

[54] **STEPPING ASSEMBLY AND CIRCUIT**

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[58] Field of Search. 307/41; 200/11 D, 153, 18; 317/139

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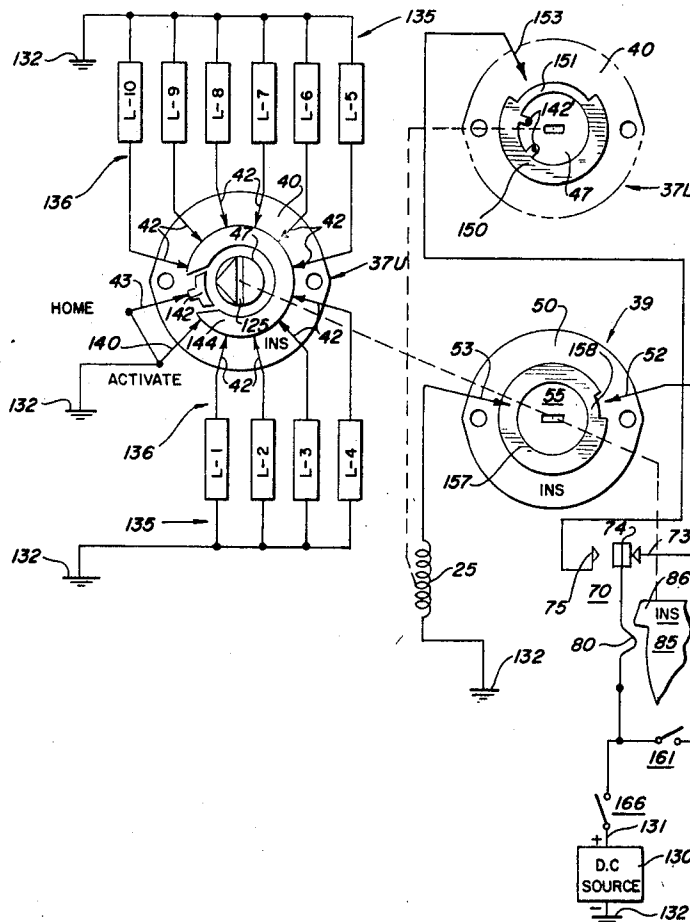
