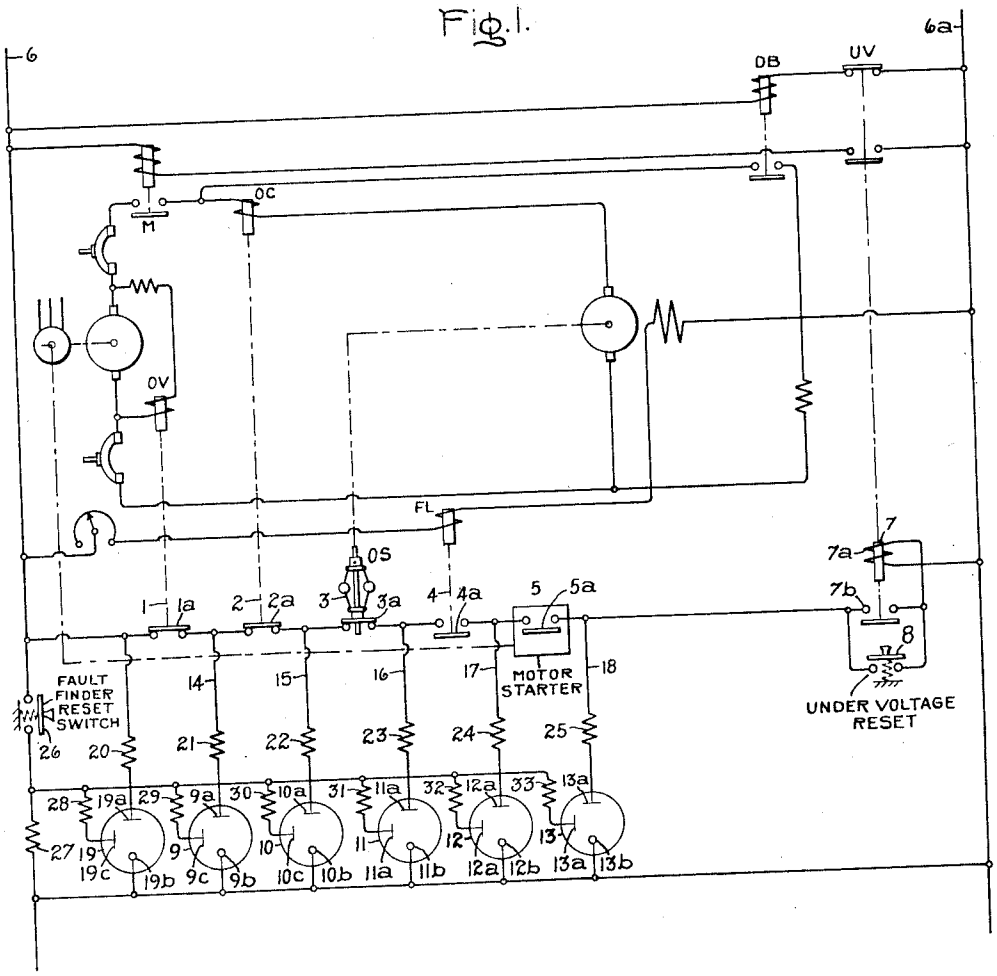
Oct. 14, 1952 L. R. FOOTE ET AL 2,614,160

INDICATING SYSTEM

Filed July 28, 1951 2 SHEETS—SHEET 1

Fig. 1.



