May 31, 1960 J. N. GLADDEN ET AL 2,938,969

SEQUENCE TIMER

Filed Sept. 19, 1958 3 Sheets-Sheet 1

FIG. 1.

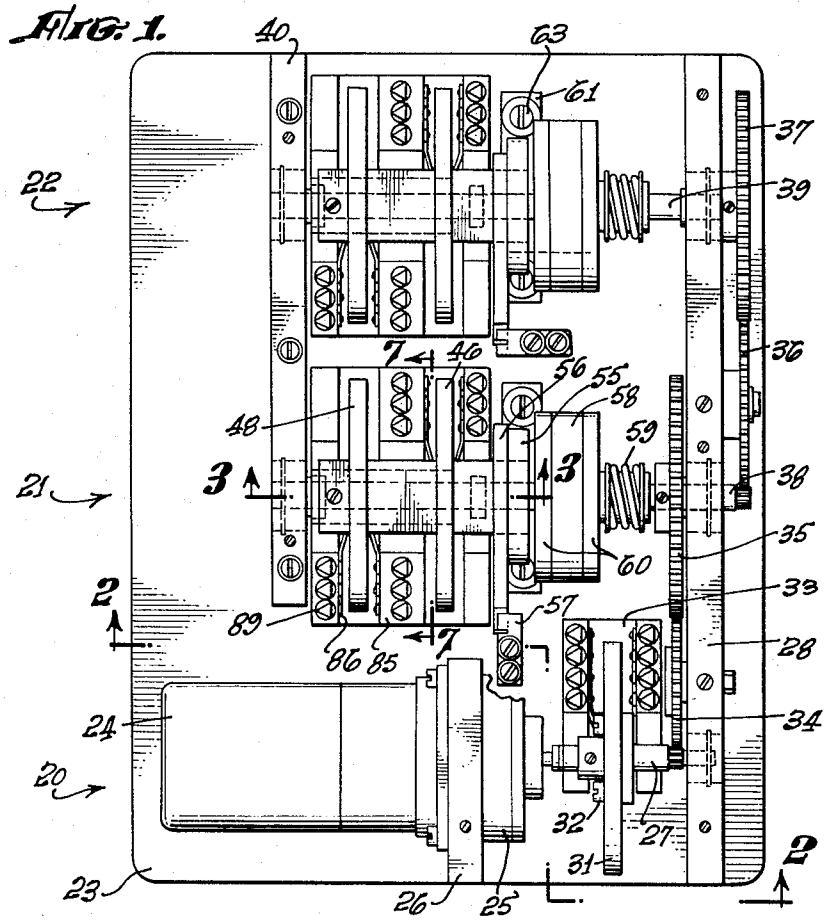
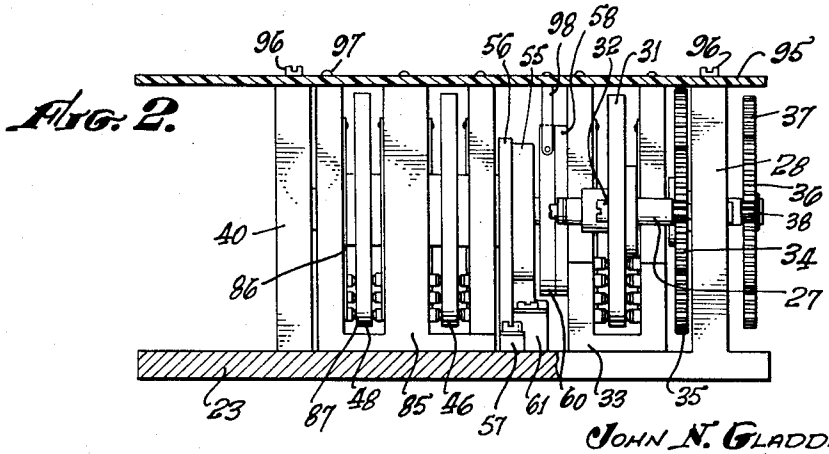


FIG. 2.



JOHN N. GLADDEN,
CHARLES E. REES, JR.,
INVENTORS.

BY THEIR ATTORNEYS.
HARRIS, KIECH, FOSTER & HARRIS.

May 31, 1960 J. N. GLADDEN ET AL 2,938,969

SEQUENCE TIMER

Filed Sept. 19, 1958 3 Sheets-Sheet 2

Fig. 3.

