United States Patent [19]

Henningsen

[11] **3,859,565**

[45] **Jan. 7, 1975**

[54] **FIRE PUMP CONTROL APPARATUS**

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[73] Assignee: **Firetrol, Inc.**, Erie, Pa.

[22] Filed: **Aug. 20, 1973**

[21] Appl. No.: **389,860**

[52] **U.S. Cl.** ..... **317/13 R**, 307/118, 317/38, 340/418

[51] **Int. Cl.** **H02h 9/00**

[58] **Field of Search** ..... 340/418, 419, 240; 317/13 R, 38; 307/117, 118

[56] **References Cited**

UNITED STATES PATENTS

3,283,236	11/1966	Legg	317/13 R
3,284,669	11/1966	Boyd	317/13 R
3,660,722	5/1072	Wilson et al.	317/38 X

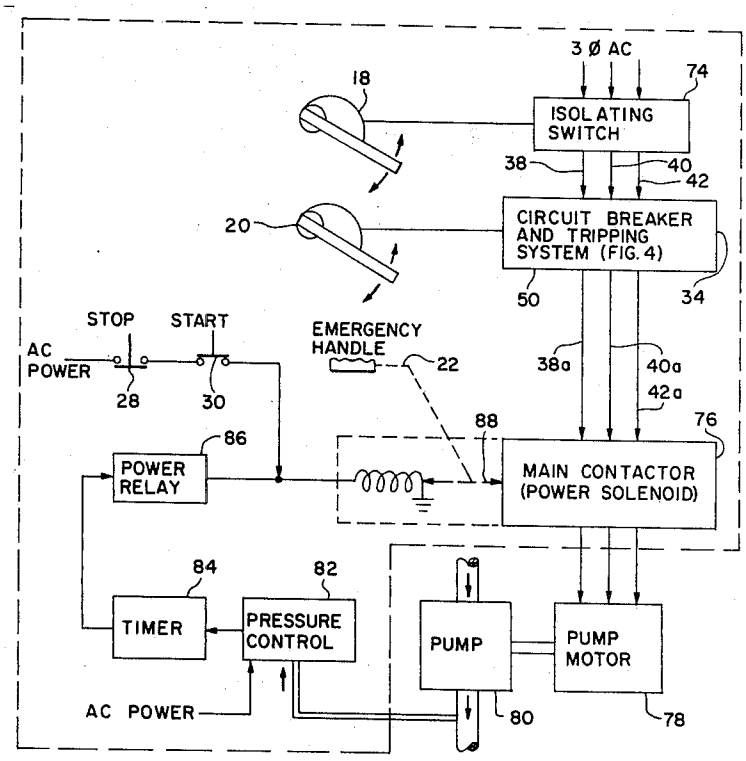
Primary Examiner—James D. Trammell

Attorney, Agent, or Firm—Allison C. Collard

[57] **ABSTRACT**

A self-contained fire pump control apparatus connected across the power lines has in combination a manually operated first circuit breaker means that is coupled with the power lines. A second circuit breaker means is serially coupled with the first circuit breaker means and includes current responsive means to sense the current flowing in the power lines. The latter means opens the second circuit breaker if a predetermined current limit is exceeded. A third circuit breaker means is serially coupled between the second circuit breaker and at least one fire pump. The third circuit breaker means includes pump output responsive means to open and close the third circuit breaker.

