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[11] **3,756,010**

[45] **Sept. 4, 1973**

[54] **MAGNETIC-INDUCTION CLOCK**

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[21] Appl. No.: **169,734**

[30] **Foreign Application Priority Data**

Aug. 11, 1970 Japan 45/70668

[52] **U.S. Cl.** .... **58/23 R,** 58/23 A, 58/23 D, 58/23 V, 58/35 W

[51] **Int. Cl.** **G04b 1/00**

[58] **Field of Search** .... 58/24 R, 152 H, 23 R, 58/23 A; 318/16

[56] **References Cited**

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Primary Examiner—Richard B. Wilkinson
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[57] **ABSTRACT**

In the clocks wherein the induction magnetic field of a commercial frequency is detected, and the detected signal is amplified, thereby driving the transistor motor, a magnetic induction type clock of which the transistor motor is driven in normal state by said detected signal but in abnormal state such as in the event of any fluctuation in the external field or power interruption, the transistor motor is driven by a signal supplied from a separately provided standard oscillation source.

7 Claims, 14 Drawing Figures

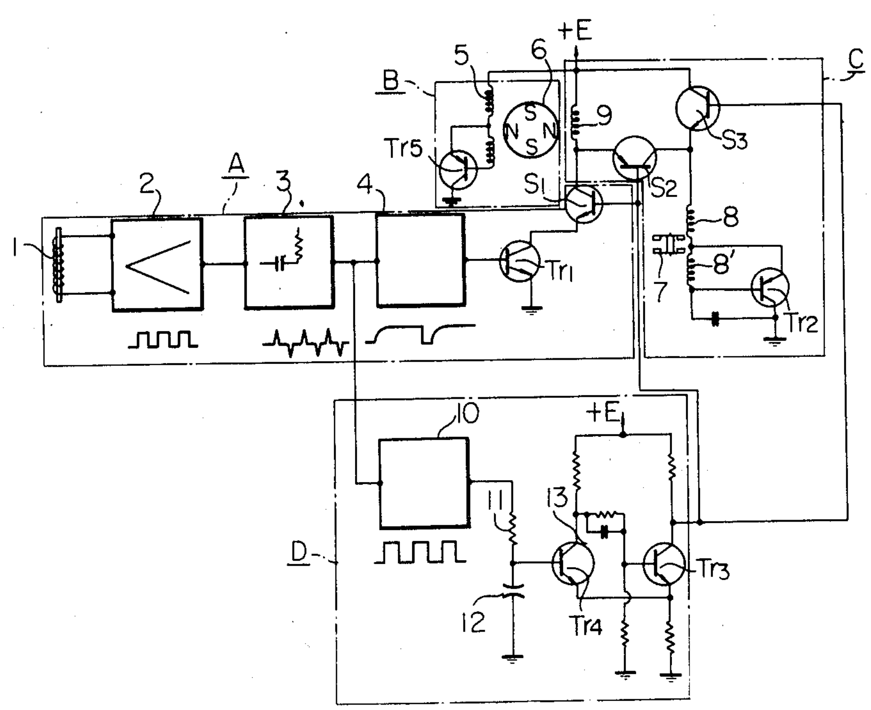


Fig. 2

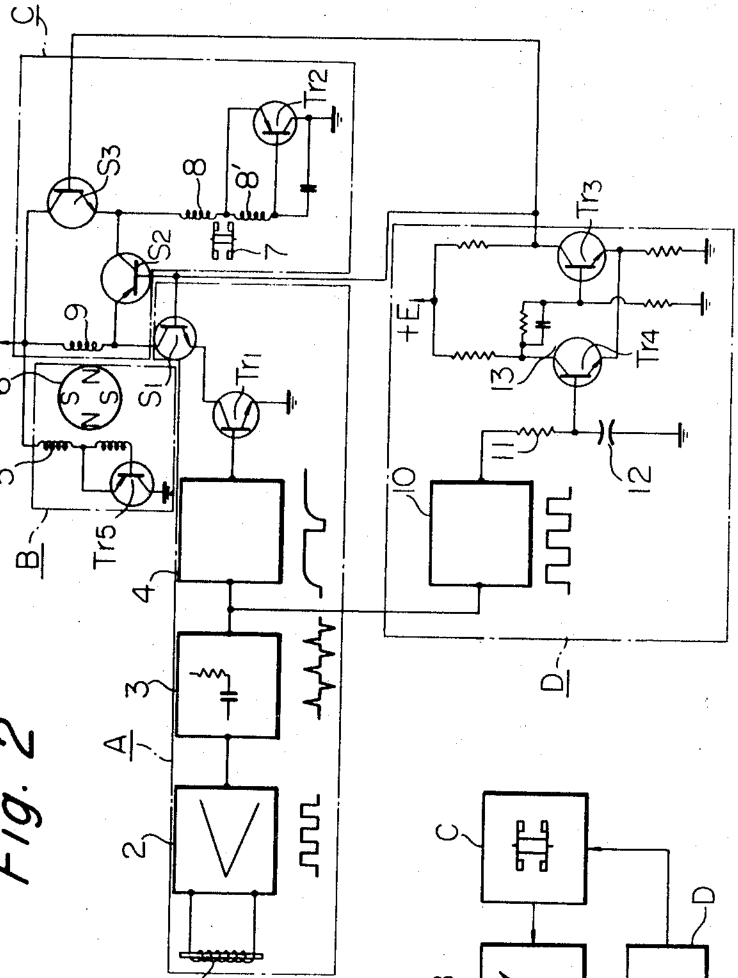
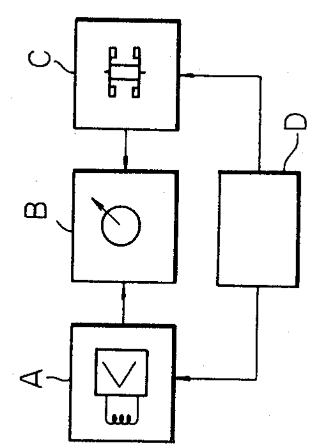


