

[54] CLOSURE OPERATOR

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[51] Int. Cl. .... E05f 15/20

[58] Field of Search ..... 160/DIG. 17, 1-9, 160/84, 167, 168-178, 331

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Primary Examiner—Peter M. Caun  
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[57] ABSTRACT

A closure operator to effect remote, failsafe opening and closing of a damper, particularly a multi-fold or interlocking slat curtain damper.

A frame or shell envelops a damper curtain which is capable of opening and closing an air passage through the frame or shell. A housing containing an electromechanical curtain operator is optionally positioned within or outside the frame or shell. The curtain is lifted by a tray connected to two wire cables, in response to the winding of the cable upon a take-up drum located within the housing.

The drum rotates, when a driven spur gear coupled to the drum is engaged with a driving spur gear, by pivoting a motor which carries the driving gear.

This pivot action is effected by lifting a pivoting arm which is connected to the motor. This arm is lifted whenever a solenoid and its associated plunger are actuated to lift a lever upon which the arm rides. An electromagnet armature fixed to the lever is held by an electromagnet when the lever is lifted so that the motor is latched in the pivoted position as required.

Thus, if the motor is pivoted so that the spur gears are driven into engagement, the take-up drum is rotated to wind the cable and elevate the curtain.

Upon occurrence of (1) a manual switch operation to effect damper closure, (2) a power failure, (3) circuit malfunctioning, or (4) the detection of an undesired condition such as smoke or fire, the motor is released from its pivoted position permitting the spur gears to disengage. This allows the drum to unwind, thus lowering the curtain and closing the damper.

In a preferred embodiment of the take-up drum, the drum includes a relatively light-weight cable anchor which is mechanically coupled by a spring clutch to the other components of the take-up drum. This clutch is engaged when the curtain is lifted to open the damper, and the clutch is also engaged when the curtain is released to close the damper. Ultimately, the clutch is disengaged when the curtain attains full closure. At this point of operation, the anchor is freed from the other drum components.

With this arrangement, the forces of drum momentum acting upon the cable and tending to rewind the cable in the opposite direction when the curtain is released are substantially minimized because the mass of the anchor is freed from the other components. Without this feature the cable is excessively flexed and strained and, therefore, has an unsatisfactory operational life. Additionally, other operator components, such as those directly related to the cable will also have a reduced operational life due to forces generated by the tendency to rewind the cable.

An air vane latch is also optionally associated with the curtain operator to delay curtain closure until the forces generated by the air passing through the damper have been reduced to permit safe lowering of the curtain.

10 Claims, 16 Drawing Figures

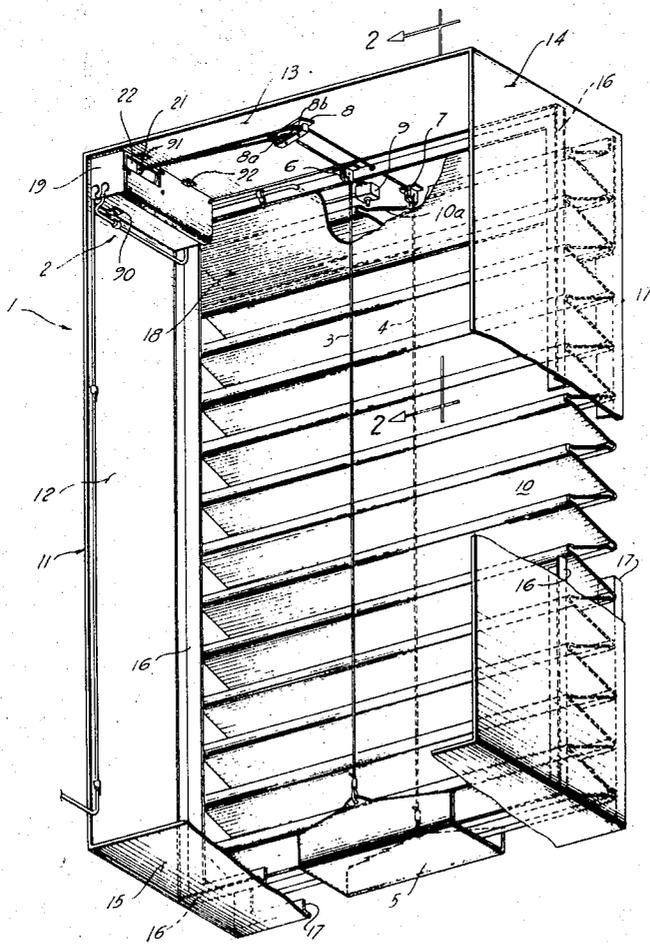
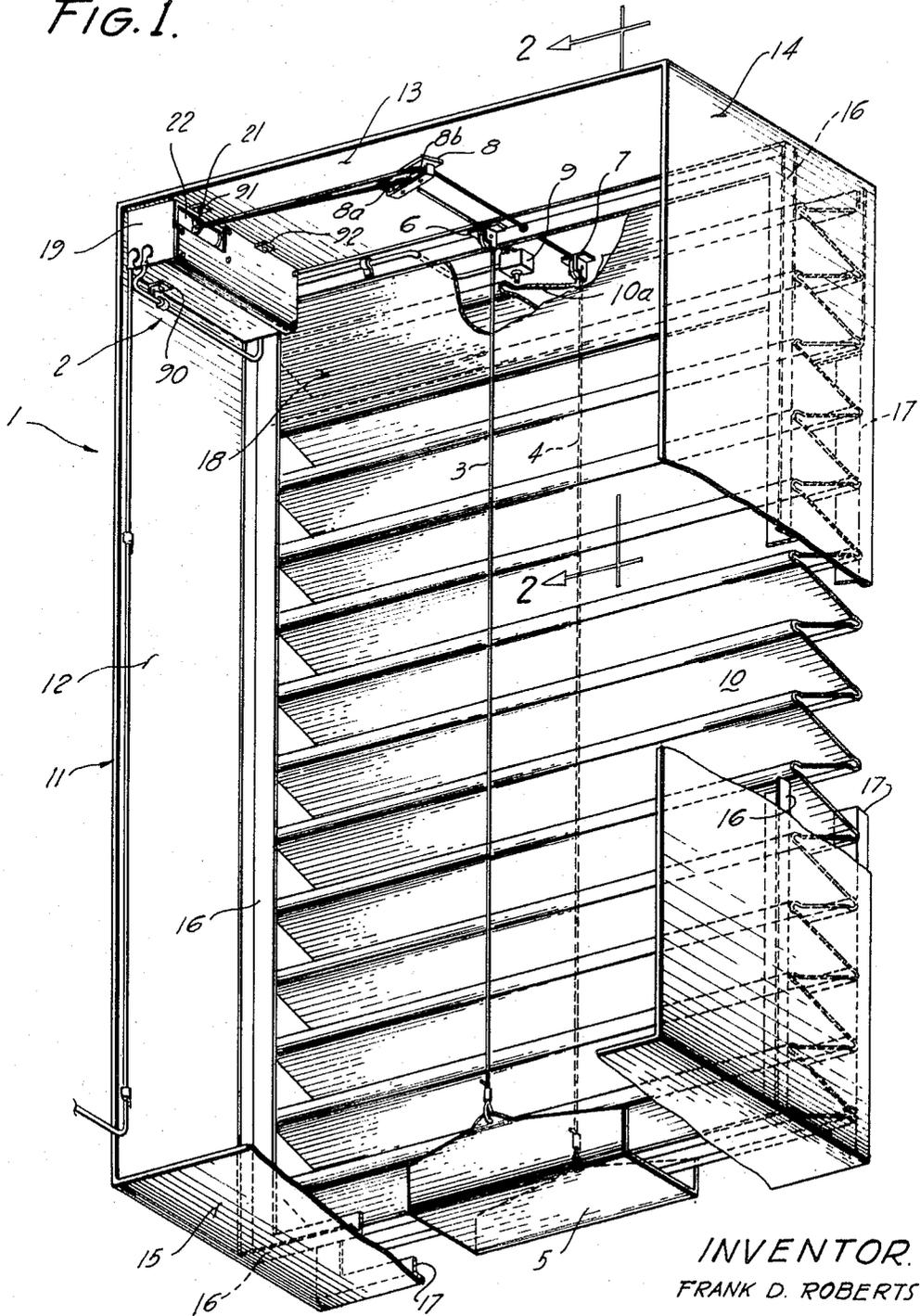


FIG. 1.



