Aug. 14, 1951 J. E. BROSSEAU ET AL 2,564,322

TIMING DEVICE

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Fig. 1

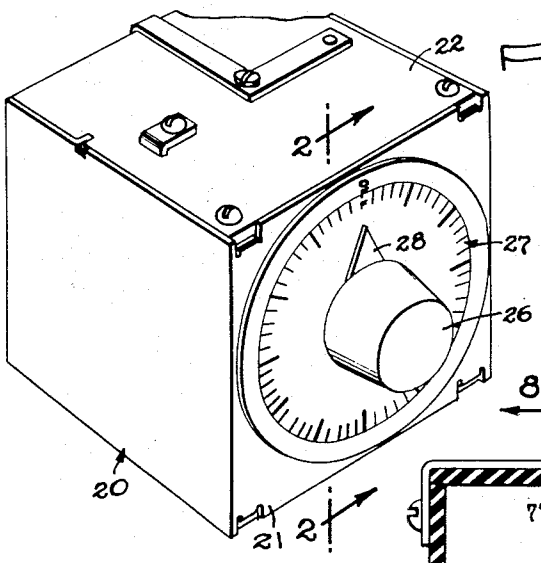


Fig. 2

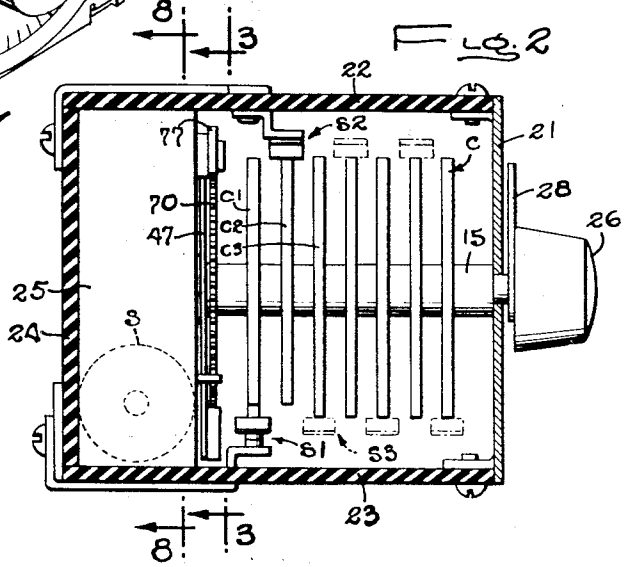


Fig. 3

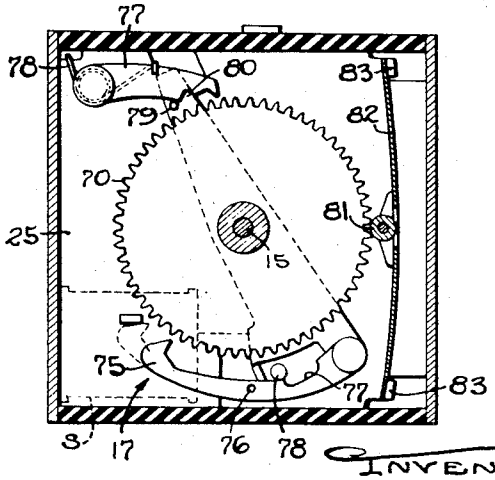
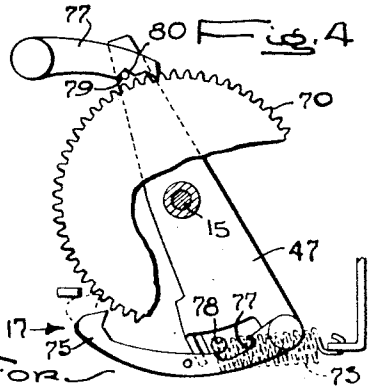


Fig. 4



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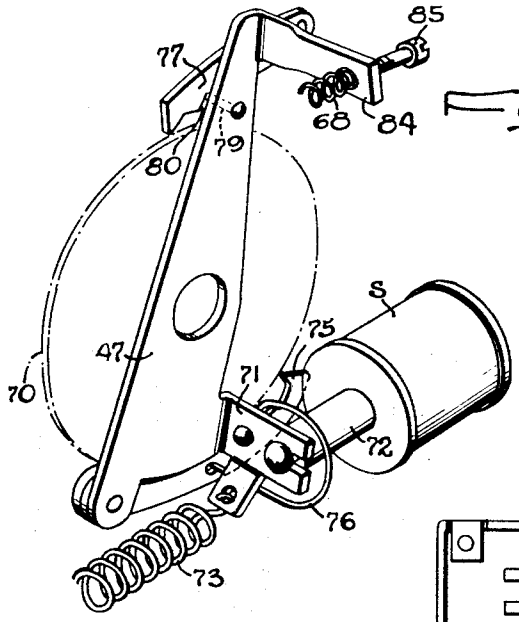


