Dec. 19, 1967 J. CLARK 3,359,381

SEQUENCE TIMING DEVICE

Filed Feb. 1, 1966 2 Sheets-Sheet 1

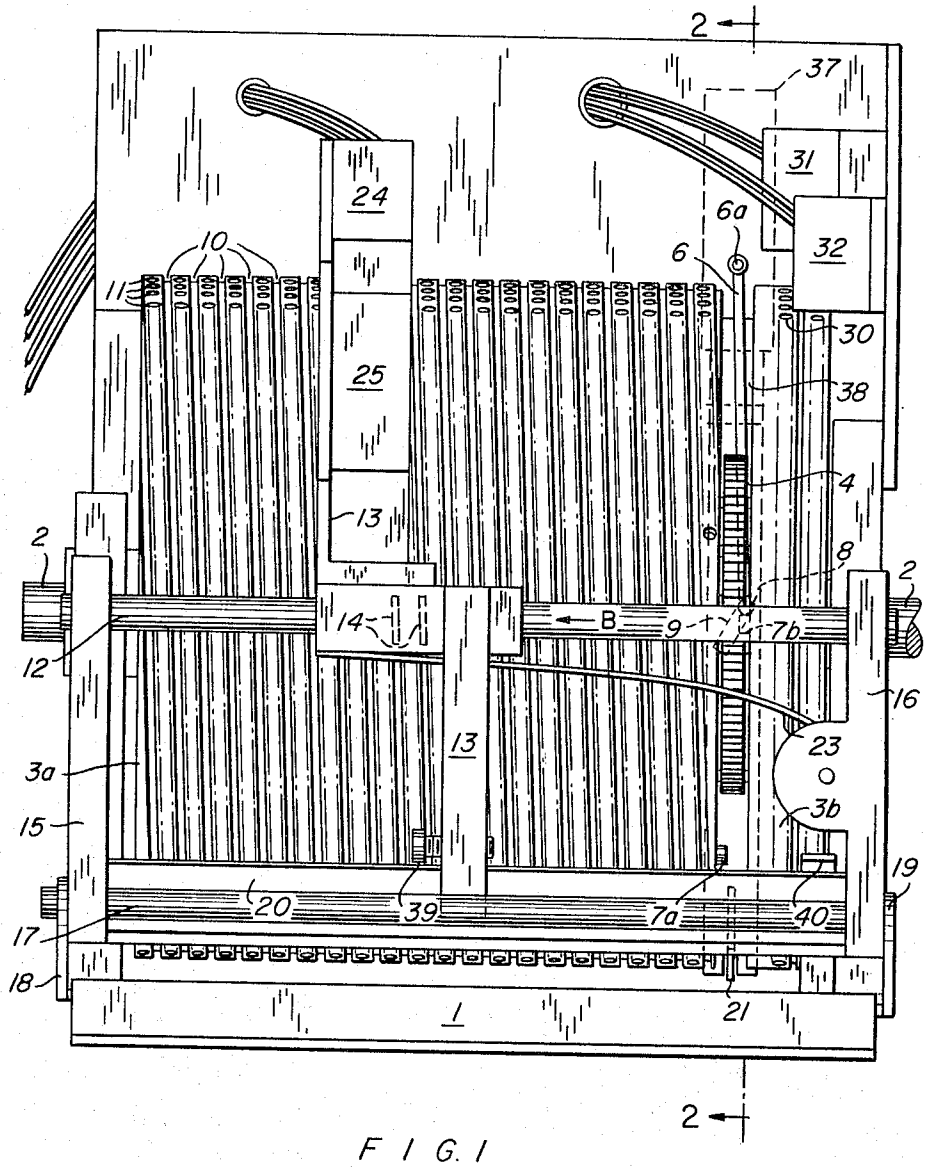

FIG. 1

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SEQUENCE TIMING DEVICE

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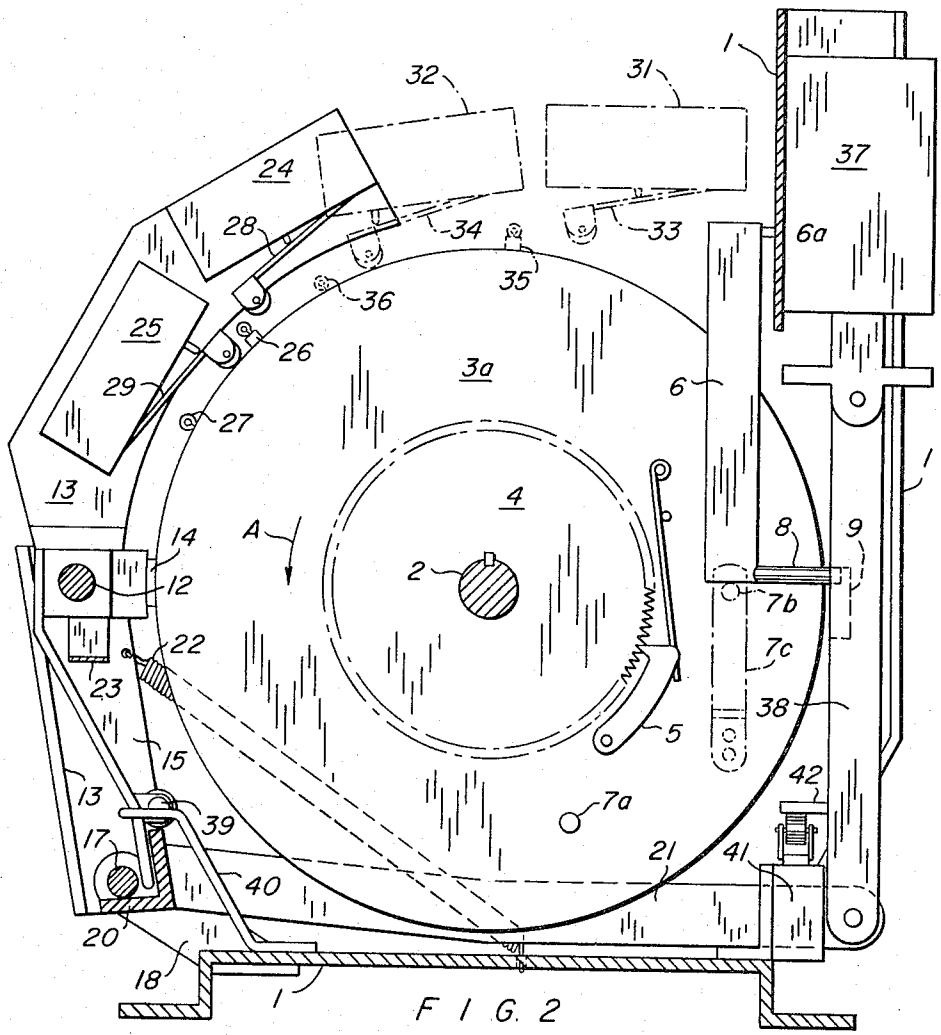

FIG. 2

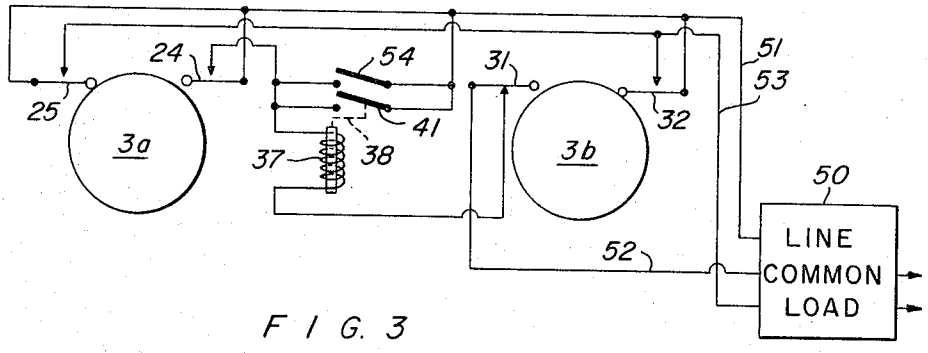

FIG. 3

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SEQUENCE TIMING DEVICE

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7 Claims. (Cl. 200—38)

This invention relates to sequence timer devices adapted to control apparatus which is to effect a predetermined sequence of operations forming a repeatable cycle.