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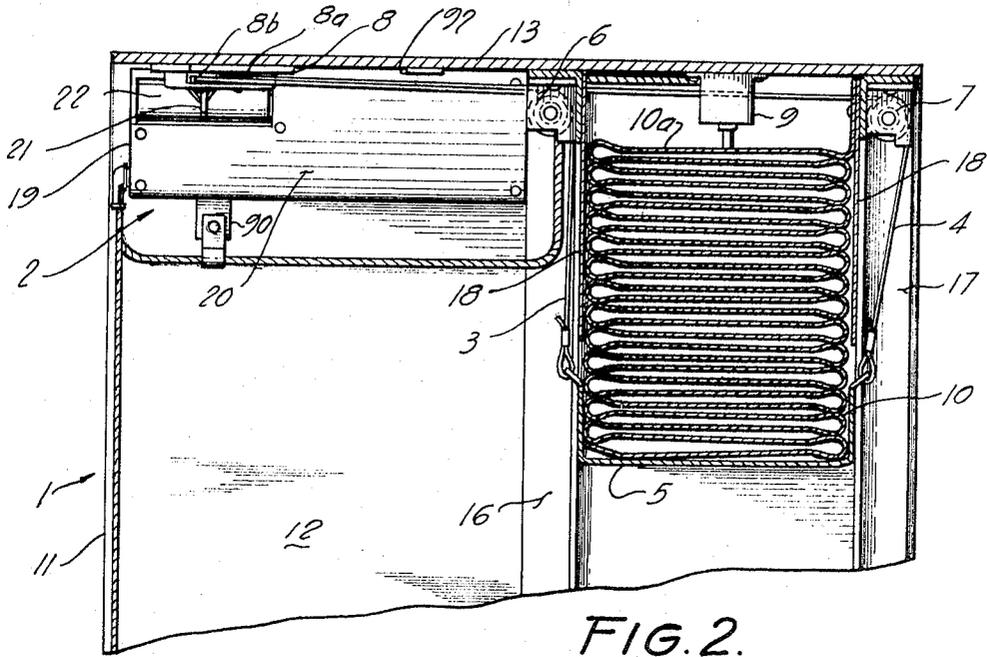


FIG. 2.

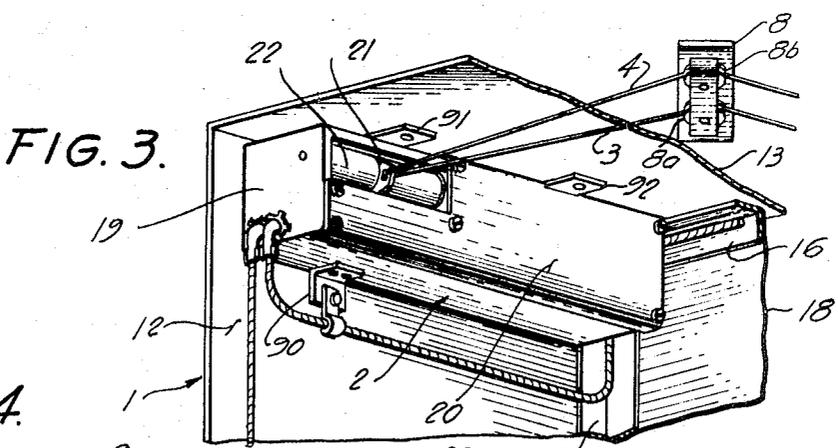
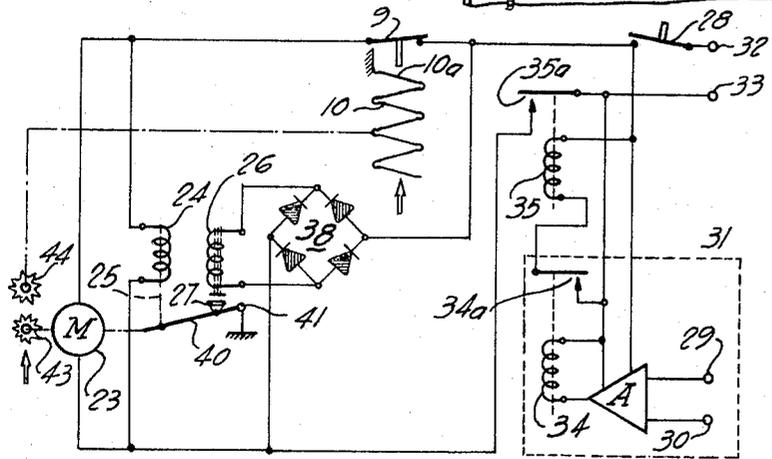


FIG. 3.

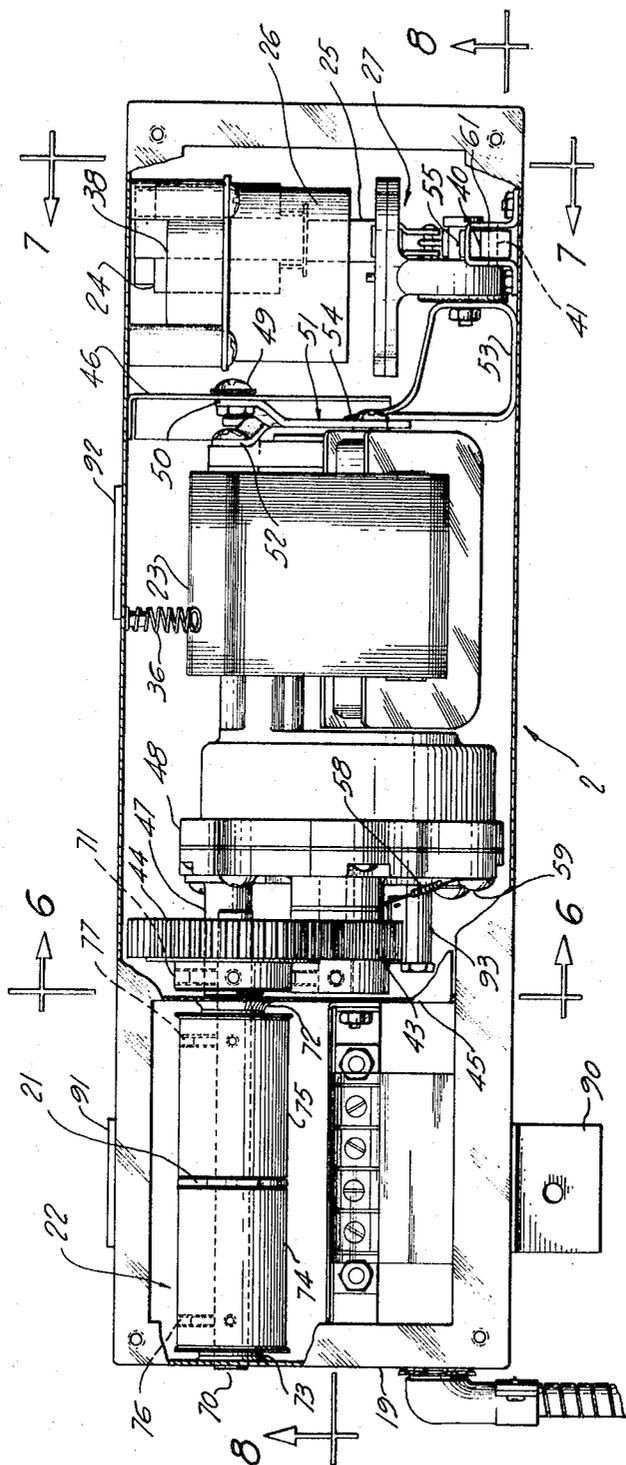
FIG. 4.



