

July 8, 1941.

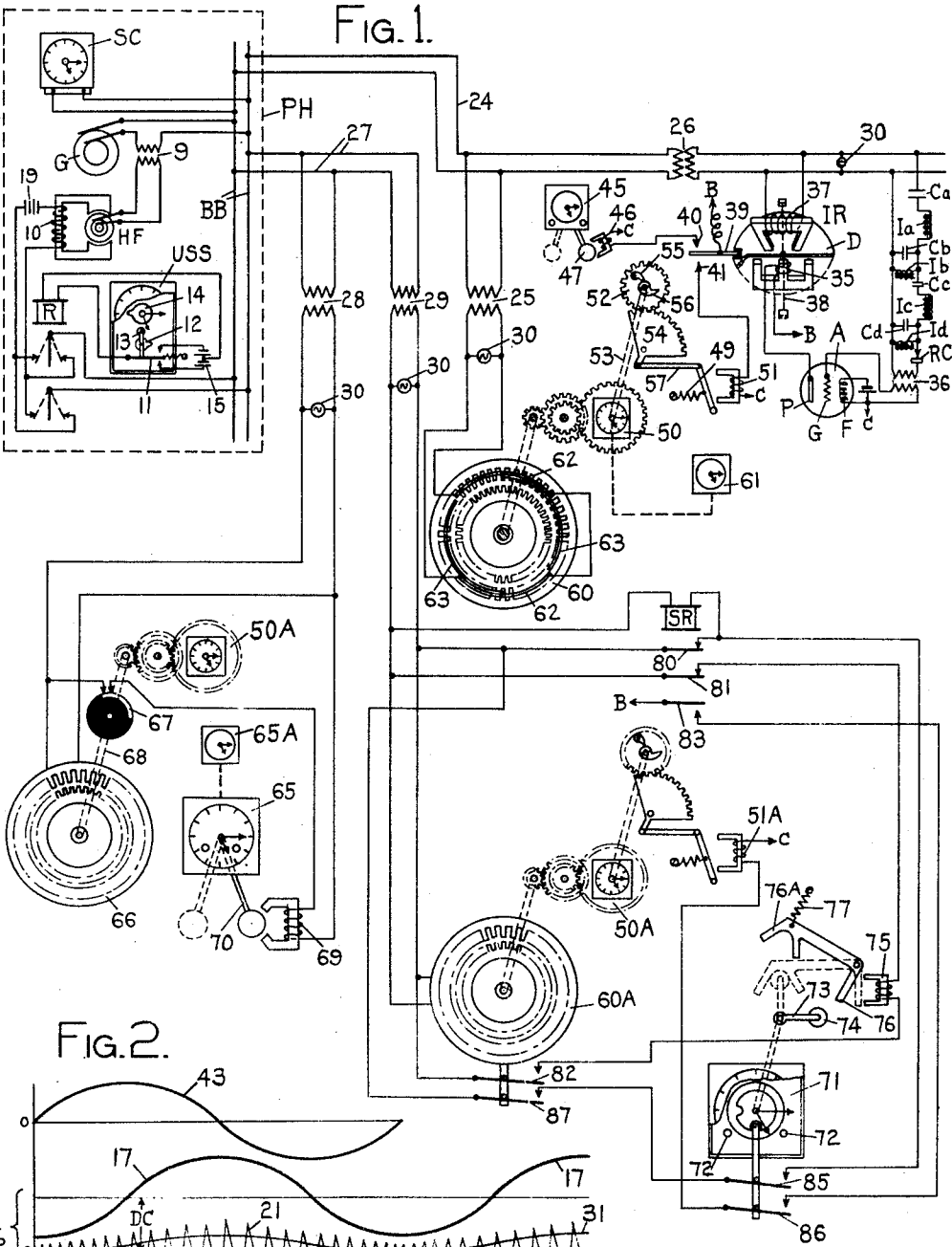
O. H. DICKE

2,248,164

MEANS FOR TRANSMITTING TIME SIGNALS

Filed May 23, 1929

3 Sheets-Sheet 1



July 8, 1941.

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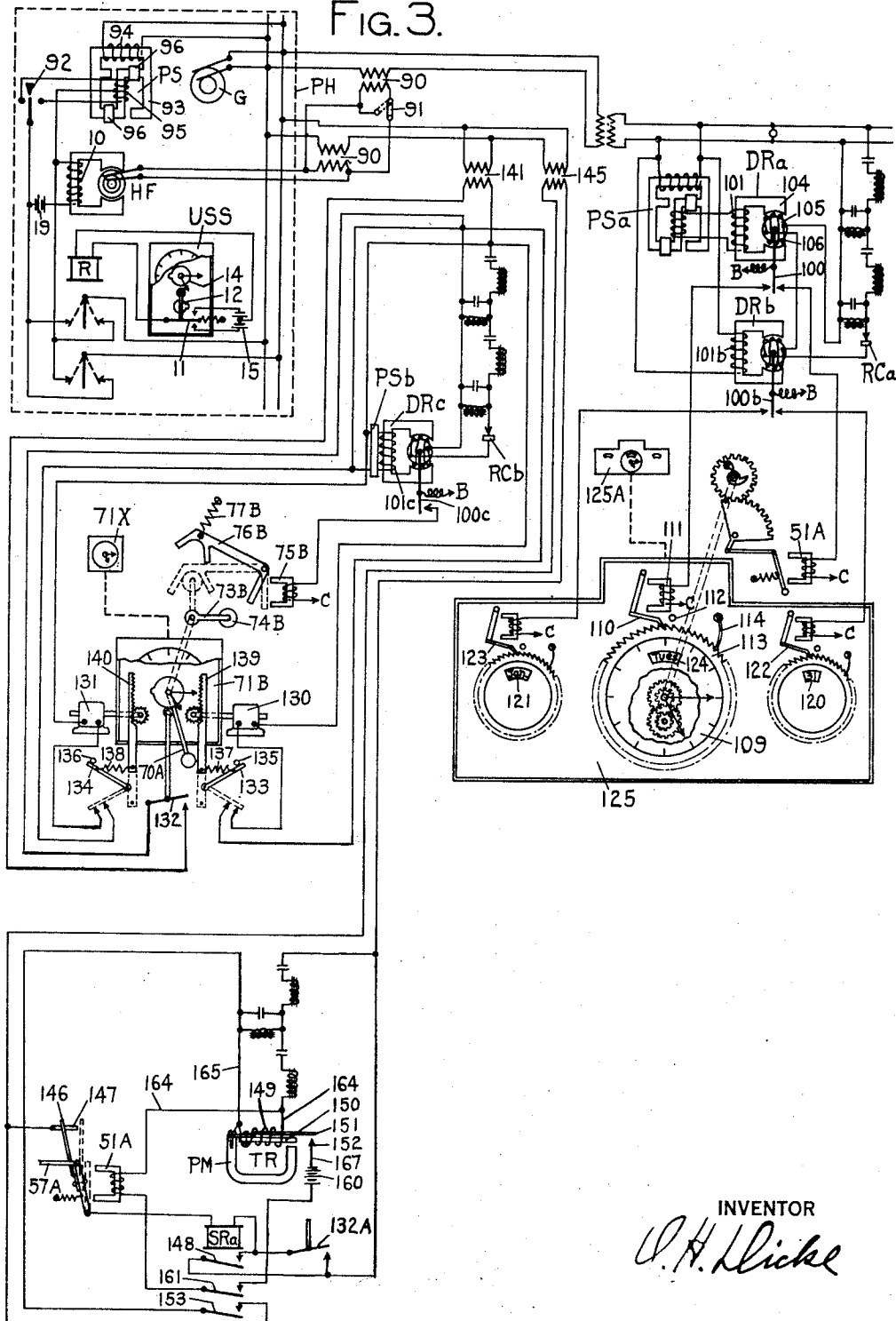
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FIG. 3.



