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[45] **Feb. 20, 1973**

[54] MEMORY TIMING DISC STRUCTURE WITH ADJUSTABLE PINS WHICH ARE SET AND RESETTABLE BY AUTOMATIC MEANS DURING CONTINUOUS CYCLIC OPERATION

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[52] **U.S. Cl.** .....**200/38 CA**, 307/141.4

[51] **Int. Cl.**.....**H01h 43/10**

[58] **Field of Search**.....200/38 CA, 33 R, 37 A; 307/141.4; 83/297

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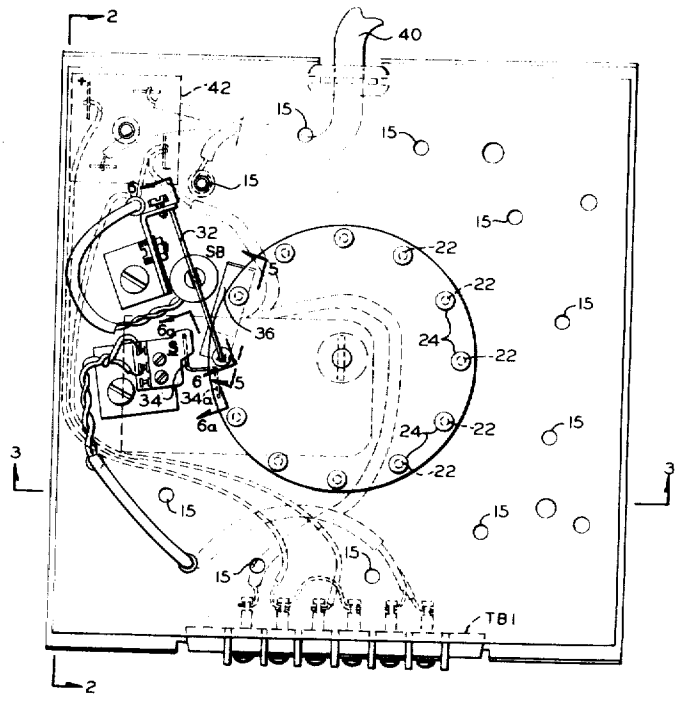
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[57] **ABSTRACT**

A mechanical storage register having a disc rotated by a stepping motor to a successive index positions. Holes spaced about the periphery of the rotatable disc have pins which are translated perpendicular to the plane of the disc to raised or lowered positions to indicate binary conditions. A groove in the periphery of the disc contains a rubber O-ring to engage the pins and hold them in raised or lowered conditions unless and until they are raised or lowered by solenoid and/or spring-operated devices arranged around the outside of the periphery of the disc.

