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A. F. POOLE

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METHOD AND APPARATUS FOR REGULATING CLOCKS

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Fig. 1

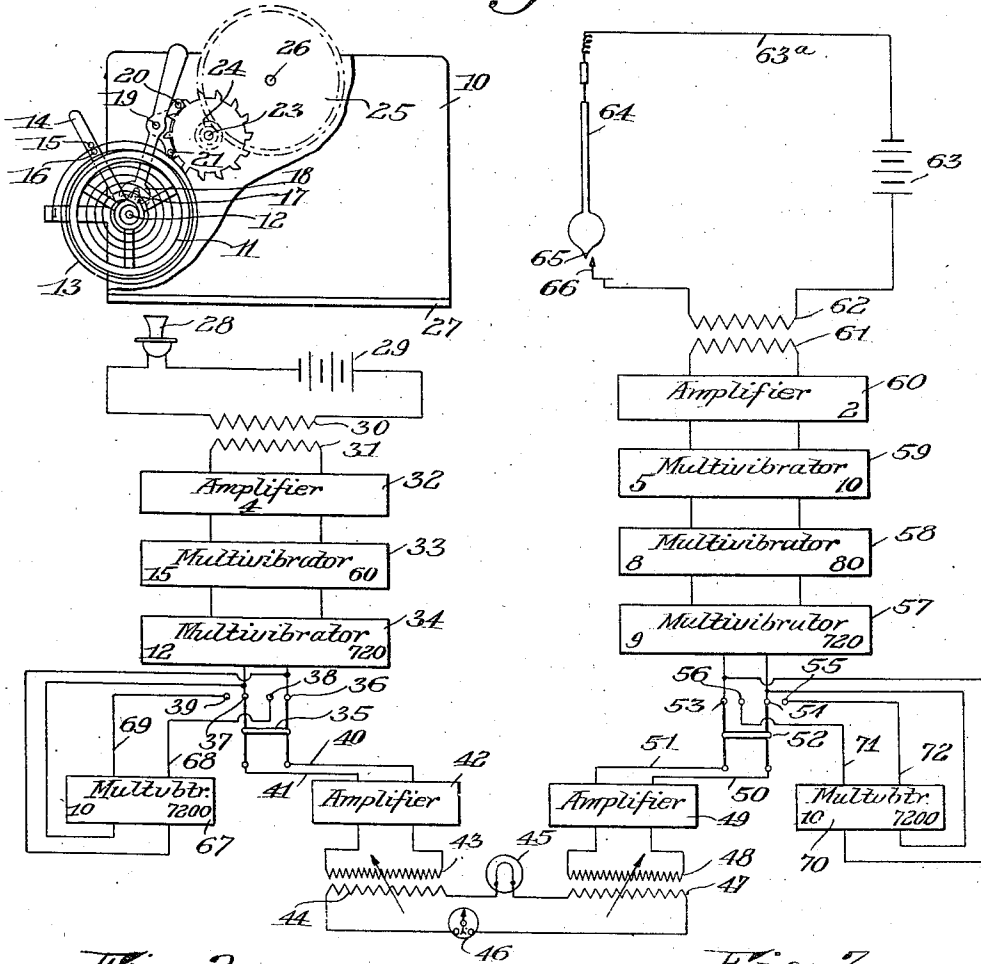


Fig. 2

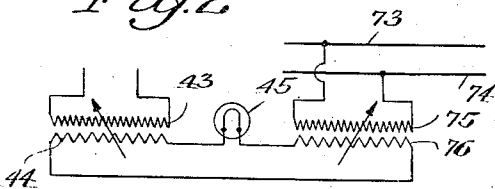


Fig. 3

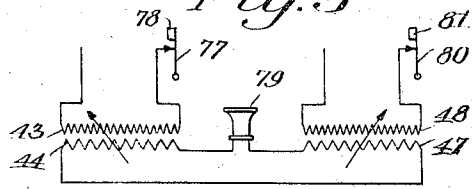
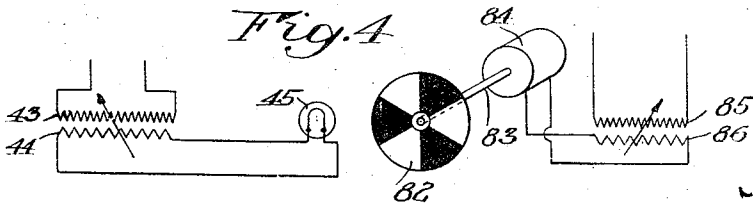


