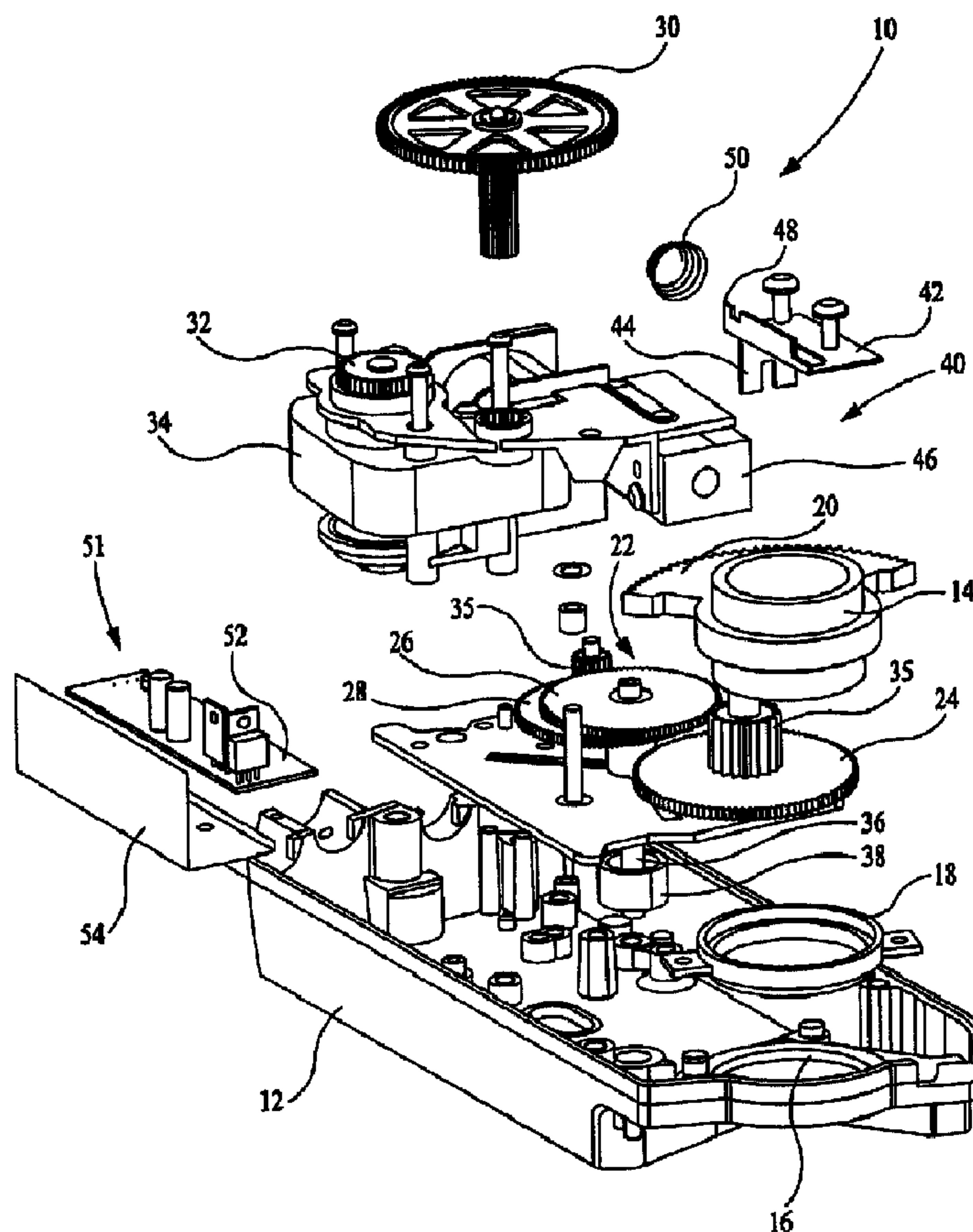




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(54) Titre : ACTIONNEUR A DISPOSITIF DE COMMUTATION COMMANDE PAR MINUTERIE  
 (54) Title: ACTUATOR HAVING TIMER-CONTROLLED POWER SWITCHING DEVICE



