Aug. 3, 1965 J. S. ROBERTS 3,198,967

VARIABLE INTERVAL STEPPING SWITCH

Filed June 30. 1961 9 Sheets-Sheet 1

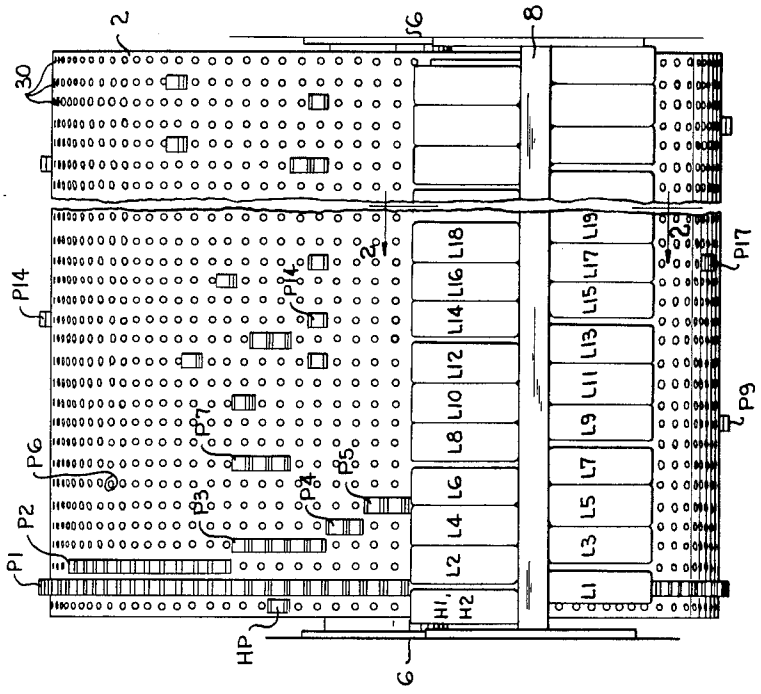


Fig. 1

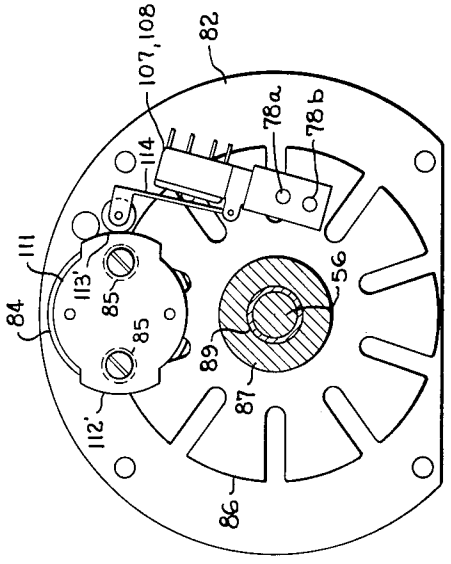


Fig. 3A

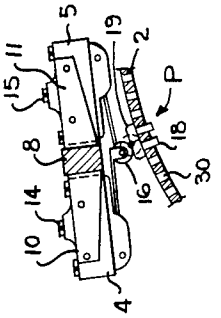


Fig. 2

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VARIABLE INTERVAL STEPPING SWITCH

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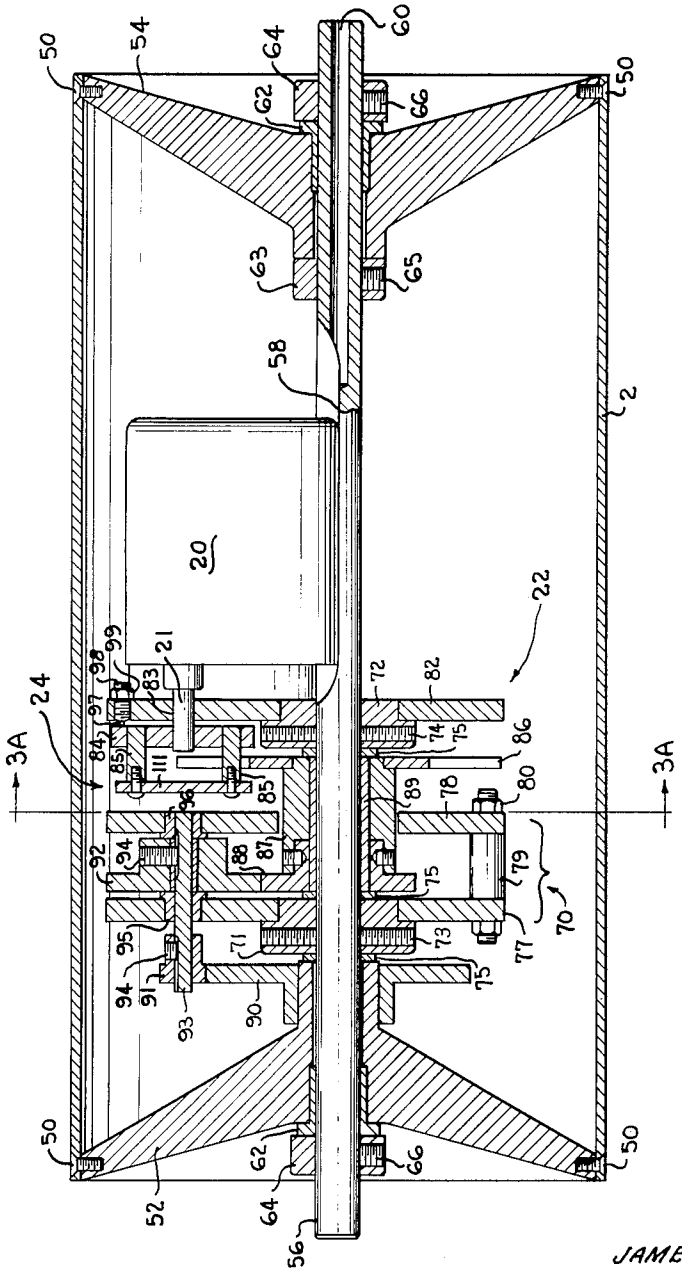


Fig. 3

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VARIABLE INTERVAL STEPPING SWITCH

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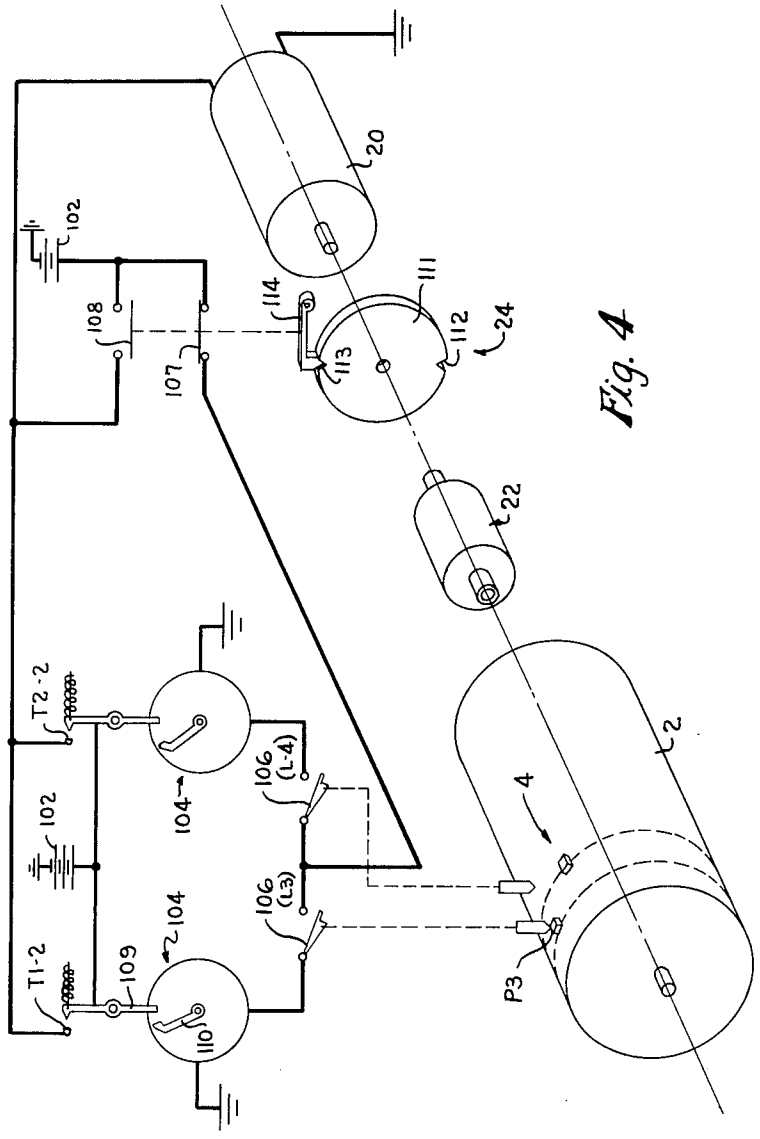


Fig. 4

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VARIABLE INTERVAL STEPPING SWITCH

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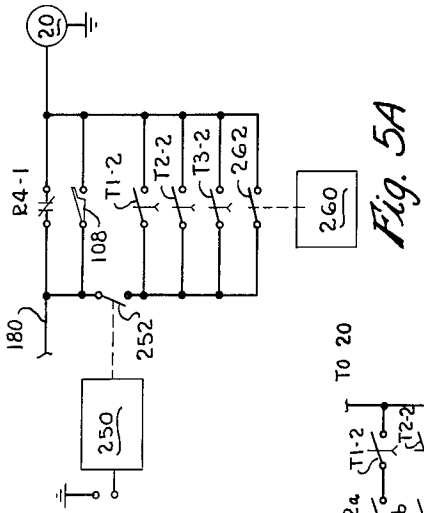


Fig. 5A

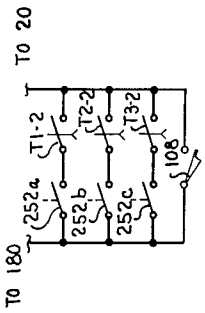


Fig. 5B

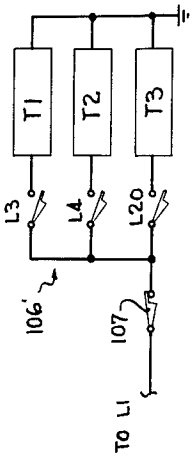


Fig. 5D

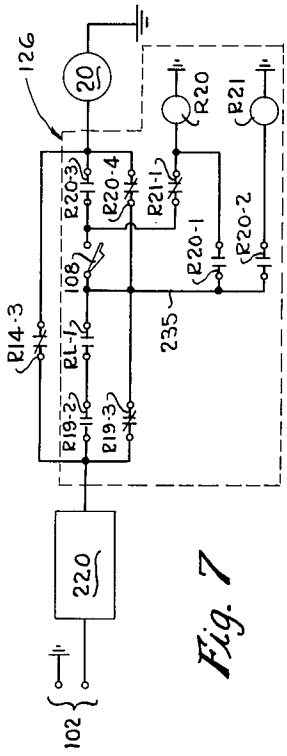


Fig. 7

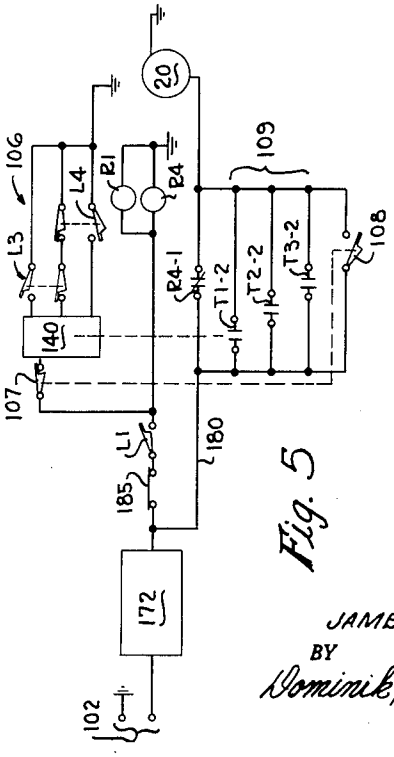


Fig. 5

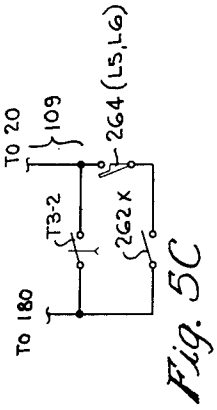


Fig. 5C

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VARIABLE INTERVAL STEPPING SWITCH