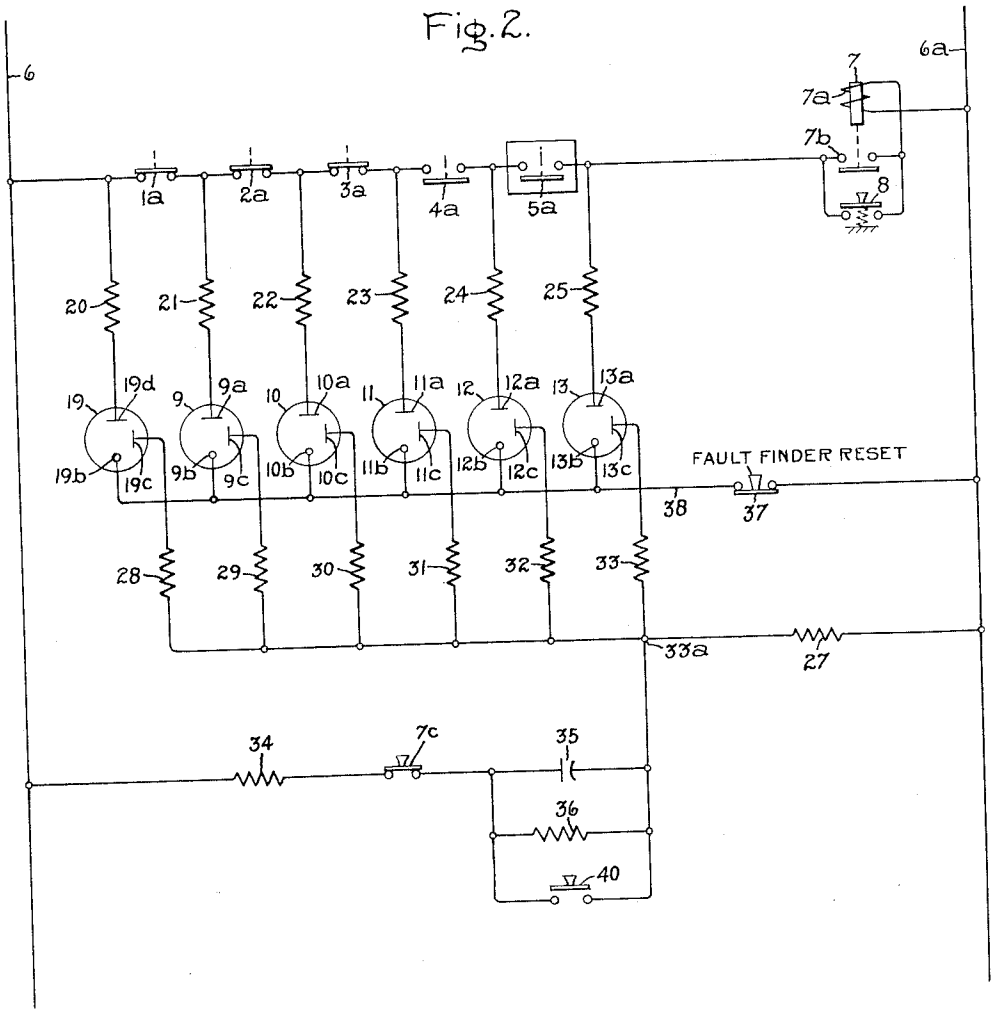
Inventors:
Lawrence R. Foote,
William L. O. Graves,
by Claude A. Mott
Their Attorney.

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INDICATING SYSTEM

Filed July 28, 1951 2 SHEETS--SHEET 2

Fig. 2.



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UNITED STATES PATENT OFFICE

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INDICATING SYSTEM

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Application July 28, 1951, Serial No. 239,154

10 Claims. (Cl. 177—311)

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This invention relates to indicating systems, more particularly to systems for indicating the operating condition of any one of a plurality of switches having their contacts connected in series relationship on a control circuit, i. e. indicating whether each switch is open or closed and it has for an object the provision of a simple, reliable and improved system of this character.

A more specific object of the invention is the provision of a memory type fault finding system for use with industrial drives which have a plurality of protective interlocks.

In carrying the invention into effect in one form thereof, the contacts of a plurality of switching devices are connected in series relationship with each other across a pair of direct voltage supply conductors, and a plurality of electric valves used as glow lamps are provided, each corresponding to a different one of the switches. Each of these valves contains within its envelope, an anode, a cathode, a control electrode and an ionizable medium. The cathodes are all connected to the negative supply conductor, and a separate connection is provided from each anode to the negative contact of a corresponding switching device. A fault finder reset switch provides for completion of the connection of the control electrodes of all these electric valves to the positive supply conductor to establish ionization and conduction and thereby effect a glow illumination thereof if the contacts of all of the switching devices are closed. Thus, the illumination of all of the valves is an indication that all of the contacts are closed.