Fig. 5

Fig. 6

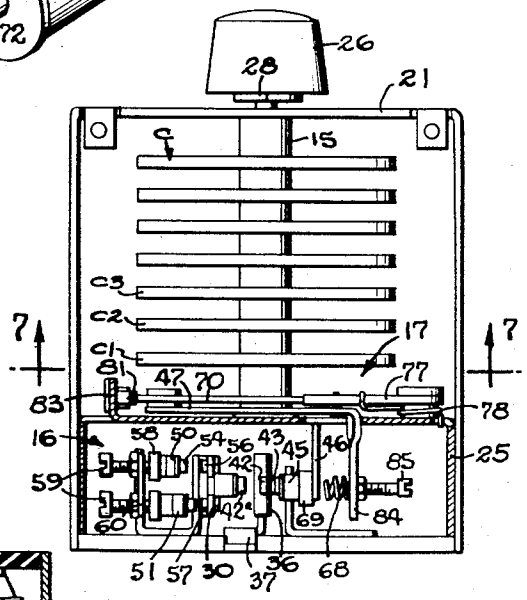
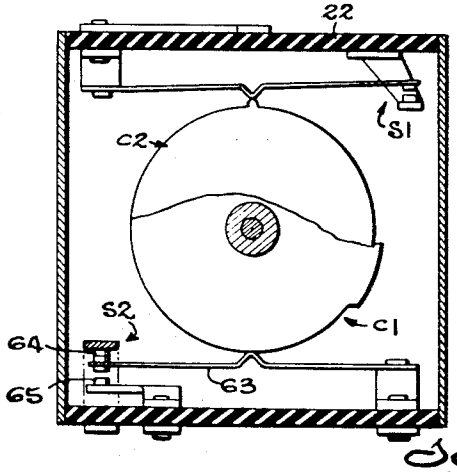


Fig. 7



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TIMING DEVICE

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Fig. 8

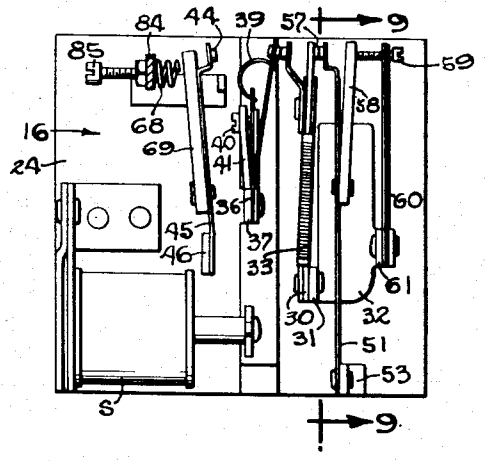


Fig. 9

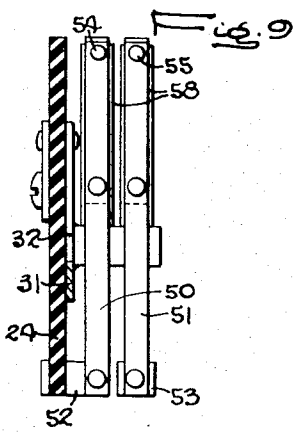
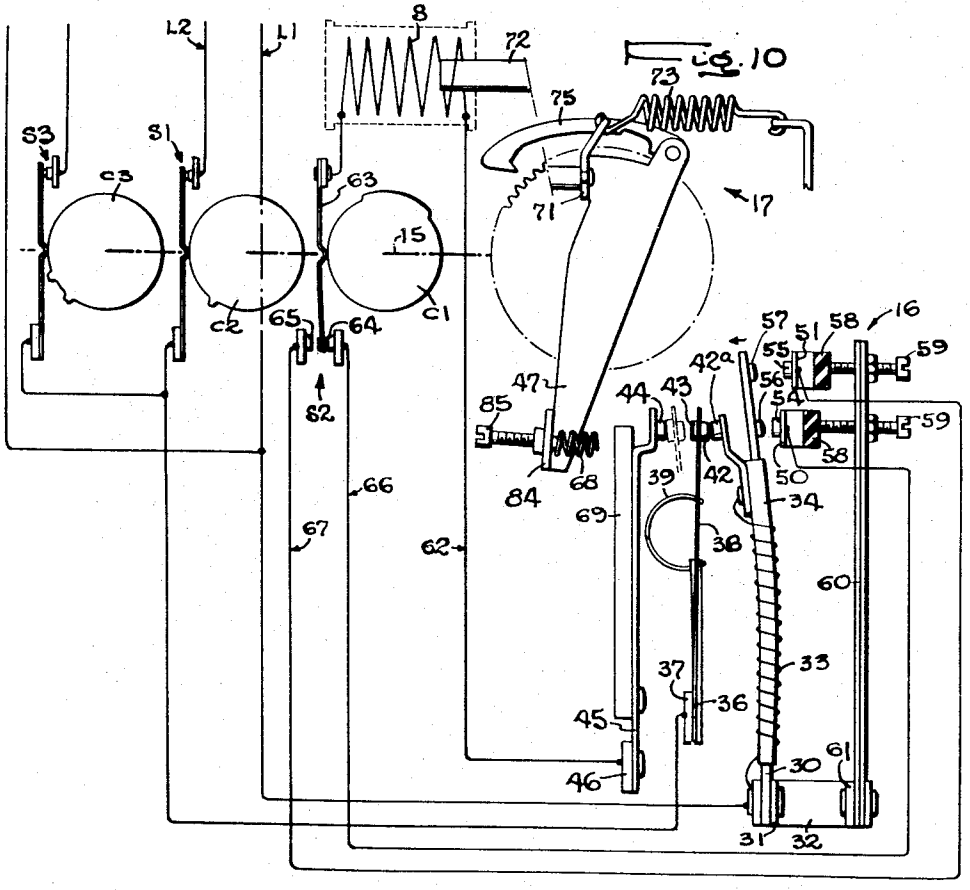


