United States Patent [19]

Boehm

[11] **3,874,117**

[45] **Apr. 1, 1975**

[54] **ELECTRIC DOOR OPENER**

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[22] Filed: **Sept. 28, 1973**

[21] Appl. No.: **401,841**

[52] **U.S. Cl.** **49/264,** 49/30, 49/340, 318/442

[51] **Int. Cl.** **E05f 13/00**

[58] **Field of Search** 49/25, 30, 263, 264, 267, 49/273, 274, 340; 318/442

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[57] **ABSTRACT**

An electric door opener to be utilized in conjunction with a standard door closer or door check to provide the elements of automatic door control. The door opener is typically mounted on the transom of the door and includes an electric motor having a drive shaft that operates through a worm grear mechanism and an electromagnetic clutch to drive a gear train. The output of the gear train is operably connected to a linkage attached to the door. An approach switch, associated with an approach mat or a photoelectric eye, is located ahead of the door, while a safety switch is similarly associated with a safety mat or photoelectric eye located behind the door. With the closing of the approach switch by a pedestrian approaching the door, high voltage power is supplied to the motor and clutch to enable the motor to drive the gear train and pivot the linkage to move the door to the open position. In addition, closing of the approach switch will also supply low voltage power to the motor. When the door is in the full open position a limit switch is actuated which acts to remove high voltage power from the motor, leaving only low voltage power on the motor. The low voltage power supplied to the motor is sufficient to overcome the force of the door closer and maintain the door in the open position. A time delay is incorporated in the system which provides time for pedestrian movement from the approach mat to the safety mat, and to clear the safety mat before the door closes.