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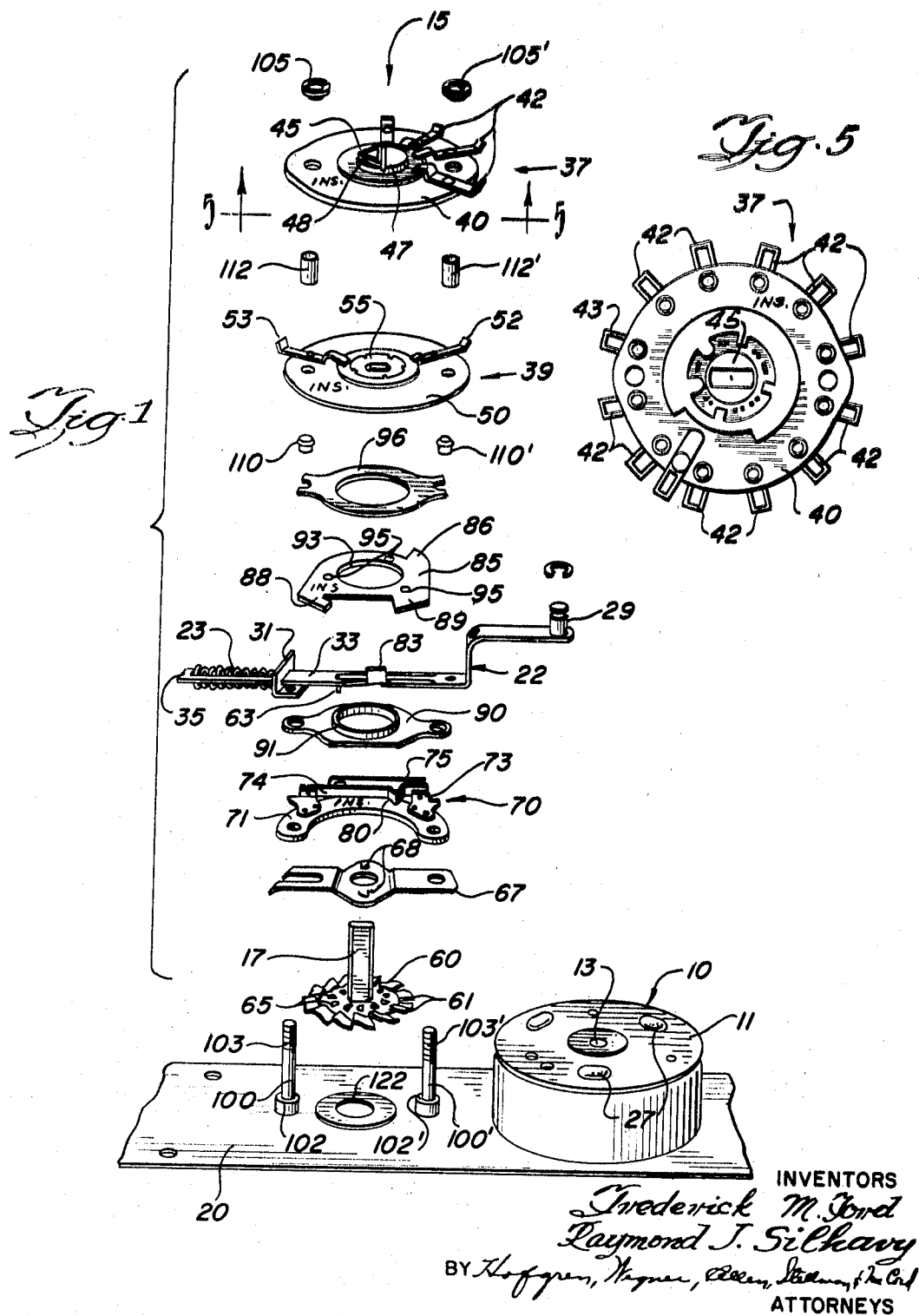
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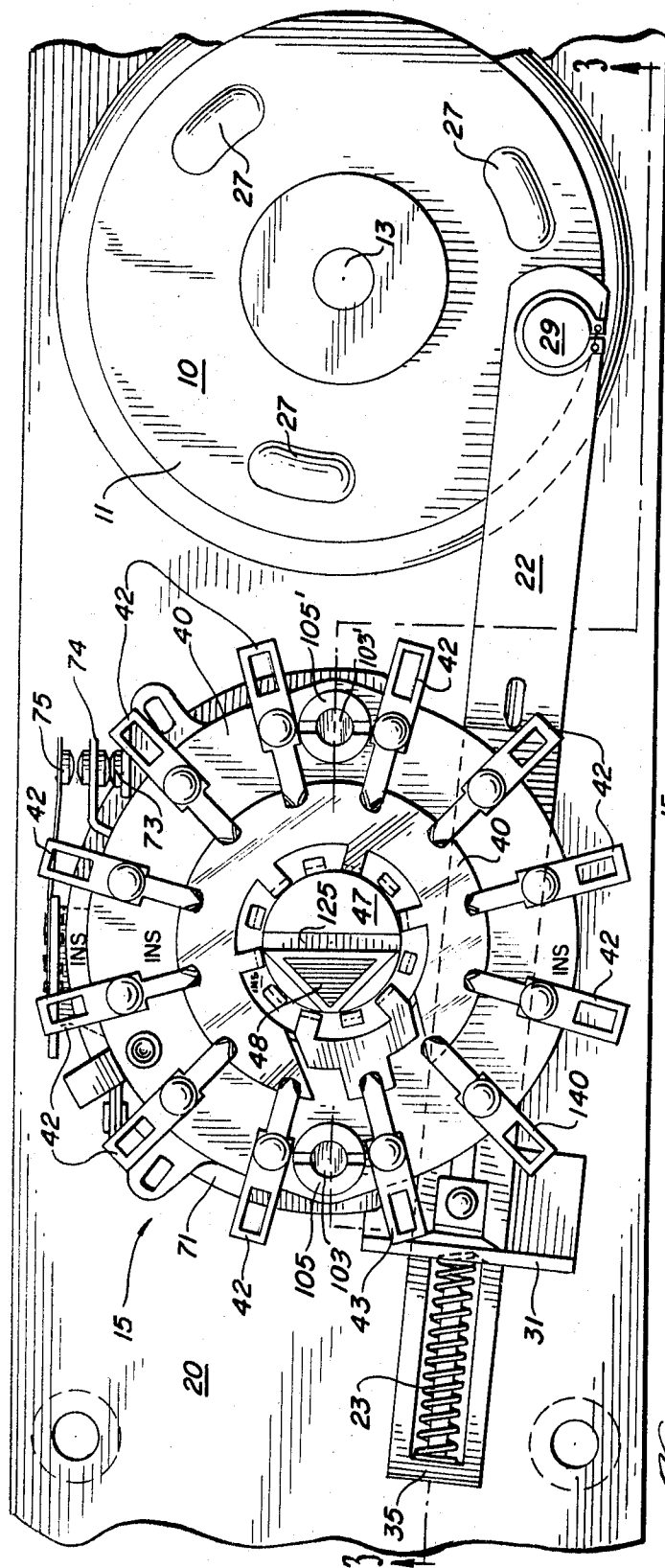
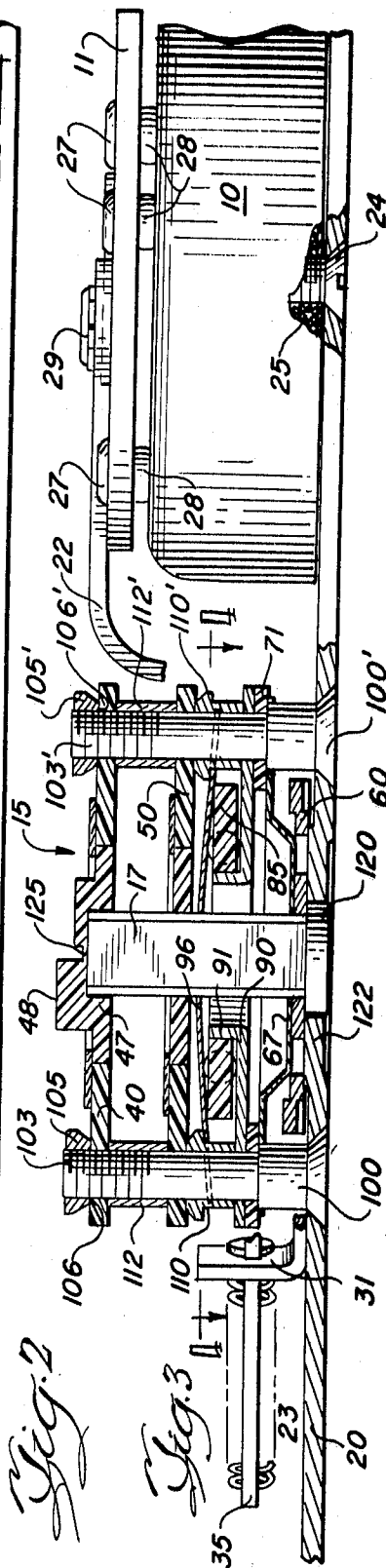
ABSTRACT