The opening of any one of the switching devices effects deionization and extinguishment of all of the electric valves having their anode connections to the positive supply conductor completed through the contacts of such switching device, and the remaining valves whose anode connections to the positive supply conductor do not pass through the contacts of such switching device remain illuminated. A knowledge of the groupings of the electric valves whose anode circuits are completed through each switching device enables the operator by observation of illuminated and dark valves, to determine which switch opened its contacts. Even though the open switch contacts are promptly reclosed the extinguished valves remain extinguished and the unextinguished valves remain illuminated. In other words, the indicating system has a "memory." After making a record of the identity of the switch which caused the interruption, the

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indicating system may be reset by closing the fault finder reset switch.

In a modification, the electric valves are all extinguished when all of the switch contacts are closed. The opening of any one of the switching devices interrupts the anode connections of all the valves which are completed through such contact when closed. A relay responds to the opening of any of the switching devices to connect the control electrodes of all of the valves to the positive supply conductors. The group of valves whose anode connections were interrupted remain dark and the group whose anodes remain connected to the positive supply conductor are illuminated. This modification also has a "memory" feature, i. e. the illuminated valves remain illuminated until a fault finder reset switch is opened to interrupt the anode-cathode circuit of all of the valves.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawing of which Fig. 1 is a simple, diagrammatical illustration of an embodiment of the invention and Fig. 2 is a simple, diagrammatical illustration of a modification.

Referring now to the drawing, plurality of switching devices 1, 2, 3, 4, and 5 are provided with interlock contacts 1*a*, 2*a*, 3*a*, 4*a*, and 5*a* respectively, each of which is closed when the operating condition which it protects has a normal operating value. These switching devices may be either electromagnetically operated or mechanically operated. For example, the switching devices 1, 2, 4, and 5 are illustrated as electromagnetic switches, and the device 3 is illustrated as a centrifugal switch.

These contacts are connected in series relationship with each other in a control circuit which extends from the positive supply conductor 6 to the negative supply conductor 6*a*. The operating coil 7*a* of an electromagnetic switching device 7 and the normally open contacts 8 of a reset switching device which is preferably of the push button type are also included in series relationship in this control circuit. The relay 7 is provided with sealing-in contacts 7*b* in parallel with the contacts of the reset switch 8.

Direct voltage of suitable polarity is supplied to the supply conductors 6 and 6*a* from any suitable source (not shown).

For the purpose of providing an indication of an operation of any one of the switches 1–5 inclusive and retaining such indication after restoration to its initial condition, a plurality of

electric valves 9, 10, 11, 12 and 13, used as glow lamps, are provided which correspond to the switching devices 1, 2, 3, 4, and 5 respectively. Although these electric valve glow lamps may be of any suitable type, they are preferably OA4–G gas triodes which are generally referred to as cold cathode thyratrons. The electric valve 9 contains within its envelope an anode 9a, a cold cathode 9b, a control electrode 9c which is usually referred to as a starting anode, and an ionizable medium such, for example, as argon, mercury vapor, or neon. The electric valves 10, 11, 12, and 13 are identical with electric valve 9.

As shown, the cathodes 9b, 10b, 11b, 12b, and 13b are directly connected to the negative supply conductor 6a. A conductor 14 connects the anode 9a of electric valve 9 to the negative terminal of the pair of switching device contacts 1a. When the contacts 1a are closed, the anode 9a is connected through these contacts to the positive supply conductor 6. Similarly, conductors 15, 16, 17, and 18 connect the anodes 10a, 11a, 12a, and 13a to the negative terminals of contacts 2a, 3a, 4a, and 5a respectively. When all of the contacts 1a, 2a, 3a, 4a, and 5a are closed, all of the anodes 9a, 10a, 11a, 12a, and 13a are connected to the positive supply conductor 6. The connection of each anode to the positive supply conductor passes through all of the series connected contacts between the negative contact to which it is connected and the positive supply conductor 6. Consequently if any selected pair of contacts is open, all of the electric valves having anode connections through such contacts (when closed) to the positive supply conductor are deionized and the illumination thereof is extinguished.

The anode-cathode circuit of electric valve 19 which is identical with lamps 9–13 inclusive is connected directly across the supply conductors 6 and 6a without passing through any switch contacts. It furnishes an indication of voltage across the control voltage supply conductors 6 and 6a.