14 Claims, 6 Drawing Figures



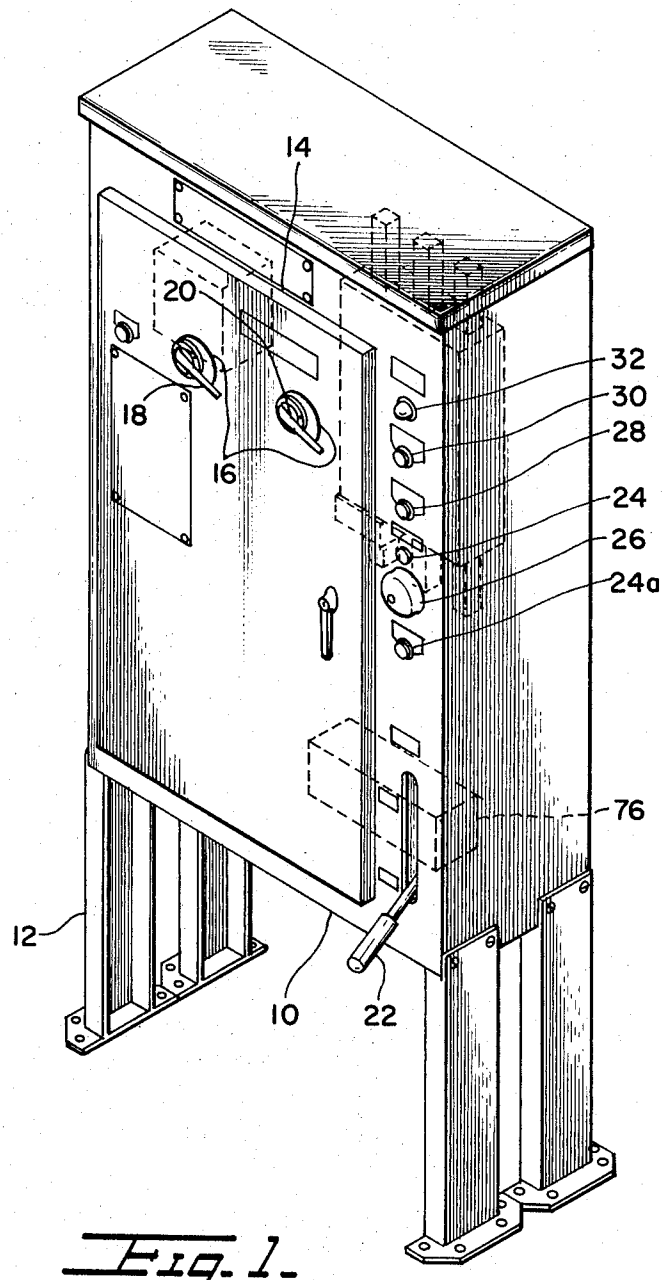


Fig. 1.

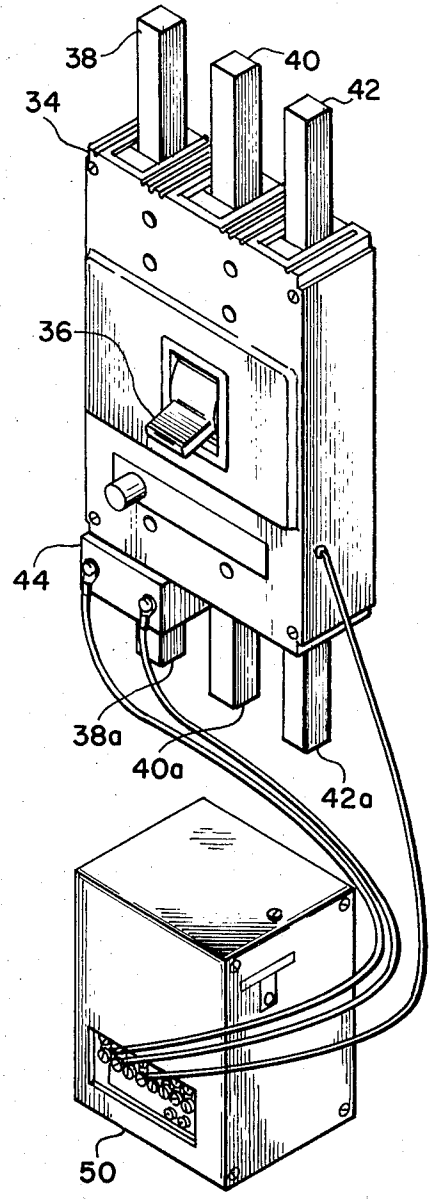


Fig. 2.

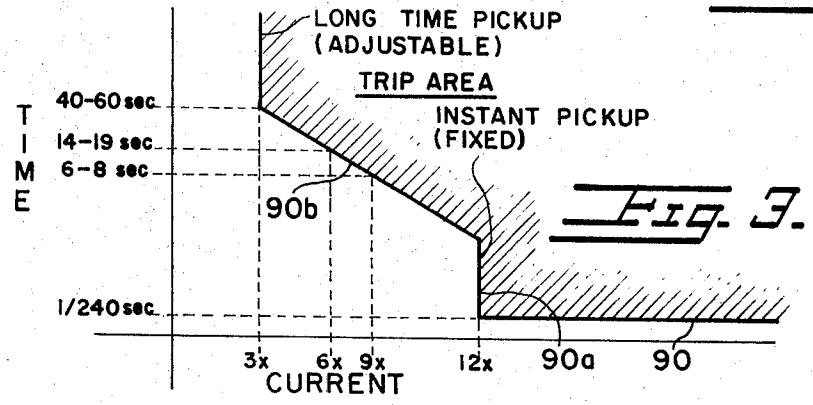


Fig. 3.

