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COMBUSTION CONTROL AND SAFETY
ALARM SYSTEM

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The present invention relates to combustion control apparatus embodying particular signal and alarm arrangements in combination therewith.

The invention is intended principally but not exclusively for industrial combustion systems, especially gas fired furnaces and boilers. The larger of these installations are usually manually controlled, that is, they are put in operation and cut out of operation manually. Other installations may be completely automatic. My invention comprehends a combination and arrangement of safety controls, alarms, and signals whereby the optimum in safety of operation is secured.

My invention features particularly an alarm arrangement so devised that an alarm is given only upon the occurrence of an unsafe condition of the system. In the past similar alarms often gave an alarm whenever the system was started or stopped, greatly disturbing personnel and causing confusion and a general exodus from the vicinity of the furnace or boiler where the alarm originated.

An object of my invention is to provide improved safety control combinations and arrangements for combustion systems wherein the system is fully automatic in operation or is manually started and stopped.

Another object is the provision of an improved automatic interlocking control arrangement for combustion systems, embodying signal devices arranged to apprise the operator of the safe or unsafe progress of the sequence of operations and the condition of the system and to give an alarm only in the event of the occurrence of an unsafe condition of the system.

Another object is to provide an alarm device and arrangement for combustion control systems wherein the alarm cannot be sounded in response to normal functions of the system but only upon the occurrence of an unsafe condition thereof.

Another object is to provide an alarm system comprising an alarm device, and interlocking relays so arranged that one relay is actuated in response to the other and the alarm only sounds when a predetermined interlocking relationship of the relays occurs in response to specific unsafe or abnormal conditions.

The figure of the drawing represents a gas fired combustion system embodying the control and alarm arrangement of my invention therein.

Referring to the drawing, at 10 I have shown a gas fired boiler which may be of a conventional

type and which forms a part of an industrial steam pressure system. While I have chosen to disclose as an example this particular form of boiler and system, my invention of course may be applied to various other types and forms of systems using different kinds of equipment.

The gaseous fuel is fed to the burner 11 through a conduit 12 which may be connected to a gas supply main (not shown). Interposed in the conduit 12 is an electrically operated gas control valve 13 which may be of a known type. The electric valve 13 incorporates an auxiliary switch 14 which is operated by the valve mechanism, and is closed whenever the valve 13 is in closed position. Ahead of the valve 13 in the conduit 12 is another valve 15 which is a manually operable valve having an operating handle 16. When the handle 16 is in the position shown, the valve 15 is closed, and when the handle 16 is moved to a vertical position the valve is opened. The valve 15 also incorporates an auxiliary switch 17 which is closed when the valve 15 is in closed position.

Adjacent the burner 11 is a small pilot burner 18 which is supplied with fuel through a tube 19 connected to the conduit 12 ahead of the valve 15. Interposed in the tube 19 is a small electric valve 20 which controls the supply of fuel to the pilot burner 18. Arranged within the combustion chamber so as to be impinged upon by the pilot burner is a control electrode 23 which co-operates in the control of my system in a manner which I will presently describe. Also arranged adjacent the outlet of the pilot burner 18 are a pair of electrodes 24 which are arranged to form a spark gap, the purpose of which is to ignite the pilot burner when it is desired to start the system in operation.

The electrodes 24 are connected to the secondary winding 33 of an ignition transformer 21 having a primary winding 34. The secondary winding 33 produces the necessary high voltage for causing a spark between the electrodes 24.

N numeral 25 designates a low water cut-off of conventional type embodying a mercury switch 25 which is arranged to be opened when the water level in the boiler falls below a predetermined level. The low water cut-off 25 is connected to the boiler drum by pipes 27 in the usual manner and also communicating with the pressure within the boiler is a pressure responsive switch 28 incorporating a mercury switch 29 which is normally closed, but is opened when the pressure within the boiler exceeds a predetermined value. Numeral 30 designates a blow

down valve for purposes of periodically blowing down and clearing the low water cut-off of scale and the like.

The control system which I employ embodies a flame detecting relay mechanism which I have designated generally at 22. The flame electrode 23 forms a part of the flame detecting mechanism 22. The flame detecting relay mechanism is of the electronic type and embodies an electronic valve 31 which takes the form of an electronic tube of the twin type amplifier which, for example, may be an RCA type 6C8 tube. The tube 31 includes two triodes in one glass envelope. The tube 31 may be properly described as an electronic valve by reason of its function in controlling a flow of electric current. One triode of valve 31 functions as a rectifier to supply a source of direct voltage for the second triode and the latter functions as an amplifier. For convenience the first mentioned triode will hereinafter be referred to as triode A and the second mentioned is triode B. The triode A includes an anode 32, a cathode 33, heater filament 29 and a control electrode or grid 34 which, as shown, is connected directly to the cathode 33. The triode B includes an anode 35, the cathode 36, heater filament 30 and a control electrode 37. The mechanism 22 includes a combination step-up and step-down transformer 38 having a primary winding 39 and secondary windings 40 and 41. The secondary winding 40 is a low voltage secondary and is connected to the heater filaments 29 and 30 by wires 42 and 43. The secondary winding 41 is a relatively higher voltage winding and is connected to the anode 32 by a wire 44, the other terminal of winding 41 being connected to a resistance 45 which forms in effect a voltage divider resistance. The cathode 33 is connected to the resistance 45 by wire 46. The triode A, as pointed out above, acts as a rectifier to supply a direct current voltage for operation of the triode B and whenever the transformer 38 is energized by reason of the triode A, a direct current voltage appears across the resistance 45. A condenser 47 is connected across the resistance 45 for the purpose of filtering out the alternating current component of the current which flows in the circuit of triode A. The positive end of resistance 45 which is connected to cathode 33 is also connected to ground as shown, through a resistance 48.