Hitherto, various timing devices such as rotating drums, operating cams, electronic systems, gear trains or pluralities of counters have been used to control automatically apparatus which effects a repeatable cycle of sequential operations. In general, these prior devices are relatively complicated and, therefore, expensive and in some applications (such as for example coil or transformer winding operations) they have displayed characteristics which limit their flexibility or accuracy, or involve time wasting operations at the end of each cycle. More particularly, in the case of prior timing devices of the type which comprises rotating drums carrying on their surface a number of pegs or cams that operate sequentially to effect switching operations, the performance obtainable therefrom can be relatively inefficient because of the time required to reset the device to its starting position following completion of each cycle of operations.

I have found that it is possible to overcome many of the disadvantages hitherto associated with sequence timer devices of the type referred to by providing such a device for controlling apparatus adapted to effect a predetermined sequence of operations which form a cycle that can be divided into primary and secondary parts. My device comprises a revolving member whose degree of rotation can be related to the cycle of operations and to the timing of the operations therein. I provide a frame on which a primary drum is rotatably mounted, such drum having on its surface in a helical path a plurality of primary switch actuating means. A carriage, having a primary control switch and a primary transfer switch, is adapted to move along the drum parallel to its surface whereby, as the drum rotates, the primary control and transfer switches are sequentially actuated by their respective actuating means in the order in which they occur along said path. A secondary drum is also rotatably mounted on the frame and has on its surface at least one secondary transfer switch actuating means. A secondary transfer switch is disposed adjacent the secondary drum for actuation by the secondary transfer switch actuating means. A drive means is provided for alternately engaging the drums to the revolving member and also serves to maintain the drum not so engaged in a predetermined starting position. A control transfer means is operatively associated with the drive means and the transfer switches so that, during the primary part of the cycle, the primary drum rotates with the revolving member and the primary control switch controls the apparatus whereas during the secondary part of the cycle the secondary drum rotates with the revolving member. Finally, the control transfer means also includes a reset means which causes the carriage to return to its initial position with respect to the primary drum during the secondary part of the cycle. By the arrangement described, a sequence timer device is provided in which, in general, a minor, final part of the cycle of operations is controlled by the secondary drum while the primary drum, which controls the apparatus during the major, initial part of the cycle, is permitted to reset itself so as to be in a position to commence a new cycle of operations substantially immediately upon termination of the previous cycle.

It is accordingly an object of the present invention to provide a sequence timing device which, by the end of any given cycle of operations, has automatically reset itself for commencement of the next cycle.

In drawings which illustrate an embodiment of a sequence timing device according to the invention,

FIGURE 1 is a front elevational view;

FIGURE 2 is a cross-sectional view taken along lines 2—2 in FIGURE 1; and

FIGURE 3 is a circuit diagram.

In FIGURES 1 and 2 of the drawings, reference numeral 1 indicates a frame which, by means of bearings, supports shaft 2 whose degree of rotation is related to the cycle of operations to be carried out and the timing of said operations within such cycle. A primary drum 3*a* and a secondary drum 3*b* are each mounted for rotation on such frame; in the particular embodiment of the invention here illustrated, such drums are mounted end-to-end about shaft 2. Although for the particular embodiment of the invention here shown such arrangement is convenient and economical, it will be apparent to persons skilled in the art that there is no necessity for drums to be journalled about the shaft whose rotation is related to the timing of the sequence of operations to be controlled, it being sufficient merely to have the drums so mounted on the frame that they can be driven in a manner which bears a predetermined relationship to the revolving member i.e. shaft 2.