Fig. 1



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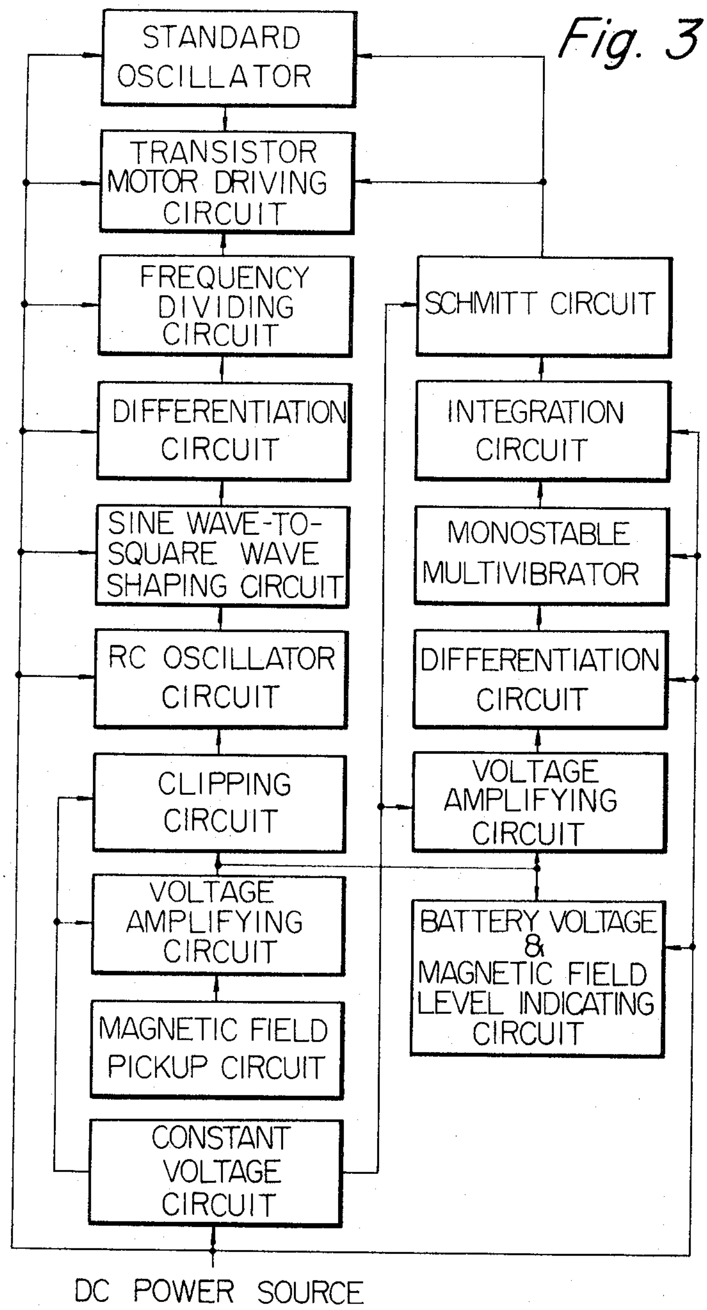

Fig. 3

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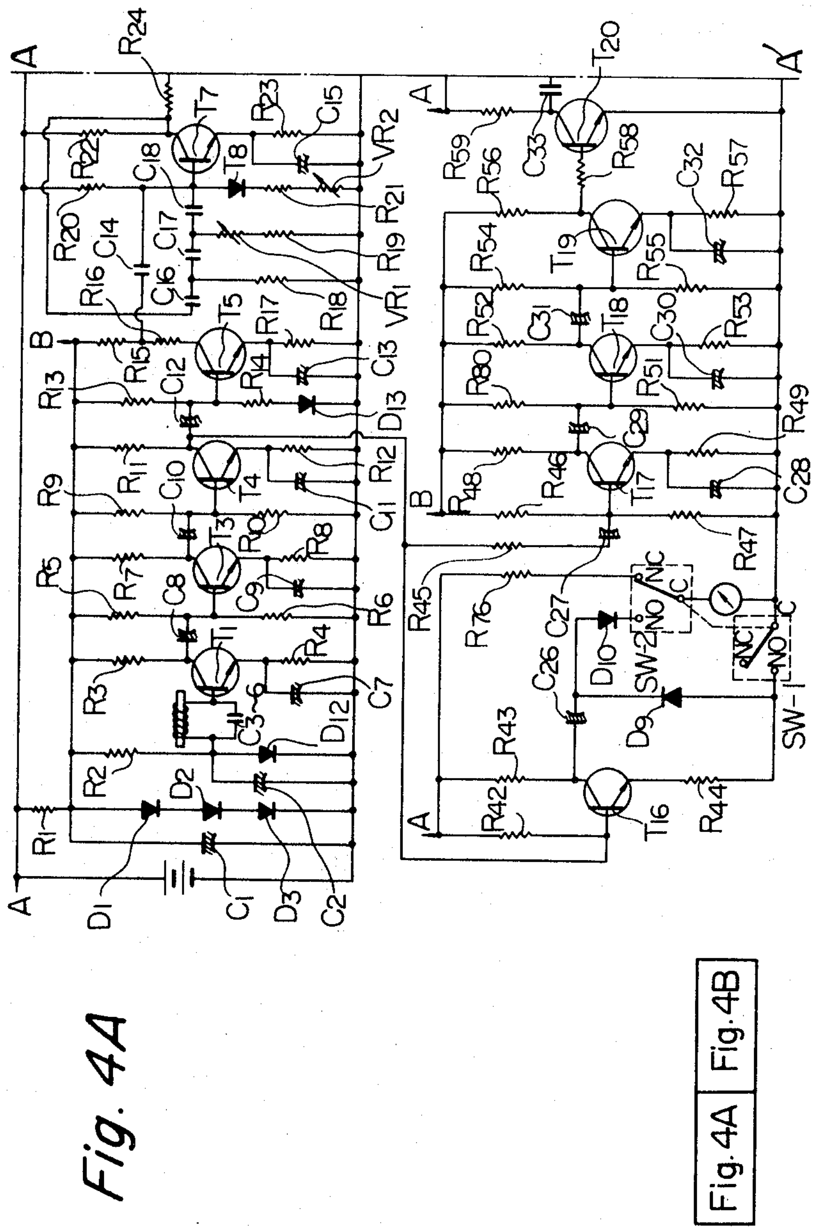

