Oct. 21, 1952 V. PFEFFER 2,614,383

METHOD AND DEVICE FOR WIRELESS CONTROL OF MASTER CLOCKS

Filed Sept. 3, 1946 3 Sheets-Sheet 1

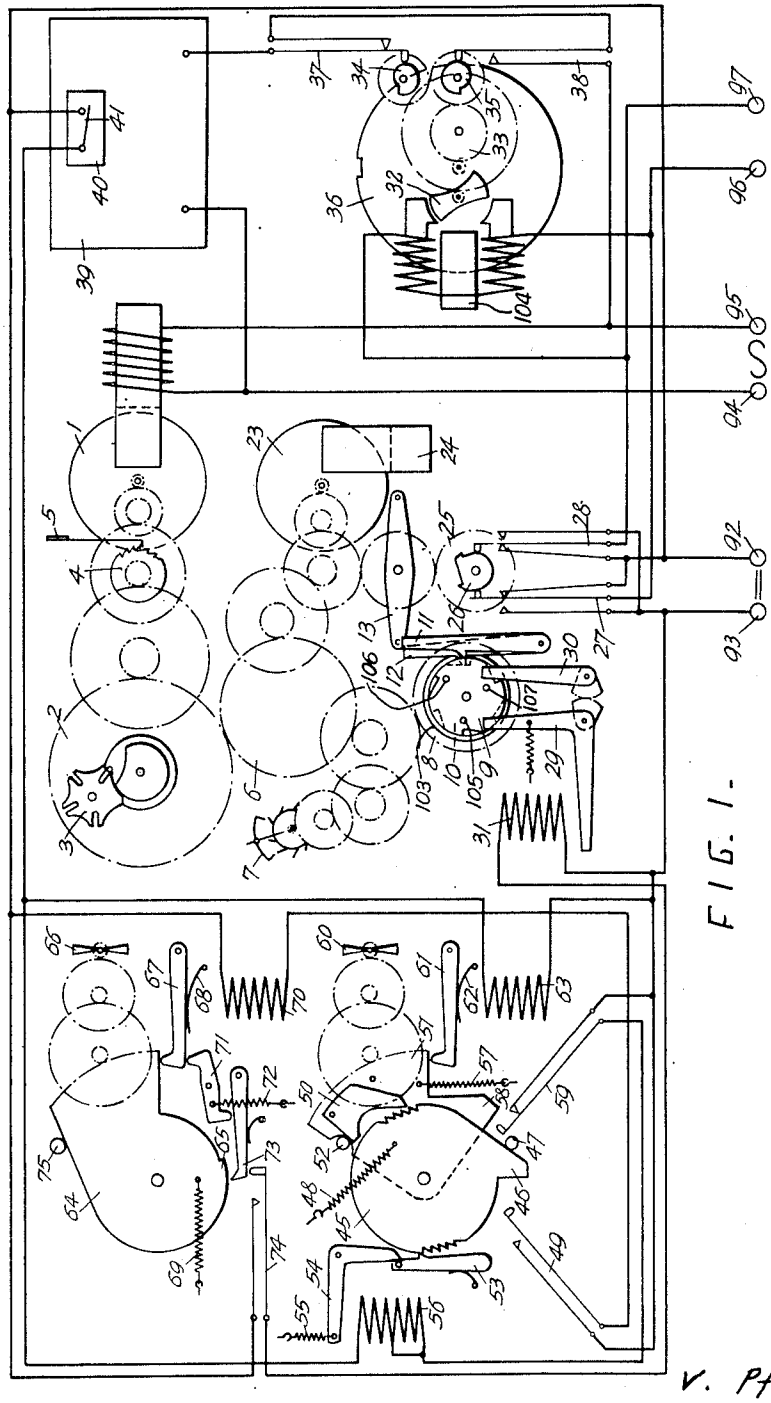

FIG. 1.

