Jan. 5, 1965 W. KOHLHAGEN 3,163,978

CORDLESS CLOCK OF COMMERCIAL POWER-FREQUENCY SYNCHRONIZED TYPE

Filed Jan. 29, 1962

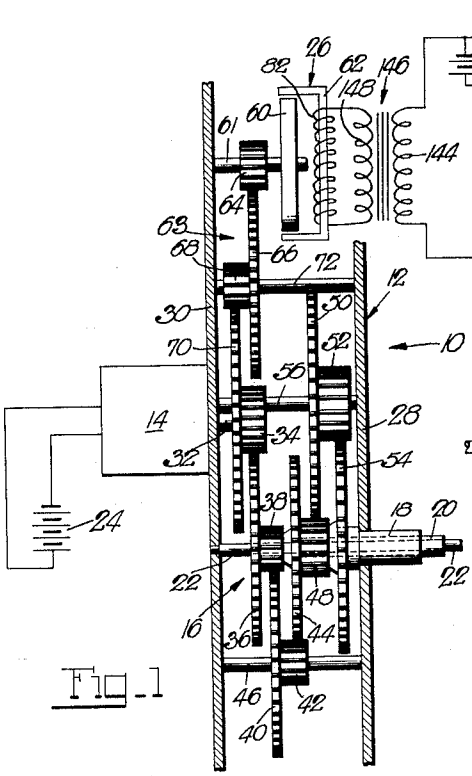


Fig. 1

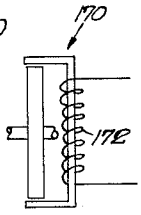


Fig. 2

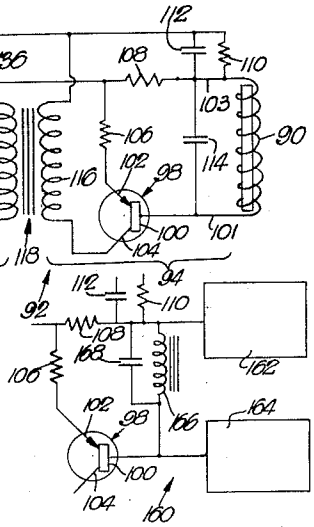


Fig. 3

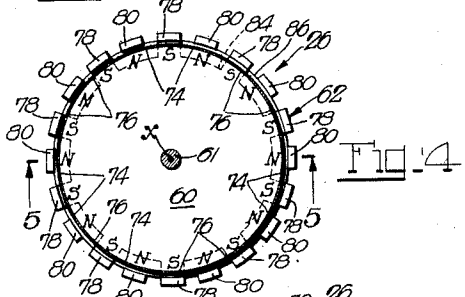


Fig. 4

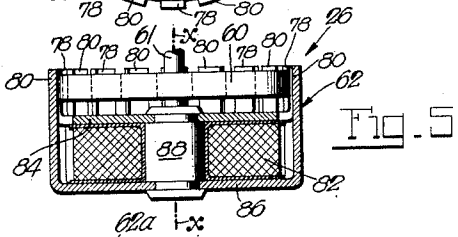


Fig. 5

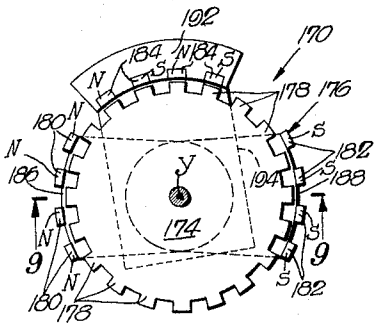


Fig. 8

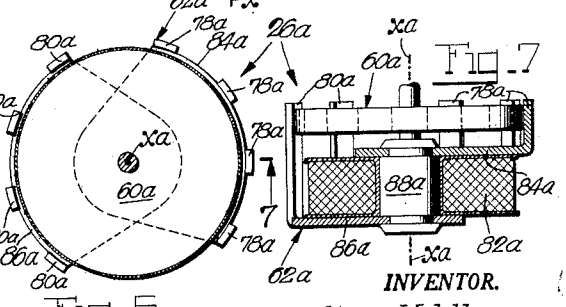


Fig. 6

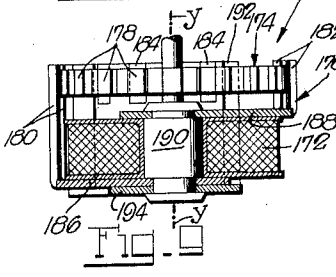


Fig. 9

Fig. 7

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CORDLESS CLOCK OF COMMERCIAL POWER-FREQUENCY SYNCHRONIZED TYPE

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This invention relates to cordless timekeeping devices in general, and to cordless clocks of power-frequency synchronized type in particular.