Fig. 4A

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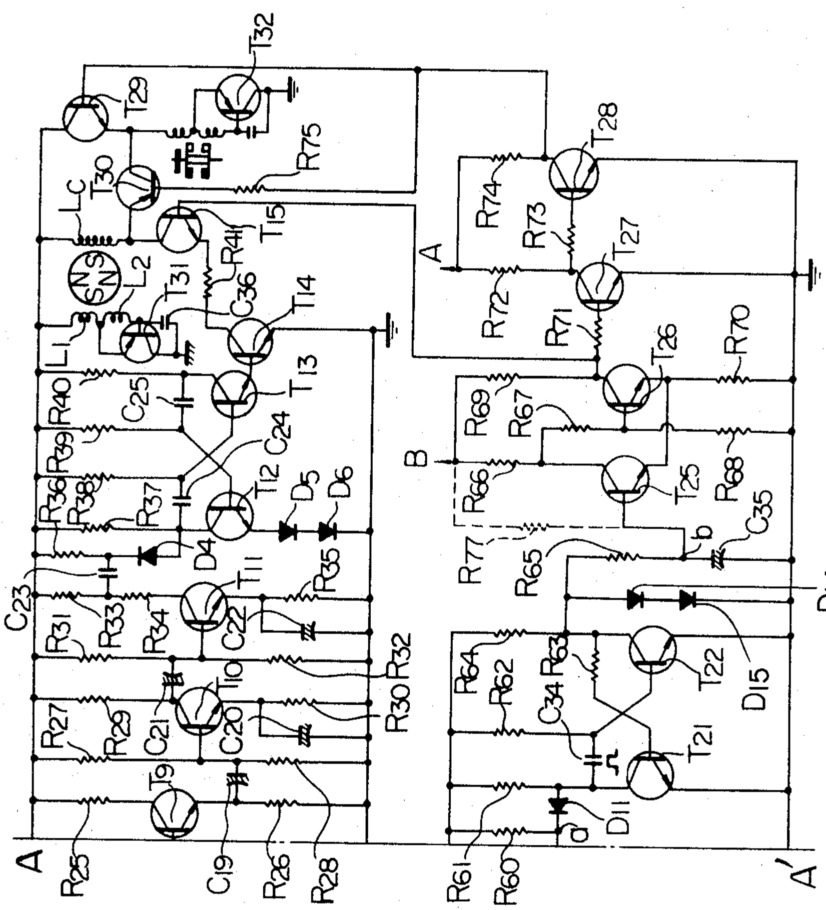

Fig. 4B

Fig. 4A	Fig. 4B

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Fig. 5(I)

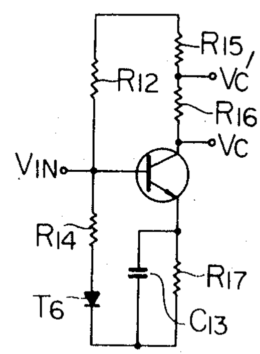

Fig. 5(II)

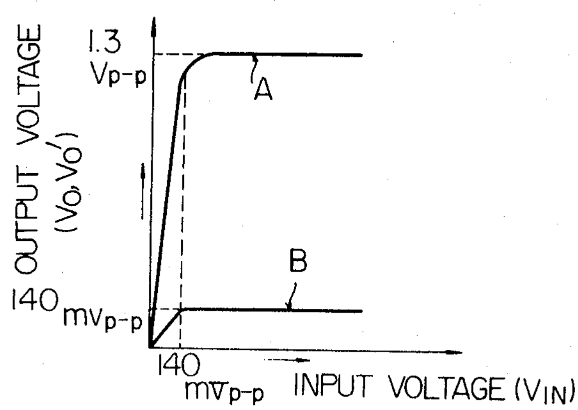

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Fig. 6

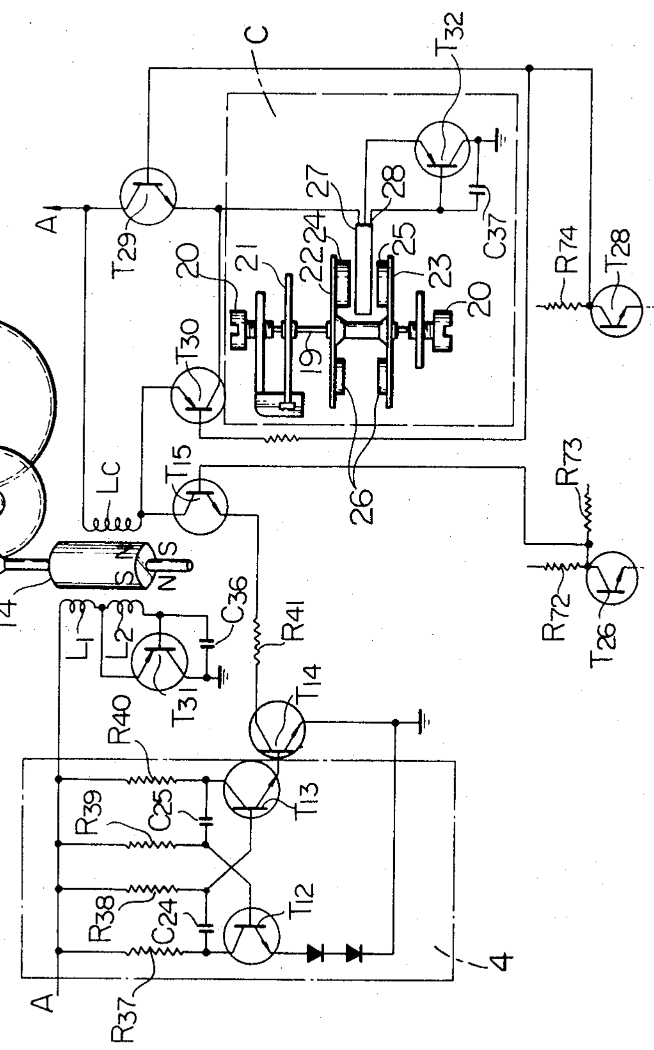

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Fig. 7(I)

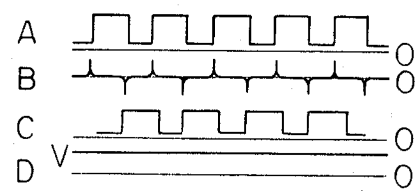

Fig. 7(II)

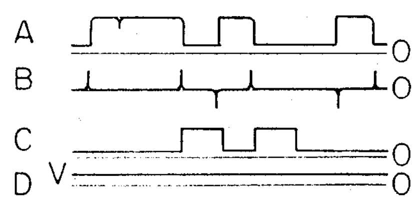

Fig. 7(III)

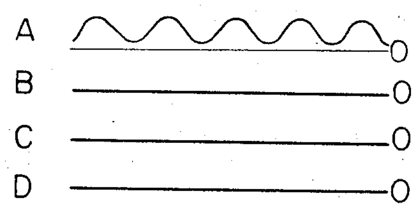

Fig. 8(I)

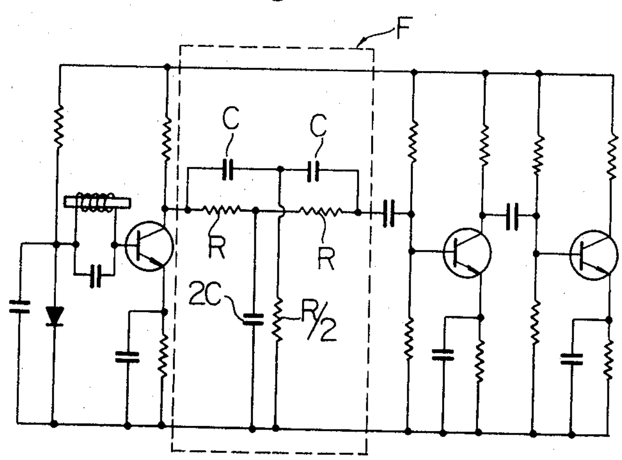

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Fig. 8(II)