A drive means is provided for alternately engaging the drums to the shaft and for maintaining the drum not so engaged in a predetermined starting position. In the embodiment shown herein, the drive means is best described with reference to FIGURE 2. It comprises the following elements. A toothed wheel 4 is keyed to shaft 2 so as to rotate therewith. A spring-loaded pawl 5 is disposed on the mutually facing ends of each of the drums 3*a* and 3*b* so that they may yieldably engage the wheel 4. A starting position index means, comprising projections 7*a* and 7*b* extend outwardly from the mutually facing ends of drums 3*a* and 3*b* respectively. Preferably projection 7*b* is mounted on drum 3*b* so as to be retractable into the end of the drum 3*b*. As shown in phantom in FIGURE 2 projection 7*b* is mounted on a flat spring 7*c*. A movable stop means 6 is disposed between the drums and, by means hereinafter described, is adapted alternately to swing between positions in which it can engage the respective index means 7*a* and 7*b*. The resulting drive arrangement is such that when the stop means 6 engages the index means 7*b* (i.e. position shown in FIGURE 2) the drum 3*b* will be prevented from rotating and the pawl 5 on the end of such drum will "ride up" on the teeth of wheel 4. On the other hand, the stop means 6 will not be in a position to engage index means 7*a* with the result that the pawl 5 on the end of drum 3*a* will continue to engage the wheel 4 thus causing the drum 3*a* to rotate with shaft 2. As will be apparent from this description, the resulting arrangement is such that one of the drums is free to rotate with the shaft 2 while the other drum is permitted to rotate only to the point where the index means 7*a* or 7*b*, as the case may be, engages with the lower end of the stop means 6 whereupon the drum in question has reached its starting position and is prevented from further rotation with the shaft 2. Projection 7*b* should be retractable as mentioned before, in order not to interfere with movement of the stop means 6 towards the position shown in FIGURE 2. Projection 7*a* could also be spring-loaded but as will become apparent hereinafter normally this is not necessary.

On the periphery of the primary drum 3*a* there is provided a continuous multi-revolution helical groove or threads 10. Evenly spaced in the land between the threads 10 are drilled a large number of small holes 11. A rod 12 is disposed parallel to the longitudinal axis of the long drum and slidably mounted thereon is a carriage or bracket 13 having a guide means 14 engaging the groove 10.

The rod 12 is part of a rectangular frame including a pair of side arms 15, 16 secured at the top to the ends of rod 12 and pivotally mounted to the frame 1 by means of a rod 17 whose ends are received in a pair of lugs 18, 19. The lower ends of the side arms 15, 16 are secured to an L-shaped member 20. An arm 21 is secured to an end of the L-shaped member 20, transverse to the aforementioned rectangular frame. The other end of the arm 21 is connected to the lowermost end of a movable bar 38. The rectangular frame is constantly urged toward the long drum 3*a* by means of a spring 22 connected between the frame 1 and the side arm 15. The bracket or carriage 13 is attached to a spiral type return spring 23 which tends to draw the carriage 13 towards the side arm 16. The bracket 13 carries a pair of miniature switches comprising primary transfer switch 24 and primary control switch 25 which are so arranged that they are directly over the holes 11 when the guide means 14 is engaged in the groove 10.

Primary drum 3*a* has on its surface in a helical path a plurality of primary control switch actuating means followed by a primary transfer switch actuating means. In the embodiment of the invention here described, the primany control switch actuating means comprise the short pegs 27, and the primary transfer switch actuating means is constituted by the longer peg 26. These pegs are placed in the holes 11 at appropriate positions along the helical path, as will hereinafter become apparent. As shown in FIGURE 2, the whisker 28 on primary transfer switch 24 is adjusted so that it can be actuated only by the primary transfer switch actuating means—i.e. by the longer peg 26. On the other hand, the whisker 29 of the primary control switch 25 is sufficiently close to the surface of the drum that it will be actuated by any one of the primary control switch actuating means 27 (and indeed would also be actuated by the primary transfer switch actuating means 26 but for reasons described below the whisker 29 will not normally reach such peg).