The cathode 36 is connected to an intermediate point on resistance 45 which may be the mid point as shown by wire 49. The grid 37 is connected to the negative end of the resistance 45 by a wire 50, there being a resistance 51 interposed in series with the wire 50. The tendency of the connection formed by the wire 50 is to bias the grid 37 negatively with respect to cathode 36. The grid 37 is also connected to the flame electrode 23 by a wire 52. The tube leading to the pilot burner 13 is grounded as shown at 53. In this type of flame detecting equipment, the pilot burner flame is adapted to create a path of lower resistance to flow of electricity between the electrode and the ground 53 than exists when the flame is not present and there is an air gap between the electrode 23 and the burner 18. When the pilot burner flame is present, this path of lower resistance is completed and the connection formed by the wire 52 and the flame to ground 53 tends to reduce the negative bias of the grid 37. Ground potential is higher than that of the grid 37.

Also embodied in the flame detecting mechanism 22 is a relay unit 55 including a winding 75

56 cooperating with an armature arranged to actuate switch blades 57 and 58 which are moved to the left into engagement with fixed contacts 59 and 60, respectively, when the winding 56 is energized. The blade 57 engages with a contact 61 when the winding 56 is deenergized. One end of the winding 56 is connected to the positive end of the resistance 45 by a wire 62 and the other end of the winding 56 is connected to the anode 35 of triode B by a wire 63.

Whenever transformer 38 is energized and there is no flame at the pilot burner 18 the grid 37 is biased sufficiently negatively so that not enough current flows in the circuit of the winding 56 to cause the blades 57 and 58 to be moved to the left. When flame appears at the pilot burner 18 as described above, a path of lower resistance is completed from the grid 37 to ground and it becomes biased less negatively so that a current flows in the plate circuit of triode B causing the relay 55 to be energized. This circuit is as follows: from resistance 45 through wire 62, winding 56, wire 63, plate 35, grid 37, cathode 36, and wire 49 back to resistance 45, the potential across resistance 45 between its positive end and the point where wire 49 is tapped off supplying the power for operating relay 55.

Numeral 65 designates a signal and alarm relay mechanism which constitutes an important part of my invention, particularly in the manner in which it cooperates with the other portions of the system. The signal and alarm relay mechanism 65 includes a relay unit 66 and a relay unit 67. The relay unit 66 has a winding 68 cooperating with an armature arranged to actuate switch blades 69 and 70 which are moved to the left into engagement with fixed contacts 71 and 72, respectively, when the relay is energized. The relay unit 67 has a winding 73 cooperating with an armature arranged to actuate switch blade 74 which is moved to the left into engagement with fixed contact 76 when the relay is energized. When relay 67 is deenergized blade 74 engages with contact 78 and 79, respectively. Numeral 80 indicates a green signal light which is on when the circuit is operating under safe conditions as will presently be described and numeral 81 indicates a red signal light which is on when an unsafe operating condition of the system occurs. Numeral 82 indicates an alarm bell which rings automatically in response to the failure or disappearance of flame in the combustion chamber, which of course is indicative of a hazardous condition by reason of the possibility of accumulation of unburned gaseous fuel in the combustion chamber.

Numeral 85 designates a manual control station embodying a stop button 86 cooperating with electrical terminals 87 and 88 and a start button 89 cooperating with electrical terminals 90 and 91.

To start the system in operation the operator pushes the start button 89 and holds it against the terminals 90 and 91 until the green light 80 comes on, this signal light being located on a panel board suitably situated so that the operator can see it from the position he is in when operating the switches at the manual control station 85. When the start button engages the terminals 90 and 91, a circuit is completed for energizing the transformer 38 provided that both the valves 13 and 15 are in closed position so that the auxiliary switches 14 and 17 are closed. The switches 26 and 29 must of course also be closed. The circuit for energizing the trans-