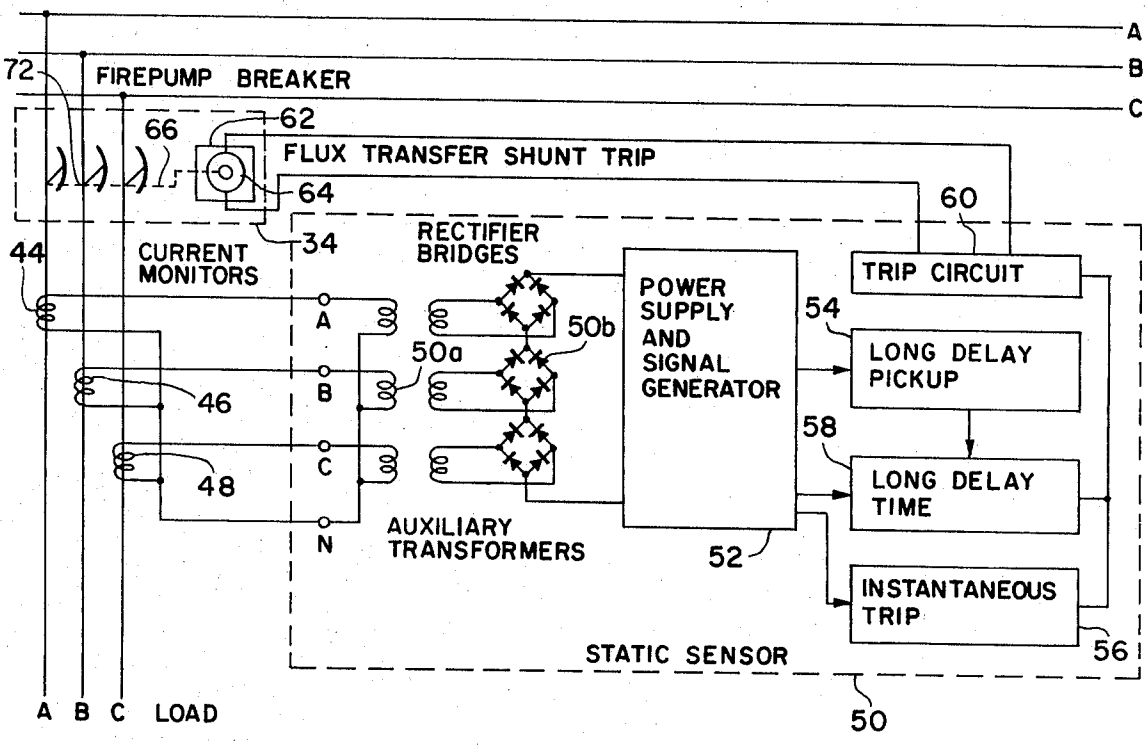

A
B
C
72
FIREPUMP BREAKER
66
62
FLUX TRANSFER SHUNT TRIP
64
60
34
RECTIFIER BRIDGES
44
CURRENT MONITORS
A
B
C
N
50b
50a
46
48
POWER SUPPLY AND SIGNAL GENERATOR
TRIP CIRCUIT
54
LONG DELAY PICKUP
58
LONG DELAY TIME
INSTANTANEOUS TRIP
56
AUXILIARY TRANSFORMERS
52
STATIC SENSOR
50
A B C LOAD

Fig. 4.

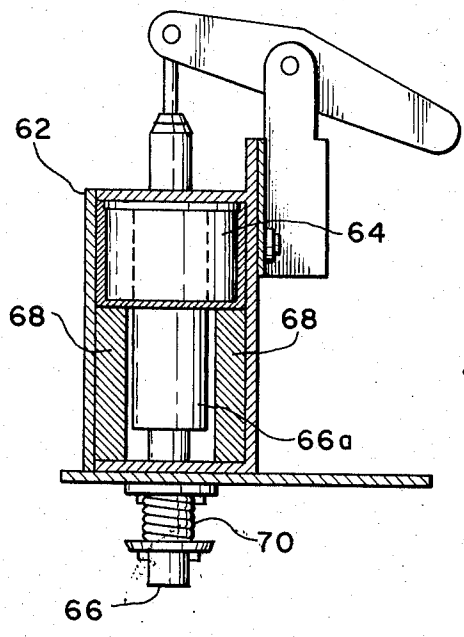

62
64
68
68
66a
70
66

Fig. 5.