Clocks of this type are known, and their most distinguishing characteristic is that their operation as well as their synchronization with the commercial frequency of an ordinary alternating current distribution system nearby, such as a household power line, is achieved without any physical connection with the current distribution system. There is thus eliminated in clocks of this type the usual cords and their mostly unsightly extension to the nearest outlets, and the clocks may also be located in places best suited or desired for them without any concern of reaching the nearest outlets with the clock cords. To the end of achieving operation and synchronization of such a clock, it is provided with a commercial frequency pick-up device and an amplifier for amplification of power of ordinary commercial frequency. The pick-up device responds to the electric or magnetic induction field of commercial frequency in the space within or about the clock whenever the latter is within such distances of an energized commercial power line as are commonly involved in ordinary household or other indoor use of the clock, and supplies to the amplifier voltage of the power line frequency for amplification. The voltage thus amplified is supplied to the clock motor for operation of the clock in synchronism with the commercial frequency, with the clock motor being of conventional synchronous type.

While these prior clocks perform quite satisfactorily, the requirement that the amplified voltage must be adequate to run the clocks presents certain drawbacks. Thus, despite the fact that the amplifier circuits of these clocks are kept as simple as possible, being mostly battery-powered transistor amplifiers to that end, the required operating voltage involves nevertheless quite considerable amplification of the voltage supplied by the pick-up devices, which necessarily entails considerable cost. To further meet the requirement of adequate operating voltage from the amplifiers of reasonable simplicity, their pick-up devices must be in a relatively strong induction field in space which may well lack the necessary strength in some desirable locations and thus impose limitations on the clocks in this respect. Further, these clocks require quite accurate and efficient and, hence, relatively costly synchronous motors in order to perform reliably with the available voltage from the amplifiers. All in all, these drawbacks in particular and still others, all springing from the drive of the clocks by the voltage from their amplifiers, have priced these clocks beyond reach of most and also account for the fact that they failed to become a popular item with the public at large.

It is an object of the present invention to provide a cordless clock of this type which is considerably simpler in construction and, hence, of considerably lower cost than prior clocks of this type, yet performs in general at least as reliably as the latter.

It is another object of the present invention to provide a cordless clock of this type which despite its aforementioned simpler construction and lower cost, even in the matter of the amplifier, will perform reliably in an induction field in space within a much wider range of field intensities, including exceedingly weak intensities, than the range of relatively strong field intensities in which the prior clocks will reliably perform.

Another object of the present invention is to provide a cordless clock of this type in which the driving power is derived from any suitable non-synchronous electric or non-electric motor, and preferably from an exceedingly simple D.C. motor that may advantageously be powered from a long-life battery, and the frequency-regulated voltage from an amplifier need merely be applied to brake the motor and permit its runaway in synchronism with the regulated frequency. In so doing, the drive component of the clock is of the utmost simplicity and is incomparably simpler than those of the prior clocks, and the voltage from the amplifier required for the specified purpose is exceedingly small so that the amplifier may have an extremely wide range of effective pick-up and the voltage supplied to the amplifier by the pick-up in even the weakest induction field in the surrounding space requires but a minimum of amplification and, hence, an amplifier of exceeding simplicity and low cost.

It is a further object of the present invention to provide a cordless clock of this type in which the voltage from the amplifier is used to operate a magnetic escapement for the D.C. powered clock drive, with the escapement being advantageously in the general structural form of a synchronous reaction motor with a field and a permanent magnet rotor, but applied as a brake by connecting the rotor with the clock drive and thus making it the runaway member of the escapement, and supplying the voltage of power line frequency from the amplifier to the coil of the fixed field. Thus, the escapement has only one movable part which, moreover, is constantly driven, and the escapement requires for its operation exceedingly small power owing to the fact that it has to overpower but that small part of the output torque of the D.C. motor which is in excess of that required for running the clock, wherefore this synchronous motor type brake may be of optimum structural simplicity and, hence, exceedingly low cost, yet will perform accurately and reliably despite even the widest tolerances in the coordination of the field poles with each other and with the rotor. Furthermore, owing to the very small power required by the escapement for its reliable operation, it is well within the capacity of the escapement to perform reliably at even wide voltage changes in the nearby power distribution system.

