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[54] **CENTRIFUGE CONTROL SYSTEM**
4 Claims, 9 Drawing Figs.
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307/117, 250/209, 250/234, 233/1 B
[51] Int. Cl..... **H01h 35/00**
[50] Field of Search..... 307/116,
117, 119; 250/209, 227, 234; 233/1 B

ABSTRACT: A centrifuge control system and apparatus is provided in the form of an improved adjustable timing means for the centrifuge; and also in the form of an improved control circuit which prevents the lid of the centrifuge from being opened so long as the rotor head is rotating and which, conversely, prevents the centrifuge motor from being energized until the lid is closed and latched.

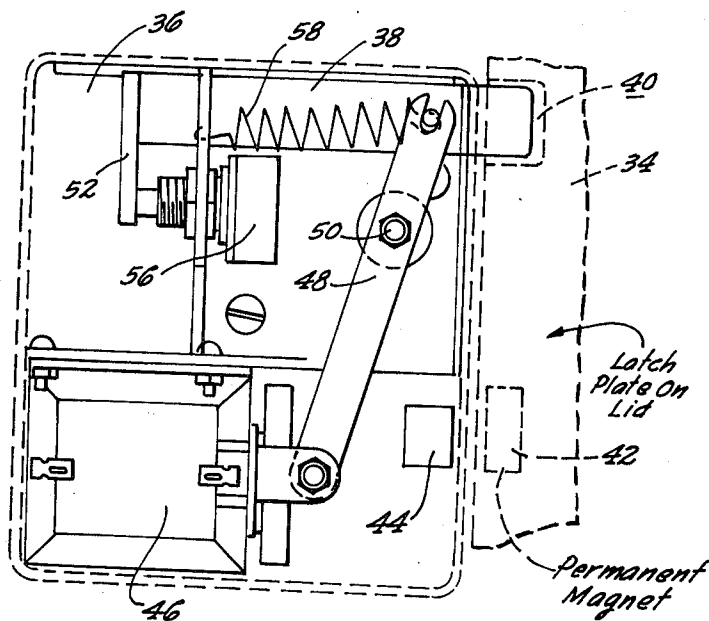


Fig. 1

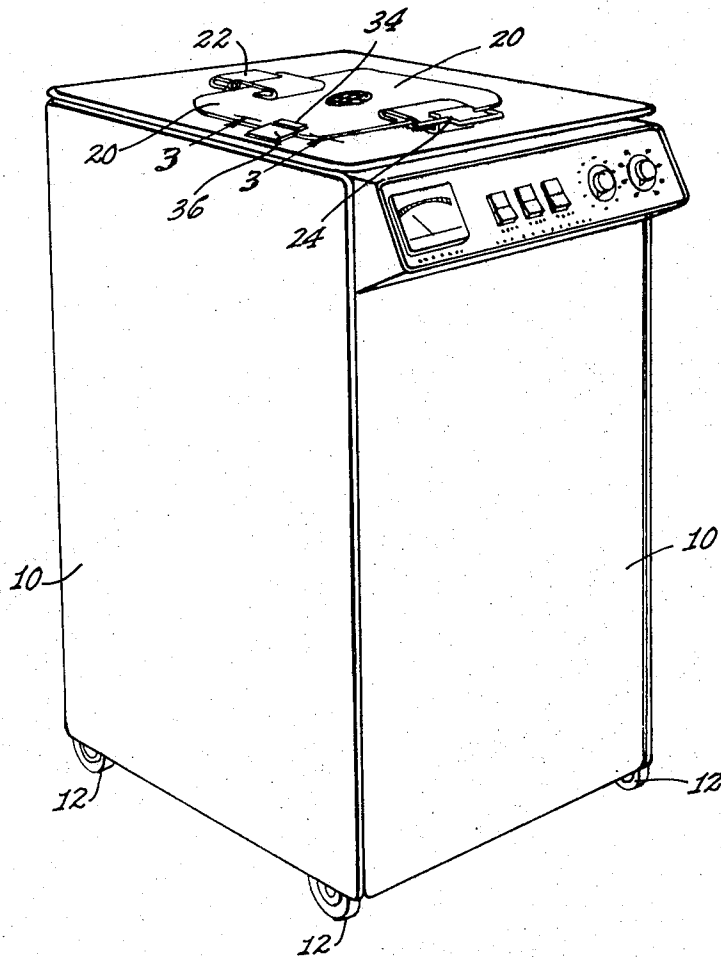


Fig. 4

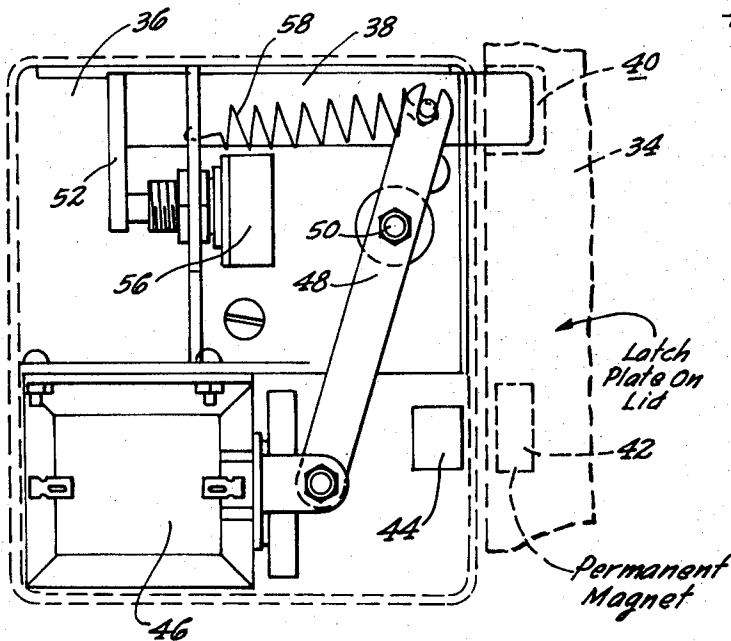
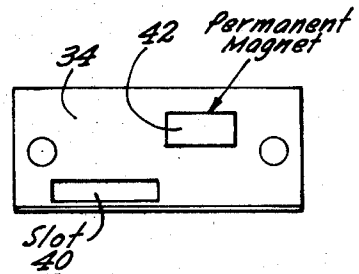
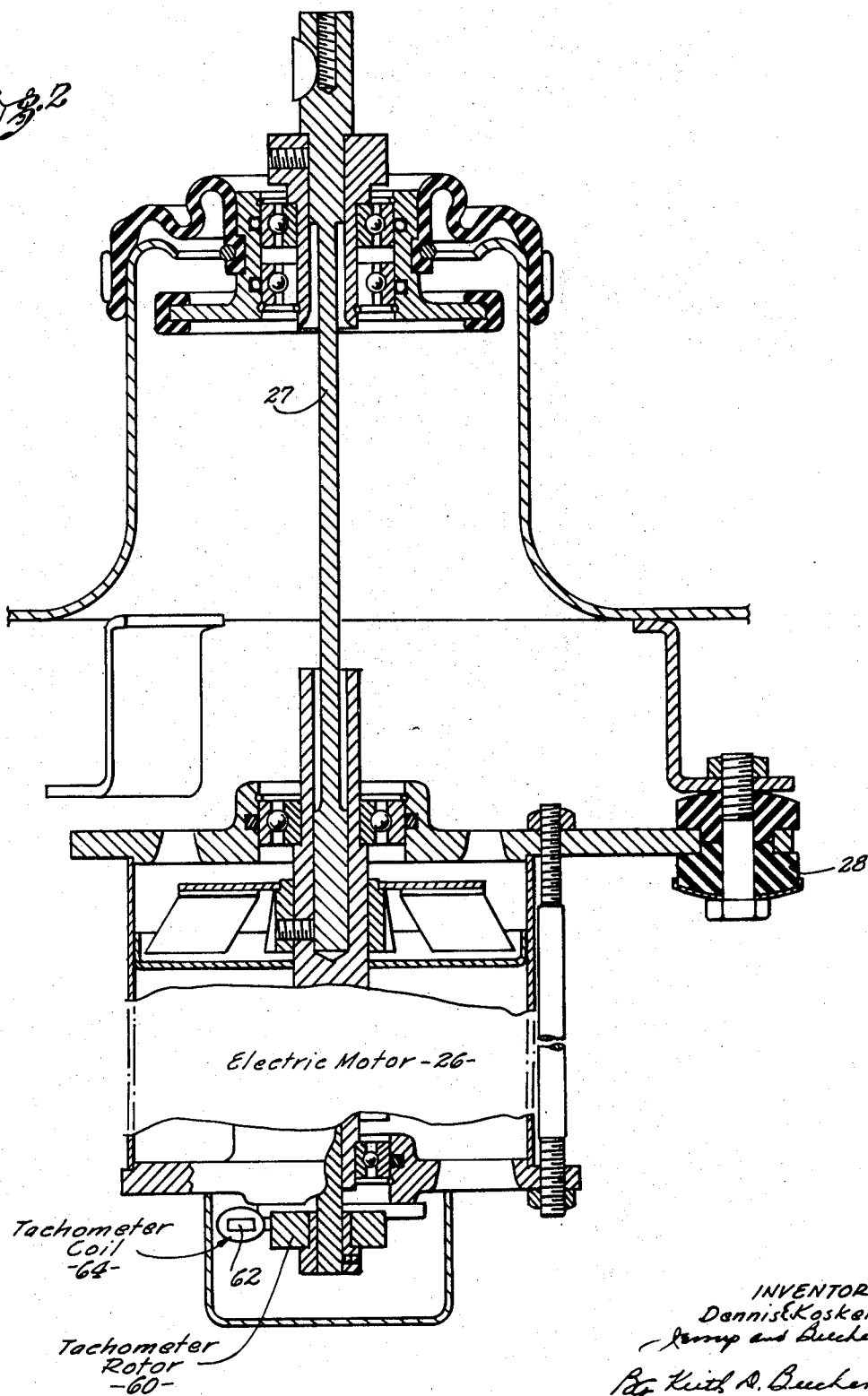