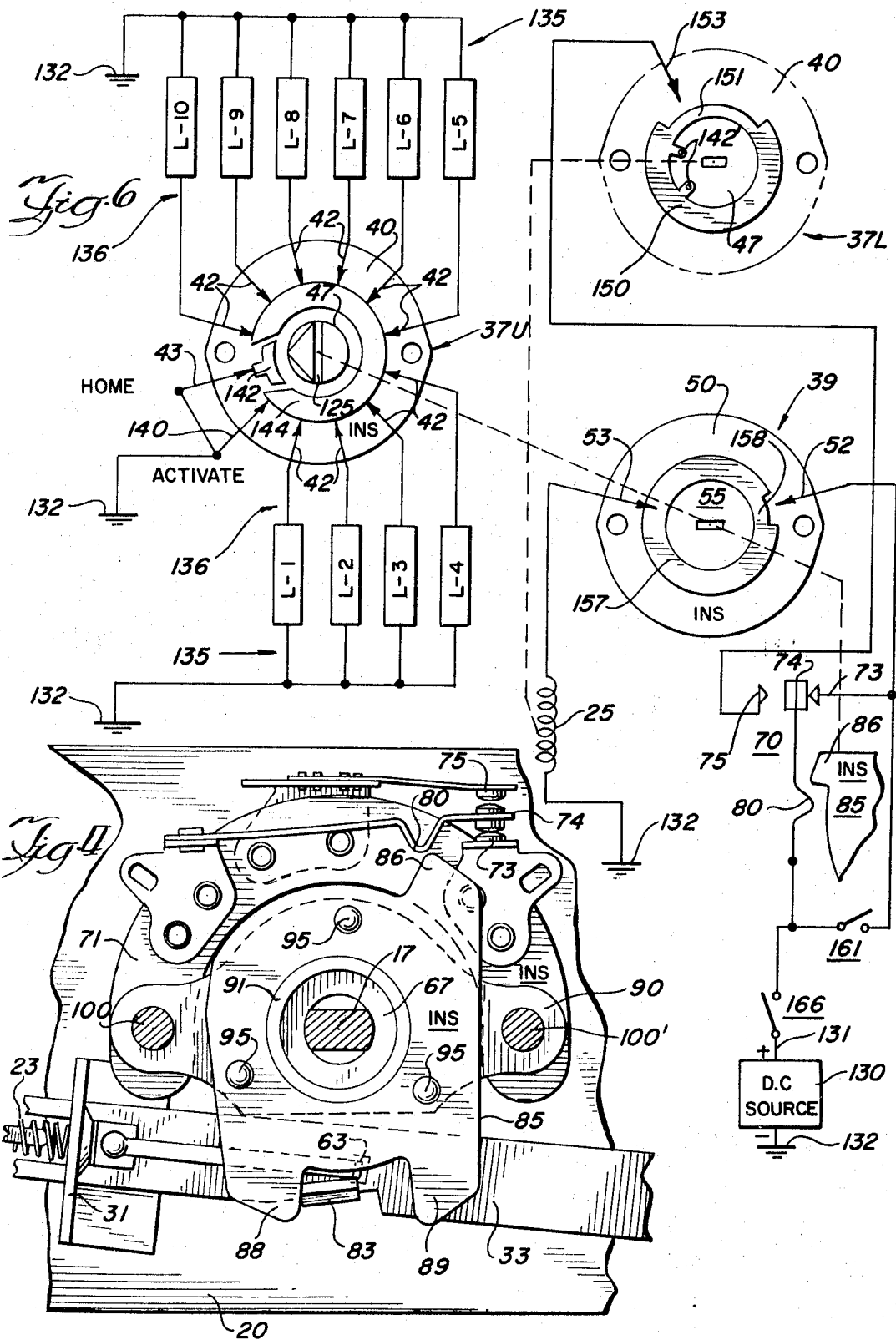
An intervalometer uses a rotary switch mounted to base through shafts which maintain concentricity. An offset stepping mechanism drives the switch under control of a drive energizing circuit having interrupter contacts on the switch. A load energizing circuit includes additional contacts on the switch for sequentially energizing a plurality of independent loads, while shunting all nonenergized loads. Separate switch sections separate the drive energizing circuit from the load energizing circuit. When the switch is in a home position, it must be manually rotated to another position before automatic sequential stepping can occur.

5 Claims, 6 Drawing Figures









STEPPING ASSEMBLY AND CIRCUIT

This patent application is a division of U. S. application Ser. No. 826,894, filed May 22, 1969 now U. S. Pat. No. 3,582,579, issued June 1, 1971.

This invention relates to an assembly and circuit for timing intervals, and more particularly to an improved stepping assembly and circuit therefore.

Intervalometers are devices which provide a series of timed electrical pulses, often coupled to separate loads. When limited mounting height is available, it has been known to use an intervalometer in which a rotary switch and a stepping motor are each mounted to a base, on offset axes. A link traversing the axes converts movement of the stepping motor into a reciprocating motion which stepwise drives the rotary switch through its positions. At each position, connection is made through electrical contacts to the loads associated therewith. Interrupter contacts carried by the switch control a self-completing circuit for energizing the stepping motor in order to cause the switch to automatically step through all of its positions. Many such assemblies of the above nature are known, an example of which is shown in a patent to Giese, Jr. et al. U.S. Pat. No. 3,405,376.