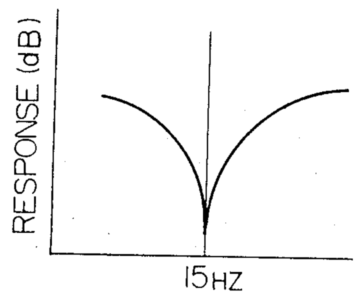
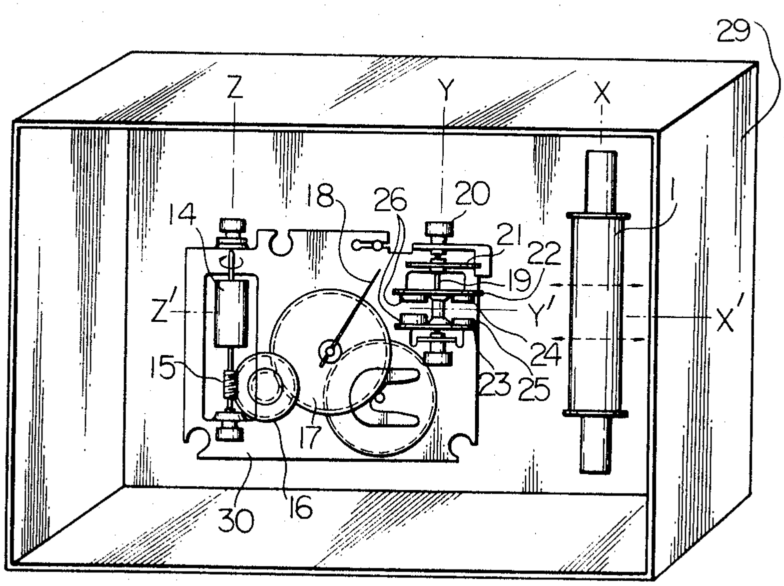


Fig. 9



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MAGNETIC-INDUCTION CLOCK

BACKGROUND OF THE INVENTION

This invention relates to induction type clocks.

The commercial service power is generally used to drive electric equipment, appliances and devices everywhere in buildings, factories, offices and homes and, thus, there are produced therearound certain induction fields (induction magnetic field and induction electric field) of the commercial frequency. Since the frequency of commercial power is very low (for example, 60Hz and 50Hz in Japan), however, there exists no radiation field (electromagnetic waves) and only an induction field exists in the vicinity of the power line. The longer the distance from the power line, the weaker becomes the induction field and, thus, unless the sensitivity of pickup means is high, it is impossible to detect the induction field.

Such induction field is produced from the electric current and electric charge, but it is known that the induction electric field is present even where no load current flows, while the induction magnetic field is produced upon occurrence of a flow of a load current.

With recent developments in power plant services, power interruption has become minimized or eliminated and, as well as the fact that the frequency accuracy has been increased, it is possible to obtain highly accurate clocks synchronizing with the commercial frequency. The clock according to this invention is to be operated in such induction magnetic field.

There have been already suggested clocks utilizing commercial power frequency, typical of which is an AC clock using a synchronous motor such as Waren motor. This type of clock has such drawbacks that for example, the use of power cord is indispensable, and the clock must be placed within the reach of power cord or near the power socket. To solve this problem the induction type clock has been proposed.

Reviewing the magnetic field intensity measured in general homes, it is known that mean field intensity is 5×10^{-4} oersted, and minimum field intensity is 2.5×10^{-7} oersted. The clock utilizing the induction magnetic field is required to be sufficiently operable in such field intensity. To this end, the detected signal must be amplified by suitable means, such as by a highly sensitive pickup. A known clock of this type, as disclosed, for example, in U.S. Pat. No. 2,786,972, is such that the induction magnetic field is detected by the magnetic pickup and then amplified by an amplifier to drive the synchronous motor, whereby the clock is operated. In the conventional induction type clock, the accuracy is high as the clock synchronizes with the commercial frequency as long as the induction magnetic field is comparatively stable.

However, the induction field is not always stable at any place or any time. Practically, various electric devices or equipments are used in the buildings, factories, offices and general homes, where the magnetic fields produced from electric devices and power lines interfere with each other, to often result in an extremely low field intensity, or in some cases, the induction field is disturbed or fluctuated by an action or movement of strong magnetic material. For example, in large type air conditioners, a large steel blower drum is rotated, thereby the magnetic field is disturbed at a frequency around 10Hz. The external magnetic disturbance takes place also at on-off occurrence of a large current in electric welding works. Further, any movement of a magnetic member in the vicinity of the magnetic pickup is also a cause of magnetic field disturbance. Nevertheless, in the prior art, no provision is made for compensating the influence due to external field disturbance, weakened field or power interruption and, as a result, the accuracy of the clock is often deteriorated.

According to the present invention, all the foregoing problems are solved by providing a induction type clock in which a highly accurate standard oscillator is separately disposed and, in the event of the external magnetic disturbance, the detected signal voltage is automatically interrupted by an electrical circuit, and the clock is driven synchronously with the frequency provided from said standard oscillator, whereby the accuracy of the clock is maintained so as to be free of any external magnetic disturbance.

A principal object of the present invention is, therefore, to provide a magnetic induction type clock operable with a high accuracy at all times free of the external magnetic disturbance.

The present invention will be disclosed in detail in the following with reference to accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a magnetic induction type clock embodying this invention,

FIG. **2** is a detailed circuitry diagram illustrating the clock in FIG. **1**,

FIGS. **3**, **4***a* and **4***b* are a block diagram and a circuit diagram, respectively showing another embodiment of this invention,

FIGS. **5**(I) and **5**(II) are circuitry and characteristic diagrams showing the operation of the clock of this invention,

FIG. **6** shows in detailed circuitry diagram transistor motor and standard oscillator sections in the clock,

FIGS. **7**(I), **7**(II) and **7**(III) are diagrams showing operations of switching circuit in the clock,

FIG. **8**(I) shows another embodiment of this invention and FIG. **8**(II) is a characteristic diagram thereof, and

FIG. **9** is a perspective view showing schematically internal arrangement of the clock with the back cover removed.

DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, there is shown in a block diagram an example of the clock according to the present invention. This clock comprises a signal detector A for detecting signals from an external induction magnetic field, a transistor motor B, a standard oscillation source C, and a switching circuit D. Further, as shown in FIG. **2**, the above mentioned signal detector circuit A comprises an induction coil **1** with a ferrite core for detecting the space magnetic field of a commercial frequency, an amplifier **2** for amplifying the detected signal, an RC differential circuit **3** for converting square wave amplified output of the amplifier into a trigger voltage, and a frequency divider circuit **4** comprising a astable multivibrator for dividing the trigger voltage into a frequency being 1/4 (for example, 15Hz) of the commercial frequency. The transistor motor B is of free-running type consisting of a transistor Tr_5 a motor coil **5**, and a four-pole rotor **6**. The standard oscillation source C consists of a balance-wheel **7** acting as a standard oscillator, a driving coil **8**, a detection coil **8'**, a synchronous coil **9**, a transistor Tr_2, and transistor switching elements S_1 S_2 and S_3. The synchronous coil **9** is magnetically coupled with the rotor of the transistor motor and electrically connected to the frequency divider **4** in the signal detector circuit through a transistor switching element S_1 and a transistor Tr_1. The switching circuit D consists of a monostable multivibrator **10** operated by the trigger voltage from the amplifier **2** and thereby generating a square wave voltage with a constant pulse width, a resistor **11** and a capacitor **12** for converting the output square wave of the monostable multivibrator **10** into a DC voltage, and a Schmitt circuit **13** having transistors Tr_3 and Tr_4. The collector of the transistor Tr_3 is connected to the bases of the switching elements S_1 S_2 and S_3 of the standard oscillation source. The switching element S_1 is of NPN type, S_2 is of PNP type, and S_3 is of NPN type, so that when the induction field is normal, S_1 will be ON, S_2 will be OFF, and S_3 will be ON, while in the occurrence of power interruption or external field disturbance S_1 and S_3 will be OFF, and S_2 will be ON.

FIG. **3** shows in a block diagram an improved induction type clock of the one in FIG. **1**. The clock shown in FIG. **3** has additionally an RC oscillator circuit and a battery voltage and magnetic field level indicating circuit. The RC oscillator circuit, which has a free-running frequency of about 50 or 60Hz receives an input signal from the voltage amplifying circuit and locks its frequency at the commercial power frequency of 50 or 60Hz. The purpose of the battery voltage and magnetic field level indicator is to monitor magnitudes of the induction magnetic field at the place the clock is placed.

The circuitry arrangement and the operating principle of the clock as in FIG. **3** will be described below with reference to FIGS. **4a** and **4b**, which shows a more detailed circuit of FIG. **3**.

The commercial frequency induction magnetic field pickup device used in the embodiment comprises an induction coil having a ferromagnetic core. A capacitor C3 **6** is connected in parallel with the induction coil, and the capacity of this capacitor is determined so that this LC circuit is tuned to the commercial frequency.

When the magnetic force lines of the induction field pass through the induction coil, a sine wave voltage of commercial frequency is produced across the induction coil. This signal voltage which being very weak is applied between the base and emitter of the transistor T_1, to obtain an amplified voltage from its collector. R_2 is a bias resistor, R_3 is a collector resistor, R_4 is an emitter resistor, and D12 is a bias compensation diode for temperature. C_1 and C_7 represent bypass capacitors. Said amplified voltage appearing at the collector of the transistor T_1 is further amplified by transistors T_3 and T_4 at an amplifying stage. R_5, R_9, $R_6$and R_{10} denote bias resistors, R_7 and R_{11} are collector resistors, R_8 and R_{12} are emitter resistors, C_8, C_{10} and C_{12} are coupling capacitors, and C_9 and C_{11} are bypass capacitors.

A transistor T_5, bias resistors R_{13} and R_{14}, a bias compensation diode D13 for temperature, collector resistors R_{15} and R_{16}, an emitter resistor R_{17}, and a bypass capacitor C_{13} constitute a nonlinear amplitude limiter circuit for clipping the input signal voltage and thus limiting an excess input voltage applied to the RC oscillator in the next stage.

A transistor T_7, bias resistors R_{20}, R_{21} and VR_2, a bias temperature-voltage compensation diode **D14**, a collector resistor R_{22}, an emitter resistor R_{23}, a bypass capacitor C_{15}, an RC feedback circuit, capacitors C_{16}, C_{17} and C_{18}, resistors R_{18}, VR_1 and R_{19} are forming an RC phase shifting type sine wave oscillator circuit, in which the oscillation frequency is set to be substantially nearly the commercial frequency (60 or 50Hz) by the resistor VR_1 which is variable. The bias resistor VR_2 is a variable resistor for setting the voltage characteristic of the oscillation frequency to be at the best point. The output signal voltage from the nonlinear amplitude limiter is applied to the base of the above RC oscillator via said coupling capacitor C_{14}. The oscillation frequency of the RC oscillator is synchronized with the input signal voltage so as to operate as an external signal synchronous oscillator.

This oscillator serves as a sort of filter circuit so that, even when the induction field is somewhat distorted by any irregular external magnetic force or other reason, the interference signal is absorbed by this filter, and the detected signal will be shaped.

If, however, an excessive input voltage is applied to the base of this oscillator and if the waveform of this input voltage is disturbed, the effect of the filter in the oscillator is reduced and the output voltage waveform becomes distorted. To increase the filter effect, therefore, it is necessary to limit the input voltage to the base to be as small as possible. On the other hand, this input voltage must be large enough to so that the oscillation frequency of the oscillator will be synchronized in its input signal frequency, even when there exist certain variations in the oscillation frequency including variations in the power supply voltage, ambient temperature and aging.

The above nonlinear amplitude limiter will be described more in detail with reference to FIGS. **5(I)** and **5(II)**. In the drawing, FIG. **5(I)** is a nonlinear amplifier circuit, and FIG. **5(II)** shows its output characteristics. As indicated by the characteristic curve A, the collector output starts to be saturated from an input voltage of 140 mVp-p. The saturated output voltage is about 1.3 Vp-p. Since this output voltage is large enough to be the input to the RC oscillator, the voltage is divided through the collector resistors R_{15} and R_{16} so as to be a clipped output voltage of 140 mVp-p in the clip output characteristic as indicated by the curve B.

Referring again to FIGS. **4a** and **4b**, the output voltage of the oscillator is applied through a resistor R_{24} to the base of an emitter follower circuit comprising a transistor T_9, a collector resistor R_{25} and an emitter resistor R_{26}. Output sine wave voltage of the emitter of the follower is applied to a two-stage nonlinear amplifier circuit comprising transistors T_{10} and T_{11} at the next stage, whereby the applied sine wave is converted into a square wave.

The output voltage from the emitter of transistor T_9 is applied to the base of the transistor T_{10} through a coupling capacitor C_{19}. This output voltage causes the transistor T_{10} to operate with a large amplitude and, as a result, the collector output voltage of the transistor T_{10} is saturated, whereby wave the output of the transistor T10 is formed into a square wave. The output voltage also causes the transistor T_{11} to operate in the same manner.