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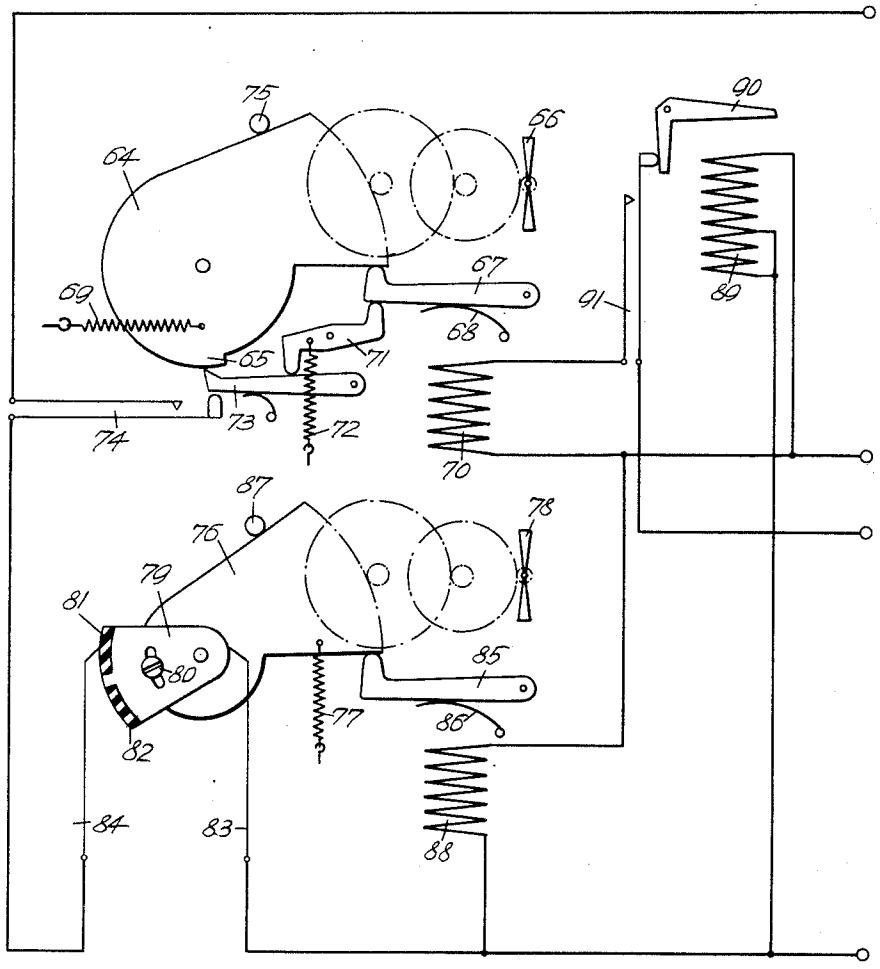

FIG. 2

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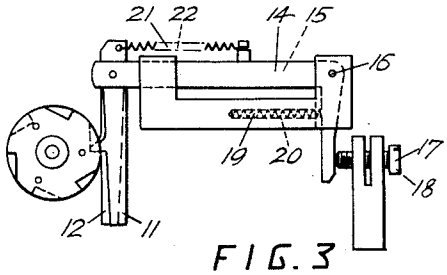

FIG. 3

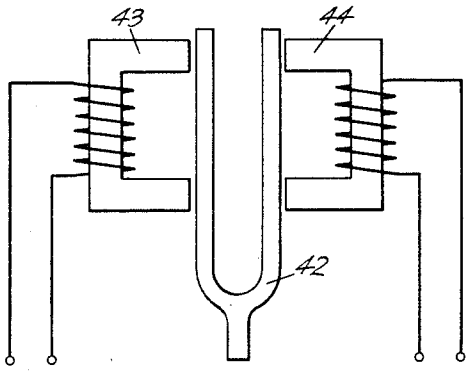

FIG. 4.

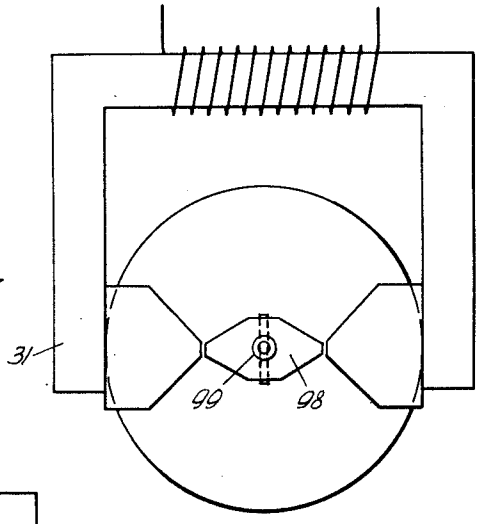

FIG. 5

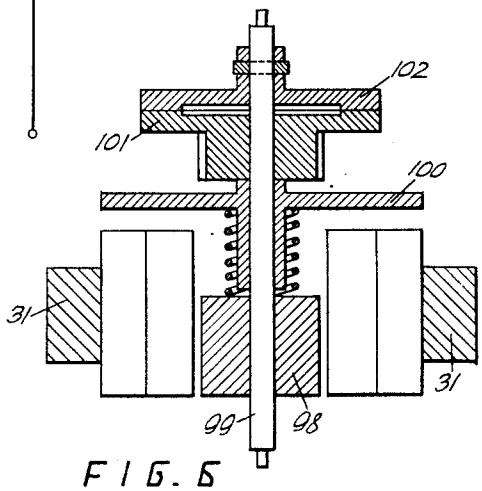

FIG. 6

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UNITED STATES PATENT OFFICE

2,614,383

METHOD AND DEVICE FOR WIRELESS CONTROL OF MASTER CLOCKS

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Application September 3, 1946, Serial No. 694,665
In Czechoslovakia September 27, 1945

2 Claims. (Cl. 58—24)

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The present invention relates to improvements in a method and a device for wireless regulation of a master-clock.