Prior rotary stepping assemblies and circuits of the nature described above have several disadvantages which greatly limit their use. The loads which are to be energized by intervalometers are often explosive devices, in which it is absolutely essential that accidental energization of the loads be precluded, both when connecting the loads to the switching assembly and during energization of other loads. Prior circuits have not precluded accidental load energization, which could occur by accidental electrical actuation of the triggering circuit while personnel are connecting the loads to the circuit. Applicants' circuit overcomes this problem by precluding electrical actuation until manual actuation of the switch enables the electrical circuit.

Another type of accidental load energization which prior circuits have allowed occurs when electrical noise or the like is coupled to the loads, resulting in false triggering. Other types of failure occur when a load is defective and short circuits the self-stepping drive circuit. In such an instance, the stepping circuit is rendered ineffective, and the remaining loads are not energized. It would be desirable that any defective load should be bypassed by the switching assembly and circuit, allowing further loads to be energized. The applicants' circuit and assembly overcome all of the above disadvantages.

The mechanical construction of prior stepping assemblies has also been unsatisfactory with respect to maintaining concentricity and long life of operation. When plural switch sections are required, the resulting stack height requires that the concentricity of the rotary switch assembly be maintained within close tolerances. Typical prior switching assemblies using screws inserted through the stack and threaded into a base plate do not have the stability necessary to maintain the desired degree of concentricity. Prior rotor bearings have also required an unnecessarily large amount of space and have been costly. These and other disadvantages of prior rotary stepping assemblies have been overcome by the improved stepping assembly also disclosed herein.

One object of this invention is the provision of an improved stepping assembly and circuit therefore.

Another object of this invention is the provision of an improved stepping assembly and circuit for sequentially energizing one load at a time, while maintaining a shorted connection across all nonenergized loads. One feature of the circuit is that it includes means for bypassing defective loads and means for preventing accidental electrical actuation by first requiring mechanical actuation of the stepping assembly.

Still another object of this invention is the provision of a rotary stepping assembly having improved concentricity for multiple switch sections. Some features of the improved switching assembly include improved bearing means, an integral pointer for indicating switch position and allowing manual actuation, and other improved design.

Further features and advantages of the invention will be apparent from the following specification, and from the drawings, in which:

FIG. 1 is an exploded perspective view of the stepping assembly;

FIG. 2 is a top plan view of the assembly of FIG. 1;

FIG. 3 is a side plan view, partly in section, taken along lines 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view taken along lines 4—4 of FIG. 3;

FIG. 5 is an upward looking plan view of the bottom face of the upper switch section, taken along lines 5—5 of FIG. 1; and

FIG. 6 is a schematic diagram of the circuit for the switching assembly.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

Turning to FIGS. 1-3, the improved stepping assembly is illustrated in detail. The assembly includes a stepping motor, such as a reciprocal driving assembly 10 which when energized rotates a plate member 11 about a longitudinal shaft axis 13. The motion in plate 11 is used to stepwise move a driven rotary switching assembly 15, illustrated in exploded view in FIG. 1. Switching assembly 15 rotates about a longitudinally extending rotor shaft 17 which is generally parallel with respect to the motor shaft 13. When minimum stack height is desired, the axes of motor shaft 13 and rotor shaft 17 may be offset, as illustrated in the drawings. Both motor assembly 10 and switching assembly 15 are mounted to a base assembly 20 of improved construction, as will appear. If stack height is no problem, the switching assembly may be axially aligned with the motor assembly and connected through a common shaft, while still retaining the advantages of the circuit and many of the advantages of the improved construction disclosed herein.

When the assemblies are offset, as illustrated, an actuator link 22 spans the distance generally between the driving and driven assemblies, and is spaced from the axes of motor shaft 13 and rotor shaft 17. Driving assembly 10 moves plate 11 along a limited arcuate path during a power stroke, when assembly 10 is energized. This movement causes link actuator 22 to be longitudinally displaced generally to the right in the drawings, causing stepwise rotation of switching assembly 15. As will appear, switching movement opens the energizing circuit for driving assembly 10. A spring 23 thereafter returns the link 22 to its rest position, after which the stepping cycle of operation is repeated by a self-completing energizing circuit, to be described later.

Driving assembly 10 may be any conventional assembly for producing a limited distance movement or a step type movement. The details of driving assembly 10 form no part of the present invention, and will only briefly be described with reference to one type of mechanism suitable for the purpose, namely, a rotary solenoid. The solenoid is fixedly mounted to the base 20 by a screw 24, FIG. 3. When a solenoid coil 25, FIG. 3, is energized, the rotary solenoid pulls plate 11 downwardly toward the coil 25. A plurality of inclined surfaces or races 27 are disposed on plate 11. Each race 27 includes a ball 28 trapped between the race and the surface of the solenoid. Upon actuation, the ball and race combination transforms the downward pull of the solenoid into a combined rotary and slight axial movement of plate 11.

Link 22 is pivotally connected to plate 11 by a stud and lock ring 29 which passes through an aperture in link 22 and is threaded into plate 11. The link 22 is longitudinally movably mounted to plate 20 by a guide plate 31 riveted to plate 20. Guide 31 includes an aperture through which the slide 33 of link 22 extends. The guide surface defining the aperture forms a bearing for slide 33.

When coil 25 is energized, plate 11 rotates counterclockwise, causing slide 33 to be longitudinally moved generally to the right in both FIGS. 1 and 2. Spring return 23, trapped between an outer end portion 35 of slide 33 and the guide 31, is compressed upon energization of the rotary solenoid. As will appear, the stepwise movement of the switching assembly 15 deenergizes solenoid coil 25. Compressed spring 23 now expands and returns slide 33 to its rest position, thereby completing one cycle of movement.