Fig. 4



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METHOD AND APPARATUS FOR
REGULATING CLOCKS

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My invention is an improved method and apparatus for regulating clocks.

One of the objects of my invention is the provision of means for transforming the beats of the clock escapement into an alternating or periodic current of a frequency which is an integral multiple of said beats and of a higher frequency. Another object of my invention is the provision of a current of standard frequency with which said clock controlled current may be compared, and a further object of my invention is the provision of means of making such comparison conveniently and accurately. A further object of my invention is the provision of means whereby a regulation of any desired degree of precision may be made by first making a regulation to a certain degree of precision and then increasing the frequency of the comparison currents to make a regulation of a much higher degree of precision. These and other objects of my invention will be described in the following specification and pointed out in the claims.

In order to carry out my invention, I provide means for transforming the beats of the clock to be regulated into an alternating current of the same frequency as the beats of the clock. I then take this A. C. current and send it through an amplifier and then through a series of multivibrators to raise this clock frequency to a relatively high one. I then provide a source of standard frequency, and means for causing said standard frequency to interfere with the clock governed frequency. By noting the interference beats I can bring the clock under test quickly and precisely into correct regulation.

My invention will be best understood by reference to the accompanying figures of which Fig. 1 is a diagram of the circuits necessary to carry out my herein described method of regulation, Figs. 2, 3, and 4 are various modifications of the apparatus necessary to detect when the clock is in correct regulation. Referring to Fig. 1, 10 represents the framework of a clock in which is mounted a balance 11 rotating on a shaft 12 and whose oscillations are governed by a hair spring 13. These parts may also be referred to as a time measuring element. The hair spring 13 is provided with the customary regulator 14 carrying the regulator pins 15 and 16 between which the hair spring is held. Rotation of the regulator in one direction or the other will either increase or decrease the rate of the clock. The hair spring 13, as is usual, has one end attached to the balance staff, and the other end is fastened in the framework. The balance 11 also carries the cus-

tomary roller pin 17 which is actuated by the fork 18 rotatably mounted in the framework on a staff 19, and having rigid therewith the impulse pins 20 and 21 which are actuated by an escapement wheel rotatably mounted on a shaft 23. The escapement wheel is driven by the pinion 24 into which engages a fourth wheel 25 rotatably mounted on the shaft 26. The parts thus far described will be recognized as parts common to any clock and are shown simply for the sake of illustration. I shall now proceed to describe the parts necessary to carry out my herein described invention.

The clock 10 is put on a shelf 27 which is preferably made of thin wood, and near said shelf is a telephone transmitter 28 in a circuit including a battery 29 and the primary 30 of an induction coil. Obviously the ticks of the clock escapement will affect the transmitter and be transformed into an undulating current whose frequency is the same as the ticks of the clock. I shall assume that the clock makes four beats per second, this being the usual frequency for alarm clocks, and, therefore, as a result of the ticking of the clock, the circuit containing the transmitter 28 has an undulating current of a frequency of four cycles per second. The induction coil is provided with a secondary winding 31 which leads to amplifier 32 to bring the current up to the level necessary to actuate a multivibrator 33 which multiplies the frequency 15 times. Since these multivibrators are well known in the radio art, I shall not describe them. An example of such a multivibrator is found in my prior Patent 1,928,793. Their function is to take a current of one frequency and to transform this current into a frequency of a higher integral multiple of the frequency which is supplied to them. The multivibrator may include a filter, if necessary, so as to suppress all frequencies except the desired one.