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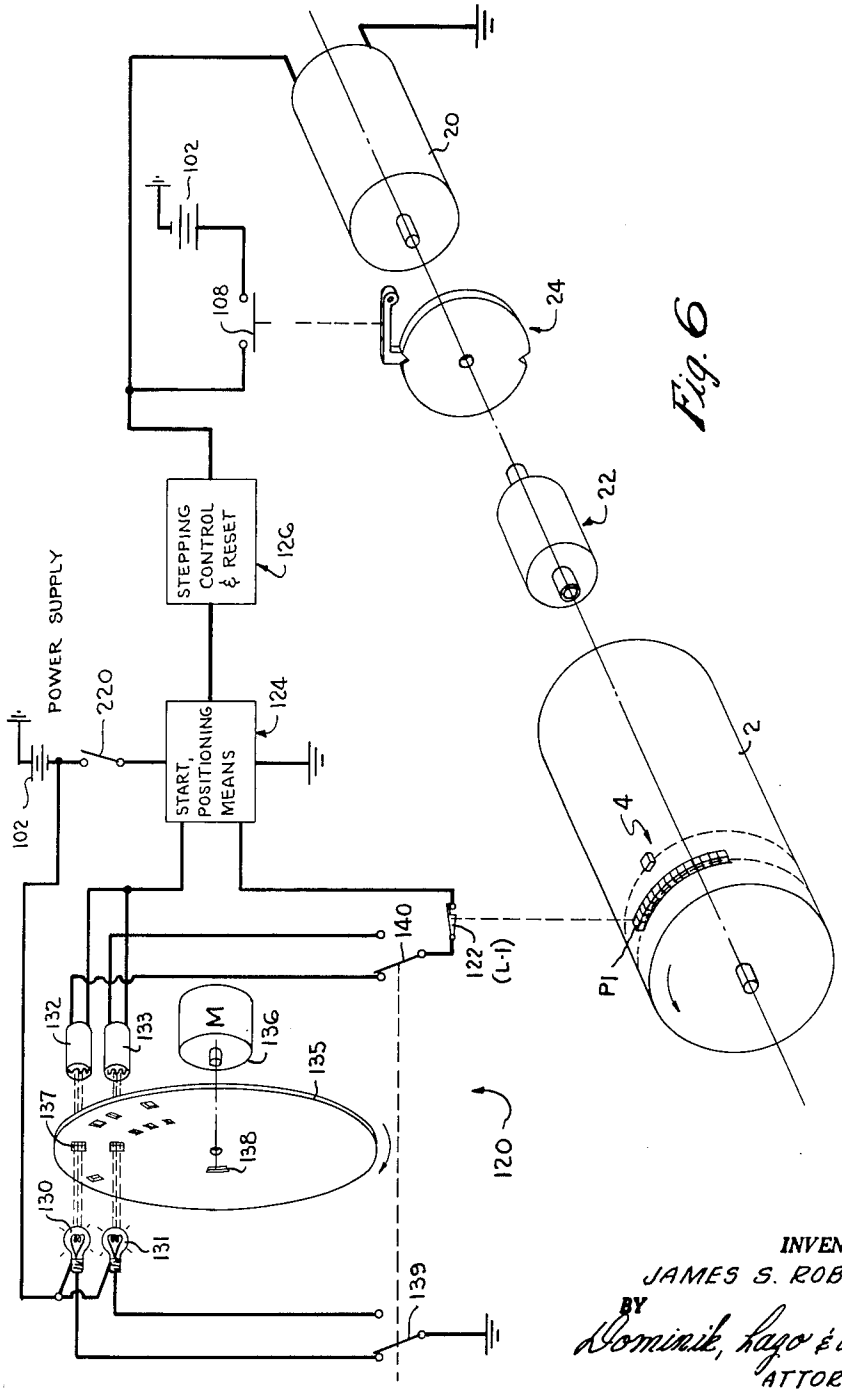


Fig. 6

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VARIABLE INTERVAL STEPPING SWITCH

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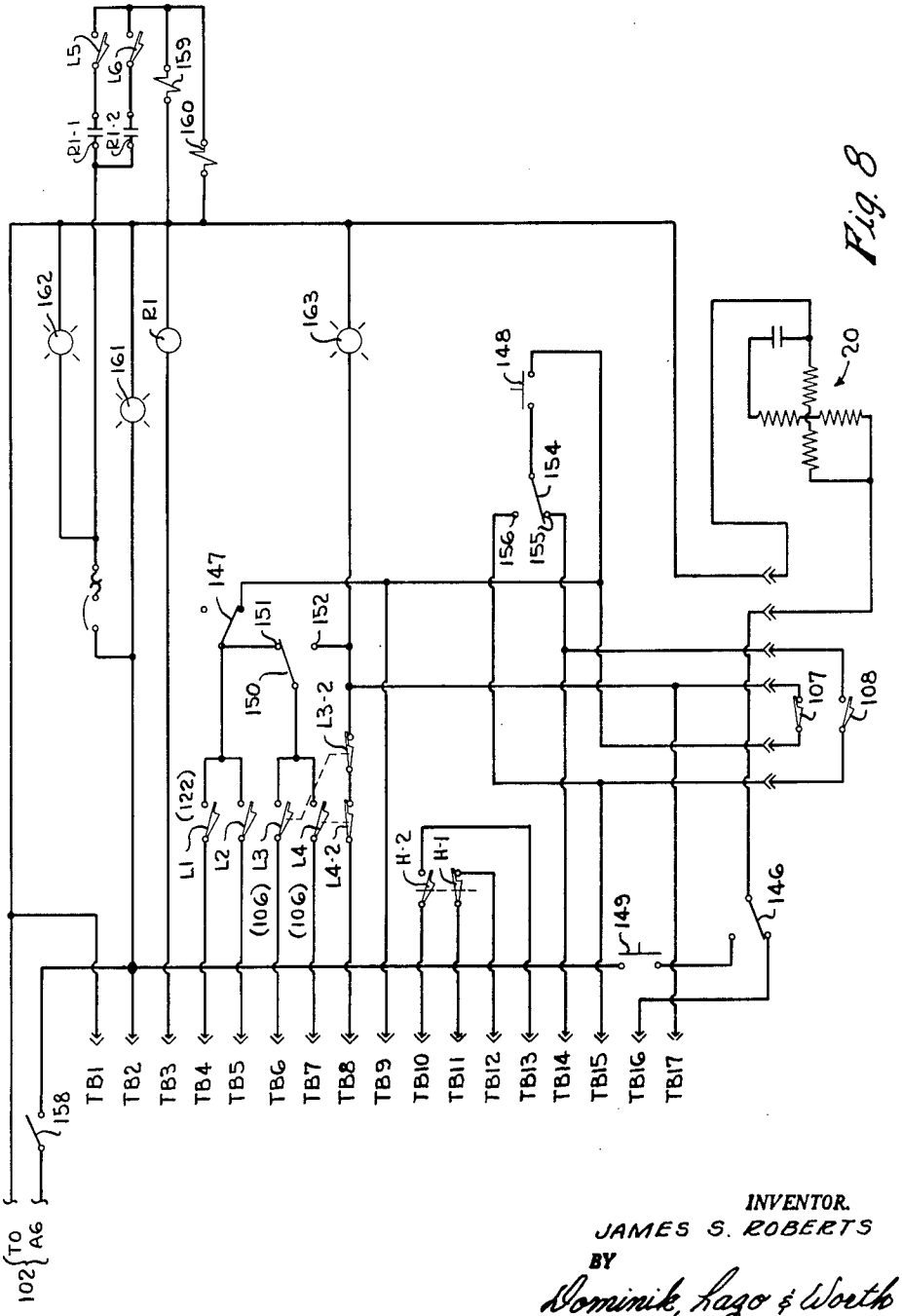


Fig. 8

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VARIABLE INTERVAL STEPPING SWITCH

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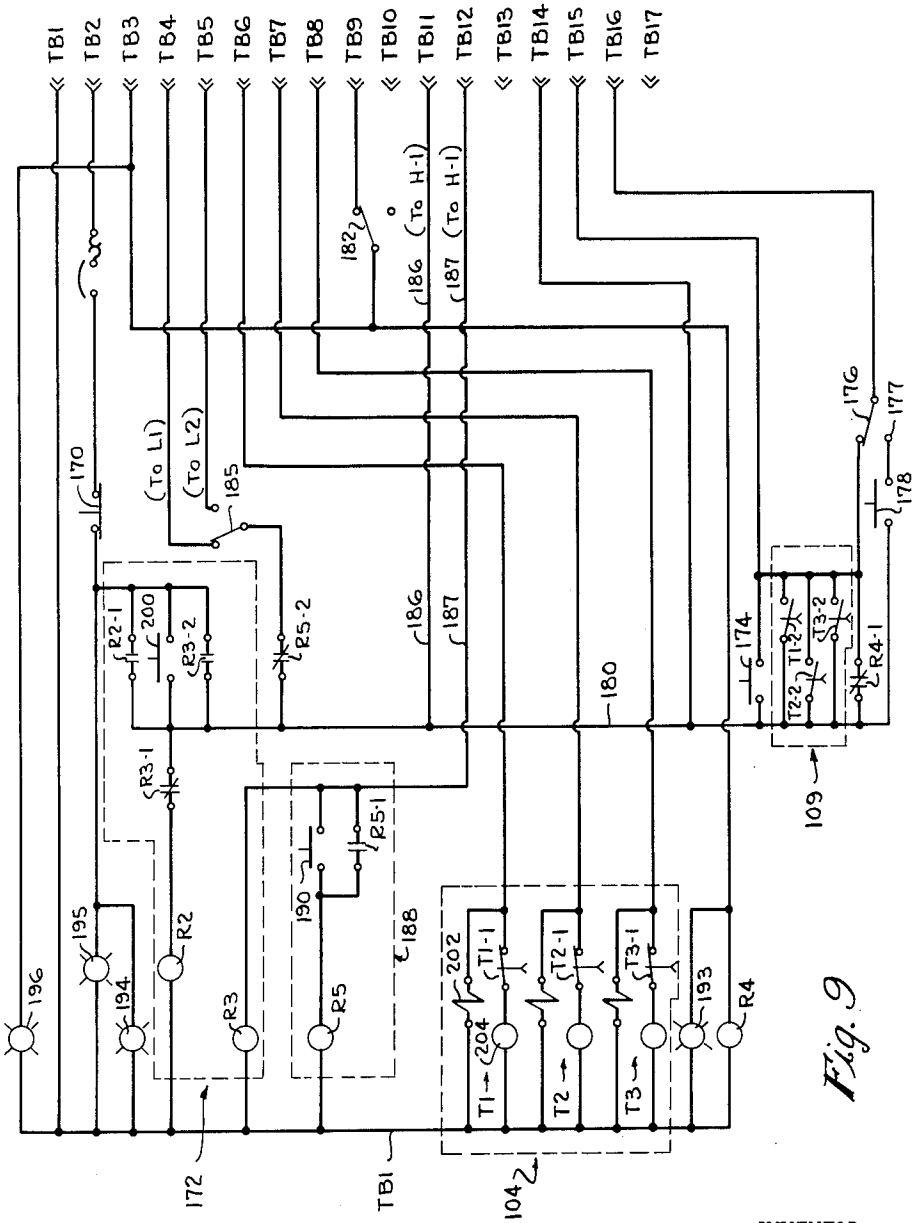


Fig. 9

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VARIABLE INTERVAL STEPPING SWITCH

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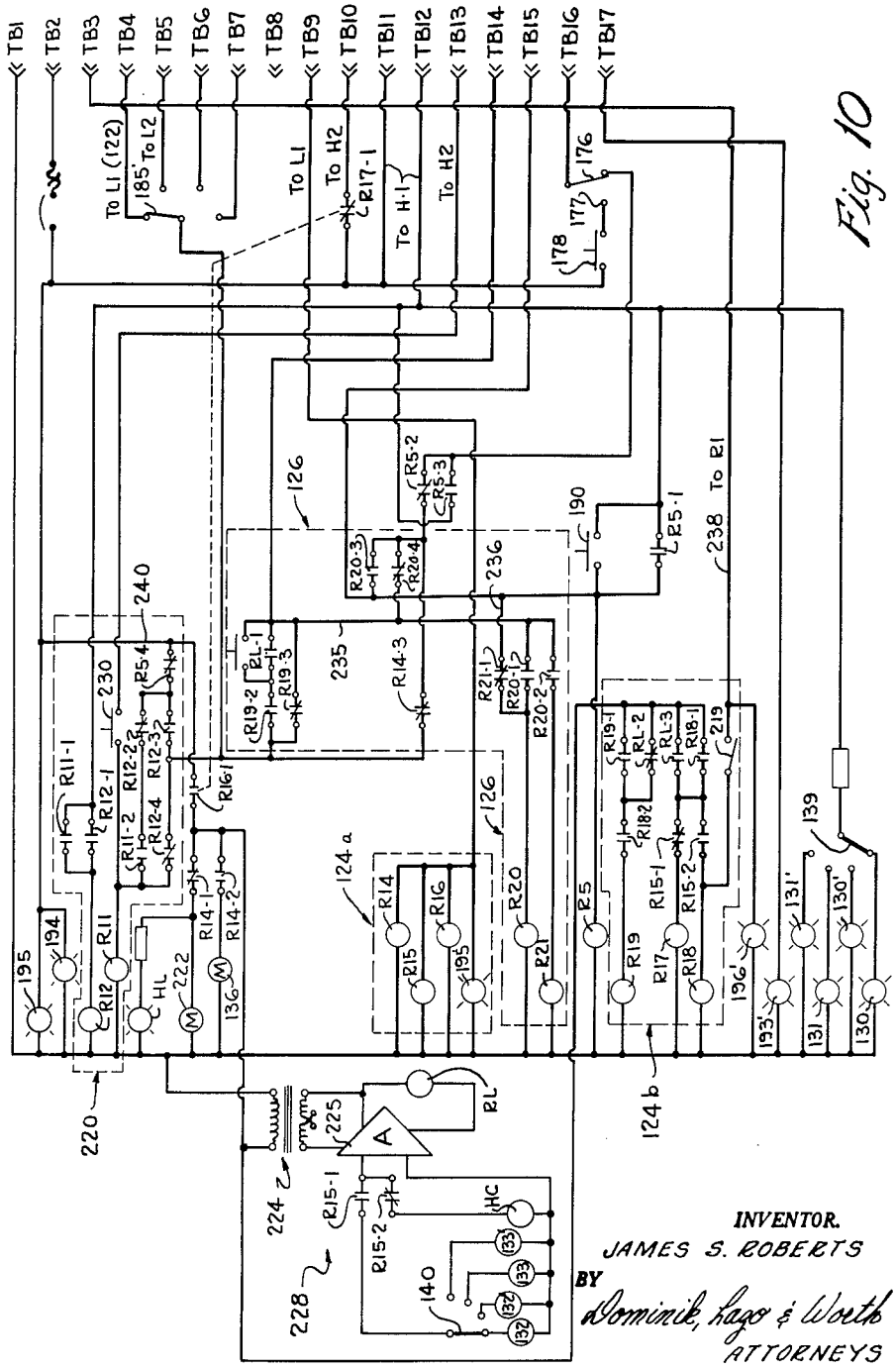