Switching assembly 15 consists of a first switch section 37 and a second switch section 39. The pair of sections 37 and 39 respectively control the energization of the load and the energization of the stepping motor 10. Each switch section 37 and 39 includes a stator which is fixed with respect to base 20, and a rotor affixed to rotor shaft 17 and which moves with respect to base 20.

Switch section 37 includes an insulated stator wafer 40 which mounts a plurality of electrical contacts, only a few of which are illustrated in FIG. 1. Certain of these contacts (labeled 42) are associated with the loads, with each contact 42 corresponding to a different load. An electrical contact 43, FIG. 2 (and FIGS. 5 and 6), not associated with any load, is used to form a home position for the rotary switch. As will appear, wafer 40 includes other contacts, some of which are located on the bottom side of the wafer.

For making connection to the fixed stator electrical contacts, a rotor 45, movable with respect to stator wafer 40, includes a rotor wafer 47 with an integral indicator 48 protruding upwardly therefrom. The bottom side of wafer 47 has a slot into which the rotor shaft 17 extends, see FIG. 3, for fixedly mounting rotor wafer 47 with respect to the rotor shaft 17. Rotor wafer 47 is fixedly connected to electrical contacts aligned for various circuit connection with the stator contacts at each stepwise rotational position of the rotary switch. The exact configuration of the rotary electrical contacts will be described later.

Switch section 39 includes an insulated stator wafer 50 mounting a pair of stator electrical contacts 52 and 53. A rotor wafer 55 is located within a central aperture in wafer 50, and has rotor contacts aligned for various circuit connection with the stator contacts. The rotor shaft 17 is press-fit within an aperture in wafer 55, for rotational movement of the rotor contacts, the details of which are described later. The cross-section of rotor shaft 17 is noncircular and corresponds to the shape of the aperture in rotor wafer 55, and with the shape of the slot within rotor aperture 47, for causing both rotor wafers 47 and 55 to rotate with rotor shaft 17.

The switching assembly 15 includes means for converting the generally reciprocating motion of plate 11 and link 22 into corresponding stepwise rotation of rotor shaft 17. A ratchet plate 60, affixed to the lower portion of rotor shaft 17, has a plurality of teeth 61 struck upwardly from the plane of the ratchet plate. The teeth 61 are axially inclined and spaced about the periphery of the ratchet 60. Slide 33 of link 22 carries a downwardly disposed pawl 63 which is located adjacent a pair of the ratchet teeth 61. As the slide 33 is moved to the right as illustrated in the drawings, pawl 63 pushes against one of the upwardly extending teeth 61, rotating the ratchet 60 counterclockwise about rotor axis 17.

In order to detent the stepwise rotor motion, ratchet 60 includes a plurality of apertures 65 disposed on the upper face of the ratchet plate. A leaf spring 67, located immediately above ratchet 60, has a pair of detents 68 struck downwardly for engagement in a pair of corresponding apertures 65 in the ratchet plate. As the rotor solenoid is energized, the movement of slide 33 and hence pawl 63 is transmitted through one of teeth 61 to the ratchet plate 60, causing the detents 68 to be forced upwardly out of their corresponding apertures 65. At the end of the power stroke, the detents 68 are urged downwardly into the next pair of apertures 65, thereby detenting the rotary switch to the next switch position. Thereafter, spring 22 urges slide 33 to the left, causing the pawl 63 to ride up and over the next tooth 61 and snap into place behind the

tooth, for subsequent pushing motion against the tooth upon the occurrence of the next power stroke.

During each cycle of stepwise rotation, an interrupter assembly 70 is actuated and changes the state of an electrical switch in order to control energization of the rotary solenoid. Interrupter assembly 70, see especially FIG. 4, is mounted on an insulated stator plate 71 which carries a fixed electrical contact 73, a movable spring contact 74, and a further fixed contact 75. The contacts 73, 74 and 75 form a single-pole, double-throw switch, with spring contact 74 normally resting against contact 73. Upon activation, spring contact 74 is first urged out of engagement with contact 73, and then into engagement with contact 75.

For actuating the switch, a part of the spring contact 74 is bent into an outwardly extending, generally V-shaped shoulder 80, which is disposed radially inward with respect to rotor shaft 17. Shoulder 80 is engaged by a cam assembly 85, FIG. 1, located on the same switch plane as interrupter assembly 70. Movement of cam assembly 85 is controlled by an upwardly extending finger 83 from slide 33. The cam assembly includes an extending head 86 located adjacent shoulder 80 of spring contact 74, as seen best in FIG. 4. The cam 85 also includes a pair of legs 88 and 89 which extend radially outward and bridge finger 83 of slide 33.

For rotatably mounting cam 85 to the switch assembly, a plate 90, disposed below the cam, including an upwardly extending extruded wall 91 having a diameter slightly smaller than the diameter of a circular aperture in cam 85, defined by a surrounding wall 93. Extruded wall 91 forms a bearing for wall 93. To reduce friction, a plurality of balls 95 are press-fit into apertures extending through cam 85, for sliding movement over the upper face of plate 90. A cam spring 96 biases balls 95 against the upper face of plate 90.

The operation of the interrupter assembly may be seen best with respect to FIG. 4. When slide 33 is in its rest position, finger 83 rests against shoulder 88, causing the head 86 of cam assembly 85 to be spaced from shoulder 80 of spring contact 74. As slide 33 is moved to the right, by reason of actuation of the rotary solenoid, rotor shaft 17 begins to turn due to the action of the pawl and ratchet mechanism previously explained. However, the cam assembly is still at rest because the space between shoulders 88 and 89 is greater than the width of finger 83.