The square wave output voltage as divided through collector resistors R_{33} and R_{34} is applied to a differential circuit comprising a capacitor C_{23} and a resistor R_{36} so that a trigger voltage is produced. Then, a negative trigger voltage is applied to astable multivibrator frequency divider circuit via a diode D_4 at the next stage. This frequency divider consists of transistors T_{12}, T_{13} diodes D_5 and D_6, timing resistors R_{38} and R_{39}, timing capacitors C_{24} and C_{25}, and collector resistors R_{37} and R_{40}. Transistor T14 amplifies the output of the frequency divider.

When the commercial power frequency is assumed to be f_{HZ}, this frequency can be divided into ¼ by so selecting the OFF time t of the transistor T_{13} determined by the capacitor C_{24} and resistor R_{38} as to be a suitable value between $(1/f)/3 < t < ¼/4$.

D_5 and D_6 represent diodes for compensating the free-running oscillation cycle of the frequency divider circuit for temperature and voltage.

The voltage of the above quarter-frequency (for example, of 15Hz in the case of 60Hz) is amplified by the amplifier transistor T_{14}, and the amplified current flows through synchronous coil L_c, transistor T_{15}, resistor **41** and transistor T_{14} to the ground.

FIG. **6** shows the transitor motor driving section. In FIG. **6**, the part encircled by the chain-line indicates a frequency divider circuit **4**, and the other region C encircled by chain-line shows a standard oscillation source. L_1 is a drive coil, L_2 is a detection coil, C_{36} is a capacitor for preventing abnormal oscillation, L_c is a sychronous coil, **14** is a rotor, **15** is a worm, **16** is a worm wheel, **17** is a second-hand wheel, **18** is a second-hand, **19** is a shaft, **20** is a bearing for the shaft, **21** is a hair spring fixed to the shaft **19, 22** and **23** are forming a pair of rotating disks mounted to the shaft **19, 24** and **25** are magnets respectively mounted to each said disk so as to oppose to each other inside the rotating disks, **26** are balancers, **27** is a drive coil, and **28** is a detection coil.

The transistor motor is adjusted for a rotation at the rate of about 450rpm. A square wave current of 15Hz which is a quarter division of the commercial frequency flows in the synchronous coil L_c to synchronize the free-running transistor motor rotated at about 450rpm for the accurate rotation of the 450rpm rate. The speed of this rotation is reduced by the worm **15,** worm wheel **16** and second-hand wheel **17,** thereby moving the second-hand **18.** This operation is performed when the induction magnetic field of the commercial frequency is stable. In the event of external field disturbance or power interruption, the detection signal current flowing in the synchronous coil is disturbed, resulting in an irregular rotation of the transistor motor and an inaccurate time keeping.

To avoid this, the switching circuit is actuated so that, in the event of external field disturbance, the switching transistor T_{15} is turned off to interrupt the 15Hz square wave current therefrom. At the same time, the synchronous signal current of 15Hz provided from the separately provided standard oscillator unit C is supplied to the synchronous coil L_c through the switching transistor T_{30}, so that the transistor motor will rotate as synchronized with the frequency of the standard oscillator unit C. FIG. **6** is illustrating an example where a balance wheel is used for the standard oscillator unit. This unit consists of a transistor T_{32}, a capacitor C_{37} for preventing abnormal oscillation, a drive coil **27,** a detection coil **28** and a balance wheel block which comprises a wheel, a balancer **26,** magnets **24** and **25,** a hair spring **21,** etc. This balance wheel oscillating unit is operated at all times.

The switching circuit comprises a voltage amplifier circuit, a differential circuit, a monostable multivibrator, an integrator circuit, a Schmitt circuit, and a two-stage inverter circuit to convert the control voltage from the Schmitt circuit to a higher level. The series arrangement of the voltage amplifying circuit, the differentiation circuit, the monostable multivibrator and the integration circuit produce a d-c. voltage to control the Schmitt circuit and the inverter circuit. The output voltage of the Schmitt circuit and inverter circuit, in turn, operate the switching transistors **T15, T29** and **T30** in accordance with the state of the external induction magnetic field. The collector of the switching transistor **T15** is connected to the positive d-c. power line A through the synchronous coil L_c, the emitter of **T15** is connected to ground through the transistor **T14** and the resistor **R41,** and the base of **T15** is connected to the collector of transistor **T26** of the Schmitt circuit. The collector of the switching transistor **T29** is connected to the positive d-c. power line A, the emitter of **T29** is connected to one end of the drive coil of the balance wheel oscillator, and the base of **T29** is connected to the collector of transistor **T28** of the inverter circuit. The emitter of the switching transistor **T30** is connected to the positive d-c. power line A, the emitter of **T29** is connected to one end of the drive coil of the balance wheel oscillator, and the base of **T29** is connected to the collector of transistor **T28** of the inverter circuit. The emitter of the switching transistor **T30** is connected to the positive d-c. power line A through the synchronous coil L_c, and the collector of **T30** is connected to the emitter of transistor **T29,** and the base of **T30** is connected to the collector of transistor **T28** of the inverter circuit through resistor **R75.** This switching circuit is operated in the following manner. Referring to waveforms illustrated in FIGS. **7(I), 7(II)** and **7(III),** respective in which A shows a collector waveform, B shows a trigger voltage waveform at the point *a* in the circuit of FIG. **4,** C shows an output waveform of the monostable multivibrator, and D shows a DC voltage waveform at the point *b* in FIG. **4.** FIG. **7(I)** shows the operation in normal magnetic field, wherein the amplified signal voltage waveform is stable as indicated by A. In this switching circuit, a voltage amplifier circuit having transistors T_{17}, T_{18}, T_{19} and T_{20} is additionally provided. The purpose of this amplifier is to ensure operation of the monostable multivibrator in the next stage since even three-stage amplifiers may not produce the trigger voltage needed to drive the monostable multivibrator in the minimum magnetic field intensity of 2.5×10^{-7} oersted at general homes. With the provision of this amplifier, the gain is increased to obtain a sufficient square amplified output, which is then converted into a voltage for triggering the monostable multivibrator. This voltage amplifier circuit is a four-stage amplifier. The amplified signal voltage of square wave is converted into a trigger voltage as in B of FIG. **7(I)** by the RC differential circuit comprising a capacitor C_{33} and a resistor R_{60}.

The monostable multivibrator is triggered by this trigger voltage, whereby a square wave signal of the same frequency as the commercial frequency is obtained, as indicated by C of FIG. **7(I)** (pulse width at a constant duty). This square wave output is converted into a DC voltage by the RC integrator circuit, as indicated by D in FIG. 7(I). When the RC time constant of this integrator is determined to be large, the square wave output is given in a DC voltage waveform.