As a result of the stepping up of the frequency by the multivibrator 33, the output of this multivibrator is a current of 60 cycles per second, which current is kept in step with the rate of the clock. The multivibrator 33 is led to a second multivibrator 34 which has a factor of 12, thereby raising the 60-cycle current to a frequency of 720, more or less, depending upon the rate of the clock under regulation. The current from the multivibrator 34 is led by means of a double pole switch 35 by conductors 40 and 41 to an amplifier 42 which is provided with an adjustable transformer, having windings 43 and 44, to raise the current to the proper level to illuminate a test lamp 45. As a result of the apparatus just described, we have a frequency of 720 cycles per second going through

the lamp 45, this frequency being an exact multiple of the number of vibrations of the clock under test.

It remains now to describe the method of securing a current of constant frequency with which to compare the current governed by the clock under test. To this end I have provided a standard pendulum or time measuring element 64 which, for the sake of the present illustration, may be taken as vibrating two times per second. The bob of this pendulum is provided with a projection 65 which cooperates with the light wire 66 in a circuit containing a battery 63, a conductor 63a, and the primary 62 of an induction coil. Thus at every swing of the pendulum, the circuit 65-66 will be closed and consequently a current of two cycles per second will be sent through the winding 62. It is to be understood that the pendulum 64 is to be provided with suitable means for maintaining it in motion, such as a clock escapement, an electric drive, or the like and is thus a reference or standard clock. A winding 61 is mounted in inductive relation to the winding 62 and leads to an amplifier 60, which is similar to the amplifier 42, which raises the standard current of two cycles per second to the proper level to actuate a multivibrator 59 which multiplies the frequency of this current five times. As before, this multivibrator may be provided with a filter so as to allow only current of 10 cycles per second to get through. The multivibrator 59 is connected to a multivibrator 58 which raises the frequency eight times. Consequently its output is a frequency of 80 cycles per second, which is led to a multivibrator 57 having a multiplying factor of nine, which raises the standard current to a frequency of 720 per second. A double pole switch 52 connects the multivibrator 57, by means of conductors 50 and 51, to an amplifier 49 which raises the current to the proper level to affect an adjustable transformer having windings 48 and 47, the latter being connected in series with the lamp 45 and a galvanometer 46.

It will be apparent that if the rate of the clock under test is exactly four beats per second, the lamp 45 will remain either permanently bright or permanently dark, but if the frequency controlled by the clock differs from the standard frequency, then the lamp 45 will make one flash for each cycle gained or lost by the clock-controlled frequency induced in the winding 44. The scheme is exactly similar to the method of comparing the frequency of two electric generators by means of a synchronizing lamp. Noting the flash of the lamp 45, the operator then manipulates the regulator 14 so as to accelerate or retard the rate of the clock. It is easy to tell in which direction to move the regulator since if it is moved in the wrong direction, the lamp 45 will flash oftener. The regulator is moved until the lamp 45 reaches a steady state, either of light or darkness, and the clock under test is then removed from the shelf 27 and another clock put in its place.

At this point it is to be noted that the particular frequency of 720 per second chosen to illustrate my invention was taken for the reason that there are 1440 minutes in a day, and consequently, if the lamp 45 were to make one flash per second, it would mean that the clock was away from the standard one part in 720, or that the clock would gain or lose two minutes per day. If the operator regulates the clock so that the lamp 45 makes one flash in two seconds, then the rate of the

clock under test departs from the true rate one minute per day.

In the event that it is desired to regulate the clock closer than noted above, I have provided a multivibrator 67, having a factor of 10, to step the current from the multivibrator 34 up to 7200 cycles per second. This multivibrator is connected to the points 38 and 39 of the double pole switch 35 by the conductors 68 and 69, and it will be seen that if the switch 35 is moved to the left, then the frequency delivered to the winding 44 will be a frequency of 7200 cycles per second. In order to step up the standard current to this frequency, I have provided a multivibrator 70, having a multiplying factor of 10, which is connected by conductors 71 and 72 to the points 55 and 56 of the double throw switch 52. Throwing this switch to the right will step up the standard current to a frequency of 7200. This, of course, will simply increase the precision of measurement by 10. One flash of lamp 45 per second, when the high frequency current is on, will correspond to a gain or loss of one-tenth of 120, or 12 seconds per day. Obviously, the stepping up of the current can be carried to any desired degree of precision.