15 Claims, 6 Drawing Figures

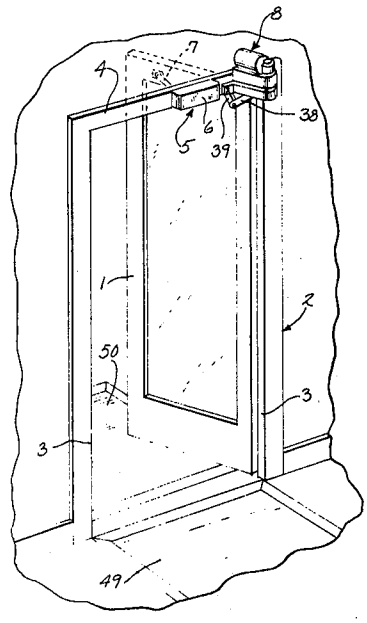

Fig. 1

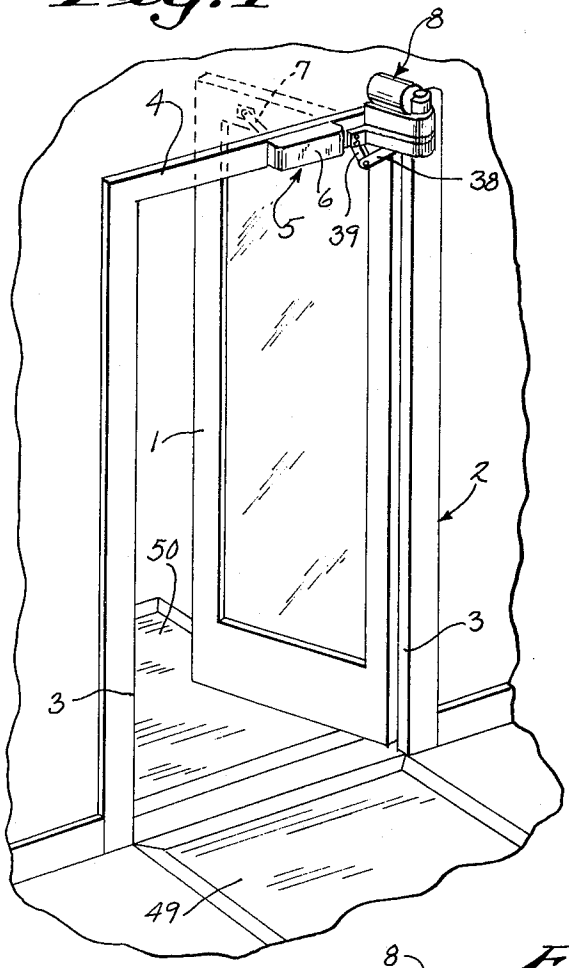

Fig. 4

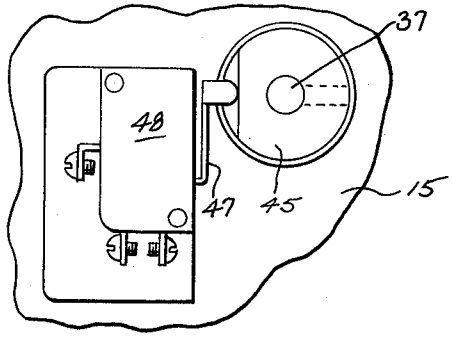

Fig. 5

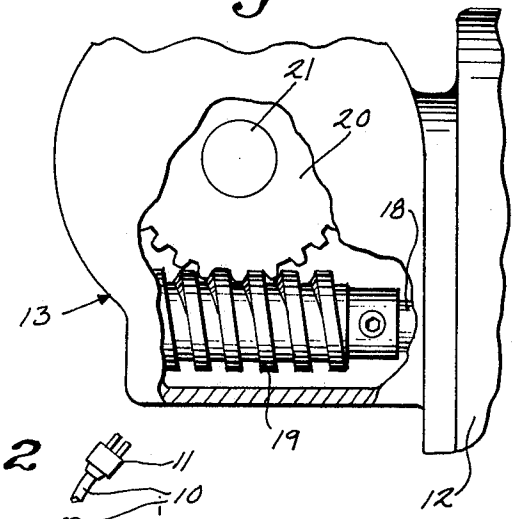

Fig. 2