Current limiting resistors 20, 21, 22, 23, 24, and 25 are connected in the anode circuits of electric valves 19, 9, 10, 11, 12, and 13 respectively. The resistance of each of these resistors is of the order of 3,500 ohms. However, this value is not critical.

For the purpose of reestablishing ionization and illumination in each electric valve, the control electrodes 19c, 9c, 10c, 11c, 12c, and 13c are connected through the normally open contacts of a fault finder reset switch 26 to the positive supply conductor 6. The reset switch is preferably a momentary contact type push button switch. A protective resistor 27 which may suitably have a resistance of 3,500 ohms is included in the connection between the switch and the negative supply conductor 6a. Suitable current limiting resistors 28, 29, 30, 31, 32, and 33 are included in the connections between the switch 26 and the control electrodes 19c, 9c, 10c, 11c, 12c, and 13c respectively. These resistors have a fairly high resistance, e. g. one-fourth megohm.

For the purpose of illustration of the application of the indicating system to a typical industrial drive the switching devices 1, 2, 3, 4, and 5 may be considered to be the overvoltage, overcurrent, overspeed, field loss and motor starter protective interlock switches of a steel rolling mill drive. A typical steel rolling mill control may have as many as sixty such protective interlocks. The relay 7 may be considered to be the undervoltage relay which provides the system undervoltage protection. In a steel mill application it operates as a master protective interlock and the mill cannot be operated unless it is energized.

With the foregoing understanding of the elements and their organization, the operation of the complete fault finder and indicating system will readily be understood from the following detailed description.

It is assumed that all the protective interlock contacts 1a, 2a, 3a, 4a, and 5a are closed. The external main anode-cathode circuits of each electric valve will be completed through all of the interlock contacts between the anode and the positive supply conductor. The electric valves, however, will remain dark since completion of the anode-cathode circuit does not result in sufficient ionization to establish conduction.

The undervoltage reset push button 8 is then depressed to close its contacts to complete an energizing circuit for the operating coil 7a of the master undervoltage relay 7. In response to energization this relay closes its interlock contacts 7b to complete a sealing-in circuit around the contacts of the undervoltage reset switch 8 which may now be released.

To illuminate all the electric valves to furnish an indication that all protective interlocks are closed, the fault finder reset switch 26 is momentarily depressed to connect the starting anodes of all the electric valves to the positive supply conductor 6. As a result, ionization is established in all electric valves and conduction is initiated between the cathodes and main discharge supporting anodes of the valves causing them all to become illuminated, which condition indicates that all protective interlock contacts are closed.

If during the operation of the mill there should be a departure from a safe value of any mill operating condition protected against by one of the protective interlock switches, such relay will open its contacts. For example, a momentary overload on the mill will cause the overcurrent relay 2 to open its contacts 2a momentarily. Upon termination of the momentary overload, the overcurrent relay will reclose its contacts.

The momentary opening of contacts 2a will interrupt the energizing circuit of the undervoltage relay 8 which will drop out and shut down the mill. Also, the four electric valves 10, 11, 12, and 13 whose anode circuits are normally completed through contacts 2a will be deionized and extinguished, and will remain extinguished even though the anode voltage is promptly restored by reclosure of the contacts 2a.

The operator may restart the mill immediately by momentarily depressing the undervoltage reset push button switch 8. After the mill has been restarted, the operator by observing the electric valves determines which interlock caused the interruption. For example, if electric valves 9–13 inclusive are extinguished, the operator knows that interlock contacts 1a opened since contacts 1a are the only contacts through which the anode-cathode circuits of all five electric valves 9–13 inclusive pass. Similarly, if electric valves 10, 11, 12 and 13 are extinguished, which is the condition assumed for the purpose of illustration, he knows that interlock contacts 2a opened, since these contacts are the only contacts other than contacts 1a through which pass the anode-cathode circuits of these valves. Since valve 9 is still illuminated, the operator knows that contacts 1a are closed. Thus, the electric valves have acted

as a "memory" device to provide an indication of the momentary opening of one of the interlock contacts and to retain or store such indication after reclosure.

The four extinguished electric valves may again be illuminated by momentarily depressing the fault finder reset push button switch.