12 Claims, 13 Drawing Figures



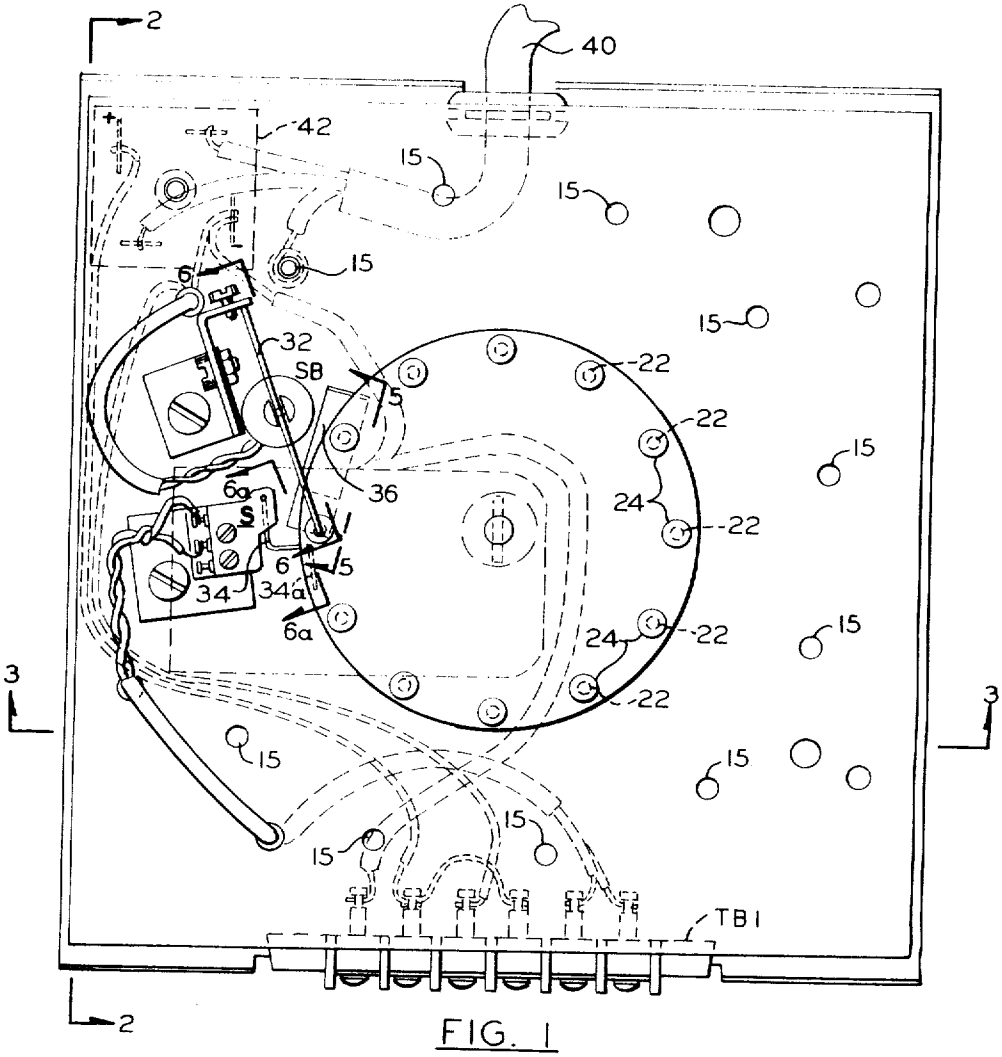


FIG. 1

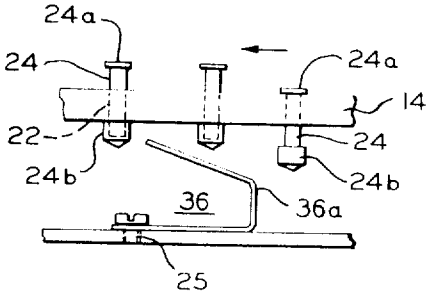


FIG. 5

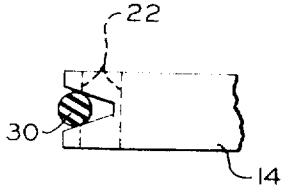


FIG. 4

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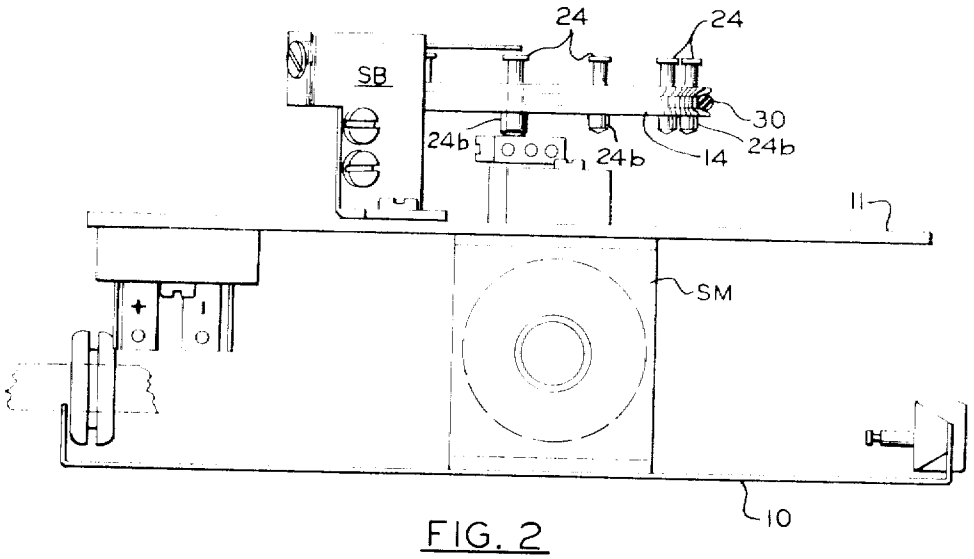


