Feb. 14, 1967 E. J. HUNTER 3,304,478

SEQUENTIAL TIMING DEVICE USING PLURAL MOTORS

Filed Aug. 27, 1963 2 Sheets-Sheet 1

FIG. 1.

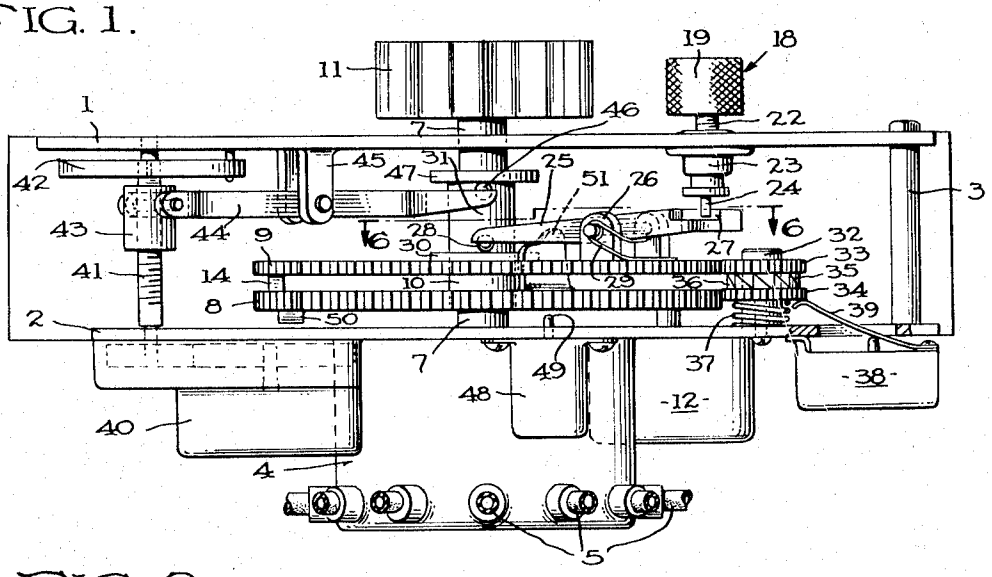


FIG. 2.

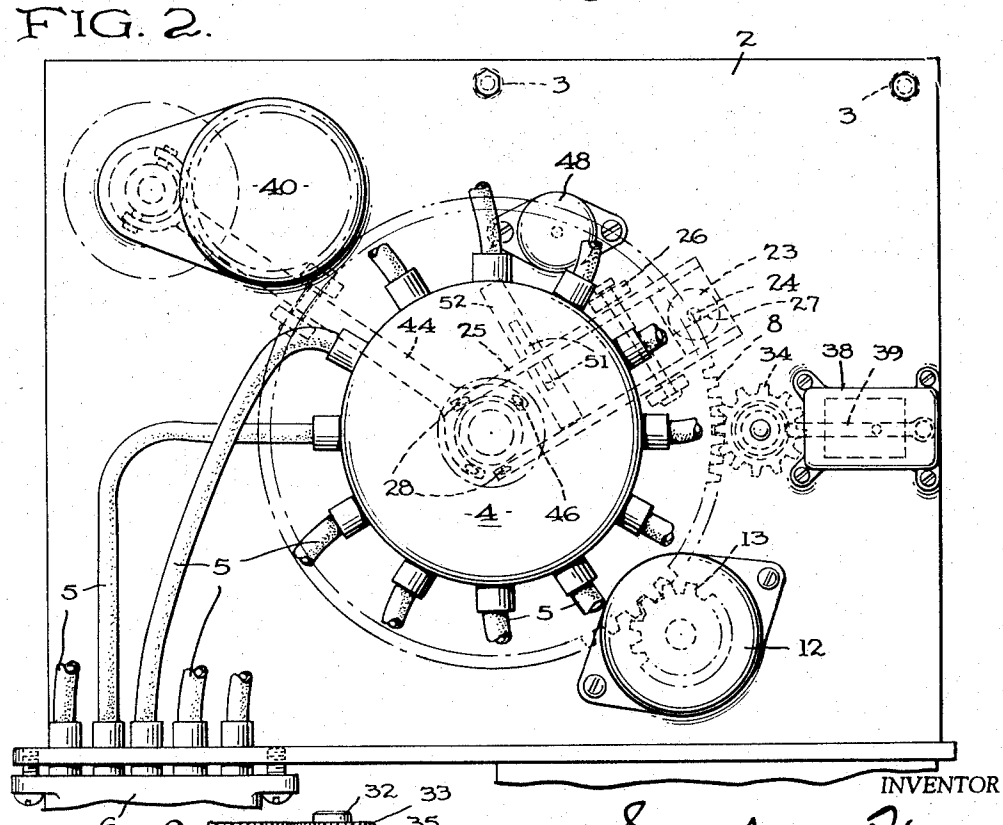
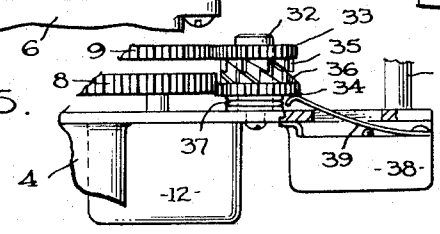


