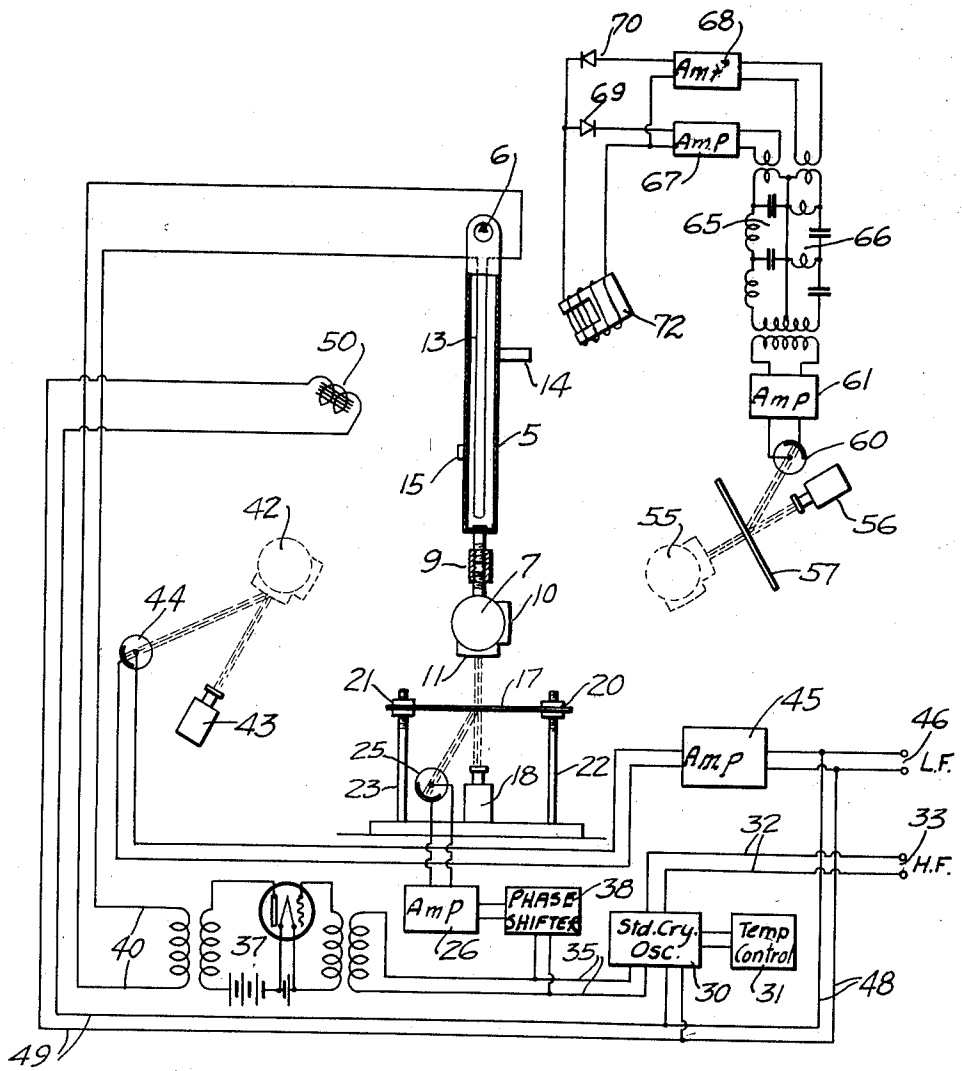


Fig. 2

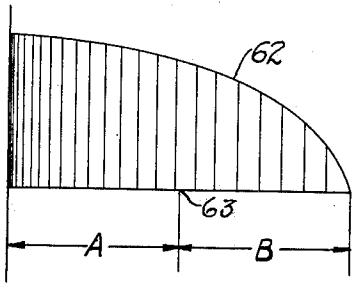
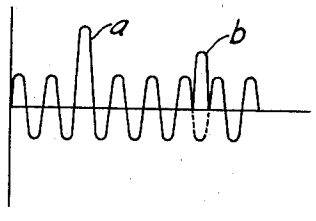


Fig. 3



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OSCILLATION CONTROL APPARATUS

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Application August 2, 1930, Serial No. 472,590

13 Claims. (Cl. 250—41.5)

This invention relates to the control of oscillations, and particularly to interferometric control of oscillating systems both mechanical and electrical.

