Feb. 3, 1970 W. KOHLHAGEN 3,492,807

TIME-SETTABLE SLAVE CLOCK UNIT

Filed Aug. 3, 1967 2 Sheets-Sheet 1

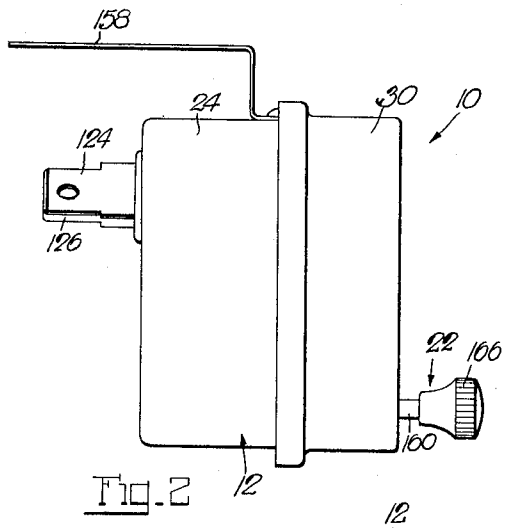


Fig. 2

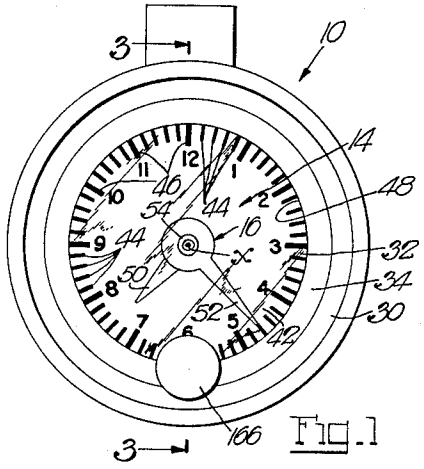


Fig. 1

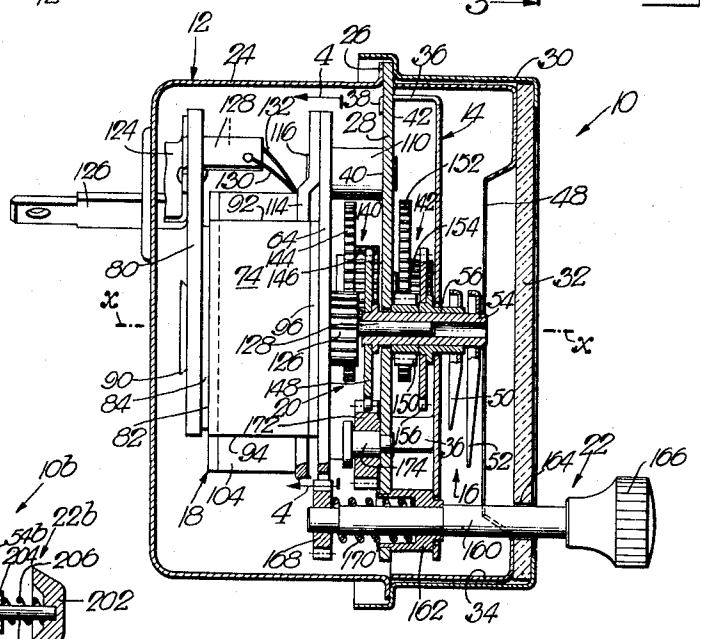


Fig. 3

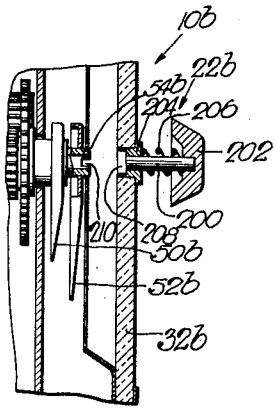


Fig. 6

INVENTOR
Walter Kohlhagen
BY
Attorney.