Fig. 10

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VARIABLE INTERVAL STEPPING SWITCH

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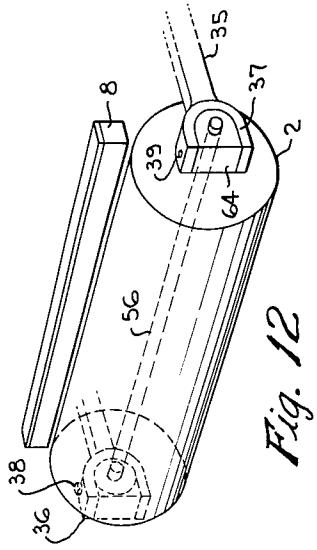


Fig. 12

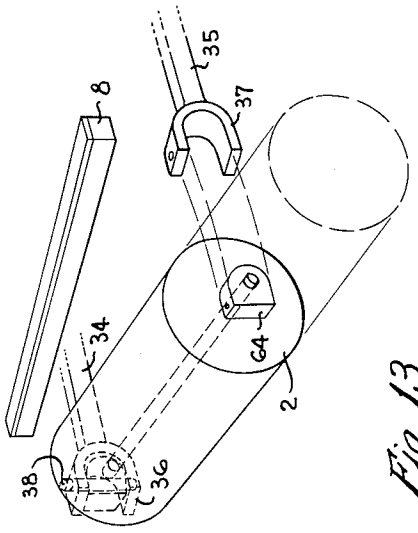


Fig. 13

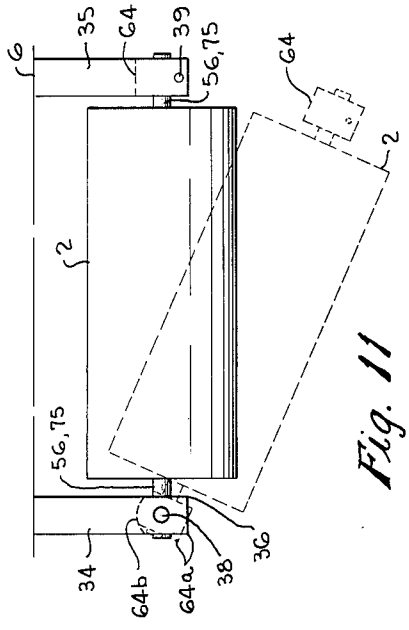


Fig. 11

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United States Patent Office

3,198,967

Patented Aug. 3, 1965

3,198,967

VARIABLE INTERVAL STEPPING SWITCH

James S. Roberts, Brookfield, Wis., assignor to Milwaukee Chaplet & Mfg. Company, Inc., Milwaukee, Wis.

Filed June 30, 1961, Ser. No. 121,241
12 Claims. (Cl. 307—141.4)

Divisional application, Serial No. 244,643, filed December 14, 1962, to a Drive Mechanism for a Stepping Switch; divisional application, Serial No. 244,644, filed December 14, 1962, to a Stepping Switch and divisional application, Serial No. 244,773, filed December 14, 1962, to a Mounting Structure for a Timer of this invention are now co-pending.

This invention relates to a means for controlling a sequence of operations and more particularly relates to that class of electrical switching means known as a stepping switch. The invention has special reference to a stepping switch with mechanical and electrical means for stepwise operation to control a sequence of events.

Stepping switches as heretofore commonly known in the art have included a memory device on which is structurally coded a predetermined program. The coded structure ordinarily represents and actuates a desired sequence of switching operations. Each switching operation in turn controls one or more events such as operating a machine, admitting liquid into a tank, closing a valve or the like. The coded structure of the memory device accomplishes this by manipulating switches which the structure engages or disengages in the course of operation.

As a general rule the memory device of such stepping switches is an intermittently rotated member. The intermittent rotation moves the member a fraction of a circle each time, dwells at the new position for some predetermined period of time, then moves to another position in like fashion and dwells again. This moving and dwelling during rotation is termed "stepping."

Ordinarily, the fraction of a circle moved and the length of time that the prior art stepping switches dwell are the same as between any two successive cycles of intermittent rotations. This restricts the time limits of the thing controlled to multiples of the single dwell period since the switches manipulated by the memory device are maintained in (or out of) position during the dwell period, or during successively occurring dwell periods if the memory structure so dictates. Where the control program of the thing controlled requires widely varying control (or dwell) periods, it may be difficult if not impossible to program adequately on the memory device. Physical spacing is one reason for this. Further, some controlled systems require interruption of the time sequencing when certain events transpire, e.q. a temperature rises too high, a fluid flow drops too low, or a chemical concentration exceeds its allowable tolerance, or a machine fails to perform properly: prior art stepping switches have often required very cumbersome construction to accommodate such interruptions and then continue with the stepping, and some could not do so at all.

United States Patent No. 2,784,786 issued to F. A. Pearson on March 5, 1957, for a "Stepping Switch Apparatus" is exemplary of the prior art.

The present invention, although it transcends the same, embodies certain features set forth in the copending United States application filed October 9, 1959, by myself and Elmer S. Welch, Serial No. 845,480 for a "Program Controller," now U.S. Patent No. 3,101,435 granted August 20, 1963.

A primary object of the invention is the provision of a stepping switch having different dwell time intervals arranged in a predetermined pattern or sequence.

Another object of the invention is a stepping switch arranged to dwell for a selected one of a plurality of

discrete time intervals in a predetermined selection sequence.

Still another object of the invention is a stepping switch arranged to dwell in a predetermined sequence for time intervals, other than discrete time intervals, of respectively different predetermined lengths.

A further object of the invention is a stepping switch construction allowing a response to an interruption by some event other than time but which resumes stepping in a predetermined fashion after such interruption.

Still another object of the invention is the provision of a stepping switch system having one or more stepping switches each of which is compatible enough with the others to be connected in master-slave relation whereby one or more of the foregoing respective objects are accomplished.

An object of the invention is a stepping switch construction allowing changing of the memory device whereby an entirely new program is achieved by substituting a new memory for an old one.

The invention has as an object a stepping switch having any single one or any combination of the foregoing objects.

The presently disclosed embodiment of the invention is adaptable either to controlling operations continuously or to manual initiation when a desired sequence of operation is to be carried out. A stepping switch constructed in accordance with the invention is particularly well suited for controlling the processing of dairy products, for example, to control operations for pasteurizing or for controlling so called "clean in place" operations. The latter, for example, involves cleaning the various pipes, valves, treating vessels, and the like by a sequence of verifying if the same are free of materials being processed, rinsing the dairy system with cold water, rinsing with hot water, contacting and cleaning with an alkali solution, contacting and treating with an acid solution, and then rinsing the whole thoroughly to remove all cleaning chemicals. The cleaning operation is ordinarily manually started by the operator but the different steps are carried out automatically until cleaning is completed. To facilitate proper starting procedures, and to advise when the process has been completed, various signalling means may also be provided. Signal lights, buzzers, or the like are exemplary of such signalling means. Irrespective of the specific use to which the present stepping switch may be put, the essential objects, features and advantages of the invention are at all times preserved.

Briefly, the invention in one form thereof includes a hollow perforated cylinder or drum fitted with removable pins. The drum and pins constitute the memory device. The program is coded by the placement of the pins. The pins are arranged in rows extending both axially and peripherally of the drum. Each peripheral row of pins is aligned with a suitable switch. Each axial (lengthwise) pin row represents a time interval in the program. Certain perpiheral rows of pins represent the program or channel selectors if there is more than one program stored on the drum. A second peripheral group of pins represents a means to connect the motor driving the drum with an appropriate time interval signal source (e.g. a clock timer) whereby the drum is caused to dwell, thereby to move in a stepping manner. Dwell is achieved by stopping the motor. Still a third group of pins and their corresponding switches is arranged to control some function or machine element in the process which is to be carried out; there can be one or a plurality of functions, machines, etc. simultaneously controlled.

In the preferred embodiment, the three groups of pins are arranged axially on the drum. When one pin in each group is aligned axially, a control function is achieved. In some instances, as detailed below, absence of an axial

pin may initiate or terminate a control function. As the drum is stepped around its cycle, respective pins make and break various electrical circuits to carry out the control and stepping functions. The length of time for a given control function is in part determined by the peripheral length of a pin row.

While running, a stepping switch according to the invention causes the drum to rotate through a predetermined angle, then to stop and dwell there for a predetermined time interval, and then to repeat until a complete cycle has been run through. When the drum (i.e. motor) stops, the second pin group through electrical means starts a timing means and enables a holding circuit to keep the drum (motor) in position (dwell) during the time interval. During the time interval other electrical means have been actuated by the third pin group to bring about the desired control function. The control function may continue from one time interval to another, if desired, except where the pins positioned on the drum determine termination of a selected control function such as opening or closing a valve. The control function may be carried out over a period of successive time intervals of either respective discrete lengths or the single predetermined length. At the end of the selected time interval the drum again steps and either continues or discontinues the control function according to the pins set on the drum. Any control function may overlap any other control function (time-or-sequence-wise) to any predetermined extent.

The drum is mounted in unique fashion so that it acts as a housing for the drum motor and the gear transmission connected betwen the motor and drum. This arrangement facilitates removal of one drum and replacement with another, thereby to change programs. In this fashion, a large number of programs can be made up and stored in advance on appropriate drums. The operator can then place the appropriate drum on the machine, zero it by locating it at its starting position, and then begin operation.

The invention also contemplates appropriate electrical means for starting, running, skipping certain operations in accordance with certain signals, permitting interruption by signals derived from a base other than time, and resetting or "holding" the entire apparatus so that the cycle may be repeated. One aspect of the electrical means includes certain ones of the switches which are manipulated by the pins.

As pointed out above, there are two species of time base with which we are primarily concerned, one of which is a discrete time interval of predetermined length and which is capable of being repeated, and the other is a time interval of any predetermined length (non-discrete interval). In a specific embodiment, the discrete time interval means includes plural clocks or timers, most advantageously three or more but not restricted solely thereto, wherein certain of the pins and switches are employed to select one timer and to disable all the other timers. In this fashion, a plurality of discrete time intervals is stored, but only one is called into use at a time. In this fashion, the dwell periods are controlled and can be any combination of multiples and/or sums of the time intervals represented by the respective timing means. Thus, the various time intervals can be repeated at will.

With respect to the non-discrete interval circuit, the invention comprehends chopping a beam of light in such fashion that a photoelectric cell provides drive pulses to the motor which operates the drum. The arrangement is such that the motor steps to its next position and then remains still until the disc which chops the light beam has moved an appropriate amount. In this fashion, a dwell period of any predetermined length is provided at any particular time in the cycle without being restricted to sums or multiples of discrete time intervals.

Another feature of the present invention is the provision of certain circuits associated with the drum motor and the pins which are so designed as to be compatible with either the discrete interval stepping switch or the non-discrete interval stepping switch as described briefly above. This particular feature promotes mass production and facilitates interchangeability of parts. Furthermore, it lends stepping switches of either character to being connected in master-slave relation one to another. It is particularly advantageous in the connection of a discrete interval timer as a slave to a master non-discrete interval timer.

In connection with the drum or memory drive system, a unique system is provided whereby the drum is moved to "dead center" in such fashion that it is rotated through a predetermined angle each time a stepping operation takes place. This assures the accuracy of the time intervals required in the control functions. The drum motor and drum are brought to dead center in such fashion that the dwell period is not upset, at least within the limits of accuracy of the stepping switch. In one particular embodiment, the drum is arranged with 60 different steps (i.e. pins or perforations for receiving the pins) whereby 6° of rotation is provided for each step.

The respective electrical means also provides for various manual selection switches whereby one particular program can be put in operation, or whereby the apparatus may be manually operated entirely.

Other objects, advantages and features will become apparent from the following description when read in conjunction with the associated drawings. Throughout the drawings, the same reference numerals are used to designate the same parts and the usual convention is employed of showing the electrical apparatus in the position assumed when all of the electricity is cut off from the circuits. In the drawings:

FIG. 1 is partial plan view of the memory device, or drum, showing the relationship of the drum and associated structure to certain microswitches engaged during a control program.

FIG. 2 is a partial elevational cross section of a relationship between the drum and switches as seen along section 2—2 of FIG. 1.

FIG. 3 is a cross sectional elevation through the drum showing the gear train along the shaft.

FIG. 3A is a cross sectional end view through 3*a*—3*a* of FIG. 3 showing the relationship of the dead centering means of the Geneva drive.

FIG. 4 is a simplified schematic and partially exploded perspective electro-mechanical view of one embodiment of the invention for operation on a selected one of a plurality of discrete time intervals, presented for explanatory purposes.

FIG. 5 is a simplified electric schematic of the embodiment of FIGS. 4, 8 and 9, presented primarily for explanatory purposes.

FIGS. 5A, 5B, 5C and 5D are all electric schematics of modifications of the system represented by FIG. 5.

FIG. 6 is a simplified schematic and partially exploded perspective electro-mechanical view of one embodiment of the invention for preferably operating on on-discrete time intervals.

FIG. 7 is a simplified schematic representation of the electric circuits of FIGS. 6, 8 and 10, showing the operating portions free of starting means and the like presented primarily for purposes of explanation.

FIG. 8 represents schematically a function enabling and memory driving circuit which is common to both of FIGS. 9 and 10.

FIG. 9 represents schematically a circuit for use with the circuit of FIG. 8 as a system for a stepping switch that steps by discrete time intervals, selecting one from a number of such intervals stored in the system.

FIG. 10 represents schematically a circuit for use with the circuit of FIG. 8 as a stepping switch system for stepping in accordance with a stored program of time intervals, usually but not necessarily of non-discrete lengths.

FIG. 11 is a simplified plan view showing the drum in

operating position (solid lines) and in drum-changing position (dotted lines) as permitted by the mounting means.