Another object of the present invention is to provide a cordless clock of this type the motor-powered drive of which may be synchronized with a synchronous motor type brake that may be operated, alternatively, by a pulsating D.C. output from the amplifier without any need for an output transformer. This is entirely feasible in view of the fact that this brake requires for its operation as little power as the aforementioned brake, and the same is structurally also as simple as the latter, merely requiring in lieu of a permanent-magnet rotor a ferrous rotor with shaped pole teeth and in lieu of a number of field poles of field-flux induced alternating polarities field poles of permanent polarity.

A further object of the present invention is to provide a cordless clock of this type in which the rotor of either of the aforementioned alternative synchronous motor type brakes is preferably connected with the fastest running element of the clock drive through intermediation of speed reduction gearing such that the rotor is the fastest running element of the clock, thereby to keep the power requirement of the brake for its operation particularly low.

It is another object of the present invention to provide a cordless clock of this type in which the rotor of either of the alternative synchronous motor type brakes is connected through speed reduction gearing with the fastest running element of the clock drive as aforementioned, with this fastest element of the clock drive being the shaft

of the drive motor which through other speed reduction gearing is connected with the second fastest running element of the clock drive, namely the sweep-second shaft. With this arrangement, the torque required from the drive motor for running the clock is especially low, and this low torque requirement of the motor is reflected in still lower power requirement of the brake for its operation.

Other objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a view, partly in section and partly diagrammatic, of an exemplary clock embodying the present invention;

FIGS. 2 and 3 are fragmentary diagrammatic views of modified components of the same clock;

FIG. 4 is a view of a prominent operating device of the clock;

FIG. 5 is a section taken on the line 5—5 of FIG. 4;

FIG. 6 is a view of a modified operating device of the clock;

FIG. 7 is a section taken on the line 7—7 of FIG. 6;

FIG. 8 is a view of a further modified operating device of the clock; and

FIG. 9 is a section taken on the line 9—9 of FIG. 8.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 10 designates a timekeeping device which in the present instance is a clock with a movement 12 having a prime mover 14 and a gear train 16 for operating the hour, minute and sweep-second shafts 18, 20 and 22, respectively. The prime mover 14 may be any suitable non-synchronous electric or non-electric motor, and is preferably a simple low-cost D.C. motor powered from any suitable D.C. source, such as the battery 24. Accordingly, since the motor 14 is non-synchronous and of runaway type, the movement 12 includes an escapement 26 to control the drive of the motor 14 for proper timekeeping purposes.

The motor 14 is in this instance carried in back of pillar-spaced movement plates 28 and 30, and the hour, minute and sweep-second shafts 18, 20 and 22 are nested together in conventional manner, with the minute shaft 20 turning on the sweep-second shaft 22 and the hour shaft 18 turning on the minute shaft 20. The shaft 32 of the motor 14 is in this instance drivingly connected with the sweep-second shaft 22 by a first speed-reduction stage of the gear train 16 which comprises a pinion 34 on the motor shaft 32 and a meshing gear 36 on the sweep-second shaft 22 between the plates 28 and 30. Interposed between the sweep-second shaft 22 and minute shaft 20 is a second reduction stage of the gear train 16 for the correct drive of the minute shaft from the sweep-second shaft, this stage comprising pairs of meshing pinions and gears 38, 40 and 42, 44 of which pinion 38 turns with the gear 36 on the sweep-second shaft 22, gear 40 and pinion 42 are fast on a rotary staff 46 between the plates 28 and 30, and gear 44 is carried by the minute shaft 20. Interposed between the minute shaft 20 and hour shaft 18 is still another reduction stage of the gear train 16 for the correct drive of the hour shaft from the minute shaft, this stage comprising two pairs of meshing pinions and gears 48, 50 and 52, 54 of which pinion 48 turns with the gear 44 on the minute shaft 20, gear 50 and pinion 52 are fast on a rotary staff 56 between the plates 28 and 30, and gear 54 is carried by the hour shaft 18.