Feb. 3, 1970 W. KOHLHAGEN 3,492,807

TIME-SETTABLE SLAVE CLOCK UNIT

Filed Aug. 3, 1967 2 Sheets-Sheet 2

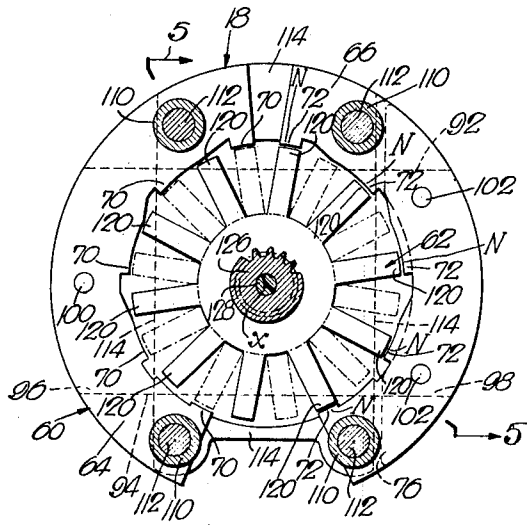


Fig. 4

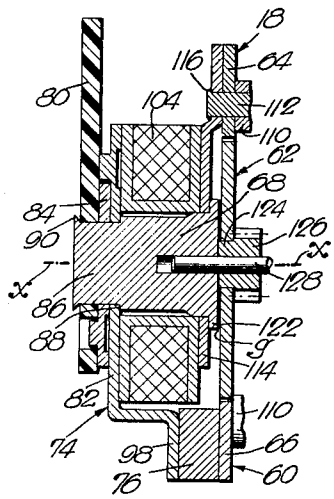


Fig. 5

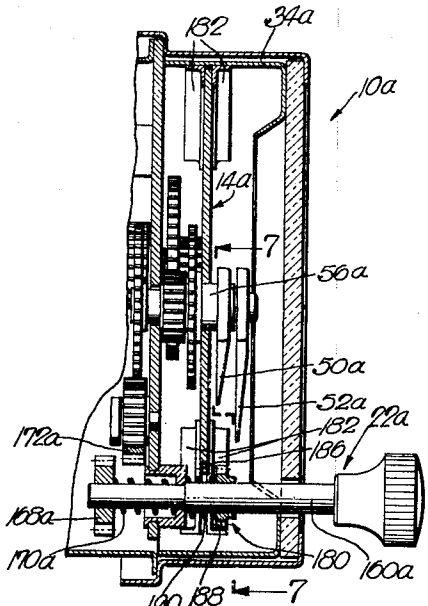


Fig. 6

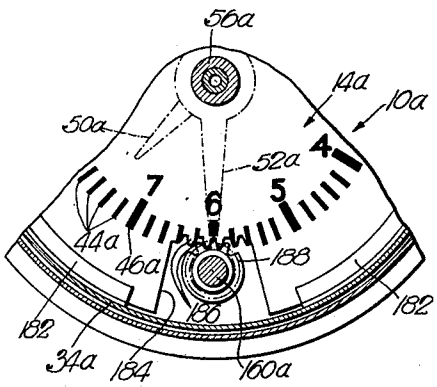


Fig. 7

INVENTOR
Walter Kohlhagen
BY
Walter Kohlhagen
Attorney.

United States Patent Office 3,492,807
Patented Feb. 3, 1970

3,492,807

TIME-SETTABLE SLAVE CLOCK UNIT

Walter Kohlhagen, Elgin, Ill., assignor to The Amphenol Corporation, Broadview, Ill., a corporation of Delaware

Filed Aug. 3, 1967, Ser. No. 658,275
Int. Cl. G04c *13/10*
U.S. Cl. 58—26 12 Claims

ABSTRACT OF THE DISCLOSURE

In a slave clock unit having a step motor with a field, a field coil and a rotary armature, the armature steps equally and unidirectionally into recurring stop positions on applying successive D.C. pulses to the coil, with the armature being between steps magnetically coupled to the field against displacement from its stop positions, and having a drive connection with time-indicating hands. Also provided is a manually operable element drivingly connectible with the drive connection for setting the hands, whereby during setting the armature is moved along.

This invention relates to clocks in general, and to automobile clocks in particular.

The automobile clocks with which the present invention is concerned are of slave-type, having a time-indicating slave unit with a powering step motor, and a remote timing unit which through wiring delivers timed D.C. pulses to the step motor. While these clocks have well-known advantages over the more conventional single-unit automobile clocks, they have hardly come into use due to cost and other factors involved in the slave unit.

It is an object of the present invention to provide for such an automobile clock a slave unit which is of sufficiently low cost and accurate and reliable performance to make its use in automobiles not only attractive but even more desirable than present conventional clocks.

It is another object of the present invention to provide such a slave unit which, besides being of low cost and accurate and reliable in its time-keeping response to a remote timing unit, is particularly immune to riding shock and vibration in its usual location on the dashboard or for that matter at any other location in an automobile.

It is a further object of the present invention to provide such a slave unit which is of exceedingly simple and rugged construction and lends itself to efficient mass production at very low cost, and which may also be made of particularly small size, whereby the slave unit may readily be fitted to most any available or desirable space on the dashboard and its mount behind the dashboard may be the simplest possible.

Another object of the present invention is to provide such a slave unit in which the armature of the step motor is coupled directly to a simple reduction gear train for the hour and minute hands, and the step motor responds to timed D.C. pulses with abrupt, snap-like steps of its armature which are as abruptly transmitted through the gearing to the hour and minute hands. With the step motor thus responding to D.C. pulses, the same and with its slave unit are particularly immune to shock and vibration.

A further object of the present invention is to provide such a slave unit in which the graduations on the time dial are arranged for cooperation with the hour and minute hands between steps thereof, and provision is made whereby after any setting of the hands the time denoted by the respective positions of the latter between steps will as unmistakably be indicated by these hands on the dial graduations, with the hour and minute hands coming between steps to rest positions in which they are invariably in progressive accurate alignment with all hour and minute graduations, respectively. Preferably, the dial has 60 equi-angularly speed graduations for a twelve-hour span, for example, and the hands step at one-minute intervals, so that the minute hand will after each step be in alignment with a dial graduation.