Fig. 10



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TIMING DEVICE

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Fig. 12

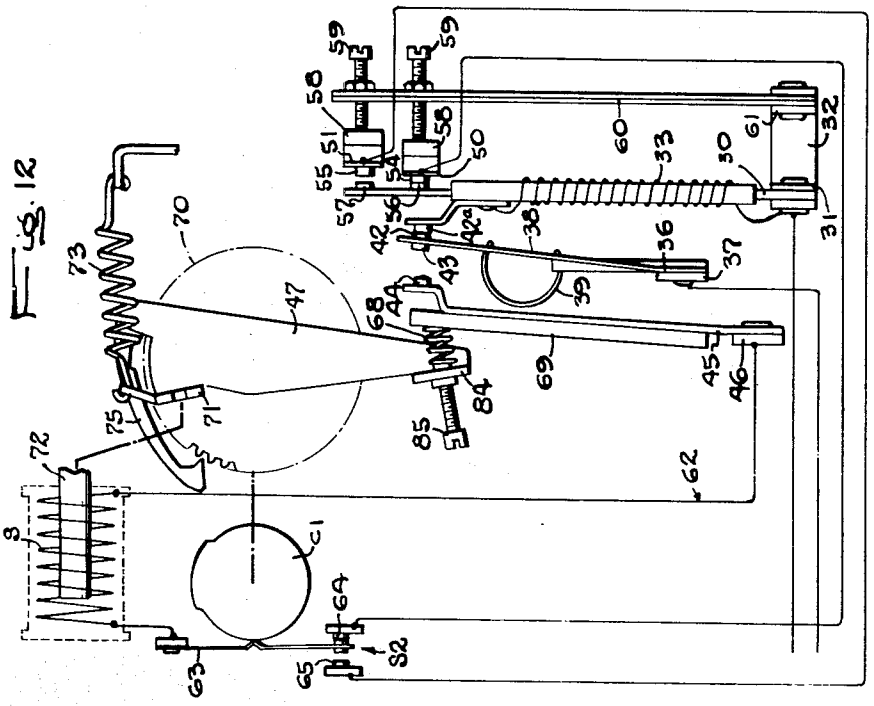
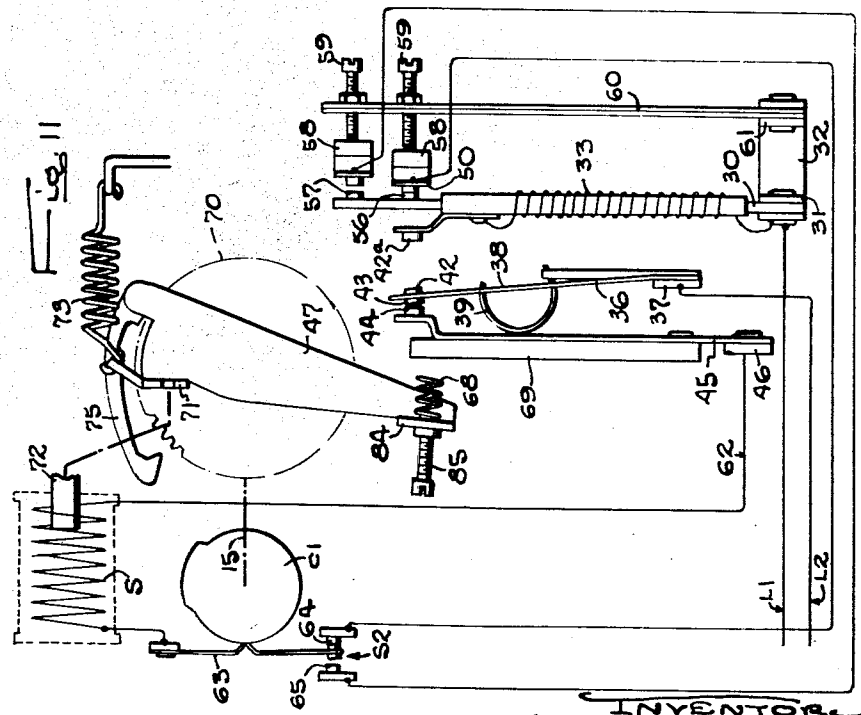


Fig. 11



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Patented Aug. 14, 1951

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UNITED STATES PATENT OFFICE

2,564,322

TIMING DEVICE

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Application October 27, 1948, Serial No. 56,752

20 Claims. (Cl. 161—1)

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The invention relates to timing devices generally, and is more particularly concerned with devices for performing a series of control functions at definitely timed intervals.

One object of the invention is to provide a practical and efficient thermally-actuated timing device of the above general character which is simple in construction and inexpensive to manufacture, and which is especially characterized by its accuracy and reliability in operation, its ability to maintain such accuracy over long periods of use, and by its convenient adjustability and adaptability to meet a wide variety of timing requirements.

Another object is to provide a timing device which is operative to measure timed intervals in any selected one of a plurality of time units.

Still another object is to provide a timing device having a thermally-operated timing mechanism for controlling the rotation of a driven control element and embodying novel drive mechanism for the element effective to prevent damage to the timing mechanism in the event of interference with the rotation of the control element.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a timing device embodying the features of the invention.

Fig. 2 is a sectional view of the device taken in a vertical plane substantially on the line 2—2 of Fig. 1.

Fig. 3 is a transverse sectional view taken in a vertical plane substantially on the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary view similar to Fig. 3, showing the drive mechanism in a different phase of its operating cycle.

Fig. 5 is a fragmentary perspective view of the drive mechanism.

Fig. 6 is a top view of the timing device with the top wall portion of the housing removed.

Fig. 7 is a sectional view taken in a vertical plane substantially on the line 7—7 of Fig. 6.

Fig. 8 is a side elevational view of the thermal timing mechanism and portions of the associated drive mechanism.

Fig. 9 is a sectional view taken in a vertical plane substantially on the line 9—9 of Fig. 8.

Figs. 10, 11 and 12 are diagrammatic views of the thermal timing mechanism and the drive mechanism showing the positions and relationship of the various elements in different phases of the operating cycle of the timing device.