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FIG. 5.



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FIG. 6.

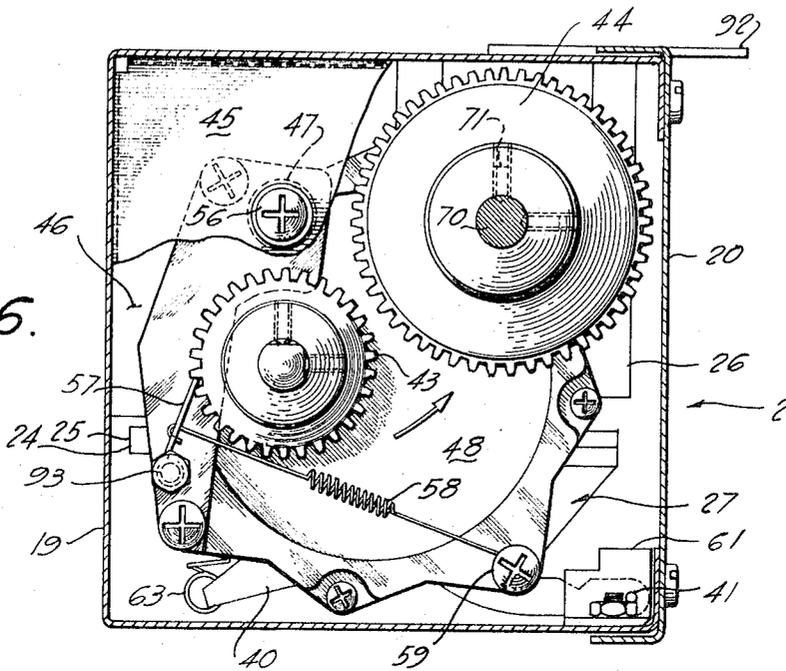
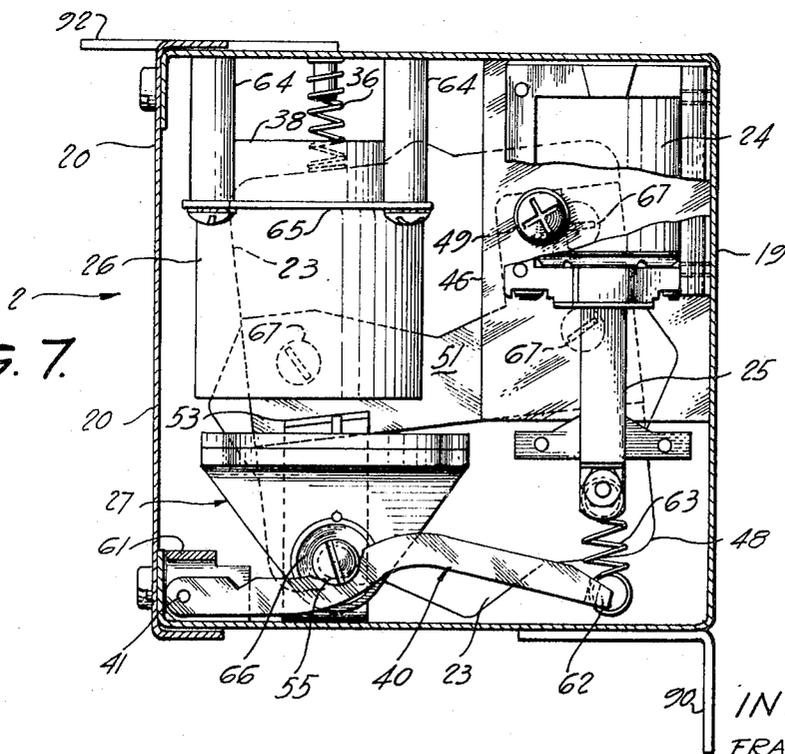


FIG. 7.



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FIG. 8.

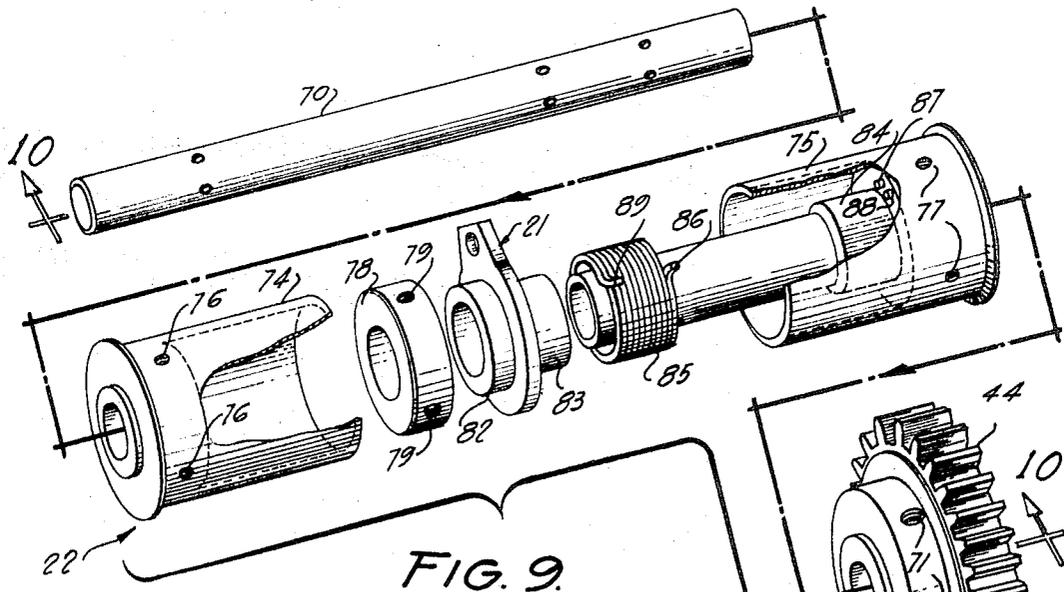
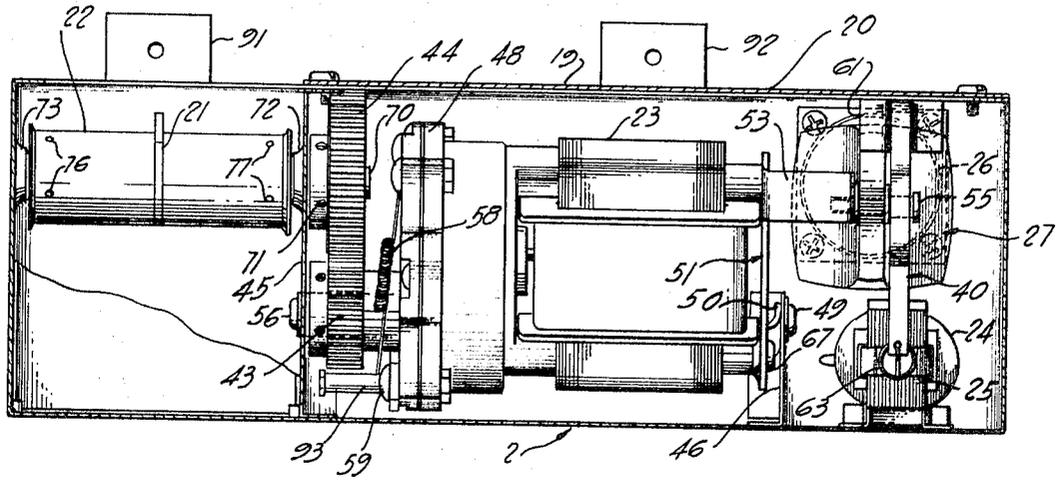


FIG. 9.