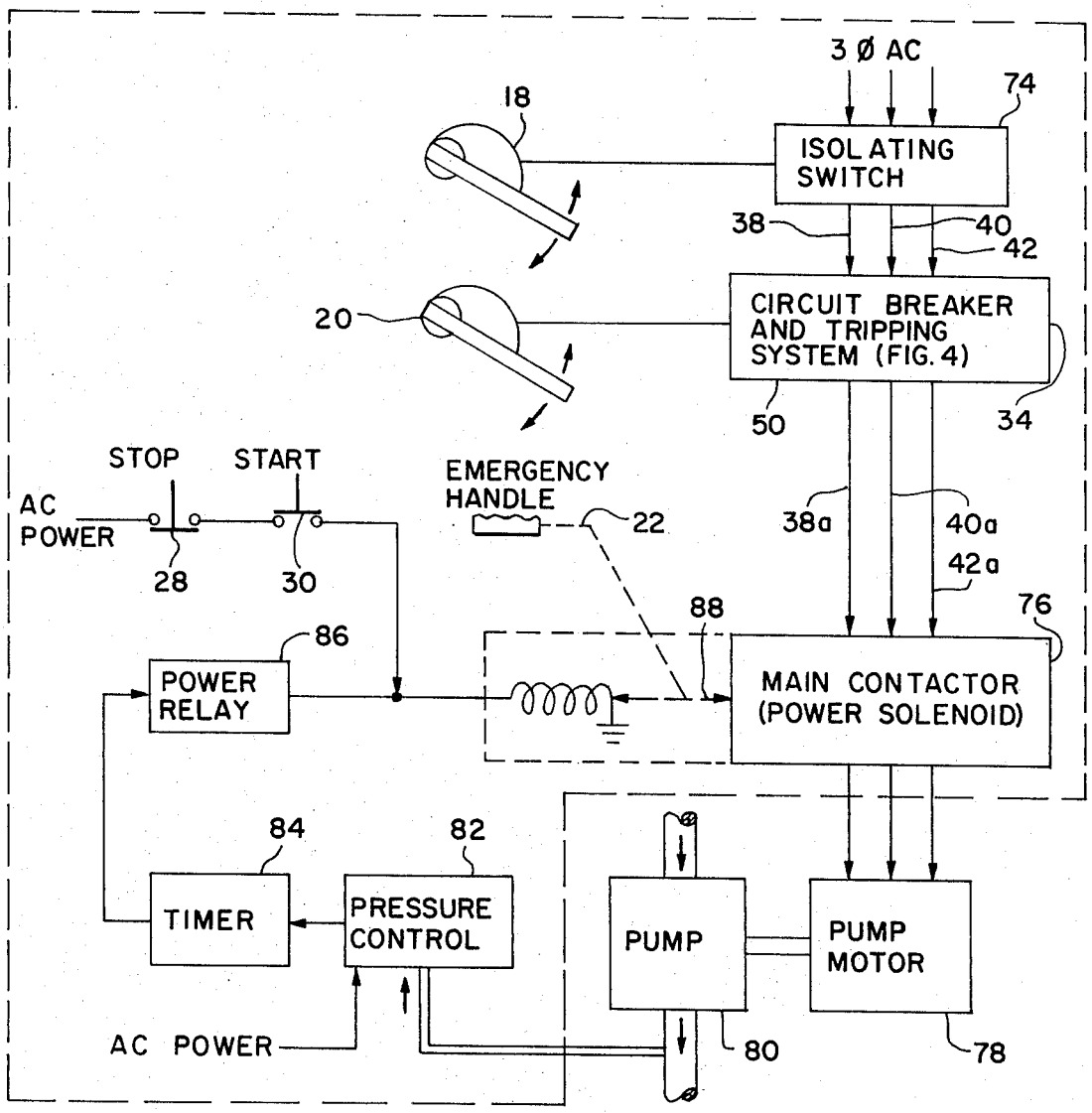

3 Ø AC
74
18
ISOLATING SWITCH
38
40
42
20
CIRCUIT BREAKER AND TRIPPING SYSTEM (FIG. 4)
50
34
STOP
START
EMERGENCY HANDLE
AC POWER
22
38a
40a
42a
28
30
88
76
86
POWER RELAY
MAIN CONTACTOR (POWER SOLENOID)
84
82
TIMER
PRESSURE CONTROL
PUMP
PUMP MOTOR
AC POWER
80
78

Fig. 6.

FIRE PUMP CONTROL APPARATUS

This invention relates to control of fire pump apparatus and more particularly to an automatic emergency control for fire pumps in modern high-rise structures.

In has been found that the pumping apparatus for fire equipment often times remains unused for extended periods of time. Owing to bearing congealment and start-up loads, an emergency demand for water pressure may cause excessive currents to flow in the pump motors and associated wiring. These excessive currents may cause the wires to exceed their load rating and excessively heat or ignite.

Accordingly, the present invention is designed to overcome these difficulties and allow predetermined excessive currents to flow to the pumps for predetermined times. In the event the current draw exceeds these pre-set limits, the apparatus will be automatically disconnected from the power lines. This is accomplished by having a plurality of sensing means used for monitoring the amount of current drawn by the pump apparatus. The output of the sensing means is applied to a control current that allows for various predetermined current levels to exist in the pump power lines.

The present invention contemplates the use of a single enclosed apparatus containing the operative components that comprise the current monitors, the isolating switch, the circuit breaker and current breaker control circuit, the main contactor, the pressure transducer, the timer and the power relay.

Thus, in the inventive design current monitors mount on the bus of the circuit breaker and continually sense the current flowing through the three-phase incoming power lines. At overload, the output of the current monitors rises approximately proportionately to the overload existing in the circuit breaker bus. The output of the current monitors is fed to a solid state tripping system that is designed to allow no more than **12** times the normal current to flow through the circuit breaker bus for short time intervals before the apparatus causes the circuit breaker to automatically trip. Automatic tripping will disconnect the current applied to the main contactor or power solenoid. The inventive circuit breaker will cause the main power lines to be disconnected on any current level exceeding **3** times normal motor running current after a time delay. At the **3** times normal motor running current level, current will be allowed to flow for 40 – 60 seconds before the solid state tripping system causes the circuit breaker to open. At the **6** times motor running current level, current will be allowed to flow for 12 – 20 seconds before the solid state tripping system causes the circuit breaker to open. At the **9** times motor normal running current level, current will be allowed to flow for 3 – 9 seconds before the solid state tripping system causes the circuit breaker to open. At any current value exceeding **12** times motor normal running current (up to rated interrupting capacity), the solid state tripping system will cause the circuit breaker to open in less than one second.