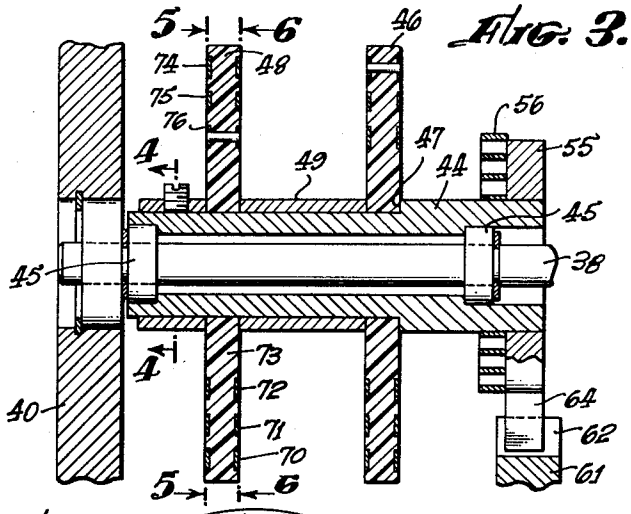


Fig. 4.

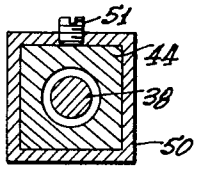


Fig. 5.

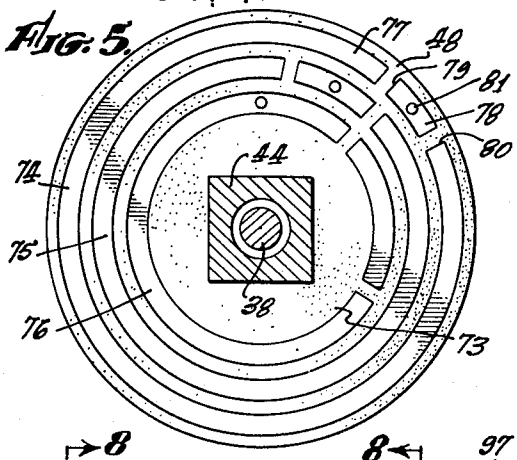


Fig. 6.

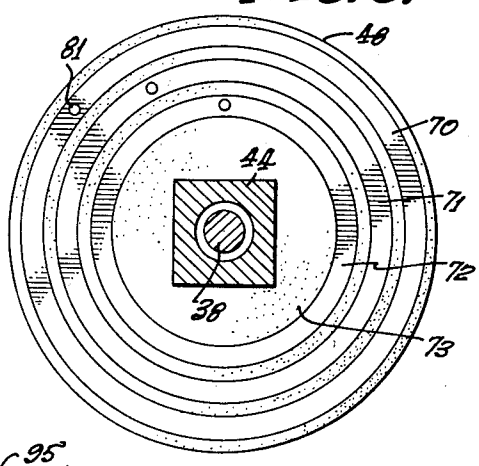


Fig. 7.

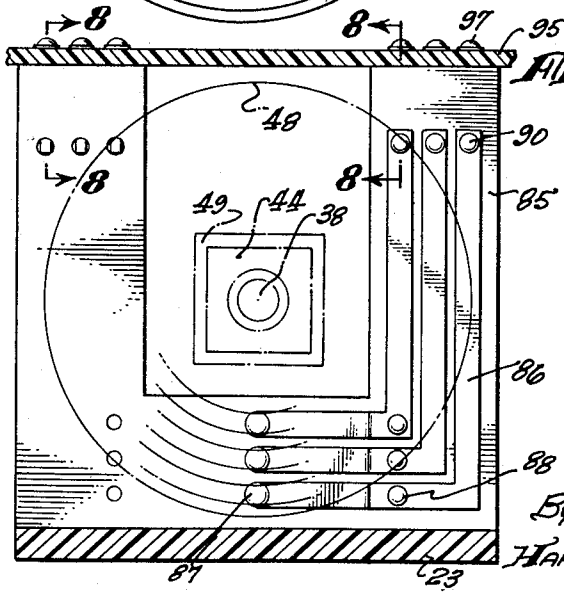
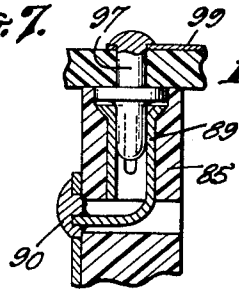


Fig. 8.