Near the end of the power stroke of slide 33, finger 83 engages shoulder 89 and subsequent movement of slide 33 is transmitted through finger 83 against shoulder 89 to cause rotation of the cam assembly. This causes head 86 to be rotated against shoulder 80, lifting the spring contact 74 out of engagement with contact 73 and into engagement with contact 75. As will appear, opening of contacts 73, 74 removes power from the rotary solenoid, allowing spring 23 to return slide 33 to its rest position. Near the end of this return stroke, finger 83 again contacts shoulder 88, moving cam assembly 85 in a clockwise direction and moving head 86 out of engagement with shoulder 80. The spring biasing of contact 74 causes the contact to move out of engagement with contact 75 and into engagement with contact 73, returning the interrupter assembly to its rest state.

In order to stack the switching assembly 15 into a single unit, and maintain all parts concentric with respect to rotor shaft 17, an improved mounting structure is utilized. Base 20 includes a pair of elongated shafts 100 and 100' which are permanently affixed to base 100, as by riveting, and extend upwardly therefrom. For clarity, only shaft 100 and the parts of the rotor assembly coaxing therewith will be described in detail, it being understood that the same disclosure applies to shaft 100'. Elements for shaft 100' which correspond to similar elements for shaft 100 are identified by the same reference number followed by a prime ('). While two mounting shafts have been illustrated, additional shafts may be provided for switching assembly 15, if desired.

Shaft 100 includes a portion of reduced diameter, starting a short distance above plate 20 and extending upwardly

therefrom for the remaining distance. A transverse shoulder surface 102, which joins the reduced diameter portion with the lower shaft portion, forms one of the mounting or clamping surfaces for the stator portion of switching assembly 15. The upstanding shaft terminates at its upper end in a guide surface 103 such as a screw. This surface is adapted to guide and engage a fastening means, such as a spanner nut 105 which is threaded over the screw. The bottom plane surface 106, FIG. 3, of spanner nut 105 abuts and forms the upper mounting surface for the stator portion of switching assembly 15.

Various stator portions of the switching assembly 15 have aligned apertures which define a pair of hollow channels through which shafts 100 and 100' extend. The nuts 105 and 105' are screwed down to clamp the stator sections in a predetermined order against the base 20. Of course, the particular order of the stator sections is generally immaterial, and groups of coaxing sections may be placed at different stack heights, as desired.

As seen best in FIG. 1, the clamped stator sections have either apertures or bifurcated fingers which completely or partially surround shafts 100 and 100'. Apertures are used for one end of spring 67, stator 71, plate 90, wafer 50 and wafer 40, and bifurcated fingers are used for the opposite end of spring 67, and spring 90. A spacer 110 is located between plate 91 and wafer 50, and a spacer 112 is located between wafer 50 and wafer 40, to provide clearance between the corresponding switch sections.

After all of the switch sections are stacked in the desired order, spanner nuts 105 and 105' are threaded onto screws 103 and 103', respectively, clamping the stator portions of the switch between shoulder 102 and the bottom surface 106 of the spanner nuts 105. In the present embodiment, the lower surface of plate 71 rather than the lower surface of spring 67 forms the stator abutment with shoulder 102, because the aperture and bifurcated fingers of the spring 67 are of greater diameter than the enlarged portion of the shafts. Spring action retains spring 67 clamped between the plate 71 and ratchet 60.

The rotor portion of switching assembly 15 is journaled within base 20, thereby being rotatable with respect to the clamped stator assembly. The end of rotor shaft 17 adjacent plate 20 has a circular cross-section, and is enlarged with respect to the remaining portion of the shaft, as seen best in FIG. 3. Enlarged portion 120 is journaled within the circular aperture of a boss 122 upstanding from base plate 20. The whole thickness of the boss plate serves as a bearing surface for the enlarged portion 120 of the rotor shaft 17, without requiring the rotor shaft to extend beyond the flat plane of the bottom surface of plate 20. As seen in FIG. 3, this construction allows a tolerance in which a portion of the rotor shaft may extend beyond the bottom surface of the bearing, but insufficiently far to extend beyond the flat plane defined by the lower surface of plate 20. The upper surface of the boss forms a bearing against which the ratchet plate 60 abuts for rotational movement.

The upper end of rotor shaft 17 is press-fit into the slot formed in rotor wafer 47. As seen in FIGS. 2 and 3, wafer 47 has an integrally formed indicator 48, which may be in the shape of an arrow, in order to visually indicate the position of the rotary switch. If desired, indicator 48 may extend through an aperture in a housing (not illustrated) for an intervalometer using the illustrated stepping assembly, in order to visually indicate rotor switch position. A portion of the rotor wafer 47 includes a screwdriver slot 125, for manually rotating the rotor assembly independent of the rotary solenoid. As will be explained, manual actuation is necessary before the stepping circuit allows automatic, self-completing electrical actuation of the rotary solenoid.

The circuit for the switching assembly will now be described in detail, along with a detailed description of the switch sections 37 and 39. As seen in FIG. 6, a plurality of loads L-1 through L-10 are to be individually, sequentially energized by

the potential difference across a source 130 of DC voltage. The potential difference is available from a positive potential line 131 and a negative potential line which is connected to a source of reference potential or ground 132. While DC source 130 has been illustrated as supplying a single DC voltage to line 131, it will be recognized that any number of DC voltages may be available therefrom, depending upon the requirements of different loads and/or the stepping motor coil 25.