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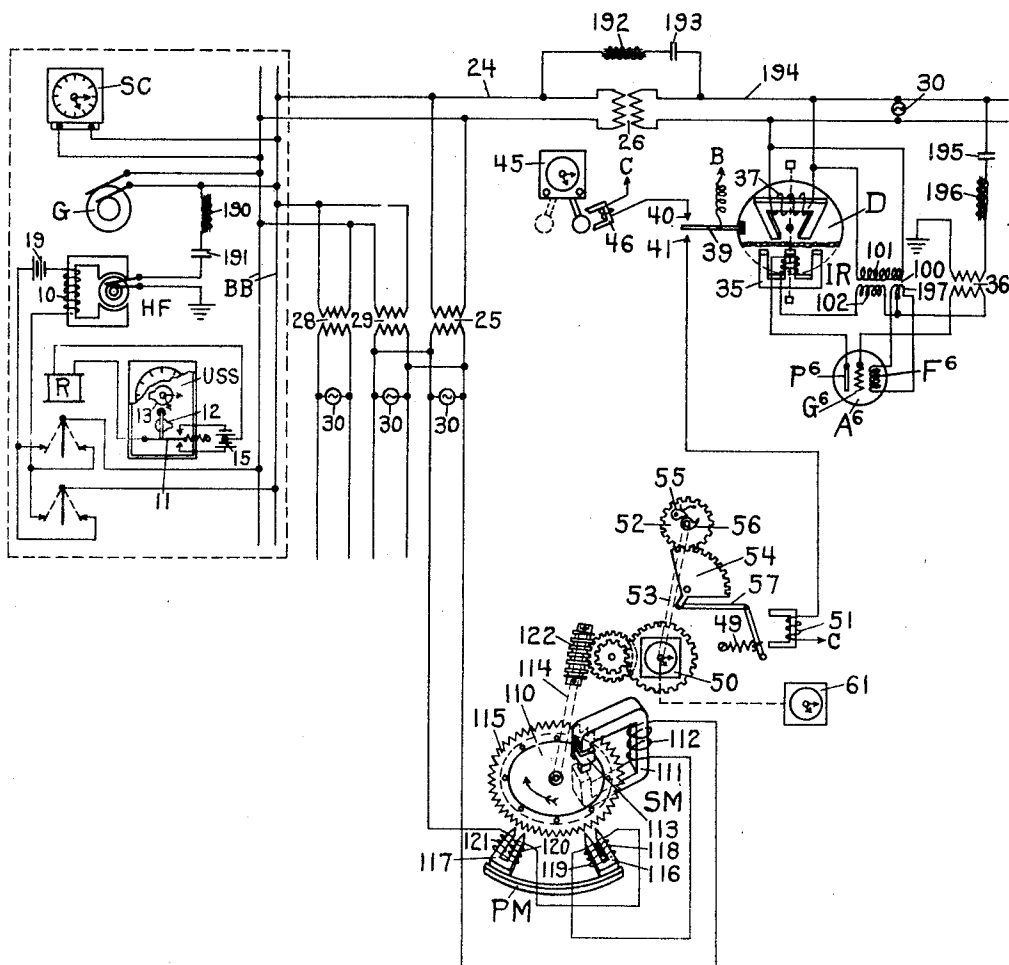
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FIG. 4.



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MEANS FOR TRANSMITTING TIME SIGNALS

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Application May 23, 1929, Serial No. 365,584

27 Claims. (Cl. 58—35)

This application is a continuation in part of my co-pending application Ser. No. 158,370 filed Dec. 31st, 1926, now abandoned.

This invention relates to means for transmitting information over power circuits, and more particularly to the transmission of time signals over an electric light and power distribution system.

If it is attempted to transmit distinctive impulses, that is, impulses of distinctive frequency higher than the light and power frequency over the distribution network of an alternative current power system it is experienced that the voltage of the distinctive frequency must be very low in order to avoid a prohibitive load to be drawn off of the generator generating such distinctive frequency. In accordance with the present invention it is proposed to accomplish the desired results by deriving part of the power for manifesting the reception of the impulse directly from the light and power source, that is, by causing the distinctive frequency and the power frequency to coact to manifest the transmission of the distinctive frequency impulse. More specifically, it is proposed to modulate the distinctive frequency at a rate corresponding to the frequency of the light and electric power source, filter out the distinctive frequency at the point or points where it is to be used, rectify such distinctive frequency current so as to obtain a modified current of the light and power frequency, to apply the modulated current to one element of a two element relay the other element of which is energized by current derived directly from the light and power net work. The direction of torque developed in the relay depends of course on the construction of the relay and the phase relation existing between the light and power current and the rectified modulated current.

Other objects of the present invention reside in the provision of means whereby the number of cycles per hour of power current generated may be kept constant and by the provision of synchronous motor clock means for indicating time at the power consumer, the provision of means for setting a mechanical escapement clock by the synchronous motor clock, and for setting the synchronous motor clock by the mechanical escapement clock in case of power failure since the last previous setting.

Another object of the present invention resides in the provision of an impulse or step-by-step clock in which the clock hands are driven by suitable impulse operated step-by-step mechanism controlled by distinctive frequency impulses.

The provision of clock setting means controlled by distinctive impulses impressed upon the power system for setting such synchronous motor clocks, such mechanical escapement clocks and such step-by-step impulse clocks.

Another object of the present invention resides in the provision of electrically operated governing means for controlling the escapement mechanism of a mechanical clock; the provision of automatic power operated winding means for the mechanical escapement clocks, and automatic energy saving means which cuts out the clock setting means except for a short period of time before and after the even hour; the provision of an automatically operated calendar for indicating the days of the month and the months of the year; and the provision of an undamped tuned reed electro-responsive means responsive to distinctive frequency impulses of small magnitude for setting such clocks.

Other objects, purposes and characteristics of the present invention will in part be obvious from the accompanying drawings and in part appear from the following detailed description.

In describing the invention in detail reference will be made to the accompanying drawings in which:

Fig. 1 shows a power house equipped with a time transmitting mechanism embodying the present invention showing only two of a large number of power feeders having time indicating and setting mechanism operated therefrom;

Fig. 2 shows graphically the time phase relation of the various voltages generated and used in carrying out the invention shown in Fig. 1;

Fig. 3 shows a modified form of power system in which four distinctive controls may be transmitted over the light and power net work without interfering with the proper transmission of current for power for lighting purposes; and

Fig. 4 shows a modified form of the invention in which the special or high frequency is applied between the network and ground.

Referring particularly to Fig. 1 the dotted rectangle P. H. represents a power house having one or more direct or alternating current generators of which the generator G, assumed to be a sixty cycle alternating current generator, only has been shown. This generator is connected to the power house bus bars BB through suitable switch means (not shown). In accordance with one form of the present invention it is proposed to indicate the time of day, at the various consumer residents, offices or factories, by driving clock hands by a synchronous motor of the usual or special

construction, these clock hands only indicating the proper time if the power house equipment generates the requisite number of cycles per hour, and for this reason the power house is furnished with a synchronous motor driven clock SC and a standard clock USS indicating United States observatory time, and the power house attendant is required to keep his frequency such that the synchronous clock SC indicates the same time as the standard clock.