JOHN N. GLADDEN,
CHARLES E. REES, JR.,
INVENTORS.

BY THEIR ATTORNEYS

HARRIS, KIECH, FOSTER & HARRIS

May 31, 1960 J. N. GLADDEN ET AL 2,938,969

SEQUENCE TIMER

Filed Sept. 19, 1958 3 Sheets-Sheet 3

FIG. 9.

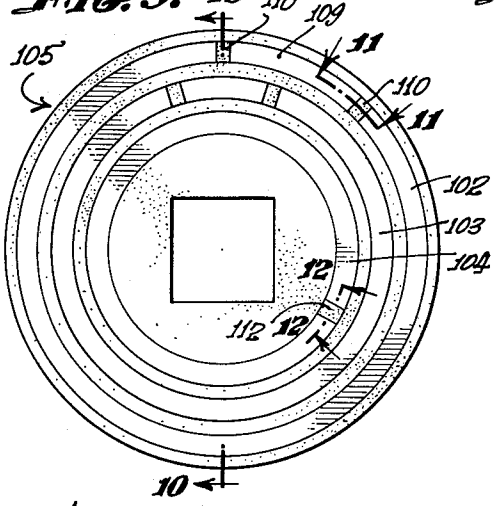


FIG. 10.

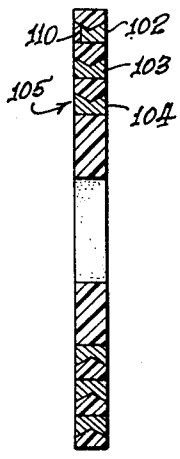


FIG. 11.

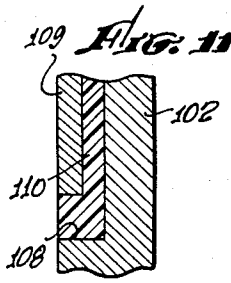


FIG. 12.

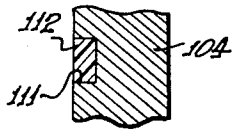


FIG. 13.

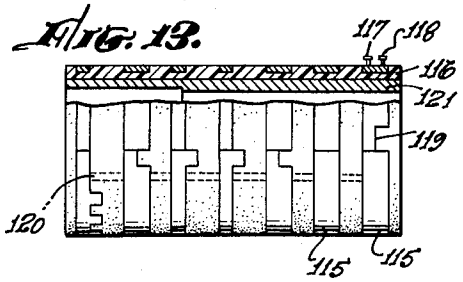


FIG. 14.

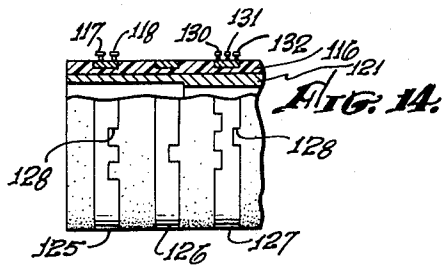
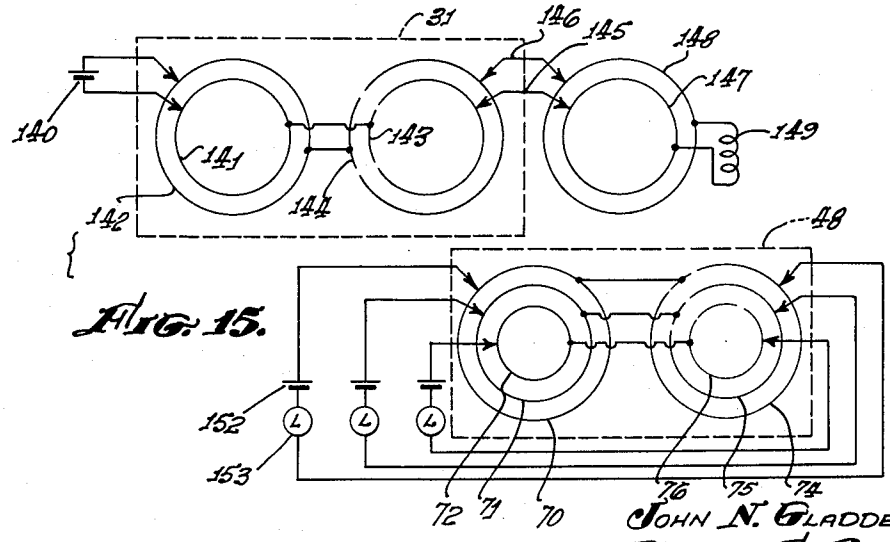


FIG. 15.