(57) Abrégé/Abstract:

An electro-mechanical actuator is adapted to be connected to an external device for displacing the external device to a predetermined position and maintaining the external device at that position. The actuator includes a housing which holds a drive

**(57) Abrégé(suite)/Abstract(continued):**

motor for driving the external device to the predetermined position when the motor is energized and a brake mechanism for maintaining the external device at the predetermined position when the brake mechanism is activated. A switching device generates switching signals for energizing the motor to drive the external device to the predetermined position and for de-energizing the motor and activating the brake mechanism when a predetermined time has passed from a moment the drive motor is energized, to maintain the external device at the predetermined position.

## 1 ABSTRACT OF THE DISCLOSURE

2 An electro-mechanical actuator is adapted to be connected to an external  
3 device for displacing the external device to a predetermined position and maintaining the  
4 external device at that position. The actuator includes a housing which holds a drive motor  
5 for driving the external device to the predetermined position when the motor is energized  
6 and a brake mechanism for maintaining the external device at the predetermined position  
7 when the brake mechanism is activated. A switching device generates switching signals  
8 for energizing the motor to drive the external device to the predetermined position and for  
9 de-energizing the motor and activating the brake mechanism when a predetermined time  
10 has passed from a moment the drive motor is energized, to maintain the external device  
11 at the predetermined position.

## ACTUATOR HAVING TIMER-CONTROLLED POWER SWITCHING DEVICE

1           The present invention generally relates to electro-mechanical actuators, and  
2 more particularly to an electro-mechanical actuator having a timer function for switching  
3 power between a drive motor and a reduced-power holding mechanism.

4           Electro-mechanical actuators are commonly utilized, for example, in  
5 heating, ventilating and air conditioning (HVAC) installations for actuating dampers or  
6 valves which are used to control air flow, especially during emergency situations where  
7 fire and smoke are involved. These actuators are typically provided with a retracting  
8 function that positions the damper to a predetermined default position when the power to  
9 the actuator is interrupted, whether intentionally shut off by an operator or through a  
10 power failure. In this manner, the actuator automatically displaces the damper, without  
11 electric power, to a safeguard position to assist in routing or containing the fire and/or  
12 smoke to areas that are designated by a preestablished fire prevention plan.

13           The retracting function of many conventional actuators is typically  
14 performed by a spring mechanism. To counteract the retracting force of the spring  
15 mechanism so that the damper is maintained at the normal operating position, some  
16 known actuators employ the same motor which initially displaced the damper away from  
17 the default position. As such, those actuators continually draw power in a stalled  
18 condition when the damper reaches a mechanical end stop that defines the normal  
19 operating position. This arrangement is disadvantageous in that the actuators provided  
20 for fire and smoke applications are typically held in the normal operating position for  
21 approximately 99% of their life, and as a result, consume relatively large amount of  
22 power. The power consumption issue becomes more significant when a multitude of

1 actuators of the same type are used in some large scale HVAC systems, because the total  
2 power consumption of these actuators over their lifetime can be very high and costly. In  
3 addition, the geartrain in the actuators for driving the damper is constantly under a load  
4 by the motor, and as a result, is prone to gear tooth damage due to 60Hz frequency  
5 vibration. Another and possibly worse problem is the high heat build-up due to holding  
6 the motor in the stalled position for long periods of time, potentially damaging the motor.

7 Alternatively, some actuators are provided with a separate holding  
8 mechanism as a way of maintaining the damper at its position during normal operation.  
9 When energized, a locking mechanism engages and locks the damper into its normal  
10 operating position. The locking mechanism requires less power than the drive motor and  
11 eliminates or at least reduces gear tooth damage. The actuators of this type are provided  
12 with an end switch for detecting whether the damper has reached its normal operating  
13 position or a speed sensing device for detecting whether the actuator has stopped driving.  
14 Once it is determined that the damper has reached its normal operating position, the  
15 actuator switches power from the drive motor to the locking mechanism. The end  
16 switches or the speed sensing devices, however, are costly and difficult to implement at  
17 the typical elevated operating temperatures of these actuators, approximately 350° F.