An object of this invention is to generate and maintain oscillations of constant frequency.

Another object of the invention is to generate a compound frequency wave and maintain the frequency thereof constant.

A further object of the invention is to control the oscillations of a pendulum coupled with a piezo-electric oscillator by the medium of interference light rings.

In many electrical systems a particular wave form of an oscillating frequency is required such as a wave having a periodically occurring cycle of greater amplitude than the body of the wave. Such an oscillating frequency is used in electrical systems such as television and the like, wherein a synchronizing or piloting impulse is desired. Such a television system is disclosed in my copending application Ser. No. 397,826, filed October 7, 1929.

It is quite essential in compound oscillators that the basic frequency be maintained constant together with the intervals between the cycles having the increased amplitude. This means that there exists a definite relation between the basic frequency which may be of relative high value and the impulse which may be of relative infrequent occurrence. The relation is brought about in the present invention by use of a pendulum which contains on its bob reflecting surfaces for reflecting light through semi-opaque semi-transparent mediums to produce interference rings. These rings are produced at different points on the travel arc of the bob of the pendulum, each group of rings producing a controlling effect through systems hereinafter described.

In the present invention a standard crystal produces the basic frequency, the crystal having a temperature control or magnetic control as disclosed in my copending application Serial No. 470,326, filed July 24, 1930. This basic frequency is maintained constant within extremely narrow limits with interferometric systems described in this copending case. Interferometric systems operated on the same general principle are also employed in the present invention, to maintain a constant frequency of oscillation of the pendulum bob. However, since the light patterns are produced by a reflecting surface moving at a non-uniform velocity, two types of control of a different nature are presented herein. One set of interference rings produce intermittent impulses of a frequency identical with that of the crystal oscillating system, any variation between which operates a heat controlling circuit. Another set of interference rings produce a band of frequencies which is divided into sub-bands, to control the oscillation of the crystal magnetically. The generated impulses, in combination with the standard basic frequency, produce the driving force for the pendulum, which also provides a certain degree of control on the oscillating pendulum.

The details of the invention will be more fully understood with reference to the following description in connection with the accompanying drawing, in which:

Figure 1 is a schematic drawing partially diagrammatic of the entire oscillating system embodying the invention;

Fig. 2 is a chart illustrating the variations in frequency produced by the oscillating bob; and

Fig. 3 is a current wave produced by the compound oscillator.

A pendulum 5 is mounted upon a knife edge fulcrum 6, and has a bob 7 of substantial mass composed of metal and the like having two reflecting surfaces 10 and 11. These reflecting surfaces are slightly curved to produce divergent reflecting rays. The length of the pendulum is adjusted with adjusting sleeve 9.

The main portion of the pendulum may be of metal containing in its interior a heater loop 13, which will heat the casing of the pendulum when the current is passed through the loop. Also mounted on the pendulum are polarized projections 14 and 15, the use of which will be explained hereinafter. Directly beneath the pendulum when in its vertical position, is a semi-opaque semi-transparent medium 17, through which light from a source 18 is passed and reflected thereto by surface 11 on the bob 7. Through the proper curvature of this medium and of the reflecting element 11, interference bands are produced on the medium 17 which contract and expand at a constant rate, notwithstanding the fact that the bob travels at a non-uniform speed during the interval that the rings are formed. The non-uniform speed is compensated for by the curvature of the mediums 11 and 17 such as an Archimedean curve. The medium 17 may be adjusted by means of adjusting nuts 20 and 21 mounted on the studs 22 and 23, respectively, and moved transversely on its carriage mounting for tuning with the standard oscillator.

A photoelectric cell 25 is focussed upon the interference area on the medium 17, this cell feeding an amplifier 26. The source of light 18 may be white or colored, but preferably, should be monochromatic, in order to obtain a better contrast between the light and dark areas formed. Movement of the bob during its oscillation within a definite angle produces contracting and expanding rings on the medium 17. These rings have a constant speed of travel across the medium. In this manner a uniform frequency is generated in the photoelectric cell 25, which is amplified by the amplifier 26.