JOHN N. GLADDEN,
CHARLES E. REES, JR.,
INVENTORS.

BY THEIR ATTORNEYS
HARRIS, KIECH, FOSTER & HARRIS.

United States Patent Office 2,938,969
Patented May 31, 1960

2,938,969

SEQUENCE TIMER

John N. Gladden and Charles E. Rees, Jr., Glendale, Calif., assignors to Gladden Products Corporation, Glendale, Calif., a corporation of California

Filed Sept. 19, 1958, Ser. No. 761,998

2 Claims. (Cl. 200—33)

This invention relates to sequence timers and to commutators suitable for use therein. A sequence timer is basically a switch which opens and/or closes one or more electrical circuits in a predetermined sequence, with the sequence repeating continuously or on receipt of some start signal.

It is an object of the invention to provide a sequence timer and commutators for use therein which may actuate a large number of circuits and have exceedingly long life and very accurate timing. A typical unit constructed according to the teachings of the invention will have an operating life in excess of 10,000 cycles while providing timing intervals as small as fractions of a second with accuracies of fractions of a second. Furthermore, such a typical instrument may have ten or twenty channels with the sequences of the various channels synchronized to millisecond accuracy.

It is an object of the invention to provide a sequence timer and commutators for use therein in which rotating commutators are carried concentric with a driven shaft with a clutch for coupling the commutators to the driven shaft for driving the commutators in one direction and a reset spring for returning the commutators in the opposite direction to a zero position. A further object of the invention is to provide such a structure wherein a plurality of commutators can be carried on a single driven shaft and wherein a plurality of driven shafts can be driven by a single drive motor. Another object of the invention is to provide such a structure wherein the various driven shafts may have different speeds to provide a wide range of sequence timing. A further object is to provide such a unit wherein the clutches may be engaged by external means or by means of commutators carried on the motor shaft providing internal timing and synchronization of the various commutator sequences.

It is an object of the invention to provide a sequence timer and commutators for use therein in which the commutator wipers are mounted on the frame of the unit and in which the stops for setting the zero positions of the commutators are also mounted on the frame and are adjustable providing simple, easy and accurate setting of the zero positions and synchronization of the various sequences.

A commutator will have alternating sections of electrically conducting and nonconducting materials of various lengths to provide the desired open and closed circuit sequence. The commutator wipers travel over these sections and the life of the unit is determined by the mechanical and electrical durability or resistance to wear and breakdown of the materials. In conventional commutators, the open circuit portions of the sequence are provided by the nonconducting sections and the closed circuit portions by the conducting sections. It has been found that after prolonged operation, the contact wipers will carry some of the nonconducting or insulating material along onto the conducting material, smearing a layer of insulating material over the conducting material adjacent the junction thereof, thereby producing errors in the timing of the sequence. Accordingly, it is an object of the invention to provide a commutator suitable for use in a sequence timer or the like wherein the smearing of insulating material over the conducting sections is substantially eliminated. A further object of the invention is to provide such a commutator wherein both the open and closed circuit sections are composed of conducting material with the sections separated by very small gaps which are filled with insulating material to provide a continuous smooth surface for the wipers.

It is a further object of the invention to provide a commutator suitable for use in sequence timers or the like at high current densities in which the conducting sections comprise solid rings of conducting material of large cross section with the nonconducting sections being pieces of conducting material inlaid into the conducting rings and isolated therefrom by insulating material. Another object of the invention is to provide such commutators which can be made in disc form and in drum form. It is an object of the invention to provide a disc type commutator comprising concentric rings of conducting and nonconducting material with the conducting rings having parallel faces exposed on both sides of the disc providing very large current carrying capacities. A further object of the invention is to provide a commutator of the drum type having a plurality of peripheral bands of conducting material with the nonconducting material of the drum projecting upward beside the conducting band to provide a continuous smooth cylindrical surface.