In order to achieve synchronization of time a master-clock is used which controls the emitting of short impulses, repeated at one minute or the like intervals, which controls any desired number of subsidiary clocks.

A system of electrically interconnected clocks is thus formed, giving the same time indication within the range of a master-clock. A master-clock, even if constructed with the utmost care and at great expense, is however not free from deviations, which are even increased by the master-clock being burdened by the controlling emitters of electric impulses to subsidiary clocks; a time difference or deviation from the correct time in a particular clock-system is the inevitable result, which is further increased by the sum of deviations multiplied by their double characteristic, i. e. in one case a positive and in the other a negative deviation. Considering the present state of art in this respect, it is, therefore, possible to speak of time synchronization only locally. In order to remove these drawbacks, and to extend the synchronization of time, clocks controlled by impulses, emitted by wireless have already been devised. Such a device requires a continuous operation of the emitter and receiver and is extremely uneconomic, because of its continuous consumption of electric current and excessive wear of components. Its practical application fails owing to dependence on special emitting stations.

In another design the time synchronization is achieved so that at certain intervals, for instance, one hour intervals, the time deviation of the clockwork is eliminated by omitting a particular wireless impulse characterized by a certain tonal frequency and a predetermined duration. Even this method, which requires a complete separation from the usual broadcasting, does not fulfill the object in view, as even with a perfect selectivity of the filtering means in the output circuit, there remain indispensable tolerances and the strictly limited field detects also tones of both neighbouring frequencies and all harmonic frequencies.

The other supposed safeguard is insufficient with respect to its one-sided limitation of the minimum length of time, leaving open the possibility of an incorrect regulation by any incidental impulse, which has reached or exceeded the predetermined limit, such as for instance an impulse formed by cumulative effect of atmospheric

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disturbances. The lack of reliability is the more serious, if a master-clock is concerned, in which case the influence of an undesirable impulse extends to the entire clock-system so that rectification by the next correct impulse is no longer possible.

According to the invention any foreign influence is reliably eliminated irrespective of whether it occurs by accumulation of atmospheric disturbances or incidental adjacent impulses, the regulation of the master-clock being independent of the emission of a special control-impulse or silence of the emitter. According to the invention the intermittent or occasional control of the master-clock is performed by a system of wireless emitted impulses of a different order and duration. So for instance, the respective member may be adjusted to respond to a suitable time signal. In a practical embodiment, described below, the device according to the invention is adjusted to a time signal, consisting of four short and one longer impulse, with interposed short intervals. The particular impulses which compose such a signal, are detected in every detail or in groups or in their total by the analyzer of the clock; the end of the last impulse of the signal combination, as measured by a pre-adjusted control-member or controller, must coincide with the control member for the sum or total. As the analyser pre-supposes an exact fulfilment of conditions to which it is set, i. e. not only the length and sequence of the assumed impulses, but also the length and sequence of the various intervals, it returns automatically into its initial position, if any one of such conditions is not fulfilled. The transmission of current to the proper control member then does not take place.

By means of the device according to the invention an absolutely reliable remote control of the master clock is achieved and thus it has been possible for the first time to obtain a universal synchronized time indication.

As a source of power for the drive of the master-clock, a spring member is provided with means which allows the winding and unwinding of the spring within the limits of its constant elasticity, preventing at the same time its overwinding. The said member is continuously brought to its fully wound position by means of a suitable gearing from a Ferraris motor and in this way accumulates power in case the electric current supply be temporarily cut off. The spring member drives by means of a gearing on the one hand a clock-work, which through

a suitable gearing, provided with a sliding clutch imparts rotation to a correcting initiator mechanism and on the other hand, to an emitter of impulses serving forth e drive of subsidiary clocks, said emitter being arranged in such a way, that in addition to normal minute-impulses of alternate polarity, it emits also special correction impulses, the current-flow of which corresponds to the polarity of the preceding normal impulse. The velocity of rotation of the said device is suitably adjusted to its purpose and may be controlled by the braking influence of eddy currents. The correcting initiator mechanism co-operates with a control member, which is operated by the above analyser at the time of reception of the expected signal, for instance once in 24 hours, to compensate for the positive or negative time-deviation by advancing the mechanism returning or arresting it, irrespective of the operation of the clock-work.

The wireless receiver of the clock, the output circuit of which is tuned to the tonal frequency of the control-signal or provided with a frequency relay, operates for a short time, for instance four minutes, beginning at about 2 minutes before the desired remote control of the clock. The receiver is operated by an associated subsidiary clock, the adjustable switching operation of which has further the purpose of a control clock.

An example of a preferred embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 represents an overall diagram of the master-clock,

Fig. 2 a simplified modification of the analyzer,

Fig. 3 a detail of the releasing mechanism

Fig. 4 a wiring diagram of a frequency relay, which may be used if desired, and

Figs. 5 and 6 a modified simple embodiment of the control-mechanism, in plan view and side view respectively.