18 Accordingly, it is a primary objective of the present invention to provide an  
19 improved actuator which is inexpensive and simple to implement.

20 Another object of the present invention is to provide such an improved  
21 actuator including a solenoid for locking a damper into its normal operating position.

22 Still another object of the present invention is to provide such an improved  
23 actuator having a timer control for switching power between a drive motor and the  
24 solenoid.

25 Yet another object of the present invention is to provide such an improved  
26 actuator having the timer control provided on a printed circuit assembly.

27 Other objects and advantages will become apparent upon reading the  
28 following detailed description, in conjunction with the attached drawings, in which:



1 includes a switching signal generator for producing signals for switching power between  
2 the drive motor and the low-power holding mechanism at a predetermined time, and a  
3 control circuit adapted to enable the signal generator to produce the switching signal.  
4 Also included is a switching device which is connected to the drive motor and the holding  
5 mechanism for switching power from the drive motor to the low power holding  
6 mechanism when the switching signal is received from the switching signal generator.

7 Turning now to FIGS. 1 and 2, the electro-mechanical actuator of the  
8 present invention is indicated generally at 10 and includes a lower housing 12 (the top  
9 housing not shown), which is configured to receive a rotatable output coupler 14 through  
10 a coupling hole 16 (best shown in FIG. 1) via a bearing ring 18. The coupler 14 is  
11 constructed to operatively couple to an external device such as a damper or a valve (not  
12 shown), and is adapted to displace the damper between a default position in the event of  
13 a power interruption and a desired operating position when power is being applied to the  
14 actuator 10.

15 The output coupler 14 includes an integral arcuate segment 20 which has  
16 a plurality of teeth for engaging a geartrain indicated generally at 22. In the preferred  
17 embodiment, the geartrain 22 includes four gear sets 24, 26, 28, 30 which are operatively  
18 engaged with respect to each other. The geartrain 22 is arranged with the axes of the gear  
19 sets 24, 26, 28, 30 generally forming a zig-zag line along the longitudinal direction of the  
20 actuator 10. The gear set 24 of the geartrain 22 is engaged with the arcuate segment 20  
21 of the output coupler 14 and the gear set 30 is operatively engaged with a drive pinion 32  
22 of a drive motor 34. In this manner, the torque produced by the motor 34 is transferred  
23 and amplified by the geartrain 22 to the output coupler 14 when the motor is energized.  
24 It should be noted that while the preferred geartrain 22 is arranged using the  
25 interconnection of four gear sets 24, 26, 28, 30 including their respective transfer pinions  
26 35 (not all pinions shown), a person of ordinary skill in the art will recognize that the  
27 geartrain 22 may include more or less than four gear sets, and can be arranged in various  
28 other configurations which would allow torque to be transferred between the drive motor  
29 34 and the output coupler 14.

1           As shown in FIG. 1, an elongated shaft 36 which is concentric with the axis  
2 of the gear 26 depends from this gear. A slotted sleeve 38 is attached to the end of the  
3 shaft 36 and is adapted to be connected to an end of a retracting spring (not shown), for  
4 example, a clock or torsion spring. When the damper is displaced away from the default  
5 position by the output coupler 14, the retracting spring is placed under a state of torsion,  
6 and applies a force on the output coupler 14 via the geartrain 22 to return the damper to  
7 its default position.

8           To prevent the damper from returning to its default position during the  
9 normal operation of the actuator 10, the actuator is provided with a brake assembly 40  
10 which when activated, locks the geartrain 22 to prevent it from rotating. The brake  
11 assembly 40 includes a slidable lever brake 42 which has an arm 44 (best shown in FIG.  
12 1) which is constructed to hook onto a translationally movable plunger (not shown) in a  
13 solenoid 46, so as to slide correspondingly with the plunger when the solenoid 46 is  
14 activated. The lever brake 42 also has a tab 48 which is adapted to catch one of the teeth  
15 on the gear 30 and lock the geartrain 22 in its place when the solenoid 46 is activated.  
16 When the solenoid is not activated, a bias spring 50 (shown in FIG. 1) pushes the solenoid  
17 plunger, and thus the brake lever 42 and its tab 48, in a direction away from the gear 30,  
18 thereby allowing the geartrain 22 to rotate either from the drive motor 34 or the retracting  
19 spring.