It is another object of the present invention to provide such a slave unit in which the aforementioned provision is in the form of the simplest clock-hand setting mechanism, involving a manual drive of the entire drive system of the unit from the motor armature to the hands, with the manual drive being connectible with the gearing between the armature and hands at a stage of its reduction at which the entire system may be driven with little manual effort. Thus, with the armature stepping equally and into the exact same recurring stop positions in which it is held by magnetic coupling to the field between D.C. pulses, except when such magnetic coupling is overpowered when setting the hands, and with the hour and minute hands having once been set correctly on their shafts to align with respective hour and minute graduations on the dial, the armature will after each setting of the hands return to correct stepping in phase with the motor field at which the hour and minute hands will, as before, come between steps to rest positions in which they are in progressive accurate alignment with all hour and minute dial graduations, respectively. Moreover, this setting mechanism and its mode of operation entirely eliminate the heretofore required friction device or even more expensive provisions for overriding the normal timed drive of the hour and minute hands in conventional setting of the latter. Elimination in this setting mechanism of the usual friction device is of still further importance in that it permits in the first place the use in the slave unit of a step motor. Thus, the time-indicating elements, such as hands or equivalent drums will at the start of a rotor step tend to remain stationary due to inertia so that a force is generated which tends to slip a friction, and a similar condition prevails at the end of a rotor step when the indicating elements will, again due to inertia, tend to overtravel and thus tend to slip the friction. Further, with higher voltage encountered in a car, the rotor will step with greater acceleration and thus increase the tendency of friction slippage. Therefore, in order to be effective at all, a friction would have to be held to extremely close limits, and even then may be subjected to operational slippage and attendant creepage of the time-indicated elements out of proper time setting due to acceleration and declaration forces. The present invention eliminates these serious disadvantages of frictions altogether.

It is a further object of the present invention to provide such a slave unit in which the setting mechanism is arranged so that the clock hands will be moved with little manual effort, yet on manipulation of the mechanism for hand setting there is distinctly felt even the momentary magnetic coupling of the armature to the field as it is being dragged through one or more of its normal recurring stop positions, thereby clearly indicating to the one manipulating the mechanism that setting of the minute hand to a fraction of a minute is impossible and that this hand will come to a stop in alignment with that minute graduation on the dial which, if not corresponding exactly to the desired time setting, is closest to it, which is sufficiently accurate for most slave units.

Another object of the present invention is to provide such a slave unit in which the hands step at the aforementioned exemplary minute intervals under the control of a remote timing unit that may apply D.C. pulses to the stepping motor at recurring moments more or less at variance with full minutes of the actual time, yet these hands may nevertheless be set with virtual absolute time accuracy relative to the dial graduations. This is achieved

by providing, in addition to the aforementioned setting mechanism, a manual device for adjusting the dial relative to the hands over a range which need not be greater than, and may be as little as one-half of, the spacing of the minute graduations on the dial. Thus, on setting the hands at the exact time of 8:30, for example, to the exact corresponding positions on the dial, i.e., with the minute hand in alignment with the "30" minute graduation on the dial, and the hands step the next time after 15 seconds, for example, from the time of setting, this means that the time indicated by the hands on the dial at the end of this next step is 45 seconds ahead of the then actual time. With the one setting the hands being aware of this, he or she need merely adjust the dial backwards at any time thereafter a distance of three-quarter of the spacing of the minute graduations in order to bring the time indication of the hands on the dial into exact accord with the actual time. Thus, with the dial so adjusted and the minute hand thereafter stepping in this example to the 45 second positions between successive minute graduations, the dial will at the end of each step of the hands indicate the exact actual time at the moment which is 15 seconds to the next full minute of the actual time. Of course, adjustability of the dial to the end explained is for the discriminating driver and need not be resorted to by many who prefer stepping of the minute hand into alignment with successive minute graduations on the dial and are not in the least concerned with the difference between the indicated and actual times which is negligible in any event, being at the most a fraction of a minute.

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

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

FIG. 1 is a front view of a slave clock embodying the present invention;

FIG. 2 is a side view of the same slave clock;

FIG. 3 is an enlarged section through the slave clock taken substantially on the line 3—3 of FIG. 1;

FIG. 4 is a section through part of the slave clock as taken substantially on the line 4—4 of FIG. 3;

FIG. 5 is a section through the same part of the slave clock as taken substantially on the line 5—5 of FIG. 4;

FIG. 6 is a fragmentary section through a slave clock embodying the present invention in a modified manner;

FIG. 7 is a fragmentary section through the modified slave clock as taken substantially on the line 7—7 of FIG. 6; and

FIG. 8 is a fragmentary section through a slave clock embodying the invention in a further modified manner.

Referring to the drawings, and more particularly to FIGS. 1 to 5 thereof, the reference numeral **10** designates a slave clock for use especially, though not exclusively, in automobiles. The slave clock has as its major components a case **12**, a dial **14**, time-indicating hands **16**, a stepping motor **18**, a drive **20** between the motor **18** and the hands **16**, and setting mechanism **22** for the hands **16**.

The case **12** is in this instance cup-shaped and has on its annular rim **24** an endflange **26** to which is suitably secured a front plate **28** that serves as a mount for most of the operating components of the clock (FIG. 3). Also suitably secured to the endflange **26** of the case **12** is a bezel **30** for a crystal **32** which is held in position therein by a retainer **34**.

The dial **14** is in this instance generally disc-shaped and provided with a plurality of rearwardly turned legs **36** that bear against the front plate **28** and have tab extensions **38** which extend through apertures in the front plate and are bent against the rear face **40** of the latter for the mount of the dial **14** on the front plate **28** in forwardly spaced relation therewith (FIG. 3). The dial **14** is on its front face **42** provided with minute and hour graduations **44** and **46** which in this instance are arranged circularly about an axis x which is the major axis of the clock. The retainer **34** provides a window opening **48** through which to view the graduated portion of the dial (FIG. 1).