This DC voltage is applied to the base of the Schmitt circuit comprising transistors T_{25} and T_{26}, resistors R_{66}, R_{67}, R_{68}, R_{69} and R_{70} at the next stage. When the induction magnetic field is stable, the square wave output of the monostable multivibrator is not disturbed, so the d-c. voltage integrated by the integration circuit is higher than the threshhold voltage of the Schmitt circuit. In this state, transistor **T25** is ON, transistor **T26** is OFF, and the inverter transistor **T28** is OFF, so that the control voltage to the base of the switching transistor **T15** is +**1.5** volts, the control voltage at the bases of transistors **T30** and **T29** is +3 volts. Consequently, the switching transistors **T15** and **T29** are ON, and the switching transistor **T30** is OFF.

While, if an external magnetic disturbance occurs, the amplified waveform becomes such as A in FIG. 7 (II), where the waveforms are linked together or intermittent at certain intermediate points. If this waveform signal is converted into a trigger voltage, the waveform becomes FIG. 7 (II) b, where the trigger disappears partly. If this trigger voltage is used, the output of the monostable multivibrator becomes FIG. 7 (II) C, where the waveform is partly lacking. The DC voltage obtained from such partly lacking waveform output of the monostable multivibrator as above when converted by the integrator circuit becomes lowered as indicated by FIG. 7 (II) D. When this DC voltage comes down below a certain threshold voltage, the state of the Schmitt circuit is inverted. At this moment, the transistor T_{25} turns OFF, and transistor T_{26} turns ON. The collector potential of the transistor T_{26} is decreased nearly to zero potential from the collector supply voltage. This zero potential is applied to the base of the switching transistor T_{15} to turn this transistor OFF. As a result, the synchronous current which is a divided quarter of the detected commercial frequency is interrupted.

The collector of the Schmitt circuit receives its supply voltage from a constant voltage source through line B. Therefore, the collector output control voltage is zero when the transistor T_{26} is ON, or it is about 1.5V when the transistor T_{26} is OFF. This voltage is too low to control the switching transistors T_{30} and T_{29} which are to control the synchronous current supplied from the balance wheel circuit. To obtain sufficient collector output control votage of 3V, a circuit comprising transistors T_{27} and T_{28} is used, whereby a control voltage of 0 to 3V is obtained from the collector of the transistor T_{28} and thus the switching transistors T_{29} and T_{30} are controlled.

As described in the foregoing, the transistor T_{26} is OFF when the magnetic field is stable. In this state, the transistor T_{27} is ON, and T_{28} is OFF. The switching transistors T_{29} and T_{30} are controlled by the collector voltage (3V) of the transistor T_{28}. The switching transistor T_{29} is of NPN type, and T_{30} is of PNP type. Under this condition, the switching transistor T_{30} turns OFF, and T_{29} turns ON. Thus the balance wheel drive current flows from the voltage source (+3V) to the ground through the switching transistor T_{29}, drive coil and transistor T_{32}, but does not flow into the synchronous coil.

On the other hand, if an external magnetic disturbance occurs, the transistors T_{25} and T_{26} of the Schmitt circuit are inverted so as to turn the transistors T_{26} and T_{28} ON and T_{25} and T_{27} OFF. As a result, the collector control voltage of the transistor T_{28} becomes zero. At this moment, the switching transistor T_{29} turns off, and T_{30} turns ON. Thus, the balance wheel drive current flows from the voltage source (+3V) to the ground through the synchronous coil, switching transistor T_{30}, drive coil and transistor T_{32}. Under this condition, the transistor motor is rotated synchronously with the oscillation frequency of the balance wheel, the latter of which must be of course regulated to oscillate at the rate of 15 vibrations/sec. The transistor motor is thus synchronized with the frequency of the balance wheel and rotated accurately, even if the induction magnetic field is affected by the external field disturbance.

In the event of very weak induction magnetic field or power interruption, referring next to FIG. 7 (III), the amplified output takes the waveform as indicated by A, which is a sine wave without being a square wave. When power service is interrupted, this amplified output may be ignored.

In such event, as shown by FIG. 7 (III) B, no trigger voltage is presented through the differentiation circuit, and the monostable multivibrator delivers no output. That is, the DC output voltage of the integrator circuit becomes substantially zero. The operation at this time is similar to the case of FIG. 7 (II), where the clock is synchronized with the oscillation of the balance wheel.

The purpose of resistor R_{75} is to block the flow of an excess current from power source (+3V) to the ground through the synchronous coil, the base and emitter of switching transistor T_{30}, and transistor T_{28} when the collector potential of transistor T_{28} becomes zero (transistor T_{28} is ON).

The purpose of diodes D14 and D15 is to make the square wave output voltage of the monostable multivibrator stable against variations in the power source voltage. At the same time, these diodes serve to slightly lower the square wave output voltage when the ambient temperature is raised. As a result, due to lowering of the rise voltage of the diode, the DC voltage of the integrator circuit is lowered. This serves to compensate for any variation in the threshold voltage due to decrease of the base-emitter voltage V_{BE} of the transistor T_{25}.

When the ambient temperature is lowered, the square wave output voltage is increased, and the DC voltage is also increased. At this time, the base-emitter voltage V_{BE} of the transistor T_{25} is increased, and, therefore, the variation in the threshold voltage is compensated for as in the case of the ambient temperature rise.

As has been described above, the switching circuit of the clock of this invention is operated in such manner that the amplified waveform of the detected signal is converted into a DC voltage, the variation in the DC potential due to irregular waveform is detected by the Schmitt circuit. Sequential inversion of the Schmitt circuit is utilized for forming a control voltage, with which the switching transistor is actuated so as to switch the synchronous current.

In the present instance, incidentally, the monostable multivibrator employed is not always necessary. However, with the provision of this monostable multivibrator, the probability of vanishing the pulse becomes higher and the DC potential tends to be readily varied (as apparently seen in FIG. 7 (II) A, B and C) when the monostable multivibrator is actuated through a trigger voltage in the event of disturbance in the amplified waveform due to external magnetic disturbance, and even if the disturbance of the amplified waveform is small. The use of the monostable multivibrator makes it possible, at the same time, to produce a square wave of constant duty. Thus, whereas the square wave duty is variable due to bias change and variation in the input magnetic field intensity if the amplifier circuit alone is relied on, the use of monostable multivibrator enables it possible to provide a switching system which is operable at a high stability, regardless of any DC potential variation due to any other reason than the external magnetic disturbance.

In view of the nature of the cordless magnetic induction clocks, it is desirable that the clock is synchronized with the commercial frequency at all times. Therefore, the level for the switching is to be set so that the Schmitt circuit is switched immediately after the waveform disturbance occurs due to external irregular magnetic field. This is because, if the operation of the frequency divider of the astable multivibrator is disturbed, the synchronous current to the transistor motor is immediately disturbed.