Combined with the above, the present invention provides for a main contactor or power solenoid. The power solenoid is serially placed between the circuit breaker and pump motor or motors. The power solenoid is controlled by various means which include an emergency "start" and "stop" button, an emergency run handle, and a pressure control device that is responsive to and monitors the fire pump pressure output. The pressure control device senses the output pressure of the various fire pumps and provides for automatic connection and disconnection from the main power line in the event of a drop in fluid pressure. The pressure control device includes a timer so that the instantaneous variations of pressure existing in the pump output will not cause immediate actuation or disconnection of the power solenoid and the pump motor will be able to reach full speed and run for a preset short time interval.

Further the apparatus provides for a manual operated isolating switch to electrically remove the line from the load. And, a manually operated circuit breaker handle provides for the opening or closing of the circuit breaker contacts on demand.

In the event that a severe emergency arises, the inventive apparatus contemplates the emergency run handle being manually actuated allowing the mechanical closing of the main contactor independent of any control circuits.

It is therefore an object according to the present invention to provide an automatic across the line fire pump control apparatus.

It is a further object of the present invention to provide a completely self-contained apparatus allowing both automatic and manual operation for controlling the power applied to fire pumps.

It is a still further object of the present invention to provide a device that continually monitors the current flowing through the fire pumps and allows the current level drawn by the pumps to exceed predetermined limits for predetermined intervals.

Other objects and features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood however, that the drawings are designed for the purposes of illustration only and not as a definition of the limits of the invention to which reference should be made to the appended claims.

In the drawings wherein similar reference characters denote similar elements through the several views:

FIG. **1** is a prospective view of the self-contained fire pump control according to the inventive design showing the positioning of various parts;

FIG. **2** is a perspective view of the circuit breaker but removed from the housing of FIG. **1** and showing a static sensor connected to a current monitor;

FIG. **3** is a plot of current versus time showing the relationship thereof;

FIG. **4** is a block diagram with some components in the schematic and generally indicating the electrical interrelation of the static sensor, shunt trip solenoid, current monitors and the fire pump circuit breaker;

FIG. **5** is a front elevational taken in section and showing the shunt trip solenoid in combination with the inventive apparatus; and,

FIG. **6** is a block diagram of the operation of the components contained in the housing of FIG. **1.**

Referring now to the drawings and in particular FIG. **1** there is shown a housing **10** that in the preferred embodiment is supported by means of feet **12.** A door **14** is hinged on housing **10.** Door **14** contains a plurality of apertures **16** through which connecting handles **18** and **20** are disposed as shown.

An emergency run handle **22** communicates through the forward face of housing **10.** Also included on the

forward face of housing **10** is an optional alarm system that might comprise visual indicator **24** or a bell **26** or both. Adjacent to the alarm system is a "stop" button **28**, a "start" button **30** and a "power on" pilot light **32**. The inventive design also contemplates an "alarm silence" device indicated at **24***a*.

Referring now to FIG. **2** there is shown a circuit breaker **34** of the present invention. Circuit breaker bus **34** contains a breaker trip handle **36** that is designed to open and close electrical connection between bus power lines **38, 40** and **42** with bus lines **38***a*, **40***a*, and **42***a*. Referring back to FIG. **1**, handle **20** comprises a circuit breaker lever that is mechanically coupled to switch tongue **36**. Thus, it will be apparent that rotating handle **20** will cause circuit breaker **34** to open or close or reset the circuit between lines **38, 40** and **42**, with lines **38***a*, **40***a*, and **42***a*.

A current monitor **44** is positioned about and inductively coupled to power line **38** and **38***a* as shown. It is to be understood, however, that while only one current monitor is shown, in use, the other power line **40***a* and **42***a* will each contain a current monitor.

Referring now to FIG. **4** there is shown current monitors **44, 46** and **48** positioned about their respective power lines **38, 40** and **42**. The signals, if any, inductively coupled in either or all coils **44, 46** and **48** are applied to a trip system **50** and hence across an auxiliary transformer **50***a* that contains a plurality of windings. In transformer **50***a*, the current induced from the monitors is stepped down to the milliampere level. Auxiliary transformer **50***a* contains a bridge rectifier circuit **50***b*, as is common in the art, to convert the AC transformer output to direct current. The rectified output of auxiliary transformer **50***a* is applied to a power supply and signal generator **52**. Supply and generator **52** provides power for energizing trip coil **62**, which will be described hereinafter, and supplied a signal for both a long delay pickup **54** and an instantaneous trip **56**.