20           In accordance with one aspect of the present invention, the actuator 10  
21 further includes a switching circuit 51 for controlling power that is applied to the drive  
22 motor 34 and the solenoid 46. The switching circuit 51 is implemented on a printed  
23 circuit board 52 and protected by an insulation plate 54. Turning now to FIG. 3, the  
24 switching circuit 51 includes a solid state timer 54 such as a 4541B type integrated circuit  
25 (IC) chip. A timer control circuit 56 is provided to enable the timer 54 to produce a  
26 desired signal. The timer control circuit 56 includes a pair of resistors 58, 60 and a  
27 capacitor 62 which are selected in accordance with the requirements of the timer 54 to  
28 allow the timer to generate the desired signal, which is supplied to a relay 64. In the  
29 preferred embodiment, the resistors 58, 60 have values of 348 and 698 ohms and the

1 capacitor 62 is 0.001 $\mu$ F. This allows the timer 54 to generate a signal that keeps a switch  
2 66 in the relay 64 connected to the drive motor 34 preferably for approximately 25  
3 seconds, which allows more than enough time for the motor to displace the damper to its  
4 normal operating position. The relay 64 is SPDT type in the preferred embodiment.  
5 After this period, the timer 54 outputs a signal which causes the switch 66 to disconnect  
6 from the motor 34 and connect to the solenoid 46, thereby activating the brake assembly  
7 40 to lock the geartrain 22, and thus the damper in its operating position. The timer 54  
8 is also provided with a pair of resistors 68, 70 for reducing the input AC voltage to a level  
9 usable by the timer. A diode 71, a capacitor 72 and a zener diode 74 are connected  
10 downstream of the resistors 68, 70 to rectify the input AC voltage and regulate it to  
11 approximately 13 VDC before it is supplied to the timer 54.

12 From the foregoing description, it should be understood that an improved  
13 eletro-magnetic actuator has been shown and described which has many desirable  
14 attributes and advantages. The present actuator includes a braking assembly which keeps  
15 the damper at its normal operating position using significantly lower power than a drive  
16 motor. Another advantage is that the present actuator uses a timer-controlled switching  
17 device for switching power from the drive motor to the braking assembly. The timer-  
18 controlled switching device is less expensive and easier to implement at elevated  
19 temperature conditions in which the actuators are required to operate.

20 While various embodiments of the present invention have been shown and  
21 described, it should be understood that other modifications, substitutions and alternatives  
22 are apparent to one of ordinary skill in the art. Such modifications, substitutions and  
23 alternatives can be made without departing from the spirit and scope of the invention,  
24 which should be determined from the appended claims.

25 Various features of the invention are set forth in the appended claims.

## WHAT IS CLAIMED IS:

1. An electro-mechanical actuator adapted to be connected to an external device for displacing the external device to a predetermined position and maintaining the external device at the predetermined position, said actuator comprising:

5 a housing;  
means provided in said housing for driving the external device to the predetermined position when said driving means is energized;

braking means for maintaining the external device at the predetermined position when said braking means is activated;

10 coupling means for connecting said actuator to said external device, and torque transmitting means operationally engaged between said driving means and said coupling means for transmitting torque between said driving means and said coupling means; and,

15 switching means for generating a first switching signal for energizing said driving means to drive the external device to the predetermined position, and a second switching signal for de-energizing said driving means and activating said braking means when a predetermined time has passed from a moment said driving means is energized, to maintain the external device at the predetermined position.

20 2. The actuator as defined in claim 1 wherein said driving means is an electric motor.

3. The actuator as defined in claim 1 wherein said braking means is a solenoid including a plunger and a frame.

25 4. The actuator as defined in claim 3 wherein said braking means includes a brake arm connected to said plunger for operatively engaging said driving means when said braking means is activated to prevent the external device from being displaced away from the predetermined position.

5. The actuator as defined in claim 4 wherein said driving means is an electric motor having a gear wheel attached to a drive shaft of said electric motor, said gear wheel being adapted to engage said brake arm when said braking means is activated.