FIG. 2

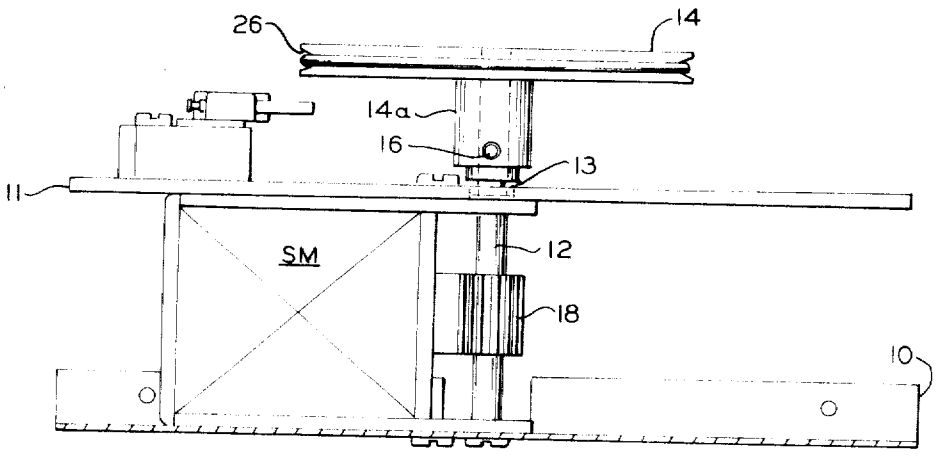


FIG. 3

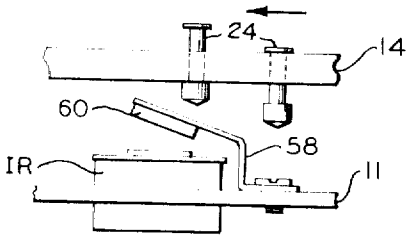


FIG. 5a

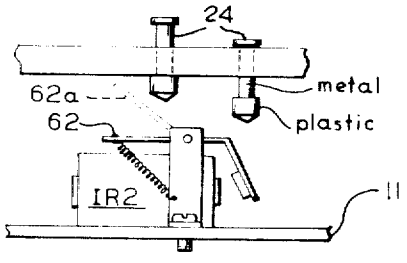
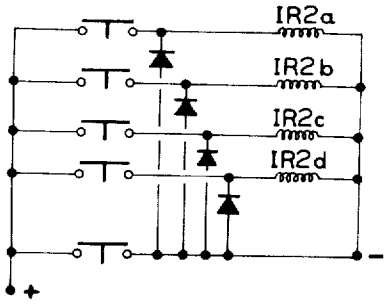