FIG. 12 is a simplified perspective view of the drum in the operating position of FIG. 11.

FIG. 13 is a simplified perspective view of the drum when swung out to drum-changing position.

General

A stepping switch constructed in accordance with the invention includes a revolvable drum 2 (FIGS. 1–4 and 11–13) mounted adjacent a row of switches H1, H2, L1, L2, L3 . . . The drum is revolvable through 360° in a series of steps, stopping at the end of each step and dwelling or holding until signalled to step again. The rotation and stopping is controlled by electrical means, hereinafter described in more detail with reference to FIGS. 4 through 10. A plurality of pins such as the homing pin HP, P1, P2, P3 . . . are located along the length of the drum with each of the so designated pins being located in rows. Only one homing pin is provided for reasons hereinafter explained. The pins in each row (each row of pins being designated as P1, P2 . . .) correspond to and engage respective limit switches L1, L2, L3 . . . The pins actuate and deactuate the switches to initiate and terminate a series of control functions. Control functions can be carried out simultaneously or individually and in a predetermined sequence.

The pins, which are removable, are only inserted where a control function is desired, thus a predetermined sequence of functions may be set on the drum and thereby bring about the control program responsive to the stepping rotation of the drum. The time intervals during which a control function is carried out are determined by the lengths of time that the drum dwells at different positions.

One homing pin HP is provided in alignment with the homing switch H1, H2. The homing pin defines the position to which the drum is driven after a control program has been completed. When the drum arrives at home, it stays there until another program, or the same program, is begun all over again.

A plurality of programs may be stored on the drum. Assuming two programs to be stored on the drum, the rows of pins P1 and P2 and their corresponding limit switches L1, L2 are arranged to define those positions at which the drum dwells. Where there is an absence of pins P1, P2 there will be no dwelling and the drum will drive to the next succeding pin in the row or to the home position. Of course, more than two programs may be stored on the drum where space permits.

Where discrete intervals of time are to be employed in stepping the drum, the rows of pins P3 and P4 along with their corresponding switches L3 and L4 are employed to select a timing means to provide the predetermined discrete time interval during which the drum will dwell in the position to which it has been stepped. As will be hereinafter explained, it is possible to use two rows of pins P3, P4 to select one of three timing means. In an alternative embodiment, three pin rows P3, P4 and P5 may be employed to select one of three timers. Thus, speaking generally, two embodiments of discrete interval timers are provided wherein one embodiment requires a pin row for each discrete interval to be included in the program while the other embodiment uses one less row of pins than there are discrete interval timers. In the last-mentioned variety one particular time interval is selected by the absence of any pin P3 and P4 in their respective rows.

Assuming two programs on the drum and that the pins P3 and P4 are employed for selecting a discrete interval, the rows of pins P5, P6 . . . and their corresponding limit switches L5, L6 . . . are employed for selecting a control function. The control function is initiated when a pin in the peripheral row engages its corresponding limit switch. More than one of the pins P5, P6 . . . may engage its corresponding limit switch simultaneously. A control function is terminated when no pin is present, in one preferred embodiment.

Thus, in the discrete interval timing means for causing the stepping operation, at least three pins must be aligned with each other, referring to alignment axially on the drum. The three pins would be the program selector pin such as P1, P2; the timer selection pin P3, P4 (or no such pin in one embodiment); and one of the function selecting pins P5, P6 . . . When such an alignment occurs, there limit switches are actuated to both carry out a stepping operation and to select a control function.

Where a variable interval (i.e. non-discrete time interval) is employed, it is still possible to program more than one control cycle on the drum by proper placement of the removable pins. In this case, the program selector pins P1 and P2 again serve their function, and additional program selector pins such as P3, P4 may be used. The other pins on the drum such as P5, P6 . . . may be used for selecting their particular control function. In this embodiment, two pins, a program pin and a function pin, are aligned axially on the drum and simultaneously actuate their corresponding switches, for example, pin P1 and P5 may be aligned.

The memory device 2 and its attendant mechanical and electrical stepping means may conveniently be enclosed in any suitable type of cabinet, preferably one that will keep out dirt, dust, moisture, and other deleterious substances which may be present in the atmosphere. The cabinet is denoted generically as 6 and has drum supporting means as described in FIGS. 11, 12 and 13 mounted therein. The cabinet should have a door or removable panel large enough to allow swinging the drum to the positions indicated in FIGS. 11 and 13.

The limit switches and the homing switch, generically denoted as 4 and 5 in FIG. 2, are mounted from a switch supporting bar 8 which is supported within the cabinet. Brackets 10, 11 extend from each side of the bar 8 in a direction generally perpendicular to the axis of the drum 2. The limit switches (actually H1, H2, L1, L2 but referred to as 4 and 5) 4 and 5 are secured in the respective brackets by any suitable means such as glue, screws 14, 15, or the like in such a position that their pin engaging members 16 (ordinarily a roller in accordance with limit switch and micro-switch construction) is aligned with the pin engaging member of all other limit switches regardless of which side of the bar 8 they are mounted on.

The drum 2 is a hollow cylindrical perforate member with holes located as shown for axial and peripheral alignment.

The support bar 8 may advantageously be hollow and perforated along the sides from which the limit switches are supported. In this fashion, wires or other electrical conduit means can be led to the respective switches through the hollow portion of the support member 8.

As shown in FIG. 2, the pins P have a T shaped cross section with a stem 18 and a head 19. The pins are removably mounted in the drum by driving the stems into the perforations 30 which are arranged in rows both axial and peripheral of the drum 2. The heads of the pins are shaped so that the pins may be positioned adjacent each other in a peripheral drum row so that they engage and maintain engaged a limit switch on two successive steps of the drum.

In one embodiment, described hereafter with reference to FIGS. 3 and 3A, the driving means is arranged to step the drum through 60 increments of 6° each in one complete cycle. Of course, other arrangements for stepping may be employed, but this is convenient because minutes and hours both have 60 seconds and minutes, respectively, and the drum is thus automatically divided into appropriate physical intervals representative of time intervals.

Thus it will be seen that the drums are pre-programmed by structure carried thereon which represents respective time intervals for stepping. Pre-program drums act as memory devices so that any process or control sequence may be stored and used later on. A plurality of control programs may be stored on the drum. Programs are easily changed in the field by relocating pins on the drum, or by slipping pre-programmed, interchangeable drums into the controller in the fashion described below with respect to FIGS. 11, 12 and 13.

FIGURES 3 and 3A

FIG. 3 shows in cross section the arrangement of the drum motor 20, the dead centering means 24, and the gear train 22. The whole is arranged so that the drum 2 may be easily removed and so that the motor and gear train is encased within the drum.

Referring now to FIG. 3, there are shown the drum 2 secured by removable means such as a plurality of screws 50 to a pair of hubs 52, 54 which are spaced apart along a non-revolvable shaft 56. The shaft 56 has a flatted portion 58 to which the motor 20 is secured by any suitable means such as screws, brackets, or the like. The shaft has a hollow portion 60 preferably disposed at the inboard end adjacent the hinge means for swinging the drum out of the bracket to change drums and thereby install a new program. Wires for the motor 20 and various switch means associated with the dead centering means 24 are led in to the inside portion of the drum through the hollow portion 60.

The hub 54 is revolvably mounted on the shaft 56 by any suitable bearing, preferably a frictionless bearing such as a ball bearing, indicated generically as 62. Hub 54 is maintained in its position on the shaft by a pair of spaced apart rings 63, 64 which are secured to the shaft by set screws 65 and 66.

The hub 52 is mounted in a partly similar fashion, but uses the gear train 22 and the supports thereof in lieu of a ring such as 63 to guard against axial displacement toward the other hub.

The gear train is supported from the shaft by support means generically denoted as 70 which is secured to the shaft and so constructed as to allow various portions of the gear train to revolve relative both to the support means and the shaft 56. The support means (and the gear train for that matter) is secured to the shaft by a pair of spaced apart gear train supporting hubs 71, 72 which are respectively secured to the shaft by set screws 73, 74. A plurality of washers 75 are disposed between the support hubs and adjacent revolving members, one of such washers being used to space the drum hub 52 from the support 71.

An idler support plate 77 is secured to the hub 71 by any suitable means such as screws, welding, or may be formed integrally therewith. A dead centering switch support plate 78 is supported in spaced apart relation to the idler plate by means of a plurality of tubular spacers 79, the whole being secured together by a corresponding plurality of nuts and bolts 80.

A motor support plate 82 is secured to the hub 72, or may be fashioned integrally therewith. The motor may be supported from this plate if desired. The motor plate 82 has an aperture 83 through which the motor output shaft 21 extends.

The motor output shaft is connected directly into the gear train by means of a Geneva wheel arrangement which includes a Geneva pin wheel 34 having in the preferred embodiment a pair of 180° spaced apart pins 85 secured thereto by any suitable means such as force fitting, welding, or the like. The reason a pair of pins is used is that the Geneva wheel 86 is a tenpoint drive having ten slots therein.

The dead centering timing wheel 111 is formed as a plate mounted to rotate in unison with the Geneva pin wheel.

A sleeve 87 is disposed between the Geneva wheel and a shaft mounted gear 88 in such fashion that the gear and Geneva wheel rotate together. Appropriate bearing means 89 are provided to revolvably support from the shaft the Geneva wheel, gear and sleeve. With this construction, the gear 88 and the Geneva wheel 86 rotate in unison.

A driven drum gear 90 is secured to the hub 52 by any convenient means such as keying or a forced fit in order that hte drum rotate in unison with the gear 90. A pair of idler gears 91, 92 connect the gear 88 to the gear 90. The idler gears are revolvably supported from the support means 70, preferably from a single shaft 93 to which they are both secured to rotate in unison. The securing means may advantageously comprise idler set screws 94 which engage flatted portions on the shaft 93.

The shaft 93 is revolvably supported by a pair of bearings 95, 96. The idler shaft bearings 95, 96 are respectively supported in the idler support plate 77 and the switch support plate 78. The bearings may conveniently be shaped as bushings so that the idler gear 92 is maintained in axial alignment with its mating gear 88.

In review, as the motor 20 rotates, the Geneva pins 85 drive the Geneva wheel 86 which revolves in characteristic intermittent Geneva fashion and causes gear 88 to move in like fashion. Idler 92 is supported in meshing engagement with gear 88 and responds to the motion, transmitting it to the idler gear 91 which then, being in mesh with the drum gear 90, drives the latter. Thus, a speed reduction is obtained at the same time the requisite intermittent motion for obtaining a stepping action is provided. In the preferred embodiment, it is desired to step the drum one 6° increment of rotation in response to a 180° rotation of the motor. Thus, a 30 to 1 reduction is preferably provided. Consistent with this, the holes for receiving the various pins are spaced at 6° intervals around the periphery of the drum.

When it is desired to remove the drum and replace it with one having a different program, the screws 50 are removed and the drum moved axially until it is free of the hubs.

In the upper central part of FIG. 3 is shown a detent mechanism for mechanically positioning the drum and the motor at dead center. This comprises a detent ball 97 which is mounted in a hole at the end of an externally threaded hollow detent case 98 which is screwed into a corresponding threaded hole in the motor support plate 82. A detent lock nut 99 further secures the detent assembly in place.

Although not shown, the hollow detent case contains a compressed helical spring which biases the detent ball 99 into frictional engagement with the face of the Geneva pin wheel 84. If desired, small depressions can be formed at dead center position in the face of Geneva pin wheel 84, which depressions are engaged at the end of rotation by the detent ball.

FIG. 3A illustrates a cross sectional view taken along line 3A—3A looking in the direction of the arrows, of FIG. 3 and shows in what position the dead centering switch 108, 107 is secured relative to the dead centering wheel 111. The dead centering switch is screwed to the switch support plate 78 by a pair of screws 78*a* and 78*b*. The arm 114 of the dead centering switch is thereby positioned with respect to the dead centering wheel 111 so that switch 108 is closed when off dead center and open at dead center as elsewhere described in greater detail. The switch 108, 107 may be any commercially available type of microswitch.

The timing wheel 111 in the preferred embodimeint is different in minor details from that shown schematically in FIG. 4, principally in that lobes 112' and 113' are provided in lieu of the notches 112, 113 shown in FIG. 4. It will be observed in FIG. 3 that the Geneva drive pins 85 are spaced apart so that one is entering a Geneva slot at the same time the other is leaving the preceding Geneva

slot. This further promotes positive positioning. Dead center is preferably arranged so that the pins 85 are in the positions shown in FIG. 3A when at dead center. This permits the driving pin 85 which is entering the slot to promote a stepping operation having a low initial and final rotational velocity, with a high intermediate velocity to get a sharp break in control functions, (i.e. break occurs during intermediate). When the driving pins 85 are positioned as shown in FIG. 3A, (i.e. "dead-center") the drum is also at "dead-center." The phrase "dead-centering" refers to the drum as well as the motor in-so-much-as the two are connected by virtue of the Geneval wheel and related gearing.

Introductory description of discrete interval embodiment (FIGS. 4, 5, 8 and 9)

The operation and construction of the discrete interval embodiment is best understood by reference to FIGS. 4 and 5. Although direct current in the form of batteries is shown for example as the power source in some instances, it is to be understood that either alternating or direct current may be used. However, it is preferable that alternating current may be used. Direct current power sources are shown in the form of batteries 102.

FIG. 4 shows a memory device or drum 2 having a plurality of pins 4 mounted thereon in the fashion of FIG. 1, described above. In the exploded portion, an electrical motor 20 drives the drum through a gear transmission assembly 22 and mounted on the motor shaft to rotate in unison with the motor in a dead centering means 24.