FIG. 5.



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FIG. 3.

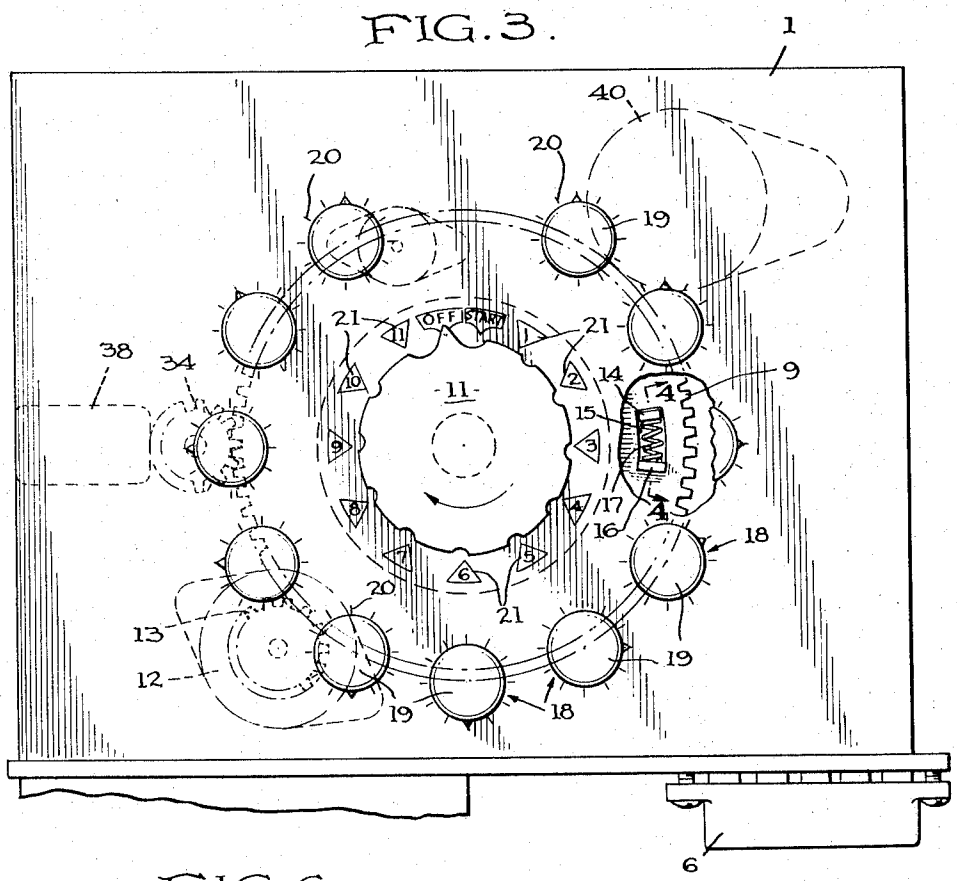


FIG. 6.