In the present system a standard crystal oscillator 30 is employed, the temperature of which is controlled through a temperature control system 31, of the type disclosed in my copending application Ser. No. 470,326, filed July 24, 1930. This standard crystal may also be controlled magnetically, as disclosed in this copending case.

This oscillating system produces a constant frequency which is high in comparison with the oscillations of the pendulum 5, and produces the basic wave for an output circuit 32 having terminals 33. This oscillator has another output circuit 35 which is connected to the input of a thermionic amplifier 37. Connected in parallel with this output circuit is the output of the amplifier 26 after passing through a phase shifter 38. Now when the frequency of the current generated in the cell 25 is made the same by adjusting the interferometer carriage with respect to the bob as that produced by the standard crystal oscillator, and is shifted 180° by the phase shifter 38, the two input sources neutralize each other. During the period, therefore, when the photoelectric cell 25 is energized and the bob 7 is oscillating at its proper frequency, no energization of the amplifier 37 occurs, and no output current exists in the output circuit 40 thereof. This output circuit 40 is connected to the heater wire 13, to heat the pendulum to a certain temperature. Thus, this production of interference bands controls the temperature of the pendulum, and operates to control the frequency of its oscillations. A rise in temperature causes the pendulum to expand and increase in length, reducing the oscillations, while a contraction of the pendulum increases them. There is heat being applied to the heater loop 13 during the periods when the pendulum is to the right or the left of the small vertical angle in which the interference bands are formed. This occurs because there are no neutralizing impulses to prevent energization of the amplifier 37 by the crystal oscillator. This heat supply keeps the pendulum at a certain temperature above the surrounding atmosphere, cooling being accomplished by a decrease in the heat supplied. Should the pendulum for any reason change its period of oscillation due to cooling, the resulting frequency produced in the cell 25 will not completely neutralize the heat supplying frequency from the standard crystal oscillator, permitting more current to pass into the loop 13. By the proper adjustment of the phase shifter any operating temperature for the pendulum may be obtained, this temperature being above that of the surrounding atmosphere. However, by the use of thermal couples which produce heating and cooling effects, according to the direction of current therethrough, a positive action in both directions may be obtained. Such a system is disclosed in my copending application mentioned above.

When the pendulum reaches its extreme position to the left, as shown by the dotted lines 42, light projected from a light source 43 is reflected by the medium 11 to a photoelectric cell 44. This impulse is amplified by an amplifier 45, and produces low frequency impulses at the terminal 46. These impulses are united over conductors 48 with the basic frequency from the standard crystal oscillator, and are fed through conductors 49 to a solenoid relay 50 having an iron core.

Referring to Fig. 3 for a moment, the wave obtained by the combination of the basic frequency and the impulses, and which is present in the conductors 49, is shown graphically. The low amplitude impulses are those produced by the standard crystal oscillator 30. The third cycle "*a*" has an amplitude about double that of the basic frequency, and is caused by the superimposing of the impulse from the photoelectric cell 44 upon the basic frequency. This impulse occurs when the bob is in the position shown at 42, and sufficiently energizes the coil 50 to cause it to impart a propelling force to the polarized element 15, sufficient to overcome friction at the fulcrum of the pendulum or of the air through which it oscillates. This impulse, therefore, drives the oscillating pendulum. Should the pendulum vary, however, so that the impulse "*a*" occurs as shown at "*b*", it will be observed that the propelling force will not be as great as when it occurred at "*a*" Furthermore, the driving force acts immediately upon energization of the cell 44 when in synchronism so that there is a retarding effect on the pendulum before it reaches its limiting position. This retarding effect increases as the bob passes its correct position to bring it back to normal. The basic frequency, of course, has no effect upon the driving of the pendulum since the negative portions thereof neutralize the positive portions, and they occur so rapidly that the pendulum could not follow this frequency. The impulse "*b*" from the cell 44 has arrived during the negative half cycle of the basic frequency which is neutralized with a small differential in the positive direction. This differential will vary according to the amount the crystal is off the proper frequency, and should the standard crystal vary, there will be a tendency through the shift of the impulse to draw the pendulum in step with the change in frequency of the standard, so that a substantially perfect compound wave will always be present at the terminals 46. Should the outputs 33 and 46, therefore, be connected together, they may be used to supply a television arc screen wherein the impulses "*a*" are used as piloting or framing impulses for the pictures or images, and the basic frequency as the arc producing supply. These impulses may also be used for synchronizing. As shown in Fig. 3, the impulses occur at every third cycle of the basic frequency but for use in a television system they would more likely occur every 100 or 1000 cycles.