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While the invention is susceptible of various modifications and alternative constructions, we have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that we do not thereby intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring to the drawings, the timed control actions of the improved timing device, which in this instance constitute the opening and closing of electrical switch contacts, are carried into effect by a control element or shaft 15 (Figs. 2–12) rotatable step by step under control of a thermally-actuated cyclically-operated timing mechanism 16 (Figs. 6, 8 and 10–12). In the exemplary device the shaft 15 is adapted to be rotated manually in one direction from a normal rest position and the time-controlled step-by-step movements are oppositely directed to return the shaft to its rest position. Such step-by-step rotation of the shaft 15 is effected through the medium of drive mechanism 17, including a solenoid S which is energized and deenergized once for each step imparted to the shaft. Operation of the solenoid is controlled by the timing mechanism 16 and the solenoid additionally interacts with the timing mechanism to terminate each operating cycle and to initiate or condition the timing mechanism for the succeeding cycle. The drive mechanism 17 also includes mechanical motion-transmitting means operative to insure appropriate stepping of the shaft 15 in response to the operation of the solenoid S but which leaves the shaft free for manual rotation in either direction and effectually prevents interference with the thermal timing mechanism or damage thereto in case the rotation of the shaft 15 is blocked.

In the timing device shown herein by way of illustration, the control element or shaft 15 carries a plurality of cams C operative in the rotation of the shaft to actuate electrical switches. While the shaft has been shown as being equipped with seven of the cams C, it will be appreciated that the number of cams provided, as well as the configuration of the cams, may be varied in accordance with the number and sequence of the timing actions to be performed by the device. In this instance, two of the cams C_1 and C_2 are utilized to control electrical switches S_1 and S_2 which are associated with and perform control functions in the operation of the timing mechanism 16, as will appear presently. A third cam C_3 serves to actuate a switch S_3 interposed

in an external circuit to be controlled. For convenience of assembly, these switches are mounted alternately on the panels 22 and 23 constituting the top and bottom walls of the housing, each switch having suitable terminals projecting at the outer side of the panel for convenience in making connection with the associated electrical circuit. It will be understood, of course, that suitable switches may be similarly associated with the other cams.

The cams C, the timing mechanism 16 and the drive mechanism 17 are enclosed in a rectangular box-like housing 20. As herein shown the housing comprises a generally U-shaped member 21 of sheet metal or other suitable material defining the front and side walls of the housing. The top, bottom and rear end walls of the housing are formed respectively by panels 22, 23 and 24 removably secured to the member 21. Preferably these panels are made of insulating material and serve as supports for the various terminals by which the elements of the timing device are electrically connected with the current supply circuit and with the external circuits to be controlled by the device.

For convenience in manufacture and installation, the timing mechanism 16 is mounted on a frame 25 (Fig. 6) for installation in and removal from the housing 20 as a unit. Preferably the frame 25 is secured to the rear panel 24 and is adapted to fit into the rear portion of the housing 20. As shown, the frame is apertured to provide a bearing for the inner end of the shaft 15 and the outer end of the shaft is journaled on the front wall portion of the member 21. The shaft is extended to project through the front wall of the housing for the reception of a knob 26 by which it may be turned manually to set or adjust the timing device. A suitably calibrated scale 27 is provided on the front wall of the housing for cooperation with a pointer 28 rotatable with the shaft and knob 26 to visually indicate the set position of the shaft.

Referring now to Figs. 8–12 of the drawings, the timing mechanism 16 in its preferred form comprises a thermally-responsive element, herein shown as an elongated bimetal strip 30 rigidly supported at one end on an arm 31 of a bracket 32 mounted on the inner face of the panel 24. For heating the element 30, a coil 33 of resistance wire is wound thereon, the coil being insulated from the element by interposed sheets 34 of mica or the like which additionally serve to delay the cooling of the element when the coil is deenergized. The element is mounted so that on heating its free end swings to the left as viewed in Fig. 10, the element returning to the normal position shown in Fig. 8 upon cooling.

Supported at one side of the element 30 for actuation thereby is the movable element of a two-position snap switch by which the circuits of the heating coil 33 and the solenoid S are controlled, as will appear presently. In the preferred form shown, the movable switch element comprises an elongated flat spring 36 supported at one end on a bracket 37 mounted on the wall 24 at one side of the bracket 32. While any suitable means may be utilized to impart the snap movements to the switch element, it is preferred to utilize an over-center spring mechanism for that purpose. To this end the switch element or spring 36 is slotted longitudinally and transversely to form a short resilient tongue 38 having a common fulcrum with the spring. A generally U-shaped resilient member or spring 39

interposed between the free end of the tongue 38 and the adjacent edge of the spring 36 acts in well-known manner to swing the spring in opposite directions with a snap action when the free end of the spring is shifted over a central or neutral position in which the two fulcrum points of the member 39 are disposed in a common plane with the fulcrum of the spring 36.

In the exemplary timer, the tongue 38 is restrained from movement, whereby the snap action movements are imparted to the free end of the spring 36. Such restraint is imposed on the tongue by an adjustable stop screw 40 threaded into an extension 41 of the bracket 37, as shown in Fig. 8. By turning the screw 40 in or out, the position of the tongue 38 may be shifted toward or from the thermal element 30, thus permitting the neutral position of the switch element to be adjusted for determining the point at which the thermal element is adapted to actuate the switch.

At its free end the spring 36 is provided with double switch contacts 42 and 43. The contact 42 is adapted to cooperate with a contact 42a carried by the thermal element 30 when the spring is in one position, and contact 43 is adapted to cooperate with a contact 44 when the spring is operated to its alternate position. As herein shown, the contact 44 is carried by a resilient spring member 45 supported by a bracket 46 mounted on the panel 24. The free end of the element 45 is positioned for coaction with a pivoted lever 47 forming a part of the drive mechanism 17, to be described hereinafter, whereby the member 45 may be shifted to swing the spring 36 back to its starting position upon operation of the drive mechanism.