FIG. 5b

FIG. 5c



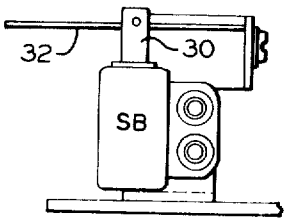


FIG. 6

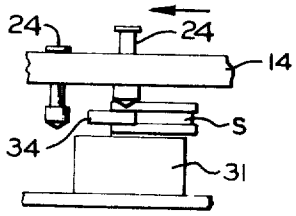


FIG. 6a

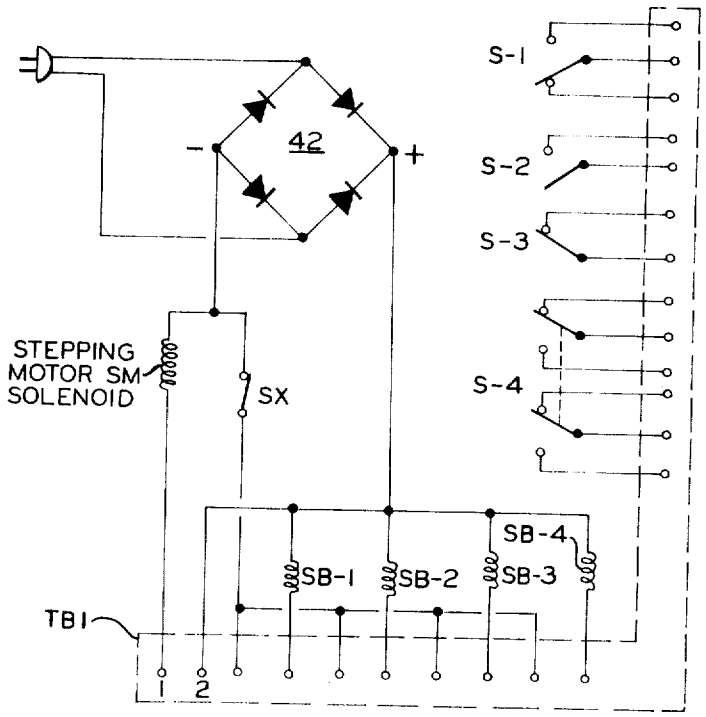


FIG. 7

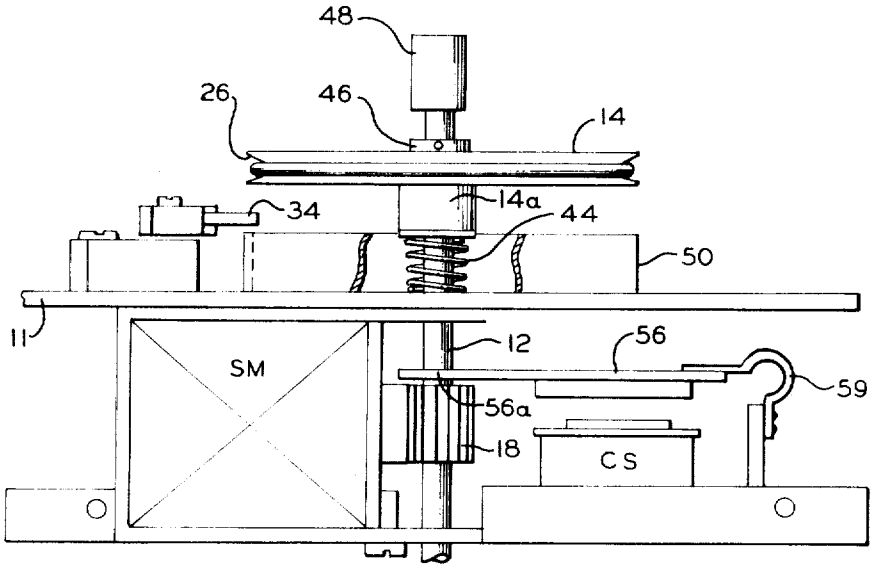

48
26
46
14
34
14a
44
50
11
12
56
59
SM
56a
18
CS

FIG. 8

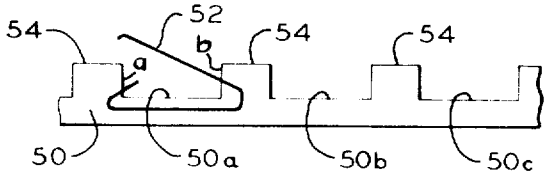

54
52
b
54
54
a
50
50a
50b
50c

FIG. 8a

MEMORY TIMING DISC STRUCTURE WITH ADJUSTABLE PINS WHICH ARE SET AND RESETTABLE BY AUTOMATIC MEANS DURING CONTINUOUS CYCLE OPERATION

My invention relates to memory devices, and particularly to an improved, simple and economical memory device. A wide variety of industrial installations include machines which perform a sequence of successive operations or tests on a workpiece or object, frequently with the workpiece or object being successively transported past a series of work stations or test stations, or with a plurality of workpieces or objects being successively transported past the successive stations, each being indexed to a further station from time to time. It is frequently desirable that a given operation or test be performed, or that some control signal or indicating signal be provided when a given workpiece or test object reaches a predetermined work or test station somewhere past its instantaneous position. A variety of timers are available to provide a signal a predetermined time after an event occurs, but if a machine or process operates at varying speeds, or sometimes stops for unpredetermined intervals, an ordinary timer may be incapable of providing a signal at the proper time, and the art has resorted to some form of storage or memory means. A wide variety of known storage devices are readily available for controlling operations in almost any desired sequence, but many of them are complex and expensive and many require an experienced electronics technician in order to adjust or service them. Furthermore, many electrical or electronic memory or register devices are undesirably "volatile," so that they lose some or all of their stored data in the event of an interruption in an electrical power. In various applications, the loss of stored data due to temporary loss of power can cause catastrophic damage or injury, so that the art has restored to the use of mechanical registers for such applications.