The master-clock consists of a receiving unit, a subsidiary clock modified for switching purposes, an analyzer of the impulse combinations and a specially arranged clock-work.

The clock-work consists of a Ferraris motor, operatively connected through a suitable gearing with a spring member **2**, which is provided with a known device **3** preventing an overwinding of the spring. As a safeguard against unwinding of the tension spring there is provided a suitably located ratchet wheel **4**, co-operating with a spring-loaded pawl **5**. The spring-member imparts rotation to a gear **6**, with which a gearing system engages which drives the clock-work itself and which at the end of the stepped-up gearing is subjected to the escapement **7**. The rate of operation of this mechanism determines the velocity of rotation of a related gear **8**, which is connected by means of a slipping clutch **103** with a correcting initiator-mechanism composed of two rigidly connected discs **9** and **10** and provided with alternately offset cam slots or notches on their circumferences.

The pitch of the notches is regular, so that the notches in the disc **9** are offset through half a pitch with regard to the notches in the disc **10**. The total number of notches in both discs is an even number which is the result of sixty divided by the number of revolutions of the correcting initiator mechanism in one hour. In the given example there are altogether six notches and by the selected ratio of the gearing the correcting initiator mechanism is rotated ten times in an hour. Pawls **11** and **12** are arranged for co-operation with the notches, said pawls being adapted to abut at their extended ends against alternating pins in a two-arm lever **13**, in such a way that a pin projecting in one direction abuts against the pawl **11**, whereas a pin projecting in the other direction abuts against the pawl **12**.

In order to prevent manufacturing inaccuracies of the pawls from influencing the accuracy of the spacing of the notches, the design may be carried out in such a way that the time of their engagement with the respective notch may be adjusted in positive and negative direction.

The practical embodiment is shown in Fig. 3, wherein the pawls **11** and **12** are linked together with two-armed levers **14** and **15**, rotatably mounted on a rigid common axis **16** and biased against set screws **17** and **18**, by the influence of pressure springs **19** and **20**. By tightening or releasing a set screw the arms of the auxiliary levers, and the pawls, which are biased into engagement with the notches by means of springs **21** and **22**, may be rocked until the desired accuracy of their engagement with the respective notches is obtained.

The two-armed lever **13** is actuated by the second gear train from the gear **6** through the intermediary of suitable transmission means, the desired velocity of which is governed by the braking influence of eddy currents, generated by the rotation of a disc **23** between the poles of a permanent magnet **24**. A gear **25** serves to control an emitter of impulses for the drive of a subsidiary clock under the control of the two-armed lever **13**. The said emitter consists of a disc **26** provided with two cams, and rigidly secured to the gear **25**, and of a pair of spring blade switches **27, 28**. The two-cam disc **26** may be mounted on a common axis with the lever **13**.

The correcting initiator co-operates with a control device, consisting of two levers **29, 30**, which are provided with intermeshing segments, mounted on the pivots of the respective levers. The two armed lever **29** is controlled by an electromagnet **31** operating against the influence of a spring.

For controlling the time indications the device is equipped with a subsidiary clock, provided with a polarized magnet system consisting of permanent magnet **104**, and with a rotating armature **32** and an adjustable switch unit, consisting of a gear **33**, rigidly secured to the axis of the minute hand and imparting rotation to a pair of cams **34, 35** and an arresting disc **36** by means of a suitable gearing. The cams together with the arresting disc, co-operate with a pair of spring blade switches **37, 38**.

The described device operates a wireless receiver **39**, the relay **40** of which closes a contact **41** when a tone of expected frequency passes through the output which is tuned by suitable filters. A frequency relay may also be used for this purpose. In such a case the output circuit of the receiver **38** remains normal and an arrangement according to Fig. 4 is used instead of the relay **40**. This arrangement consists of a tuning fork **42**, influenced by an electromagnet **43**, the coil of which is connected with the output of the receiver **39** and further of a permanent magnet **44** provided with a suitable coil. If a current of a frequency corresponding to the resonance of the chosen tuning fork flows through the coil of the electromagnet **43**, the fork is set in vibration and current is induced in a

known way in the coil of the permanent magnet 44.