A plurality of timers 104, generically, are connected in parallel between the power supply and the ground. A timer selection means 106 (L3, L4 in FIGS. 5 and 8) is associated with each timer, being connected in series between the timer and power supply arranged to enable one timer and disable all other timers. The selector switches are actuated by the pins 4 on the drum. A timer enabling switch 107 is ganged with the dead centering switch 108 so that each is disposed between the power supply on one hand and, respectively, the timer selection switches 106 and the drum motor, respectively.

Stated broadly, the mode of operation of the discrete interval embodiment contemplates that each of the interval timers 104 is set for different lengths of time. The pins on the drum are arranged to select one timer while disabling all the others at each step of operation. The system is so arranged that the drum motor 20 cannot operate while any one of the interval timers is running and so that the interval timers cannot operate until the motor 20 has reached a predetermined motor position. The dead centering means denoted generically as 24 enables the motor 20 and the selected one of the interval timers to operate alternately but never simultaneously.

Assume the system has been properly started and is in operation, referring to FIG. 4. Also assume that the drum or memory device 2 has been stopped at the position shown in FIG. 4. The pin P3 engages the left hand timer selection switch 106 causing the left hand timer to begin operation. The entire system stands still for the particular discrete interval for which the left hand timer 104 is set. This may be, for example, thirty seconds, five minutes, fifteen minutes, or any desired quantity since the timers are adjustable. During the time interval, as the timer runs the timer arm 110 approaches the timer contact arm 109 and thereby completes a circuit from the power supply to the motor 20.

The motor responds by starting to turn and in doing so the timer enabling switch 107 is opened thereby preventing any of the timers from operating until the switch is closed, and permits the spring to reset contact arm 109 (i.e. open circuit to motor 20). With the arrangement shown, the switch does not close again until the motor has rotated 180°. At the same time that 107 is opened, the switch 108 is closed and thereby establishes another circuit from the power supply to the motor: the circuit thus established enables the motor to drive until it reaches dead center 180° away, at which time the switch 108 is opened.

When the motor has driven through 180° and reached its predetermined position, the operation is again repeated with license to select a different timer, the other steps remaining the same.

For purposes of explanation, the dead centering switch and timer enabling switch 108, 107, are shown as actuated by a timing wheel 111 having timing notches 112, 113 180° apart to actuate the switch arm 114. A more detailed embodiment will be described below with respect to the details of FIGS. 1–3.

It will be appreciated that a control function such as opening a valve and maintaining it open is carried out during the time that the drum 2 is at rest. The length of time that the drum is at rest, or dwells, is determined by the interval timer and therefore the particular control function to ultimately be carried out is determined on a time basis.

A more detailed explanation, including the structure and operation required for starting, skipping and holding is set forth below in greater detail with reference to FIGS. 5, 8 and 9. As will be seen, more than two timers may be employed and more than one particular control program can be stored on the drum 2.

Introductory description of FIG. 8

The circuit of FIG. 8 is arranged so that it can be used either with the circuit of FIG. 9 or with the circuit of FIG. 10. As will be explained below, when FIG. 8 is connected with one of FIGS. 9 and 10, the arrangements of FIGS. 4 and 6, respectively results. The system of FIG. 8 may also be arranged for manual operation. FIG. 8 is shown set up for automatic operation in conjunction with the circuit of FIG. 10. Manually operated selector switches 145, 147 are used to set the system of FIG. 8 for either manual or automatic operation. Automatic operation means automatic stepping in conjunction with one of the systems of FIGS. 9 or 10. Switches 146, 147 are shown positioned for automatic operation. Manually operated switches 148, 149 are used respectively for manually stepping or for manually rotating the motor 20, and during setup operation.

Manually operated cycle selector switches 150, 154 are used to set the system of FIG. 8 for use with either the system of FIG. 9, or that of FIG. 10. As shown, cycle switches 150, 154 are set for use with the FIG. 10 system through engagement with their respective contacts 151, 155. The cycle switches 150, 154, are moved against their respective contacts 152, 156 when it is desired to use the FIG. 8 system in conjunction with that of FIG. 9.

The system of FIG. 8 also includes timer enabling switch 107 and dead centering switch 108 which are, respectively, normally closed and normally open at motor 20 dead center. Switches 107 and 108 are, respectively open and closed when the motor is off dead center, e.g. when the motor is running. Dead center is where the motor should be after the drum has been stepped to a proper predetermined position.

A terminal block is provided having terminal block connections TB1 to TB17. These terminal block connections are identical to those shown in FIGS. 9 and 10. The power supply 102 is connected to the system through a power switch 158, which latter is always closed before the system is put into operation.

Program master switches L1 and L2 are connected between the terminal block and switch 147. Discrete interval timer selection and alternative program master switches L3 and L4 (106 in FIG. 4) are connected between their terminals and cycle switch 150. In the preferred embodiment switches L3 and L4 are ganged to additional switches L3–2 and L4–2 both of which latter are normally closed and connected in series with each

other between the terminal and switch 107. An alternative embodiment denoted as 106' is illustrated in FIG. 5D.

For convenience later on, it is to be observed that the switch numbers L1 . . . L4 all correspond to a row of pins on the drum so that L1 corresponds to P1, L2 to P2, and so forth.

Ganged homing switches H1 and H2, operated by homing pin HP are provided. H1 is open at home, closed during running (drum off home). H2 is closed at home and open when the drum is off home (i.e. during a program).

A relay R1 is provided having a plurality of contacts R1–1, R1–2 . . . each of which contacts is normally open and connected in series between the power supply and a controlled function switch L5, L6 . . . . The controlled function switches L5, L6 . . . each correspond to a row of pins on the drum such as P5, P6 . . . . It is to be understood that any number of contacts R1–1 etc. and any number of function switches L5 etc. may be provided. Ordinarilly, the function switch controls some process step by operating an electrical device, shown by way of example as solenoids 159 and 160. The solenoids may operate a valve, a switch, or the like. It is to be understood that the thing controlled, represented by the various solenoids, may be any suitable means for achieving the desired control function. A plurality of signal lights 161, 162 and 163 are provided for convenience in determining if various circuits are operating. The switches L3 and L4 of FIG. 8 correspond to the switches 106 of FIG. 4 as indicated by the numbers in parentheses. As described with more particular reference in FIG. 5, the switches L3 and L4 are employed for selecting a timer while the switches L1 and L2 are employed as a master programming switch. As explained elsewhere with reference to the configuration of pins on the drum, it will be observed that at least one of the switches L1 . . . L4 has to be closed by a pin and one of the switches L5, L6 . . . has to be closed by an axially aligned pin in order to achieve a control function. Where the system of FIG. 9 for stepping with discrete intervals is employed, it is further required that a third pin on the drum be aligned so that one of the switches L3 and L4 is closed at the same time one of the other two is closed.

Introductory description of FIG. 9

In the embodiment of FIG. 9, power is brought in through the power supply of FIG. 8, through terminal 2 past a normally closed manually operated emergency stop switch 170 to a starting circuit generically denoted 172. The starting circuit is connected across the power supply between leads from terminals TB1 and TB2. A plurality of timers (see FIG. 4) are connected between terminal TB1 and respective terminal blocks shown here as blocks TB6, TB7 and TB8. The timer operated contact arms generically denoted as 109 (FIG. 4) are connected in parallel with each other between the starting switch and terminal TB15.

As an optional feature a manually operated stepping switch 174 is provided in parallel with the timer switches 109. Switch 174 is normally open. An automatic selector switch 176, similar in function to switches 146, 147 of FIG. 8, is provided to connect between terminal TB16 and the block of timer operated switches 109. Selective switch 176 is shown in the position required for automatic stepping operation. If desired to manually operate the system of FIG. 9, when connected with FIG. 8, switch 176 is moved against contact 177 to place it in series with the normally open manually operated rotating switch 178 which latter is connected to the lead 180 that is connected to the starting switch. A second automatic selector switch 182 is shown connected between terminal TB9 and the start jogging relay R4. The switch 182 is shown closed for automatic stepping operations when FIGS. 8 and 9 are operating as one system: in order to put the system on manual operation the switch 182 must be opened and the switch 176 moved against contact 177. For convenience switches 182 and 176 may be ganged.

The relay R4 manipulates a set of normally closed switch contacts R4–1 which are connected in parallel with the timer operated switches 109.

A manually operated program selector switch 185 is provided to connect between the lead 180 and a selected one of the program master switches L1 and L2. This permits storing two programs on each drum, the master switch L1 controlling one and the other program being controlled by L2. The particular program on which the system is to be operated is selected by positioning the switch 185, here shown as selecting the program defined by the master switch L1 by connecting the master switch to the lead 180 coming out of the starting circuit 172.

Leads 186 and 187 (FIG. 9) serve to connect the homing switch H1 (FIG. 8) in series between the starting circuit 172 and the starting circuit 188. The reset circuit (FIG. 9) includes a resetting or holding relay R2 which when energized changes the state of the respectively normally open and closed switches R3–2 and R3–1; and includes manually operated resetting switch 190 which is normally open and connected in series between the homing switch H1 and reset relay R5. The reset relay R5 controls the normally closed contacts R5 which are in series between the starting switch and the program selector switch 185 and also controls the normally open switch R5–1 which is in parallel with the manual switch 190. As long as operation of the system is ordinary and normal, the manual reset portion of 188 is not employed. It is ordinarily employed to make adjustments without the danger of starting the various control functions.

A plurality of signal lights 193–196 are provided as desired to denote various conditions of the system during operation and when at rest.

The operation of the starting circuit 172 will be better understood when a description of the operating and starting functions of the FIGS. 8 and 9 system is given. For the present, it should be observed that the starting circuit 172 includes a system starting switch 200 connected in series with a convenient starting relay R2 across a normally closed switch R3–1 which is manipulated by the relay R3. A normally open contact R2–1 is controlled by relay R2, the former being connected in parallel with the system switch 200. A normally open switch R3–2 is also connected in parallel with the system switch and is manipulated by relay R3. The relay R2 is provided so the operator will not have to hold the system switch 200 closed until operation has gotten well under way and for that reason is a convenience relay. The relay R3 is used to stop the motor and drum at the home position, as elsewhere described.

A plurality of individual timers T1, T2 and T3 are included in the group of timers 104 in FIG. 9. Preferably, each of these timers is constructed alike except each is adjusted so that it provides a different discrete time interval than any of the others. These timers are conveniently adjustable. The construction of only one timer will be described, it being understood that the remainder are constructed in similar fashion. Each conventional timer includes a clutch solenoid 202, a timer motor 204, a timer stop switching assembly (which may be a relay) T1–1 and a drum motor starting switch T1–2. Timers T2 and T3 also have their respective drum motor starting switches T2–2 and T3–2 as shown generically by reference number 189.

These timers are of well known conventional construction. Each timer resets itself automatically after it has run for a discrete time interval. Although one type of timer construction is shown and described, any kind of conventional timer may be used as long as it automatically resets. Preferably, each timer is adjustable for discrete time intervals over a range, whereby one such discrete interval is selected for each timer for each program, all as well known in the art.

Operation of the system of FIGS. 8 and 9 (see also FIGS. 4 and 5)

Before the system is started, for automatic operation, the switches 146, 147, 176 and 182 are all moved to the positions shown. Then the cycle selector switches 150, 154 are moved to engage their respective terminals 152, 156 and the program selector switch 185 is moved to select the particular program, shown as that controlled by pin P1 and the switch L1 for purposes of explanation. Also, the two homing switches H1 and H2 are adjusted so that H1 is always open when the system is at home and that H2 is always closed when the system is at home. The homing pin HP on the drum operates switches H1 and H2 which are conveniently ganged together. The switches H1 and H2 are shown in their position during the running portion of the cycle for future convenience. The system switch 200 is closed by the operator, and as with switches of this nature it very shortly returns to its open position. Relay R2 is actuated responsive to this and closes the contacts R2–1. Closing the system switch also applies power through lead 180 across normally closed contacts R4–1 to the motor 20 which then moves out of the home position and thereby closes homing switch H1, simultaneously opening switch H2.

Closing of switch H1 completes a circuit to the holding relay R3 via leads 186, 187. The holding relay then shuts off the convenience relay R2 by opening contacts R3–1 and establishes a power supply by closing contacts R3–2. It is assumed that the switch 158 has been closed to provide power.

The motor now drives the system until the first pin P1 engages its corresponding switch L1. The drum even drives past its dead center any predetermined number of times to allow this to occur. The operation of driving past dead center is termed skipping and is more readily understood by reference to FIG. 5 where it is seen that a circuit is complete to the motor across the switch R4–1 motor runs and while it is off dead center, the dead cen- as long as switch L1 has not been closed. While the tering switch 108 is closed. The dead centering switch only comes open at dead center for reasons best understood by reference to FIG. 4. In FIG. 4, as well as in FIGS. 1–3, it is to be observed that the timing wheel 111 manipulates the dead centering switch 108 to keep the latter closed at selected times while the motor is away from dead center. This is achieved by proper positioning of the means for actuating dead centering switch, which means are shown as the notches 112 and 113 in FIG. 4 but may also comprise the lobes of timing cams as described with reference to FIGS. 1–3.

The motor drives the drum through the skipping operation until the first occurring pin P1 closes switch L1, thereby actuating relay R4 and opening the contacts R4–1. Ordinarily this occurs slightly ahead of the dead centering position, as does opening of the dead centering switch 108 whereby the motor inertia allows motor 20 to coast to dead center.

Referring now to all FIGS. 5, 8, and 9, when the motor 20 has arrived at its first dead center position the switch 108 is open. There are at this time no circuits completed from starting circuit 172 to the motor. However, the timer enabling switch 107 has closed and the pin P3 has closed one of the timer selection switches 106, it being assumed that the particular switch closed is L3. The means 104, 109 assume that all other timers are disabled and cannot run. A circuit is then completed through L3 and 107 to timer T1. (See FIGS. 8 and 9, TB 6.) This starts the timer running at the very instant the motor 20 has stopped at its dead center. Of course, any other timer selection means such as L4, L4–2 and L3–2, or L20 (FIG. 5D, explained below) can start its associated timer and leave all other timers disabled.