It is also an object of the invention to provide a method of manufacturing the commutators referred to above. The invention also comprises novel details of construction and novel combinations and arrangements of parts, together with other objects, advantages, features and results, which will more fully appear in the course of the following description. The drawings merely show and the description merely describes preferred embodiments of the present invention which are given by way of illustration or example.

In the drawings:

Fig. 1 is a top view of a preferred embodiment of the invention with the top plate removed;

Fig. 2 is a sectional view taken along the line **2—2** of Fig. 1 with the top plate in position;

Fig. 3 is an enlarged sectional view taken along the line **3—3** of Fig. 1;

Fig. 4 is a sectional view taken along the line **4—4** of Fig. 3;

Figs. 5 and 6 show opposite sides of a commutator of the structure of Fig. 4;

Fig. 7 is an enlarged sectional view taken along the line **7—7** of Fig. 1;

Fig. 8 is an enlarged sectional view taken along the line **8—8** of Fig. 7;

Fig. 9 is a side view of an alternative form of commutator;

Fig. 10 is a sectional view taken along the line **10—10** of Fig. 9;

Fig. 11 is an enlarged partial sectional view taken along the line **11—11** of Fig. 9;

Fig. 12 is an enlarged partial sectional view taken along the line **12—12** of Fig. 9;

Figs. 13 and 14 show alternative forms of drum-type commutators; and

Fig. 15 is a schematic diagram showing one manner of interconnecting the sequence timer of Fig. 1.

The structure of Fig. 1 includes a drive unit **20** and driven units **21** and **22** mounted on a base plate **23**. A motor **24** with a gear reduction unit **25** is mounted in a

bracket 26 carried on the base plate 23 to form the drive unit 20, with the output shaft of the gear reduction unit driving a pinion gear 27 which is journaled in another bracket 28 carried on the base plate.

A disc commutator 31 is carried on the shaft of the pinion gear 27, being held in position by two screws 32 which pass through slotted openings (not shown) in the commutator permitting rotational adjustment of the commutator relative to the pinion gear. A set of commutator wippers is carried in a U-shaped block 33 mounted on the base plate 23. The wipers provide for electrical contact between the commutator segments and the remainder of the circuit and the details of the commutator and the wipers will be described below in conjunction with one of the driven units. It should be noted that the particular number and arrangement of commutators and commutator segments depend upon the use of each particular timer, the arrangement of Fig. 1 being typical.

The motor 24 drives a gear train consisting of the pinion 27, an idler 34, a spur gear 35, another idler 36 and another spur gear 37. The idler gears 34 and 36 are journaled in the bracket 28 and the spur gears 35 and 37 are mounted on driven shafts 38 and 39, respectively, each of which is journaled between the bracket 28 and a bracket 40 also carried on the base plate 23. The motor 24 may be a conventional constant speed motor and will run substantially at constant speed throughout the operation of the sequence timer of the invention because the load thereon is constant. It should be noted that there are no cams or switches or toggle actions included in the structure of the invention to place varying loads on the motor.

The driven units 21 and 22 are essentially identical in construction, being driven at different rates and having different commutator sections as determined by the particular application of the unit. Referring now to the driven unit 21, a commutator shaft 44, best seen in Fig. 3, is supported on bearings 45 carried on the driven shaft 38 so that the commutator shaft will rotate concentric with the driven shaft. A commutator 46 is positioned on the shaft 44 against a shoulder 47. A second commutator 48 is also positioned on the shaft spaced from the commutator 46 by a spacer 49, with the two commutators being held in position by another spacer 50 and set screw 51. The commutator shaft 44 is preferably square in cross section and the commutators have mating square openings therein, as seen in Figs. 4, 5 and 6, to prevent rotation of the commutators relative to the commutator shaft.

A plate 55 which serves both as a clutch face and a stop is carried on the commutator shaft adjacent the right end as viewed in Fig. 3. A spring 56 having a square shaped inner turn is also carried on the commutator shaft adjacent the plate 55, the outer end of the spring being fixed in a block 57 carried on the base plate 23, as shown in Figs. 1 and 2.

A clutch housing 58 carrying a solenoid is mounted on the driven shaft 38 for rotation therewith, the housing being movable axially along the shaft to engage and disengage the plate 55. A clutch spring 59 is positioned around the driven shaft 38 with one end fixed to the shaft and the other end fixed to the housing to urge the housing to the disengaged condition as shown in Fig. 1. Two slip rings 60 are provided on the housing 58 for conducting power to the clutch solenoid. A bracket 61 having an upstanding stop flange 62 is mounted on the base plate 23 by means of screws 63 which pass through slotted openings in the bracket (Figs. 2 and 3). The plate 55 carries an outwardly projecting tongue 64 which engages the stop flange 62.