This current, after suitable amplification, or the current obtained by the closure of contact 41, operates an analyzer of combinations of impulses, said analyzer consisting of two controllers, one of which serves to register short impulses and to bring the other controller into operation which latter registers long impulses or the last impulse of the combination. The first controller consists substantially of a ratchet wheel 45 with a pair of toothed portions and with a cam or projection 46 abutting in operative position against a stop 47 under the influence of a spring 48. Its purpose is to operate the spring blade switches 49. The right hand teeth of the said partial ratchet wheel are adapted to co-operate with a pawl 50 biased into engagement with the teeth by means of a spring and journalled on a segment 51, mounted for swinging movement. The shape of the pawl 50 is such that in in-operative position of the segment its engagement with the teeth of the ratchet wheel is positively prevented by an abutment pin 52. The left hand teeth of the partial ratchet wheel co-operate with a pawl 53 controlled by a two-arm lever 54, pulled by a spring 55 against the bias of the pawl. This two-arm lever co-operates with an electromagnet 56 which when energized attracts the lever, whereas the release of the lever is electrically delayed for a predetermined time interval in a manner known per se. The segment 51 mounted for rotation on a common shaft with the partial ratchet wheel 45, is urged clockwise by a spring 57 and its projection 58 co-operates with a spring blade switch 59. Its movement is braked by wings 60 rotated through a stepped up gearing from the toothed circumference of the segment 51. One member of this gearing is provided with a one-way clutch (not shown), so that the braking influence of the wings 60 is effective only during movement of the segment in the direction of pull of the spring 57, whereas its return movement is carried out quickly by a spring 62, operating a lever 61, if the latter is not attracted by an electromagnet 63.

The other controller consists of a segment 64, mounted for swinging movement and provided with a lug or notch for a pawl, to be described later, and with teeth which impart accelerated movement to braking wings 66, the action of which is controlled by a one-way clutch (not shown) similar to the arrangement of the first controller. Also the lever 67, loaded by a spring 68, operates in a similar way, said lever serving to return or maintain the segment in its initial position against the pulling action of the spring 69, if not influenced by an electromagnet 70. The lever 67 co-operates with a rocking cam 71, loaded by a spring 72 and limiting the movement of a pawl 73, which in this position opens the spring blade contact 74. A pin 75 serves as an abutment for the return movement of the segment 64.

The described device serves for a detailed detection of a time signal and may be replaced by a device for a summary or totalized reception. In such a case an arrangement according to Fig. 2 is used, which also consists of two controllers, the first being initiated by the individual impulses of the control combination, whereas the other registers their total length with the addition of the length of the individual intervals.

The first controller consists of a swingable segment 76, subjected to the pull of a spring 77 and of wings 78 for one-way braking effect similar to those described above. Connected with the segment 76 and insulated against it is a smaller segment 79, which may be secured in its adjusted position by a screw 80. Its partial circumference is provided with two insulating inserts 81, 82 arranged so as to leave a conductive part between them. A pair of brushes 83, 84 is arranged for co-operation with the segment. A lever 85, loaded by a spring 86, if not influenced by the electromagnet 88, maintains in, or returns to, its initial position the swinging segment 76, its initial position being fixed by an abutment pin 87.

The other controller is similar to the one just described for long impulses or the last impulse of the combination, explained in connection with the analyser for a detailed detection of a time signal. A difference resides only in the fact that the controller for registering the total or summary reception in the arrangement according to Fig. 2 is adjusted for other time intervals, so that the oscillations of its segment 64 are more effectively braked. For this reason the wings 66 may be replaced by a more efficient braking arrangement such as braking by eddy currents or the like. The analyzer for the reception of a time signal in the form of a summary (totalized) unit, i. e. the arrangement according to Fig. 2, is completed by a relay 89, the armature 90 of which, co-operating with a spring blade contact 91 is quickly picked up, when the relay is energized by a current flowing therethrough, whereas its dropping off is electrically delayed for a predetermined time interval in a manner known per se.

The device described operates as follows:

The electromagnets of the incorporated subsidiary clock 32, energised in equal, e. g. one minute intervals, rotate in a manner known per se the shaft of the minute hand and the gear 33 rigidly connected therewith. The gear 33 imparts rotating movement through a suitable gearing to two gears, which are rigidly secured to the cams 34, 35 and the arresting disc 36. The ratio of the gearing is such that the cams 34, 35 are rotated through one revolution once in an hour, where as the arresting disc 36 carries out one revolution once in 24 hours. The cam 35 comes therefore to lie with its operative notch against a lug of the spring blade contact 38 every hour similar to the cam 34, which comes into position against the lug of the spring blade 37. While the lug of the switch 37 swings into the notch of the cam 34 during each of its revolutions, the lug of the switch 38 is retained in its open position by the engagement of the periphery of the arresting disc with a lug of the switch and movement of the lug into the cut out portion of the cam 35 to close the switch is permitted only if the notch in the disc 36 is simultaneously positioned against it. By the effect of the chosen ratio this coincidence occurs once in 24 hours. The position of the cam 34 is adjustable and its cut off portion may be set so that the spring blade switch 37 is operated for instance four minutes later than the contact 38. As both contacts are connected in series, it is clear that after the lapse of the predetermined time the circuit closed by the contact 38 is broken by the contact 37. By the arrangement of a plurality of notches in the disc 36 the switch apparatus of the subsidiary clock may turn on the respective circuit in a plurality of exactly limited time sections while the emission of control signals

is performed. It is clear that the turning on and off of both contacts occurs immediately irrespective of the inclination of the cam path.