The magnetic induction clock in FIG. 4 showing an embodiment of this invention is provided with an induction magnetic field and battery voltage indicator mechanism, which comprises a transistor T_{16}, a bias resistor R_{42}, a collector resistor R_{43}, an emitter resistor R_{44}, diodes D_9 and D_{10}, a coupling capacitor C_{26}, switches SW–1 and SW–2 and a high sensitivity ammeter.

The amplified output voltage from the transistor T_4 is applied to the base of the transistor T_{16}, to further amplify the output voltage. This signal is supplied to the loads D_9 and D_{10} and to the meter through the coupling capacitor C_{26}. When the field intensity is strong, a large output voltage is obtained at the collector of the transistor T_{16}, whereby a large half cycle current of the signal frequency flows in the meter, whereas when the induction field intensity is weak, the collector output voltage is small, and a small current flows in the meter to actuate the indicator in a small extent. Since a capacity is not connected in parallel with the meter, the meter maintains good damping (but the meter indication does not follow the input at a degree of a half cycle of the signal frequency). When the detected signal waveform is disturbed due to entrance of an irregular external magnetic field of low frequency, the meter pointer fluctuates unstably in response to the disturbance.

By operatively associating the switch SW–1 and SW–2, it is possible to use the meter for both battery voltage indication and induction field intensity indication.

Further in the embodiment of FIG. 4, a resistor R_1, diodes D_1, D_2 and D_3, and a capacitor C_1 constitute a constant voltage circuit, which is capable of maintaining a constant voltage of 1.5V even if the battery voltage is varied to near 2V from 3V. C_1 is a smoothing capacitor for removing ripple voltage.

FIG. 8 (I) shows another embodiment of the invention, wherein a filter F for absorbing the disturbed signal caused by rotation of the rotor and vibration of the balance wheel is inserted between the induction magnetic field detector and the voltage amplifier circuit. In this circuit, only the voltage of the desired frequency can be voltage-amplified to drive the transistor motor. The response characteristic thereof is as shown in FIG. 8 (II). According to this embodiment, the circuitry block diagram can be simplified.

FIG. 9 schematically shows the internal arrangement of the induction type clock of this invention, with the rear side lid removed. In the drawing, 29 is a case, 1 is an induction coil, 30 is a base plate to which the clock mechanism is installed, 19 is a shaft, 20 is a pair of bearings, 21 is a hair spring, 22 and 23 are balance wheels, 24 and 25 are magnets, 26 are balancers, 14 is a rotor, 15 is a worm, 16 is a worm wheel, 17 is a second-hand wheel, and 18 is a second-hand. X, Y and Z denote, respectively, the axial direction of the magnetic core of the induction coil, the axial direction of the shaft 21, and the axial direction of the rotor 14.

Because the rotor and balance wheel using magnets are used for the clock driver unit and the standard oscillator unit, a magnetic disturbance is produced by the rotation and vibration of these units, and such magnetic field (at a frequency of 15Hz) is detected by the induction coil. To minimize the influence of this magnetic field, the induction coil 1, the rotor of the transistor motor, and the balance wheel are arranged, as shown in FIG. 9, so that their shafts (X, Y, and Z axes) are parallel with each other and these elements are located at the mid point so as to be on the same perpendicular line Z′, Y′ and X′ with respect to the axes X, Y and Z. With this arrangement, the magnetic interference from the driver unit and standard vibration unit which are to cross the induction coil can be minimized.

According to this invention, as has been described above, the transistor motor is rotated as synchronized with the commercial frequency when the induction magnetic field is normal. In the event of power interruption or irregular external field or weak magnetic field, the synchronous signal from the commercial frequency is automatically blocked and the transistor motor is synchronized with the frequency of the standard vibration unit which is vibrated at all times. Thus, the clock operation is perfectly free of the influences of power interruption, field disturbance or weak magnetic field, and a highly accurate induction clock can be realized.

While a few embodiments of the invention and particular modifications thereof have been described above, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claimed is:

1. A battery-driven cordless induction clock comprising a first synchronizing signal source including a signal detector unit having an induction coil for magnetically detecting the spatially leaking induction magnetic field of commercial frequency and producing an electrical output signal in response to the detected magnetic field, and an amplifier for amplifying the output signal of said detector unit, and a transistor motor unit operated by the output signal of said detector unit for driving the clock, a second synchronizing signal source including a standard oscillator producing an output signal at a standard frequency equal to the commercial frequency a synchronous coil for magnetically coupling the rotor of said transistor motor unit to said synchronizing signal sources, first switching means connected between said synchronous coil and said first synchronizing signal source, second switching means connected between said synchronous coil and said second synchronizing signal source, and actuating means re-

sponsive to the output signal from said first signal source for turning said first switching means on and said second switching means off to connect said synchronous coil only to said first signal source when said output signal indicates a normal magnetic field, and for turning said first switching means off and said second switching means on to connect said synchronous coil only to said second signal source when said output signal indicates an abnormal magnetic field.

2. A battery-driven cordless induction clock in accordance with claim **1**, in which said actuating means comprises a circuit for differentiating the output signal from said amplifier, a monostable multivibrator operated by a trigger output from said differentiation circuit, an integrating circuit for integrating the output signal from said monostable multivibrator, and a Schmitt circuit operated by the output signal from said integrating circuit.

3. A battery-driven cordless induction clock in accordance with claim **1**, in which said actuating means includes means for converting the output signal from said amplifier into direct current and means for detecting variations in said direct current to indicate whether said magnetic field is normal or abnormal.

4. A battery-driven cordless induction clock in accordance with claim **1**, in which said amplifier comprises a voltage amplifier circuit, a clip circuit for clipping the output of said voltage amplifier circuit, an RC oscillator circuit to which the output of said voltage amplifier circuit is applied, a square wave shaper circuit connected to the output of said RC oscillator circuit, a differentiation circuit for differentiating the output of said square wave shaper circuit, and a frequency divider circuit operated by the trigger output of said differentiation circuit.

5. A battery-driven cordless induction clock in accordance with claim **1**, in which a filter circuit for passing only the signal of a frequency component close to the commercial frequency is disposed betweeen said induction coil and said amplifier.

6. A battery-driven cordless induction clock in accordance with claim **1**, in which said transistor motor is of free-running type, said second synchronizing signal source is a balance wheel driver unit comprising a drive coil, a detection coil, transistor elements and balance wheels, and said synchronous coil magnetically coupled with the rotor of said transistor motor is disposed in the vicinity of said rotor.

7. A battery-driven cordless induction clock in accordance with claim **6**, in which the axial direction of said induction coil, the axial direction of the balance wheel of said standard oscillation source, and the axial direction of the rotor of said transistor motor unit are disposed in parallel with each other on the same plane.

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