There is another independent control for the pendulum 5 which is extremely accurate, the correcting factor being operable to within a wave length of light and substantially instantaneous in its action. When the bob reaches a position shown by the dotted lines 55, the reflecting surface 10 reflects light which arises from a source 56, preferably, monochromatic light, and which has emerged from a semi-opaque semi-transparent medium 57, to form an interference pattern on the medium 57. The surface 10 has, preferably, a more pronounced curvature than that of surface

11, causing the interference bands to vary in frequency from some value in the neighborhood of 100 kilocycles to zero, the zero frequency being at the limiting position of the bob swing. Associated with this interferometric system is a photocell 60 directed on the interference area, the output of this cell being amplified by an amplifier 61. The impulses produced in the cell 60 will be a band of frequencies from 100 kilocycles to zero.

In the chart in Fig. 2, there is a graphic illustration of the curved surface of the reflector 10, represented by 62, the distance between the lines under the curve representing the frequency values of the current produced in the cell 60. This frequency band produced is divided up into two sub bands A and B. This is accomplished by two combined unbalanced filter sections 65 and 66. The high frequency channel passing through filter 66, and the low frequency through filter 65. Each sub band is amplified in the respective amplifiers 67 and 68, in the output circuits of which are one-way rectifiers 69 and 70, respectively. The output circuits then are joined into a common circuit which feeds the windings of a slotted core solenoid 72.

The operation of this control circuit is as follows: As the bob comes within the interference forming range, an extremely high frequency is produced because of the rapid shifting of the interference bands, which is transmitted through the filter 66, amplified in amplifier 68 and reduced to a uni-directional current in the windings of the electromagnet 72. The current produced at this time is such as to attract the polarized projection 14, which is approaching or has just entered the slot in the core, farther into the core of the coil. This current in fact aids the swing and continues to do so until the frequency produced passes the cut off value of the filter 66 and that of the filter 65. This point is 63 in Fig. 2, the band A representing the frequencies which produce a unidirectional current tending to attract the pendulum. From this point or cut off frequency on to zero frequency the currents produced by the interference areas are of such value that they will pass through filter 65, energize the amplifier 67 and pass unidirectional current through the windings of the coil 72 in the opposite direction such as to repel the polarized magnet 14. The band B in Fig. 2 represents the frequencies producing this force. This repulsion force will exist on the backward swing until the frequency produced is above that of the cut off point of the filters. From then on a retarding effect is produced, since the pendulum has reversed its direction. By adjustment of the filter elements in the filters 65 and 66, it is possible to make this retardation and repulsion effect interchange at any particular frequency desired such that one force is greater than the other. The correction by this feature is accomplished by the fact that should the pendulum remain in the area B longer than in the area A, a differential effect tending to drive the pendulum faster is obtained to bring it back to its proper oscillating frequency. The reverse effect is true when the swing is too great. Furthermore the velocity of the bob determines the upper limit of the frequency band, and any change therein will be compensated for by the time periods during which the magnet 72 acts on the pendulum.

The combination of the temperature control and the magnetic control by the interference light patterns is such as to maintain the oscillation of the pendulum at a substantially constant frequency, and at a frequency which will give a wave form shown by the left hand portion of Fig. 3, the distorted portion being shown for purposes of explanation. There may be a slight distortion in the compound wave form for a very small portion of the cycle, but the magnetic correcting effect is so rapid that the wave is brought back to normal before the distortion has been prolonged to an appreciable extent.

This invention is applicable to many systems wherein a constant relationship is desired between two oscillations, and is to be limited only by the scope of the appended claims.