As shown in FIG. **4**, long delay pickup **54** is coupled with a long delayed time **58**, the output of the latter is coupled with instantaneous trip **56** and thence applied to and forms the input to trip circuit **60**. The output of trip circuit **60** is applied to a solenoid or trip device **62**. Trip device **62** is contained in and automatically operates breaker **34**.

Solenoid or trip device **62** is shown enlarged in FIG. **5**. Trip device **62** contains permanent magnets **68** and a magnetic armature **66** a portion of which, **66***a*, is disposed between magnets **68**. A pulse coil **64** containing a plurality of windings has its input connected across trip circuit **60** as seen in FIG. **4**. The orientation of the magnetic field of permanent magnets **68** in conjunction with magnetic armature extensions **66**a is such that armature **66***a* urges armature body **66** upwardly when looking at FIG. **5**. A compression spring **70** is carried along the periphery of a portion of armature **66** extending outside of trip frame **62**. The confining of spring **70** about armature **66** is such that the co-acting forces of magnet **68** with magnetic armature **66** is slightly greater than the compressive force exerted by spring **70** against armature **66**. However, when a current appears in coil **64**, the magnetic field excited in pulse coil **64** is directed so as to weaken the magnetic field exerted on armature **66***a*. This will cause spring **70** to force armature **66** downwardly when looking at FIG. **5**.

Armature **66** is coupled to a trip bar, schematically represented by numeral **72** in FIG. **4**. Solenoid **62** and trip bar **72** is contained in circuit breaker bus **34** as above mentioned, and operates to open the circuit existing between power lines **38, 40** and **42** with **38***a*, **40***a*, and **42***a*.

Referring now to FIG. **6** a schematic diagram of the inventive combination contained in frame **10** is shown. In addition, FIG. **6** shows the schematic representation of the pump and pump motors connected in accordance with the inventive design. The handle **18** comprises a means for control of an isolating switch **74**. Isolating switch **74** is serially connected between power lines **38, 40, 42** and bus **34**. Switch **74** is adapted to isolate the combination of power lines **38, 40,** and **42** from a remote power source. It will be seen that the circuit breaker bus **34** is fed from isolating switch **74**.

Handle **20** mechanically coupled with circuit breaker switch **36** provides manual means for operating and resetting circuit breaker **34**. In addition to manual means **20** for interrupting the current flowing through circuit breaker bus **34**, tripping system **50** as seen in FIG. **4**, in conjunction with trip plunger **62** provides automatic interrupting capability for circuit breaker **34**. This automatic system is responsive to the amount of current drawn by the fire pumps.

Electrically connected with the output leads of circuit breaker **34** is a main contactor or power solenoid **76**. Electrically coupled with and powered from main contactor **76** is a pump motor **78**, the output of the latter mechanically driving pump **80**. The pressure existing at the output of pump **80** is sensed by a pressure control **82**. Pressure control **82** provides a signal when the pump output pressure drops below a preset pressure level. This signal is applied to a minimum period timer **84** having its output connected to a power relay **86**. The output of power relay **86** is coupled to power solenoid or main contactor **76** as shown. Power solenoid **76** contains a contactor armature **88** the operation of which is controlled by either power relay **86**, the operation of which is described below, or emergency run handle **22**.

Emergency run handle **22** provides a manual means for electrically isolating power lines **38***a*, **40***a* and **42** a from pump motor **78**. Referring back to FIG. **1** it will be seen that emergency run handle **22** extends from frame **10** and is designed for convenient access.

As seen in FIG. **6** both "start" button **30** and "stop" button **28** are serially connected with a remote power source. Thus the "start" and "stop" button operating in conjunction with the remote power source co-act to provide an additional means for control of main contactor **76**.

In FIG. **4**, power supply and signal generator **52**, connected to the output of bridge rectifiers **50***b*, produces at its output an analog signal proportional to the magnitude of the current sensed by current monitors **44, 46** and **48**. One output of generator **52** is connected to long delay pickup **54** which in a preferred embodiment, consists of a solid state time delay circuit. Another output of generator **52** is connected to the input of long delay pick up circuit **54**. Pick up circuit **54** is also connected to long delay time circuit **58**. The output of long delay time circuit **58** is connected to trip circuit **60**. An instantaneous trip circuit **56** is also provided having its input coupled to generator **52**, and its output coupled to trip circuit **60**.

In accordance with the standards set by the National Fire Protection Association (N.F.P.A.) for certifigal

fire pumps, the instantaneous current applied to the pump motor is not to exceed 12 times normal, full load motor current. After a running time of between 14 to 19 seconds, the motor current should be below six times normal, and after 40–60 seconds, the current should be below three times normal load.

To comply with these standards, instantaneous trip circuit **56**, includes on its input, a voltage divider, and a back-biased diode coupled to its output so that when a signal from generator **52** representing a current greater than 12 times normal is applied to the voltage divider, the diode will conduct and provide a signal to trip circuit **60** so as to open circuit breaker **34**. Instantaneous trip circuit **56** operates independently of pick up circuit **54** and long delay time circuit **58** so that the pump motor will be disconnected from its source of input power anytime the motor current exceed 12 times it full load rating.