In the operation of the unit of Fig. 1, the shaft 38 is driven in rotation continuously by the motor 24. With the clutch in its disengaged condition, the spring 56 holds the commutator shaft fixed with the tongue 64 engaging the stop 62. When the clutch solenoid is energized, the clutch housing is pulled into engagement with the plate carried on the commutator shaft against the urging of the spring 59 and the commutator shaft is driven in rotation in synchronism with the driven shaft 38. When the clutch solenoid is de-energized, the clutch is disengaged and the spring 56 immediately returns the commutator shaft to the stop or zero position.

An important feature of the present invention is the provision for adjusting the zero position of each commutator shaft independently of the drive motor and the other commutator shaft. This is accomplished by sliding the bracket 61 along the base plate 23 to vary the angular position of the commutator shaft at which the tongue 64 engages the stop flange 62.

A typical commutator is shown in Figs. 3, 5 and 6, comprising three concentrically disposed continuous rings 70, 71, 72 of electrically conducting material positioned in one face of a disc 73 of electrically nonconducting material and segmented rings 74, 75 and 76 of conducting material positioned in the opposing face of the disc. Such a commutator may be manufactured using conventional molding techniques by placing the conducting rings in a die and casting the nonconducting material therein.

The ring 74 has two segments 77, 78 which are separated from each other by gaps 79, 80, which gaps are filled with the nonconducting material of which the disc 73 is formed to provide a smooth continuous path around the ring 74. A pin 81 of conducting material is fixed in the disc in electrical contact with the ring 70 and the segment 78 providing for electrical conduction therebetween. Hence, there will be a closed circuit between two wipers engaging respectively the rings 70 and 74 when one of the wipers is riding on the segment 78 but an open circuit when this wiper is riding on the segment 77 or the gap between the segments. The rings 75 and 76 may be similarly segmented with particular segments conductively connected to rings on the opposite face of the disc. The number of segments and their lengths are determined by the particular sequence of closed and open circuit conditions required for the particular instrument.

Referring again to the ring 74, the segment 78 will provide a closed circuit for about 15° of rotation of the commutator. However, the nonconducting arc comprising about 345° of rotation consists mainly of the conducting segment 77 with only very short lengths of nonconducting material adjacent each end of the segment 78. The gaps 79 and 80 are merely made long enough to prevent electrical breakdown thereacross and are very short in length in comparison to the conducting segments of the ring. Such construction produces a tremendous increase in the operating life of the commutator. Mechanical wear and breakdown almost always occur in the insulating material rather than in the conducting material because of their relative hardness and, in the commutator of the invention the very short length of insulating material disposed between pieces of conducting metal has a much longer operating life than the longer pieces of insulating material encountered in conventional commutators. Furthermore, since there is only a very small angle during which the wipers travel over insulating material, very, very little insulating material will be smeared onto the conducting segments, hence maintaining a sharp line of demarcation between conducting and nonconducting material. This permits maintenance of the time tolerances on the opening and closing of the circuits over the operating life of the instrument. Reduction of the volume of insulating material between the conducting and nonconducting segments also reduces to a minimum the effect of temperature changes on the actual dimension of the interruption, substantially the entire track or ring being of one material. Furthermore, the small insulating strip is less apt to crack or chip, due to its lesser strength, than is a large block or section and provides for easier molding as there is less

volume of plastic which must be free of trapped air bubbles.

Two sets of commutator wipers are carried in an E-shaped block **85** mounted on the base plate **23** for contacting the commutators **46** and **48**, there being a wiper for each ring on each face of each commutator (Figs. 1 and 2). Typical wipers are shown in detail in Figs. 7 and 8, as consisting of an L-shaped strip **86** of resilient conducting material with a commutator contact button **87** at one end thereof. The strip **86** is fixed to the block **85** by a suitable rivet **88** and is connected to a terminal **89** carried in the upper end of the block **85** by a solder joint as shown at **90**.

