Feb. 14, 1956 L. T. McRAE 2,734,336

CLOCK SYSTEM

Filed May 22, 1953

Fig. 1.

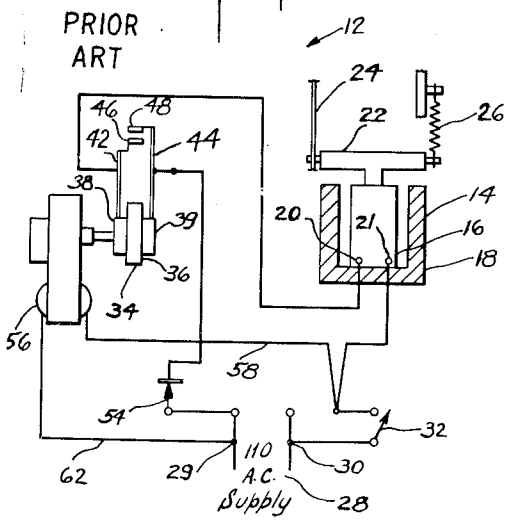


Fig. 2.

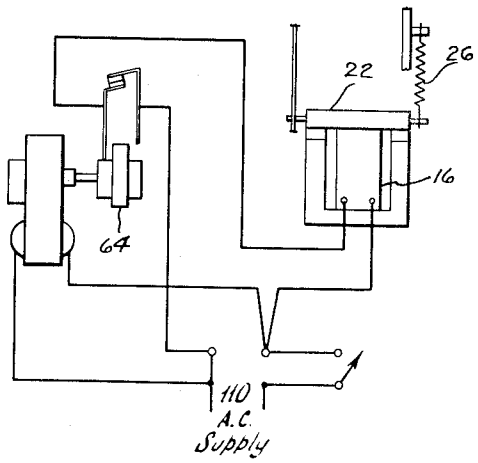


Fig. 3.

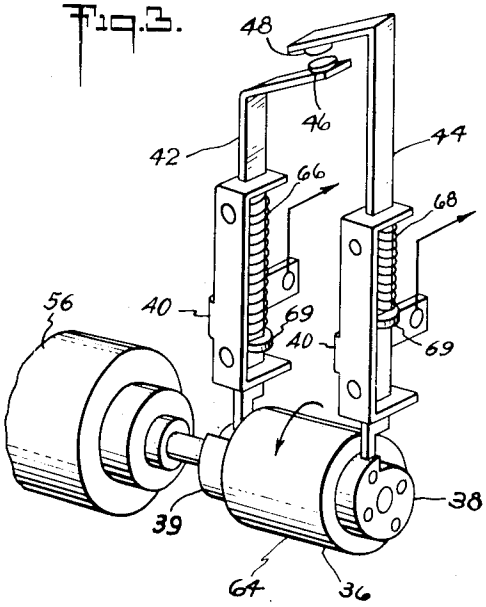
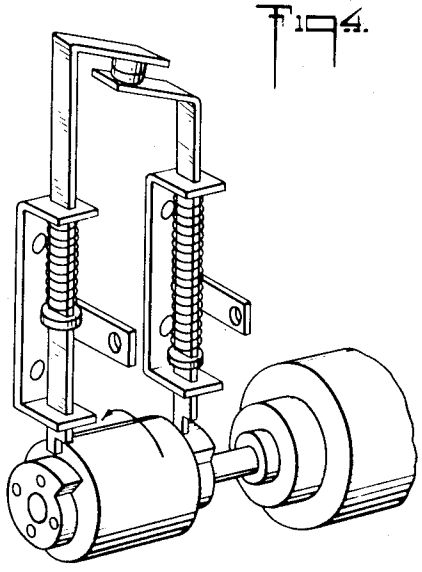


Fig. 4.



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CLOCK SYSTEM

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6 Claims. (Cl. 58—24)

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to improvements in time clocks and more particularly to improvements in time clocks that are solenoid actuated for moving the type wheel of the time clock whereby when a time card is inserted in the clock the time is recorded thereon.