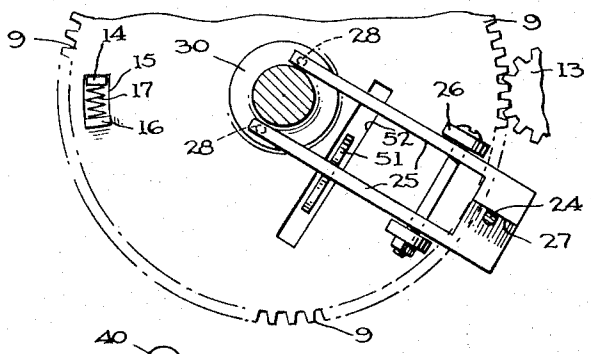
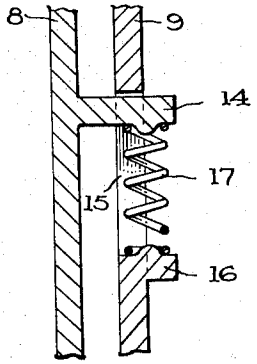


FIG. 4.



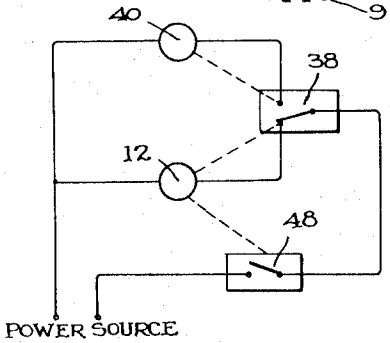


FIG. 7.

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United States Patent Office 3,304,478 Patented Feb. 14, 1967

3,304,478

SEQUENTIAL TIMING DEVICE USING PLURAL MOTORS

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Filed Aug. 27, 1963, Ser. No. 304,842
9 Claims. (Cl. 318—102)

This invention relates to an improved sequential timing device for controlling the duration of a plurality of successive operations.

Sequential timing devices of this type find application, for instance, in water sprinkling systems wherein sections of land are to be irrigated in succession for variable lengths of time, or in automatic laundry equipment wherein a plurality of sequential operations of changeable duration (washing, rinsing, spinning, drying, etc.) has to be programmed.

An object of the invention is to provide a sequential timing device of improved structure which may be set for a plurality of time values for determining the duration of each of a plurality of sequential operations.

Another object of the invention is to provide a sequential timing device of improved structure wherein the adjustment of the time values may be carried out independently of each other.

A further object of the invention is to provide a sequential timing device including improved means whereby the device may be manually set to any desired control position.

A further object of the invention is to provide a sequential timing device of improved structure wherein wear of frictionally engaging surfaces does not affect the accuracy of the timing mechanism.

Still a further object of the invention is to provide a sequential timing device including improved means for a more positive and accurate indexing than heretofore possible.

Still another object of the invention is to provide a sequential timing device, the timing range of which may be widely varied by the simple exchange of one inexpensive component.

The details of the invention, as well as additional objects and advantages, will be clearly understood with reference to a preferred embodiment illustrated in the accompanying drawings employing similar reference numerals to identify the same elements in each of the several views, and in which:

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

FIG. 2 is a rear elevation view of the same embodiment;

FIG. 3 is a front elevation view of the same embodiment with the front panel partially broken away;

FIG. 4 is an enlarged sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a partial top plan view of the same embodiment with some parts in an alternate position;

FIG. 6 is a fragmentary view taken along line 6—6 of FIG. 1; and

FIG. 7 is a circuit diagram symbolically illustrating the electrical and mechanical connections between several parts of the timing device.

Briefly, the timing device of the invention is a mechanism for intermittently rotating and arresting the shaft of a multiple position control unit. The device comprises an indexing motor associated with an indexing mechanism to turn the shaft successively from one position to the next one, a plurality of adjustable stationary stopping mechanisms arranged in a circular array around the shaft and a timing motor associated with a timing mechanism adapted to abut against each stopping mechanism, thereby

arresting the motion of the shaft and maintaining the same stationary for lengths of time pre-selected by the adjustable stopping mechanisms. The invention pertains in particular to the structure and operation of the stopping and timing mechanisms.

Referring now to FIGS. 1 and 2, the timing device comprises a front panel **1** and a rear mounting panel **2** held in spaced parallel relation by means of a plurality of spacer posts **3** (only one shown).