In addition to furnishing light and power current which may be direct or alternating current, but is assumed to be sixty cycle alternating current, it is proposed to impress or superimpose upon such a sixty cycle current a current of high frequency, which may or may not be modulated by any suitable means, but in accordance with certain forms of the invention shown is modulated or interrupted to give half the number of waves as that of the lighting frequency current, and power frequency, that is, there is one modulation per cycle of power frequency, so that if this high frequency is filtered out at the consumer location and is rectified, the rectified component will be the same frequency as the light and power frequency. It therefore appears that if the phase relation of the modulation is properly chosen at least four distinctive indications can be given. This is accomplished by causing the modulating current to either lead or lag by substantially 90 electrical degrees, or by placing such modulations either in time phase or in time phase opposition with the light or power current, these distinctive indications being obtainable by applying the rectified current and the light and power current to the two elements of a dynamometer and induction type relay, respectively.

In Fig. 1 of the drawings, means has been shown for generating high frequency current of say from 300 to 1500 cycles modulated so as to result in two different and distinctive kinds of current only. This high frequency generator HF is connected across the primary of a current transformer 9 and has its field winding 10 at times energized by pulsating current derived by connecting the source of light and power frequency current and a source of direct current in series. In the particular arrangement shown the relay R is energized automatically in one direction once per second and is energized in the opposite direction exactly at the end of each hour. As conventionally shown the contact 11 controlled by the standard clock USS is momentarily raised every second by the cam portion of the second wheel 12 acting on the roller 13 and is momentarily depressed at the end of each hour by the cam portion of the wheel 14 acting on the roller 13. The contact 11 if raised applies current of one polarity from the battery 15 to the polar relay R causing this relay to assume one dotted position, and if depressed applies current to this relay R of the opposite polarity to cause it to assume the opposite dotted position.

With the relay R energized to the right, say by reason of the contact 11 being in the raised position, a pulsating field current will flow in the field winding 10 of the high frequency generator HF which by reason of the high self induction of the field winding will lag the voltage of the light and power potential by substantially 90 degrees as shown by the curves 18 and 43 in Fig. 2. These currents are pulsating as distinguished from alternating by reason of the battery 19 connected in series therewith, this direct current being indicated by the line DC in Fig. 2. This battery 19

is used so as to make the modulations of the high frequency the same per second as are the number of cycles of the light and power current per second as indicated by the high frequency voltage curves 21 and 22 shown. Had the battery 19 been omitted there would have been two waves or modulations for each cycle of light and power current which is not desired for reasons which will be apparent from the following description.

To one of the lighting feeders, namely feeders 24, are connected a plurality of lighting transformers which reduce the voltage from the distribution potential, of say 2200 volts, to a voltage suitable for consumer's use, say 110 volts. Of these transformers the transformers 25 and 26 only have been shown. The feeder 27 has transformers 28 and 29 connected thereto. To illustrate a lighting load for which this distributing net work is primarily used the lamps 30 have been shown. The distribution load may include some motor load which has for convenience not been shown.

In order to take advantage of the phase relation of the modulations of the high frequency waves 21 and 22 to that of the lighting frequency, this high frequency is separated or filtered from the lighting frequency current, and is then rectified. Although any suitable mechanism or expedient may be resorted to for filtering out this high frequency, four sets of resonated units Ca—Ia, Cb—Ib, Cc—Ic, and Cd—Id have been shown. Of these units the devices Ca, Cb, Cc and Cd are condensers of the proper capacities, and the devices Ia, Ib, Ic and Id each comprise an inductance consisting of a core of magnetic material, which may be either closed or contain an air-gap, having a winding thereon. Of these resonated units the units Ca—Ia and Cc—Ic are resonated to current resonance for the superimposed high frequency, and the units Cb—Ib and Cd—Id are resonated to potential resonance for this high frequency and very effectively restrict the flow of this high frequency current. By this arrangement the high frequency can easily reach the rectifier RC and the light and power frequency will not readily flow through the units Ca—Ia and Cc—Ic and that small amount of current that will find its way through these units will find an easy path back to the other wires of the feeder through the units Cb—Ib and Cd—Id. On the other hand the units Cb—Id will act almost as a perfect insulator to the high frequency current. If desired the units Cc—Ic and Cd—Id may be omitted. Also if desired the inductance Ib may be connected in series with the condenser Cb instead of in multiple in which event the unit Cb—Ib will be turned to current resonance for the light and power frequency.

This high frequency current when rectified will take the form of a pulsating current of light and power frequency which will either lead or lag the light and power frequency by substantially 90° as indicated by the curves 32 and 31 respectively. This current may be directly applied to the winding 35 of the induction type relay IR or may be supplied thereto through the medium of a transformer, but in the arrangement shown is applied to the primary winding of the transformer 36, the secondary winding of which is connected in the grid circuit of an amplifying tube A of the thermionic or vacuum tube type, commonly known as an audion, and having a plate P, a filament F and a grid G. This amplifier, in the arrangement shown, has the coil 35 of the induction relay IR

connected in the plate circuit thereof, this circuit deriving its energy from a suitable battery having terminals B and C. The other winding 37 of the induction relay IR is preferably connected directly across the light circuit mains, as shown. The phase relation of the current flow in these windings may be adjusted by suitable compensating means. The fluxes produced by the currents flowing in the coils 35 and 37, which by reason of proper construction of the various devices are preferably displaced substantially 90 electrical degrees, that is, the rectified current as indicated by the curve 31 lags the light and power current graphically illustrated at 43. These fluxes produce eddy currents in the disc D of this relay which eddy currents act upon these fluxes to produce a torque in the disc about its supporting spindle 38 in a direction depending upon whether the current in coil 35 leads or lags the current in coil 37. In any event the various connections are so made that the contact 39 engages the contact 40 once every second due to lifting of the contact 11 of the standard clock USS, and the contact 39 engages the contact 41 at the end of each hour due to the depression of the contact 11 at the end of each hour. The clock 45 conventionally represents a clock of the mechanical escapement pendulum type, and preferably is one that is designed to beat half seconds, that is, swing to the right once per second.

It is well understood by those skilled in the art of chronometric instruments, that a clock of the mechanical escapement type whether of the balance wheel or pendulum type, can not possibly keep perfect time, and in accordance with the invention illustrated in connection with the clock 45 of Fig. 1, it is proposed to electro-magnetically synchronize the movement of the pendulum of the clock 45 with the repeated lifting of the contact 11 of the standard clock by the magnetic flux of the electro-magnet 46 acting on the soft iron weight 47 of the pendulum of the clock. By this arrangement the pendulum of clock 45 will beat in time phase with the flux emitted by magnet 46 due to the current flowing from the terminal B of a suitable source of current through contacts 39-40, winding of electro-magnet 46 to the terminal C connected to the other side of said source of current intermittently at second intervals. In the event of power failure for a short time the clock 45 will operate without the superimposed synchronous control and will therefore have the unpreventable error of this pendulum clock injected only during the time of electric power failure. If the mechanical clock which is to have synchronized control superimposed thereon is a balance wheel clock the electro-magnetic action will act on the escapement in a similar way.