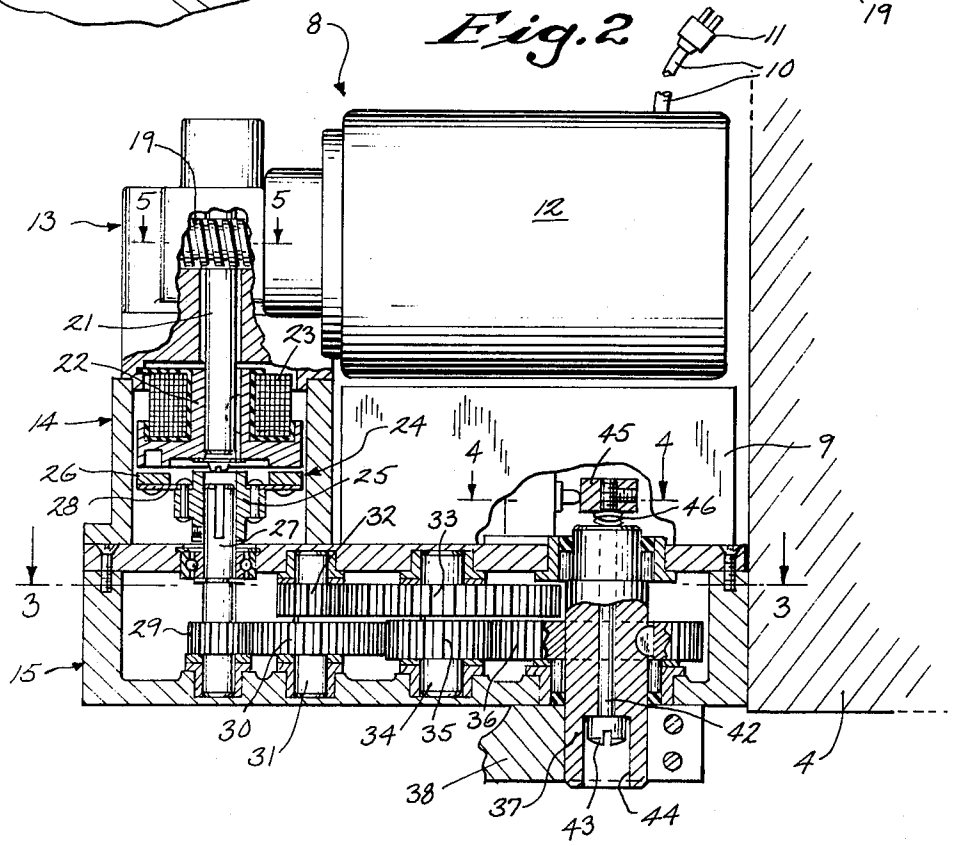

Fig. 3

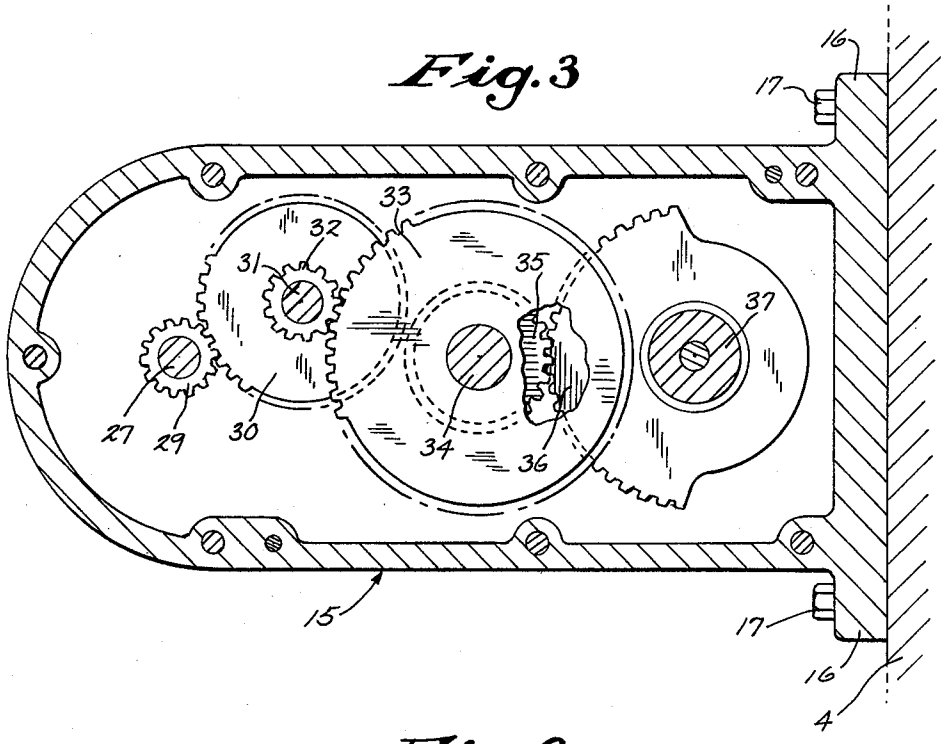
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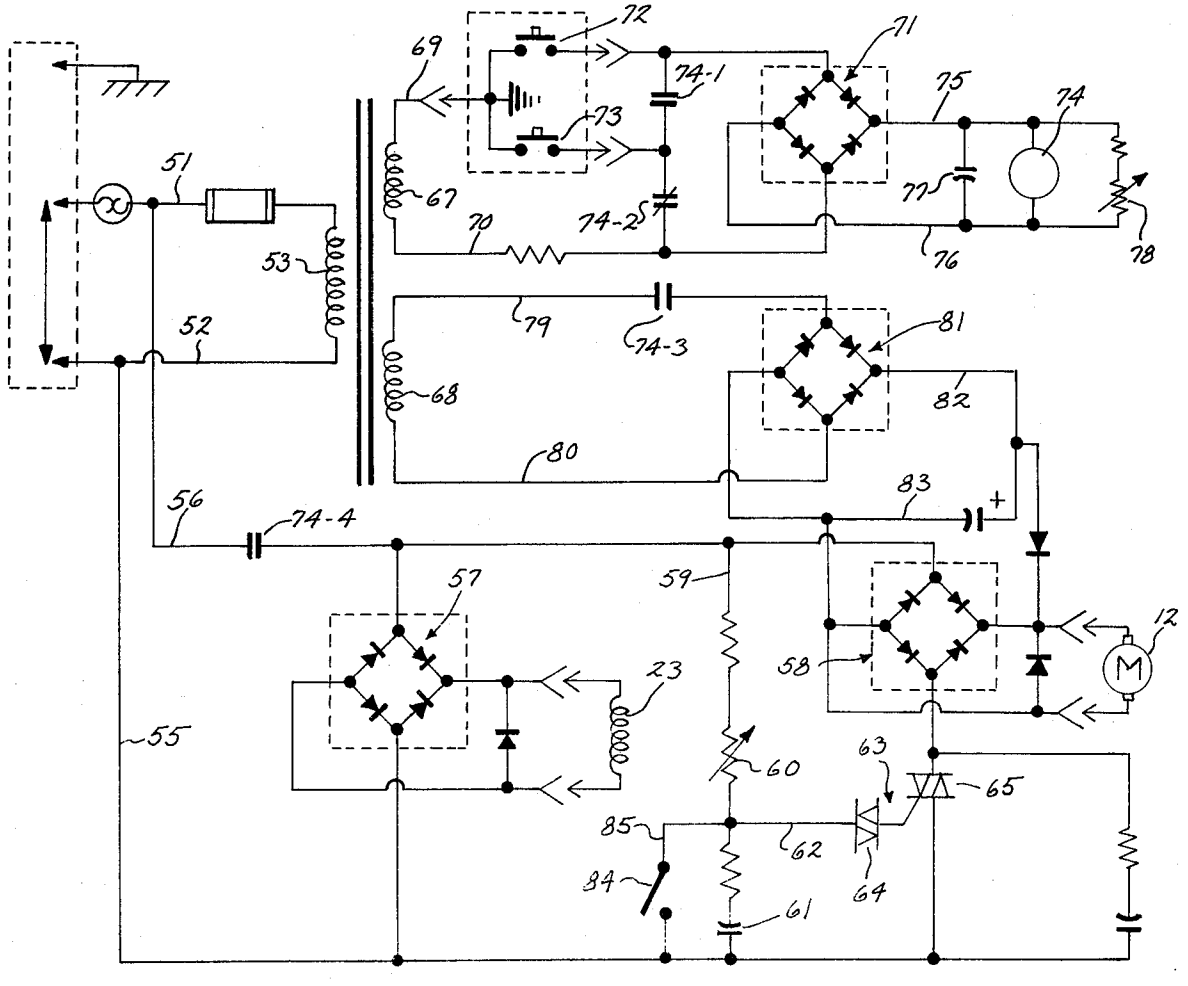
Fig. 6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ELECTRIC DOOR OPENER