The time-indicating hands **16** are in this instance an hour hand **50** and a minute hand **52** which cooperate with the time dial **14**. The minute hand **52** is mounted in usual manner on the forward end of a minute shaft **54** in front of the dial **14**, with this shaft **54** being mounted for rotation about the axis x in a manner described hereinafter. The hour hand **50** is also mounted in usual manner on the forward end of an hour shaft **56** in front of the dial **14**, with this shaft **56** being hollow and mounted on the minute shaft **54** for independent rotation about the axis x.

The stepping motor **18**, which may be, and in the present example is, like that shown in my copending application Ser. No. 550,756, filed May 17, 1966, has a field **60** and an armature or rotor **62**. The field **60** provides in this instance two ferromagnetic field plates **64** and **66**, a ferromagnetic core **68** and magnetic flux paths between the core **68** and respective field plates **64** and **66** (FIGS. 4 and 5). The field plates **64** and **66** are formed with sets of field poles **70** and **72** which in this instance are arranged circularly about the axis x that is also the rotary axis of the rotor **62**. The magnetic flux paths between the core **68** and respective field plates **64** and **66** are formed by a ferromagnetic field strap **74** and also by a permanent magnet **76**. The core **68**, which is centered on the axis x, is mounted in the bottom **82** of the field strap **74** through intermediation of a back plate **80** and a washer **84**. The core **68** is thus mounted in the field strap **74** by a reduced shank **86** of the core **68**, of which a shoulder **88** bears against the bottom **82** of the field strap **74** and the outer end is at **90** staked to the back plate **80** (FIG. 5). The field plates **64** and **66** are carried by the field strap **74** at the top thereof, with the permanent magnet **76** being in this instance interposed between the field plate **66** and field strap **74**. The field strap **74** is in this instance cut away on opposite sides as at **92** and **94** (FIGS. 3 and 4) so as to be in the form of a field strap having at its top outwardly extending endflanges **96** and **98** of which endflange **98** (FIG. 5) is axially nearer the strap bottom **82** than is the other endflange **96** (FIG. 3). The field plates **64** and **66** are secured to the endflanges **96** and **98** of the field strap by suitable fasteners **100** and **102** (FIG. 4), with the permanent magnet **76** being interposed between field plate **66** and the lower endflange **98** so that both field plates **64** and **66** are axially on the same level (FIG. 5). Also included in the field **60** is a field coil **104** which is arranged in the field strap **74** in surrounding relation with the center core **68**. The motor **18** is mounted on the front plate **28** in rearwardly spaced relation therewith by pillars **110** and pins **112** (FIGS. 3 to 5) of which the pins **112** extend through the field plates **64**, **66** and through an assembly plate **114** and are at **116** staked to the rear face of the latter. The plate **114** serves in this instance for initial assembly of the field plates **64** and **66** with their respective field poles **70** and **72** in accurate coordination with each other, with the field plates being to this end preassembled with the plate **114** by the pins **112**, whereupon this preassembly is at **100** and **102** secured to the endflanges **96** and **98** of the field strap **74** (FIG. 4) and thus assembled with the rest of the field **60**. Since the assembly plate **114** bridges both field plates **64** and **66** (FIG. 4), the same is of any suitable non-magnetic material to prevent magnetic short-circuiting of the field plates across this assembly plate. A more detailed description of the arrangement and advantages of this assembly plate **114** is given in my aforementioned copending application Ser. No. 550,756.

The rotor **62** is in this instance a ferromagnetic plane disc having on its outer periphery poles **120** which cooperate with the field pole sets **70** and **72**, with all poles being coordinated in a manner described hereinafter for rotor stepping on each energization and deenergization of the

field coil **104**. The rotor **62** is mounted for rotation about the axis *x*. In the present instance, the rotor **62** is secured to a shank **124** of a drive pinion **126** on a shaft **128** which is journalled in the center core **68**. The rotor **62** is in sufficiently close proximity to the center core **68** to form a continuing flux path therewith in magnetic circuits across the rotor **62** and respective field plates **64** and **66**. Thus, the flux path of one magnetic circuit is from the permanent magnet **76** via field strap **74**, center core **68**, rotor **62** and field plate **66** back to the magnet **76**, with this circuit being permanently closed owing to continuous flow therein of flux emanating from the permanent magnet **76**. The flux path of the other circuit is via the other field plate **64**, rotor **62**, center core **68** and field strap **74** back to the field plate **64**, with this circuit being an electromagnetic circuit which is closed on coil energization and otherwise interrupted.