The present invention, like many prior art mechanical storage devices, uses the mechanical displacement or movement of a mechanical element from one position to another to signify the storage of one bit of information, such as "on" or "off," and a plurality of such elements are used to store plural bits of information. It is desirable that each movable element which is displaced to register a bit be small and be movable against little friction, so that a powerful means for moving such elements between their two positions is not required. On the other hand, it is necessary, once that such an element has been moved to a given position, that it remain reliably in that position, and not be dislodged due to gravity or machine vibration or the like. In the construction of mechanical memories, the prior art has sometimes utilized movable elements comprising magnets which are allowed to move with minimum friction and held in their two positions by magnet forces. Such systems are generally quite expensive. The prior art also has resorted to the use of bistable overcenter spring systems, which disadvantageously are subject to wear. One of the main problems of prior mechanical memory devices has been their inability to function reliably after many thousands of cycles, and a principal object of the invention is to provide a simple, inexpensive and reliable mechanical memory device.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. **1** is a top view of a preferred embodiment of the invention.

FIG. **2** is an end view taken at lines **2—2** in FIG. **1**.

FIG. **3** is a side elevation view taken at lines **3—3** in FIG. **1**.

FIG. **4** is an enlarged cross-section view of a portion of FIG. **3**.

FIG. **5** is a detail elevation view taken at lines **5—5** in FIG. **1**.

Fig. **5***a* is a view similar to FIG. **5** showing a modified form of reset device.

FIG. **5***b* is a view similar to FIG. **5** showing a further modified form of reset device.

FIG. **5***c* is a schematic diagram showing one manner in which reset devices of the type shown in FIG. **5***b* may be used.

FIG. **6** is a detail elevation view taken at lines **6—6** in FIG. **1**.

FIG. **6***a* is a view taken at lines **6***a*—**6***a* in FIG. **1**.

FIG. **7** is an electrical schematic diagram of one form of the invention.

FIG. **8** is a view generally similar to FIG. **3** showing modifications which may be made to the device of FIG. **1**.

FIG. **8***a* is an unrolled view of a portion of a ring device used in the arrangement of FIG. **8**.

Referring not to the figures, the device will be seen to include a box-like housing having a base **10**. One end of shaft **12** is rotatably journalled in base plate **10** and the other end of shaft **12** carries rotatable disc **14**, a hub **14a** of disc **14** carrying pin **16** to affix disc **14** to shaft **12**. A ratchet **18** is rigidly affixed to shaft **12** intermediate with its ends. A conventional stepping motor SM mounted on base **10** engages and rotates ratchet **18** to rotate disc **14** through discrete angular increments. In the embodiment shown ratchet **18** is provided with **12** teeth, so that each operation of stepping motor SM rotates disc **14** through an angle of 30°. A conventional detent (not shown) engaging ratchet **18** prevents any rotation of the disc by means other than motor SM. An upper mounting plate **11** is carried on motor SM. Shaft **12** extends through a hole **13** in plate **11**, which carries a variety of devices to be described.

Disc **14** is provided with 12 through-holes **22,22** around its periphery with the holes spaced 30° from each other. Stepping motors which step in other than 30° angular increments are readily available and may be used in the memory device. If, for example, a stepping motor which steps in 10° increments is used, disc **14** will be provided with **36** holes around its periphery. A plurality of generally cylindrical pins **24**, **24** are slidably mounted in holes **22**. Both ends of each pin are preferably widened to a diameter greater than that of holes **22** so as to retain the pins in disc **14**. The pins may comprise rivets each having a widened head **24a** and a rubber, plastic or metal button **24***b* forced

onto their lower ends after the pins are inserted in the disc holes. The diameter of holes **22** is made large enough so that pins **24** are loosely slidable in their respective disc holes. A V-shaped groove **26** extends around the peripheral edge of disc **14** as shown, and as shown in FIG. **4**, each hole **22** is situated near enough to the edge of disc **14** that it intersects groove **26**. Thus a portion of each pin **24** extends into V-groove **26**. An elastic O-ring **30** is seated in groove **26**, and hence O-ring **30** engages each pin **24**, urging it inwardly against the inner edge of its respective hole **22**. The radially inward force applied by the O-ring to each pin **24** provides friction between each pin and its respective hole, and friction between the pin and the O-ring, which resists longitudinal movement of each pin in its respective slot. Inasmuch as the O-ring applies the same inward force to all of the pins, it will be apparent that all of the pins are provided with the same amount of friction. If, after long usage, the motion of the pins has caused grooves to be worn in the O-ring, it will be seen that the effect of such wear may be completely nullified by merely rotating the O-ring around slightly in groove **26**, so that different portions of the O-ring engage the pins. The use of an elastic ring seated within a groove to engage the sides of the pins carried in disc **14** is an important feature of the invention, since the O-ring engages the pins to prevent movement of the pins by vibration, gravity or inertia, but allows the pins to be moved easily by solenoid and spring means to be described. Reliable operaafter many thousands of operations is an important requirement in a memory device, and unlike various prior art devices, the movement of the pins in the present invention causes very little wear.