Time clocks of the type used in places of employment by the employees for recording starting time and finishing time on a job have been widely used for a long time. Generally the use of the time clock involves a time card which is adapted to be inserted into a slot provided in the time clock and withdrawn from the slot in the time clock with a record left on the time card to indicate when the card was inserted into the clock. Many of the time clocks now in use rely upon the periodic energization and deenergization of a solenoid coil for advancing a ratchet wheel step-by-step and thereby advancing the clock mechanism. The energization and deenergization of the solenoid is controlled by a periodic switch. A synchronous motor operates the periodic switch and generally causes the switch to close a circuit to the solenoid sixty times an hour. The opening of the switch and the closing of the switch, respectively, occur at identically spaced intervals. An armature is associated with the solenoid and is connected by suitable linkages to the ratchet wheel. The armature is normally biased to one position and adapted to be moved to a second position upon energization of the solenoid through the periodic switch. In time clocks presently in use the solenoid controlled by the periodic switch is energized for a small fraction of the one minute cycle and deenergized for the remainder of the cycle. During the fraction of the cycle that the solenoid is energized the armature is urged into engagement with the magnetic core and/or frame of the solenoid and is substantially immovable relative to the solenoid. During the remainder of each cycle the armature is biased to its other position by a spring and is retained in that position by the spring only; through shock or vibration it is possible to cause the armature to move against the restraint offered by the spring during the latter portion of each cycle. Though it is likewise possible to cause the armature to move relative to the solenoid when the solenoid is energized, the difference in energy level of applied shock required for moving the armature against the bias of the spring as compared to that necessary for moving the armature relative to the energized solenoid is very considerable. In the case of the latter, the applied shock may be ample to effectively destroy the time clock.

In use it has been found that time clocks are tampered with by employees wanting to advance the clock. Where the armature is retained in one position by a spring only for substantially all of a one minute cycle those people who care to tamper with the clock have discovered that by striking the clock manually at a certain average repetition frequency they arrive at the resonant frequency of

the armature and its associated parts causing the latter to vibrate and to thereby advance the ratchet wheel several steps before the vibration is terminated due to energization of the solenoid. Another expedient resorted to by those people who are desirous of advancing the clock is to insert a thin tool into one of the apertures of the clock such as the slot that receives the time card in order to physically move the armature against the bias of the spring thereby advancing the clock. In this case as in case of vibration of the armature due to shock, movement of the armature is substantially impossible during the period of time the solenoid is energized.

This invention improves upon time clocks known to the prior art by increasing the fraction of the cycle during which the solenoid is energized so that the fraction of the cycle during which the solenoid is deenergized is not long enough to permit vibration of the armature, if any, to have any effect on the ratchet wheel. Furthermore, use of a thin tool for moving the armature is discouraged since the armature is relatively immovable practically all the time. One would have to keep applying force continuously on the armature to move it when the solenoid is deenergized.

An object of this invention is to provide an improvement in time clocks.

A further object is to provide an improvement in time clocks which will discourage tampering with the time clocks.

A further object is to provide an improvement in time clocks whereby damage and maintenance are minimized.

A further object is to provide an improved time clock that minimizes pilfered time.

A further object is to provide an improvement in time clocks whereby time clock solenoids are energized for a period of time exceeding a predetermined critical period.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a schematic diagram of a portion of a circuit forming part of one type of time clock sold commercially by a company well-known in the time clock field.

Fig. 2 is a schematic diagram including the improvements of this invention, and

Fig. 3 and Fig. 4 illustrate in two operating conditions a periodic switch that is generally of the type used in a particular time clock embodying the circuit of Fig. 1, and including the necessary modifications and improvements for use in the improved circuit of Fig. 2.

In Fig. 1 there is shown schematically a circuit **12**. The circuit **12** includes a solenoid **14** having a coil **16** that is wound for D. C. operation and a supporting magnetic frame **18**. The coil **16** has terminals **20** and **21**. An armature **22** is mounted on a supporting frame **24**. The supporting frame **24** permits the armature **22** to move into abutting relationship with the magnetic supporting frame **18** of the solenoid **14**. A tension spring **26** biases the armature **22** toward a raised position which the armature **22** occupies when the solenoid **14** is deenergized. When the solenoid **14** is energized the magnetic field generated by the solenoid coil causes the armature **22** to be quickly drawn into abutting relationship with the magnetic supporting frame **18** of the solenoid and against the bias of the spring **26**. In order to insure quick movement of the armature **22** when the solenoid **14** is energized the solenoid is designed to generate a magnetic field which exerts a force that greatly exceeds the force exerted upon the armature **22** by the spring **26**. The armature **22** is adapted to be connected to a suitable linkage mechanism, not shown, for actuating the clock mechanism, likewise not shown.

The solenoid **14** is conventionally periodically energized by an A. C. lighting circuit supply **28**. The circuit between the supply **28** and the solenoid coil **16** is selectively manually controllable by means of a switch **32**. When the switch **32** is closed the circuit including the coil **16** and the supply **28** is cyclically completed and interrupted through a periodic switch **34**.