The rotor poles **120** are in this instance equi-angularly spaced and also of equal peripheral width. The sets of field poles **70** and **72** are coordinated with each other in the exemplary manner shown in FIG. 4, with the main characteristic of their coordination being that the field poles of either set **70** or **72** are in full register with their nearest rotor poles **120**, while the field poles of the other set are out of full register with their nearest rotor poles **120** to such an extent that the rotor **62** will on the next coil energization and de-energization step clockwise from the exemplary full-line position into the dot-and-dash line position and then into the full-line position in FIG. 4, with the rotor thus stepping a distance equal to the spacing of successive field poles **72**. Thus, assuming that the polarity of the field poles **72** in the described permanent magnetic circuit is N as indicated in FIG. 4, the induced polarity of their nearest rotor poles **120** is then S when the described electromagnetic circuit is interrupted, wherefore these rotor poles will be attracted into full register with the field poles **72** (FIG. 4). Now on passing D.C. current through the field coil **104**, and on first arranging this coil to induce on energization S polarity in the field poles **70** in the electromagnetic circuit, the rotor poles **120** cooperating with the field poles **70** will assume N polarity in the same electromagnetic circuit and, hence, be attracted clockwise to their nearest field poles **70** from the full-line position into the interim dot-and-dash line position in FIG. 4, with this initial phase of a rotor step being unfailing owing to provisions to be explained to impress substantially the entire rotor **62**, including all of its poles **120**, with the same N polarity on closure of the electromagnetic circuit so that the rotor poles cooperating with the field poles **72** will then also be repelled from the latter with their exemplary N polarity. The rotor **62** will thus remain in the interim dot-and-dash line position in FIG. 4 while the field coil **104** remains energized. However, as soon as the coil **104** is deenergized and the electromagnetic circuit interrupted in consequence, the permanent circuit will solely take over and by the then induced S polarity in the rotor poles **120** nearest the field poles **72** of N polarity attract these rotor poles into full register with the field poles **72** with ensuing passage of the rotor through a final phase of a step from the dot-and-dash line position into the full-line position in FIG. 4. Unidirectional, in this example clockwise, stepping of the rotor **62** is achieved by appropriate unbalanced arrangement of the field poles **70** and **72** as shown in FIG. 4 and as more fully described in my aforementioned copending application Ser. No. 550,756. It also follows from the preceding that an operational step of the rotor **62** is divided into two phases, namely an initial phase on coil energization and a final phase on coil deenergization.

Significantly, the field coil **104** is placed around the center core **68** which is a flux path common to both described magnetic circuits, and the center core **68** and rotor **62** are coordinated so that the magnetic reluctance between them is particularly low. This particularly low magnetic reluctance between them is in this instance achieved by dimensioning the center core **68**, and particularly its end **122**, so that its cross-sectional area is quite substantial and way beyond possible magnetic saturation under any operating conditions, and by keeping an equally substantial surface area of the rotor **62** spaced from the core end **122** by a minimal gap *g*. The minimal gap *g* is maintained in this instance by having the rotor **62** narrowly spaced from the end of the pinion shank **124** which rests and runs on the center core **68** (FIG. 5). With this arrangement, the flux flow through the core **68** in consequence of energization of the coil **104** will even at fairly low ampere-windings of the latter sufficiently dam the flux flow through this core emanating from the permanent magnet **76** to achieve substantially throughout the core end **122** the singular coil-induced polarity and a quite high magnetic potential, and the particularly low reluctance between the core end **122** and rotor **62** will compel substantially the entire rotor, including all of its poles **120**, to assume the aforementioned singular coil-induced polarity of the core end **122** and also be of substantially the same high magnetic potential as the latter when the coil is energized. Thus, owing to the explained magnetic circuits and their actions in the present motor, each rotor step in consequence of energization and deenergization of the field coil is quite forceful and snap-like, especially when the field coil receives, as contemplated, brief periodic D.C. pulses that do not permit the rotor to dwell between initial and final step phases in the interim dot-and-dash line position in FIG. 4, and, instead, compel the rotor to surge without pause through each complete step. The present motor thus steps with its rotor equally and unidirectionally into recurring stop positions on applying successive D.C. pulses to the field coil, and the rotor is between steps magnetically coupled to the field against displacement from these stop positions. Of course, in lieu of the described motor **18**, any other known step motor of the same or similar operational characteristics just described may be used in the present slave clock.

The back plate **80**, serving as a board for electric terminals **124** and **126**, is of any suitable electrical insulation material, with the terminals **124** and **126** projecting beyond the rear of the case **12** for application thereto of wires from a timer unit to-be-described, and having tabs **128** for connection with the respective ends **130** and **132** of the field coil **104** (FIG. 3).

The drive between the motor **18** and time-indicating hands comprises in this instance two reduction gear trains **140** and **142**, of which gear train **140** drivingly connects the motor **18** with the minute shaft **54**, and gear train **142** drivingly connects the minute and hour shafts **54** and **56**, with the gear trains **140** and **142** being in this instance arranged behind and in front of the front plate **28**. Also, the minute shaft **54** is in this instance hollow and conveniently mounted for independent rotation on the shaft **128** of the drive pinion **126** which carries the rotor **62** of the stepping motor. The gear train **140** has in this instance two reduction stages of which the first stage is formed by the drive pinion **126** and a therewith meshing gear **144**, and the second stage is formed by a pinion **146** and a therewith meshing gear **148** which is fast on the minute shaft **54**, with the gear **144** and pinion **146** being coaxial and turnable in unison on a suitable rear stud (not shown) on the front plate **28**. The other gear train **142** has in this instance also two reduction stages, of which a first stage comprises a fast pinion **150** on the minute shaft **54** and a therewith meshing gear **152**, and the second stage comprises a pinion **154** and a therewith meshing gear **156** which is fast on the hour shaft **56**, with the gear **152** and pinion **154** being coaxial and turnable in unison on a suitable front stud (not shown) on the front plate **28**.