In the modification illustrated in Fig. 1, the indicating valves are continuously conducting and illuminated during normal conditions, i. e. when all protective interlock contacts 1–5 inclusive are closed. This shortens the useful lives of the electric valves.

A modified indicating system in which the valves are extinguished during the normal condition and illuminated in selective groupings during an abnormal operating condition is illustrated in Fig. 2. This modification is generally similar to the modification of Fig. 1 and identical parts in both figures are represented by the same reference character. In the modification of Fig. 2 certain changes have been incorporated in the firing circuit, i. e. the control electrode circuit in order to provide for an indication of the normal condition by extinguishment of the valves.

In this modification, a resistor **34**, a pair of auxiliary normally closed contacts **7***c* of the undervoltage relay **7** and a capacitor **35** are connected in series relationship between the positive supply conductor **6** and the common control electrode terminal **33***a*. A discharge resistor **36** is connected in parallel with capacitor **35**.

Although the values of resistors **34** and **36** and capacitor **35** are not critical, resistor **34** may have a resistance of 3,000 ohms, resistor **36** a resistance of 1 megohm and capacitor **35** may have a capacity of .01 mfd.

The fault finder reset switch **37** is illustrated as a normally closed push button type switch connected in a common conductor **38** between the cathodes of all of the valves and the negative supply conductor. A test switch **40** which is illustrated as a push button type switch having normally open contacts, is connected in parallel with capacitor **35**.

The operation is as follows: Assuming that all interlock contacts **1***a*–**5***a* inclusive are closed, and that the undervoltage relay **7** is deenergized and dropped out, the normally closed contacts **7***c* of the undervoltage relay **7** are closed. Capacitor **35** is charged to the full line voltage across supply conductors **6** and **6***a* so that the voltage applied to the control electrodes is substantially the voltage of the negative supply conductor **6***a*. Consequently, the valves are deionized and extinguished. The test switch **40** may be momentarily closed to connect the control electrodes of all valves to the positive starting conductor. Each valve which is in good operating condition will be ionized and illuminated. A defective valve will remain dark and must be replaced.

Following the testing of the valves, the fault finder reset switch is depressed to interrupt the common cathode circuit thereby to extinguish all valves. The undervoltage reset switch **8** is then closed to complete an energizing circuit for the operating coil of the undervoltage relay **7**. Responsively to energization, relay **7** picks up and closes its normally open contacts **7***b* to complete a sealing-in circuit and opens its normally closed contacts **7***c* to interrupt the charging circuit of capacitor **35** which discharges through resistor **36** in a very brief interval of time, e. g. .01 second. The switch **8** may now be released. All valves **9**–**13** inclusive are dark and this condition indicates that interlock contacts **1***a*–**5***a* inclusive are closed.

If contact **3***a*, for example, should open in response to an abnormal value of an operating condition, it disconnects the anodes **11***a*, **12***a*, and **13***a* from the positive supply conductor and interrupts the energizing circuit of undervoltage relay **7**. Relay **7** drops out and closes its normally closed contacts **7***c* to complete a charging circuit for the capacitor **35** to the positive supply conductor **6**. Since the capacitor cannot charge instantaneously, the voltage of the common control electrode terminal becomes substantially the voltage of the positive supply conductor **6**. Consequently, the valves whose anodes are still connected to the positive conductor, i. e. valves **9**, **9**, and **10** are illuminated and the valves **11**, **12**, and **13** whose anodes were disconnected from the positive supply conductor by the opening of contacts **3***a* remain dark. Since contacts **1***a*, **2***a*, and **3***a* are the only contacts through which anodes **11***a*, **12***a*, and **13***a* are connected to the positive supply conductor **6**, the operator knows that contacts **3***a* must be open because the illumination of valves **9** and **10** informs him that contacts **1***a* and **2***a* are closed.

Once conduction has been initiated, the valves remain conducting until their anode-cathode circuits are interrupted. Similarly, the darkened valves remain extinguished after reclosure of the open interlock contacts because ionization sufficient to initiate conduction is produced only during the brief fraction of a second following closing of contacts **7***c* in which the capacitor **35** is sufficiently discharged to elevate the voltage of the control electrodes above the critical ionization value. Thus, the electric valves have acted as a "memory" device to provide a continuing indication of the momentary opening of one of the interlock contacts and to retain such indication after reclosure.