A top cover plate **95** is fixed to the upstanding brackets **28** and **40** by screws **96** (Figs. 2, 7 and 8). This cover plate is made of a nonconducting material and carries a plurality of pins **97** for engaging the terminals **89** of the commutator wipers. The top cover plate also carries conventional slip ring wipers **98** for contacting the slip rings on the clutch housings. Conductors such as the conducting strip **99** of Fig. 8 are attached to the various terminals carried in the cover plate **95** for interconnection of the terminals and for connection of the instrument into an external system.

An alternative form of construction for a commutator suitable for use with large current is shown in Figs. 9 through 12. Rings **102**, **103**, **104** of electrical conducting material are cast or molded into a disc **105** with the hub and the material between the rings being a nonconducting material. Each ring preferably has an irregular cross section, such as the concave section shown in Fig. 10, in order to lock the rings into the cast disc. The commutator wipers ride on the opposed parallel faces of a ring and the solid ring structure provides a low resistance, high current path between the wipers.

An open circuit section is provided in a ring of the commutator of Fig. 9 by first engraving or cutting away a portion of the ring to provide a reset or opening **108** (Fig. 11) corresponding in length to the desired open circuit section. Then a segment **109** of conducting material nearly as long as the opening **108** is positioned in the opening and additional nonconducting material is cast or molded around the segment **109** to fill the opening **108**, the newly cast nonconducting material being indicated at **110** in the drawing. The segment **109** and the material **110** are made to have a continuous smooth surface with the exposed face of the ring **102** providing a single continuous path for the wiper as in the commutator of Figs. 5 and 6. Also, the length of the sections of nonconducting material along the path between the segment **109** and the ring **102** is very short in comparison with the length of the open circuit section. These very short lengths of nonconducting material serve the same purposes as those in the commutator of Figs. 5 and 6 and the same superior results are achieved. Additional nonconducting sections of any desired length may be provided in the rings of the commutator in the manner described above. When a very short nonconducting section is desired, a simpler type of construction may be utilized.

Referring to the ring **104** as shown in Figs. 9 and 12, after the commutator disc has been cast a portion of the ring is engraved or removed to provide the very short opening **111**, which opening is the exact length of the desired nonconducting section. Then this opening is filled with nonconducting material **112** by molding in the same manner as the segment **109** was installed. This provides a short nonconducting section of the exact desired duration while achieving the aforesaid advantages of high current capacity, long operating life and accurate control of off and on time throughout the operating life.

While the commutators of Figs. 5 and 6 and Figs. 9 through 12 have been shown in the form of a disc, it is clear that the same type of construction can be used to produce commutators in the form of a drum with the

conducting rings being axially spaced along the drum and with the wipers riding on the outer surfaces of the rings. Fig. 13 shows a drum-type commutator having a plurality of rings or bands **115** of electrically conducting material set in a piece **116** of nonconducting material. A pair of wipers **117**, **118** may be positioned side by side for engaging a ring so that there is a closed circuit between the wipers when the ring is at its full width and an open circuit when the ring is of reduced width as at the section **119**.

In a preferred method of manufacturing the drum of Fig. 13, the bands **115** having the required narrow and wide sections are formed from a single flat piece of conducting material with interconnecting crosslinks **120** by the conventional photo etching process or the like. Then this grid of conducting material is bent into a cylindrical shape and placed in a mold or die around a sleeve **121**. The nonconducting material is then cast in the die filling the space between the conducting grid and the sleeve and bonding the grid into position. The interconnecting links **120** are then removed by suitable means, such as by engraving, and the resulting openings are filled by casting with additional non-conducting material to produce the desired smooth and continuous peripheral surface for the wipers to ride on.

In the drum of Fig. 14, a number of solid continuous rings **125**, **126**, **127** are cast in position around the sleeve **121** using a conventional split mold or die. After casting, the outside diameter of the drum is machined to provide a smooth continuous surface of insulating and conducting materials. The timing for each ring is determined by cutting notches **128** in the rings prior to casting so that the wipers **117**, **118** will have open and closed circuits at the desired intervals. More than one circuit can be controlled by a single ring if desired. For example, the ring **127** is notched at different intervals on each edge and three wipers **130**, **131** and **132** are utilized.