Preferably and advantageously, the drive of the minute shaft **54** is arranged so that the latter steps sixty times for one complete revolution, and the total number of graduations on the dial **14** is sixty, whereby in operation of the clock the minute hand **52** will step into accurate alignment

with successive dial graduations once this hand has been adjusted into accurate alignment with any dial graduation preferably at the factory. Thus, with the exemplary number of field poles of the motor **18** being ten and the rotor **62** thereof stepping through a distance equal to the pitch of the field poles, i.e., 36°, it stands to reason that the reduction of the gear train **140** must be six to one in order that the minute hand **52** will with each step of the rotor step through 6° which is equal to the spacing of the exemplary 60 dial graduations. On the other hand, with the range of the dial **14** being in this instance 12 hours, the reduction of the other gear train **142** must be twelve to one in order that the hour hand **50** will for each revolution of the minute hand **52** pass through one-twelfth of a revolution.

With the drive of the minute and hour hands being arranged in the exemplary manner described above, it stands to reason that the rotor **62** must step once in every minute in order that the hands **50** and **52** may indicate the actual time on the dial **14**. Accordingly, the field coil **104** of the motor must receive a D.C. pulse once every minute. These pulses are supplied by a remote timing unit of any known type which is connected with a battery and by suitable timing means delivers D.C. pulses at exact one-minute intervals to the field coil **104** via the aforementioned wires and the terminals **124** and **126**. With the present slave clock **10** being an exemplary auto clock which is usually mounted on the dashboard, the remote timing unit (not shown) may be mounted at any othe convenient place in an automobile where it is well protected and least exposed to riding shock and vibration. Further, with the timing unit being thus separated from the slave clock, and the latter being in its reliable performance for all practical purposes immune to riding shock and vibration owing to the forceful and snap-like stepping of the rotor **62** and parts driven thereby, and the equally forceful magnetic coupling with the field of the rotor in its recurring stop positions between steps, the mount of the slave clock may be the simplest possible. In the present instance, the slave clock **10** has for its exemplary mount behind a dashboard in an automobile a simple mounting bracket **158** (FIG. 2).

The setting mechanism **22** provides in this instance a set stem **160** which is turnable and axially slidable in a bushing **162** in the front plate **28** (FIG. 3). The set stem **160**, which extends through an aperture **164** in the crystal **32**, carries a knob **166** at its front end and a pinion **168** at its rear end, with the set stem being normally urged into the retracted or inactive position in FIG. 3 by a spring **170**. In accordance with an important aspect of the present invention, the entire normal drive of the hands **50** and **52**, including the rotor **62** of the motor, is to be operated for setting the hands, with the gear **168** on the set stem **160** being to this end drivingly connectible with this drive, and in this instance with the reduction gear train **140** for operating the same with relatively little manual effort. With the set stem **160** being necessarily out of the sweep region of the minute hand **52** and preferably also largely outside the confines of the window opening **48** in the crystal retainer **34** (FIG. 3), the pinion **168** on the set stem is well out of reach of any of the gears of the train **140**. To bring this pinion **168** within operating reach of the gear train **140**, there is provided an idler pinion **172** which is turnable on a rear stud **174** on the front plate **28**, and which in this instance is in mesh with the gear **148** of the train **140**. Thus, on pulling the set stem **160** at the knob **166** forward against the spring **170** to mesh the set pinion **168** with the idler pinion **172**, and then turning the knob **166**, both gear trains **140**, **142** and the shaft and hand parts **52** to **56** connected therewith will be driven, with the rotor **62** of the motor being also dragged along against the resistance it encounters by virtue of its magnetic coupling to the field between pulse-induced steps. With the gear **148** of the train **140** being carried by the minute shaft **54**, and by virtue of the interposition of the idler pinion **172** between this gear **148** and the set pinion **168**, the hands **50** and **52** will advantageously be set in the same direction in which the knob **166** is turned.

In thus setting the hands **50** and **52**, the rotor **62** will after each setting of the hands return to correct stepping in phase with the motor field at which the hour and minute hands will, as before, come between steps to rest positions in which they are in progressive accurate alignment with all hour and minute graduations, respectively. It is of particular importance, however, that the present setting mechanism and its mode of operation entirely eliminate the heretofore required friction device or even more expensive provisions for overriding the normal timed drive of the hour and minute hands in conventional setting of the latter. Elimination in this setting mechanism of the usual friction device is of still further importance in that it permits in the first place the use in the slave clock of a step motor of the forceful and snap-like stepping of its rotor and ensuing advantages, for with inevitable changes in any applied battery voltage and also with different indicated battery voltages for various automobile makes, it would be virtually impossible to provide in a slave clock a friction device which would not slip in normal stepping of the motor under inertial reaction to such motor stepping of the drive beyond the friction device of the clock hands, or for that matter of time-indicating drums, in either hesitating to start stepping with the motor or failing to come to a stop exactly at the end of a motor step, or both, with the result that the clock would inevitably malfunction in its time-indicating performance.

Setting of the hands **50** and **52** via the reduction gear train **140**, and more especially via the last gear **148** in the two-stage reduction thereof, is further advantageous in that the clock hands may be set with little manual effort, yet on manipulation of the setting mechanism there is distinctly felt even the momentary magnetic coupling of the rotor to the field as it is being dragged through one or more of its normal recurring stop positions, thereby clearly indicating to the one manipulating the mechanism that setting of the minute hand to a fraction of a minute is impossible and that this hand will come to a stop in alignment with that minute graduation on the dial which, if not corresponding exactly to the desired time setting, is closest to it, which is sufficiently accurate for most slave clocks. Of course, there is also this to consider that the time indicated on the dial by the minute hand immediately after each step thereof is most likely at some variance with the corresponding full minute of the actual time, because the remote timing unit will apply D.C. pulses to the stepping motor at the exemplary recurring one-minute intervals which more likely than not are not precisely concurrent with full minutes of the actual time. It will be appreciated, however, that whatever variance there may be between a full minute indication of the time by the clock and the actual time at the same full minute, such variance is in any event exceedingly small and, hence, negligible, for all practical purposes.