BACKGROUND OF THE INVENTION

Automatic door operators are commonly used in supermarkets, airports, department stores, and other high volume traffic areas where pedestrians are burdened with packages or luggage. Automatic door operators are normally installed in the transom of the door, or alternately, under the floor, and are usually actuated by walk-on approach mats or a photoelectric eye. The automatic door operator performs the functions of opening the door, cushioning the opening action, stopping the opening action, closing the door and cushioning the door in the closed position. Automatic door operators are relatively complex in structure, expensive to install and maintain, and require frequent maintenance by specially trained service personnel.

Door closers or door checks are commonly used in association with residential, commercial or industrial doors. The conventional door closer provides opening speed control, opening cushioning, a stop for the opening action, as well as providing closing power and closing cushion for the door. The conventional door closer is mounted externally on the transom or on the door itself, and as the door is manually opened, the door closer stores energy to provide the closing power when the door is released. Conventional door closers are relatively inexpensive, reliable and easy to install and maintain.

SUMMARY OF THE INVENTION

The invention relates to an electric door opener to be utilized in conjunction with a standard door closer or door check, together accomplishing automatic door operation with reliable, easy to install and maintain, relatively low cost elements. The electric door opener is typically mounted on the transom of the door and includes an electric motor having a drive shaft that operates through a worm gear drive and an electromagnetic clutch to drive a gear train. The output of the gear train is operably connected to a linkage attached to the door. An approach switch, which can take the form of a walk-on approach mat or a photoelectric eye, is located in front of the door and a safety switch, which can similarly take the form of a safety mat or photoelectric eye, is located to the rear of the door. As a pedestrian steps on the approach mat, the approach switch is closed which acts to energize the motor and the electromagnetic clutch to thereby drive the gear train and pivot the linkage to move the door to the open position. When the door is fully opened a limit switch is actuated which acts to remove the full power from the motor, leaving only low voltage power on the motor. The low voltage power is sufficient to overcome the force of the door closer and maintain the door in the open position.