The periodic switch **34** includes a rotatable support **36** for fixedly mounting a pair of disc cams **38** and **39** in fixed relationship thereto. The pair of contact arms **42** and **44** support a corresponding pair of contacts **46** and **48** respectively. The ends of the contact arms **42** and **44** opposite to those to which the contacts **46** and **48** are secured bear against the periphery of the disc cams **38** and **39**. The disc cams **38** and **39** are so designed that for a small fraction of a complete revolution of the cam support **36** the contacts **46** and **48** are permitted to engage and for the remainder of the revolution the contacts **46** and **48** are separated. The contacts **46** and **48** are in series between one terminal **20** of the solenoid coil **16** and one terminal **29** of the supply **28**. The model **14** time clock produced by the Stromberg Electric Company includes the above described circuit. It further includes a rectifier **54** in series with the terminal **29** of the supply **28** and the terminal **20** of the solenoid coil **16** to permit only unidirectional current to flow through the coil **16**.

The cam support **36** is continuously driven by a synchronous motor **56** at a speed of 1 R. P. M. When the manual switch **32** is in closed circuit position the energization circuit of the synchronous motor is completed and includes the lead **58** electrically connecting one side of the motor to the terminal **30** of the supply **28** through the switch **32**. The other side of the motor **56** is connected to the terminal **29** of the supply **28** by means of a lead **62**. Therefore, whenever the switch **32** is closed the synchronous motor **56** rotates continuously driving the cam support **36** at a constant speed of 1 R. P. M. At precisely the same instant during each cycle or each complete revolution of cam support **36** the contacts **46** and **48** are caused to engage and at precisely the same instant during each cycle the engaged contacts **46** and **48** are permitted to disengage. Since the contacts **46** and **48** are in series in the energization circuit of the solenoid coil **16**, engagement of the contacts **46** and **48** are substantially instantly followed by movement of the armature **22** into abutment with the magnetic supporting frame **18** of the solenoid **14**. Conversely as soon as the contacts **46** and **48** separate the armature **22** is withdrawn by means of the tension spring **26**. The periodic movement of the armature **22** is transferred by a linkage mechanism, not shown, to the ratchet of the time clock and thereby to type wheel, all of which are conventional and consequently not shown.

In use it has been found that time clocks employing this type of circuit are not entirely satisfactory. Employees in numerous places of employment have found that by manually striking the housing of the time clock at a certain repetition frequency, it is possible to cause the armature **22** to vibrate at its resonant frequency thereby advancing the clock by several minutes. Advancing the clock in this manner is achieved by causing the amplitude of vibration to equal the movement caused by energization of the solenoid. Because knowledge of this inherent weakness in this type of time clock can become common knowledge of all the employees called upon to use the time clock in a particular place of employment it can become what may be likened to an attractive nuisance. Employees coming to the time clock several minutes previous to the time that they are supposed to punch out to afford an indication of a complete day's work rendered, and finding that they are a few minutes ahead of time are sorely tempted to strike the clock if they are cognizant of the inherent weakness mentioned above. Even when practiced by a relatively small percentage of the total number of employees this expedient resorted to by the small percentage of the employees can cause a considerable expense in damaged clocks, pilfered time, and an increased need for maintenance service to reset the clock.

Another expedient resorted to by employees attempting to advance the clock is to insert a thin tool such as an engineer's scale or a hooked wire depending upon the arrangement of the armature, in order to force the armature to move against the bias of the spring attached thereto.

To overcome this inherent weakness in time clocks including a circuit of the type shown in Fig. 1, resort is had to increasing the fraction of each cycle during which the solenoid coil is energized. During the interval that the armature is retained in engagement with the frame of the solenoid it is substantially impossible to transfer sufficient energy to the armature to cause it to move relative to the frame of the solenoid against the influence of the magnetic field generated by the solenoid. If the clock were struck with sufficient force to cause the armature to move relative to the energized solenoid, the time clock would be seriously damaged possibly even to the degree that the individual having caused the damage could not punch out.

It has been observed through experiment that there is a critical period of time involved; it is impossible to set up sympathetic vibrations of sufficient amplitude in the armature assembly by manually striking the clock in less than this critical period. This critical period varies in accordance with the mass of the armature. It may be readily determined by experiment. It has been found in practice that if the armature of one clock that has been tried is retained in engagement with the solenoid frame for about fifty-five seconds or more of a sixty-second cycle that insufficient time remains for setting up vibrations in the armature of sufficient amplitude to advance the clock. To insure against tampering with a time clock with a thin tool such as an engineer's scale or wire hook the interval of energization of the solenoid coil may be increased to fifty-eight seconds of a sixty-second cycle or thereabout. It is not likely that anyone would care to risk discovery by holding a tool in position for the necessary period before the solenoid is deenergized for the remaining small fraction of a cycle.