In the embodiment shown, the secondary drum 3*b* also includes a plurality of small holes 30 arranged, in this case, along two separate circular rows which extend around the secondary drum 3*b*. A pair of miniature switches comprising secondary control switch 32 and secondary transfer switch 31 are disposed above the respective rows of holes by appropriate mounting on the frame 1. As best shown in FIGURE 2 the secondary transfer switch has a whisker 33 adapted to be actuated by pegs 35 in the row of holes nearer the primary drum 3*a* whereas the secondary control switch 32 has a whisker 34 adapted to be actuated by pegs 36 in the other row of holes on the secondary drum 3*b*. This arrangement has, however, been adopted only for the purpose of convenience and it will be apparent that a single row of holes could be used on the secondary drum 3*b* so long as the switch 31 is arranged in such a way that its whisker 33 is actuated only by a secondary control switch actuating means such as a long peg 35.

A solenoid 37 is used to control the position of a movable bar 38 which travels up and down. A lug 8, extending from the bottom of the stop means 6 is accommodated in an oblique slot 9 (see FIGURE 1) of the bar 38 so that when the winding of solenoid 37 is energized, the bar 38 is raised, thus causing the lug 8, and, therefore, the stop means 6, to move from right to left in FIGURE 1—i.e. from a position adjacent the end of secondary drum 3*b* (where it is capable of engaging the index means 7*b*) to a position adjacent the end face of primary drum 3*a* (where it is capable to engaging the index means 7*a*). As mentioned before, the lower end of the bar 38 is connected to arm 21, with the result that upward movement of the bar 38 rocks or swings the rectangular frame which supports the carriage 13, and does so in a way which moves the carriage counterclockwise about the rod 17 i.e. away from the surface of the primary drum 3*a*. In this position, the guide means 14 no longer engages the thread 10 with the result that the return spring 23 causes the carriage 13 to move back to its starting position at the right (in FIGURE 1) of primary drum 3*a*. The precise location of the starting position of the carriage 13 is adjusted by a screw 39 positioned to engage a stop member 40. A further miniature switch 41 is mounted on the arm 21 adjacent a lug 42 of the frame 1 so that as the bar 38 rises it closes switch 41 for the purpose hereinafter to be described.

Referring now to the circuit diagram shown in FIGURE 3 of the drawings, the primary drum 3*a* and the secondary drum 3*b* are represented by means of circles 3*a* and 3*b* respectively. The miniature switches 24, 25, 31, 32 and 41 referred to hereinbefore are represented by single-pole, single-throw contacts 24, 25, 31, 32 and 41 respectively. A terminal block 50 supplies voltage to the circuit by means of terminals LINE and COMMON via leads 51, 52 respectively whereas lead 53, connected to terminal LOAD, sends pulses of voltage to the controlled apparatus as hereinafter described. Primary and secondary control switches 25, 32 are connected in parallel between leads 51 and 53. Primary transfer switch 24, the winding of solenoid 37 and the secondary transfer switch are serially connected between leads 51 and 52. Finally miniature switch 41 and a reset switch 54 are connected in parallel between lead 51 and the junction between winding 37 and primary transfer switch 24. Switch 41 which is linked to the armature of solenoid 37 via bar 38 forms a seal-in circuit to solenoid 37. Reset switch 54, normally of the push-button type, may be used to transfer the timing device to the second, minor part of the cycle of operations before completion of the major part thereof, thereby to expedite completion of the cycle.

The circuit shown in FIGURE 3 has two basic functions namely (a) to connect lead 51 to lead 53 to send a pulse of voltage to the controlled apparatus via terminal "LOAD" of terminal block 50 whenever one of switches 25, 32 is actuated by a control switch actuating peg, and (b) to energize solenoid 37 whenever primary transfer switch 24 closes and to open the feed circuit of solenoid 37 whenever secondary transfer switch 31 opens.

The "LOAD" and "COMMON" terminals of terminal block 50 should be connected to any suitable drive control means of the controlled apparatus such as, for instance, a latching clutch-and-brake arrangement.

Operation of the sequence timer

The operation of the above described embodiment according to the present invention is now given in connection with a controlled apparatus which includes a rotating element to which the shaft 2 of the timer is geared. In the starting position the components of the sequence timer are disposed as follows: The stop means 6 is in position to engage the projection 7*b* of the econdary drum 3*b*, the primary drum 7*a* is free to rotate with the toothed wheel 4, the carriage 13 is in the starting position with its guide means 14 in the groove 10, and the whisker 29 of primary control switch 25 is directly above hole number 0 of the primary drum 3*a* where a first short peg 27 maintains primary control switch 25 closed.