The door opener also includes a time delay which provides time for a pedestrian to leave the approach mat and reach the safety mat before the door will begin to close. Through use of a variable resistor the time delay can be selectively changed to suit the particular system.

The door opener of the invention is adapted to be used in conjunction with a standard door closer, and can be used with either new or existing doors. As the door opener does not include a mechanism for controlling closing of the door, the overall structure is simplified and the cost is substantially reduced over that of conventional automatic door operators which provide both an opening and closing function.

The unit includes a symmetrical housing which can be directly installed on either right hand or left hand doors and can be utilized with either center hung or butt hinged doors without modification to the opener or to the door.

The door opener of the invention also includes simple adjustments for opening speed of the door, time delay before closing, and direction of operation. The door opener also provides a power operated low voltage holding action to hold the door in the open position when a pedestrian is either on the approach or the safety mat, so that there is no danger of overheating the motor under this "hold-open" condition.

DESCRIPTION OF THE DRAWINGS

The drawings illustrate the best mode presently contemplated of carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of the door opener of the invention as associated with a door;

FIG. **2** is a vertical section of the door opener;

FIG. **3** is a horizontal section taken along line **3—3** of FIG. **2**;

FIG. **4** is a section taken along line **4—4** of FIG. **2**;

FIG. **5** is a section taken along line **5—5** of FIG. **2**; and

FIG. **6** is a wiring diagram.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** illustrates a hinged door **1** which is mounted within a doorway defined by a frame **2.** The frame includes a pair of vertical jambs **3** which are connected at their upper ends by a transom or lintel **4.** A standard door closer or door check **5** is associated with the door and can be a conventional hydraulic or mechanical type. The door closer **5** includes a housing **6** which is mounted on the transom and a pair of pivoting arms **7** are connected to the door. When the door is opened, energy will be stored by the door closer **5** which will then act to return the door to the closed position in a conventional manner.

Door **1** is adapted to be opened by a door opener which is indicated generally by **8** and is mounted on the transom **4.** As best shown in FIG. **2,** the door opener **8** includes an electrical control box **9** which contains the electrical components of the system and lead wires **10** are connected to the electrical components and are provided with a plug **11** which can be engaged with a standard 110 volt output. A three-conductor socket, not shown, is also furnished on the control box **9,** to provide connections to the approach mat and safety mat, the function of which will be hereinafter described.

The door opener **8** also includes a permanent magnet motor **12,** a worm gear reducing unit **13,** a clutch assembly **14,** and a gear box **15.** To mount the opener on the transom **4,** gear box **15** is provided with a pair of flanges **16** which are connected by bolts **17** to the transom (FIG. **3**).

As best shown in FIG. **5,** the drive shaft **18** of motor **12** is connected to the worm gear reduction unit **13** which includes a worm **19** which drives gear **20** mounted on the upper end of vertical shaft **21.** The

worm gear unit 13 not only provides a stage of reduction, but also will act to prevent the door from being slammed to the open position by a gust of wind during the opening cycle.

The lower end of the shaft 21 is keyed to a hub 22 of the clutch assembly 14. The hub 22 is journalled for rotation within a non-rotatable annular electromagnetic core 23. The clutch assembly 14 also includes an armature unit 24 including a central hub 25 and an outer ring 26. Ring 26 is normally spaced from the lower surface of the hub 22 to provide an air gap therebetween. The hub 25 of armature unit 24 is connected to the upper end of a shaft 27 and a flat spring 28 connects the hub 25 to the ring 26. When the core 23 is energized a magnetic field will be developed which will move the ring 26 upwardly into engagement with the hub 22, thereby bending the spring 28 upwardly, to provide a driving connection between the shaft 21 and the shaft 27. When core 23 is deenergized, the force of the deformed spring 28 will move the ring 26 downwardly out of engagement with the hub 22 to thereby disconnect the shafts 21 and 27.

As illustrated in FIG. 2, the shaft 27 is journalled for rotation within the gear box 15 and carries a gear 29 which drives a gear 30 mounted on shaft 31, which is similarly journalled within the gear box 15. Shaft 31 carries a small gear 32, which is engaged with a large gear 33 on shaft 34, and shaft 34 also carries a small gear 35 which drives a gear segment 36 mounted on the shaft 37. The lower end of shaft 37 projects outwardly of the gear box and is connected to one end of an arm 38. The opposite end of arm 38 is pivotally attached to one end of an arm 39 and the opposite end of arm 39 is pivotally connected to a clevis 40 that is attached by screws to the door 1. With this construction, rotation of the shaft 37 will cause the arms 38 and 39 to pivot to move the door to the open position.