In the device shown, the condition of one bit of data is specified by the position of each pin in disc **14**. Thus a downward (in FIG. **5**) position of a pin, so that its rivet head **24*a*** abuts the top of disc **14** may comprise a logic 1 or "set" bit, while the opposite position of a pin, with its lower button abutting the bottom of disc **14** may comprise a logic 0 or "reset" bit.

Stepping motor SM is connected to receive indexing pulses from a machine (not shown) to be controlled and each index pulse rotates disc **14** through 30°. After each such rotation, the machine may or may not send a "set-bit" signal to the memory device. Solenoid SB mounted on plate **11** has a movable core **30** (FIG. **6**) which is pulled down into the solenoid coil when the solenoid is energized. One end of spring arm **32** is rigidly affixed, an intermediate portion of arm **32** is affixed to core **30** (such as by passing through a hole in core **30**), and the other end of spring arm **32** extends from solenoid SB in cantilever fashion. Solenoid SB is mounted to upper mounting plate **11** as shown in FIG. **1** so that the cantilever end of spring arm **32** lies above one pin in disc **14**. The "set bit" signals are connected to energize solenoid SB, and upon energization solenoid SB will be seen to pull spring arm **32** downwardly, so that the end of arm **32** presses down on the top of the pin, urging the pin to its "set" or logic 1 position.

Also mounted on upper mounting plate **11**, but situated below disc **14**, microswitch S mounted on a RISER BLOCK **31** is shown. See FIG. **6*a***. Spring arm **34** of switch S extends horizontally under disc **14** to a location such that shoulder **34*a*** of the arm occupies space which a lowered or "set" pin will occupy when indexed to that angular position. Thus whenever disc **14** indexes so that a lowered pin moves to that space, the lowered pin will operate the microswitch either momentarily or maintain it operated until disc **14** is again advanced. If the pin is not lowered, however, it will pass over the top of arm **34**, leaving the switch unoperated. Switch S may comprise a normally open or normally closed SPST switch, or a SPDT switch, or even a multi-pole switch. When the stepping motor SM indexes, a lowered pin engaging arm **34** will be seen to flex the arm to push past it, after which arm **34** will snap to its unoperated position, returning switch S to its unoperated condition. The snap action of arm **34** is desirable to minimize arcing at the switch contacts and allows one to use inexpensive microswitches which themselves do not incorporate a snap-action movement, although switches which do incorporate such movements can, of course, also be used.

Referring now to FIGS. **1** and **5**, it will be seen that a simple generally U-shaped leaf spring **36** is mounted on upper mounting plate **11** with its apex **36*a*** pointing opposite to the direction of movement of the pins which pass over it, and with its upper leg rising gradually in the direction of such movement. As disc **14** rotates (counterclockwise in FIG. **1**, leftwardly in FIG. **5**), spring **36** will be seen to return any lowered or set pins to their upper or reset position.

The 12 index positions of pins **22** may be numbered 1 to 12 going counterclockwise around disc **14**. If the position of reset spring **36** in FIG. **1** is regarded as preceding index position No. **1**, the set bit solenoid arm **32** will be seen to act on the pin **22** at index position No. **2**. Such an arrangement is only one simple example of thousands of different arrangements which are possible. A plurality of threaded mounting holes **15,15** are provided in platen **11** so that a set bit solenoid assembly or a sensing switch assembly may be mounted around disc **14** at each of the 12 index positions. A plurality of threaded holes **25,25** are also provided in platen **11** so that a reset spring may be mounted around disc **14** at each of the 12 index positions. Thus each index position may incorporate (1) a set bit solenoid assembly alone, or (2) a sensing switch assembly alone, or (3) both a set bit solenoid assembly and a sensing switch assembly, or (4) a reset spring, or (5) none of these actuating or sensing means. It will become apparent that no useful function would be provided by installing both a set bit solenoid assembly and a reset spring at the same index position, since any pins set by the solenoid assembly would be immediately reset when the disc was next indexed, nor would it be useful to install a sensing switch assembly immediately following a reset spring since the switch manifestly never would be operated.