A galvanometer 46 responsive to alternating current may be provided as an indicator in the event that the flashing of the lamp 45 is not easily visible. Swings of the galvanometer needle will indicate flashings of the lamp 45 and give like information as to the relative frequencies of the standard current and that under test.

For the sake of clearness I have shown the switches 35 and 52 as separate, in practice they would be combined into one so that when 35 was thrown 52 would be thrown also.

In Fig. 2 I have shown a modification of my device in which instead of using a current from a master clock as the standard current, I have used the ordinary regulated A. C. current used for driving synchronous motor clocks. In work such as regulating alarm clocks, a regulated current of this kind is accurate enough, and it is unnecessary to have the standard frequency equipment of the pendulum 64 and its associated multivibrators. In this arrangement the coil 43 in said figure is connected to the multivibrator 33 so as to get a current of a frequency of 60 cycles per second to compare with the 60 cycle current from the mains 73 and 74.

In Fig. 3 I have shown another modification of the detecting apparatus, in that a telephone receiver 79 is placed in the circuit 44-47. This receiver will, of course, give a sound corresponding to the frequency of the alternating current sent through it, and this sound will have beats if the two frequencies are not exactly alike. Key 77, manipulated by a button 78, and key 80, manipulated by a button 81, are provided so that either the test circuit or the standard may be cut off to tell readily whether the clock under test is running fast or slow.

In Fig. 4 I have shown the lamp 45, which, in this case, should be a neon lamp, illuminating a rotating disc 82 divided into sectors mounted on a shaft 83 of a synchronous motor 84 which is run from the standard current by means of an adjustable transformer whose windings are 85 and 86. This stroboscopic method of determining the rate of the clock under test will be apparent to those skilled in the art without further description.

While I have described my improvement as applied to the timing of a clock, it is obvious that

it is equally applicable to the regulating of watches, since it is only necessary to make the transmitter circuit 28 and the amplifier 32 sufficiently sensitive to pick up the ticks of a watch put on the shelf 27. By this means one is able to bring a watch to the rate of a few seconds per day in three or four minutes. Many variations may be made from the precise apparatus herein described without departing from the spirit of my invention, since I claim:

1. The method of regulating clocks which comprises transforming the periodic sound of a clock into a pulsating current, stepping up said pulsating current to a high frequency current, and comparing said high frequency current with a standard frequency current.

2. The method of regulating clocks which comprises transforming the periodic sound of a clock into a pulsating current, stepping up said pulsating current to a high frequency current, and comparing said high frequency current, by interference with a standard frequency current.

3. The method of regulating clocks which comprises transforming the periodic sound of a clock into a pulsating current, stepping up said pulsating current to a higher frequency current, comparing the interference beats of said higher frequency current with a standard frequency current, correcting the rate of said clock accordingly, then stepping up both the clock governed high frequency current and the standard frequency current to still higher frequency currents, and making a second comparison of the interference beats.

4. In an apparatus for timing clocks the combination of means responsive to the periodic sounds of said clock, said means acting to control an alternating current in step with said sounds; means of transforming said current into a periodic current of high frequency; a source of current of standard high frequency; means to cause said periodic current to interfere with said standard frequency current and an indicator to respond to the frequency of said interference.

5. In an apparatus for timing clocks the combination of means responsive to the periodic sounds of the clock for controlling a periodic current of the same frequency as said beats, means for transforming said current into one of high frequency governed by said clock, a source of standard frequency current, means to step up said standard frequency current to approximately the frequency of said clock governed current and means to compare the frequency of said currents.

6. In an apparatus for timing clocks the combination of means responsive to the periodic sounds of a clock for producing a periodic current of a frequency higher than that of said sounds, a source of current of standard frequency, means to step up said last mentioned current to a higher frequency and means of comparing the frequencies of said high frequency currents.