As shown in FIG. 2, a pin 42 is mounted within a central bore in the shaft 37 and pin 42 is provided with an enlarged head 43 that is located in a recess 44 in the end of the shaft 37. The upper end of the pin 42 projects beyond the end of the shaft 37 and carries a cam 45. A pair of Belleville springs 46 surround the pin 42 and provide frictional contact between the cam 45 and the shaft 37 to restrict free rotation of the pin within the bore of the shaft. Cam 45 pivots with the shaft 37 and the arm 47 of a switch unit 48 rides against the peripheral surface of the cam 45. When the door is pivoted to the full open position the cam 45 is adapted to actuate the switch unit 48, as will be hereinafter described.

The door opener is adapted to be actuated by closing of an approach switch as a pedestrian approaches the door. As shown in FIG. 1, the approach switch is associated with an approach mat 49 which is located on the floor in front of the door 1. As the pedestrian steps on the approach mat 49, the approach switch is actuated to thereby operate the door opener. In addition to the approach switch, a safety switch is associated with a safety mat 50 that is located on the floor behind the door. While the drawings illustrate the approach and safety switches to be associated with mats, it is contemplated that various types of switches can be utilized, such as those actuated by photoelectric eyes, push bars, sonic actuation, or the like.

As shown in the wiring diagram, FIG. 6, 120 volt power from lines 51 and 52 is supplied to the high voltage winding 53 of a transformer 54. The power lines 51 and 52 are also connected through lines 55 and 56 to full wave bridge 57, the output of which is connected to coil 23 of the clutch assembly 14, and to full wave bridge 58, the output of which is connected to the permanent magnet motor 12. Line 59 is connected across lines 55 and 56 and a variable resistor 60 and capacitor 61 are connected in line 59. Line 62 connects line 59 with line 55 and solid state switch unit 63 is connected in line 62 and serves to control the current flow through line 55. Switch unit includes a diac 64, and a triac 65. The variable resistor 60 and capacitor 61 function as a voltage dividing network, and adjustment of resistor 60 will determine the point in the half cycle in which the triac will fire and thus provides a speed control for the motor.

Transformer 54 also includes a pair of low voltage windings 67 and 68, and in practice the winding 67 can be 28 volts while winding 68 is 14 volts.

Lines 69 and 70 of a control circuit connect winding 67 to full wave bridge 71 and the command or approach switch 72 and the safety switch 73, associated with approach mat 49 and safety mat 50, respectively, are connected in parallel in line 69. The output of bridge 71 is connected to relay 74 by lines 75 and 76, and capacitor 77 and a variable resistor 78 are connected across line 75 and 76.

Lines 79 and 80 of a low voltage circuit connect the low voltage winding 68 to full wave bridge 81, and the output of bridge 81 is connected to the motor 12 by lines 82 and 83.

As the pedestrian walks on the approach mat 49, switch 72 closes and the relay 74 is energized. Energizing relay 74 will close the normally open contacts 74-1, will open the normally closed contacts 74-2, will close the normally open contact 74-3 in line 79 and will close the normally open contacts 74-4 in line 56. With the closing of contacts 74-4 power will then be supplied from the power lines 51 and 52 to the motor 12 and clutch coil 23 to operate the motor and engage the clutch. Closing of contacts 74-3 will serve to supply low voltage power to the motor though the lines 79 and 80. Engagement of the clutch provides a driving connection between the motor 12 and the gear train to thereby pivot arms 38 and 39 and move the door to the open position.

When the door moves to its fully opened position, the cam 45 will close the normally open limit switch 84 of the switch assembly 48. Limit switch 84 is connected in line 85, which is connected between line 55 and line 59. With the closing of limit switch 84 power will follow the path of least resistance through line 85, thereby bypassing the switch unit 63 so that the supply of high voltage power to the motor 12 will be terminated, since the triac is off. The low voltage power being supplied through lines 79 and 80 to the motor will be sufficient to maintain the door in the open position against the force exerted by the door closer 5. This situation, in which low voltage power is supplied to the motor 12, will continue to exist while the approach switch 72 is closed.