The escapement 26, which is shown diagrammatically in FIG. 1, is of magnetic type and has a rotor 60 on a shaft 61 and a fixed field structure 62, of which the rotor is drivingly connected with the clock drive, and in this instance with the shaft 32 of the motor 14. Preferably, and for reasons explained hereinafter, the rotor

60 is connected with the motor shaft 32 through reduction gearing 63 comprising two pairs of meshing pinions and gears 64, 66 and 68, 70 of which pinion 64 is carried by the rotor shaft 61, gear 66 and pinion 68 are fast on a rotary staff 72 between the plates 28 and 30, and gear 70 is fast on the motor shaft 32.

In operation of the clock, the motor 14 drives the time shafts 18, 20 and 22 through intermediation of the gear train 16, and the motor 14 also drives the rotor 60 of the escapement 26 which in a manner described hereinafter permits the escape of the motor-driven rotor at the correct rate at which the sweep-second, minute and hour shafts 22, 20 and 18 will be driven at the usual rates of one revolution per minute, one revolution per hour and one revolution per twelve hours, respectively.

The exemplary escapement 26, which is shown in detail in FIGS. 4 and 5, is structurally like a synchronous reaction motor, with the rotor 60 being of permanent-magnet type and having pole faces 74 and 76 of the indicated exemplary permanent polarities, and the field 62 having two sets of field poles 78 and 80, and a field coil 82. The poles 78 are formed on one field plate 84 and the poles 80 are formed on another field plate 86, with both field plates 84 and 86 being connected by a magnetic center core 88 which provides a preferably lubricated bearing (not shown) for the rotor shaft 61. The field coil 82 surrounds the core 88 and is interposed between the field plates 84 and 86 in conventional manner. The field poles 78 and 80 are arranged circularly about the rotor axis x, and successive poles of either set 78 or 80 alternate in this instance with successive field poles of the other set. Also, the field poles 78 and 80 are in this instance equal in number to the pole faces 74 and 76 of the rotor 60. The escapement 26 may be mounted with its field plate 86 on the front movement plate 28 (FIG. 1).

Assuming that the escapement 26 were disconnected from the clock drive, the escapement would on energization of the field coil 82 perform like a synchronous motor. Thus, on supplying the field coil 82 with alternating current, there will be produced in the field poles 78 and 80 instantaneous opposite polarities, respectively, which change with the alternation of the current, and the rotor 60 would step in either direction in phase with the current. In the performance of the escapement 26 as such, the rotor 60 steps in the direction dictated by the clock drive and in phase with the supplied alternating current and, hence, in synchronism with the frequency of the current, but the field 62 acts as a brake on the motor-driven rotor 60 to hold its runaway speed and, hence that of the clock drive in synchronism with the current frequency. To do so, the running torque of the escapement 26, being in this instance brake torque rather than driving torque in its effect on the rotor 60, need merely be in excess of the torque of the rotor 60, and since the motor 14 may readily be of such capacity that its output torque is only reasonably in excess of that required for the clock drive, it stands to reason that the running torque of the escapement may indeed be quite small.

This requirement of low operating torque of the escapement 26 is highly advantageous. Thus, the escapement will perform quite reliably despite even wide tolerances in the coordination of the field poles 78, 80 with each other as well as with the rotor 60, and the rotor may also be of most any low-cost permanent-magnet material. Also, since the drive direction of the rotor is dictated by the clock drive, the present escapment requires no provisions for unidirectional start and drive of its rotor. Accordingly, the escapement readily lends itself to efficient mass production at particularly low cost. Furthermore, due to the required low operating torque of the escapement, the same will perform reliably within an exceedingly wide voltage range, and even at exceedingly low voltages of the applied current, and this assumes particular significance as explained hereinafter.