The timer runs for its predetermined time interval and, as heretofore described, shuts itself off (by opening switch T1–1) and closes switch T1–2 to thereby start the motor 20 again. When the motor moves off dead center, the timer automatically resets itself in accordance with its own internal construction and the motor drives to the next position and selects one of the timers, repeating the stepping operation.

If there is no pin in row P1, the switch L1 comes open if there is no pin in the corresponding row. This allows the contacts R4–1 to close and thereby a skipping operation occurs past any predetermined number of dead center positions until the next pin occurs to close switch L1 at which time occurs the above described sequence of dead centering, enabling the timer via the timer selection switch such as L3 or L4, and then starting the timer via closing switch 107.

A similar procedure occurs if program selector switch 185 is connected to terminal TB5 whereby pins P2 via swtiches L2 operate in the fashion described for P1 and L1.

As previously stated, this procedure assures that the motor 20 does not operate while the timer is running and that the timer cannot start until the motor has reached dead center. This is because of the cooperation between the two switches 107, 108 and the fact that the pins on the drum set up the timer circuits through L1 and L3 to put the switch 107 in control of the situation while the motor is dead centering.

As best seen in FIG. 5, at the same time the switch L1 is closed by a pin, relay R1 (FIG. 8) is actuated so that its various contacts R1–1, R1–2 . . . are closed to complete circuits to the respective control function switches L5, L6 . . . . If a pin is arranged on the drum to engage and close one or more of switches L5, L6 . . . then a control function is initiated. When there is no pin on the drum, the control function is terminated. In the embodiment shown, there have to be three pins aligned axially on the drum to achieve a control function, with certain exceptions as explained later. The three pins which have to be aligned are: one of the program switches L1, L2 (in this embodiment), one of the timer selection switches L3 or L4, and one of the control function switches L5 . . . . Of course, more than one control function may be obtained at the same time which merely requires aligning more pins axially in the P5, P6 . . . rows of pins on the drum.

After the drum has stepped and skipped, as the case may be, through its complete cycle of controlling functions, it then must home by bringing the motor to dead center with the homing pin H engaging the homing switches to open switch H1 and close switch H2 (see FIGS. 8 and 9). When the motor starts to home there are no more pins to maintain switch L1 closed and therefore contacts R4–1 close and drive the motor as with skipping. When the homing pin engages switch H1, it breaks the circuit extending from the starting switch to the holding coil R3 which then returns R3–1 and R3–2 to the position shown in FIG. 9, thereby shutting off all power to the motors. Thus, when the motor drives the drum to home position, the homing pin serves as a means for stopping the motor at the predetermined homing position by shutting off all power to the motor.

When the motor has homed, the various switching connections between the starting circuit 172 and the motor 20 are in substantially the position shown in FIG. 5. Observe that when the last pin P1 has passed and the motor starts its homing function, the relay R1 shuts off all current to the control function switches by opening the contacts R1–1 and R1–2. Thus, there are no controlled functions during homing.

The embodiments of FIGS. 5A, 5B, 5C and 5D

These embodiments show variations in the system of FIG. 5. For convenience those portions of FIG. 5 which remain the same are omitted.

FIGS. 5A, 5B, and 5C are all concerned with means for interrupting the time interval basis of stepping by

discrete intervals. The interruptions are of such nature as to either lengthen or shorten the time intervals in response to some event in the control cycle other than time. This event may be the achievement of a predetermined pressure, temperature, velocity, weight, or chemical composition in the system being controlled. Suitable means such as recorder controllers may be employed in these embodiments.

FIG. 5D represents a modification of the FIG. 5 means 109 for selecting a timer.

FIGURE 5A

The embodiment of FIG. 5A shows that portion of the circuit of FIG. 5 which has been modified to either lengthen or shorten the time interval of a dwell period by some control signal other than time. Examples of such control signals are chemical composition as drawn from an infra red or ultra violet recorder controller, flow, velocity, pressure, temperature, to cite a few by way of example but not limitation.

The modifications in FIG. 5A include elements 250 and 260. Both of these elements represent some control signal source for closing a switch. The control signal source may be assumed as a recorder controller or any other suitable means.

A means for interrupting the timer operation to lengthen the time of dwell, that is to increase the length of time that the drum is held at one particular position, is indicated by the means 250. Assuming this to be, for example, a pressure response means, wherein it is desired to continue a control function until a certain pressure reaches a predetermined level, the means 250 will close its switch 252 when that level is reached. Until that time, the switch 252 is open and therefore, regardless of whether one or more of the timers has closed its corresponding motor starting switch T1–2, T2–2 . . . the motor will not start until such time as the switch 252 is closed.

If it be desired to shorten the length of time responsive to a signal, let us make the same assumptions as before so that when the pressure reaches a predetermined level the means 260 closes the time delay switch 262. Means 260 and switch 262 are constructed for making rapidly and breaking after a delay. Closure of switch 262 starts the motor 20 and causes a stepping operation as before. The time delay of means 260 and switch 262 is such that the switch breaks the circuit before the motor reaches dead center, whereby the dead center switch 108 stops the drum movement.

FIGURE 5B

The modification of FIG. 5B illustrates a system generally similar to that of FIG. 5A whereby individual timer control circuits for starting the motor have their respective time intervals lengthened in an individual fashion. This permits one or more time intervals to be lengthened in response to respectively different control signals.

FIG. 5B shows time interval lengthening means such as switches 252*a*, 252*b*, and 252*c*, respectively, in series with a timer controlled motor starting switch T1–2, T2–2, and T3–2. Each of the time lengthening switches 252*a* . . . may be responsive to a different event requiring lengthening of the time interval. Thus, switch 252*a* may be responsive to a predetermined pressure while switch 252*b* may be responsive to a predetermined weight, and 252*c* may be responsive to a predetermined temperature. The signal for operating each of switches 252*a*, 252*b* and 252*c* may be drawn from sources such as 250, 260 of FIG. 5A.

FIGURES 5C and 5D

FIG. 5C shows an embodiment whereby the interrupting means can be programmed into the system so that it is disabled except at predetermined times which are selected by the function switches L5, L6 . . . described with respect to FIG. 8. FIG. 5C is generally like FIG. 5 except for the portion shown which includes the interrupting switch 262*x* and the interruption selector switch 264. During operation the drum rotates and closes the switch 264 whereupon the interrupting means 260 can, upon command, close the switch 262*x* thereby shortening the time interval.

A further modification would include means for selecting a time lengthening function which would involve connecting a normally closed switch in parallel with switch 252 of FIG. 5A. When desired to interrupt the time basis of stepping, the paralleled switch is opened thereby putting switch 252 in command. The paralleled switch is operated by one of the pins on the drum and corresponds with one of the switches L5 . . . .

FIG. 5D shows a modification for selecting one of the timers T1, T2 or T3. A comparison with FIG. 5 is in order at this time. When selecting one of the timers in FIG. 5, one of the switches L3 or L4 is closed to select its timer. In doing so a ganged switch L3–2 or L4–2 of FIG. 8 opens to disable the third one of the timers. In this fashion only two selector switches L3, L4 have to be used. Similar arrangements may be employed so that you have one less row of pins on the drum to select a timer than you have timers. With the embodiment of FIG. 5 the third timer is selected when there is no pin at all present to actuate switches L3 or L4.

In FIG. 5D there has to be a pin on the drum to close the appropriate one of the switches L3, L4 . . . L20. Each of the timer selection switches starts its own timer. With this embodiment the number of timer selection switches and rows of pins corresponds to the number of timers used.

Introductory description of non-discrete interval embodiment (FIGS. 6, 7, 8, and 10)

FIG. 6 shows in skeleton detail certain characteristics of this embodiment. It will be observed that the drum, gear drive, dead centering means, and motor are arranged in generally the same fashion as described with reference to FIG. 4. A pulse source 120 provides starting pulses to the drum motor through a pulse source control switch 122, a start positioning means 124, and a stepping control and reset means 126. The dead centering switch 108 is in the circuit and continues to serve as a means for stopping the motor after it has arrived at its predetermined position, i.e. for stopping the motor after it has moved sufficiently to execute one step of the drum. The remainder of the circuit is provided to enable the drum to start in response to pulses from the pulse source so that the switch 108 can complete the circuit through itself from the power supply 102 to the motor. The means 126 is arranged, as described below with reference to FIGS. 7, 8, and 10, to reset itself responsive to the ending of a pulse from the pulse source. Thus, the pulses are long enough on a time base so that the motor can step once, the resetting taking place after the motor has stepped.

It will be observed that there is a row of pins P1 arranged consecutively around the periphery. The row P1 assures that the circuit through 122 is maintained for the particular period of the control program indicated by the peripheral length of P1.

In the presently preferred embodiment, the pulse source contemplates a plurality of light sources 130, 131. A corresponding plurality of photoelectric cells 132, 133 is arranged on the other side of a light beam chopping disc 135 which is driven by a dial timing motor 136. The disc 135 has a plurality of slots 137 arranged therein. The slots are arranged in annular or circular rows so that one entire circular row comprises one program. An elongated homing slot 138 is provided for purposes which will be explained with reference to the homing operation in FIGS. 8 and 10.

Each disc 135 may include a large number of pro-

grams, each occupying its own annular ring of slots. As the disc is rotated, the slots establish a light beam from the source **130** to the photoelectric cell **132**. The beam continues to exist for a length of time required for the slot **137** to pass between the light source and photo cell. This length of time should exceed that required for the motor **20** to step and stop responsive to the dead centering switch **108**.

Each disc **135** ordinarily has a large number of programs stored thereon. Each program occupies its own annular circular track or path. With the embodiment shown, transient light from one light source may cause several of the photoelectric cells to produce pulses simultaneously. This occurs in random fashion and, if not controlled, serves to confuse the system and cause the drum to be stepped where stepping is not part of the program set forth in the slots on the disc.

The ganged selector switches **139**, **140** serve to eliminate this transient light. Before operation the selector switches are moved to the positions shown, thereby selecting the program indicated by the outermost row of slots **137**. This program corresponds to that indicated and aligned with the pin row P1. The selector switches turn on only one light and establishes circuit from only one photocell to the start positioning means **124**. In the embodiment shown, light **130** and photoelectric cell **132** have been placed in circuit.

Operation is believed to be evident from the foregoing. Briefly, however, it is to be understood that the selector switches are first put in position and when the starting system is closed, the system moves from its "home" position to a "zero time" position at which time the drum is synchronized with the first slot on the timing disc. Thereafter, operation requires merely rotation of the disc to intermittently establish light means in some predetermined fashion. Each time a beam is established between the light source and a cell a pulse is generated which causes the motor **20** to move off dead center and to drive to the next dead center position where it stops in response to switch **108** breaking the circuit. The light pulse then stops as the disc interposes itself between the source **130** and the cell **132**, whereupon the reset portion of means **126** prepares itself to receive the next pulse. It is to be observed that the time interval for effecting a control function is realized by the length of time between the slots **137** and whatever program is selected on the disc.

Appropriate circuitry for describing in detail the responses to the pulses during running, as well as for starting and homing, will be described below with reference to FIGS. 7, 8 and 10.

Introductory description of the embodiment of FIG. 10

The circuit of FIG. 10 is used in conjunction with the circuit of FIG. 8, assuming that the various manually operated switches are set in the positions shown in FIG. 8 and that switch **158** is closed. This allows there to be four programs stored on the drum or on the disc, or on both as the case may be, as indicated by the switch arrangement of FIG. 8 and also by there being four light sources **130**, **130'**, **131**, **131'** and four photoelectric cells **132**, **132'**, **133**, and **133'** in FIG. 10. As evident by comparison of FIGS. 6 and 10, any suitable number of programs may be provided for in accordance with the number of lights, cells, annular rings of slots on the disc, and the like. In the embodiment shown in FIGS. 8 and 9 four programs are allowed and accordingly the selector switch **185'** of FIG. 10 is provided with four contacts for selecting one of the four programs. In the embodiment shown, it is assumed that the program controlled by the master switch L1 is selected.

Referring now to FIG. 10, a manual function switch **219** is provided and is closed anytime the circuit is to be placed in operation. A plurality of signal lights **193'**, **196'**, **194** and **195** are provided as desired. Similarly, a manually operated reset circuit including the normally open switch **190** and relay R5 are included, serving the same purposes as in FIG. 9. The various elements of the stepping control and automatic reset means **126** (FIG. 6) are shown as are the portions of the start positioning means **124**. The elements **124** and **126** will presently be described in detail. A starting circuit **220** receives power from terminal TB2 and by means of the holding circuit is used to start and maintain the system in operation until the starting circuit itself is disabled responsive to the motor **20** having driven the drum to a home position. Although not shown in FIG. 6, a homing motor **222** is provided so the disc can be rapidly driven to home position once a given program has been completed. Thus, there are two motors, the ordinarily slow operating electric motor **136** for driving the disc **135** through a program and the homing motor **222**, all in addition to the drum motor **20**.

A homing light HL and the homing cell HC are provided for cooperation with the homing slot **138** in the light chopping disc **135**.

A transformer **224** receives power through the starting circuit **220** and applies to a photoelectric cell amplifier **226** which latter receives signals from a selected one of the light cells, amplifies it, and then actuates a relay RL. Thus, there is provided a means for responding to a beam of light admitted through one of the slots **137** to thereby cause the drum motor to step responsive to such light.

The system of FIG. 10 is arranged to cooperate with FIG. 8 so that a particular program may be selected and when the system is started, both the drum motor **20** and the dial timing motor **136** are brought into synchronization on a time base so that the drum is positioned in accordance with the disc **135**. More specifically, the system is arranged so that the drum motor starts in response to a beam of light and drives one step to dead center, after which the beam of lights cuts off and resets the system for the next operation. The details of this are described below but attention is now directed to the relay RL and its normally opened contacts RL–1. The starting procedure and the cooperation of the elements of FIG. 10 are so arranged that RL–1 starts the motor **20** when a beam of light strikes the light cell **132**. Relay RL also controls two other contacts, normally open switch RL3 and normally closed switch RL–2.