What is claimed is:

1. In an oscillating system, a standard electrical oscillating circuit, a mechanical oscillating device under control of said electrical oscillator, means for generating electrical oscillations with said mechanical oscillator and means utilizing said electrical oscillations for maintaining said mechanical oscillations constant. said means employing reflected light from said mechanical oscillating device.

2. In combination, a mechanical oscillating system, means for producing electrical oscillations from said mechanical system, said oscillations being of variable frequencies, means for separating said frequencies into a plurality of channels. and a device for changing the period of said mechanical system in accordance with the current in each channel.

3. In combination, a mechanical oscillator, means for producing from said oscillator intermittent current impulses of constant frequency, means for producing from said oscillator intermittent current impulses of varying frequencies, means for heating said mechanical oscillator with said constant frequency currents, and means for magnetically controlling said mechanical oscillator with said variable frequency currents.

4. In combination, means for generating low frequency oscillations, said means including a mechanical oscillator, independent means for generating high frequency oscillating currents, said means including an electrical oscillator, and means combining said oscillations for operating said mechanical generating means.

5. In combination, a mechanical oscillator, an electrical oscillator associated therewith, independent means for controlling the oscillations of said mechanical oscillator, a second independent means for controlling the oscillations of said electrical oscillator. means for transforming said mechanical oscillations into electrical oscillations, and means for heating said mechanical oscillator with the combined oscillations from said electrical oscillator and the transformed oscillations from said mechanical oscillator.

6. In combination, a mechanical oscillator producing intermittent current impulses of a certain frequency, an electrical oscillator producing continuous waves at the same frequency as said intermittent current impulses, means for combining said intermittent current impulses and said continuous waves, and means for generating heat with said combined waves in accordance with the amount of phase shift therebetween.

7. In combination, a mechanical oscillator in the form of a pendulum, means for causing said pendulum to produce uniformly varying light interference areas, means for transforming said varying interference areas into electrical currents having a certain frequency dependent upon the oscillations of said pendulum, means for producing continuous waves of the same frequency for heat-

ing said pendulum, and means for combining said interference area produced currents with said continuous waves, the resulting current having a value dependent upon the variation in period of said mechanical oscillator.

8. The method of maintaining oscillations of a mechanical oscillator constant, comprising producing interference bands from reflected light at periodic intervals, and transforming said interference bands into electrical currents for lengthening and shortening the oscillating period in accordance with the frequency of said interference bands.

9. The method of maintaining the oscillations of a pendulum constant, comprising producing interference bands by light reflected from said pendulum, transforming said bands into electrical impulses, combining said impulses with continuous impulses of constant frequency and applying said combination impulses to the lengthening and shortening of said pendulum.

10. In combination, an oscillating pendulum having reflecting surfaces thereon, a plurality of means associated with said reflecting surfaces for producing a plurality of sets of interference bands at mutually exclusive intervals during the oscillation of said pendulum, means for translating one of said sets of interference bands into constant frequency currents, means for translating the other set of interference bands into currents of a plurality of frequencies, means for heating said pendulum with said constant frequency currents, and means for propelling and repelling said pendulum with said currents of a plurality of frequencies.

11. The method of maintaining the oscillations of a pendulum constant, comprising producing interference bands by light reflected from said pendulum in motion, said interference bands moving at a non-uniform rate, translating said bands into electrical current impulses, dividing said current into channels in accordance with their frequencies, and applying said currents to the propulsion and repulsion of said pendulum in accordance with the frequency of said currents.

12. In combination, an oscillating pendulum, a source of light, means adjacent one position of said pendulum to produce interference bands from light reflected from said pendulum when in said position, a photo-electric cell for translating said interference bands into electrical currents said currents having a plurality of frequencies, means for segregating currents of a definite band of frequencies into one channel, and segregating other frequencies into another channel, magnetically propelling means for said pendulum, and circuits connecting the output of said segregating means to said magnetic means for operating said magnetic means.

13. In a compound oscillating system, means for producing a basic high frequency current, said means including an electrical oscillator, means for producing low frequency impulse current, said means including a mechanical oscillator, means for combining said impulse current and basic frequency current, and means for controlling the generation of said low frequency impulse current.

ALEXANDER McLEAN NICOLSON.