In order to start the apparatus, the operator must manually engage a control means of the apparatus so as to "bypass" the LOAD terminal of block terminal 50. As soon as the apparatus starts to operate, the shaft 2 drives the primary drum 3*a* in the direction of arrow A by means of the toothed wheel 4 and the spring loaded pawl 5 of the primary drum. During rotation of the primary drum 3*a* the secondary drum 3*b* rotates until the projection 7*b* thereof reaches the end of the stop means 6. Simultaneously the carriage 13 moves along rod 12 in the direction of arrow B so that each hole 11 passes under whiskers 28 and 29 in succession. Each time a short pag 27 actuates whisker 29, primary control switch 25 sends a pulse of voltage to the LOAD terminal which is connected to the drive means of the controlled apparatus with the result that the apparatus stops, thereby to enable the operator to carry out whatever operation is required. Thereafter the operator reengages the apparatus.

This goes on until the end of the first portion of the cycle, at which time a long peg **26** closes primary transfer switch **24** to energize solenoid **37**. As mentioned before solenoid **37** moves the stop means **6** to the left (FIGURE 1), pivots the arm **21** and carriage **13** about rod **17** and closes seal-in switch **41**. Therefore this energization of solenoid **37** releases the secondary drum **3***b*, places the stop means **6** in a position to engage projection **7***a* of the primary drum, allows the return spring **23** to pull the carriage **13** to the right (FIGURE 1) and closes the seal-in circuit of the solenoid **37**. During this operation by solenoid **37** and until the end of the second portion of the cycle, control of the apparatus is effected by the secondary drum **3***b*. The short peg **36** of secondary drum **3***b* will stop the apparatus through actuation of secondary control switch **32** as was previously described in connection with the primary drum **3***a* and primary control switch **25**. At the end of the second part of the cycle the long peg **35** will operate secondary transfer switch **31** which will open the circuit of solenoid **37**. Thus the bar **38** returns to its lower position and in so doing moves the stop means **6** to the right (FIGURE 1), opens seal-in switch **41** and returns the carriage **13** towards the surface of the primary drum **3***a* where the whisker **29** will meet the first short peg **27** (in hole number zero of the primary drum) and stop the controlled apparatus by means of primary control switch **25**. The cycle is completed and the sequence timer is in the starting position for the next cycle.

Numerical example

A numerical example is now given in which a sequence timer according to the present invention is used to control winding operations of a transformer winding machine. In this embodiment there are 100 holes per revolution on the periphery of the primary and second drums and shaft **2** of the timer is geared directly to the spindle of the winding machine so that each turn of the winding spindle rotates the shaft over an angle corresponding to the distance between two successive holes in the drums. The drive control means of this machine consists of a manually operated latching clutch and a solenoid adapted to release the latching clutch and apply a brake to the spindle upon receipt of a pulse of voltage from the LOAD terminal of terminal block **50**.

The operations to be carried out are as follows:

(1) Wind 75 turns,
(2) Stop the winding machine, take off a tap lead,
(3) Wind 237 turns,
(4) Stop the winding machine, take off a tap lead,
(5) Wind 103 turns,
(6) Stop the winding machine, take off a tap lead,
(7) Wind 20 turns,
(8) Stop the winding machine, secure the winding, end of the cycle.

Therefore the winding machine is to complete a total of 435 turns and should be stopped three times before the end of the cycle.

The settting of pegs would be as follows:

(1) Set short peg No. **1** in hole No. **0** of primary drum (always)
(2) Set short peg No. **2** in hole No. **75** of primary drum
(3) Set short peg No. **3** in hole No. **312** (237+75) of primary drum
(4) Set long peg No. **4** in hole No. **400** of primary drum i.e. nearest even 100 before total number of turns which is 435
(5) Set short peg No. **5** in hole No. **15** of the second row of the secondary drum to stop winding operation after 415 turns (75+237+103)
(6) Set long peg No. **6** in hole No. **35** in the first row of the secondary drum for the remaining 20 turns.