Located at the other side of the thermal element 30 are a pair of spring members 50 and 51 supported in side-by-side relation at their lower ends by brackets 52 and 53 carried on the panel 24. The spring members are provided at their free ends with contacts 54 and 55 engageable respectively by contacts 56 and 57 carried by the thermal element 30. In practice the contact pairs are spaced apart laterally as shown in Figs. 6 and 9 but for convenience of illustration they have been shown spaced apart vertically in the diagrammatic views.

Provision is made for independently adjusting the position of the contacts 54 and 55 with respect to the thermal element, whereby to determine the time of engagement of the thermal element contacts therewith as the element is cooling down. For this purpose each of the springs 50 and 51 is provided with an elongated strip 58 of insulating material secured at its lower end to the spring and engageable at its upper end by an adjusting screw 59 threaded into an upright metal bar 60 supported on an arm 61 of the bracket 32.

The brackets 32, 37, 46, 52 and 53 by which the various spring members are supported on the panel 24 may be conveniently utilized as terminals for connecting those elements in circuit relation. In the exemplary timing device operating current is received via a line comprising conductors L_1 and L_2. The conductor L_1 is connected to the bracket 32 and the conductor L_2 is connected through the switch S_1 to the bracket 37. The latter bracket supports and is electrically connected with the movable over-center switch member 36. Bracket 46 is connected by the conductor 62 with one terminal of the solenoid S, which has its other terminal connected with a movable switch member 63 to the switch S_2.

This switch member is movable alternately between two switch contacts 64 and 65, in this instance by the cam C_1. Switch contacts 64 and 65 are connected by conductors 66 and 67 to the brackets 52 and 53 which carry the contact springs 50 and 51.

With the above circuit arrangement, the operation of the timing mechanism is generally as follows. At the beginning of an operating cycle the parts occupy the positions shown in Fig. 8. Upon closure of the switch S_1, in this instance by manual rotation of the shaft 15 from normal rest position, a circuit is closed by way of the switch member 36, contacts 42 and 42a, heater 33 and bracket 32 to the other side of the supply line for energizing the heater 33. As the temperature of the thermal element 30 increases, the free end of the element swings to the left (as viewed in Fig. 10) and the movable switch member 36 is shifted in the same direction. When the thermal element reaches a predetermined temperature, the switch member 36 is swung past its over-center position and is thereupon quickly snapped over to its alternate position in which the contact 43 engages contact 44. Closure of these contacts prepares a circuit for the solenoid S and separation of the contacts 42a and 42 opens the circuit for the heater 33. The latter is accordingly deenergized and the thermal element 30 begins cooling down, its free end swinging to the right as viewed in the drawing. Since the switch member 36 remains clear of the thermal element during such cooling, the movement of the element is unaffected by external forces thus insuring uniform accurate timing of the cooling portion of the cycle.

Upon cooling down to a predetermined lower temperature, thermal element contact 56 engages contact 54 and upon still further cooling contact 57 engages contact 55. Closure of one or the other of these contacts completes an energizing circuit for the solenoid S, the particular switch contacts functioning for that purpose being determined by the position of the switch S_2. The latter switch thus serves to selectively determine the cooling interval of the thermal element and thus the "time unit" by which the action of the device is timed.

Energization of the solenoid S serves to condition the drive mechanism 17 for operation, as will be described in detail hereinafter. For present purposes it is sufficient to state that the energization of the solenoid serves to swing the lever arm 47 counterclockwise (as viewed in Fig. 10) and in such movement a resilient bumper 68 carried by the arm engages a strip 69 of insulating material secured to the spring member 45 to shift the latter to the right. As the contacts 43 and 44 are engaged at this time, the over-center switch member moves with the spring 46 until it passes the over-center position whereupon the switch member snaps over to the initial or starting position, closing contacts 42 and 42a. The separation of contacts 43 and 44 interrupts the energizing circuit for the solenoid S which thereupon becomes deenergized. Closure of the contacts 42 and 42a re-establishes the circuit for the heater 33 and thereby initiates another operating cycle of the timing mechanism. This sequence of operations is repeated periodically as long as the switch S_1 remains closed. In the particular device illustrated the cam C_2 is shaped so as to open the switch upon return of the shaft 15 and the cams C to normal rest position.

As indicated heretofore the solenoid S in addition to controlling the cyclic operation of the timing mechanism 16 acts through the drive mechanism 17 to effect the step-by-step rotation of the shaft 15. The drive mechanism 17 is preferably of the pawl-and-ratchet type and is associated with the solenoid and with the shaft in a manner which prevents interference with the operation of either element. More particularly, the drive mechanism is constructed and arranged to insure accurate stepping of the shaft in each operating cycle of the timing mechanism while leaving the shaft free for rotation manually in either direction.

Furthermore, the arrangement is such that the solenoid and associated timing mechanism can function substantially in normal manner in the event that the rotation of the shaft 15 is blocked. In other words, the timing mechanism and the solenoid can continue their periodic operations under those conditions without becoming overheated or otherwise damaged.

As shown in Figs. 3–5, the drive mechanism 17 comprises a ratchet wheel 70 non-rotatably fixed on the inner end of the shaft 15. The lever arm 47 in this instance constitutes a pawl carrier and is loosely supported on the shaft between the ratchet wheel and the adjacent face of the frame 25. As best shown in Fig. 5, the arm 47 is formed with a bent-up lug 71 adapted to extend through a suitable opening in the frame 25 adjacent one end of the solenoid S which in this instance is supported on the rear panel 24 of the housing. The armature of the solenoid S, comprising a cylindrical plunger 72, is secured at one end to the lug 71. In the present instance a spring 73 connected between the frame 25 and the lug 71 urges the lever arm toward a normal rest position in which the plunger 72 was withdrawn from the solenoid. Upon energization of the solenoid the arm is rocked away from the rest position (counterclockwise as viewed in Fig. 5), thus tentioning the spring 73.