Reference is now had to FIGS. 6 and 7 which show a modified slave clock **10*a*** in which the hour and minute hands **50*a*** and **52*a*** step at the same exemplary minute intervals under the control of a remote timing unit that may apply D.C. pulses to the stepping motor at such intervals more or less at variance with full minutes of the actual time, yet these hands may nevertheless be set with virtual absolute time accuracy relative to the minute and hour graduation **44*a*** and **46*a*** on the dial **14*a***. This is achieved by providing, in addition to the setting mechanism **22*a***, a manual device **180** for adjusting the dial **14*a*** relative to the hands **50*a***, **52*a*** over a range which need not be greater than, and may be as little as one-half of, the spacing of the graduations on the dial. The device **180** provides for limited turnability of the dial **14*a*** on the one hand, and for its manual adjustment on the other

hand. For its turnability, the dial **14***a* is in this instance turnable on the hour shaft **56***a* and additionally peripherally guided in ways formed by spaced legs of angle-like members **182** in the crystal retainer **34***a*. For its angular adjustability, the dial **14***a* has a peripheral notch **184** the bottom edge of which is in the form of a few teeth **186**, and there is further provided a pinion **188** which may be meshed with the dial teeth **186** and turned for adjustment of the dial. The pinion **188** is in this instance carried by the set stem **160***a* and normally held out of mesh with the dial teeth **186** by a spring **190** which coacts with the spring **170***a* in normally biasing the set stem into the inactive position in FIG. 6. Thus, in order to set the hands **50***a* and **52***a*, the set stem **160***a* is pulled forwardly against the force of the spring **170***a* to mesh the set pinion **168***a* with the idler pinion **172***a*, whereupon the set stem is turned for the desired hand setting. On the other hand, the dial **14***a* may be angularly adjusted on pushing the set stem **160***a* inwardly against the force of the spring **190** in order to bring the pinion **188** into mesh with the dial teeth **186**, whereupon the set stem is turned very slightly in any event and in the required direction.

Assuming now that the hands **50***a*, **52***a* are set at the exact time of 7:30, for example, to the exact corresponding positions on the dial as shown in dot-and-dash lines in FIG. 7, and the hands step the next time after 15 seconds, for example, from the time of setting, this means that the time indicated by the hands on the dial at the end of this next step is 45 seconds ahead of the then actual time. With the one setting the hands being aware of this, he or she need merely adjust the dial **14***a* at any time thereafter, backwards in this example, a distance of three-quarter of the spacing of the minute graduations in order to bring the time indication of the hands on the dial into exact accord with the actual time. Thus, with the dial **14***a* so adjusted and the minute hand thereafter stepping in this example to the 45 second positions between successive minute graduations, the hands will at the end of each step indicate on the dial the exact actual time at the moment which is 15 seconds to the next full minute of the actual time. Of course, adjustability of the dial to this end is for the discriminating driver and need not be resorted to by many who prefer stepping of the minute hand into alignment with successive minute graduations on the dial and are not in the least concerned with the difference between the indicated and actual times which is negligible in any event, being at the most a fraction of a minute.

Reference is now had to FIG. 8 which shows a slave clock **10***b* that may in all respects be like the described clock **10** of FIGS. 1 to 5, except that the setting mechanism **22***b* is different. Thus, the present clock **10***b* lacks the set stem **160**, set pinion **168** and idler pinion **172** of the clock **10** and, instead, provides a plunger **200** with a knob **202** for operating the entire drive of the hands **50***b* and **52***b* via the minute shaft **54***b*. To this end, the plunger **200** is turnable and axially movable in a bushing **204** in the crystal **32***b*, and is urged by a spring **206** into the retracted position shown in which a flat tongue formation **208** at the inner end of the plunger bears against the bushing **204**. The forward end of the minute shaft **54***b* is provided with a transverse groove **210** in which the tongue formation **208** is fittedly received on depressing the plunger **200** inwardly and appropriately turning the same at the knob **202** to bring the tongue formation **208** into register with the groove **210**. On then turning the plunger **200** at the knob **202**, the hands **50***b* and **52***b* will be set, as will be readily understood.

While the present invention has been demonstrated to advantage in the form of a time-indicating slave clock, it is obvious that prominent features of the invention apply equally to devices other than time-indicating devices, such as counters, for example, which have in common with a time-indicating slave clock the counting of applied pulses and setting or resetting of a stepping counting element.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

What is claimed is:

1. A slave clock unit having a step motor with a field including a set of poles, a field coil, and a rotary armature including a set of poles, of which poles of one of said sets have permanent polarities, with the poles of said sets cooperating to step said armature unidirectionally into recurring stop positions on applying successive D.C. pulses to said coil, and said permanent polarity poles of said one set cooperating with poles of the other set magnetically to couple said armature between steps to said field against displacement from said stop positions; means for indicating the time in hours and minutes, said means including a rotary minute shaft and reduction gearing connecting said armature and shaft for the drive of the latter by said armature at a reduced rate; and manual time-setting mechanism including an element drivingly connectible with said time indicating means to operate the latter, whereby during time setting between successive armature steps of said time-indicating means for each time interval corresponding to one armature step said armature is first dragged along against the force of its magnetic coupling with said field in any stop position and then magnetically attracted into the next succeeding stop position.