5

6. The actuator as defined in claim 1 wherein said switching means comprises:

a timer for generating said first and said second switching signals;

a control circuit for providing an input signal required for said timer to

10 generate said first and second switching signals; and

an electronic relay connected to said timer for electrically connecting said timer to said driving means when said first switching signal is received from said timer, and to said braking means when said second switching signal is received.

15

7. The actuator as defined in claim 1 wherein said driving means is an electric motor and said torque transmitting means is a geartrain arranged and adapted to transmit torque generated by said electric motor to said coupling means.

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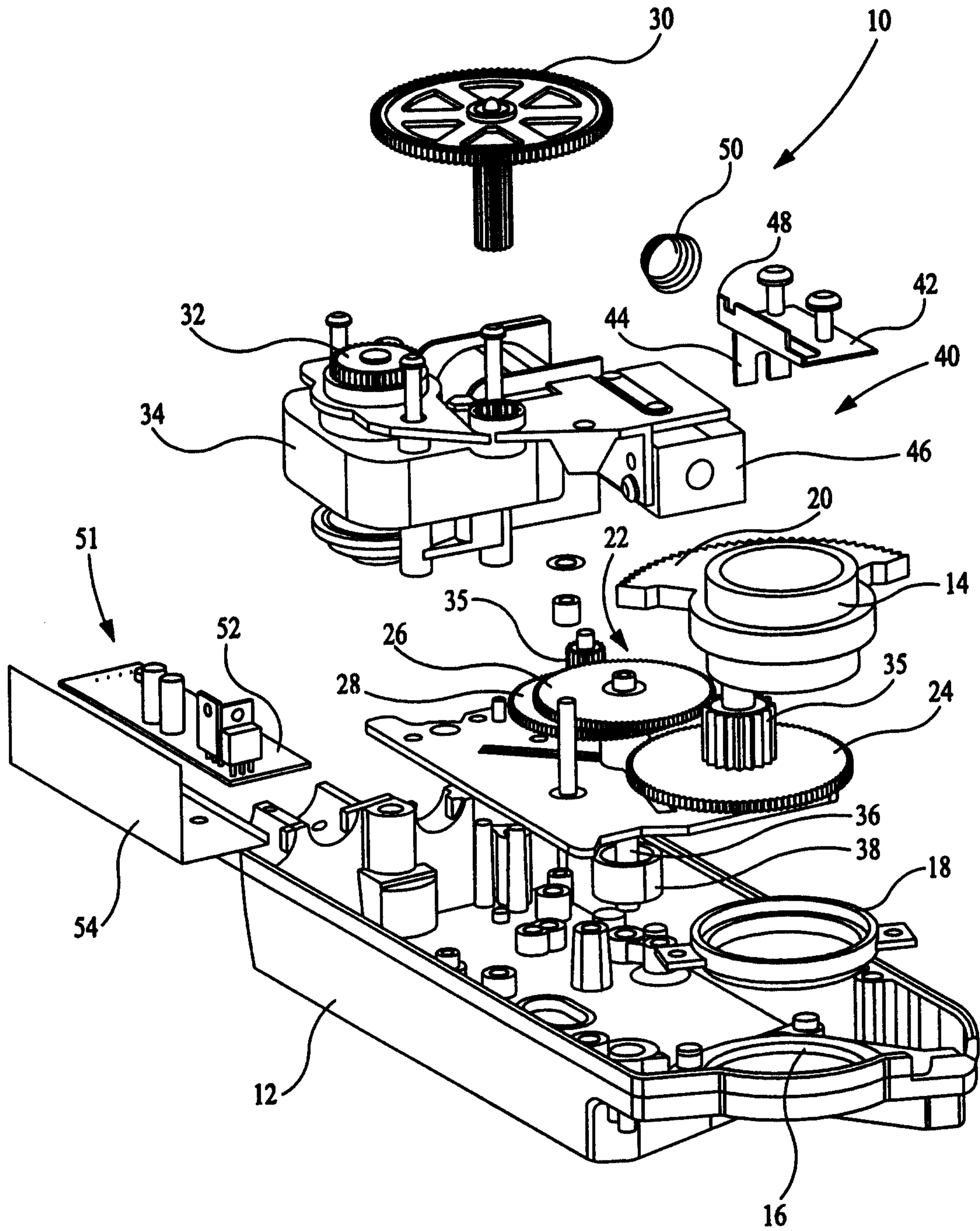