If the pedestrian moves through the open door from approach mat 49 to the safety mat 50, approach switch 72 will open, and the capacitor 77 is employed to maintain energization of the relay 74 in the event the approach switch 72 and safety switch 73 may both momentarily be open as the pedestrian passes through the

doorway. Capacitor **77** also provides a time delay when the pedestrian leaves the safety mat **50,** or leaves the approach mat **49** and does not step onto the safety mat **50,** before the door will begin to close and permits the pedestrian to be safely out of the way of the door when it begins its closing action through operation of the door closer **5.** Adjustment of the variable resistor **78,** which is typically mounted on the control box **9,** permits the duration of the time delay to be selected for each installation.

When the pedestrian has stepped off of the safety mat **50,** and there is no pedestrian on the approach mat **49,** both the switches **72** and **73** will be open, and after discharge of the capacitor **77** relay **74** will be deenergized. Contacts **74-1, 74-3** and **74-4** will then open while contacts **74-2** will close to shut off power to the motor **12** and to clutch coil **23** and permit the closer **5** to return the door to the closed position without torque being transmitted back through the motor.

The door opening logic can be illustrated by the equation:

$$Qn + 1 = S.Q_n + \overline{S}.A$$

where Q is the state of memory element (relay **74**) and when $Q = 1$ the relay is energized and when $Q = 0$ the relay is deenergized; n is a state of time and $n + 1$ is the next state of time;
A is the approach mat switch and $A = 1$ when the switch is closed and $A = 0$ when the switch is open;
S is the safety mat switch and $S = 1$ when the switch is closed and $S = 0$ when the switch is open.

Using the above equation, the following table of conditions can be determined:

INPUTS		OUTPUT
A	S	Q_{n+1}
0	0	0
0	1	Q_n
1	0	1
1	1	Q_n

Thus, the next state of the relay **74** (Q_{n+1}) is deenergized if A and S are 0, is equal to the existing state if S is 1 and A is 0 or 1, and is energized if A is 1 and S is 0.

The door opener of the invention is adapted to be used in conjunction with a standard door closer and may be associated with any new or existing door. It can be mounted on the door and is symmetrical for installation in either left hand or right hand doors. The door opener can be utilized with any type of contact closure, such as walk-on floor mats, photoelectric eyes, push-bars, or the like.

The door opener includes simple adjustment for the opening speed through operation of the variable resistor **60** and for the time delay through operation of variable resistor **78.**

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. An electric door opener to be operably connected to a door to open the same, comprising a uni-directional electric motor having an output shaft, a worm gear unit connected to said output shaft, gear means having an input and an output, electromagnetic clutch means interconnecting the worm gear unit and the input of the gear means, said clutch means having an engaged and a disengaged position, a pivotable linkage connecting the output of the gear means to the door, operation of said gear means acting to pivot the door through said linkage to an open position, approach switch means located ahead of the door and disposed to be actuated by a person approaching the door, means responsive to actuation of said approach switch means for engaging said clutch means and for supplying the combination of high voltage power and low voltage power to said motor, deactivation of said approach switch means curtailing the supply of power to said motor and disengaging said clutch means, and limit switch means responsive to opening of the door to a predetermined position for withdrawing the high voltage power and maintaining the supply of low voltage power to said motor whereby the low voltage power will retain the door in the open position.

2. The door opener of claim **1,** and including time delay means for delaying the curtailing of power to said motor and the disengagement of said clutch means for a predetermined time after deactuation of said approach switch means.

3. The door opener of claim **2,** and including safety switch means located behind the door and disposed to be actuated by a person located behind the door, and means responsive to actuation of said safety switch means for engaging said clutch means and for supplying the combination of high voltage and low voltage power to said motor, so that the door will be maintained in the open position while said safety switch means is actuated.

4. The door opener of claim **2,** and including means operably connected to said time delay means for selectively varying said predetermined time.

5. The door opener of claim **4,** and including means responsive to actuation of said approach switch means and said safety switch means for preventing opening of said door.