It may be noted that each set bit solenoid assembly is situated largely above disc **14**, while each sensing switch assembly is located below disc **14**. This feature, together with the fact that these assemblies are spaced radially outside the periphery of the disc and provided with arms extending generally radially inwardly, makes it possible to provide both types of assemblies at a given index position without greatly increasing the size of the device.

In FIG. **1** line cord **40** is shown connected to a rectifier **42** mounted in housing **10**, and the schematic diagram of FIG. **7** illustrates one manner in which the sole-

noids and switches may be wired. A pair of contacts (not shown) in a machine or system are connected to terminals 1 and 2 of terminal board TB1 and arranged to close when the machine indexes. Closure of those contacts allows current to flow from the plus terminal of rectifier 42 through the contacts to energize the coil of stepping motor SM and cause rotation of disc 14. FIG. 7 assumes that four set-bit solenoid assemblies are positioned at selected index positions about the periphery of disc 14. The coils of these solenoid assemblies, which are labelled SB-1 to SB-4, are each connected in series with the rectifier supply to a respective pair of terminals, so that four pairs of remote contacts (not shown) can cause the four set-bit solenoid assemblies to be selectively actuated. FIG. 7 assumes that four sensing switch assemblies S-1 to S-4 are mounted about the periphery of disc 14, and the contacts of these switches are connected to terminal board contacts, from where they are connected to devices to be controlled.

The basic system of FIG. 7 as thus far explained assumes that due to the nature of the equipment being controlled, that none of the pairs of contacts connected to the set bit solenoids will be energized at the same time that the remote contacts controlling the stepping motor will be energized, which is a valid assumption for many types of machines. If a set bit solenoid were energized while the stepping motor is energized to rotate the disc, the lowered arm of the energized set-bit solenoid would become trapped between a pair of pins 22, either bending and damaging the arm or stalling the stepping motor or both. To avoid such a problem, a further microswitch SS (not shown) may be mounted adjacent the stepping motor solenoid, with its contacts arranged to be closed only when the stepping motor solenoid is in its de-energized position, and with the set bit solenoids connected to power through the contacts of switch SS. Alternatively, the coil of a relay SR (not shown) may be connected in parallel with the coil of stepping motor SM, with the relay contacts arranged to prevent actuation of any set bit solenoid while the stepping motor solenoid is energized. The contacts of either switch SS or relay SR are shown at SX in FIG. 7.

As thus far described, the memory device will be seen to include provisions for selectively setting the bit at one or more predetermined index positions, provisions for sensing the condition of the bit at one or more predetermined index positions, and means for always resetting the bit at one or more predetermined index positions. While those functions are sufficient for most applications, certain optional additional features may be added for some applications. In FIG. 8, which corresponds generally to FIG. 3, the flange 14*a* of disc 14 is splined to shaft 12, and coil spring 44 normally urges disc 14 upwardly against collar 46 near the upper end of shaft 12. Button 48 on the end of shaft 12 extends out through a hole in the cover of the device. A circular ring 50 is mounted on platen 11. Though shown in FIG. 8 as a simple ring for convenience in drafting, ring 50, as shown in unrolled form in FIG. 8*a*, has a plurality of notches 50*a*, 50*b* each extending between a pair of adjacent index positions. Reset springs 52 of a modified form may be affixed in any of the notches as shown, to reset a pin as it rotates to a given index position. Spring 52 comprises a simple piece of flat stock having a slot extending down its center and bent to the shape shown. The slot extends from point *a* to point *b* in FIG. 8*a*, and the spring force of the spring bites into ring 50 at points *a* and *b*, holding the spring 52 in the ring 50. At each index position a rigid shoulder or pedestal 54,54 on ring 50 extends up to just below the arms 34 of the sensing switch assemblies. Thus, if an operator momentarily pushes downwardly on button 48, against the force of coil spring 44, the lowering of disc 14 will cause the pedestals 54 on ring 50 to engage any lowered or set pins 22 and restore them to a reset position. Thus the entire register may be cleared by simply pushing on button 48. Obviously, a knob (not shown) can instead be installed on the opposite end of shaft 12, to be pulled out momentarily in order to reset the device. It is necessary, of course, that ratchet 18 on shaft 12 be of sufficient length to prevent it from unmeshing with the stepping motor when the shaft is translated to clear the register. FIG. 8 also shows a further solenoid CS mounted below platen 11. The armature 56 of solenoid CS has a yoke end 56a surrounding shaft 12 and normally resting above ratchet 18. Energization of solenoid CS pulls shaft 12 downwardly to clear the entire register.