FIG. 1

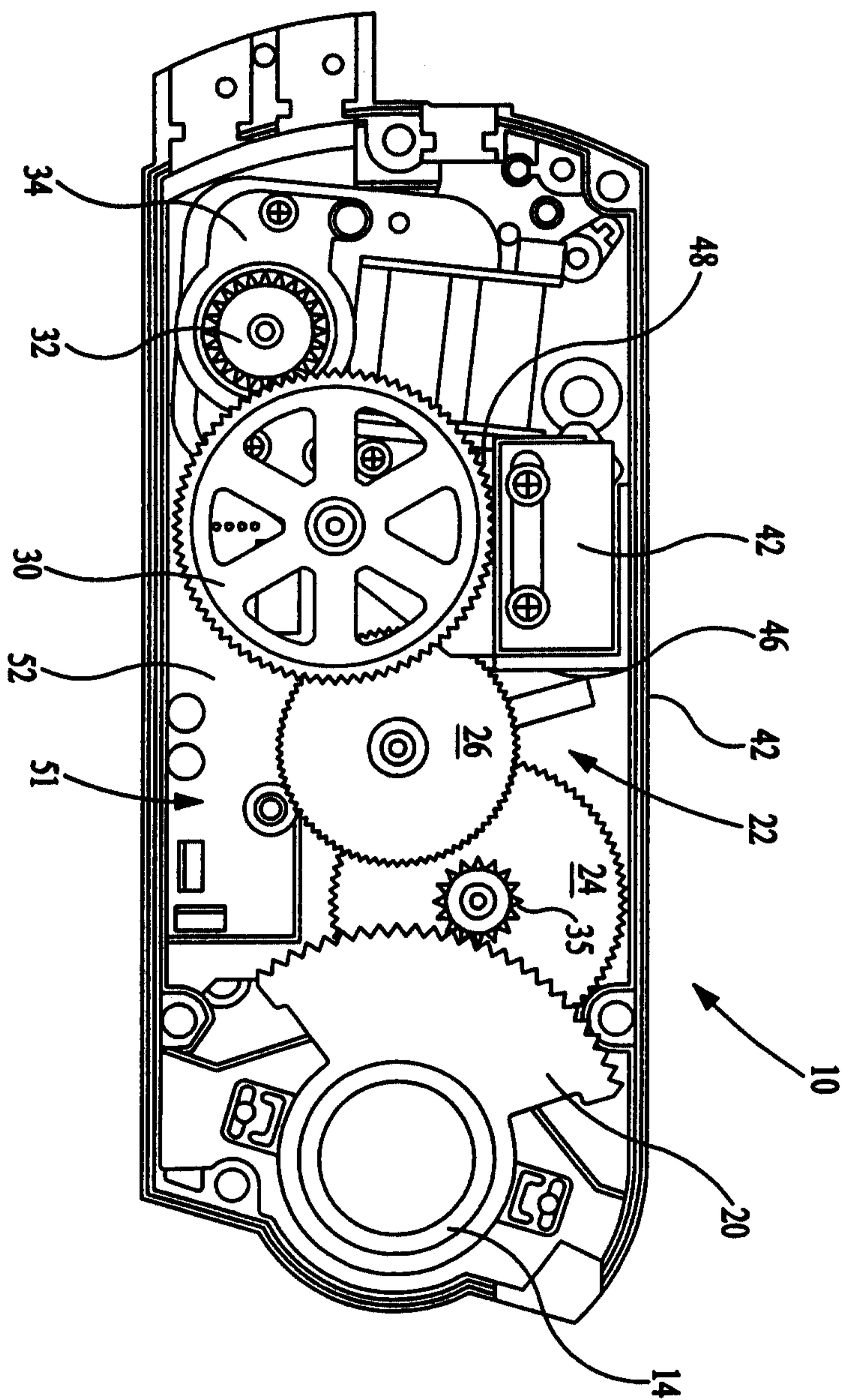