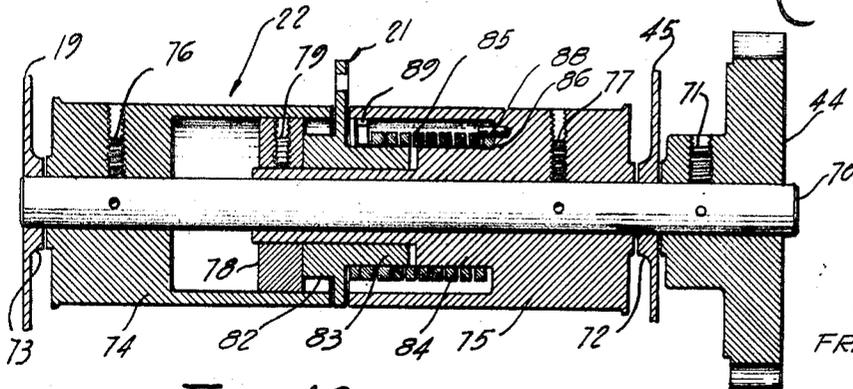


FIG. 10.

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FIG. 11.

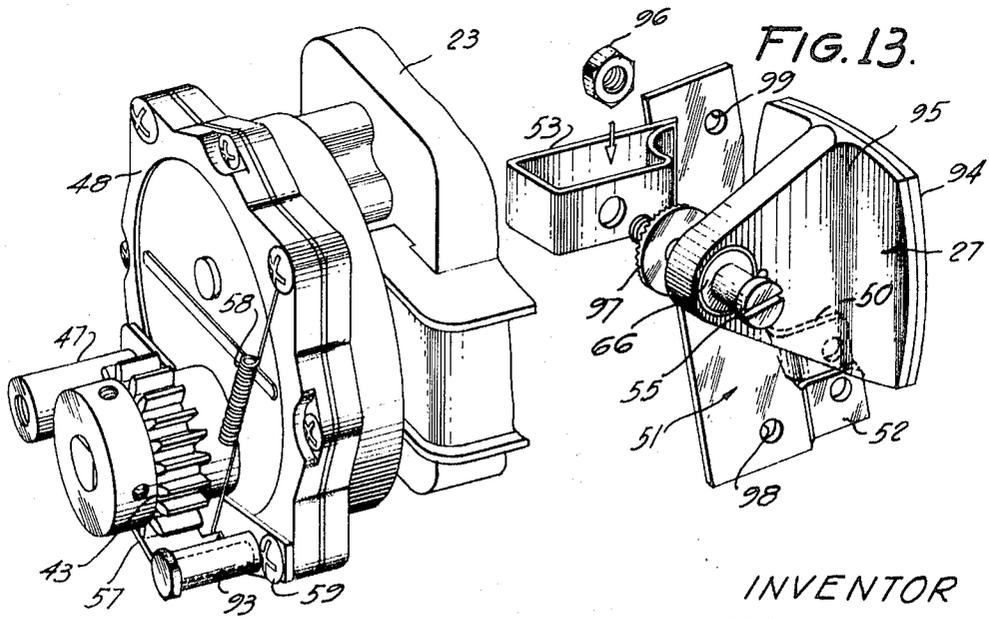
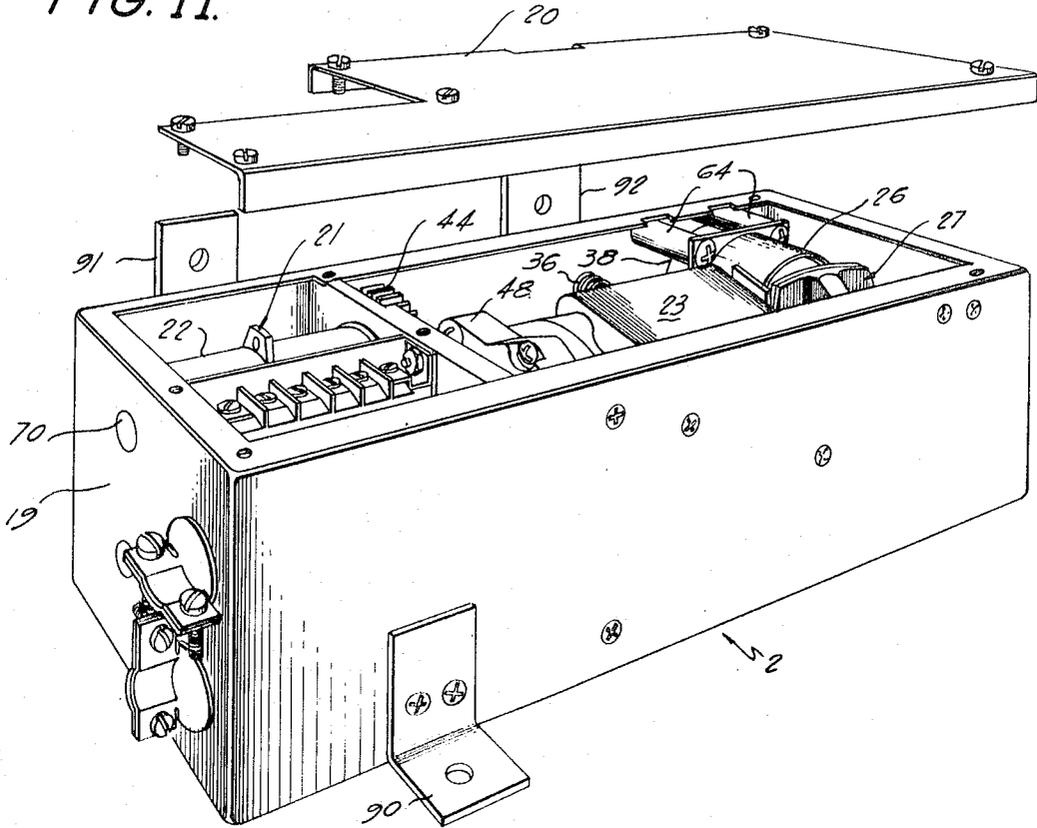


FIG. 12.

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FIG. 14.

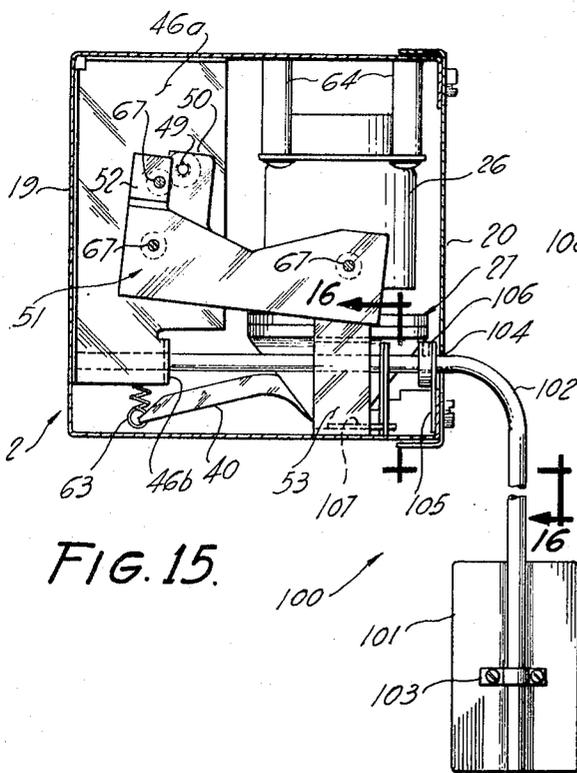
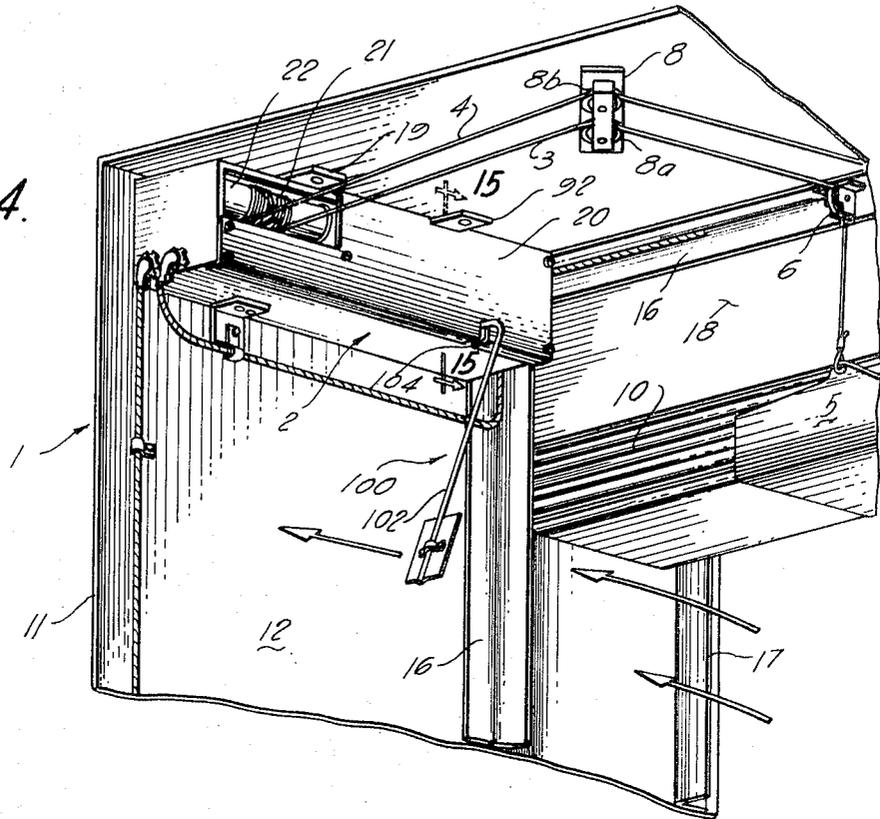