On rear panel **2** there is mounted a housing **4** surrounding a multiple position control unit, such as a rotary hydraulic selector valve of known construction (not shown). A plurality of conduits **5**, each connected to an output port (not shown) of the selector valve, extend from apertured housing **4** to outlet box **6**. For more clarity most of the conduits are shown in a fragmentary manner only in FIGS. 1 and 2. The outlet box **6** is adapted to receive a multiple-conduit hydraulic conductor (not shown) for transmitting pressure signals from the selector valve. It is understood that instead of a hydraulic selector valve, the housing **4** may enclose a multiple contact electric stepping switch, in which case the hydraulic conduits **5** are replaced by electric conductors, each connected to a stator contact of the stepping switch. Further, in case an electric stepping switch is used, outlet box **6** is adapted to receive a multiple prong plug, or the like, for connecting a plurality of electric control circuits to the stepping switch.

The multiple position control unit comprises a shaft **7** which extends through panels **1** and **2** and carries gears **8** and **9** which are disposed in parallel relation and have substantially the same circumferential area. Gear **8** is fixedly keyed to shaft **7**, while gear **9** is free to rotate relative thereto. Also mounted on shaft **7** is collar **10** for holding gear **9** in a spaced relation with respect to gear **8**. To the free end of shaft **7** there is keyed a knob **11**.

An indexing motor **12** (FIG. 2) mounted on panel **2** drives gear **8** by means of pinion gear **13**. The indexing motor may have a speed of approximately 5 r.p.m. and the gear ratio between pinion gear **13** and gear **8** may be, for example, 12 to 1.

Referring now more particularly to FIGS. 3 and 4, gear **9** is connected to gear **8** by means of an eccentric lug **14** which is formed as an integral part of gear **8**. Lug **14** projects through an opening **15** provided in gear **9** and is arranged to confront an offstanding lug **16** which is formed as an integral part of gear **9**. A coil spring **17** is disposed between the offstanding confronting surfaces of lugs **14** and **16** and is of adequate resistance to transmit the rotational force of driven gear **8** into gear **9** without compression thereof unless gear **9** is mechanically arrested during its rotation, as will be better understood as the description progresses.

As seen in FIG. 3, a plurality of stationary timing units **18** are mounted in a circular array about shaft **7** on front panel **1**. Each timing unit **18** comprises a timing knob **19** having an integral pointer to be set to any desired value on scale **20**. Each timing unit **18** is associated with a position number **21** that is applied in any suitable manner to the outer face of panel **1** adjacent to each timing unit.

Referring once again to FIG. 1, it will be observed that plate **1** is suitably apertured to receive a threaded screw **22**, with a knob **19** being provided thereon adjacent to the front side of said panel with its opposite extremity received in a nut **23** which is fixedly attached to the back side of said panel. Integral with screw **22** is a timing pin **24** extending coaxially therefrom with said pin arranged to be advanced into a desired position by setting the pointer of knob **19** to a selected value on scale **20**. For clarity only one timing unit **18** is shown in FIG. 1.

A bifurcated timing arm 25, supported by means of bracket 26 formed as an integral part of gear 9, is arranged to be carried thereby through an orbital path for successively cooperating with any one of the serially arranged timing pins 24. Timing arm 25, adapted to be pivotally mounted in bracket 26 in a plane normal to its plane of orbital travel, has a face 27 which is adapted to abut against and slide relative to timing pin 24. The other end of arm 25 is provided with riders 28 urged by spring 29 into continuous slidable engagement with the inner rim 30 of spool 31. Spool 31 is freely rotatable on shaft 7 and axially slidable between the back of panel 1 and gear 9.

Fixedly mounted on rear plate 2 is a pinion shaft 32 about which pinion gears 33 and 34 are journaled. In addition to rotary movement about pinion shaft 32, gear 34 is also adapted to be axially slidable thereon. Gears 33 and 34 have complemental, oppositely disposed ratchet teeth 35 and 36, respectively, which are adapted to assume an interleaving, fully engaged position as shown in FIG. 1. A coil spring 37 disposed about shaft 32 is interposed between the opposite surface of gear 34 and the inner confronting surface of plate 2 thus urging the beforementioned ratchet teeth into completely engaged condition.