Let us now observe how the hourly setting of the clock 50 by downward movement of the contact 11 is accomplished. Depression of the contact 11 causes the rectified current as indicated by curve 32 to lead instead of lag the power current as shown by the curve 43 in Fig. 2, and will cause the contact 39 to engage the stationary contact 41 thus energizing the electro-magnet 51 at the end of every hour. This energization of the magnet 51 causes pinion 52 to be rotated almost one complete revolution through the medium of gear sector 54 and link 57 against the action of spring 49. This pinion 52 is loose on the shaft 53 driving the minute hand, and its rotation in the clockwise direction causes dog

55 to engage the single notch ratchet tooth 56 secured to the shaft 53, to rotate this shaft 53 in the event the clock has lost time, and to move the minute hand to the top. The usual frictional connection between the shaft 53 and the clock hand driving mechanism is preferably provided. The clock hands of the clock 50 are driven by a synchronous motor of any suitable construction but are preferably driven by a novel synchronous motor 60 having an extremely low synchronous speed. The operation of this novel motor is based on the principle that if the number of teeth of the rotor is different than the number of teeth in the stator only certain of these teeth can be in alignment, and that a rotating magnetic field will cause the alignment of the teeth to rotate with the magnetic field. In this particular arrangement shown, there are 48 teeth on the stator and 50 on the rotor so that the rotor will rotate through an angle of 2 teeth for each cycle assuming a two-pole distributed coil type stator winding 62, and if a sixty cycle power current is used the motor will have a synchronous speed of 144 revolutions per minute. Any desired synchronous speed can of course be obtained by selecting the number of rotor and stator teeth per magnetic pole and the number of magnetic poles. The stator winding is preferably a distributed winding and may be two phase, of which one phase is connected directly to the line and the other phase derives its current from a phase shifter such as shown at PSa in Fig. 3, or the winding may be connected split phase or it may be a single phase winding 62 having short circuited shading rings or coils 63 associated therewith, so as to obtain a two-pole rotating magnetic field. In any event, the preferred type of motor has a large number of teeth per pole and has a difference of one between the rotor and stator teeth per pole, and is constructed to operate on single phase current. The minute shaft 53 and in turn the minute hand is driven by the motor through any suitable type of gear train, such as shown, assuming of course that the proper gear ratio is selected, the small or hour hand being driven by the minute shaft through the medium of suitable gearing, such for instance as shown at the broken away portion of dial 109, in Fig. 3. The clock 50 may drive or control any number of suitable repeater clocks, such as the clock 61 shown. It therefore appears that if the clock should not run for a short period of time due to power failure this clock would be set at the end of the hour and would therefore indicate the correct time thereafter.

In the same manner as the clock 45 is synchronized by the energization of the electro-magnet 46 once a second due to impulses superimposed upon the light and power frequency the mechanical escapement pendulum clock 65 may be synchronized by electric impulses the time spacing of which is determined by contacts operated by a synchronous motor 66 which is of the same construction as the synchronous motor 60. In the particular arrangement shown the synchronous motor 66 has the number of teeth per pole of the rotor and stator so chosen that the rotor through the medium of one or more contacts 67 mounted on but insulated from the motor shaft 68 closes the circuit for the magnet 69 once for each oscillation of the pendulum 70 of the clock 65 whereby this clock is caused to keep correct time. The attraction of this pendulum, which preferably includes some iron,

by the electro-magnet 69 will cause the clock 65 to indicate correct time so long as there is no power failure. During the time of power failure the clock 65 will keep correct time within such small margin that it cannot be detected for power failures of the ordinary kind. Also, if desired, the clocks 45 and 65 may be set hourly by mechanism such as shown in connection with the clock 50. Also clock 65 may control repeater clocks 65A.

As is apparent from the foregoing description and as is well known by power distribution engineers, power failures will at times occur, and in accordance with one form of the present invention it is proposed to employ a mechanical escapement clock and a synchronous selector motor clock and to provide means for setting the mechanical escapement clock by the electric motor clock at repeated intervals so long as no power failure has occurred and to set the synchronous clock by the mechanical escapement clock at least once after each power failure.

Referring to the lower right hand part of Fig. 1 the clock 50A is the same in every respect as the clock 50, that is, it is a synchronous motor clock having a motor 60A provided with means for setting the same hourly or in multiple time units thereof, except that its setting means is controlled differently, and that it is provided with contacts 82 and 87, that close momentarily at exactly the end of each hour. The clock 71 is a mechanical escapement clock which may or may not be electrically wound automatically in a manner as shown in Fig. 3, and for simplicity hand winding key holes 72 only have been shown. Since a clock of the mechanical escapement type of good quality is invariably correct within a very small margin a simple form of setting means may be employed. In the conventional arrangement shown the large or minute hand which rotates once per hour is provided with a rotating arm preferably containing a roller 74. An electro-magnet 75 is provided having an armature 76 which is held in its retracted position by a spring 77. This armature 76 preferably has a centering device 76A associated therewith which is constructed so that if the long hand is near the top, energization of the electro-magnet 75 will bring it exactly to the top.

In this form of the invention there is provided a stick relay SR for determining whether the synchronous motor clock 50A shall set the mechanical escapement clock 71 or the mechanical escapement clock 71 shall set the synchronous motor clock 50A. This stick relay SR is normally energized and receives its energizing current through the stick circuit including the secondary winding of transformer 29, the winding of the relay SR and the front contact 80 of this relay. So long as there is no power failure the mechanical escapement clock 71 will be set at the end of each hour by the energization of the electro-magnet 75 through the following circuit:—beginning at the secondary winding of transformer 29, front contact 81 of the relay SR, winding of the electro-magnet 75, contacts 82 of the synchronous motor clock 50A closed momentarily exactly when the large hand reaches the top or full hour position, back to the transformer 29. It thus appears that closure of the contacts 82 at the end of each hour sets the clock 71 providing no power failure has taken place.

Let us now assume that by reason of line trouble, or the like, power goes off at 5:15 p. m. and that the motor driven clock 50A stops. This

failure of power also drops the stick relay SR; the closure of back contact 83 does however not complete any circuit at this time. Let us now assume that power does not come back on again until at 6:20 p. m. When it is 6:00 p. m. by the clock 71 the contacts 85 and 86 close momentarily, and closure of the contact 86 closes a circuit through the winding of the electro-magnet 51A which includes the back contact 83 of the relay, this circuit also including an independent source of energy having terminals B and C. The completion of this circuit causes the hands of the clock 50A to be moved to indicate 6 p. m. At 6:20 p. m. when power comes back on, as has been assumed, the clock 50A starts again but for obvious reasons this clock 50A is now 20 minutes slow. The return of power however does not pick up the stick relay SR, because, although contacts 87 are closed, the contacts 85 are open and the pick-up circuit for relay SR is open. When the clock 71 indicates 7 p. m. (the correct time within a very small degree) the clock 50A will indicate 6:40 p. m. and the contacts 82 and 87 will be open. In other words, the relay SR will not be picked up but closure of contacts 86 will effect setting of clock 50A for reasons already given. The setting of clock 50A will effect closure of contacts 82 and 87 and since this happens very quickly the contact 85 will still be closed and the following pick-up circuit for the relay SR will be closed:—beginning at the secondary winding of the transformer 29, winding of the relay SR, contacts 85 and 87, back to the other end of said secondary winding. The moment the relay SR assumes its energized position its stick circuit including the stick contact 80 heretofore traced is completed, and the relay remains energized. By reason of the rapidity with which the relay SR picks up, it is possible that the clock 71 will also be set for obvious reasons, but since it already assumes the even hour position no harm is done. It is desired to be understood that although only one motor driven clock has been shown any number of such clocks may be used all of which are set after each power failure in a manner as described in connection with the clock 50A.

Referring now to Fig. 3 of the drawings, wherein a modified form of the invention has been shown, the lighting generator G, the high frequency generator HF, the standard clock USS and the manner in which it applies two kinds of field current to the generator through the medium of the relay R, is the same as that shown in Fig. 1 except that the voltage generated by the generator HF is superimposed on the voltage generated by the generator G by applying it to the primary winding of one or more series transformers 80 each having its secondary winding connected in series with a distribution circuit, is shown. Each of these transformers 80 may have a switch 91 associated therewith, so that in those systems where daily settings only are made, each of the various circuits may have setting impulses applied thereto at the ends of different hours, if desired. These switches 91 are preferably so arranged that they short-circuit the primary winding of their corresponding transformer when no impulse is to be transmitted.