FIG. 15.

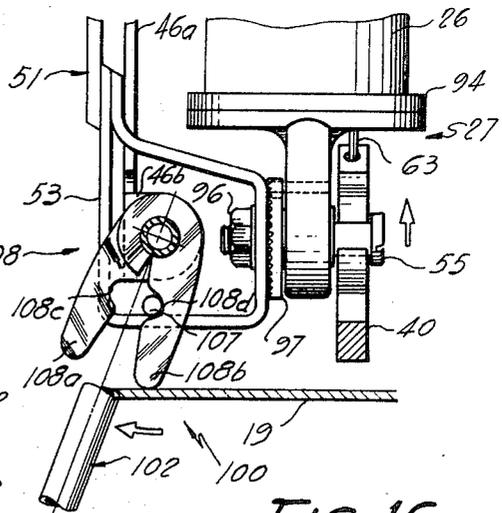


FIG. 16.

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## CLOSURE OPERATOR

## BACKGROUND OF THE INVENTION

In recent years an increased emphasis has been placed upon the need for improved safety devices to minimize the loss of life and property occurring from the products of combustion. The prevalence of large buildings with air conditioning and ventilating ducts through walls requires the installation of dampers in these openings to isolate an unsafe building area from the remaining areas in the event of a hazardous condition. These dampers must close reliably in the event of a fire, otherwise the products of combustion will travel through the damper containing ducts or fire walls. Additionally, the dampers should preferably be capable of restoration to an open condition without extensive manual servicing occasioned by the necessary replacement of components, such as fusible links, or the rearming of the damper operator by reengaging various linkages.

The damper control system should also be failsafe in the sense that a power failure, or other circuit malfunction in the undesired-condition detecting system will automatically close the damper. Additionally, upon restoration of power, or correction of the circuit malfunction, the damper must be operated without the necessity for a serviceman to obtain access to the damper to replace or rearm components.

## DESCRIPTION OF THE PRIOR ART

Almost invariably damper control devices of the prior art have employed fusible links. The melting of these links effects damper closure by activating a closer mechanism. The use of fusible links is generally unsatisfactory due to the delay involved in melting the link which enables the products of combustion to spread. Additionally, such systems are not failsafe; and they require manual replacement of each link before the dampers are readied for further operation.

Examples of fusible link systems are shown in U.S. Pats. Nos. 3,467,163, 3,337,991 and 3,273,632.

Other remotely related patents have described louver, vane or door positioners. The controls for these devices have in some instances dispensed with fusible links, but in most instances, the systems are either not failsafe, or alternatively, upon occurrence of an undesired condition, manual restoration of the system is required.

Examples of these systems appear in U.S. Pats. Nos. 3,249,148, 3,219,104, 3,207,273, 3,177,367, 3,164,404 and 2,980,970.

## SUMMARY OF THE INVENTION

The closure operation of this invention features a drum and its motor drive housed and mounted adjacent the damper frame. In a preferred embodiment, the closure operator is located in a duct or fire wall which is remote and difficult to service.

Inasmuch as a fusible link is eliminated, and a quickly responsive fire or smoke detector, such as a photocell or ionization type sensor, is employed, damper closure is effected before the products of combustion have a chance to spread.

A manual switch remotely located can also open or close the damper as required.

In the event of a power failure, or circuit malfunctioning, the damper automatically closes. Upon correction of these conditions, the damper is automatically restored to the desired position.

The structure for attaining these functions is briefly described in the foregoing abstract, and in more detail in the specification appearing hereafter.

## DETAILED DESCRIPTION OF THE DRAWINGS

In order that all of the structural features for attaining the objects of this invention may be understood, reference is made to the following drawings wherein:

FIG. 1 is a perspective view showing the closure operator of this invention typically positioned within the damper frame and applied to a multi-fold curtain damper with the individual folds shown in the damper closed position;

FIG. 2 is a section view taken along line 2—2 of FIG. 1 with the modification, however, that the curtain has been folded to the damper open position;

FIG. 3 is a perspective view of that portion of the damper and frame including the curtain operator housing and the guide pulleys adjacent the housing;

FIG. 4 is a schematic circuit diagram showing the electrical connection of the drum drive motor, its pivoting electrical components (solenoid-plunger, electromagnet-armature), limit microswitch, and manual operate switch to a condition detector (smoke or heat, for example) to effect failsafe operation of the damper;

FIG. 5 is a side elevation of the curtain operator with the housing cover removed;

FIG. 6 is a section view taken along line 6—6 of FIG. 5 showing the drum driving and the motor driven spur gears disengaged;

FIG. 7 is a section view taken along line 7—7 of FIG. 5 showing the electromechanical assembly for lifting the lever and the pivoting arm carried thereby to pivot the motor to engage the spur gears;

FIG. 8 is a bottom view of the curtain operator with the housing bottom broken away;

FIG. 9 is an exploded view of the cable take-up drum including the cable anchor clutch;

FIG. 10 is a section view taken along line 10—10 of FIG. 9;

FIG. 11 is a perspective view of the curtain operator with the housing cover removed;

FIG. 12 is a perspective view of the drum drive motor, the reduction gear box, and the motor driven spur gear;

FIG. 13 is a perspective view of the electromagnet-armature, the motor pivoting arm, and the lever actuated lift arm;

FIG. 14 is a view corresponding to FIG. 3 modified to show an air vane latch;

FIG. 15 is a section view taken along line 15—15 of FIG. 14 (modified to show the air vane latch disengaged from the latch pin); and

FIG. 16 is a section view taken along line 16—16 of FIG. 15 (modified to show the air vane latch engaging the latch pin).

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the opening and closing of multi-fold curtain damper 1 is controlled by a closure operator the main components of which include curtain operator 2, wire cable sections 3, 4 which are a continuous length, curtain lift tray 5 to which the ends of wires 3, 4 are tied, single cable pulleys 6 and 7, paired cable pulleys 8 which include two single pulleys 8a and 8b, and a limit microswitch 9.

Multi-fold curtain damper 1 is of conventional construction in which curtain 10 is formed from a plurality of sheet metal folds. Alternatively, the curtain may be formed from hinged slats. Curtain 10 is enveloped or housed within frame or shell 11 which includes side wall 12, top 13, side wall 14, and bottom 15.