From the foregoing it will be apparent that when gear 34 is rotated with respect to gear 33, a camming action is thus generated between the ratchet teeth 35 and 36 forcing gear 34 to slide axially away from gear 33. The ratchet teeth 35 and 36 are shown in their cammed, separated position in FIG. 5.

A microswitch 38 mounted on rear plate 2 has a leaf spring contact 39 extending through a slot in plate 2 and is adapted to engage the smooth surface of gear 34. With reference to FIG. 7, microswitch 38—depending upon the position of leaf spring 39—establishes an electric circuit for operation of either the indexing motor 12 or a timing motor 40. When the ratchet teeth 35 and 36 are in the position shown in FIG. 1, gear 34 is in complete contact with gear 33, at which time leaf spring 39 is in a released position and microswitch 38 maintains a closed circuit for indexing motor 12. When gear 34 is forced axially away from gear 33, it depresses leaf spring 39 of microswitch 38 interrupting the circuit to indexing motor 12 and establishing an electric circuit to timing motor 40 (FIG. 5).

Timing motor 40 is a well-known clutch-type motor, the output shaft of which is automatically disengaged from the gear train when current thereto is interrupted.

Timing motor 40 is attached to rear plate 2 and is adapted to slowly rotate the worm gear 41 which is disposed between front panel 1 and rear plate 2 (FIG. 1). A torsion spring 42 mounted on panel 1 coaxially of worm gear 41 is tensioned when worm gear 41 is driven by motor 40.

A traveler 43 threadedly engaging worm gear 41 is adapted to move axially therealong when the latter rotates. A bifurcated lever 44 is pivotally supported on panel 1 by means of a fulcrum 45 with one end thereof being pivotally attached to traveler 43 and its opposite free ends carrying riders 46 (only one shown) which slidably engage the inner face of rim 47 of the aforementioned spool 31.

Also mounted on panel 2 is a limit switch 48 which is adapted to stop indexing motor 12 by breaking the electric circuit thereof after one complete revolution of gear 8. A switch actuating arm 49 extends from limit switch 48 through a slot in panel 2 and is adapted to be contacted by the protruding cam means 50 carried by gear 8. When gear 8 brings cam 50 into registry with arm 49, the latter is depressed to interrupt the circuit of indexing motor 12, thereby stopping gear 8. Cam 50 has a relatively short actuating surface so that a few (for example not more than 10) degrees of additional rotary motion imparted manually to gear 8 through knob 11 will cause the actuating face of cam 50 to pass arm 49. The release of arm 49 causes switch 48 to energize indexing motor 12.

Referring now to FIGS. 1 and 6, a cam 51 integral with gear 8 extends through slot 52 in gear 9 positioned thereabove and is thus disposed adjacent arm 25 between rider 28 and bracket 26. The cooperation between the cam 51 and the arm 25 makes possible manual setting of shaft 7 to any desired control position by means of knob 11 as will become apparent from the operation of the device described in detail hereinbelow.

OPERATION

Having set forth the structural features of the timing device comprising the invention, one cycle of operation will now be described.

Before initiating a cycle of operation, limit switch 48 is opened; neither indexing motor 12 nor timing motor 40 is energized (FIG. 7). In this pre-cycle condition gear 8 is in a position where cam 50 depresses switch actuator arm 49 keeping the limit switch 48 open. At this time the pointer of knob 11 is in "Off" position.

By manually turning knob 11 several degrees to its "Start" position (FIG. 3), cam 50 will release switch actuator arm 49 which, in turn, closes limit switch 48. It will be understood that, instead of manual actuation, limit switch 48 may be closed by means of an electric signal generated at any predetermined hour of the day by a conventional time clock not described here.

When limit switch 48 is closed, indexing motor 12 is energized and gear 8 starts rotating. Gear 9, coupled to gear 8 by coil spring 17, turns in synchronism with gear 8 and carries timing arm 25 in an orbital path towards the first of timing units 18. When timing arm 25 is in alignment with the first of timing units 18, the timing pin 24 thereof abuts against surface 27 of timing arm 25 abruptly arresting the motion of gear 9 and meshing pinion gear 33. Gear 8, which is still being driven by indexing motor 12, continues to rotate a few degrees thus compressing spring 17 between lugs 14 and 16. The pinion gear 34, rotated by gear 8, is forced to move axially away from arrested gear 33 due to the reciprocal camming action of the now immobile ratchet teeth 35 of gear 33 and the moving ratchet teeth 36 of gear 34 (FIG. 5). When axially displaced, pinion gear 34 depresses spring leaf contact 39 of microswitch 38 thus breaking the circuit of indexing motor 12 and closing the circuit of timing motor 40.