Returning for a moment to the starting circuit **220**, a master switch **230** is connected across the power supply and in series with homing switch H–2. A convenience relay R–11 responds to closure of the master switch by actuating the holding relay R–12 which latter is connected in series with homing switch H1. In doing so, R11 changes the state of normally open contacts R11–1 and R11–2 until the motor is moved on home position thereby opening contact H–2 to disable relay R11 and closing switch H1 to thereby enable the holding coil R12 during the course of the entire program and until the drum has been returned to home. It will be observed that the reset relay R5 had additional contacts R5–2, R5–3 and R5–4, the latter two being normally closed.

The power supply to the timing disc motor **136**, the homing disc motor **222** and the pulse source **120** (FIG. 6), **228** (FIG. 10) is independent of the starting circuit. The homing function of the pulse source is thus independent, in a fashion, of the drum.

The starting positioning means **124** as arranged in FIG. 10 is divided into two portions **124*a*** and **124*b***. A plurality of parallel connected relays **R14**, **R15**, and **R16** are disposed in the means **124*a*** and connected to terminal **9** thence to the selector switch **185'** and one of the pin switches, e.g. L1 (or . . . L4). Relay **R14** is provided to turn on the motor **136** at an appropriate time and, during homing operation, to turn on the homing motor **222**, by manipulating contacts R14–1 and R14–2. The timing motor is operated during starting and homing and by normally closed contact R14–3.

Relay R15 manipulates switches R15–1 and R15–2 to thereby select the source of input signals to the pulse source amplifier 225. Normally open contact R15–1 channels signals from the selector switch 140 while normally closed contact R15–2 channels signals from the homing cell in the amplifier. Relay R15 also controls a portion of the circuit 124*a* by manipulating switches R15–3 and R15–4.

Relays R16 and R17 are a push-pull type of relay which control their contacts so that one is engaged and one is disengaged and so that it takes two signals applied first to one relay R16 and then to the other relay R17 to move the contacts out and then return them to their initial position. In other words, when the contacts R17–1 are closed, those at R16–1 are open and vice versa. Switch contacts R17–1 are closed at home position.

The embodiment of FIGS. 6, 7, 8 and 10

Broadly speaking, the mode of operation of the embodiment represented by FIGS. 6, 7, 8 and 10 is to cause the drum motor 20 to step in response to a pulse drawn from the pulse source 120, to stop the stepping operation in response to the dead centering means 108, and to reset the stepping control circuit for the next operation in response to termination of the pulse. In the disclosed embodiment, the pulse is generated by aligning one of the slots in the light chopping disc 135 with a photocell and a light, thereby to actuate said switches. More specifically, the pulse causes switch RL–1 (Figs. 7 and 10) to close thereby to start the motor 20 and move it off dead center. Termination of the pulse restores switch RL1 as well as the rest of the stepping control circuit 126 to appropriate positions, thereby resetting the means 126.

The starting procedure for this embodiment is arranged to bring the drum motor and drum into a timed relationship with the rotating light chopping disc 135. Also, the entire starting procedure arranges the circuit so that switch RL1 may operate as just described.

During starting there are two phases: skipping wherein only the drum motor 20 runs, and the drum is rotated until the first programming pin P1 engages its corresponding switch L1 and thereby starts the timing motor 136, and then a dwell of the drum during which time the timing motor drives the disc until a first pulse is produced to thereby start the control functions via L5, L6 . . . . The drum subsequently is stepped responsive to subsequent pulses. These two phases may also be described as: moving off home to zero position, and dwelling until zero time is established by the first pulse thereby beginning the control of functions. The latter position is termed the "zero time" position because that is when the drum motor 20 and the pulse source (i.e. disc motor 136) are brought into the proper timed relationship for carrying out the remaining stepping operation.

A description of the operations of the embodiment of FIGS. 8 and 10 will facilitate an understanding of the construction. At the outset, the various manually operated switches are moved to the positions shown in FIGS. 8 and 10 and switch 158 is closed to provide power. Switch 185' selects row P1 and switch L1 as the program, and switches 139, 140 select the light and light cell corresponding thereto. Moroever, as best illustrated in FIG. 1, for this embodiment, the row of pins P1 is arranged with all of the pins positioned adjacent each other and consecutively so that stepping operations during the control cycle are from one adjacent pin to the next whereby the program switch L1 is maintained closed. Moreover, attention is directed to the ganged switches R16–1 and R17–1 (FIG. 10) which are adjusted so that the latter is closed at the home position while the former is open at such position. Two relay coils R16 and R17 are alternately operated to respectively position the switches so that one is open when the other is closed. As it turns out, R16–1 remains closed during normal operations and R17–1 is open, the respective positions being reversed at the home position.

There are two home positions involved—one for the drum 2 and one for the light chopping disc 35. The disc is driven to its home position by the high speed motor 222 which conveniently is mounted on the same shaft as the synchronous timing motor 136.

Referring first to FIG. 10, the starting circuit 220 has a master switch 230 which starts the operation of this embodiment by being manually closed to thereby actuate the convenience relay R11 and to close the two contacts controlled thereby in order to set up the conditions for actuating the starting switch holding coil R12. Coil R12 is in series with the homing switch H1 across the power supply and is therefore disabled at the instant of starting because H1 is open at home.

However, referring to FIG. 7, the motor 20 is moved away from its home position by reason of a circuit through normally closed contacts R14–3. When the motor is off home, the holding coil R12 is enabled and changes the position of the contact switches controlled thereby, thus holding itself in and maintaining a power supply to the entire system until such time as the cycle has been completed. In order to do this, the homing switch H1 closes.

Also, when the motor moves off dead center, switch 108 closes and energizes relay R20 which in turn energizes relay R21. The contacts of relays R20, R21 have now changed state from that shown in FIG. 7.

With power now being supplied to the motor and to the system, the motor 20 starts and drives through a skipping operation (i.e. moving over dead center) until the first pin P1 (or P2, P3, P4 according to setting of selector switch 185') closes its corresponding switch L1 (122 in FIG. 6). The drum motor 20 now goes through an initial dead centering operation after which the drum dwells until it is time to step to the next succeeding pin after the disc 135 has furnished the first pulse. Referring for a moment to FIG. 7, the initial dead centering operation is carried out by a circuit to the motor through the normally closed contacts of R19–3 and of R14–3, the cross coupling lead 235, and a circuit including the dead centering switch 108 and the now-closed (normally open) contacts R20–3. Also, relay R21 is actuated by closure of switch R20–2. The purpose in actuating relay R21 is to open the circuit through lead 236 to the coil R20.

With the switches in the circuit of FIGS. 7 and 10 in the position just described, the motor 20 dead centers in response to opening of the switch 108 because all other channels for power delivery have been disabled by opening appropriate switches. The channel through switch R14–3 is opened in response to closure of L1 when the three positioning relays R14, R15 and R16 are actuated to change the position of their respective contacts as shown in FIGS. 7 and 10. Pulse source motor selector R14 is thus actuated to select motor 136 for the duration of the cycle, at the same time rejecting the homing motor 222 and the homing light by opening the switch R14–1. The drum motor control circuit switch R14–3 is also opened at this time so that the dead centering operation can take place in response only and solely to the dead centering switch. The pulse source enabling switch control coil R16 is actuated in response to the closure of L1 and simultaneously with the motor selecting relay, thereby turning on the motors by closing switch R16–1 and opening the ganged contact R17–1. The pulse source is now in operation, the motor 136 driving the disc and power being delivered to the amplifier 225 through the transformer 224.

Simultaneously with operation of relays R14 and R16, the function and homing setup relay R15 is actuated to disable the homing setup relay R17 for the remainder of the control program (i.e. until switch L1 is open). The

function setup relay also sets up the circuit to the function relay R1 of FIG. 8 by closing switch R15–2 to thereby set up a circuit to the zero time setup relay R18, the latter remaining de-energized until the first light pulse completes a circuit by closure of light relay RL–3.

Responsive to the closure of R18–1, a circuit through lead 238 is completed to relay R1 (FIG. 8) thereby causing the function switches R1–1, R1–2 . . . to close. Any pins axially aligned with P1 on the drum may now close their respective switches L5, L6 . . . to actuate the function control means designated generically for convenience as solenoids 159, 160.

In review, during startup the drum drives to the first pin in the selected row at which point the pulse source is started in operation by turning on the motor 136 and by actuating the function relay R1. The drum dwells in this position until the first pulse, causing certain switching operations, is sent into the system responsive to aligning a light 130, a cell 132 and a slot in the disc, as is shown in FIG. 6. During the dead centering operation or start up, the two reset relays R20 and R21 are actuated thereby changing the position of all of their contacts and in particular closing contact R20–3 and R20–4. Relays R20, 21 are reset responsive to the first light pulse. The relay R20 memorizes the fact that the drum motor is off dead center while the relay R21 responds to the disappearance of a pulse to disable R20 and thereby reset the circuit of FIG. 7 for a next succeeding pulse, in a fashion to now be described.

Up to this time there has been no pulse sent into the system. The first pulse is utilized to arrive at the zero time by starting the control function and by resetting the circuit 126 for the next succeeding pulse. Means 124*b*, particularly relay coil R19, memorizes the first (zero time) light pulse. There has been no control function carried out because no circuit to the function relay R1 via lead 238 has been completed—this requiring closure of either switch RL3 or switch R18–1. The pulses are of long enough time duration that the motor 20 has an opportunity to drive to its next succeeding dead center position, that is, to move the drum one stepping increment, at which time or later the pulse ends and thereby resets the circuit means 126 as will shortly be described.

With the appearance of the first pulse, the light relay RL changes the sense of its three contacts to close both RL–1 (in circuit 126—see FIG. 7) and RL–3 and at the same time to open contact RL–2. Closure of RL–3 actuates relay R18 and causes it to close both of its switches R18–1 (thereby holding itself in position) and R18–2 (thereby setting up relay R19). Relay R19 does not actuate this time because both of the switches capable of energizing it (R19–1 and RL–2) are open: actuation and pulse memorization occurs when the first pulse ends and R12 closes. However, relay R19 does serve to memorize, for the duration of the program corresponding to row P1, the fact that there has been a complete first pulse and since this pulse is the zero time of the system, it does allow energization of relay R1 responseive to the closure of switch RL–3 which is connected by lead 238 to R1. When the first pulse of light disappears the light relay RL switches all return to the positions shown in FIG. 10 and in response to this, there now being a circuit through RL–2, relay R19 is energized.

Function relay R1 of FIG. 8 is energized via RL–3 and RL15–2 (now closed) in response to the appearance of the first pulse. This starts the control functions for those having pins P5, P6 . . . axially aligned with P1 on the drum. Relay R1 remains energized due to contacts R18–1 creating a self-holding circuit for coil R18 and also to lead 238.

Responsive to the energization of relay R19, all of its contacts change sense so that R19–3 (FIGS. 10 and 7) is opened and switches R19–1 and R19–2 are closed. Closure of R19–1 maintains relay R19 in an energized position so that it has the effect of memorizing the first pulse of light, i.e. of memorizing arrival at zero time for starting the control cycle. In review, the first pulse of light energizes relay R1 and permits the function switches to energize selected functions while at the same time closing the switch R19–2 and opening R19–3. Operation of the latter two, as best seen in FIG. 7, serves to set (and reset) the system of FIG. 7 for sequential steps of operation. A channel to start the drum motor 20 has now been created which is responsive only to the pulses appearing to cause closure of the light relay switch RL1. This channel as best seen in FIG. 7 extends from the starting switch through the now-closed contact R19–2, the now open contact RL–1, the lead 235, the now closed contacts R20–4, thence to the motor 20.

The contacts R20–4 have been returned to their closed position by deenergization of relays R20 and R21 when the pulse terminates thereby opening the switch RL1 which shuts off power to relays R20 and R21.

With the system now at zero time and the first pulse having been memorized by relay R19, the entire system remains in position until the next pulse is created. The drum remains stationary during this time but the motor 136 continues to drive the disc thereby to present the next succeeding slot and generate the required pulse. When this pulse appears, the switch RL–1 is closed and completes a circuit from the starting switch to the motor via a bypass around the dead centering switch 108. The bypass is through the lead 235 and normally closed contacts R20–4. When the motor moves off dead center position, the dead centering switch 108 is closed and thereby causes the relays R20 and R21 to energize in sequence. This breaks the circuit through switch R20–4 but simultaneously establishes a circuit through switch R20–3. The motor continues to drive until it arrives at dead center whereupon switch 108 comes open and the motor stops. As previously explained, the pins on the drum are arranged in a solid row (see FIG. 6) so that the switch L1 remains closed. However, new functions are initiated as far as the control system is concerned by the particular arrangement of pins in the other rows to energize function switches such as L5, L6 . . . . The pulse has a time duration sufficient to allow the motor to step to dead center as just described. This is achieved by providing the slots 137 with sufficient peripheral length so that the pulse is sustained despite the fact that the motor 136 continues to run throughout the cycle. After dead centering, the light slot 137 moves out of the beam, cuts off the light, and thereby the pulse terminates.

When the pulse terminates, the motor control system of FIG. 7 resets itself. Resetting is necessary because the dead centering switch has energized relays 20 and 21 which remained in that condition as long as the switch RL1 was closed. Thus, termination of the pulse changes the light relay RL and causes the switch RL1 to come open thus deenergizing the relay 20 and 21 and thereby resetting the system of FIG. 7.