To accomplish this result the circuit of Fig. 1 has been modified as shown in Fig. 2. Substantially all of the circuit modification is centered in the periodic switch. The switch **34** of Fig. 1 has been modified to provide switch **64** for use in the circuit of Fig. 2 and is shown in detail in Fig. 3 and Fig. 4. The only differences between the illustrations of the switch **64** in Fig. 3 and Fig. 4, respectively, are that the views are taken from different directions and that the switch **64** is in open circuit position in Fig. 3 whereas it is in closed circuit position in Fig. 4.

Switch **64** includes a cam support **36**. A pair of substantially identical disc cams **38** and **39** respectively are secured to opposite ends of the cam support **36**. Both disc cams are formed from circular discs and have a peripheral notch. The cam support **36** is fixed to the shaft of a synchronous motor **56**. A pair of brackets **40** are fixedly mounted relative to the motor shaft and each include a pair of guide openings that are aligned with the cams **38** and **39**, respectively. Contact arms **42** and **44** are slidably mounted in the guide openings of the brackets **40**. Compression coil springs **66** and **68** are disposed around the contact arms **42** and **44**, respectively. A collar **69** is secured to each contact arm whereby when the contact arm **42** or **44** is moved upwardly, the corresponding coil spring **66** or **68** is compressed between associated collar **69** and the top of the associated bracket **40**. One end of each of the contact arms **42** and **44** is adapted to bear against a respective one of the cam discs **39** and **38**. The opposite end of the contact arm **42** is bent to define an angle that is somewhat greater than ninety degrees; the opposite end of the contact arm **44** is bent to define an

angle that is less than ninety degrees whereby when the lengths of the contact arms 42 and 44 are parallel the bent ends are parallel. Contacts 46 and 48 are secured to the ends of the contact arms 42 and 44, respectively.

The structure of switch 64 described above is similar to the structure of switch 34, shown in Fig. 1; the switch 34 shown in Fig. 1 corresponds to the switch in model 14 time clock produced by Stromberg Electric Company and mentioned previously in this description.

In switch 34 of Fig. 1, the cams are arranged to cause the contacts 46 and 48 to be separated about two seconds out of every minute. In switch 64, Fig. 3 and Fig. 4, the cams are arranged to cause the contacts 46 and 48 to be engaged on the order of fifty-eight seconds out of every minute. Switch 64 includes substantially the same structure as switch 34 to produce this result. The main difference is that cam support 36 in the switch 64 is assembled on the shaft of motor 56 oppositely to the cam support 36 of switch 34. In other words, if the cam support 36 of switch 34 is disassembled from the motor shaft and then is reassembled on the motor shaft so that the positions of cam discs 38 and 39 are interchanged, the resulting arrangement would be essentially that of the switch 64. Additionally, the direction of rotation of motor 56 of switch 64 is made opposite to that of motor 56 of switch 34. Additionally, while the ends of the contact arms 42 and 44 of switch 34 are bent to define a right angle, the corresponding ends of the contact arms 42 and 44 of switch 64 are bent to define an angle other than a right angle for the reason given below.

Because the disc cams 38 and 39 are substantially identical, both being formed from circular discs having a notch for permitting a rapid inward movement of the contact arms 42 and 44 under the bias of springs 66 and 68 and a smooth outward movement of the contact arms the total result is that the order in which the contacts are permitted to move inwardly is reversed. For example, for the direction of rotation shown in Fig. 3 the contact arm 42 has been permitted to move inwardly dropping into the notch of the disc cam 39 whereas the contact arm 44 is still maintained in raised position and is just about to drop into the notch in the cam 38. Before modification it was the contact arm 44 that moved inwardly first followed by the contact arm 42. In the switch 34 as shown in Fig. 1 the contacts 46 and 48 are supported on portions of the contact arms 42 and 44 that are bent to project perpendicularly to the contact arm. When both of the contact arms 42 and 44 in the periodic switch 34 of Fig. 1 are resting on the circular portions of the disc cams 38 and 39 the contacts 46 and 48 are spaced apart. In the modified switch 64 shown in Figs. 3 and 4 the contact arms 42 and 44 have been bent so that the contacts 46 and 48 are in engagement when the contact arm 42 is bearing against the circular periphery of the disc cam 39 and contact arm 44 is in a raised position above periphery of disc cam 38, as shown in Fig. 4 for a period of from 55 to 58 seconds. The contacts 46 and 48 in the modified switch 64 do not separate until the disc cam 39 rotates to present the notched interruption in its periphery to the arm 42. Since the disc cam 39 presents its notch interruption to the contact arm 42 before the disc cam 38 presents its interruption to the contact arm 44 the two contact arms 42 and 44 separate momentarily until the contact arm 44 moves into the notched interruption in the periphery of the disc cam 38. During the portion of the cycle that the contact arm 42 engages the circular periphery of the disc cam 39 contact arm 44 is supported out of engagement with the disc cam 38 as may be seen in Fig. 4. This insures good continuous contact between the two contacts 46 and 48 during that fraction of the cycle. For substantially an entire revolution the contacts 46 and 48 are engaged as shown in Fig. 4.