The de-energization of indexing motor 12 stops the rotation of shaft 7 in position with spring 17 compressed and exerting a rotational force on gear 8 and arm 25.

The selector valve in housing 4 has now assumed the first of a plurality of consecutive positions. Rotated by shaft 7, knob 11 now points towards the first timing unit 18. The timing mechanism, whose operation will now be described, determines how long the selector valve remains in its first position before being indexed into its second and subsequent positions.

Timing motor 40, energized by the microswitch 38, slowly rotates worm gear 41 and winds the torsion spring 42. The rotation of worm gear 41 imparts a linear motion to traveler 43 which, through fulcrumated lever 44, causes spool 31 to slide on shaft 7. As spool 31 moves axially on shaft 7, its rim 30 causes timing arm 25 to slowly pivot in bracket 26 in a plane normal to its orbital path, whereby surface 27 of timing arm 25 slides along timing pin 24 towards the end thereof. The length of time surface 27 requires to clear timing pin 24 depends on the distance surface 27 has to travel along timing pin 24. This distance is preset by retracting or advancing pin 24 by manual adjustment of timing knob 19.

When surface 27 of timing arm 25 clears timing pin 24, gear 9 is released and urged by compressed spring 17, it will now rotate a few degrees and carrying timing arm 25

past timing pin **24** in an orbital path normal to the axis of the timing pin **24**.

The spring actuated rotation of gear **9** turns pinion gear **33** with respect to immobile gear **34**. The ratchet teeth **35** and **36** of gears **33** and **34**, respectively, change their relative position eliminating the camming action therebetween and urged by spring **37**, gear **34** now moves axially back toward gear **33** releasing the leaf spring **39** of microswitch **38**. The release of leaf spring **39** actuates microswitch **38** which now de-energizes timing motor **40** and re-energizes indexing motor **12**.

As timing motor **40** is de-energized and its output shaft becomes freely rotatable, wound torsion spring **42** spins worm gear **41** in reverse, causing traveler **43** to move back to its initial position where it was before the timing motor **40** was first energized. The resetting of traveler **43** also causes—through lever **44**—the timing arm **25** to assume its initial position ready to abut the timing pin **24** of the next timing unit **18**.

It is apparent that the timing range of the device is determined by the speed of travel of surface **27** along pin **24**. This speed, on the other hand, depends upon (1) the rotational speed of the timing motor output shaft and (2) the pitch of threading on worm gear **41**. However, replacing the timing motor for the purpose of changing the timing range involves considerable expense. Whereas, replacing the worm gear, however, is inexpensive and requires only ordinary mechanical skill. Thus, for example, if the timing range of the timing units **18** is to be changed from 0–60 minutes to 0–3 hours, a worm gear and traveler having a thread-pitch ⅓ as large is substituted. Worm gear **41** and traveler **43** should preferably, therefore, easily be removable as a unit from the timing assembly.

The re-energization of indexing motor **12** restarts gear **8** which turns shaft **7** towards it second position. This motion is again arrested, in this instance by timing pin **24** of the second timing unit **18**, by abutting against surface **27** of timing arm **25**. In the event no timing is desired for one or several positions, the knob **19** of the respective timing unit or units **18** is set to zero. At this time, pin **24** is sufficiently retracted as not to abut against surface **27** of timing arm **25**. Therefore, stepping switch shaft **7** will move uninterruptedly to its next position.

After one full revolution of gear **8**, cam **50** depresses switch actuator arm **49**. Switch **48** opens and breaks the circuit to both indexing motor **12** and timing motor **40**. The timing device has completed one cycle and is now de-energized; the pointer of knob **11** has now returned to its "Off" position. The beginning of a new cycle has to be initiated again either by manually turning knob **11** to "Start" position, or by closing switch **48** by means of a signal from a conventional time clock (not shown).