6. In combination, a door to enclose a doorway and movable between an open and a closed position; a door closer having a force operating to move the door from the open to the closed position; and a door opener separate from said door closer to move the door from the closed to the open position; said door opener comprising a uni-directional electric motor having an output shaft, a worm gear unit connected to said output shaft, gear means having an input and an output, electromagnetic clutch means interconnecting the worm gear unit and the input of the gear means, said clutch means having an engaged and a disengaged position, a pivotable linkage connecting the output of the gear means to the door, operation of said gear means acting to pivot the door through said linkage to an open position, approach switch means located ahead of the door and disposed to be actuated by a person approaching the door, means responsive to actuation of said approach switch means for engaging said clutch means and for supplying the combination of high voltage power and low voltage power to said motor, deactivation of said approach switch means curtailing the supply of power to said motor and disengaging said clutch means, and limit switch means responsive to opening of the door to a predetermined position for withdrawing the high voltage power, said low voltage power being sufficient to overcome the closing force of the door closer to

thereby maintain the door in the open position until deactivation of said approach switch means.

7. The combination of claim **6,** wherein said approach switch means is associated with a walk-on floor mat.

8. The combination of claim **6,** and including safety switch means located behind the door and disposed to be actuated by a person located behind the door, and means responsive to actuation of said safety switch means for engaging said clutch means and for supplying the combination of high voltage power and low voltage power to said motor, so that the door will be maintained in the open position while said safety swtich means is actuated.

9. The combination of claim **8,** wherein said safety switch means is associated with a walk-on floor mat.

10. The combination of claim **6,** and including time delay means for delaying the curtailing of power to said motor and the disengagement of said clutch means for a predetermined time after deactuation of said approach switch means.

11. In combination, a door to enclose a doorway and movable between an open and a closed position; a door closer to move the door from the open to the closed position, and a door opener to move the door from the closed to the open position, said door opener comprising an electric motor having an output shaft, a worm gear unit connected to said output shaft, gear means having an input and output, electromagnetic clutch means interconnecting the worm gear unit and the input of the gear means, said clutch means having an engaged and a disengaged position, a pivotal linkage connecting the output of the gear means to the door, operation of said gear means acting to pivot the door through said linkage to an open position, a first electrical circuit connected to a source of high voltage power, a transformer having a high voltage winding connected in said circuit and having a pair of low voltage windings, an approach switch located ahead of the door and disposed to be closed by a person approaching the door, a safety switch located behind the door and disposed to be closed by a person being in a position behind the door, a second electrical circuit connected to a first of said low voltage windings, said approach switch and said safety switch being connected in parallel in said second circuit, a relay connected in said second circuit and having a plurality of contacts, whereby closing of said approach switch or said safety switch will energize the relay to actuate said relay contacts, a third electrical circuit connected to the source of high voltage power, said motor and said clutch means and a first of said contacts being connected in series in said third electrical circuit whereby closing of said first contact through energization of said relay will operate said motor and engage said clutch means, a fourth electrical circuit connecting the second low voltage winding to said motor, a second of said contacts being connected in series with said motor in said fourth circuit, whereby energizing of the relay will close said second contact to thereby supply low voltage power to said motor, and a limit switch disposed to be actuated when the door is opened to a predetermined position and connected in the third circuit, actuating of the limit switch will open the third circuit to cut off the supply of high voltage power to the motor, whereby the low voltage power supplied to the motor through said fourth circuit will retain the door in the open position.

12. The combination of claim **11,** and including a capacitor connected in parallel with said relay in said second circuit, the discharge of said capacitor acting after opening of said approach switch means and said safety switch means to continue energization of said relay for a predetermined period of time.

13. The combination of claim **12,** and including a variable resistance disposed in parallel with said relay and said capacitor in said second circuit, adjustment of said variable resistance acting to adjust the predetermined period of time.

14. The combination of claim **11,** wherein a solid state switch unit is connected in said third circuit, said switch unit includes a triac and a diac, said limit switch being connected in said third circuit in a manner such that closing of said limit switch will bypass firing voltage to said switch unit and prevent firing of said triac to thereby cut off the supply of high voltage power to the motor.

15. The combination of claim **14,** and including voltage dividing means connected across said third circuit and including variable resistance means and a capacitor, said voltage dividing means arranged to set the voltage at which the triac fires to thereby vary the magnitude of the high voltage power supplied to the motor.

* * * * *