Pivotally supported at the lower end of the arm 47 is an elongated generally arcuate pawl 75 having its tip portion formed for engagement with the teeth of the ratchet wheel 70. A spring 76 yieldably urges the pawl toward the ratchet wheel. As shown in Figs. 3 and 4, the inner edge portion of the pawl 75 is formed with a cam surface 77 adapted to cooperate with a pin 78 projecting from the frame 25 whereby the pawl is held out of engagement with the ratchet wheel when the arm 47 is in normal rest position. The cam surface, however, permits the pawl to engage the ratchet wheel when the arm is rocked to operated position, thus rendering the pawl effective to advance the ratchet wheel and associated shaft 15 one step when the arm 47 is returned to normal rest position by the action of the spring 73. Since the pawl is normally disengaged from the ratchet wheel it offers no interference with the manual rotation of the shaft.

Means is provided for positively limiting the movement of the shaft to a single step in each operation of the solenoids S. This means, as herein shown, comprises a locking dog 77 pivotally supported on the frame 25 at one side of the ratchet wheel 70, as best shown in Fig. 3. A spring 78 acts on the dog to urge its tip into locking engagement with the teeth of the ratchet. The dog, however, is normally held out of engagement with the ratchet wheel by a pin 79 carried by the arm 47 and engaging the lower edge of the dog. To permit the dog to function at the proper time, the lower edge portion is

formed with a notch 80 adapted to receive the pin 79 as the arm 47 approaches rest position. This notch is so located that the dog drops into the ratchet teeth immediately upon the completion of the stepped advance of the shaft 15 so that any overrun is effectually prevented. Upon further movement of the arm 47 the dog rides up on the pin 79 and is thus withdrawn from engagement with the ratchet wheel, leaving the wheel and shaft free for manual rotation.

In order to prevent accidental movement of the shaft from a position in which it is set either by the drive mechanism or manually, yieldable detent means is provided in association with the ratchet wheel. As shown in Fig. 3, the detent means comprises a roller element 81 supported intermediate the ends of a spring member 82 which is supported at opposite ends on brackets 83 carried by the frame 25. The spring member 82 is tensioned so as to hold the roller 81 in engagement with the teeth of the ratchet wheel, but is adapted to yield and permit the teeth to pass over the roller 81 when the wheel is turned either by the drive mechanism or manually.

As heretofore explained, the arm 47 is effective toi reset the timing mechanism 16 through the action of the resilient bumper 68. As shown in Fig. 5, this bumper is in the form of a coiled spring and is supported on an inwardly turned finger 84 formed on the upper end of the arm 47. Preferably the bumper is carried on the end of a screw 85 threaded into the finger 84, whereby its effective position may be conveniently adjusted. This is highly advantageous as the timing of the resetting action of the arm requires accurate coordination with respect to the stepping of the shaft 15.

It will be apparent from the foregoing that the invention provides a thermally-actuated timing device of simple and inexpensive construction which is accurate and reliable in operation. As the timing actions are controlled by readily replaceable cam elements, the device may be readily adapted to meet a wide variety of timing requirements. Moreover, since the "time units" by which the time intervals are measured can be varied during the operation of the device, its utility and adaptability are further extended.

Rotation of the control element or shaft is effected in a reliable and certain manner through the medium of the novel drive mechanism, which leaves the element free for manual rotation in either direction for setting or resetting purposes. Moreover, the drive mechanism prevents interference with the operation of the timing mechanism or the actuating solenoid so that overheating of or damage to those elements by either intentional or unintentional blocking of the control element against rotation is effectually prevented.

We claim as our invention:

1. In a timing device having a shaft to be driven, means including a solenoid adapted to be periodically energized and deenergized for effecting step-by-step rotation of the shaft, timing means for controlling the energization and deenergization of said solenoid comprising a thermally responsive element, a heater for said element, an over-center switch member operative in one position to initiate the operation of said heater, said thermally-responsive element acting when heated to a predetermined elevated temperature to shift said member from said one position to an alternate position and thereby interrupt the operation of said heater, said element upon cooling to a predetermined lower temperature acting jointly with said member while in said alternate position to effect the energization of said solenoid, and means operable in response to the energization of said solenoid for shifting said switch member from said alternate position to said one position whereby to deenergize the solenoid and to initiate another operating cycle of the heater.

2. In a timing device having a shaft to be driven, means including a solenoid for effecting step-by-step rotation of the shaft, means for periodically energizing and deenergizing said solenoid including a thermally-responsive element, a heater for said element, an over-center switch member operable in one position to initiate the operation of said heater and in an alternate position to interrupt the operation of the heater and to prepare an energizing circuit for said solenoid, said thermal element being operative when heated to a predetermined elevated temperature to shift said member from said one position through the over-center position to said alternate position and being further operative upon cooling to a predetermined lower temperature to complete the energizing circuit for said solenoid, said solenoid upon energizing returning said switch member to said one position to effect the deenergization of the solenoid and to initiate another operating cycle of said heater.

3. In a timing device having a shaft to be driven, means including a solenoid for effecting step-by-step advance of the shaft, an energizing circuit for said solenoid including two sets of switch contacts, means for periodically opening and closing said circuit including a thermally-responsive element, a heating coil located closely adjacent said element, a snap-over switch member supported at one side of said element, said member being operative in one position to close a circuit for said heating coil and in the other position to close one set of switch contacts, said thermally-responsive element operating when heated to a predetermined elevated temperature to actuate said member for snap-over movement to said other position whereby to open the circuit for said heating coil and prepare the circuit for said solenoid, said thermal element upon cooling acting to close the other of said switch contact sets and thereby complete the circuit for said solenoid, and means operative upon energization of said solenoid for actuating said switch member for snap-over movement to said one position.