It is apparent from the preceding description that the rotation of shaft **7** is interrupted by each timing unit **18** for a duration determined by the setting of each knob **19**. Stated in other terms, during one cycle of operation the indexing motor **12** intermittently rotates shaft **7** one full revolution. The selector valve (or stepping switch) is stationary in each control position for a duration preset by adjusting knob **19** of timing units **18**, each associated with one control position of the selector valve (or stepping switch).

The operation of the device, as described hereinabove, is entirely automatic through a whole cycle. It is, however, a desideratum to manually set shaft **7** by knob **11** to any desired control position by omitting one or more timing units from the sequence. The output shaft of indexing motor **12** is provided with overrunning clutch means (not shown) so as not to block the faster manual rotation of shaft **7**. Thus, for example, if only control positions "9" and "10" are to be sequentially timed, positions "1" through "8" are "jumped" manually and after the sequential timing of control positions "9" and "10," position "11" is "jumped" and knob **11** is manually returned to "Off" position. By virtue of cooperation between cam **51** and arm **25**, such manual "jumping" of any control positions can be achieved without retracting the respective timing pin **24** of the control station **18** to be omitted. When knob **11** is manually rotated, face **27** of timing arm **25** abuts against the first-encountered timing pin **24**. Gear **9** and timing arm **25** are stopped, while shaft **7** and gear **8** carrying cam **51** continues to rotate. As gear **8** rotates with respect to gear **7**, cam **51** lifts arm **25** so that face **27** thereof immediately clears timing pin **24** thereby releasing timing arm **25** and gear **9**. The camming action between cam **51** and arm **25** is repeated each time the face **27** abuts against a timing pin **24** when shaft **7** is rotated manually by knob **11**. It is important to point out that during normal timing operation cam **51** always stays clear of timing arm **25**. The camming face of cam **51** is so positioned with respect to arm **25** that during automatic operation the relative rotation of gear **8** with respect to gear **9** is stopped, due to the de-energization of indexing motor **12**, before camming action can take place. Only an additional few degrees of rotation of gear **8** with respect to gear **9** will cause cam **51** to contact arm **25**. Such an additional rotation, however, can be achieved only by manually turning knob **11**.

Although only one embodiment of the invention has been depicted and described, it will be apparent that this embodiment is illustrative in nature and that a number of modifications in the apparatus and variations in its end use may be effected without departing from the spirit or scope of the invention as defined in the appended claims.

What I claim is:

1. A device for sequentially timing a multiple position control unit having a shaft adapted to set said unit to any one of a plurality of control positions comprising an indexing motor for rotating said shaft to successive control positions, a timing member mechanically linked to said shaft, means for driving said timing member in an orbital path, a plurality of spaced, stationary timing units disposed along said path, each said timing unit including a timing pin adjustably extending into said path and adapted to abut against said timing member for stopping the orbital motion thereof, a timing motor for advancing said timing member along said abutted timing pin towards the free end thereof in a path substantially normal to said orbital path, means for maintaining said shaft stationary in any one of said control positions for the duration of contact between said timing member and any one of said timing pins, and camming means for causing said timing member to move out of contact with said abutted timing pin when said shaft is manually advanced.

2. A device for sequentially timing a multiple position control unit having a shaft adapted to set said unit to any one of a plurality of control positions comprising, an indexing motor for rotating said shaft to successive control positions, a timing member mechanically linked to said shaft, means for driving said timing member in an orbital path, a plurality of spaced, stationary timing units disposed along said path, each said timing unit including a timing pin adjustably extending into said path and adapted to abut against said timing member for interrupting the orbital motion thereof, a timing motor, a worm gear rotatable by said timing motor, a traveler threadedly received by said worm gear, linkage means connecting said traveler to said timing member for advancing said timing member along said abutted timing pin towards the free end thereof when said worm gear is rotated by said timing motor, means for energizing said timing motor when the orbital motion of said timing member is arrested by any of said pins, means for de-energizing said timing motor when said timing member clears any of said timing pins and means for maintaining said shaft stationary in any one of said control positions for the duration of

contact between said timing member and any one of said timing pins.