Coil forms are fitted to the spindle of the winding machine and wires are attached thereto.

The winding operation is as follows:

(a) The operator of the winding machine engages the clutch, and the spindle starts to rotate with the shaft **2** and primary drum **3***a* of the timer. After 75 turns of the spindle, peg No. **2** engages whisker **29** of primary control switch **25** with the result that the winding machine stops.
(b) Tap is taken off the coil and is secured thereto.
(c) The clutch is re-engaged and the winding machine rotates a further 237 turns to bring short peg No. **3** in contact with the whisker **29** of primary control switch **25** thus stopping the winding operation.
(d) Tap is taken off the coil and secured.
(e) Clutch is re-engaged causing the spindle to rotate a further 88 turns to bring long peg No. **4** in contact with the whisker **28** of primary transfer switch **24**.

This energizes the winding of solenoid **37** which lifts bar **38** to rock the carriage **13** away from the primary drum **3***a*. The movement of bar **38** also causes the stop means **6** to free the secondary drum **3***b* and move to a position for engagement with the projection **7***a* of the primary drum **3***a*. The secondary drum **3***b* rotates over an angle corresponding to 15 turns of the spindle where the short peg No. **5** operates the whisker **34** of secondary control switch **32**. This stops the machine.

(f) Tap is taken off the coil and secured, and
(g) The clutch is re-engaged allowing the spindle to rotate a further 15 turns where the long peg No. **7** reaches the whisker **33** of secondary transfer switch **31**. This switch de-energizes the winding of the solenoid **37** allowing the bar **38** to drop to its lowermost position and causing the guide means **14** to engage the threads **10**. Simultaneously the stop means **6** is transferred back to the right hand side (FIGURE 1) so as to free the primary drum **3***a* and move to a position to engage the projection **7***b* of the secondary drum **3***b*. Of course the engagement can only take place once the secondary drum **3***b* has returned to its starting position. However, as the carriage **13** lowers towards the primary drum **3***a* the whisker **29** of primary control switch **25** encounters the short peg No. **1** which operates the clutch-and-brake mechanism of the winding machine and therefore stops the spindle thereof. The coils are removed from the spindle and new coil forms are fitted thereto. The sequence timer is in the starting position for the next cycle, i.e. the next winding operation.

It should be mentioned that the location of the primary transfer switch actuating means (long peg No. **4** in the above example) is of some importance in that (a) it must be sufficiently close to the end of the cycle because the secondary drum can only control the controlled apparatus for at the very most 99 turns, (b) it must be sufficiently far from the end of the cycle so that the secondary drum rotates long enough before reaching the end of the cycle for the primary drum to return to its starting angular position and (c) it must enable the secondary drum to rotate a minimum number of turns before completion of the cycle otherwise the carriage **13** would not have sufficient time to return to its original starting position which is at the right in FIGURE 1 of the drawings. A convenient method of determining the position of the primary transfer switch actuating means is (1) to place it in the hole of the primary drum that will enable the primary drum to rotate the largest number of complete revolutions, provided that there remains at least 10 turns to be performed by the controlled apparatus before completion of the cycle, or (2) if there remains less than 10 turns of the controlled apparatus after the primary drum has completed its last revolution, to locate the primary transfer switch actuating means in a position where transfer will be effected exactly 10 turns from the end of the cycle.

It is clear that by setting the pegs in accordance with this method, the projection **7***a* does not need to be spring loaded since stop means **6** always moves towards the pri-

mary drum just before projection 7*a* reaches stop means **6**.

In order to ensure that the secondary drum **3***b* will rotate sufficiently long for the carriage **13** to return to its starting position, the row of the secondary drum which receives the secondary transfer switch actuating means may be provided with a blank space in place of the first 10 holes thereof.

As a convenience in setting the pegs in the primary and secondary drums, score lines parallel to the axis of rotation of the drums are provided on their respective periphery at every fifth or tenth hole, and these score lines may also be labelled at any convenient place on the surface of the drums.