4. In a timing device having a rotatable control element, a solenoid, timing mechanism operable through a cycle to complete an energizing circuit for said solenoid, said solenoid operating when energized to interrupt said circuit and to reset said mechanism for another cycle of operation, drive mechanism for said control element conditioned for operation by the energization of the solenoid and operative upon deenergization of the solenoid to impart a rotative step to said control element, said drive mechanism having a non-positive connection with said shaft permitting substantially normal periodic operation of said timing mechanism and said solenoid in the event that said control element is blocked against operation.

5. In a timing device having a rotatable control element, a solenoid, timing mechanism operable through a cycle to complete an energizing circuit for said solenoid, said solenoid operating when energized to interrupt said circuit and to reset

said mechanism for another cycle of operation, and drive mechanism for said control element conditioned for operation by the energization of said solenoid and operative upon deenergization of the solenoid to impart a rotative step to said control element, said drive mechanism being normally disassociated from said element to leave the element free for manual rotation in either direction.

6. In a timing device, in combination, a rotatably supported shaft, drive mechanism including a solenoid for advancing said shaft step by step, timing mechanism including a timing element, a switch member adapted in one position to close an operating circuit for the timing element and in another position to close an energizing circuit for said solenoid, said timing element being operative after a predetermined interval of operation to shift said switch member from said one position to said other position to energize said solenoid and said solenoid being operative when energized to return the switch member to said one position thereby deenergizing the solenoid and initiating another operation of the timer, means included in said drive mechanism conditioned for operation by the energization of said solenoid and operable upon deenergization of the solenoid to impart a rotative step to said shaft, said means being operatively associated with the shaft only during such stepping action so as to leave the shaft normally free for rotation manually in either direction.

7. In a timing device having a shaft adapted to be manually rotated in one direction from a starting position, drive mechanism associated with said shaft for rotating it step by step in the opposite direction to return it to said starting position, a solenoid, timing mechanism controlling the operation of said drive mechanism including a member operable through a predetermined cycle to energize said solenoid, said drive mechanism being conditioned for operation by the energization of said solenoid, said solenoid operating upon energization to effect its own deenergization and to reset said member for another operating cycle, and means included in said drive mechanism for disassociating it from said shaft during the operating cycles of said member so as to leave the shaft free for manual rotation in either direction.

8. In a timing device having a rotatably supported shaft, means for rotating said shaft step by step in one direction including a ratchet wheel secured to the shaft, a lever arm pivoted intermediate its ends on said shaft, spring means yieldably urging said lever arm to a rest position, power-operated means for rocking said arm to an operated position against the action of said spring means, a pawl carried at one end of said arm engageable with said ratchet wheel in the movement of said arm toward rest position, a locking dog pivotally supported at one side of said ratchet wheel, and means carried on the other end of said arm coacting with said dog in said operating movement of the arm for momentarily dropping said dog into engagement with said ratchet wheel to positively limit the rotational movement of the wheel and shaft to a single step and then withdrawing said dog from engagement with the ratchet wheel as said arm approaches rest position to leave the wheel and shaft free for rotation manually.

9. In a timing device having a control element adapted to be rotated manually in one direction from a starting position, drive mechanism for rotating said element step by step in the opposite direction to return it to the starting position, timing mechanism for said drive mechanism including a thermally-responsive element, an electrically-operated heater associated with said thermally-responsive element, an electrical switch closed upon rotation of said control element from starting position, switch means including a two-position over-center switch member operative in one position to complete an energizing circuit for said heater through said electrical switch when closed, said thermally-responsive element acting when heated to a predetermined temperature to shift said switch member to its alternate position to interrupt the circuit for said heater, means operative upon the cooling of said thermally-responsive element and while said switch member is in said alternate position for actuating said drive mechanism to impart a rotative step to said control element, and means for shifting said switch member back to said one position in response to the stepping of said control element whereby to initiate another operating cycle of said thermally-responsive element, said electrical switch being opened upon the return of the control element to starting position to terminate the operation of the timing device.

10. A timing device comprising, in combination, a thermally-responsive element, a heater for said element, means for initiating the operation of said heater, means operative upon the heating of said element to a predetermined temperature for interrupting the operation of said heater, a plurality of electrical switches actuated at spaced intrevals by said element upon cooling down from said predetermined temperature, a rotatably supported control element, means operative in response to the closure of one of said switches for imparting a rotative step to said control element, and means operable to select said one switch from said plurality and thereby determine the timed interval between successive steps of the control element.

11. A timing device comprising, in combination, a thermally-responsive element, a heater for said element, means for initiating the operation of said heater, means operative upon the heating of said element to a predetermined temperature for interrupting the operation of said heater, a plurality of electrical switches actuated successively by said element upon cooling down from said predetermined temperature, means operable to condition any selected one of said switches for operation, and means responsive to the actuation of the selected switch for reinitiating the operation of said heater.

12. In a timing device, in combination, a rotatably-supported shaft, actuating means for advancing said shaft step by step, timing mechanism for said actuating means including a thermally-responsive element, first and second switch means one of which includes a two-position over-center switch member operative in one position to initiate the heating of said thermally responsive element and operative when shifted to the other position to terminate the heating of the element, said element acting when heated to a predetermined temperature to shift said switch member from said one position to said other position and being operative upon cooling to actuate the other switch means, said other switch means when actuated with said switch member in said other position acting to initiate the operation of said actuating means, and said actuating means

being operative to return said switch member to said one position.