All loads L-1 through L-10 have individual first terminals 135 connected in common to ground 132, and a second or energizing terminal 136 connected through individual lines to a corresponding stator load contact 42 on the upper face 37U of switch section 37. In addition to the ten stator contacts 42, a home position contact 43 and an additional activate contact 140 are also mounted on the upper face 37U, providing a total of twelve equally spaced stator contacts. The home stator contact 43 and the activate stator contact 140 are both coupled directly to ground 132.

For connection to the stator contacts, the rotor on upper face 37U consists of a first element or short ring segment 142, connected to only a single of the stator contacts at any one time, and a second element or ring segment 144 which is common to all of the remaining stator contacts. Rings 142 and 144, electrically insulated from each other, are mechanically affixed to the rotor wafer 47 and rotate with movement of the rotor shaft.

The lower face 37L of switch section 37 also contains stator and rotor parts. The ring segment 142 on upper face 37U has a pair of contiguous electrical leads 142' which extends through the insulated rotor wafer 47 and electrically connect to a circular rotor ring 150 on face 37L. Ring 150 has an arcuate section 151 of reduced radial diameter. A single stator contact 153 has a length which continuously contacts rotor ring 150 except when the segment 151 is located adjacent thereto. Contact 153 is directly connected to the normally open contact 75 of interrupter switch assembly 70. It should be understood that the lower face 37L in FIG. 6 is being viewed from the top, with wafer 40 being broken away so that only the rotor ring 150, wafer 47 and stator contact 153 are illustrated. Therefore, as viewed in FIG. 6, as the rotor on the upper face 37U is rotated counterclockwise, the rotor on the lower face 37L is similarly rotated counterclockwise.

Switch section 39 has a continuous rotor ring 157 which is mechanically connected for rotation with rotor wafer 55. Ring 157 includes an arcuate section 158 of reduced radial diameter, extending over an arc corresponding to one stator contact position. Stator contact 52 has a short radial length which continuously contacts ring 157 except when segment 158 is located adjacent thereto. Stator contact 53 has a long radial length which continuously contacts ring 157, including when segment 158 is located adjacent thereto.

Switch section 39 forms a part of the circuit which generally controls energization of coil 25 for controlling the stepping movement of the switching assembly. This section is electrically separate from the circuits associated with switch section 37, which control energization of the loads L-1 through L-10, as will be explained. Stator contact 52 of switch section 39 is directly electrically connected to the normally closed contact 73 of the interrupter switch 70. The spring contact 74 of the interrupter switch is electrically connected through a single-pole, single-throw switch 166 to positive lead 131. A single-pole, single-throw switch 161 shunts contacts 73 and 74. To complete the solenoid energizing circuit, stator contact 53 is connected to one side of coil 25, the other side of which is directly connected to ground 132.

In operation, switch 166 is closed when the stepping assembly and circuit are to be operative. Switch 161 when open allows an operator to select automatic, and when closed to select manual sequential actuation of the loads. The operation will first be described for automatic operation, i.e., switch 161 remains open at all times.

When the switching assembly is in its home position, as illustrated, rotor segment 142 is electrically connected to home

contact 43. At this time, ground is shunted across terminals 135 and 136 of all loads L-1 through L-10, by means of the direct connection from terminals 135 to ground 132, and by means of terminals 136 being connected to common ring 144, which is connected through stator contact 140 to ground 132.

The rotor segment 142 is also grounded by home contact 43 which is directly connected to ground 132. This grounds ring 150 via leads 142'; however, this has no immediate effect because segment 151 is adjacent and hence spaced from contact 153. Electrical actuation of the switching assembly is not possible at the home switch position, because no source of power can be connected to coil 25. Even if switch 166 is closed, the power connection through contacts 73, 74 to stator contact 52 has no effect because segment 158 is located adjacent and hence spaced from stator contact 52.

The home position described above represents a safety condition in which accidental electrical actuation of the stepping assembly and/or energization of the loads is precluded. Personnel can safely connect loads, such as explosives, into the circuit at this time without the possibility of accidental electrical actuation, even by stray electrical field pick-up, because the loads are all shorted across ground. To activate the electric circuit for subsequent operation, it is necessary to manually rotate the rotor out of its detented home position and to the next detented or activate position, at which segment 142 contacts activate contact 140. In the activate position, home contact 43 contacts common ring 144, thus maintaining ground across all loads. Also, contact 153 remains disconnected from ring 150 because a portion of segment 151 is still located adjacent thereto.

Manual rotation to the second or activate switch position causes ring 157 on section 39 to rotate adjacent and connect with contact 52, thereby connecting coil 25 to normally closed contact 73 of interrupter switch assembly 70. When electric power is applied to the system by closing of switch 166, automatic self-completing energization of the circuit is initiated. More particularly, positive potential from line 131 is connected to coil 25, energizing the rotary solenoid. The resulting power stroke stepwise rotates the rotor shaft one position and causes ring segment 142 on face 37U to rotate adjacent stator contact 42 associated with load L-1. Also, ring 150 on face 37L is rotated in contact with stator contact 153, connecting ring segment 142 via leads 142', ring 150 and stator contact 153 to normally open contact 75 of the interrupter switch 70. All other loads L-2 through L-10 are maintained shunted across ground, because common ring 144 is connected to ground 132 via both home contact 143 and activate contact 140.

At the end of the power stroke, cam assembly 85 is rotated, as previously described, causing head 86 to mechanically abut shoulder 80. This lifts spring contact 74 off of contact 73, disconnecting power to coil 25, thereby deenergizing the rotary solenoid. Before the return stroke begins, however, the inertia of the system causes the rotor and hence cam 85 to continue to rotate, causing spring contact 74 to abut contact 75 and connect positive voltage via contact 153, ring 150, leads 142', ring segment 142 and contact 42 to terminal 136 of load L-1, electrically energizing the load. The load remains energized until the end of the return stroke, when cam assembly 85 is again rotated back to its initial position, causing spring 73 to return to contact 73.