During a control cycle, the above running procedure continues by providing pulses to start the motor by closing switch RL–1, stopping the drum motor responsive to the dead centering switch 108, and then resetting the system of FIG. 7 by opening switch RL–1 responsive to the termination of the pulse. This allows the drum motor to start in response to the beginning of a pulse, to stop responsive to driving to its next step, and then for the system to reset itself responsive to termination of the pulse. In accomplishing this, a bypass around the dead centering switch is provided so that the motor can jog off dead center.

After completing the cycle of operations, both the drum 20 and the light chopping disc must be brought to their appropriate and respective home positions. To accomplish this it is desired to turn on the high speed homing motor 222 and to cause the drum motor to drive so that it moves past any successive number of dead center positions until both the drum and the disc 135

have been brought to their respective home positions, at which time the holding coil R12 is deenergized and the entire system returns to the state shown in FIGS. 8 and 10. The drum motor **20** and the holding motor **222** are almost independent of each other in driving to their respective home positions. However, the homing operation is initiated when the timing motor **136** moves its last slot **137** into light beam-establishing position to cause the motor **20** to begin a step as heretofore described.

When the last slot **137** has created a pulse, the drum motor moves off dead center and in doing so moves the last pin in the row out from under switch L1 so that the latter comes open. Opening of switch L1 deenergizes relays **14**, **15** and **16**.

Responsive to deenergization of relay **14**, the switches R14–1 and R14–2 are returned to the position shown in FIG. 10 and thereby shut off the timing motor **136** and turn on the homing motor **222** and its corresponding light HL.

No immediate response is made when relay R16 is deenergized because of its coupling to relay R17. This particular combination involves two ganged switches R16–1 and R17–1 and two opposite acting coils R16 and R17. When one of the coils has moved the switch to a given position, the switches remain in that position regardless of the energy state of said one coil. The only way the contact switches are moved to another position is by energizing the second of the two coils. In view of this, the switch R16–1 remains closed and connects the homing motor **222** to the power supply by means of lead **240**. This connection is independent of the starting switch **220** whereby the homing motor may continue to drive to its respective homing position independently of whether or not the drum motor has reached its home position.

Deenergization of relay **15** responsive to opening switch L1 stops all functions because relay R1 is deenergized responsive to opening of contact R15–2. At the same time relay **15** sets up relay **17** for energization by returning contacts R15–1 to the closed position.

Responsive to the opening of contact R15–2, the relay R18 is also deenergized in response to which relay **19** is deenergized when contacts R18–2 are returned to their normally open position.

Referring for a moment to FIG. 7 for convenience, the switch contacts R19–2 and –3 are returned respectively to their normally open and normally closed positions (shown) when relay **19** is deenergized. This resets the system for the next cycle of operation.

Still referring to FIG. 7, the deenergization of relay **14** closes contacts R14–3 and thereby supplies a sustaining voltage to the drum motor **20**, which permits the latter to drive home. When the drum motor **20** reaches home it deenergizes itself by opening homing switch H1 thereby shutting off all power because the holding coil R12 is deenergized. The drum motor has now arrived at home and in doing so has reset the homing switches H1 and H2 at their respective open and closed positions at home.

While the drum motor is driving to its home position, the pulse source is doing the same, being driven by the homing motor **222** until the home slot **138** establishes a final home pulse. When this final home pulse is established, the light relay RL closes the contacts RL–3 and completes a circuit to energize relay R17 which causes the contacts R17–1 to close (thus resetting the system for the next operation) and simultaneously opens the switch R16–1 to shut off the homing motor and the homing light, thereby deenergizing the light relay and returning all light relay switches and contacts to the starting position.

The home slot **138** is spaced angularly from the last program slot **137** in each of the programs on the disc **135**. The angular spacing is such that the drum motor **20** has time to drive to its home before the home slot establishes the home pulse. As seen, the home pulse sets up the system for the next starting operation.

FIGURES 11, 12 and 13

The basic structural features for enabling easy removal of the drum so that drums can be interchanged to provide different programs is illustrated in FIGS. 11–13. A cabinet generically denoted as **6** provides a pair of spaced apart bracket supports **34**, **35** each of which has its respective offset bifurcated end **36**, **37**. Each of the ends **36**, **37** preferably has an internal shape like a U laying on its side to thereby engage a matingly shaped drum positioning ring **64** which is secured to the shaft **56** and spaced from the drum by the washers **75**, all as described in detail with respect to FIG. 3. The offset of the ends is sufficient to receive the rings **64** while avoiding interference with the drum (see FIG. 3).

Referring for a moment to FIG. 11, the left hand ring *64a* may have a partly cylindrical or spherical portion *64b* likewise engaging a mating portion on the bracket end **36** in order that the drum may be swung about its pivot shaft **38** in order to move it to a position suitable for removing and/or replacing the drum. The pivot pin **38** is preferably arranged vertically (FIGS. 12 and 13) with its central longitudinal axis coinciding with the axis of the spherical (or at least partially cylindrical) surface *64b*. The pivot pin **38** may comprise any suitable pivoting means and may be secured to one of the ends **36** or the ring *64a* and revolvably connected to the other of the ring or end whereby pivotal rotation as indicated by FIGS. 11 and 12 may be achieved.

A securing means **39** which may comprise a set screw, a spring biased detent, a drift pin, or the like is provided to the right hand of the bracket ends **37** in order to secure the corresponding end of the shaft and the ring **64** in place. The member **39** removably or detachably engages the ring **64**, which engagement is broken when the drum is moved to the position shown in FIG. 13.

I claim:

1. A stepping switch timer for stepping through a cycle of electrical events in steps each of a discrete time interval and for selecting one discrete interval from a plurality of such intervals for each step and comprising

a plurality of timing means, each such means for operating for a predetermined time interval and for resetting itself for its own time interval at the end of each time interval of operation thereof;

a movable memory device having switch actuating means as part thereof;

drive means for driving said memory device;

a first switching means engaged by said switch actuating means for selecting and starting one of said timing means and for disabling all other of said plurality of timing means in response to engagement by said switch actuating means;

a second switching means responsive to said first switching means for stopping said drive means simultaneously with the starting of the one timing means by said first switching means and for starting said drive means after said one timing means has operated for its preselected discrete time interval;

and a third switching means engageable by said switch actuating means, for controlling a predetermined event in a process for the time interval of said one timing means responsive to said first switching means whereby said memory device is stepped from one position to another in sequence with preselected discrete time intervals between steps, the motor being turned on for respective steps and being turned off during the intervals between.

2. A stepping switch according to claim **1** wherein said first switching means comprises

a normally open program switch aligned with a selected portion of said switch actuating means and connected in series with all of said timing means;

a first plurality of normally open timer selection

switches connected in series with said program switch;

a second plurality of normally closed timer selection switches all connected in series with each other and each ganged to a corresponding switch in said first plurality;

means for connecting said second plurality of timer switches in series with said program switch;

first connection means for connecting one of said plurality of timing means in series with said second plurality of selection switches, and

second connection means for connecting in parallel with said first connecting means each of the remaining timing means in series with a corresponding one of said first plurality of selection switches

whereby the switch actuating means of said memory device enables all of said timing means by closing said program switch and similarly selects one of said timing means either by closing one of said first plurality of selection switches or by leaving all of said second plurality of selection switches open, the remaining timing means all being disabled by leaving open a selection switch in series therewith.

3. A stepping switch according to claim 1 wherein said first switching means comprises

a normally open program switch aligned with a selected portion of said switch actuating means of said memory device, and

a plurality of time selection switches each corresponding to one of said plurality of timers,

all of said timer selection switches being connected in series with said program switch,

at least a portion of said timer selection switches being connected in parallel with each other and aligned with a selected portion of said switch actuating means of said memory device,

whereby driving said memory device closes said program switch to enable all said timer selection switches and selects one timer by manipulating said timer selection switches.

4. A stepping switch according to claim 3 wherein all of said timer selection switches are connected in parallel.

5. A stepping switch for stepping through a cycle of electrical events in steps each of a discrete time interval and for selecting for each step one discrete interval from a plurality of such intervals, and comprising in combination

a plurality of timing means, each for operating for a different predetermined discrete time interval and for resetting itself for its own discrete time interval at the end of each discrete time interval of operation thereof;

a revolvable electric motor;

a starting switch for said motor;

circuit means for connecting said starting switch to said motor;

motor control switching means connected in said circuit means for providing a plurality of electrical paths therethrough, each of said paths being selectively opened and closed in accordance with a predetermined program encoded on the hereinafter defined memory device;

a timer selection means for selecting one of said plurality of timing means and for disabling the remainder of said plurality in accordance with a predetermined program on the next-said memory device;

a memory device driven by said motor and having a part thereof a means for defining said predetermined program

including a programming means for enabling all of said timing means responsive to movement of said memory device to a predetermined position by said motor,

said memory device means for defining also including means for engaging and operating said timer selection means in accordance with said program responsive to said memory device being driven by said motor to such predetermined position;

said motor control means having a means for disabling one of said plurality of paths in response to said programming means arriving at said predetermined position;

said motor control means further including a means for keeping selected one of said paths, each selected path corresponding respectively to one of said timers, disabled during the discrete time interval of operation of its respective timer and to enable completion of a circuit through said path in response to the respective timer having run for its time interval, thereby to start said motor;

a first dead centering means for keeping said timing means disabled until said motor reaches a predetermined position and for starting the timing means selected by said selection means responsive to said motor arriving at a predetermined motor position; and

second dead centering means for maintaining a path through said switching means between said motor and said starting switch whenever said motor is not in said predetermined motor position, and for opening such path when said motor is in position, said motor control means including said second dead center means,

all the above-recited plurality of paths to said motor being disabled during the discrete time interval that the selected one of said timing means is running, timing means selected to run not starting until until the motor arrives at dead center.

6. A stepping switch in accordance with claim 5 and further including in said motor control means an interrupting means for shortening said discrete time interval and connecting said motor to said starting switch responsive to a parameter other than time.

7. A stepping switch in accordance with claim 5 and further including in said motor control means an interrupting means for lengthening said discrete time interval by disabling all of said timer-responsive switches until a predetermined event in response to which event all of said timer switches are enabled.

8. A stepping switch in accordance with claim 5 and further including in said motor control means an interrupting means for shortening said time interval and connecting said motor to said starting switch responsive to a parameter other than time, and

means for lengthening said time interval by disabling all of said timer-responsive switches until a predetermined event in response to which event all of said timer switches are enabled.

9. A stepping switch in accordance with claim 5 wherein said starting switch includes a holding means for maintaining a connection between the rest of the circuit and a power source, said stepping switch further including a homing means responsive to a single position on said memory device for breaking said holding means connection.

10. A stepping switch in accordance with claim 5 and further including a means for lengthening the time interval of at least one of said timers responsive to an event other than time by maintaining disabled the means for keeping in said motor control means until such event occurs.

11. A stepping switch for stepping through a cycle of electrical events in steps each of a discrete time interval and for selecting one discrete interval from a plurality of such intervals for selected steps and comprising

a plurality of timing means, each timing means for operating a different predetermined discrete time interval and, after operating, for resetting itself for its own discrete time interval;

a revolvable electric motor;

a movable memory device having an array of switch actuating means supported thereon to define at least one predetermined program of events;

means connected between said motor and said memory for driving said memory responsive to rotation of said motor;

a starting switch means for connecting said motor to an electrical power source;

a timer enabling and selection circuit that includes—

a program means for enabling all of said timing means in a predetermined sequence responsive to first preselected ones of said switch actuating means engaging said program means when said memory device is moved to one in a succession of predetermined positions,

timer selecting means for selecting one of said timers and for disabling the remaining timers responsive: to engagement of said timer selecting means by second selected ones of said switch actuating means, to enablement by said program means, and to enablement by the next-said first dead center means, and

first dead center means for preventing said timing means from operating until said motor arrives at a predetermined motor position;

and a motor control switching circuit means connected between said starting switch means and said motor for turning said motor on and off by making and breaking the circuit therebetween and further including—

means for breaking a normally maintained circuit between said motor and said starting switch responsive to said program means, and

a plurality of timer-operated motor control means, each corresponding to a selected one of said timers, each for breaking a circuit to said motor during the time interval of its respective timer and for making a circuit to said motor at the end of said time interval, and

a second dead center means for operating in unison with said first dead center means to drive said motor to said predetermined motor position by maintaining a circuit to said motor and then disabling the last said circuit responsive to the achievement by said motor of said motor position,

whereby a stepping action is obtained by alternately

operating said motor and a selected one of said timers.

12. A stepping switch for stepping through a cycle of electrical events in steps each of a discrete time interval and for selecting one discrete time interval from a plurality in accordance with a predetermined program, said stepping switch comprising

a plurality of timing means, each timing means for operating for a different predetermined discrete time interval and for, after operating, resetting itself;

an electric motor;

means for connection between said motor and said plurality of timing means for selecting any one of said timing means and disabling all the remaining timing means responsive to being moved to one of a predetermined sequence of positions by said motor;

means for starting said motor responsive to the one selected timing means having run for its respective discrete time interval;

dead centering means for continuing motor operation until the motor arrives at a predetermined motor position;

means operating in unison with the last said means to start the one timing means selected responsive to said motor arriving at said predetermined motor position and for preventing any timing means from operating until said motor has arrived at said predetermined motor position.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,198,967 August 3, 1965

James S. Roberts

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 57, for "on-discrete" read -- non-discrete --; column 8, line 10, for "hte" read -- the --; line 69, for "embodimeint" read -- embodiment --; column 11, line 19, for "Ordinarilly" read -- Ordinarily --; column 12, line 17, for "starting circuit" read -- reset circuit --; same line 17, for "reset circuit" read -- starting circuit --; column 13, lines 38 and 39, for "motor runs and while it is off dead center, the dead cenas long as switch L1 has not been closed. While the" read -- as long as switch L1 has not been closed. While the motor runs and while it is off dead center, the dead cen- --; column 26, line 31, strike out "until", second occurrence.

Signed and sealed this 14th day of June 1966.

SEAL)
ttest:

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