Fig. 3



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Fig. 3.2



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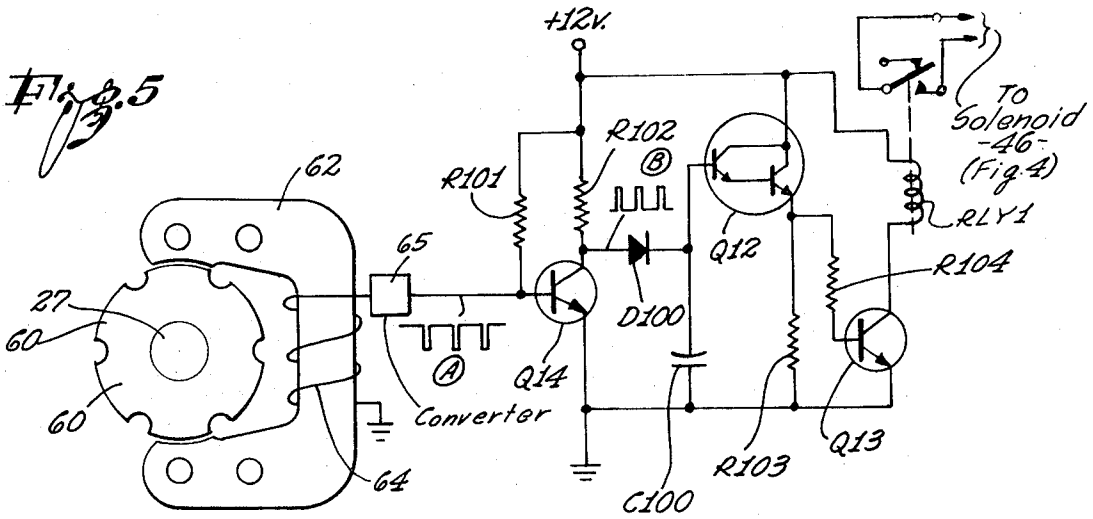