The wireless receiver 39, connected to the terminals 94, 95 of alternating current by the intermediary of spring blade contacts 37, 38 and operated by the described switch arrangement of the subsidiary clock is adapted to energize the relay 40, when a tone having the frequency of the expected signal passes through the output. By closure of the contact 41 the winding of the electromagnet 63 is connected to a positive terminal 92, the other end of its winding being connected directly with the negative terminal of a direct current supply. The contact 41 energizes an electromagnet 56, connected in parallel with the electromagnet 63, the other end of the winding of the electromagnet 56 being connected with a terminal 93 through the contacts of the spring blade switch 59. The electromagnet 63 attracts the lever 61, so that the released segment 51 is swung under the influence of the spring 57. The pawl 50, freed from the abutting pin 52, swings under the influence of its spring into engagement with a tooth of the partial ratchet wheel 45 entraining the latter in the direction of movement of the segment 51. The velocity of these movements is determined by the braking effect of the wings 60. Simultaneously with the action of the electromagnet 63, the electromagnet 56 attracts the two-arm lever 54, one arm of which releases the pawl 53, which under the action of its spring engages the circumference of the partial ratchet wheel 45.

If the receiver 39 receives the expected signal, the duration of closure of the contact 41 is equal to the duration of the first impulse of the signal combination, i. e. also to the time interval to which the described controller is adjusted. In this case the segment 51 shifts in the manner described above, the partial ratchet wheel through an angle equal to the pitch of the teeth, enlarged by about ⅓. Its purpose fulfilled, the first impulse of the prescribed combination now ends. The contact 41 breaks the circuit. The lever 61 swings off under the influence of the spring 62, returning the segment 51 quickly into its initial position. Under the influence of the abutting pin 52, the pawl 50 swings out of engagement with the teeth of the partial ratchet wheel 45, the latter being retained by the pawl 53 in its position, advanced by one tooth. The circuit of the electromagnet 56 has been disconnected concurrently with that of the electromagnet 63, but its artificially increased remanence does not permit the lever 54 to swing and so to disengage the pawl 53 before the end of the predetermined interval between the individual impulses of the signal combination. Assuming, that the expected signal is detected, the receiver 39 receives the next impulse before the pawl 53, leaves the teeth of the partial ratchet wheel 45 under the influence of the two arm lever 54. The relay 40 causes for the second time the contact 41 to close and the described operation is repeated.

At the end of four short combination impulses including the intervals between them, the partial ratchet wheel 45 has been shifted through four teeth and assumed a position in which the lug or projection 46 lies in close proximity of the lug of the spring blade contact 49. The receiver 39 receives now the last long impulse of the prescribed combination. The controller initiated by the electromagnets by the repeated closure of the contact 41 is thus brought into operation, and the pawl 50 enters the last tooth of the partial ratchet wheel 45. By the first part of its rotation the projection 46 deflects the blade of the spring contact 49 closing thus the latter. Because the last impulse of the combination is a long one and the electromagnet 63 remains operative during its entire duration, the swinging segment 51 continues another moment in its rotating movement until stopped by abutting against the lever 61, which has been attracted by the electromagnet. Its projection 58 deflects hereby the blade of the spring contact 59, opening the latter and breaking thus the circuit of the electromagnet 56. After the lapse of time during which its artificially increased remanence has been active the lever 54 swings under the influence of the spring 55 and its arm disengages the pawl 53 from the teeth of the partial ratchet wheel 45. The described process occurs in the initial part of the duration of the last impulse of the series. From this moment on the partial ratchet wheel 45 is no more dependent on the pawl 53 and being retained in its position only by the pawl 50 in consequence of the swung out position of the segment 51, it returns under the influence of its spring 48 into its inoperative position limited by the abutting pin 47, when the last impulse of the prescribed series ends.

The contacts of the spring switch 49, closed in the described way, connect the coil of the electromagnet 70 with the terminal 93, while the other end of the coil is directly connected with the terminal 92. The electromagnet thus energized attracts the lever 67 which allows the swingable segment 64 to be rotated by its spring 69. The lever 67 rocks the rocking cam 71. The pawl 73 released by the latter and biased by a spring abuts against the circumference of the circular part of the segment 64. The velocity of rotation of this segment is determined by the described braking effect of the wings 66. After the lapse of a predetermined time the segment 64 is rotated with its projection 65 against the pawl 73 which, biased by its spring, moves into engagement, releasing thus the blade of the spring switch 74. The closure of its contact connects the coil of the electromagnet 31 to the terminal 92. The other end of the coil of the electromagnet 31 is connected directly to the terminal 93. In consequence of the adjusted timing of the other controller the electromagnet 31 is energized just before the termination of the last combination impulse.

The segment 64 continues therefore its rotation for another moment, while the electromagnet 31, under co-operation of the respective parts of the arrangement, carries out the actual control of the master-clock.