After the necessary corrective measures have been taken, the indicating system may be reset, i. e. the illuminated valves may be extinguished by opening the fault finder reset switch **37**.

Although in accordance with the provisions of the patent statutes, this invention is described as embodied in concrete form and the principle of the invention has been explained together with the best form in which it is now contemplated, applying that principle, it will be understood that the apparatus shown and described is merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of the invention or from the scope of the annexed claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An indicating system comprising in combination first and second supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said contacts and each having first and second main discharge supporting electrodes, a control electrode and an ionizable medium, a source of ignition voltage for said control electrodes, a common electrical connection from said control electrodes to one terminal of said source, a second common connection from said first main discharge supporting electrodes to said first supply conductor and a plurality of sepa-

rate electrical connections each extending from the corresponding terminal of a different one of said contacts to the second main discharge supporting electrode of the corresponding electric valve to produce in response to opening of one of said contacts a pattern of illumination in which each of said valves having its main electrode circuit remaining completed is illuminated and each of said valves having its main electrode circuit interrupted is extinguished, and a reset switching device included in one of said common connections for restoring the initial condition of illumination of said valves existing prior to said opening of said switch contacts.

2. An indicating system comprising in combination first and second supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said contacts and each having a first main discharge supporting electrode connected to said first supply conductor, a control electrode, a second main discharge supporting electrode and an ionizable medium, a source of ignition voltage for said control electrodes, an electrical connection from each of said control electrodes to said source and a plurality of separate electrical connections each extending from the corresponding terminal of a different one of said contacts to the second main discharge supporting electrode of the corresponding electric valve to produce in response to opening of one of said contacts a pattern of illumination in which each of said valves having its main electrode circuit remaining completed is illuminated and each of said valves having its main electrode circuit interrupted is extinguished, and a reset switching device for restoring the initial condition of illumination of said valves existing prior to said opening of said switch contacts.

3. An indicating system comprising in combination first and second supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said contacts and each having a first main discharge supporting electrode connected to said first supply conductor, a control electrode, a second main discharge supporting electrode and an ionizable medium, an electrical connection from each of said control electrodes to one of said supply conductors and a plurality of separate electrical connections each extending from the corresponding terminal of a different one of said contacts to the second main discharge supporting electrode of the corresponding electric valve to produce in response to opening of one of said contacts a pattern of illumination in which each of said valves having its said second main discharge supporting electrode remaining connected to said second supply conductor is illuminated and each of said valves having its said second main discharge supporting electrode disconnected from said second supply conductor is extinguished, and a reset switching device for restoring the initial condition of illumination of said valves existing prior to said opening of said switch contacts.

4. An indicating system comprising in combination first and second supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said contacts and each having first and second main discharge supporting electrodes, a control electrode and an ionizable medium, a common connection from said control electrodes to one of said supply conductors, a second common connection from said first main discharge supporting electrode to said first supply conductor and a plurality of separate electrical connections each extending from the corresponding terminal of a different one of said contacts to the second main discharge supporting electrode of the corresponding electric valve to produce in response to opening of one of said contacts a pattern of illumination in which all of said valves having a second main discharge supporting electrode remaining connected to said second supply conductor are illuminated and all of said valves having a second main discharge supporting electrode disconnected from said second supply conductor are extinguished, and a reset switching device included in one of said common connections for restoring the initial condition of illumination of said valves existing prior to said opening of said switch contacts.

5. An indicating system comprising in combination, positive and negative supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves, each corresponding to a different one of said switch contacts and each having a cathode connected to said negative supply conductor, a control electrode, an anode and an ionizable medium, an electrical connection from each of said control electrodes to said positive supply conductor and a plurality of separate electrical connections each extending from the negative terminal of a different one of said switch contacts to the anode of the corresponding electric valve to effect in response to opening of one of said contacts a pattern of illumination in which all of said valves having an anode remaining connected to said positive supply conductor are illuminated and all of said valves having an anode disconnected from said positive supply conductor are extinguished, and a reset switching device for restoring the initial condition of illumination of said valves existing prior to said opening of said switch contacts.