Fig. 3.7

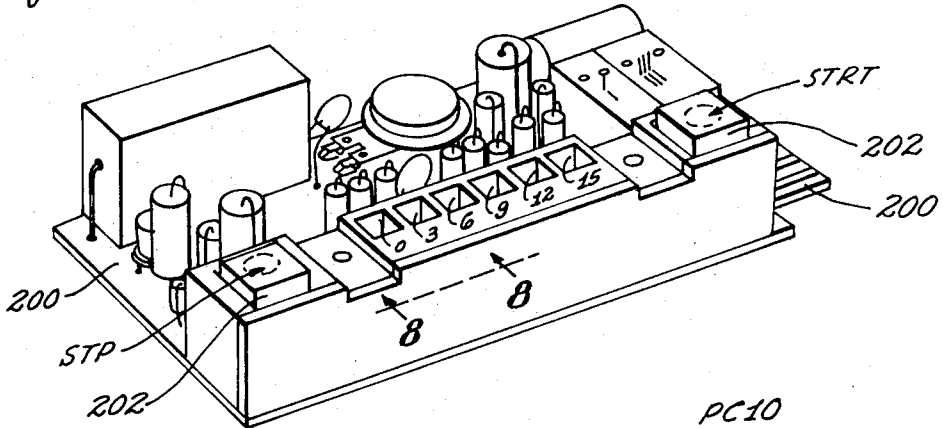


Fig. 3.8

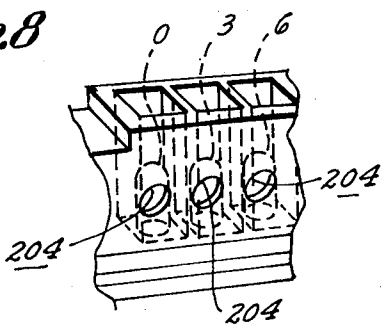
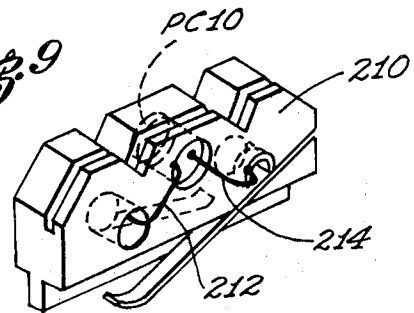
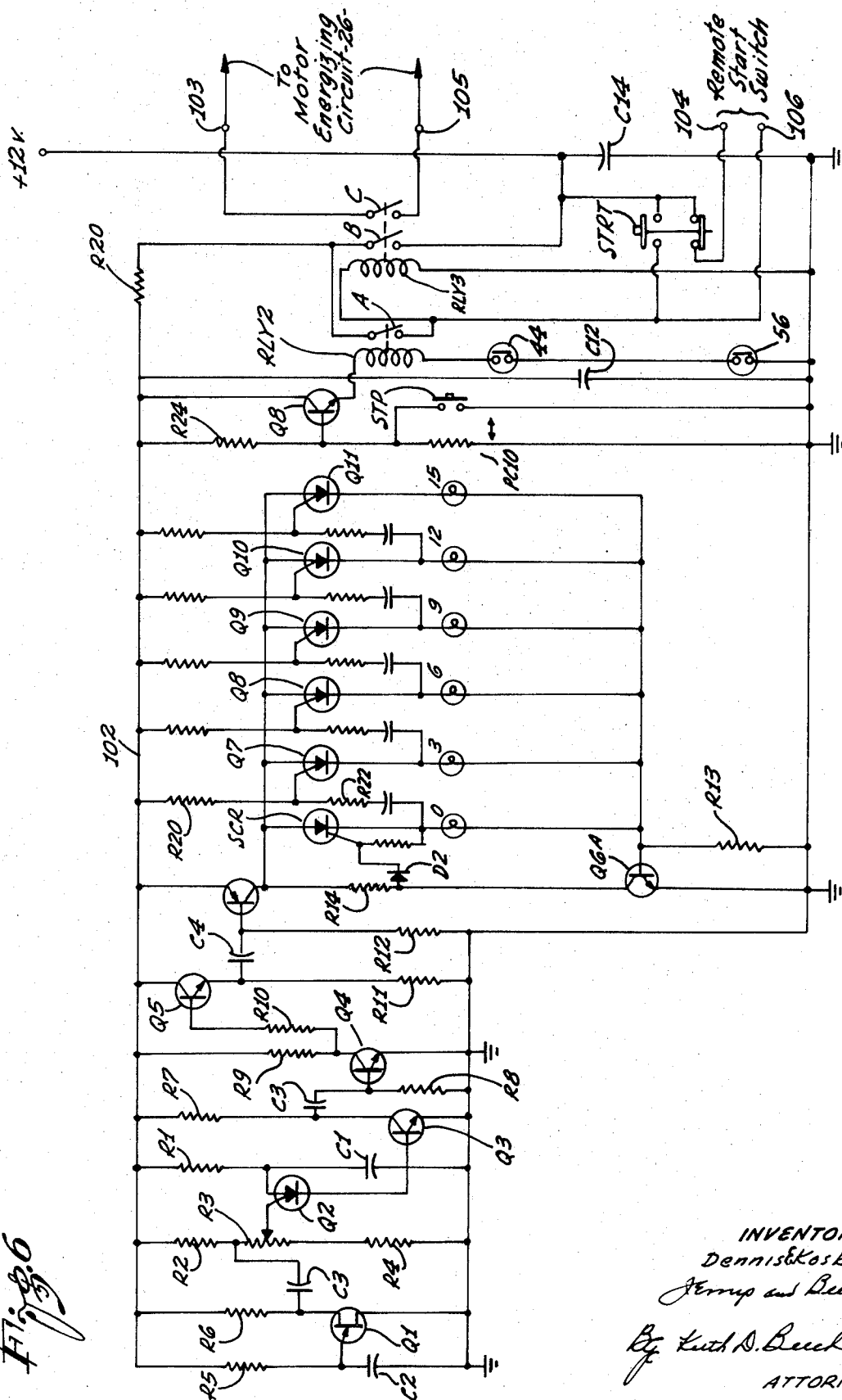