The circuit of Fig. 16 illustrates one manner of operating the sequence timer of the invention. A source of power **140** is connected across the wipers which ride on two continuous rings **141**, **142** of the commutator **31** which is driven continuously by the motor. Ring **141** is connected to a segment **143** on the opposing face of the commutator and ring **142** is connected to a segment **144**. Commutator wipers **145**, **146** which ride on the segments **143**, **144**, respectively, are connected to corresponding wipers which ride on slip rings **147**, **148** of a clutch for energizing the solenoid **149**. The commutator **48** is driven by the clutch when the solenoid **149** is energized. A power source **152** and an indicator light **153** are connected in series across the wiper riding on the ring **70** and the wiper riding on the ring **74**. Similar power sources and lamps are connected across the other sets of wipers riding on the commutator. Then when the solenoid **149** is cyclically energized due to rotation of the commutator **31**, the commutator **48** will be rotated to open and close the circuits to the lamps in a predetermined timing sequence. Of course, the sequence timer ordinarily will not be used to energize lamps, this circuit being given merely as an illustration of the application of the instrument. Also, of course, any number of open and closed circuit conditions can be established in a single ring on a commutator, the invention not being limited to a single open and closed cycle.

The sequence timer of the invention is not limited in application to the particular circuit shown in Fig. 15. For example, the power source **140** may be coupled to the solenoid **149** through only a single ring on the commutator **31** with the return line being directly connected to the power source. Also, the clutch solenoids may be energized from external sources operated independently of the rotation of the drive motor. Furthermore, the continuously driven commutator on the drive motor may be used to produce a continuous timing sequence as well as to energize the clutches.

Although exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiments disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

We claim as our invention:

1. In a sequence timer, the combination of: a frame; a motor mounted on said frame and having an output shaft; a plurality of driven shafts journaled in said frame for continuous rotation relative to said frame; means coupling said output shaft to said driven shaft in continuous driving relationship; a corresponding plurality of commutator shafts journaled in said frame for intermittent rotation relative to said frame with each commutator shaft disposed concentric with the corresponding one of said driven shafts, respectively; clutch means carried on each set of corresponding driven and commutator shafts, with each clutch means having an engaged condition for driving the shaft in synchronism in a first direction and a disengaged condition for permitting rotation of the driven shaft alone; at least one commutator carried on each of said commutator shafts; another commutator carried on said output shaft; a set of commutator wipers corresponding to each of said commutators and fixed to said frame for engaging said corresponding commutator; spring means positioned between each of said commutator shafts and said frame, with each of said spring means urging the engaged commutator shaft in rotation in a direction opposite to the direction which said shaft is driven when the corresponding clutch is engaged; and stop means carried on said frame for engaging each of said commutator shafts and limiting rotation thereof in said opposite direction.

2. In a sequence timer, the combination of: a frame; a motor mounted on said frame and having an output shaft; a driven shaft journaled in said frame for rotation about an axis; means coupling said output shaft to said driven shaft in continuous driving relationship; a commutator shaft journaled in said frame for rotation about said axis concentric with said driven shaft; clutch means carried on said shaft, said clutch means having an engaged condition for driving said shaft in synchronism in a first direction and a disengaged condition permitting rotation of said driven shaft alone, said clutch means including a set of slip rings for conducting electrical energy to the clutch solenoid; a first commutator carried on said output shaft; a first set of commutator wipers fixed to said frame for engaging said first commutator; a second commutator carried on said commutator shaft; a second set of commutator wipers fixed to said frame for engaging said second commutator; a third set of wipers fixed to said frame for engaging said slip rings; spring means positioned between said commutator shaft and said frame and urging said commutator shaft in rotation in a direction opposite to said first direction; stop means carried on said frame for engaging said commutator shaft and limiting rotation thereof in said opposite direction; and circuit means for interconnecting said first and third sets of wipers with a power source for energizing said clutch means as a function of the angular position of said output shaft.

References Cited in the file of this patent

UNITED STATES PATENTS

1,343,141	Kenagy	June 8, 1920
1,993,793	Mead	Mar. 12, 1935
2,094,060	Busch	Sept. 28, 1937
2,634,342	Baechler et al.	Apr. 7, 1953
2,707,731	Backus	May 3, 1955
2,715,169	Hight	Aug. 9, 1955
2,748,857	Field	June 5, 1956
2,777,193	Albright et al.	Jan. 15, 1957
2,792,460	Bleeze	May 14, 1957
2,796,497	Barden	June 18, 1957
2,834,095	Lozzopina et al.	May 13, 1958