Curtain 10 is sandwiched between guide angles 16 and 17, both of which angles are formed into continuous individual rectangles. These guide angles constrain possible lateral movements of curtain 10 within permissible limits.

A pair of baffle plates 18 extend between the upper portions of guide angle 16 and angle 17 so that curtain 10 is located entirely between these plates when folded. Thus, dirt and other foreign particles are not collected excessively within the deep recesses of curtain 10 when this curtain is in the elevated position.

The electromechanical components comprising curtain operator 2 are housed within box housing 19 which includes a removable cover 20. The upper left corner of cover 20 is

notched so that wires 3, 4 are connected to anchor 21 of take-up drum 22.

As is hereafter explained in detail, when drum 22 and its anchor 21 rotate in a counterclockwise direction (as is viewed in FIG. 1), wires 3, 4 are wound around the drum cylinder sections, thus elevating tray 5 and lifting curtain 10.

As is shown in the partial section view of FIG. 2, tray 5 lifts curtain 10 sufficiently so that the top fold 10a of the curtain makes contact with the actuating arm of normally closed limit microswitch 9. When the contact occurs, take-up drum 22 ceases its rotation. Thus, the damper is maintained in the open position shown in FIG. 2.

FIG. 3 is an enlarged perspective view of that portion of damper 1 and frame 11 including the curtain operator housing 19 and the paired cable pulleys 8 located adjacent the housing. It should be noted that this pulley pair is mounted at an angle relative curtain operator housing 19, so that wires 3, 4 may be turned to a direction at which the portions of these wires between pulley pair 8 and drum 22 are essentially radial to the drum. With this disposition of the wires, cable anchor 21 can smoothly wind these wires upon the drum cylinders during the lifting of the curtain.

FIG. 4 is a schematic circuit diagram which includes the electrical components of curtain operator 2 located within housing 19 so that take-up drum 22 may be appropriately rotated.

The schematic circuit diagram shows the electrical connection of drum drive motor 23, its pivoting electrical components (solenoid 24-plunger 25; electromagnet 26-armature 27), limit microswitch 9, and manual operate switch 28 to a condition detector (not shown), connected to amplifier input terminals 29 and 30.

The schematic circuitry incorporates a condition responsive detector and amplifier unit 31 which is failsafe in operation. In particular, if all of the components of detector and amplifier circuitry 31 are properly operative, damper 1 will open upon the manual closure of switch 28. If, however, detector and amplifier unit 31 is not properly operative or, alternatively, the detector (not shown) connected to input terminals 29 and 30 senses a condition such as flame or smoke, damper curtain 10 will drop if raised or will remain lowered if in a closed position.

Detailed operation of the circuitry of FIG. 4 is as follows.

Assuming detector and amplifier unit 31 is in proper operating condition and that the detector (not shown) input at terminals 29 and 30 indicates an absence of a flame or smoke condition, damper 1 may be opened or closed in response to the manual operation of switch 28. That is, closure of switch 28 applies line voltage from line terminals 32 and 33 to amplifier A of detector and amplifier unit 31. The application of line voltage to amplifier A energizes amplifier output relay 34, thereby closing normally open contact 34a.

The closure of contact 34a applies line voltage to the winding of power relay 35. With this occurrence, normally open power relay contact 35a is closed, thereby applying line voltage to energize motor 23, solenoid 24 and electromagnet 26 through rectifying bridge 38. When solenoid 24 is energized, plunger 25 is drawn upwardly in a characteristic manner into the bore of solenoid 24. This upward movement of plunger 25 lifts lever 40 which is anchored at pivot 41.

Magnetic armature 27 is pivotally coupled to the body of lever 40; therefore the upward movement of lever 40 carries armature 27 into the effective magnetic field of electromagnet 26. When this is done, armature 27 is magnetically fixed to the core of electromagnet 26, thereby latching lever 40 in its upward position, irrespective of the energized condition of solenoid 24.

Solenoid 24 and electromagnet 26 are both required to pivot and latch lever 40 because of the mechanical construction of the elements. In particular, a solenoid-plunger combination (that is 24-25) is capable of producing a greater movement in lever 40 than can an electromagnet-armature combination (26-27). Thus, solenoid-plunger combination

24-25 produces a starting movement of lever 40 until armature 27 is magnetically attracted by electromagnet 26; thereafter, electromagnet 26 and its armature 27 are sufficiently attracted to retain lever 40 in its upward position.

When lever 40 is pivoted upwardly, motor 23 which is coupled thereto mechanically is also pivoted thereby carrying its driving spur gear 43 into engagement with driven spur gear 44.

As is hereafter set forth, driven spur gear 44 is connected directly to take-up drum 22; thus, the rotation of gear 44 produces a responsive rotation in drum 22 which causes wires 3, 4 to wind upon the cylinders of drum 22, thus lifting tray 5 and causing curtain 10 to fold.

When curtain 10 is sufficiently folded so that top fold 10a opens microswitch 9 (see FIG. 2), motor 23 is deenergized as is also solenoid 24. Lever 40, however, is held in the upward position due to the fact that latching electromagnet 26 still holds its armature 27 in place inasmuch as the electromagnet energizing circuit is not broken. Motor 23, therefore, maintains the pivoted position by which driving spur gear 43 is engaged with driven spur gear 44. Thus drum 22 and the forces exerted thereon by the spur gears and the motor are enabled to hold curtain 10 in the open or lifted position as is shown in FIG. 2.

Assuming curtain 10 to be in the lifted position shown in FIG. 2, in the event of (1) a power failure appearing at terminals 32 and 33, (2) an opening of manual operate switch 28, (3) a malfunctioning of detector and amplifier unit 31, or (4) the sensing of an undesired condition at input terminals 29, 30, then amplifier output relay 34 releases its contact 34a. This in turn causes deenergization of power relay 35 which in turn releases its contact 35a.

With the occurrence, line voltage is no longer applied to rectifying bridge 38 to energize electromagnet 26. The electromagnet, therefore, releases armature 27 which enables lever 40 to pivot downwardly carrying with it motor 23 and driving spur gear 43. Spur gears 43 and 44 are thus disengaged.

The weight of the curtain carried by wires 3, 4 through anchor 21 causes drum 22 to rotate so that the curtain 10 is immediately lowered.

When curtain 10 has been lowered completely, the mass of cable anchor 21 is disengaged from the substantially greater mass of take-up drum 22 by the clutch. Thus, there is no tendency for the rapid dropping of curtain 10 to cause wires 3 and 4 to exert sufficient rewind momentum on the light mass cable anchor. The anchor will not rewind the wires in the opposite direction upon the cylinders of take-up drum 22. As previously noted in the introductory portion of the specification, without this feature wires 3, 4 are excessively strained and flexed. The associated operator components could also be damaged. These strains can cause premature breakdown which cannot be tolerated in reliable damper operation.

The general physical disposition of the electrical and mechanical components (diagrammatically and schematically represented in FIG. 4) is shown in FIG. 5. This figure is in general a side elevation of curtain operator 2 with housing cover 20 removed to show the internal components.

Take-up drum 22 and its cable anchor 21 are disposed in the upper left corner of the housing. Drum drive motor 23 is centrally disposed; and electromagnet 26, its armature 27, solenoid 24 and its plunger 25 are disposed at the right end portion of housing 19.

In this figure, it is important to note the general structure by which motor 23 is pivoted upwardly in opposition to coil spring 36 so as to bring driving spur gear 43 into engagement with driven spur gear 44. Inasmuch as driven spur gear 44 is shaft coupled to drum 22, this engagement effects rotation of the drum.

The pivoting of motor 23 occurs on two brackets 45 and 46. Bracket 45 is in effect a partition which subdivides the cavity within housing 19 so that drum 22 is located on the left of this partition and spur gear 44 which is coupled to the drum is located on the right of the partition. Pivot post 47 is located

immediately below spur gear 44 in this view. This post extends between plate 45 and reduction gear housing 48 of motor 23 and is fixed to the reduction gear housing. Pivot post 47 is so coupled to bracket 45 and housing 48 that the motor 23, housing 48 and the driving spur gear 43 pivots relative bracket 45 on pivot post 47.