In addition to the apparatus just mentioned whereby impulses may be transmitted, which impulses if rectified produce current of lighting frequency which lead and lag the lighting frequency voltage by substantially 90 electrical degrees, there is provided means including the manually operable switch 92 and the phase shifter PS for

transmitting impulses which if rectified are substantially in time phase and time phase opposition with the lighting frequency voltages. The phase shifter PS comprises a static transformer of peculiar construction and is fully described in the patent to Lucas No. 1,566,333 dated December 22, 1925; and consists of a core 93 of laminated transformer iron, preferably of the general shape shown, which contains a primary winding 94, a secondary winding 95 and two bucking or shading coils 96. This phase shifter is so constructed that the voltage induced in secondary winding 95 is displaced substantially 90 electrical degrees with respect to the voltage impressed upon the primary winding 94. This middle point of this secondary winding is connected to the field coil 10 of the high frequency generator HF and one or the other ends of this secondary winding may through the medium of the switch 92 be connected in series with the battery 19 to the other end of the field winding 10. In other words, the powerhouse equipment shown in Fig. 3 is provided with means whereby four distinctive impulses may be transmitted, provided the superimposed high frequency voltages are filtered out, rectified and then the phase relation of the rectified currents with respect to the lighting frequency is determined. These phase relations will for reasons already given be as follows:—when contact 11 is raised the filtered out rectified current will lag substantially 90 degrees and cause the contact 100 of the dynamometer relay DRa to be moved to the left, a phase shifter PSa being provided to obtain current of the desired phase on the stator winding 101 of this relay; when the contact 11 is lowered the superimposed voltage when filtered out and rectified will lead the lighting frequency voltage by substantially 90 degrees and cause the contact 100 to be moved toward the right; when the contact 92 is moved toward the right the field winding of the high frequency generator is energized so as to produce an impulse which if filtered out and rectified is in time phase with the lighting frequency and causes the contact 100B of the relay DRb to be moved to the right; and if the hand switch 92 is moved to the left this field winding 10 will be so energized that the filtered out and rectified superimposed impulse will result in a voltage in time phase opposition with the voltage of the lighting frequency and will cause the contact 100B of the relay DRb to be moved toward the left. The phase shifter PSa is constructed similarly to the phase shifter PS heretofore described, and the dynamometer relays DRa and DRb are of a construction including a field core 104 constructed of laminated iron, a stationary cylindrical magnetic core portion 105 around which the movable coil 106 is adapted to move. These relays DRa and DRb as well as the relay IR are biased to the neutral position by suitable means. The filtering means shown in connection with these relays DRa and DRb is the same as that shown in Fig. 1.

As heretofore mentioned in connection with Fig. 1 the contact 11 of the standard clock USS is moved to its upper position once per second, of course any other suitable periodicity of these impulses may be used if desired, and in the arrangement shown in Fig. 3 the contact 11 is moved up once per minute and therefore the contact 100 is moved to the left once per minute and the large hand of the clock 109 is ratcheted one minute ahead for each impulse by the ratchet 110 operated by the electro-magnet 111. The stop 112 is provided to avoid overthrow of the ratchet wheel

113, and the spring pawl 114 is provided to retain the ratchet wheel in its ratcheted position. Obviously, it is possible for a power failure to occur and the clock 109 will of course not be operating during such power failure. In order to assure correct time it is desirable to set this clock at the end of each hour and this is accomplished in the same manner as already described in connection with Fig. 1, that is, the contact 11 of standard clock USS will be moved to its lower position at the end of each hour and by so doing will effect the generation of an impulse which will cause the contact 100 to be moved toward the right and thereby will momentarily energize the electro-magnet 51A which will set the clock for reasons already given.

Since the number of days in each month is not the same it is difficult to drive a calendar indicating the day of the month from the wheels of the clock, and in accordance with the present invention, it is proposed to operate an automatic calendar by the distinctive impulses heretofore mentioned as being capable of operating the relay DRb in one direction or the other as the case may be. In the particular arrangement shown, the operator at the powerhouse will at the end of each day operate the manually operable switch 92 toward the right the necessary number of times to cause the right number to indicate in back of the opening 120, that is, a number corresponding to the day of the month. If the preceding month has less than 31 days the operator will be required to operate the handle 92 to the right more often at the end of the last day of such month. In the same manner, the operator will operate the handle 92 toward the left the necessary number of times on the last day of the month to bring the name of the next month in back of the opening 121.

Each impulse transmitted due to operation of the handle 92 will of course cause the ratchet pawl 122 or 123, depending on the direction the switch 92 is operated, to advance the corresponding ratchet wheel one notch, so that both the proper month and the correct day thereof are indicated. The small hand of the clock 109 is operated by the large hand through the usual reduction gears, as shown. The dial of the clock 109 has an opening 124 therein through which the day of the week is indicated. The disc back of this opening on which the days of the week have been inscribed is preferably operated from the small hand of the clock 107, so as to advance this disc one step (one-seventh of one revolution) every 24 hours either gradually or intermittently, by suitable means old in the chronometer and odometer art. It is desired to point out here that if desired the dial back of opening 121 indicating the month of the year, may be operated by the disc back of opening 120, that is, each revolution of the disc back of opening 120 will advance the disc back of opening 121 one step (one-twelfth of a revolution) by ratchet means operated only at the end of such revolution, in the same manner as the contact 11 is operated downwardly at the end of each hour, and by such construction only one character of impulse is required to operate the calendar. The combination clock and calendar 125 just described may have any number of repeater clocks and calendars 125A operated therefrom by means and in a manner well known to those skilled in this art.

Referring now to the left hand portion of Fig. 3 there is provided in a residence, office or factory an electro-responsive device DRc, of

which the stator winding 101C is energized by lighting frequency current derived from the phase shifter conventionally shown at PSb, and the rotor winding of which is energized by the resulting current derived by filtering out the high frequency current by filtering means as heretofore described, which current is then rectified by the rectifier RCB. As heretofore mentioned the depression of contact 11 of the standard clock USS at exactly the end of each hour causes the contact 100 to be moved toward the right. In the same way and for the same reason the contact 100C is moved toward the right momentarily at the end of each hour, and in so doing sets the mechanical escapement clock 71B by setting apparatus such as heretofore described, and which is identified by similar reference characters. The clock 71B is a mechanical escapement clock of the usual construction having a pendulum 70A of which the main spring is adapted to be automatically wound by a motor 130, and the spring for driving the striking mechanism is automatically wound by a motor 131, which motors are controlled in a manner more fully described presently.

The clock 71B is provided with an energy saving contact 132 which is closed only when the large hand assumes a position between, say, about two minutes before the hour and about two minutes after the hour, so that four minutes are allowed for the setting and winding of this clock. It should be noted that the contact 132 when open cuts all energy off of the winding and setting mechanism. This clock 71B is also provided with two snap acting pivotally supported contacts 133 and 134, which under the wound up condition of the clock 71B are held against stops 135 and 136 respectively, by springs 137 and 138, respectively. These springs 137 and 138 are fastened to the end of racks 139 and 140, respectively, which racks assume the upper position, in which they are shown, when the main spring and striking spring respectively are in their wound up condition. These racks 139 and 140 move down gradually as the clock and striking mechanism run down. Let us assume that at 5:45 the main spring is run down to such an extent that that point of rack 139 where the spring 137 is fastened gets below the pivoted point of the switch blade 133, that is, gets over center. This relation of the parts will cause the contact 133 to be operated by the spring 137 so as to close the circuit for the motor 130 at this point, but the motor will not run because the motor circuit is still open at the contact 132, the energy for operating this motor being derived from the secondary winding of transformer 141. When now the large hand indicates two minutes of six o'clock, the contact 132 closes thus completing the circuit for the motor. The current flow in this circuit causes the motor 130 to operate and through suitable gearing causes the main spring to be wound up and the rack 139 to be returned to the normal position. Just before the rack 139 reaches the normal position the spring 137 gets by the pivotal point of switch 133 and causes the switch 133 to again leave the stationary contacts illustrated by arrows and causes it to be moved in position against the stop 135, thus stopping the motor. The spring of the striking mechanism is wound in substantially the same way by the motor 131. If the clock 71B has now gained or lost some time, this being assumed to be less than two minutes, the clock will be set when the distinctive impulse due to down-

ward movement of the contact 11 is transmitted, all in a manner as already explained. The clock 71B may control any number of repeater clocks 71X in any suitable and well known manner.