13. In a timing device, in combination, a rotatably-supported control shaft, actuating means for said shaft, an operating circuit for said actuating means, timing mechanism for said actuating means including a thermally-responsive element adapted to swing in one direction when heated and in the opposite direction upon cooling, switch means including an over-center switch member shiftable between two positions in response to the oppositely directed movements of said thermal element, other switch means actuated by said thermal element upon a predetermined swing in said opposite direction, said switch member being operative to control the heating and cooling of said thermal element and being operative jointly with said other switch means to open and close the operating circuit of said actuating means.

14. In a timing device, in combination, a rotatably-supported control shaft, actuating means operable to advance said shaft step by step, timing mechanism for said actuating means including a thermally-responsive element, an electrically-operated heater for said element, switch means including an over-center switch member operative in one position to close an energizing circuit for said heater, said thermal element when heated to a predetermined temperature by said heater acting to shift said switch member through its over-center position to an alternate position and thereby interrupt the circuit for said heater, actuating means for mechanically shifting said switch member back through its over-center position to its initial position and for advancing said shaft one step, and an operating circuit for said actuating means including switch contacts closed by said thermal element upon cooling down to a predetermined lower temperature in cooperation with other switch contacts closed by said switch member while the latter is in said alternate position.

15. In a timing device, in combination, a rotatably-supported shaft, a ratchet wheel mounted on said shaft, a pawl cooperating with said ratchet wheel, a carrier for said pawl pivotally supported on said shaft, actuating means for rocking said carrier to an advance position, spring means operative to return said carrier to a retracted position and thereby impart an increment of movement to said shaft through said pawl and said ratchet wheel, timing mechanism for said actuating means including a thermally-responsive element, an electrically operated heater associated with said thermally-responsive element, switch means for controlling the operation of said heater and said actuating means including a two-position over-center switch member, said thermally-responsive element being operative when heated to a predetermined temperature to shift said switch member to one position and means on said pawl carrier engageable with said switch member to shift the switch member to its other position.

16. In a timing device having a movable control member and drive mechanism operable to impart an advancing step to the member, means for timing the operation of said drive mechanism comprising a thermally responsive element, means for initiating the application of heat to said element, said element being operative when heated to a predetermined elevated temperature to interrupt the application of heat, a plurality of electrical switches spaced apart for actuation successively by said element as it cools down from said elevated temperature following such interruption of heat application, and selectively operable means for conditioning one of said switches for controlling the operation of said actuator and for rendering the other of said switches inactive.

17. A timing device comprising, in combination, a thermally responsive element, a heater for said element, means for initiating the operation of said heater, means operative upon the heating of said element to a predetermined elevated temperature for interrupting the operation of the heater, a first electrical switch actuated by said element upon cooling from said elevated temperature to a predetermined lower temperature, a second electrical switch actuated by said element upon further cooling from said lower temperature, a movable control element, driving mechanism operable to impart an advancing step to said element, and selector means settable to condition either one of said switches for controlling said drive mechanism.

18. A timing device comprising, in combination, a thermally responsive element, switch means including a two position switch member movable with a snap action from either position to the other, a heater associated with said thermally responsive element, an operating circuit for said heater closed when said switch member is in said one position, said thermally responsive element operating when heated to a predetermined elevated temperature to shift said switch member to its alternate position and thereby interrupt the circuit of said heater, a control element shiftable manually in one direction from a starting position, drive mechanism operable periodically to shift said control element step by step in the opposite direction to return it to the starting position, an operating circuit for said drive mechanism including switches respectively actuated by said switch member in said alternate position and by said thermally responsive element upon cooling to a predetermined lower temperature, and means actuated by said drive mechanism when operated for shifting said switch member from said alternate position to said one position.

19. A timing device comprising, in combination, a thermally responsive element, switch means including a two position switch member movable with a snap action from either position to the other, a heater associated with said thermally responsive element, an operating circuit for said heater closed when said switch member is in said one position, said thermally responsive element operating when heated to a predetermined elevated temperature to shift said switch member to its alternate position and thereby interrupt the circuit of said heater, a control element shiftable manually in one direction from a starting position, drive mechanism including a ratchet associated with said control element, a pawl supported for coaction with said ratchet, spring means yieldably urging said pawl in a direction to shift the control element in the opposite direction, a solenoid operative when energized to retract said pawl against the action of said spring means, an energizing circuit for said solenoid including a first switch actuated by said switch member in said alternate position and a second switch actuated by said thermally responsive element upon cooling to a predetermined lower temperature, and means operable upon retraction of said pawl for shifting said switch member from said alternate position to said one position to thereby interrupt the circuit

for said solenoid and to reestablish the operating circuit for said heater, said solenoid upon deenergizing releasing said pawl to the action of said spring means for imparting an increment of movement to said control element.

20. A timing device comprising, in combination, a thermally responsive element, switch means including a two position switch member movable with a snap action from either position to the other, a heater associated with said thermally responsive element, an operating circuit for said heater closed when said switch member is in said one position, said thermally responsive element operating when heated to a predetermined elevated temperature to shift said switch member to its alternate position and thereby interrupt the circuit of said heater, a rotatably supported control shaft adapted to be rotated manually in one direction from a starting position, a ratchet wheel associated on said shaft, a pawl supported for coaction with said ratchet wheel, spring means yieldably urging said pawl in a direction to return said shaft toward its starting position, a solenoid operative when energized to retract said pawl and tension said spring means for advancing the ratchet wheel upon deenergization of the solenoid, an energizing circuit for said solenoid closed jointly by said thermally responsive element upon cooling to a predetermined

temperature below said elevated temperature and by said switch member is in its alternate position, and means operable incident to the energization of said solenoid for shifting said switch member from said alternate position to said one position to interrupt the energizing circuit for said solenoid and reestablish the operating circuit for said heater.

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