Pivot nut and bolt 49 are carried on bracket 46. Bent flange 50 is pivotally coupled to pivot 49. This flange is a part of motor pivot arm 51 which is rigidly fixed to motor 23 by means of bent flange 52 and three screws 67 (FIG. 7).

Motor pivot arm 51 includes a coupling loop 53 which is joined to the body of the arm by weld 54.

Lift arm 55 couples armature 27 to loop 53. When lift arm 55 is elevated by lever 40, as is explained hereafter, motor pivot arm 51 is elevated, thereby pivoting motor 23 and driving spur gear 43 on pivot post 47 and pivot 49. It should be noted that pivot 47 and pivot 49 are in axial alignment.

The structural details of the general assembly of FIG. 5 is better shown in the views hereinafter described. In particular, the section view of FIG. 6 shows screw 56 upon which pivot post 47 pivots relative support bracket 45. The axis of screw 56 serves as the pivot axis for motor 23 and reduction gear housing 48. When the motor and the reduction gear are moving in the counterclockwise direction (of the arrow) about screw 56, driving spur gear 43 is engaged with driven spur gear 44.

Pawl 57 is held in engagement with spur gear 43 by helical spring 58. The left end of spring 58 is hooked to pawl 57; and the right end of spring 58 is anchored on screw 59 which is attached to reduction gear housing 48.

FIG. 7 is a section view taken along line 7—7 of FIG. 5. This figure shows the electromechanical assembly for pivoting lever 40 upwardly to lift arm 55 which in turn elevates loop 53 which is a part of motor pivot arm 51. This lifting action pivots motor 23 about screw 56 and pivot 49 as previously outlined with reference to FIG. 5.

Lever 40 has a generally irregular shape in side elevation, the left end of which is pivoted on pivot 41 which is carried on pivot bracket 61. The right end of lever 40 is formed with a hook 62 which engages helical spring 63. The upper end of helical spring 63 is coupled to T-plunger 25. T-plunger 25 is received within the bore of solenoid 24 when this solenoid is energized as previously explained with reference to the schematic circuit diagram of FIG. 4. A portion of solenoid 24 is broken away so that pivot 49 which is supported on bracket 46 may be shown.

Electromagnet 26 is supported relative housing 19 by four posts 64.

The rectifiers comprising bridge circuit 38 are sealed within a pot located on the upper side of electromagnet support plate 65.

As is hereafter explained, armature 27 is coupled to lift arm 55 by spherical bearing 66. This enables armature 42 to align itself in low reluctance contact with the adjacent surface of electromagnet 26 when this electromagnet is energized.

Pivot arm 51 is coupled to motor 23 by three screws 67 which engage motor 23.

It will be recalled with reference to the operation of the circuit of FIG. 4, that solenoid 24 is first energized. When this solenoid is energized, T-plunger 25 is drawn into the bore of the solenoid, thus lifting the right end of pivot 40 by a lifting force exerted by helical spring 63.

When the right end of lever 40 is elevated, lift arm 55 is carried upwardly to bring armature 27 into magnetic attraction engagement with electromagnet 26. With this occurrence, electromagnet 26 and armature 27 latch lever 40 in the pivoted or elevated position, and motor 23 is pivoted relative pivots 56 and 49 so that spur gears 43 and 44 are engaged to thus drive drum 22.

It will be recalled that after curtain 10 is lifted to the position at which top fold 10a opens microswitch 9, solenoid 24 and motor 23 are deenergized. Electromagnet 26, however, is not deenergized at this time and inasmuch as the magnetic at-

traction forces of this electromagnet are sufficient to hold armature 27 into contact with electromagnet 26, motor 23 remains in the pivoted position which is required to hold drum 22 from unwinding in opposition to the spur gears.

FIG. 8 is a bottom view of curtain operator 2 with the housing bottom broken away. This view shows the components previously described with reference to FIGS. 5 through 7 from the bottom and therefore further detailed explanation is not required.

FIGS. 9 and 10 show the details of take-up drum 22 and cable anchor 21. FIG. 9 is an exploded view of the components shown in the sectional view of FIG. 10.

Referring to these two figures, spur gear 44 is fixed to drive shaft 70 by set screw 71. Drive shaft 70 is supported on boss bearing 72 formed in bracket 45 and boss bearing 73 formed adjacent the end wall of housing 19.

Drum cylinders 74 and 75 are fixed to shaft 70 by set screw 76 and 77, respectively.

Clutch retaining collar 78 is fixed to drum cylinder 75 by set screw 79. Cable anchor 21 is sandwiched between clutch collar 78 and drum cylinder 75.

Cable anchor 21 is formed with an annular flange 80 which has an apertured projection 81 which receives wires 3, 4 as has been previously described. Annular flange 80 is integral with hubs 82 and 83 which have different diameters. Drum cylinder 75 includes a shoulder 84 which is adjacent hub 83.

Helical spring 85 is carried on hubs 83 and shoulder 84.

Nib 86 of spring 85 is locked between anchor posts 87 and 88; and nib 89 of spring 85 merely facilitates the opening of the spring to permit easy assembly. When spur gear 44 is rotated in such a direction that drum cylinder 75 tends to wind spring 85, the spring is tightened on hub 83 and shoulder 84, thereby locking these elements and causing anchor 21 to rotate in engagement with drum cylinder 74 and 75 which are fixed to drive shaft 70. In particular, anchor 21 is engaged to the remaining drum portions of drum 22 whenever wires 3, 4 are wound upon cylinders 74 and 75.

When drive spur gear 44 is released from driving spur gear 43, spring 85 maintains its engaged position relative hub 83 and shoulder 84. When curtain 10 is fully lowered, wires 3, 4 restrain anchor 21. At this point of operation, the spring clutch disengages forcing anchor 21 and allowing the mass of the remaining components of drum 22 to continue to rotate until the forces which would otherwise tend to rewind the wires are dissipated. As soon as all drum 22 components attain a static condition, the clutch again engages anchor 21 to the remaining components.

FIG. 11 is a perspective view of curtain operator 2 with housing cover 20 removed. Brackets 90, 91 and 92 which are fixed to housing 19 support the curtain operator 2 relative frame 11.

FIG. 12 is a perspective view of drum drive motor 23, reduction gear box 48, and driving spur gear 43.

Additionally, pivot post 47 is also shown fixed to reduction gear 48; and post 93 upon which pawl 57 pivots is also shown. Pawl 57 locks spur gear 43 in the reverse drive direction.

FIG. 13 is a perspective view of electromagnet-armature 27.

Armature 27 comprises a magnetic plate 94 which is fixed to a nonmagnetic (aluminum, for example) plate carrier 95. Lift arm 55 passes through a hole formed in plate carrier 95 which houses a spherical bearing 66 which enables armature 27 to swivel to a limited degree relative lift arm 55. Lift arm 55 is fixedly coupled to loop 53 of motor pivot arm 51 by nut 96 and serrated lock washer 97.

In this view, the construction of bent flanges 50 and 52 is clearly shown. Bent flange 50 receives pivot nut and bolt 49 so that motor 23 pivots on bracket 46. The hole in bent flange 52 and holes 98 and 99 formed in motor pivot arm 51 receive the three screws 67 shown in FIG. 7 which couple pivot arm 51 to motor 23.

FIGS. 14 through 16 show an air vane latch 100 which is optionally associated with curtain operator 2. Air vane latch 100 delays the closure of curtain 10 until the forces generated by

the passing of air through damper 1 have been reduced to permit safe lowering of curtain 10.

In particular, air vane latch 100 comprises a flat plate-like vane 101 which is fixed to the generally vertical leg of tubular elbow 102 by clamp 103.

As is particularly shown in FIG. 14, vane 101 projects into the air flow passage of damper 1 when curtain 10 is elevated as is shown in this figure. Cover 20 is modified to include slot 104, so that the horizontal arm of elbow 102 may be supported within housing 19 of closure operator 2.