2. A slave clock unit, having a step motor with a field including a set of poles, a field coil, and a rotary armature including a set of poles, of which poles of one of said sets have permanent polarities, with the poles of said sets cooperating to step said armature equally and unidirectionally into recurring stop positions on applying successive D.C. pulses to said coil, and said permanent polarity poles of said one set cooperating with poles of the other set magnetically to couple said armature between steps to said field against displacement from said stop positions; time-indicating means providing first and second shafts carrying minute and hour hands, respectively, a first reduction gear train between said armature and first shaft for the drive of the latter by the former at a reduced rate, and a second reduction gear train between said shafts for the drive of said second shaft by said first shaft at a reduced rate; a graduated time dial with which said hands cooperate; and manual setting means including an element drivingly connectible with said time-indicating means to operate the same for setting said hands, whereby during setting between successive armature steps of said hands for each time interval corresponding to one armature step said armature is first dragged along against the force of its magnetic coupling with said field in any of said stop positions and then magnetically attracted into the next succeeding stop position.

3. A slave clock unit as in claim **2**, in which said element of said setting means is engageable with said first gear train.

4. A slave clock unit as in claim **2**, in which said first gear train is of a reduction to step said first shaft through one-sixtieth of a revolution for each step of said armature, and said dial carries equi-angularly spaced minute graduations with successive ones of which said minute hand aligns in stop positions between successive steps of a recurring number of said first shaft.

5. A slave clock unit as in claim **4**, in which there are sixty of said minute graduations on said dial, wherefore said minute hand will between each two successive steps align with successive minute graduations.

6. A slave clock unit as in claim **2**, in which said first gear train has two reduction stages of two gears each, of which the smaller and larger gears of the respective stages are coaxial and turn with said armature and first

shaft, respectively, and said element of said setting means is a set gear drivingly connectible with said larger gear.

7. A slave clock unit as in claim 6, in which said setting means further provides a manually turnable and axially slidable set stem carrying said set gear, and there is further provided an idler gear in mesh with said larger gear turning with said first shaft, with said set gear being by said set stem movable axially into mesh with said idler gear to set said hands in either direction on then turning said stem in the same direction.

8. A slave clock unit as in claim 1, in which said time indicating means also includes an hour shaft telescoped with said minute shaft, with said minute shaft being the inner shaft and extending with its forward end beyond said hour shaft, and there is further provided a crystal located in front of said forward shaft end and having an aperture in axial alignment with said minute shaft, and said time-setting mechanism provides a part mounted in said crystal aperture for rotary and axial movement and having in back and front of said crystal coupling and knob formations, respectively, with said knob formation serving to move said part with its coupling formation into and from coupling relation with said forward shaft end and to turn said part while in coupling relation with said forward shaft end for time-setting operation of said time-indicating means.

9. A slave clock unit as in claim 8, in which said part is with its coupling formation normally spring-retracted from coupling relation with said shaft end.

10. A slave clock unit as in claim 8, in which said coupling formation on said part is a flat key, and said shaft end has a transverse groove in which said key is receivable.

11. A slave clock unit as in claim 2, in which said first gear train is of a reduction to step said first shaft through one-sixtieth of a revolution for each step of said armature, and said dial is turnable about the axis of said first shaft and carries 60 equi-angularly spaced minute graduations with successive ones of which said minute hand aligns in the successive stop positions of said first shaft between successive steps thereof, and there is further provided means for angularly adjusting said dial to afford time indication by the stepping minute hand on the dial of the actual time within any fraction of a minute.

12. A slave clock unit as in claim 2, in which said setting means further provides a manually turnable and axially slidable set stem carrying said element for drivingly connecting the latter with said first gear train and operating the same for setting said hands on shifting said stem into one axial position and turning it in said position, said first gear train is of a reduction to step said first shaft through one-sixtieth of a revolution for each step of said armature, and said dial is turnable about the axis of said first shaft and carries 60 equi-angularly spaced minute graduations with successive ones of which said minute hand aligns in the successive stop positions of said first shaft between successive steps thereof, and there is further provided on said stem a part drivingly connectible with said dial for angularly adjusting the same on shifting said stem into another axial position and turning it in said other position, thereby to afford time indication by the stepping minute hand on the dial of the actual time within any fraction of a minute.

References Cited

UNITED STATES PATENTS

2,242,654	5/1941	Maxwell	58—26
2,242,655	5/1941	Maxwell	58—26
2,308,243	1/1943	Lunden	58—24
2,308,244	1/1943	Lunden	58—24
2,507,798	5/1950	Maxwell	310—49 X
2,607,188	8/1952	Bourquin	58—85.5
2,645,077	6/1953	Olson	58—85.5
2,700,867	2/1955	Doane	58—85.5
3,392,293	6/1968	De Boo et al.	310—49

RICHARD B. WILKINSON, Primary Examiner

EDITH C. SIMMONS, Assistant Examiner

U.S. Cl. X.R.

58—34