The end of the long impulse terminates the entire time-signal. By opening the contact 41, the relay 40 opens the circuit of the electromagnet 63 and in a manner described above returns the segment 51 into its initial position. The contacts of the spring switch 59 are closed again but without any influence on the electromagnet 56, as its circuit is broken by the contact 41. The partial ratchet wheel 45, not being retained by the pawl 53, follows under the influence of its spring 48 the return movement of the segment 51 and is stopped in its position of rest by abutting pin 47. The contact of the spring switch 49 is hereby opened, breaking thus the circuit of the electromagnet 70. The lever 67 biased by its

spring swings and the rocking cam 71 swings in opposite direction under the influence of the spring 72. In this way the pawl 73 is disengaged and by opening the contacts of the spring switch 74 the circuit of the electromagnet 31 is broken. The segment 64, the projection 65 of which is now unobstructed, returns quickly into its initial position, limited by the abutting pin 75. The analyzer having fulfilled its operation, is in a position ready to receive a further time signal.

It is clear that if the prescribed length even of a single one of the short impulses is not observed, a regulation of the master-clock does not take place. In this connection it is irrelevant if the deviation in length occurred for instance, by curtailing the duration of the impulse, as in such a case the required movement of the partial ratchet wheel 45 does not take place, the pawl 53 does not enter into engagement, so that the ratchet wheel returns into its preceding position. If the prescribed length of any of the impulses is exceeded, the lug 58 breaks the circuit of the electromagnet 56 so that the engagement of the pawl 53 with the teeth of the partial ratchet wheel 45 is discontinued at an undesired moment. The consequence is the same, the ratchet wheel returns into its original position. The same happens also in the case when any of the intervals between the individual impulses exceeds its predetermined time limit. The safety of this arrangement is further enhanced by the other controller which operates under a condition that the last combination impulse has a definite minimum length.

The described device may be replaced by another analyzer shown in Fig. 2 and detecting the control signal by a totalizing method. This device operates as follows:

The relay 89 and the electromagnet 88 are connected in a circuit, controlled by the contact 41 in Fig. 1. They are therefore energized in dependence on the received signal and operate as follows:

When the lever 85 is attracted by the electromagnet 88, it releases the segment 76 for rotation; the relay 89 is also operated and attracts the armature 90, which closes the contacts of the spring switch 91. The energized electromagnet 70 operates the device described above. The difference resides only in the fact that in the arrangement according to Fig. 2 the adjusted time of swinging movement of the segment 64 equals the total length of the expected time signal with the addition of the length of the intervals between the various impulses whereas the adjusted length in the arrangement according to Fig. 1 is equal only to the length of the last combination impulse.

Assuming that the expected signal is received, an interval occurs after the lapse of time reserved for the first combination impulse. The circuit of the electromagnet 88 is broken, the lever 85, biased by its spring 86, swings and returns the segment 76 to its abutment pin 87 before the segment has reached its operative position. Simultaneously also the circuit of the relay 89 is broken. Its armature 90 remains, however, attracted under the influence of the artificially increased remanence of the relay 89. If the interval does not exceed the predetermined duration of the increased remanence, the second combination impulse arrives before the armature 90 opens the contacts of the spring switch 91 and the continuous movement of the segment 64 is not interfered with. In this way the controller, influenced by the electromagnet 70 summarizes the various impulses and intervals of the prescribed time signal, while in the other controller, which is influenced by the electromagnet 88, the segment 76 returns into its initial position after the termination of each individual impulse. Only during the long final impulse of the signal combination the rotation of the segment 76 brings the latter into operative position, in which the conducting portion of the smaller segment 79 electrically connects the two brushes 83, 84. By suitably adjusting the velocity and relative position of the small segment, the contacts are closed before the termination of the last combination impulse, i. e. in a moment when the segment 64 has swung so far that its lug 65 comes against the pawl 73, which by its engagement closes the contacts of the spring switch 74. In this moment the circuit of the control electromagnet 31 is completed.

It is clear that also the analyzer, operating on an addition (totalizing) basis reliably prevents any undesired adjusting of the master-clock and necessitates for the adjustment of the clock the reception of the prescribed signal which fulfills the predetermined conditions. There remains still the operation of the clock-work to be described.

The spring member 2, continuously tensioned by the Ferraris motor 1, which latter is connected to a source of alternating current by terminals 94, 95, divides its driving energy by means of gear 6 between the clockwork itself and the apparatus for emitting electric impulses to the subsidiary clocks. The correcting initiator, driven by the clockwork, rotates in clockwise direction and co-operates with pawls 11, 12 in such a way that the pawl 11 engages the notches in the disc 9 and the pawl 12 the notches in the disc 10. In consequence of the described spacing of these notches the pawls 11, 12 carry out their rocking movements in equal, e. g. one minute, intervals. If, for instance, the pawl 12 engages a notch in the disc 10, the pawl 11 abuts against the outer circumference of the disc 9 and its projecting end serves as an abutment to one of the pins of the two-armed levers 13. During further rotation of the initiator a notch in the disc 9 comes in register with the pawl 11. By the engagement of the latter the support of the said pin is removed and the two-armed lever 13, which is driven by the spring member 2 through the gear 6 is rotated with a velocity determined by the influence of the braking device, described above. After rotating through 180° its other pin, projecting to the other side, abuts against the extending end of the pawl 12, now out of engagement, so that the two-armed lever 13 is brought to a standstill for such time until the pawl 12 engages the next notch, i. e. for one minute. The described operation of the machine is repeated continuously.