When the pump motor is initially operated, the current applied to the motor will increase to about **6** times its full load rating before the motor reaches it operating speed. As the motor current increases above three times normal full load current, long delay pick up circuit **54** will operate and turn on long delay time circuit **58**. Circuit **58** will then set up a current threshold level which decreases from 12 times to three times full load motor current, over a time interval of 40–60 seconds, as shown in FIG. **3**.

FIG. **3** shows a typical log. plot of current versus time where line **90** represents the current flow to the pump motor during a time interval. Line **90***a* has been set for **12** times rated current and will always trip the circuit breaker if the current ever exceeds that value during its operation. Line **90***b* represents the transition between instantaneous trip **56** and long delay pickup **54** which is set between 12 times rated current to three times rated current for a period of about 40–60 seconds.

Long delay time circuit **58** is preferably constructed as a solid state time delay circuit which serves to decrease the motor current trip level over a time interval of about 40–60 seconds, as in FIG. **3**. Circuit **58** will decrease the breaker trip level so that after **6-8** seconds of elapsed time, the trip or threshold current will be about nine times full load rating. To comply with the N.F.P.A. standards, the current trip level will decrease to about six times normal motor current between 14–19 seconds, and will reach three times normal current in about 40–60 seconds. After 40–60 seconds, the trip level is maintained at three times full load motor current. Under normal motor operating conditions for non-fire pump use, the motor current should not exceed 1.25 times full load value for any extended time interval. However, for fire pump use, it is more important to keep the motor and pump operating to maintain water pressure, so the standards require the motor circuit be capable of receiving up to three times its full load current during its operation without being disconnected.

To operate the fire pump control, isolating switch **74** and circuit breaker **34** are closed to connect power to main contactor **76** as shown in FIG. **6**. If the pressure at the output of pump **80** is below a present level, pressure control **82** will produce a signal at the input of timer **84** so that power relay **86** will be energized. Relay **86** will couple power to the solenoid of main contactor **76** to close the contactor and connect power to pump motor **78**. When the pressure at the output of pump **80** rises to a level that is preset in pressure control **82**, the control de-energizes timer **84**, relay **86** and the solenoid. Thus, after a short time delay, contactor **76** opens to shut off motor **78**. If there is a drop in fluid pressure at the pump output, due to the operation of a sprinkler head the fire pump control system will automatically operate to maintain a preset pressure in the sprinkler system.

The fire pump control system may be manually operated such as for tests purposes by depressing start button **28** which is located on the front face of housing **10**. Start button **30** will connect power to the solenoid of main contactor **76** in order to energize pump motor **78**. The start button bypasses pressure control switch **82** so that the system can be left turned on if required. Pump **80** generally includes an internal fluid bypass so as to protect the pump from excessive pressures by allowing some of th output pressure to be fed back into the input if the pressure exceeds a present level. Where a plurality of fire pump control systems are used, the start and stop buttons may be remotely located on a main control panel in the basement of the building so that maintenance personnel can check a plurality of fire pump control systems located on different floors from a single control panel.

The fire pump control system also includes the emergency run handle **22** shown projecting through an opening on the front face which mechanically urges the solenoid of main contactor **76** closed, so that the pump motor will remain permanently connected to circuit breaker **34** until the handle is returned to its "off" position.

When the pump motor is connected to the power source by any one of the three previously-mentioned steps, the current applied to the pump motor in each electrical phase is sensed by tripping system **50** shown in detail in FIG. **4**. In a preferred embodiment of the invention, instantaneously trip **56** has been set to operate at 12 times the normal rate of current of pump motor **78** so that if the normally rated pump current in any of the three power lines **38, 40** or **42** exceeds **12** times the current rating of the pump motor, instantaneous trip **56** will provide a signal to operate trip circuit **60** and cause circuit breaker **34** to disconnect the pump motor from the power lines. Instantaneous trip **56** operates separately and independently from delay circuits **54** and **58**.

While only one embodiment of the present invention has been shown and described it will be apparent to those skilled in the art that many changes and modifications may be made thereto without departing from the invention's spirit and scope.

What is claimed is:

1. A self-contained fire pump control apparatus connected across the power lines for providing power to a fire pump motor to maintain fluid pressure in a fire protection system comprising in combination:

a housing containing the apparatus;

a first manually operated circuit breaker serially coupled with the power lines for disconnecting power from the power lines;

second circuit breaker means serially coupled to said first circuit breaker means;

current responsive means coupled to the power lines and connected to said second circuit breaker means said current responsive means having a decreasing current threshold level in response to the start of the fire pump motor, the threshold level

being set at a large multiple of the full load current of the motor and decreasing to several times its full load current to maintain fluid pressure for fire protection;

third circuit breaker means serially coupled between said second circuit breaker means and the fire pump motor; and

pressure detection means coupled to the output of the fire pump for closing said third circuit breaker means to connect electrical power to the fire pump motor when the fluid pressure drops below a predetermined pressure level.