While reset spring of FIG. 5 always clears the bit at a given index position, it is sometimes desirable to provide selective clearing of the bits at individual index positions. FIG. 5*a* illustrates a modified form of reset spring 58 having a magnetic bar 60 which is attracted to solenoid IR against the force of spring 58 when that solenoid is energized, preventing the spring from raising any pin to reset position. FIG. 5*b* illustrates a further modified form of reset spring arrangement wherein energization of solenoid IR2 pivots reset spring 62 into operative position (wherein its end is shown in dashed lines at 62*a*) so that it will raise each passing pin to reset position. Spring 63 restores arm 62 when coil IR2 is de-energized. If each index position is provided with a solenoid controlled reset spring, clearing of the entire register may be effected by the circuit of FIG. 5*c* rather than by translating the disc as in FIG. 8. Closing of any one of the top four switches will operate a respective solenoid to clear a single bit, while closure of the bottom switch will operate all four solenoids to clear four bits.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained, and since certain changes may be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mechanical memory device which is automatically settable and re-settable in response to electrical signals, comprising, in combination: a disc rotatable about an axis and having a plurality of through holes spaced in a circle about said axis adjacent the periphery of said disc; a plurality of pins slidably mounted in said holes to allow sliding movement of said pins substantially parallel to said axis, each of said pins having a widened portion on opposite sides of the disc to limit

motion of each pin to first and second limit positions representing a pair of binary conditions; motor means responsive to successive electrical signals for rotating said disc through discrete successive angular increments corresponding to the angular spacing of successive holes around said disc to position said pins at successive angular stations around said axis; solenoid means responsive to electrical signals for selectively moving pins successively located at a first station around said axis to said first limit position; switch means positioned to be engaged and operated by each successive pin which is situated at its first limit position as it arrives at a second station around said axis for providing successive electrical signals; and reset means situated at a third station around said axis for automatically returning successive pins which arrive at said third station in their first limit positions to their second limit positions.

2. A device according to claim 1 wherein said solenoid means comprises a solenoid mounted radially outside the periphery of said disc and a cantilever-mounted spring arm attached to said solenoid and extending to a space in the direction of said second limit position relative to a pin located at said first station, whereby operation of said solenoid in response to said electrical signal causes said spring arm to urge a pin located at said first station in a direction substantially parallel to said axis to said first limit position.

3. A device according to claim 1 wherein said switch means comprises a switch mounted radially outside the periphery of said disc; and a spring switch-actuating arm attached to said switch and extending to a space which a given pin will occupy when said disc has rotated said given pin to said second station around said disc if and only if said given pin has been moved to said first limit position.

4. A device according to claim 1 having a plurality of solenoid means fixedly spaced at a plurality of different stations spaced around said axis for selectively moving pins carried by said disc to said plurality of stations.

5. A device according to claim 1 having a plurality of switch means fixedly spaced at a plurality of different stations around said axis for providing electrical signals indicating the respective limit positions of the pins at said different stations.

6. A device according to claim 1 wherein said reset means comprises spring means situated at said third station for automatically returning each pin which arrives at said third station in its first limit position to its second limit position.

7. A device according to claim 1 wherein said reset means comprises second solenoid means responsive to electrical signals for selectively returning pins at said third station to their second limit positions.

8. A device according to claim 1 wherein said pins are rotatably as well as slidably mounted in said holes of said disc, whereby said pins may rotate when engaged by either said solenoid means or said switch means.

9. A device according to claim 1 wherein said rotatable disc has a groove extending about its peripheral edge and a solid elastomeric band seated within said groove, a portion of each said holes through said disc intersecting said groove, whereby said band frictionally engages each of said pins and resists movement of said pins in said holes.

10. A device according to claim 9 in which said solid elastomeric band comprises a ring having a circular cross-section.

11. A device according to claim 1 having means for translating said disc parallel to its axis of rotation to move all of said pins which may be at their first limit position to their second limit position.

12. A device according to claim 11 in which said means for translating said disc comprises second solenoid means.

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