Fig. 3.9



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CENTRIFUGE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

Many types of centrifuge units are on the market for laboratory and other uses. These centrifuges, for the most part, comprise an outer housing with an inner rotating head or rotor, the rotor being driven by an electric motor at a high speed so as to establish the desired centrifugal forces within the apparatus. The apparatus is also usually provided with a hinged lid, and associated electrical controls.

One of the electrical controls which is incorporated into the prior art centrifuge units is a timer, which can be set so that the unit will continue for a predetermined time interval, and will then automatically stop. One of the features of the present invention is the provision of an improved timing control, which may be conveniently set to any one of a number of preselected time intervals, and when so set causes the apparatus to be activated precisely for that interval.

Another feature of the invention is the provision of an improved latching control for the lid of the centrifuge which prevents the lid from being opened until the centrifuge rotor slows down to a safe speed, after it has been deenergized. Many accidents in the past have occurred when the technician turns off the power to the centrifuge, and then opens the lid and attempts to remove the carriers from the centrifuge rotor head before it has slowed down to a safe speed.

As mentioned above, the latching control system of the invention also prevents the centrifuge motor from being energized until the lid is closed and latched at the beginning of each operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side perspective view of a typical centrifuge apparatus, which may incorporate the improved control system of the invention;

FIG. 2 is a detail of a drive assembly to be mounted in the apparatus of FIG. 1;

FIG. 3 is a view taken along the line 3—3 of FIG. 1;

FIG. 4 is a top view of the latching mechanism, with the cover of the mechanism removed so as to reveal the internal operating components;

FIG. 5 is a head rotation sensor which senses the rotation of the rotor to produce pulses for controlling the latch control mechanism;

FIG. 6 is a circuit diagram of the timer control circuitry included in the control system of the invention;

FIG. 7 is a perspective view of the mechanical details of a timer control unit which may be incorporated into the apparatus in accordance with the concepts of the invention;

FIG. 8 is a section along the line 8—8 of FIG. 7; and

FIG. 9 is a perspective view of one component of the control unit of FIG. 7.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The centrifuge apparatus shown in FIGS. 1 and 2, for example, is a commercial unit made by the Phillips-Drucker Corporation of Astoria, Oregon. The illustrated unit includes, for example, an external housing 10 which may be supported on ball bearing casters 12. A lid 20 is hinged to the top 18 of the housing by means, for example, of an appropriate hinge 22, and the lid is held closed by means of a latch assembly 24. An electric motor assembly 26 (FIG. 2) is suspended within the housing 10 by means, for example, of appropriate resilient hangers such as the hanger 28. The motor 26 drives a shaft 27 which is mounted in appropriate bearings 30, and which is described in more detail in copending application, Ser. No. 15,761, filed Mar. 2, 1970, in the name of Kenneth Drucker. The rotor head of the centrifuge is keyed to the upper end of the shaft 27, and it is rapidly rotated within the housing 10 when the motor is energized.

As shown in FIG. 1, a latch plate 34 is mounted on one edge of the lid 20, and a latch mechanism 36 is mounted on the top

18 adjacent the latch plate 34. As shown in FIG. 4, for example, a latch 38 is slidable in the latch mechanism 36 and extends into a slot 40 in the latch plate 34 (see also FIG. 3). As also shown in FIGS. 3 and 4, a permanent magnet 42 is mounted on the latch plate 34, so that when the lid 20 is closed, the permanent magnet is brought into proximity with a reed switch 44 to actuate the switch 44 when the lid is closed.

The latch 38 is moved to its position illustrated in FIG. 4 when a solenoid 46 is energized. The solenoid is coupled to the latch through a lever arm 48 pivotally mounted in the latch mechanism by means of a pin 50. When the latch 38 is in the illustrated position of FIG. 4, a bracket 52 at the left-hand end of the latch actuates a switch 56. A spring 58 returns the latch to the left in FIG. 4 when the solenoid 46 is deenergized. It will be appreciated, of course, that other types of latch mechanisms may be used to suit different lid configurations.