The two-cam disc 26 is rotated by means of a gear 25 in dependence on the two-armed lever 13, the operation of which it follows, so that it carries out half a revolution every minute. During this movement its operates alternatively the pair of spring switches 27, 28 so that within half a revolution it rocks twice in succession the blade of the spring switch 27, leaving the blade of the switch 28 at rest, whereas during the next half rotation the switch 27 is left at rest and the blade of the switch 28 swung

out. The two-cam disc 26 transmits thus to the wire of the subsidiary clocks, connected to the terminals 96, 97, including the subsidiary clock, incorporated in the master-clock device, every minute a special correcting impulse besides the normal driving impulse. This is of particular importance if the subsidiary clock is used together with a device for a continuous synchronisation according to co-pending application Serial No. 648,702 filed February 19, 1946. From the description and wiring diagram as shown it is evident that the current flow of the emitted impulses alternates every minute, the polarity of the correcting impulse corresponding compulsorily to the polarity of the main impulse.

The compensation of the time deviations which may occur is carried out by the control mechanism, operated by the energising of the electromagnet 31, described above, which by attracting one arm of the lever 29 swings out its other arm. Under the influence of the intermeshing segments the lever 30 is simultaneously deflected in opposite direction. The movement of the two levers is similar to the movement of toggles. One of the closed levers engages one of the pins 105, 106 and 107, mounted on the discs 9, 10. If the clockwork is slow, the pin is within the range of the lever 30. As a result of its shifting movement to the central position between the two levers the rotation of the discs 9, 10 is accelerated by an amount, corresponding to their retardation. In this way the notch is brought against the pawl, which in a given moment arrests the movement of the two-armed lever 13. The pawl moves into engagement, the lever 13 rotates through half a revolution and an impulse is transmitted to the wire of the subsidiary clocks, which impulse, without the operation of the control device, would have occurred only after the lapse of such time, by which the clockwork with the exact or true time indication was slow. If the clockwork was fast and the resulting deviation opposite, the pin would be within the range of the lever 29. In this case the lever 29 returns the pin to the central position between the two levers. The two discs 9, 10 are thus rocked against the direction of their rotation, so that the initiation of a new impulse is delayed by a time equal to the said time deviation. Because the discs 9, 10 are provided with six notches, corresponding to six minutes of the time scale and with the three compensation pins 105, 106 and 107, the control of the initiator may take place every other, for instance every even minute.

It is clear from the foregoing description, that the control device, operated by the described mechanism, compensates the positive as well as the negative time deviation only by regulating the initiator, entrained by the said sliding clutch, i. e. irrespective of the operation of the clockwork itself. The sliding clutch causes some braking influence at the moment of compensation and can even bring the clockwork to a standstill. The latter could not then be restarted without an outside impulse. It is, therefore, advisable to use a magnetic clutch, operated by the compensating electromagnets.

An example of such an arrangement is shown in Figs. 5 and 6. The releaser, which consists of the two discs 9, 10 with the three pins 105, 106 and 107, as its mechanical actuating device consisting of the pair of levers 29, 30, are replaced by an armature 98 keyed onto shaft 99 and rotatable between the two poles of the electromagnet 31. On shaft 99 there is also a friction coupling consisting of two plates 101, 102 together with the relieving member 100. The two plates of this coupling are as usual kept in mutual contact by the spring-pressed relieving member. However, as soon as the electromagnet is excited in order to actuate the armature 98, then the relieving member 100 is drawn down against the spring pressure by electromagnet 31 and thus releases the plate coupling even before the movement of the armature is carried out. As a result, the operation of the clock mechanism cannot be affected by the movement of the armature.

What I claim is:

1. A system of clocks including a master clock and a series of subsidiary clocks actuated thereby comprising means for periodic correction by a time signal comprising a combination of impulses transmitted by wireless, wherein a signal of a predetermined frequency is passed over a filter circuit in a receiver as a tone frequency current, and means such as a control device are provided for analyzing the signal received so that only when it consists of the right combination of impulse will the correction means be operated, and wherein said correction means adjusts a releaser of an initiator mechanism for transmitting the actuating impulses from the master to the subsidiary clocks.

2. Clock system according to claim 1, wherein a central device is inserted in the output circuit of the receiver for the wireless transmitted impulses and influenced by the individual impulses of the time signal, said control device having two cooperating parts and on correctly receiving the time signal releasing a coupling between the clockwork of the master clock and the releaser, and effecting the time adjustment by means of an adjusting device for the releaser, which also brings about the adjustment as to time of a contact device for emitting the current impulses to the subsidiary clocks.

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