In the present exemplary clock, the brake torque of the escapement **26** may be particularly low since the rotor **60** is the fastest driven element of the clock, its speed being in the present example stepped up from that of the rotor shaft **32** at the ratio of 50 to 1 by the gearing **63**. Thus, assuming that the frequency of the current supplied to the field coil **82** is 60 cycle, as is usual in the United States, and with the field poles **78** and **80** numbering twenty in this instance (FIG. 4), the rotor **60** will have an escape rate of 180 r.p.m., while the motor shaft **32** will at the aforementioned 50 to 1 ratio have an escape of 3 r.p.m. This entirely practical example serves to demonstrate particularly well that the brake torque of the escapement **26** may be indeed be exceedingly small in order to keep the clock drive in synchronism with the frequency of the current supplied to the field coil **82**. The required brake torque of the escapement **26** for keeping the clock drive in synchronism with the frequency of the current supplied to the field coil **82** is particularly low in the present exemplary clock since the motor **14** is drivingly connected with the sweep-second shaft **22**, not directly but through intermediation of the described first reduction stage **34**, **36** of the gear train **16**, which further reduces the torque requirement of the motor **14** for the drive of the clock. In the present example, the speeds of the motor shaft **32** and sweep-second shaft **22** are at the ratio of 3 to 1 at the aforementioned exemplary synchronous speed of the motor shaft **32** of 3 r.p.m.

In accordance with another important aspect of the present invention, the clock is provided with a commercial frequency pick-up device or field-sensing element and an amplifier for amplification of power of ordinary commercial frequency. The sensing element responds to the induction field of commercial frequency in space within or without the clock whenever the clock is within such distances of a commercial power line as are involved in household or other indoor use of the clock, and supplies to the amplifier for amplification voltage of the power line frequency. The amplified voltage is supplied to the field coil **82** of the escapement **26** for operation of the latter.

The field-sensing element and the amplifier with the field coil **82** in the output stage thereof are shown in a circuit diagram in FIG. 1, it being understood that the amplifier is preferably located in the clockcase (not shown) while the field-sensing element may be located within or without the clockcase. The field-sensing element is, in the present instance, a preferably ferrite-cored pick-up coil **90** which is sensitive to the magnetic induction field established by a nearby power distribution system, such as a commercial power line in a wall, for example, of a room in which the clock is present. As long as the clock with its pick-up coil **90** is in this magnetic induction field, there will be generated in this coil **90** a voltage of the frequency of the power distribution system. This generated voltage is, of course, much too small for operation of the escapement **26** despite its exceedingly low operating torque requirements, wherefore this voltage, or current, is amplified in the amplifier **92** which in the present instance is of battery-powered transistor type and has two amplifier stages **94** and **96**. The current of commercial frequency generated in the coil **90** is thus amplified by the first amplifier stage **94**, which comprises a transistor **98** with the base **100**, emitter **102** and collector **104**, the bias resistors **106**, **108** and **110**, a bypass condenser **112** and a fixed turning condenser **114**. The current generated in the coil **90** is applied between the base **100** and emitter **102** of the transistor **98** by leads **101** and **103**, and the transistor amplifies this current, with the amplified output from the collector **104** thereof being applied to the primary coil **116** of an interstage coupling transformer **118**. For the amplification of the generated current, the battery **120** supplies the necessary currents and voltages, and the resistors **106**, **108** and **110** establish the proper bias voltages at the base **100** and emitter **102** of the transistor **98**, while the bypass condenser **112** applies the generated current to the emitter **102** of the transistor **98**. The amplified current of commercial frequency induced in the secondary coil **122** of the interstage coupling transformer **118** is further amplified in the second amplifier stage **96**, which in this instance comprises a transistor **124** with a base **126**, emitter **128** and collector **130**, the bias resistors **132**, **134** and **136**, and a bypass condenser **138**. The current induced in the secondary coil **122** of transformer **118** is applied between the base **126** and emitter **128** of the transistor **124** by leads **140** and **142**, with the amplified output from the collector **130** being applied to the primary coil **144** of an output transformer **146**. For the current amplification in this second stage **96**, the resistors **132**, **134**, **136** and the bypass condensor **138** perform the same functions as their respective counterparts **106**, **108**, **110** and **112** of the first amplifier stage **94**. The further amplified current of commercial frequency induced in the secondary coil **148** of the output condenser **146** is supplied to the field coil **82** of the escapement **26**.