Referring to the lower part of Fig. 3, there is shown another clock setting mechanism 51A—57A, which may be of any suitable construction but has been illustrated as being the same as that used in connection with the clock 50 shown in Fig. 1, and has for this reason been assigned similar reference numbers. In this form of the invention a somewhat different principle for selecting the high frequency impulse is employed in that both mechanical and electrical tuning is employed. In this form of the invention there is provided a stick relay SRa which is picked up in response to momentary closure of the contact 132A, of a clock of which only the setting mechanism and this contact has been shown, at about say one or two minutes before the end of the hour. This pick-up circuit starts at one side of the secondary of transformer 145, contact 132A, winding of the relay SRa, contacts 146—147 of the clock setting mechanism 51A, to the other side of the secondary winding of transformer 145. The flow of light and power current frequency in this circuit causes this relay to assume its energized position thereby closing the stick circuit which is the same except that the stick contact 148 is substituted for the contact 132A. The contact 132A will of course only remain closed for a very short time sufficient to allow this relay to pick up. At this point it may be stated that in practicing this form of the invention a continuous high frequency impulse continuing for one or two seconds is preferably used instead of a modulated impulse, as has heretofore been mentioned, but this is not essential; and further no impulses of the same high frequency are transmitted at any other time during each hour when this form of the invention is practiced.

At exactly the end of the hour the high frequency setting impulse is transmitted in a manner similar to that heretofore described. The filtering condensers and inductances having constants as heretofore mentioned permit only the high frequency current to flow through the circuit including the contact 153 and the coil 149 surrounding the soft iron armature 150 of a tuned reed relay TR, and are such as to make this high frequency current a maximum. This armature is spring supported by a spring of such stiffness as to cause the natural period of vibration of this armature to be such as to have the same number of complete vibrations as there are modulations per second of the high frequency current. The high frequency current is modulated to a frequency different and preferably lower than the power frequency so that the reed is tuned to a comparatively low frequency. This armature is spring supported against one end of a U-shaped permanent magnet PM so that during each wave of the modulated direct current, derived by rectifying the high frequency current by a rectified RCB connected in series with the coil 149, the armature is attracted. If desired the permanent magnet PM may be omitted. When the armature has reached an amplitude sufficient to cause the contacts 151—152 to close, the following stick circuit is closed which causes the continuous attraction of the armature 150:—beginning at the battery 160, wire 167, contacts 151—152, coil 149, wires 164, the coil of the clock setting

electro-magnet 51A, contact 161, back to the other side of the battery 160. The circuit just traced is a stick circuit for relay TR because the current therein is of such polarity as compared with the magnetic polarity of the permanent magnet PM as to hold the contacts 151—152 of this relay and in this circuit closed. The flow of current in this circuit sets the clock (not shown in detail), and in so doing opens the stick circuit for the relay SRa at the contacts 146—147. This causes the stick relay SRa to drop and open the clock setting stick circuit at the contact 161 and also causes opening of the high frequency circuit at the contact 153.

In this form of the invention the coil 149 is preferably supported separate from the armature 150 in a manner to allow vibration of the armature therein. One reason that a tuned reed relay TR of this type is extremely efficient, that is, closes its contacts by the consumption of very little energy, is because the forces exerted by the successive cycles of current flow are cumulative. It should be noted that this tuned reed relay does not do any work because there is no contact intermittently made. This relay is so connected that if its armature has once reached an amplitude sufficient to cause the slightest contact between the contacts 151—152 a direct current stick circuit is closed which will hold the armature attracted to the permanent magnet PM. The polarity of direct current flowing in this circuit is such as to attract the armature toward the permanent magnet. The energy required to operate this relay is primarily used or dissipated in two different ways, namely, (1) molecular friction due to flexing of the spring supporting the armature, and (2) windage loss due to the armature fanning the surrounding air.

Modified system Fig. 4.—In the modified form of the invention illustrated by the system shown in Fig. 4 of the drawings, the high frequency energy instead of being directly superimposed on the power frequency is impressed between the ground and the light and power distribution network or rather it includes one phase wire of the high potential system and one phase wire of the low potential system connected in series through units tuned to the high frequency and insulated for light and power frequency potentials, and a ground return.

Referring to Fig. 4 of the drawings the power house equipment is exactly the same as that shown in Fig. 1, except that the transformer 9 has been omitted and that the high frequency generator HF is connected directly between one of the bus wires and ground through the medium of inductance 190 and condenser 191, this inductance and condenser being connected in series and having constants to tune them to current resonance at the high frequency, as distinguished from potential resonance, the condenser 191 having a break-down voltage above the voltage of generator G. In that the remaining parts of the power house equipment are the same as those Fig. 1, like parts have been assigned like reference characters.

The high frequency net work heretofore mentioned is the same as certain members of the low frequency net work, but includes special means for bridging from the high voltage side to the low voltage side of the distribution transformer, such as the transformer 26. In the case of the transformer 26 the high voltage wire 24 is connected to the 110 v. secondary wire through

the medium of inductance 192 connected in series with condenser 193, this inductance and condenser having electrical constants to tune them to resonance at the high frequency, this in order to render a ready flow of high frequency current from the generator HF to the 110 v. distribution wire 194, and at the same time prevent the flow of low frequency current. This high frequency circuit is then completed as in a residence of the consumer through another condenser 195 connected in series with an inductance 196, this inductance 196 and condenser 195 have electrical constants to constitute a tuned unit which resonates at the high frequency, the circuit continuing through the primary of the transformer 36. The amplified tube A⁶, has its filament or heater F⁶ connected across the secondary winding 197 of the transformer 100, the primary winding 101 of which is connected across the 110 v. circuit distribution line, another secondary winding 102 being provided to furnish the plate potential. The grid G⁶ of the amplifier A⁶ is connected to the secondary winding of the transformer 36 and therefore receives high frequency potential at those times when high frequency is impressed upon high frequency net work. The amplifier A⁶ not only acts as an amplifier but also acts as a detector and changes the high frequency current to a low frequency current corresponding to the modulation as illustrated by the curve 17. In other words, the amplifier A⁶ rectifies the high frequency, resulting in the application of low frequency potential as illustrated by the curve 31 effective on the grid of the amplifier, and this low frequency potential 31 is amplified to result in the potential as illustrated by the curve 17, so that the two-phase induction type relay IR will have a torque produced in its disc D, this because the voltage applied to the element 37 of this relay is out of phase with the voltage applied to the element 35. Although the transformer 100 may cause a certain small amount of light and power current to flow in the element 35 of the relay, this current will be substantially in phase with the current flow in the element 37 so that no torque will be produced due to this current. On the other hand the current derived from the high frequency source which has its modulations displaced substantially 90 degrees will, when rectified and amplified by the amplifier A⁶ and applied to the element 35 of the relay, cause this relay to operate.

The remaining portion of Fig. 4 of the drawing illustrates a system which is the same as that shown in Fig. 1 except that the synchronous motor for driving the hands of the clock 50 is of somewhat different construction, for which reason like parts will be assigned like reference characters. The construction of this motor will now be taken up.

