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

Inventor: Wallace Utter, Vestal, N.Y.
Assignee: Thunder Projects Incorporated, Binghamton, N.Y.
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Primary Examiner—J. R. Scott
Attorney—Richard G. Stephens

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 bi-
ary 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
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 unpredictable 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. 5a is a view similar to FIG. 5 showing a modified form of reset device.

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

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

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

FIG. 6a is a view taken at lines 6a—6a 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. 8a 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 journaled 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 slidable 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 24b 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 slideable 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 30 to each pin 24 provides friction between each 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 operation after 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 24a 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 is mounted on a RISER BLOCK 31 as shown. See FIG. 6a. Spring arm 34 of switch S extends horizontally under disc 14 to a location such that shoulder 34a 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 36a 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 assem-
bles, which are labelled SB-1 to SB-4, are each con-
nected 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 assem-
bles to be selectively actuated. FIG. 7 assumes that
two 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 con-
tacts, from where they are connected to devices to be
controlled.

The basic system of FIG. 7 as thus far explained as-
sumes 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 sole-
noid 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, provi-
sions 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 cor-
responds generally to FIG. 3, the flange 14a 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. 8a, has a plurality of
notches 50a, 50b each extending between a pair of ad-
djacent 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. 8a, 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 momen-
tarily 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 posi-
tion. 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 un-
meshing 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 surround-
ing 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 pro-
vide selective clearing of the bits at individual index
positions. FIG. 5a 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 rais-
ing any pin to reset position. FIG. 5b 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 62a) 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. 5c,
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 descrip-
tion 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 exclu-
spensive property or privilege is claimed are defined as fol-

1. A mechanical memory device which is automatic-
ally 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 substan-
tially parallel to said axis, each of said pins having a
widened portion on opposite sides of the disc to limit
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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 springs 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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