The described exemplary amplifier **92** may be entirely conventional, and any other suitable amplifier may be used in lieu thereof. However, regardless of the type of amplifier that may be used, the same may be simple and, hence, of very low cost, with the required overall amplification of the current generated in the pick-up coil **90** being relatively low for operation of the escapement **26**. Thus, the present exemplary two amplifier stages will in most cases be more than adequate for supplying the field coil **82** with the requisite current for the reliable operation of the escapement **26**, this in view of the fact that the escapement requires exceedingly low power for its operation, as explained. Also, in view of the exceedingly low power requirement of the escapement **26** for its reliable operation, the amplifier will supply to the field coil **82** adequate current for the purpose even if the signal received by the pick-up coil **90** from the surrounding induction field should be exceedingly weak, and even much weaker than the signal of minimum intensity which on even higher amplification in prior clocks would barely be adequate for operating their synchronous drive motors. Accordingly, the present clock will perform reliably in an induction field of most any strength, including the lowest, wherefore the clock will perform at most any distance from the nearest power distribution system, including distances at which the prior clocks would not perform. The pick-up range of the sensing element is thus extremely wide. Also, in view of the low power requirement, and hence also low current requirement, of the escapement **26** for its operation, the same will perform at most any voltage changes in the power distribution system, including the lowest voltages at which the prior clocks would fail to operate.

The strength of the magnetic induction field surrounding the pick-up coil **90** is determined by the magnitude of the load current in the near by power distribution system, and if no current is caused to flow in the distribution system the field will disappear and the clock will fail in consequence. However, today's numerous electrical appliances in household and other indoor use would most likely cause a load current to be constantly drawn through the power distribution system in the magnetic induction field of which the clock would be placed so that the clock would never fail. In this connection, the low current requirement of the escapement **26** is also particularly advantageous because the amplifier would respond to even the weakest signal from the induction field and supply adequate operating current to the field coil **82** of the escapement.

Further in view of the low power requirement of the escapement **26**, the number of its field poles may be less than the number of pole faces of its rotor, or vice

versa, and the escapement may structurally be further simplified. Such a simplified escapement is shown at 26*a* in FIGS. 6 and 7, the same having a rotor 60*a* which in this instance is identical with the rotor 60 of FIGS. 4 and 5, but the field 62*a* is different and simplified. Thus, the field plates 84*a* and 86*a* have only a few, presently four, field poles 78*a* and 80*a*, respectively, which are arranged on opposite sides of the rotor axis *xa*. With the field coil 82*a* surrounding the center core 88*a* and being interposed between the field plates 84*a* and 86*a*, the field poles 78*a* and 80*a* will, on energization of the field coil 82*a*, have instantaneous opposite polarities, respectively, which change with the alternation of the current supplied to the field coil, with the rotor 60*a* stepping in synchronism with the frequency of this current. Thus, while the present escapement 26*a* is structurally simpler and necessarily produces less power than the escapement 26 of FIGS. 4 and 5, its power output is nevertheless quite adequate for synchronization of the clock drive with the frequency of a nearby power distribution system.

Reference is now had to FIG. 3 which shows a capacitive pick-up device 160 for the amplifier of FIG. 1. This capacitive pick-up device is sensitive to the surrounding electric field produced by the nearby power distribution system, with the advantage that the strength of the signal received by the pick-up device does not vary with varying amounts of load current in the nearby power distribution system since the electric field will be substantially unaffected by such varying amounts of load current. The capacitive pick-up device 160 comprises in this instance two plates 162 and 164 and a parallel tuned circuit comprised of a coil 166 and a condenser 168 which is tuned to the frequency of the nearby power distribution system, with the pick-up device being connected with the exemplary amplifier of FIG. 1 as indicated by like referenced components thereof in FIG. 3.

The clock of FIG. 1 may also be controlled by a magnetic escapement 170 (FIG. 2) which is operated by pulsating D.C. current, with the current pulsating at the frequency of a nearby power distribution system. To this end, the amplifier 92 of FIG. 1 may be used with the magnetic pick-up device 90 or the capacitive pick-up device 160 of FIG. 3, with the amplifier being modified, however, so that the final transistor amplification stage thereof is operated as a class B amplifier. To this end, there is substituted for the output transformer 146 and field coil 82 in FIG. 1 an output coil 172 which is the field coil of the escapement 170 (FIG. 2).