As shown in FIGS. 1 and 5, a tachometer rotor 60 is mounted on the shaft 27 of the motor 26 so as to rotate with the motor shaft. The tachometer rotor 60 is formed of appropriate magnetic material, and it is centrally located in a laminated magnetic core 62. A sensing winding 64 is wound around the core 62, and that winding, for example, may comprise 325 turns of No. 30 wire. As the motor shaft rotates, an alternating waveform is produced across the winding 64 which is applied to a usual converter 65. The converter changes the alternating waveform into discrete pulses (A), and these are fed to the base of an NPN-transistor Q10, the emitter of which is grounded. The converter 65 may have any appropriate circuit.

The collector of the transistor Q10 is connected to the positive terminal of a 12-volt source through a resistor R102, and the base of the transistor is connected to that terminal through a resistor R100. The transistor Q10 serves to invert the pulses (A) from the converter to produce positive pulses such as shown by the waveform (B). The positive pulses of waveform B are applied through a diode D100 to a capacitor C100 which introduces a resulting analog signal to a Darlington circuit designated Q12. The Darlington circuit exhibits the desired high-input impedance, and it produces an output analog signal across the grounded resistor R103. The latter signal is applied to an NPN-transistor Q13 through a limiting resistor R104, and the latter resistor serves to energize a relay designated "RLY 1."

The positive pulses (B) applied through the diode D100 are used to charge the capacitor C100 to a particular direct current level which depends upon the repetition frequency of the pulses which, in turn, depends upon the speed of rotation of the shaft 27. The capacitor C100 may have a value, for example, of 0.27 microfarads. Only when the speed of rotation of the rotor head falls below a predetermined threshold speed, does the voltage across the capacitor C100 fall to a sufficiently low value to cause the relay RLY 1 to become deenergized so as to cause the normally open contacts associated with that relay to open. When the aforesaid contacts open the solenoid 46 of FIG. 4 is deenergized which permits the lid 20 to be unlatched and opened. Other types of electromechanical arrangements, such as inductive devices or mechanical dash pot devices, may be mechanically coupled to the motor shaft, so as to control the aforesaid solenoid 46 and cause it to become energized only when motor speed is below a particular threshold.

The motor 26 is energized by the control circuit shown in FIG. 6. In the control circuit of FIG. 6 a unijunction transistor Q1, which may be of the type presently designated 2N2646 may be connected as a pulse generator in circuit with a 560-kilohm resistor R5, a 560-ohm resistor R6, and a grounded 0.1 microfarad capacitor C2. The negative pulses from the transistor Q1 are introduced through a 200 picofarad coupling capacitor C3 to the junction of a 10-kilohm potentiometer R3 and a 5.6 kilohm resistor R2. The potentiometer R3 is connected to a grounded 33 kilohm resistor R4. The negative pulses appear across the resistors R2, R3 and R4, and these pulses are picked up by the adjustable arm of the potentiometer R3

and applied to the gate electrode of a programmable unijunction transistor Q2. The anode of the unijunction transistor Q2 is connected to a 44-megohm resistor R1 and to a grounded 3.3 microfarad capacitor C1, and the cathode of the transistor Q1 is connected to the base of an NPN-transistor Q3.

The latter transistor may be of the type designated 2N3394, and it is connected as a pulse shaper. The collector of the transistor Q3 is connected to the junction of a 2.7-Kilohm resistor R7 and 0.56-microfarad coupling capacitor C3. The latter capacitor is connected to the base of an NPN-transistor Q4 and to a grounded 470-ohm resistor R8. The transistor Q4 may also be of the type designated 2N3394, as may a subsequent NPN-transistor Q5. The collector of the transistor Q4 is connected to a 2.7-kilohm resistor R9 and to a 180-ohm resistor R10.

The resistor R9 is connected to the positive terminal of the 12-volt source, and the resistor R10 is connected to the base of the transistor Q5. The collector of the transistor Q5 is directly connected to the positive terminal, and the emitter is connected to the junction of a 560-ohm grounded resistor R11 and 0.1-microfarad coupling capacitor C4. The coupling capacitor C4 is connected to the base of a PNP-transistor Q6 of the type designated D24A4 and to a grounded 1-kilohm resistor R12.

The collector of the transistor Q6 is connected through a 10-Kilohm resistor R14 and through a diode D2 to the gate electrode of a silicon-controlled rectifier SCR, the anode of which, together with the collector of the transistor Q6 are connected to a common lead 100.