6. An indicating system comprising in combination, positive and negative supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch contacts connected in series relationship, a plurality of electric valves, each corresponding to a different one of said switch contacts and each having a cathode, a control electrode, an anode and an ionizable medium, a common connection from said cathodes to said negative supply conductor, a second common connection from said control electrodes to said positive supply conductor, and a plurality of separate electrical connections each extending from the negative terminal of a different one of said switch contacts to the anode of the corresponding electric valve to produce in response to opening of one of said contacts a pattern of illumination in which all of said valves having an anode remaining connected to said positive supply conductor are illuminated and all of said valves having an anode disconnected from said positive supply conductor are extinguished, and a reset switching device included in one of said common connections for restoring the initial

condition of illumination of said valves existing prior to said opening of said switch contacts.

7. An indicating system comprising in combination, positive and negative supply conductors, a control circuit connected across said supply conductors comprising a plurality of switch interlock contacts connected in series relationship, a corresponding plurality of electric valves each containing a cathode connected to said negative supply conductor, a control electrode, an anode and an ionizable medium, a corresponding plurality of connections, each extending from the negative terminal of one of said switch interlock contacts to the anode of a corresponding one of said electric valves, to effect in response to opening of one of said contacts the deionization and extinguishment of all of said valves having an anode connected to a terminal more negative than the positive terminal of said open contact, a connection from each of said control electrodes to said positive supply conductor and a reset switching device included in said last mentioned connections for effecting ionization and initiating conduction in all of said extinguished electric valves in response to momentary closure of said reset switching device after reclosure of said open interlock contact.

8. An indicating system comprising in combination, a plurality of switching devices each having a pair of contacts, positive and negative supply conductors, a control circuit connected across said supply conductors comprising said switch contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said switching devices and each containing a cathode connected to said negative supply conductor, a control electrode, an anode and an ionizable medium, a corresponding plurality of connections each extending from a different one of said anodes to the negative contact of a corresponding one of said switching devices to effect in response to opening of a selected pair of said contacts deionization and extinguishment of those of said electric valves having anode connections to said positive conductor completed by said selected contacts when closed, a separate connection from each of said control electrodes to said positive supply conductor and a reset switching device included in said last mentioned connections for effecting ionization and restoring conduction in said extinguished electric valves in response to momentary closure of said reset switching device after reclosure of said selected contacts.

9. An indicating system comprising in combination, positive and negative supply conductors, a plurality of switching devices each having a pair of contacts, a control circuit connected across said supply conductors and comprising said contacts connected in series relationship, a plurality of electric valves each corresponding to a different one of said switching devices and each containing a cathode connected to said negative supply conductor, a control electrode, and anode and an ionizable medium, a plurality of separate electrical connections each extending from a different one of said anodes to the negative contact of a corresponding one of said switching devices, each of said pairs of contacts in opening serving to deionize and extinguish all of said lamps having anode connections to said positive conductor completed thereby, connections from said control electrodes to said positive supply conductor, a reset switch included in said control electrode connections for reestablishing ionization and conduction in said extinguished valves in response to momentary closure of said reset switch after reclosure of said opened contacts.

10. An indicating system comprising in combination, positive and negative supply conductors, a plurality of switching devices each having a pair of contacts, an undervoltage relay having an operating coil, an undervoltage reset switch having normally open contacts, a control circuit connected across said supply conductors and comprising said switching device contacts, said normally open contacts and said operating coil connected in series relationship, a pair of sealing-in contacts on said relay short-circuiting said normally open contacts in the picked-up position of said relay, a plurality of electric valves each corresponding to a different one of said switching devices and each containing a cathode connected to said negative supply conductor, a control electrode, an anode and an ionizable medium, a plurality of separate electrical connections each extending from a different one of said anodes to the negative contact of a corresponding one of said switching devices, each of said pairs of switching device contacts in opening effecting deionization and extinguishment of all of said valves having anode connections to said positive conductor completed thereby, connections from said control electrodes to said positive supply conductor, a second reset switch included in said control electrode connections for reestablishing ionization and conduction in said extinguished valves in response to momentary closure of said second reset switch after reclosure of said opened contacts.

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