FIG. 2

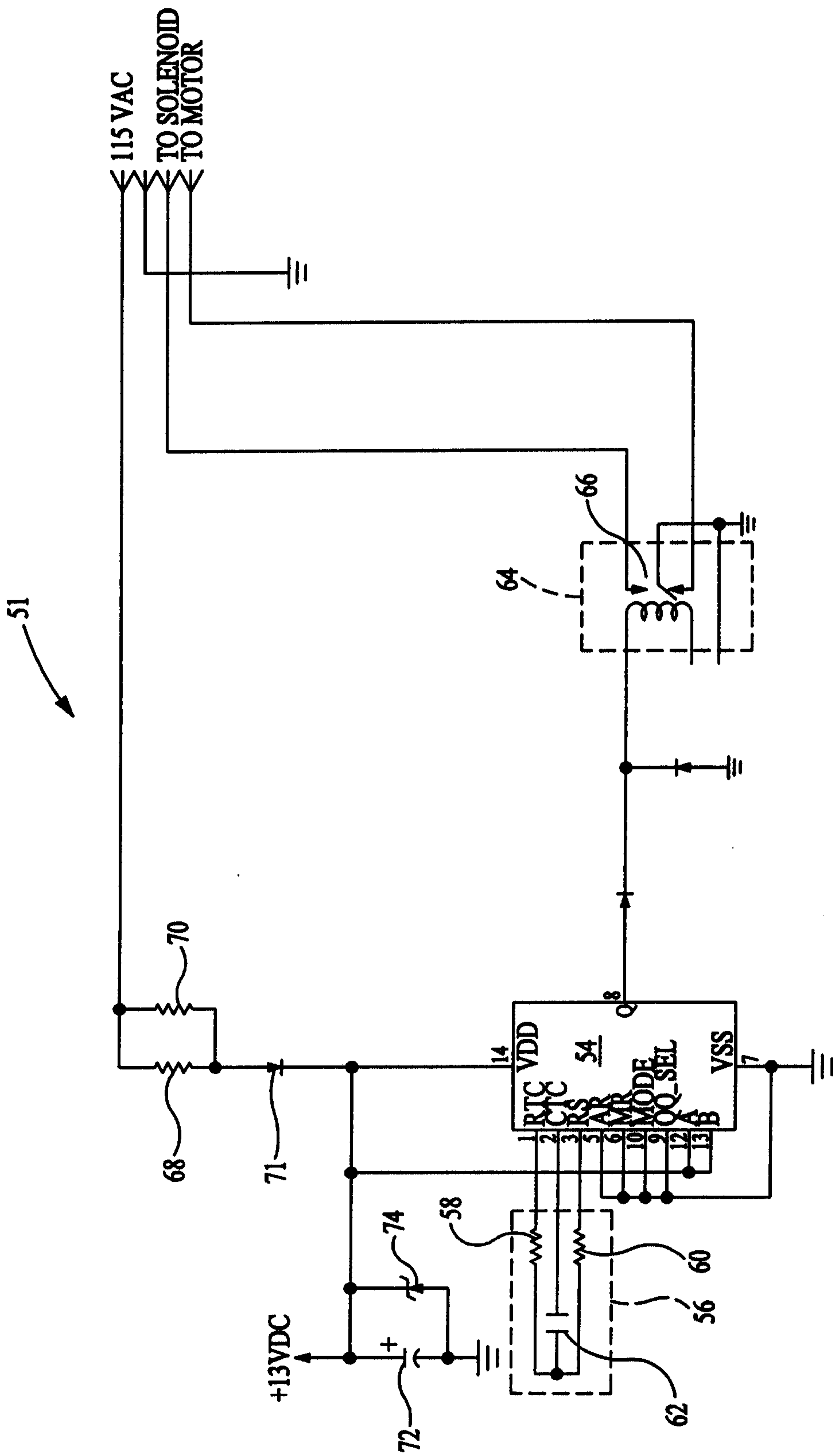


FIG. 3