The synchronous motor SM shown in Fig. 4 of the drawings constitutes a conducting disc 110 of aluminum or other suitable metal, very much the same as those used in induction watt hour meters, this disc tends to be rotated by the induction element constituting a core 111 having a winding 112 thereon, this core 111 having an air gap through which the disc 110 passes. One or both of the poles of the core 111 is bifurcated and has a slug or shading coil 113 on one leg thereof, so that the aluminum disc 110 has a torque producing therein, tending to rotate the disc about its axis or shaft 114 in the direction of the arrow. This torque is due to the fact that

there is a shifting magnetic field penetrating the disc, because the flux passing through the bifurcation containing shading coil 113 lags in phase behind the remaining flux, this causing a torque.

The disc 110 rotates the hands of the clock 50 in the proper direction and substantially at a rate to conform with the lapse of time. This rate of turning of the disc 110 would however vary due to frictional resistance and the voltage applied, so that the time indicated by this induction disc would be inaccurate, this apparatus thus far described constituting induction motor apparatus and constitutes the apparatus necessary to produce a uni-directional torque to operate the clock hands.

In addition to this induction motor apparatus the disc 110 has a brim 115, constituting a toothed ring or soft iron, the number of teeth in this ring being such that rotating of one tooth per cycle of the low or power frequency current will rotate the clock hands of clock 50 through the medium of suitable gearing including the worm 122, at a rate to keep correct time, and this portion of the motor is conveniently called the synchronizing or synchronous apparatus.

In order to allow one tooth to pass for each cycle of current a permanent magnet PM is disposed adjacent to the brim 115. To this permanent magnet are connected two U-shaped soft iron cores 116 and 117, each core terminating into two pointed teeth, which teeth are spaced one or more teeth plus a half tooth apart. The U-shaped cores 116 and 117 contain windings 118, 119, 120, and 121, which windings are connected in series with the winding 112 in such a way that the magnetic flux emitted by the permanent magnet flows first through the winding 118 and 120 and then through the winding 119 and 121 during each cycle of the low frequency current. In other words, during one-half cycle of the alternating current the flux of the permanent magnet PM passes through the legs containing coils 118 and 120 and during the other half cycle of this alternating the flux of the permanent magnet PM passes through the legs containing coils 119 and 121, and since the disc 110 tends to rotate by action of induction element 111—112—113, and the alternating current flowing in coils 118—121 diverts this flux through one or the other of two soft iron paths, causes the brim 115 to be synchronized with the diverted flux to allow the disc to take a half step for each half cycle of low frequency alternating current only. In other words the permanent magnet PM and its associated parts constitute synchronizing means for synchronizing the speed of rotation of the eddy current inductance driven disc 110 with the frequency of the alternating current.

Applicant's modified construction of Fig. 4 thus affords a synchronously driven clock driven by an electric motor having an extremely low speed, thus reducing wear on the bearings, windage loss, vibration and making it noiseless. Also by impressing the high frequency clock setting current between the light and power net-work and ground the high frequency potential cannot flow to the light and power consuming devices, such as lamps and industrial motors.

Having thus shown and described several embodiments of my invention, and having shown them rather specifically although certain elements thereof have been illustrated conventionally, it is desired to be understood that this has been done to exemplify the invention in a convenient manner; and it is desired to be under-

stood that the invention is not limited to the particular arrangement shown either specifically or conventionally, for instance, the method of transmitting impulses may be used for many other purposes, such as for supervisory control of power sub-stations by code impulse means such as shown in the patent to Field No. 1,562,211, dated November 17, 1925, or for selectively controlling any one of different devices by code controlled means such as shown in the patent to Field No. 1,343,256, dated June 15, 1920; that various changes and modifications may be made to adapt the invention to any particular light and power distributing or similar system without departing from the scope of the invention or the idea of means underlying the same.

What I desire to secure by Letters Patent is:

1. In a combined light and power distributing and time signal distributing system; in combination with the usual high voltage distributing feeders; step-down transformers on said feeders; means at a power station for supplying alternating current power and signal impulses to said feeders comprising a low frequency generator continuously connected to these feeders, and a high frequency generator only at times connected to said feeders; and means connected to the low voltage winding of one of said step-down transformers responsive if both high and low frequency are applied to the feeders at the power station and not responsive if low frequency current only is applied to such feeders.

2. Means for indicating correct time at a power consumer location comprising, a power distribution system to which voltage is supplied for power consumption purposes, means for at definite time periods superimposing a high frequency alternating current voltage on the voltage of said system, a clock of the mechanical escapement type at a light and power consumer location, means responsive to the high frequency alternating current for controlling the setting of said clock, and energy saving means for disconnecting said last mentioned means from the light and power system at all times except during a reasonable time before and after such definite time periods.

3. In combination, a power distribution system including a high voltage network, a plurality of low voltage distribution branches, a transformer for connecting each branch to said network, power alternating current generating means for feeding said network with power current of comparatively low frequency, other alternating current generating means for at the proper time superimposing a higher frequency current upon said power current, mechanism having a timing function, setting means for said mechanism, and means responsive jointly to said power current and said higher frequency current and connected to one of said branches for controlling said setting means.

4. In combination, time indicating means, operating means operated substantially in accordance with the lapse of time, frictional means connecting said time indicating means to said operating means to cause said operating means to drive said time indicating means but allow said time indicating means to be set with respect to said operating means to indicate correct time, an alternating current power distribution system including step-down transformers connecting high voltage supply feeders and low voltage distribution feeders, means for continuously impressing upon said high voltage feeders an alternating current of low frequency for power con-

sumption purposes and to supply power to operate said operating means, means for at definite time periods only impressing upon said high voltage feeders a high frequency current, filtering means connected to said low voltage feeders at each of a plurality of points to allow an appreciable flow of high frequency current only, an amplifier for amplifying said high frequency filtered out current, and electro-responsive means connected to each of said amplifiers and operated in response to said high frequency amplified current for setting the time indicating means located at that particular point with respect to its operating means.

5. In a combined power distributing and time signal distributing system; a plurality of high voltage feeders each of which constitutes a plurality of wires; a plurality of low voltage feeders each constituting a plurality of wires; transformers inductively connecting said high voltage feeders to said low voltage feeders; means for constantly impressing between the wires of said high voltage feeders a high voltage alternating current of low frequency to transmit power to said low voltage feeders; filtering means connected to the wires of said low voltage feeders which permits only the flow of high frequency current; means for momentarily at the end of each of successive definite time intervals impressing between the wires of said high voltage feeders high frequency potentials; time manifesting means; and electro-responsive means connected to receive current from said filtering means for correcting said time manifesting means to any extent that may be required up to but not in excess of said definite time interval.

6. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a friction slip clutch, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said friction slip clutch, means for superimposing upon said commercial current a special frequency clock setting alternating current impulse at the end of each successive definite time periods, and electro-responsive means responsive to such special frequency impulse for setting said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccurately by reason of temporary power failure to the extent of said failure for any power failure which does not exceed such time period.

7. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a friction slip clutch, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said friction clutch, means for superimposing upon said commercial current a higher frequency current modulated to the frequency of said commercial current at definite time periods, means for converting said modulated higher frequency current into an alternating current, and electro-responsive means responsive only if said commercial current and said converted current are simultaneously applied thereto for setting said time manifesting means with respect to said motor in the event said time

manifesting means indicates time inaccurately by reason of temporary power failure to the extent of said failure for any power failure which does not exceed such time period.

8. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a frictional driving connection, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said frictional connection, means for superimposing upon said commercial current a special frequency clock advancing alternating current impulse at the end of each of definite equal time periods, means for amplifying said impulses and electro-responsive means responsive to such special frequency amplified impulse for advancing said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccurately by reason of temporary power failure and to an extent dependent upon the duration of said failure up to but not in excess of said time period.

9. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a frictional driving connection, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said frictional connection, means for superimposing upon said commercial current a higher frequency current modulated to the frequency of said commercial current at the end of each of definite time periods, means for converting said modulated higher frequency current into an alternating current and for amplifying the same, and electro-responsive means responsive only if said commercial current and said converted current are simultaneously applied thereto for advancing said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccurately by reason of temporary power failure to the extent of the duration of said failure up to said period but not in excess of said period.

10. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a frictional connecting means, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said frictional connecting means, means for impressing between said distribution system and ground a clock setting impulse at the end of each of definite time periods, means for amplifying said impulse, and electro-responsive means responsive to such amplified impulse for setting said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccurately by reason of temporary power failure to the extent of the duration of said failure for any power failure less than such period but not for a power failure in excess of such period.

11. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof

measure the lapse of time, time manifesting means, a frictional connecting means, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of said frictional connection, means for impressing between said distribution system and ground a special frequency clock setting alternating current impulse at the end of each of definite time periods, means for amplifying said impulse, and electro-responsive means responsive to such amplified special frequency impulse for advancing said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccuracy by reason of temporary power failure, the extent of advancing of said time manifesting means by said electro-responsive means being substantially the same as the duration of said failure for any power failure not in excess of said period.

12. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a frictional connecting means, a synchronous motor operated by current supplied by said system and driving said time manifesting means through the medium of a frictional connection, means for impressing between said distribution system and ground a higher frequency current modulated to the frequency of said commercial current at definite time periods, means for converting said modulated higher frequency current into an alternating current and for amplifying the same, and electro-responsive means responsive only if said commercial current and said converted current are simultaneously applied thereto for setting said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccuracy by reason of temporary power failure.

13. In a combined electric light and correct time distributing system, the combination with an alternating current distributing system including a high voltage distributing network continuously supplied with low frequency alternating current and connected through step-down transformers to a low voltage distributing network insulated therefrom, of a clock at a consumer location receiving electrical light energy from said low voltage distribution network, distinctive frequency alternating current generating means for impressing a distinctive high frequency potential between ground and said high voltage distributing network, means permitting the flow of said distinctive frequency current but not said low frequency alternating current from said high voltage network to said low voltage network, and electro-responsive means for setting said clock connected to said low voltage network and responsive only to the reception of distinctive high frequency potential.

14. In a combined electric light and correct time distributing system, the combination with an alternating current distributing system including a high voltage distributing network continuously supplied with low frequency alternating current connected through step-down transformers to a low voltage distributing network insulated therefrom, of a clock at a consumer location receiving electric light energy from said low voltage distribution network, distinctive alternating current generating means for impressing a distinctive high frequency potential be-

tween ground and said high voltage distributing network, filtering means permitting the flow of said distinctive current from said high voltage network to said low voltage network including a condenser and an inductance connected in series and tuned to resonate at said distinctive high frequency, and electro-responsive means for setting said clock connected to said filtering means and responsive to the reception of distinctive frequency potential.

15. A clock system including a master clock, a single circuit system extending therefrom to a remote point, a multiple wire secondary clock system at such remote point, means at the master clock for transmitting current impulses of identifiable characteristics over the single circuit, and means at the remote point for receiving and identifying the transmitted impulses and for re-transmitting the identified impulses over the multiple wire secondary clock system.

16. In an electric control system for clocks, the combination of a pair of commercial power mains, a master clock, a generator of comparatively high frequency alternating current associated with the clock and connected to transmit periodic high frequency impulses superimposed on the commercial current in the mains, a tuned receiver connected to the mains, a low voltage rectifier in the receiver circuit, a condenser in series with the receiver, and a secondary clock controlled by said rectified current.

17. The combination with a clock having a current polarity responsive relay for effecting its operation, means normally biasing said relay to one position and means including a tube relay device for periodically overcoming said biasing means and operating said current polarity responsive relay to another position.

18. A clock system including a multiple wire system for secondary clock synchronization and actuation, in combination with a single circuit system extending to a remote master clock, and means for receiving controlling impulses from the single circuit system and for imparting corresponding chronological impulses to the multiple wire system.

19. A clock system including a master clock, a single circuit extending therefrom to a remote point, a multiple circuit clock system at such remote point, means at the master clock for transmitting current impulses of identifiable characteristics over the single circuit, and means at the remote point for receiving and identifying the transmitted impulses and for re-transmitting the identified impulses over the multiple circuit clock system.

20. Clock controlling means including a multiple circuit for secondary clock synchronization and actuation, in combination with a single circuit extending to a remote master clock, and means for receiving controlling impulses from the single circuit and for imparting corresponding chronological impulses to the multiple circuit.

21. The combination with a clock having a relay for effecting its operation said relay being operated in accordance with the relative polarity of current applied thereto and tending to operate in the reverse direction if the relative polarity is reversed, means normally biasing said relay to one position and means including a tube relay device for periodically overcoming said biasing means and operating said relay to another position.

22. In combination, a pair of power line conductors, means for transmitting power current

thereover used for power and illumination purposes, means for at the end of each hour superimposing a special clock setting current upon said power current, a clock, electro-responsive setting means for setting said clock and responsive to said setting current but not responsive to said power current connected to said conductors, and a contact operated by said clock and closed only for a short time before and after the setting time as manifested by said clock and included in series with said electro-responsive setting means, whereby said electro-responsive means is connected to line conductors when necessary but for a small fraction of the total time only.

23. In combination, power lines for transmitting alternating power current for illuminating and power purposes, means for at regular time intervals superimposing on said lines a high frequency clock setting current, a filter allowing the free flow of high frequency current but only a slight flow of power current, a rectifier for rectifying the filtered-out high frequency current, a clock, an electro-responsive clock setting means responsive to said rectified current for setting said clock, and a contact controlled by said clock for at times connecting said filter to said lines.

24. In a clock system, a master clock, a secondary clock including clock hands advanced by a rotary synchronous motor, a line circuit connecting said master clock and said secondary clock, means associated with said master clock for applying alternating current to said line circuit to operate said synchronous motor, means governed by said master clock for applying a distinctive and higher frequency current to said line circuit at time spaced intervals each interval defining a particular time period, and means controlled by said higher frequency current for correcting the said clock hands to any extent not in excess of a major portion of said time period.

25. In combination, an alternating current commercial power distribution system continuously supplying commercial alternating current of regulated frequency so that the cycles thereof measure the lapse of time, time manifesting means, a synchronous motor operated by current supplied by said system and driving said time

manifesting means, means for superimposing upon and in addition to said commercial current a high frequency clock correcting impulse at the end of each of successive definite time periods, and electro-responsive means responsive to such impulse for correcting said time manifesting means with respect to said motor in the event said time manifesting means indicates time inaccurately by reason of temporary power failure, said electro-responsive means being capable of correcting said time manifesting means to the extent of said failure for any power failure not in excess of such time period.

26. In combination, a pair of line wires, means for applying a plurality of characters of currents including clock correcting current impulses to said line wires, a clock having a time shaft, electro-responsive means for after each of equal time intervals correcting the indicating position of said time shaft, a contact operated by said time shaft and closed a predetermined time before and opened a predetermined time after the correcting time point in each revolution of said shaft, an asymmetric unit included in series with said electro-responsive means, and circuit connections for allowing said contact to control the flow of current derived from said line wires through said asymmetric unit and electro-responsive means in series.

27. An electric control system for clocks comprising electric means, a master clock having a contact closed at the end of each of a plurality of successive time periods, a generator for generating alternating current of comparatively high frequency, a condenser, a circuit containing said generator and said condenser in series and rendered active by the contact controlled by the master clock to supply high frequency current impulses to said mains, a receiving means comprising a coil and a condenser tuned to the frequency of the generator and connected to said mains, means for rectifying current received by said receiving means, a secondary clock, and means for correcting said secondary clock to any extent not in excess of such time period and controlled by said rectified current.

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