When spring contact 74 again abuts contact 74, the above described cycle of operation is repeated. That is, coil 25 is energized, rotating the rotor shaft and causing interruption of power to coil 25 and subsequent energization of load L-2, after which the cycle is repeated for the next load. Each of the loads L-1 through L-10 is thereby energized for a prescribed period of time, controlled by various mechanical dimensions of the switching assembly, including the length of the reciprocating path for link 22, FIG. 1, and the dimensions of cam 85.

After the last load L-10 has been energized, the switching assembly rotates ring segment 142 adjacent home contact 43.

Just prior to home contact 43 grounding segment 142, stator contact 153 is disconnected from ring 150 as segment 151 is rotated adjacent thereto. At the same time, segment 158 of switch section 39 is rotated adjacent contact 52, thereby disconnecting contact 73 from connection with coil 25. Thus, the home switch configuration prevents the DC source 130 from again energizing coil 25 as spring contact 74 returns to its normally closed position against contact 73, precluding further electrical actuation of the circuit.

The above described circuit and switching assembly has many advantages. The circuit maintains all loads shunted across ground except for the single load which is being energized. This prevents stray electrical signals or the like from accidentally being coupled to a different load than the one which is to be energized. The home position of the switching mechanism and circuit requires manual actuation before electrical actuation is possible, thereby providing a safety factor for personnel who must connect loads to the circuit.

Another advantage results from switch segments 37 and 39 being electrically separate from each other. In prior circuits for intervalometers of this type, a defective load, i.e., shorted, would result in disabling of the self-completing stepping circuit. In the present circuit, should a load be defective, the remaining loads are not thereby affected. DC source 130 desirably includes sufficient internal resistance means to prevent harm when a defective load presents a direct short to ground 132. Each time spring contact 74 returns against contact 73, positive line 131 is connected to coil 25, irrespective of whether or not the prior load presented a short to ground 132. This allows the stepping assembly to bypass the defective load. Many other advantages will also be apparent to those skilled in the art.

If manual rather than automatic self-stepping is desired, switch 161 is initially closed. When switch 166 is thereafter closed, power is connected as previously described to coil 25, causing a stepwise movement of the switch. However, movement of contact 74 off of contact 73 and against contact 75 no longer discontinues energization of coil 25, due to the shunting action of switch 161. A load is energized in the same manner as previously described, however, upon return of contact 74 against contact 73, another stepping cycle is not initiated because coil 25 has remained energized at all times. As contact 74 abuts contact 73, one cycle of operation is completed, with coil 25 still energized.

To initiate the next stepping cycle, the switch 166 is opened and then again closed, causing another power stroke to occur. Switch 166 may be of the momentary make type, in which the depression of a push button closes the switch for a short period of time sufficient for contact 74 to abut contact 75 and energize a load. For the purpose of automatic operation, switch 166 should also have a locked closed position, so that power may be connected to the circuit for the whole cycle of self-stepping energization of all loads. Thus, switches 161 and 166 allow selection of either automatic self-stepping or manual stepping of the switching assembly.

We claim:

1. A stepping assembly and circuit for sequentially energizing a plurality of separate loads each having at least first and second terminals, comprising:

a stepping motor assembly actuable to move a member along a path;

a source of electric power having reference means and potential means with a potential difference therebetween for energizing said plurality of loads;

switching means including a plurality of contacts each associated with one of said loads, rotor means including a first element sequentially connectable with each of said contacts and a common element connectable with the remaining contacts not connected to said first element;

means individually connecting each of said plurality of contacts to the second terminal of the load associated therewith;

link means connecting said stepping motor assembly member to said rotor means for step movement of said rotor means upon actuation of said stepping motor assembly;

means for periodically actuating said stepping motor assembly to stepwise move said rotor means;

means connecting said common element to said reference means; and

means connecting said first element to said potential means for energizing only one of said plurality of loads for each step movement of said rotor means, whereby the nonenergized loads remain coupled across said reference means.

2. The stepping assembly and circuit of claim 1 wherein said switching means includes interrupter means actuable by step movement of the rotor means for changing the electrical state of a switch,

said reciprocal drive assembly includes a coil energizable by said potential difference for actuating said reciprocal drive assembly to move said member along said path, and said periodically actuating means includes means connecting said coil in series with said switch and across said reference means and said potential means for energizing said coil for each stepwise movement of said rotor means.

3. The stepping assembly and circuit of claim 2 wherein said switching means includes a home contact in addition to said plurality of contacts each associated with one of said loads,

said rotor means connecting said first element to said home contact when said switching means is stepwise at a home position, and

said coil connecting means includes means effective when said switching means is at said home position for substituting the connection to said potential means with a connection to said reference means, whereby both said coil and said plurality of loads are coupled across said reference means when said switching means is at said home position.

4. The stepping assembly and circuit of claim 3 wherein said rotor means includes manually movable means for stepwise moving said switching means from said home position to another position to allow said circuit to thereafter control stepping of said switching means, whereby said switching means requires manual actuation before said circuit automatically sequentially energizes said plurality of loads.

5. The stepping assembly and circuit of claim 2 wherein said rotor means includes a first rotor section having said first element and said common element mounted thereon and a second rotor section having a third element electrically independent of said first element and said common element, said switching means further includes contact means connectable with said third element, and

said coil connecting means includes said contact means and said third element in series with said coil and said switch.

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