In cases where complete cycles are less than one revolution of the primary drum (in the above example: less than 100 holes), two or more cycles could be set up consecutively to bring the total count to more than one complete revolution of the primary drum. On the other hand the capacity of a sequence timer can be doubled, tripled, etc. by gearing its shaft **2** through a 2:1, 3:1, etc. transmission but at the expense of being accurate to every second, third turn etc. In other applications the shaft **2** of the sequence timer may be driven by a synchronous motor such that the distance between two consecutive holes on the drums represents one second or any fraction or multiple thereof, depending on the driving ratio.

As will be obvious to persons skilled in the art, in the sequence timer referred to the helical groove **10** could be replaced by a helical projection, the contacts of switch **41** could be those of a relay whose coil would be in series with the winding of solenoid **37** and the initial position of the bracket or carriage **13** could be toward the left side of FIGURE 1 rather than to the right. Moreover it is conceivable that in some applications sequence timers according to the present invention would never have to control controlled apparatus during the second part of any cycle of operations. In such circumstances the secondary control switch is not needed and the secondary drum requires only one row of holes.

The embodiment hereinbefore described was adapted to operate a single control means namely a clutch and brake mechanism. However, certain applications may require that a number of different circuits be controlled sequentially. This may be accomplished by means of a solenoid-operated ratchet type multi-point switch connected to lead **53**. If a ten point switch is available and only six circuits are needed, four extra primary control switch actuating short pegs could be inserted in the primary drum **3***a* merely for the purpose of advancing the multi-point switch over the four unused points.

What I claim as my invention is:

1. A sequence timer device for controlling apparatus adapted to effect a predetermined sequence of operations which form a cycle that can be divided into primary and secondary parts, said device comprising: a revolving member whose degree of rotation can be related to said cycle and the timing of said operations therein; a frame; a primary drum rotatably mounted on said frame, and having on its surface in a helical path a plurality of primary control switch actuating means followed by a primary transfer switch actuating means; a carriage having a primary control switch and a primary transfer switch adapted to move along said drum parallel to the surface thereof, whereby as said drum rotates, said primary control and

transfer switches are sequentially actuated by their respective actuating means in the order in which they occur along said path; a secondary drum rotatably mounted on said frame and having on its surface a secondary transfer switch actuating means; a secondary transfer switch disposed adjacent said secondary drum for actuation by said secondary transfer switch actuating means; a drive means adapted alternately to engage said drums to said revolving member and maintain the drum not so engaged in a predetermined starting position; and control transfer means operatively associated with said drive means and said transfer switches whereby, during the primary part of the cycle the primary drum rotates with said revolving member and the primary control switch controls said apparatus, and during the secondary part of the cycle the secondary drum rotates with said revolving member, said control transfer means also including reset means for causing said carriage to return to its initial position during said secondary part of the cycle.

2. A device as claimed in claim **1**, comprising secondary control switch actuating means on the secondary drum; and a secondary control switch actuated thereby, said switch being adapted to control said apparatus during the secondary part of the said cycle.

3. A device as claimed in claim **1**, wherein said drive means comprises yieldable connection means between each drum and said revolving member; starting position index means projecting from each drum; and a movable stop means adapted for alternate engagement with said index means whereby said stop means terminates rotation of each drum at such predetermined starting position.

4. A device as claimed in claim **3** wherein said revolving member is a shaft to which is secured a toothed wheel, said yieldable connection means consisting of a pair of spring loaded pawls respectively mounted on each drum adjacent said toothed wheel.

5. A device as claimed in claim **1**, wherein said primary drum has a helical groove on its surface and the primary control and transfer switch actuating means are located on the land between successive turns of said groove; and the carriage is provided with a guide member adapted to follow said groove; and said control transfer means includes means for moving said guide member out of said groove upon actuation of said primary transfer switch at the end of said path and back into said groove at the beginning of said path upon actuation of said secondary transfer switch.

6. A device as claimed in claim **5** wherein on said land are provided a plurality of evenly spaced holes adapted selectively to receive said primary control and transfer switch actuating means.

7. A device as claimed in claim **6** wherein said secondary drum has two rows of evenly spaced holes to receive said secondary control and transfer switch actuating means.

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