The escapement 170 may be of the exemplary form shown in FIGS. 8 and 9, comprising a rotor 174 and a field structure 176 with the field coil 172. The rotor 174 is of ferrous material and has shaped pole teeth 178 which in this instance number twenty, the same as the pole faces of the described permanent-magnet rotor 60 of FIG. 4. The field structure 176 has two sets of field poles 180 and 182 of flux-induced polarities and a set of field poles 184 of permanent polarities, of which the poles 180 and 182 are formed by field plates 186 and 188, respectively, that are connected by a magnetic center core 190. The field poles 180 and 182 are only a few in number, in this instance four each, and they are arranged on opposite sides of the rotor axis *y* and in this instance spaced at the pitch of the rotor teeth 178. The field poles 180 and 182 are further arranged so that all may simultaneously be in alignment with adjacent rotor teeth 178. The field poles 184 of permanent polarities are permanent magnets in a magnetic member 192 on a non-magnetic plate 194 that may suitably be secured to the field plate 186. The field poles 184 are fewer in number than the combined field poles 180 and 182, and number four in this instance, and they are spaced apart at the pitch of the rotor teeth 178. Furthermore, the field poles 184 are arranged so as to be in alignment with adjacent rotor teeth 178 when the other field poles 180 and 182 are out of alignment with adjacent rotor teeth (FIG. 8).

In operation of the escapement 170, the rotor 174 is driven by the clock drive and its runaway speed is in synchronism with the frequency of the nearby power distribution system. To this end, the rotor 174 steps with its teeth 178 alternately into alignment with the field poles 180, 182 and with the field poles 184. In this connection, the pulsating D.C. current in the field coil 172 will produce always the same polarities in the field poles 180 and 182, with those of the field poles 180 being opposite to those of the other field poles 182 in the exemplary manner indicated. Thus, assuming the drive direction of the rotor 174 to be clockwise in FIG. 8 and the permanent polarities of the field poles 184 to be as indicated, the rotor 174 has just been permitted to escape with its teeth 178 into alignment and, hence, magnetic coupling relation with the field poles 184 which restrain the rotor against further clockwise drive until the next pulse in the field coil 172 produces the indicated polarities in the field poles 180 and 182. When this occurs, the field poles 180 and 182 combine to force the rotor 174 with its teeth 178 clockwise from alignment with the field poles 184 and to restrain further clockwise escape of the rotor when the very next rotor teeth align with the field poles 180 and 182. As the pulse in the field coil 172 disappears, the field poles are momentarily without effective polarity and the rotor will be permitted to escape clockwise until its teeth next align with the field poles 184 of permanent polarity. The rotor 174 thus steps with its teeth 178 alternately into alignment with the field poles 180, 182 and with the field poles 184 in synchronism with the frequency of the pulsating D.C. current from the amplifier and, hence, in synchronism with the frequency of the nearby power distribution system.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

What is claimed is:

1. In a clock, the combination with a movement, of a non-synchronous motor connected with said movement for operating the same, but at excessive speed; and a device for synchronizing said motor with the frequency of a power distribution system nearby without electrical circuit connection therewith, said device comprising an escapement having a permanent-magnet rotor with pole faces and an associated multi-polar field with a coil in flux-inducing relation therewith, of which said rotor is drivingly connected with said motor, and power amplifying means and associated field sensing means for amplifying electromotive force of the frequency of and produced by said distribution means and picked up from the field in space by said sensing means in said field, with said coil being supplied with said amplified electromotive force, and said escapement acting as a self-energized generator and exerting a braking force which is the product of the permanent and induced magnetic forces in the escapement, thereby requiring minimum power amplification.

2. The combination in a clock as set forth in claim 1, in which said field has two sets of field poles arranged circularly about said rotor of which successive poles of either set alternate with successive poles of the other set, said coil produces in said pole sets opposite polarities, respectively, changing with the alternation of said amplified electromotive force, and said rotor poles and field poles cooperate to keep the motor-drive of said rotor in synchronism with the frequency of said amplified electromotive force.

3. The combination in a clock as set forth in claim 1, in which said field has two sets of field poles arranged

circularly about said rotor of which the poles of each set are successive with each other, said coil produces in said pole sets opposite polarities, respectively, changing with the alternation of said amplified electromotive force, and said rotor poles and field poles cooperate to keep the motor-drive of said rotor in synchronism with the frequency of said amplified electromotive force.

4. The combination in a clock as set forth in claim 1, which further comprises reduction gearing for driving said rotor from said motor at a speed which is a multiple of the motor speed.

5. The combination in a clock as set forth in claim 1, in which said movement includes a sweep-second shaft, and there is further provided reduction gearing for driving said rotor from said motor at a speed which is a multiple of the motor speed, and other reduction gearing between said motor and shaft for the drive of said shaft at a fraction of the motor speed.

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