3. A device for sequentially timing a multiple position control unit having a shaft adapted to set said unit to any one of a plurality of control positions comprising, a first gear keyed to said shaft, an indexing motor connected to said first gear for rotating said shaft to successive control positions, a second gear disposed in spaced parallel relationship with respect to said first gear, eccentric drive means connecting said gears, a timing member mounted on said second gear and adapted to be carried in an arbital path thereby, a plurality of spaced, stationary means disposed along said orbital path for successively abutting against said timing member thereby arresting the rotation of said shaft, a timing motor for maintaining said timing member and any one of said stationary means in an abutting relationship for selected periods of time, switching means connected to said gears and actuated thereby at the beginning and at the end of said selected periods of time for energizing and de-energizing said timing motor.

4. A device according to claim 3, wherein said switching means include two axially aligned pinion gears, one meshing with said first bear and the other meshing with said second gear, one of said pinion gears adapted to be axially displaced to actuate a switch for energizing and de-energizing said timing motor.

5. A device according to claim 4, wherein each of said pinion gears include opposed camming means for causing said axial displacement of one of said pinion gears when rotated relative to each other and spring means for axially urging said pinion gears towards one another.

6. A device according to claim 3, wherein said eccentric drive means includes a first lug integral with said first gear and extending into said second gear through an aperture therein, a second lug integral with said second gear and arranged in spaced relation with respect to said first lug, a spring disposed between opposed faces of said lugs to urge said gears in opposed rotary direction, said spring yieldable only when said timing member is arrested by one of said stationary means.

7. A device according to claim 3, wherein said first gear carries a cam extending through a slot in said second gear and disposed adjacent said timing member, said cam adapted to cause said timing member to slide out of contact with said abutted stationary means when said shaft is manually advanced.

8. A device for sequentially timing a multiple position control unit comprising, a front mounting panel and a rear mounting panel, means for maintaining said panels in a spaced, parallel relation, a unidirectionally rotatable shaft extending through said panels and adapted to set said unit to any one of a plurality of control positions, a first gear keyed to said shaft and disposed between said panels in substantially parallel relation thereto, an indexing motor mounted on one of said panels and connected to said first gear, a second gear rotatably mounted on said shaft and spaced from said first gear by means of a collar disposed around said shaft, a freely rotatable spool disposed on said shaft between said second gear and said front panel and adapted to axially slide therebetween, said spool having two radially extending spaced rims, a timing arm mounted on said second gear and adapted to pivot thereon in a plane substantially parallel to said shaft, spring means for urging one end of said timing arm against one rim of said spool, a plurality of spaced timing units mounted on said front panel in a circular array about said shaft, each said timing unit including a timing pin extending in a plane parallel to the plane of pivotal movement of said timing arm, each of said units including means for adjusting the extent of projection of said pin associated therewith, and each of said pins adapted to abut against the end of said timing arm distal of said spool when said timing arm is carried in an orbital path by said second gear, a timing motor mounted on one of said panels, a worm gear rotatably received by at least one of said panels and extending therebetween, said worm gear connected to said timing motor, a traveler threadedly surrounding said worm gear, spring means connected to said worm gear and tensioned by said timing motor, a lever pivotally mounted on one of said panels and disposed therebetween, one end of said lever attached to said traveler, the other end of said lever engaging the rim of said spool distal from the end of said timing arm, a pinion shaft fixedly held by at least one of said panels, a first and a second pinion gear rotatably mounted on said pinion shaft and disposed in meshing relationship with said first and second gears, respectively, each of said pinion gears including opposed camming means for causing an axial displacement of one of said pinion gears away from the other when rotated relative to each other, spring means for axially urging said pinion gears toward one another, a switch mounted on one of said panels and actuated by said axially displaceable pinion gear, said switch adapted to energize said timing motor while de-energizing said indexing motor and energizing said indexing motor while de-energizing said timing motor, a first eccentric lug integral with said first gear and extending into said second gear through an aperture therein, a second eccentric lug integral with said second gear and positioned in spaced relation with respect to said first lug, and a spring disposed between opposed faces of said lugs to urge said gears in opposed rotary direction, said spring being yieldable only when said timing member is arrested by one of said timing pins.

9. A device according to claim 8, wherein said first gear carries a cam extending through a slot in said second gear and disposed adjacent said timing arm, said cam adapted to cause said timing arm to slide out of contact with said abutted timing pin when said shaft is manually advanced.

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