7. In mechanism for regulating a timepiece having an escapement, the combination of means for creating a periodic current whose periodicity is synchronized with and bears a multiple relationship to the periodicity of said escapement, a source of current of a known frequency, and means for comparing the frequencies of said currents by causing said currents to interfere and cause beats.

8. In a mechanism for regulating a timepiece having an escapement, the combination of means for creating a periodic current whose periodicity

is synchronized with and bears a multiple relationship to the periodicity of said escapement, a source of current of known frequency, means for comparing the frequencies of said currents by causing said currents to interfere and cause beats, and a lamp to detect said beats.

9. The method of comparing the operation of a commercial clock with a standard reference clock, which comprises impressing upon a circuit an undulating current having a frequency synchronized with the time measuring element of the commercial clock, impressing on the same circuit a periodic current having a frequency synchronized with the time measuring element of the reference clock, continuously comparing the frequencies of said currents, and regulating the rate of the time measuring element of the commercial clock until the frequency of the undulating current bears an unchanging and desired synchronized relation to the frequency of the periodic current.

10. The method of regulating a timepiece which comprises producing a time regulated, periodic, visual signal at an integral multiple of the frequency desired for the time measuring part of said time piece, and producing another periodic, visual signal at an integral multiple of the actual frequency of the time measuring part of said timepiece, and regulating the operation of said time measuring part until the frequency of said second set of signals equals the frequency of said first set of signals.

11. The method of regulating a timepiece which comprises producing an undulating current synchronized with the time measuring part of said timepiece, producing a periodic current having a regulated frequency, stroboscopically comparing the frequencies of said currents, and regulating said time piece until the frequency of said undulating current bears a desired time relation to said regulated frequency.

12. In an apparatus for timing a commercial clock, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, means for increasing the frequency of said periodic currents in an exact multiple relation, a source of standard frequency currents, and a common circuit into which both said currents are introduced and indicating means in said circuit whereby said two frequencies may be compared.

13. In an apparatus for timing a commercial clock, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, means for increasing the frequency of said periodic current in an exact multiple relation, a source of standard frequency currents, and stroboscopic means for comparing said high frequency and said standard currents.

14. In an apparatus for testing a commercial clock, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, means for increasing the frequency of said current in an exact multiple relationship, a source of standard frequency currents, a motor driven by said source of currents, a visual indicator driven by said motor, light producing means actuated by said current of increased frequency, whereby said two currents may be compared as to frequency by the action of said light falling on said indicator.

15. In an apparatus for testing a commercial clock, means responsive to the periodic sounds

of the clock under test for producing a periodic current in time with said sounds, means for increasing the frequency of said currents in an exact multiple relationship, a source of standard frequency currents, a common circuit into which said standard currents and said currents of raised frequency are introduced, and audible signal means in said circuit whereby said two frequencies may be compared.

10 16. In an apparatus for testing clocks, the combination of a source of standard currents, a motor driven thereby, indicating means driven by said motor, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, light producing means actuated in timed relationship with said periodic currents, whereby the instantaneous position of said indicating means can be determined by allowing said light to fall on said indicator, and the relative frequency of the clock under test with respect to the standard currents be determined thereby.

15 17. In an apparatus for testing clocks, the combination of a source of standard currents, a motor driven thereby, indicating means driven

by said motor, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, means for increasing the frequency of said periodic currents in multiple relationship, light producing means actuated by said currents of increased frequency, said light producing means being so positioned that said light falls on said indicating means, whereby the time of said clock may be compared to the said standard currents.

10 18. In an apparatus for testing clocks, the combination of a source of standard currents, a motor driven thereby, an indicator driven by said motor, means responsive to the periodic sounds of the clock under test for producing a periodic current in time with said sounds, an oscillating circuit under the control of said periodic currents for altering the character of said periodic current, light producing means actuated by said altered current, and positioned so that the light produced thereby illuminates said indicator, whereby the relative frequency of said clock and said standard currents may be determined.

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