The pulse generator circuit of the transistor Q1 generates negative pulses which appear across the resistors R2 and R3 and potentiometer R3. As mentioned, the transistor Q2 is a programmable unijunction transistor, and it has its gate electrode connected to the movable contact of the potentiometer R3. The negative pulses generated by the pulse generator circuit of the transistor Q1 repeatedly fire the transistor Q2. As shown, the anode of the transistor Q2 is connected to the common junction of resistor R1 and capacitor C1. The transistor Q2 is fired each time the voltage on its gate electrode approximates its anode voltage.

Therefore, a mutual relationship exists, and the transistors Q1 and Q2 cooperate to generate pulses at a predetermined repetition rate. These pulses are applied to the transistor Q3 which, together with the transistors Q4 and Q5 act as driver stages, and serve to shape the pulses so that a narrow driving pulse at line voltage is obtained. This pulse is used for driving a ring counter made up of a series of programmable unijunction transistors designated Q7, Q8, Q9, Q10 and Q11.

The transistors Q7-Q11 of the ring counter are connected between the 12-volt lead and ground in a known type of counter circuit, and each transistor in the ring counter includes a circuitry associated with it comprising, for example, a 1-kilohm resistor R20, a 1-kilohm resistor R22, and a 0.56-microfarad capacitor C10. The driver stages Q3, Q4 and Q5 are used to produce the aforesaid narrow drive pulses, since the pulses produced directly from the transistor Q2 tend to have exponential trailing edges.

As the pulses from the aforesaid pulse generator (waveform C) are applied to the ring counter circuit, the ring counter is caused to step from one count to the next in a manner known to the art. For each step of the ring counter a different lamp 1, 2, 3, 4, 5, 6 is energized.

A photocell designated PC10 is supported, in a manner to be described, so that it can be moved to be activated by any one of the lamps 1, 2, 3, 4, 5 or 6. When the photocell PC10 is activated, it causes an NPN-transistor Q8 to be nonconductive. The transistor Q8 is of the type designated 2N3394. It has a base electrode connected to a 15-kilohm resistor R24, a collector directly connected to the positive terminal of the 12-volt source, and an emitter connected to a grounded winding of a relay RLY2. A 70-microfarad capacitor C12 is connected across the power source. The photocell PC10 is shunted by a stop switch designated STP.

The aforesaid ring counter may be controlled so that, for example, the lamp 1 comes on at the first pulse applied to the ring counter; the lamp 2 comes on at a fixed interval, such as 3 minutes, later when the second pulse is applied; lamp 3 comes on, for example, in 6 minutes from the start pulse; lamp 4 comes on, for example on in 9 seconds, and so on. The photocell PC10 may be moved along a slot, as will be described, so that it is energized a predetermined time interval after the start pulse, depending upon which of the lamps 1-6 is in optically coupled relationship with the photocell. When the photocell is energized it turns off the transistor Q8 and deenergizes the relay RLY2. When the circuit is first energized by means, for example, of a start switch designated STRT, the relay RLY2 is energized, and is latched in its energized state by latching contacts A. When the latching contacts close a second relay RLY3 is also energized, and it causes relay contacts B, C, and D to close. When the relay contacts B close, the +12-volt source is connected to a lead 102 through a 100-ohm resistor R20. When the relay contacts C close, an energizing circuit is established to the motor 26 of FIG. 1, which is connected to the terminals 103 and 105. A 0.1-microfarad capacitor C14 is connected between the positive terminal of the 12-volt source and its negative terminal, which is designated as ground.

The start switch STRT also includes a pair of normally open contacts which permit the mechanism to be started by a remote start switch connected, for example, across the terminals +12, 106. The magnetic switch 44 is connected in circuit with the relay RLY2, to prevent the relay from being energized, and the motor started, unless the lid 20 is closed, so that the permanent magnet 42 (FIG. 4) is in position to close the magnetic reed switch 44. The switch 56 of FIG. 4 may also be connected in circuit with the relay RLY2 to prevent the relay from being energized so long as the latch 38 is withdrawn from the slot 40 permitting the lid to be opened.

It will be appreciated that when the ring counter circuit reaches a stage so that the photocell PC10 is energized to turn off the motor, the pulse generator circuit as well as the ring counter circuit are also turned off as the relay contacts B associated with the relay RLY3 open. However, the next time the circuit is started, by closing the start switch STRT, or the remote start switch, the circuit is immediately energized by the latching of the relay RLY2, and the pulse generator again starts to generate pulses which continue until the timed interval is completed, at which time the system turns off, as described above.