As is shown in FIG. 15, the horizontal arm of elbow 102 is rotatably supported within housing 19 by bearing flange 46b and bracket bearing 105. In the bracket modification 46a shown in FIGS. 15 and 16 incorporating the air vane latch, bracket 46 shown in the prior figures is modified to include flange bearing 46b so that the horizontal arm of elbow 102 may be supported by and pivoted with respect to this bearing.

Bracket bearing 105 is rigidly fixed to housing 19 by a weld or other means. This bearing is formed with a hole through which the horizontal arm of elbow 102 passes. Collar and set screw 106 are carried by the horizontal arm of elbow 102 so that the collar prevents axial movement of elbow 102 relative to the components of curtain operator 2.

As is shown in FIGS. 15 and 16, loop 53 which is fixed to motor pivot arm 51, carries latch pin 107. Latch pin 107 is rigidly fixed to loop 53 by a weld so that this pin moves correspondingly with the movements of loop 53.

Latch 108, which is a pair of ears 108a and 108b, is rigidly fixed to the horizontal arm of elbow 102. Latch ear 108a is formed with a latch notch 108c; and latch ear 108b is formed with a latch notch 108d. As is shown in the drawings of FIGS. 15 and 16, air vane latch 100 is not "handed". That is, latch pin 107 is engaged by latch 108 irrespective of the direction of rotation of elbow 102. For all practical purposes, inasmuch as air flow through damper 1 will be generally in one direction, namely right to left as is shown in FIG. 14, latch ear 108a in this situation is surplusage.

The operation of air vane latch 100 is as follows. In the event that damper curtain 10 is closed, as previously explained, electromagnet 26 will be deenergized and armature 27 will be separated from the electromagnet. With this conditioning of components, loop 53 rests against the bottom of operator housing 19. Accordingly, spur gears 43 and 44 are disengaged as previously outlined.

When electromagnet 26 is energized and armature 27 is drawn thereto, lever 40 carries lift arm 55 upwardly thereby elevating loop 53. The elevation of loop 53 carries latch pin 107 from its position shown in FIG. 15 to its elevated position shown in FIG. 16.

Flow of air through damper 1 in a right to left direction, as is shown in FIG. 14, exerts a force against vane 101 which rotates elbow 102 in such a direction that notch 108d of latch ear 108b engages pin 107.

With this latching engagement, loop 53 and motor pivot arm 51 latch in the pivoted position at which spur gears 43 and 44 are engaged.

So long as these spur gears are engaged, take-up drum 22 retains wire coils 3, 4 to prevent lowering of curtain 10.

When the circuit of FIG. 4 is operated as previously outlined so that the system calls for lowering of curtain 10, air vane latch 100 maintains spur gears 43 and 44 in an engaged position until such time that the wind forces passing through damper 1 are reduced sufficiently that vane 101 will return to a vertical position.

With this vertical positioning of vane 101, pin 107 is disengaged from latch 108, accordingly loop 53 and its associated motor pivot arm 51 are lowered from the position shown in FIG. 16 to that shown in FIG. 15. With this recurrence spur gears 43 and 44 are disengaged, thus enabling drum 22 to unwind responsively uncoiling wires 3, 4 to permit lowering of curtain 10.

Air vane latch 100 is a safety feature inasmuch as it prevents the lowering of curtain 10 until such time that the air forces within damper 100 are safely reduced.

It should be understood that the structures previously shown are merely preferred embodiments and that modifications can be made to these structures without departing from the scope of the invention.

5 What is claimed is:

1. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, and electromechanical means responsive to all of the following three conditions to release an opened damper curtain upon the occurrence of any one or more of the following:

- a. a power failure;
- b. the opening of a manual operate switch; or
- c. the malfunctioning of undesired condition sensing apparatus.

2. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, a housing enclosing the curtain operator and located within an upper corner of the damper frame adjacent the curtain with the curtain masking the operator and laterally offset therefrom when the curtain is folded so that the housed curtain operator will not obstruct air flow through the damper when the curtain is folded, the operator drum being disposed within the housing and rotatable on an axis perpendicular to the plane of motion of the curtain, and the housing being formed with an access opening through which the one or more cable sections pass for winding and unwinding on the drum to move responsively the curtain relative the frame.

3. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, the drum including a clutch, a wire cable anchor, and one or more drum cylinders which receive the one or more wires during a winding operation on the drum surface, the clutch engaging the anchor to the drum in the wire take-up direction to enable winding of the wire about the drum and the anchor being disengaged from the remaining drum components when the curtain is lowered to its fully closed position to free the anchored wire from the momentum of the unwinding one or more drum cylinders.

4. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage

defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, a motor to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, means capable of selectively engaging the motor output to drive the drum in response to the pivoting of the motor, the selective engaging means including a driven spur gear coupled to the drum and a driving spur gear coupled to the motor, and in which the means for pivoting the motor includes a lever, an arm coupled to the motor, and electromagnetic means for moving the lever to move responsively the arm to pivot the motor to lock engagingly the spur gears one to the other to drive the drum to elevate the curtain, and means for deenergizing the electromagnetic means to enable the motor to pivot in response to the force of gravity to disengage the spur gears to enable the drum to be freed from the motor to effect rapid lowering of the curtain.

5. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, a motor to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, means capable of selectively engaging the motor output to drive the drum in response to the pivoting of the motor, the selective engaging means including a driven spur gear coupled to the drum and a driving spur gear coupled to the motor, means for pivoting the motor including a lever, an arm coupled to the motor, electromagnetic means for moving the lever to move responsively the arm to pivot the motor to lock engagingly the spur gears one to the other to drive the drum to elevate the curtain, means for deenergizing the electromagnetic means to enable the motor to pivot in response to the force of gravity to disengage the spur gears to enable the drum to be freed from the motor to effect rapid lowering of the curtain, and the electromagnetic means including a solenoid-plunger coupled to the lever, a solenoid to draw the plunger into the bore of the plunger, a magnetic armature coupled to the lever, and an electromagnet associated with the armature, and in which the energization of the solenoid draws the plunger thereby moving the lever, and thus its coupled armature into magnetic holding attraction by the electromagnet so the lever is latched when the solenoid is deenergized thus maintaining the motor in the pivoted position.

6. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is

anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, coupling means including an element connected to the drum and an element connected to the motor which elements are engaged only when the motor is pivoted, and means for pivoting the motor to engage the elements when the curtain is lifted and to disengage the elements when the curtain is lowered, the pivoting means including means to initiate pivoting of the motor, and also additional means for latching or holding the motor into the pivoted element engaging position when the initiating means is deactivated.

7. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper, in which the drum includes a relatively low mass cable anchor which is locked to the drum when the cable is wound thereon, and disengaged from the remaining portions of the drum when the curtain is completely lowered.

8. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means including one or more wire cable sections coupled to the curtain for lifting the curtain relative the frame to open the passage, a curtain operator associated with the damper and including a rotatable drum to which the one or more wire cable sections is anchored, means to wind the one or more wire cable sections upon the drum to lift the curtain, means to terminate the cable winding operation when the curtain is fully opened, means to enable the drum freely to release the one or more cable wires to enable the curtain to drop to close the damper upon occurrence of a predetermined condition, and means directly and primarily responsive to air flow to delay the release of the drum after the occurrence of the predetermined condition until the forces generated by air passing through the damper subside to or are at a predetermined safe level which will not damage the curtain.

9. An operator for a multi-fold curtain damper having a frame or shell enveloping the damper curtain and in which the curtain is capable of opening and closing an air passage defined by the frame or shell, comprising means to lift the curtain relative the frame to open the passage, means to release the curtain to close the passage upon occurrence of a predetermined condition, and means to delay the release of the curtain after the occurrence of the predetermined condition until the forces generated by air passing through the damper subside to or are at a safe level which will not damage the curtain.

10. The combination of claim 9 in which the delay means includes a vane which is moved by the force of air exerted against the vane to effect a delay in curtain closure.

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