2. The apparatus as in claim **1** wherein said current responsive means comprises current monitor means coupled to the power lines, a static sensor having its input coupled to the output of said current monitor means, a shunt trip solenoid coupled to the output of said static sensor and mechanically connected to open said second circuit breaker means, said static sensor operating said shunt trip solenoid when the current in the power line exceeds predetermined levels.

3. The apparatus as in claim **2** wherein said static sensor comprises an auxiliary transformer including rectifier bridges for stepping down and rectifying the current output of said current monitor means, a power supply and signal generator coupled to the rectified output of said auxiliary transformer and rectifier bridges, trip means having an input coupled to the output of said signal generator and an output applied to said shunt trip solenoid so that when the current exceeds predetermined levels, said shunt trip solenoid will open said second current breaker means.

4. The apparatus as in claim **3** wherein said trip means includes an instantaneous trip having its input coupled to the output of said power supply and signal generator and the output of said instantaneous trip coupled to said shunt trip solenoid, said trip being set at a first current threshold level so that when said level is exceeded, said shunt trip solenoid operates to open said second circuit breaker means.

5. The apparatus as in claim **4** wherein said trip means includes a long delay time circuit having an input coupled to said power supply and generator and its output coupled to said shunt trip solenoid, said delay time circuit having a decreasing current threshold level from said first level to a second current level over a preset time interval, said long delay time circuit operating said shunt trip solenoid when said decreasing current threshold level is exceeded.

6. The apparatus as recited in claim **5** wherein said trip means further comprises a pick up circuit having its input coupled to said power supply and generator and its output coupled to said long delay time circuit, said trip means operating said long delay time circuit when said second current level is exceeded.

7. The apparatus as in claim **3** wherein said third circuit breaker means comprises a main contactor that includes a power solenoid to open and close the circuit between at least one fire pump and said second circuit breaker means.

8. The apparatus as in claim **7** wherein said main contactor additionally comprises an emergency run handle mechanically connected to the power solenoid and extending to the front face of said housing to provide means to manually open and close the contacts of said main contactor.

9. The apparatus as in claim **8** wherein said pressure detection means further comprises a pressure control transducer having one end coupled to the output of at least one pump, a timer having an input coupled to the output of said transducer and including electrical averaging means for time averaging the instantaneous pressure variations detected at least one pump output, a power relay whose input is coupled with the output of said timer, the output of said power relay being coupled to the power solenoid so that when the pump output pressure exceeds a predetermined level for a predetermined time, the signal from said transducer, averaged by said timer will drive said power relay to cause the power solenoid to open the circuit of said main contactor.

10. The apparatus as in claim **9** wherein said output responsive means further includes an emergency stop button serially connected with the power solenoid to open the circuit of said main contactor and an emergency start button serially connected between said stop button and the power solenoid to close the circuit of said main contactor.

11. The apparatus as in claim **1** wherein said second circuit breaker means includes a manually operated tripping switch extending through the front face of said housing and including mechanical means coupled with said second circuit breaker means for opening and closing the latter means.

12. The apparatus as in claim **1** wherein said first circuit breaker means comprises an isolating switch that includes a circuit breaker for each phase of the power lines and having a manually operated handle controlling the operation of said isolating switch, said handle extending through the front face of said housing.

13. The apparatus as recited in claim **4** wherein said first current threshold level is set at twelve times the full load capacity of the motor.

14. A self-contained fire pump control apparatus connected across the power lines for providing power to a fire pump motor to maintain fluid pressure in a fire protection system comprising in combination:

a housing containing the apparatus;

a manually operated switch connected to the power lines;

a circuit breaker serially connected to the switch and including a current sensor having a current threshold level for opening the breaker which decreases from twelve to three times the full load current of the pump motor after the motor is operated to maintain fluid pressure for fire protection;

a solenoid operated main contactor serially connected to said circuit breaker and having its output for connection to the pump motor;

a pressure detector coupled to the output of the pump for closing the solenoid operated main contactor when the fluid pressure drops below a predetermined pressure level.

* * * * *

Disclaimer

3,859,565.—*Lee A. Henningsen*, Erie, Pa. FIRE PUMP CONTROL APPARATUS. Patent dated Jan. 7, 1975. Disclaimer filed Mar. 8, 1976, by the assignee, *Firetrol, Inc.*

Hereby enters this disclaimer to claims 1, 2, 11, 12, and 14 of said patent.

[*Official Gazette May 25, 1976.*]

Disclaimer

3,859,565.—*Lee A. Henningsen*, Erie, Pa. FIRE PUMP CONTROL APPARATUS. Patent dated Jan. 7, 1975. Disclaimer filed Mar. 8, 1976, by the assignee, *Firetrol, Inc.*

Hereby enters this disclaimer to claims 1, 2, 11, 12, and 14 of said patent.

[*Official Gazette May 25, 1976.*]