As shown in FIG. 7, the circuitry of FIG. 6 may be mounted on an appropriate circuit board 200, and a plastic block 202 is supported on the forward end of the board. The plastic block 202 forms a housing for the start switch STRT and for the stop switch STP, both of which may be of the illuminated type. The block also forms individual cylindrical housings for the respective lamps 1, 2, 3, 4, 5 and 6 of the ring counter. As shown in FIG. 8, for example, these lamps extend up into their individual housings, and are shielded from one another. However, apertures 204 in the individual housing extend to a longitudinal slot 206 extending along the forward end of the block 202.

A plastic slider 210 (FIG. 9) is movable in the slot 206 from one end of the slot to the other. The photocell PC10 is mounted in the slider 210, and connections are made from the photocell to the circuitry on the board of FIG. 7 by means of a pair of resilient electrically conductive strips 212 and 214 which act as runners, and which contact respective printed conductors on the circuit board 200 in sliding contact therewith, as the slider 210 is moved along the slot 206. The slider 210 may be moved along the slot 206 to any selected position adjacent a corresponding one of the lamp housings so as to be directly adjacent one of the apertures 204. Then, when the corresponding lamp is illuminated, the photocell PC10 is energized to control the relay RLY2 of FIG. 6.

It will be appreciated, therefore, that the slider 210 can be moved to any position 0, 3, 6, 9, 12 or 14, by an appropriate

external knob (not shown), depending upon the timing desired. The operator can watch the progress of the system, since there will always be one of the lights 1, 2, 3, 4, etc., illuminated, until the light which activates the photocell PC10 in the slider 210 is reached. Also, when a time interval is selected, the timing is precise, since that interval is dependent upon the pulses generated by the pulse generator of FIG. 6, which pulse generator is precisely controlled.

The invention provides, therefore, an improved control system for a centrifuge unit, and provides precise timing controls for the unit, as well as latching controls and interlocks for safety reasons.

Although a particular embodiment of the invention has been shown and described, modifications may be made, and it is intended in the claims to cover all modifications which fall within the spirit and scope of the invention.

What is claimed is:

1. In a centrifuge apparatus which includes a housing, an electric motor mounted in said housing and including a drive shaft for rotatably driving a rotor head, and a lid mounted on the housing; the combination of a latching mechanism mounted on said housing and including a latch for selectively engaging said lid, a solenoid, linkage means mechanically coupling said solenoid to said latch, tachometer means mounted on said motor for generating an electric signal representative of the angular speed of said shaft, and control circuitry electrically connecting said tachometer means to said solenoid for actuating said solenoid to release said latch only when the speed of rotation of said motor drive shaft falls below a preestablished minimum, a magnetically operated electric switch positioned to be actuated when said lid is in a closed condition, a permanent magnet mounted on said lid for actuating said switch when said lid is closed, and circuitry electrically connecting said switch in the energizing circuit of said motor to prevent the motor from being energized until said lid is closed.

2. The combination defined in claim 1, and which includes a timing circuit for said motor, said timing circuit including pulse generator means and a counter circuit, and circuitry for activating said pulse generator means when said motor is energized, so as to cause said pulse generator means to introduce counting pulses to said counter, and further circuitry responding to a predetermined count of said counter for deenergizing said motor.

3. The combination defined in claim 1, in which said counter circuit includes a plurality of electric lamps connected to be individually energized as said counter is stepped from one count to the next, and in which said further circuitry includes a photocell mechanically adjustable to be energized by a selected one of the aforesaid lamps to deenergize said pulse generator and counter after said counter has been stepped to a predetermined count.

4. In a centrifuge apparatus which includes a housing, an electric motor mounted in said housing including a drive shaft for rotatably driving a rotor head, a timing circuit for said motor including: pulse-generating circuit means for generating electric pulses having a predetermined repetition frequency, a counter circuit coupled to said pulse-generating circuitry and responsive to the pulses therefrom to be stepped from one count to another, and further circuitry coupled to said counter and responsive to a predetermined count of said counter for deenergizing said rotor and for deactivating said counter and said pulse-generating circuit means, in which said counter includes a plurality of electric lamps respectively connected in circuit therewith to be successively energized as the counter is stepped from one count to another, and in which said further circuitry includes a photocell movable to be optically coupled to a selected one of the aforesaid lamps, so as to deenergize said motor and deactivate said pulse-generating circuit means and said counter after said counter has reached a predetermined count.

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