The relative angular positioning of the disc cams 38 and 39 determine the fraction of a cycle during which the contacts 46 and 48 are disengaged. The time during which the contacts are disengaged is based upon the result of experiments for determining the critical period for causing the armature to vibrate by manually striking the casing of the time clock. It is not necessary to be cognizant of this critical period where there is no concern over the average current flowing through the solenoid coil 16. In that case the energization of the coil 16 need only be interrupted long enough to permit the armature to be completely retracted by the spring 26. It can then be immediately reenergized. With this mode of operation the possibility that anyone can successfully tamper with the clock is reduced to a minimum.

The modified circuit of Fig. 2 eliminates the rectifier 54 shown in Fig. 1. Instead, the solenoid coil is wound for A. C. operation with attention given to modifications in the core and frame structure of the solenoid for minimum eddy current losses and the like.

In operation the armature 22 associated with the solenoid coil 16 is retained in abutting relationship with the frame of the solenoid for substantially the entire cycle of the periodic switch 64. During a small fraction of the cycle the coil 16 is deenergized permitting the armature 22 to be withdrawn by the spring 26 for the purpose of actuating the mechanism of the time clock. An ancillary result of this arrangement is that the additional heat generated in the solenoid due to the increased average current flow through the coil 16 is of particular advantage where the time clock is used in low temperature environment. Ordinarily in low temperature environment an auxiliary heater is necessary for proper operation of the time clock. However, the additional heating due to the increased current through the solenoid coil 16 makes the need for an auxiliary heater unnecessary.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. In combination with a time clock of the type having an armature, a solenoid for actuating said armature, an electric circuit for energizing said solenoid and a periodic switch in said circuit, said periodic switch including a pair of contacts for opening said circuit to deenergize said solenoid and for closing said circuit to energize said solenoid, the improvement comprising; means in said periodic switch for positively closing said contacts for a time extending from the beginning of a predetermined period to just prior to the end of the period and for positively opening said contacts for the remainder of the period whereby said armature is actuated for substantially all of the predetermined period.

2. A time clock as defined in claim 1 wherein said means includes cam means.

3. A time clock as defined in claim 2 wherein said switch includes a pair of parallel reciprocative members for supporting said contacts, and said cam means includes a pair of disc cams, one for each of said members.

4. A time clock comprising an armature movable to a first position and second position, a spring biasing said armature to said first position, a solenoid for actuating said armature to said second position, an electric circuit for energizing said solenoid, a periodic switch in said circuit having a pair of parallel reciprocative members, a contact supported by each member for opening said circuit to deenergize said solenoid and for closing said circuit to energize said solenoid, a pair of disc cams, one for each of said members, biasing means for each of said members to bias said members against the respective disc cams, each of said cams being substantially circular and formed with a brief interruption, the interruptions being staggered whereby said contacts are normally engaged, but are separated during the time interval required for an angular movement of the disc cams equal to the angular staggering of the interruptions.

5. The time clock defined in claim 4 wherein the inter-

ruptions in the cams are slightly staggered to permit a short break and a long make.

6. A method of operating a time clock through periodic, substantially instantaneous, movement of a mass between two limits, said method comprising the steps of continuously applying a first force to normally urge the mass in one direction toward one limit of its movement and to restrain the mass at the one limit of its movement, periodically applying a second force to the mass exceeding the first force plus any manual force that may be applied for purposes of tampering, said second force urging the mass in the opposite direction against the influence of said first force for moving the mass substantially instantaneously to the other limit of its movement and to restrain the mass

at the other limit of its movement, the length of time of application of said second force being on the order of 58 seconds out of every 60 seconds whereby extraneous force applied for purposes of tampering will not cause the mass to move.

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