former 38 is as follows: from wire 92 through the stop button 86, wire 93 through the start button 89, wire 94, switch 14, wire 95, switch 17, wire 96, wire 97, switch 26, wire 98, switch 29, wire 99, wire 100, wire 101, winding 39 of the transformer, wire 102 back to the wire 93. The wires 92 and 93 may be connected to a suitable source of external power (not shown). At the same time that transformer 38 is energized a circuit is completed for energizing the ignition transformer 21 as follows: from wire 92 through stop button 86, wire 93, start button 89, wire 94, switch 14, wire 95, switch 17, wire 96, wire 97, switch 26, wire 98, switch 29, wire 99, wire 100, wire 103, switch blade 57, contact 61, wire 104, winding 84 of transformer 21, wire 105 and wire 106 back to wire 93. At the same time as the circuits just described are completed, a circuit is also completed for energizing and opening the valve 20 for admitting gas to the pilot burner 18. This circuit is as follows: from wire 92 through stop button 86, wire 93, start button 89, wire 94, switch 14, wire 95, switch 17, wire 96, wire 97, switch 26, wire 98, switch 29, wire 99, wire 107, valve 20, wire 108, wire 109, wire 110 and wire 106 back to wire 93. Energization of the ignition transformer 21 causes a spark to be produced between the electrodes 24 which ignites the gas from the pilot burner 18, gas beginning to flow of course as soon as the valve 20 is open. As soon as the flame appears at the pilot burner 18, a low resistance path will be produced as described above from the grid 37 to ground and due to the less negative bias now on the grid 37, current will be permitted to flow in the plate circuit of triode B thus energizing the relay 55, the circuit being as described above. If the pilot burner failed to ignite, the relay 55 will of course not be energized in the manner described. As soon as the relay 55 is energized, closure of switch 58 completes a circuit for energizing the transformer 38 which is independent of the start button 89 and the switches 14 and 17. This circuit is as follows: from wire 92 through the stop button 87, wire 93, wire 111, wire 112, wire 113, contact 60, switch blade 58, wire 114, wire 97, switch 26, wire 98, switch 29, wire 99, wire 100, wire 101, winding 39 and wire 102 back to wire 93. This circuit is made independent of the switches 14 and 17 so that the valves 13 and 15 can now be opened without causing deenergization of transformer 38. When the circuit last described is completed, a circuit for energizing valve 20 is also completed which circuit is likewise independent of the start button 89 and the switches 14 and 17. This circuit is as follows: from wire 92 through stop button 86, wire 93, wire 111, wire 112, wire 113, contact 60, blade 58, wire 114, wire 97, switch 26, wire 98, switch 29, wire 99, wire 107, valve 20, wire 108, wire 109, wire 110, and wire 106 back to wire 93. It will be seen that the circuits for transformer 38 and valve 20 which extend through the switch 58 are common as far as wire 99. Now at the same time that relay 55 is energized and causes completion of the above described circuits which are independent of the start button, a circuit is also completed for energizing and opening the valve 13 as follows: from wire 92 through stop button 86, wire 93, wire 111, wire 112, wire 113, contact 60, blade 58, wire 114, wire 97, switch 26, wire 98, switch 29, wire 99, wire 100, wire 103, blade 57, contact 59, wire 115, wire 116, valve 13, wire 117, wire 110 and wire 106 back to wire 93. When valve 13 is automatically opened as described the system is in readiness

for operation, it now only being required that the operator manually open the valve 15. That the system is in readiness for the valve 15 to be opened is indicated to the operator by the green light 80 coming on which comes on at the same time that valve 13 opens. The circuit for the light 80 will be described presently. At the same time that valve 13 opens, a circuit for energizing the relay 67 is completed as follows: from wire 92 through stop button 86, wire 111, wire 112, wire 113, contact 60, blade 58, wire 114, wire 97, switch 26, wire 98, switch 29, wire 99, wire 100, wire 103, blade 57, contact 59, wire 115, wire 118, wire 119, winding 73, wire 120, wire 121, wire 122, wire 123, wire 109, wire 110, and wire 106 back to wire 93. As soon as relay 67 is energized relay 66 also becomes energized through the following circuit: from wire 92 through stop button 86, wire 93, wire 111, wire 112, wire 124, blade 74, contact 76, wire 127, wire 128, winding 68, wire 129, wire 121, wire 122, wire 123, wire 109, wire 110, and wire 106 back to wire 93. As soon as relay 66 is energized it causes a maintaining circuit for itself to be completed which is independent of the relay 67. This maintaining circuit is as follows: from wire 92 through stop button 86, wire 93, wire 111, wire 130, blade 70, contact 72, wire 141, wire 128, winding 68, wire 129, wire 121, wire 122, wire 123, wire 109, wire 110, and wire 106 back to wire 93. At the same time that valve 13 and winding 73 are energized the green light 80 is lighted it being seen that the light 80 is connected in parallel with the winding 73 by wires 131 and 132 which connect to the wires leading to the terminals of winding 73. When the operator sees the green light is on he knows that the system has properly gone through its starting sequence and he then releases the start button and manually opens the valve 15 admitting fuel to the combustion chamber where it is ignited by the flame of the pilot burner 18.

My system is primarily intended to give an alarm and warning in the event of a flame failure during operation of the system but not to give such an alarm or warning at any other time such as would tend to frighten personnel in the vicinity of the boiler unnecessarily. Alarms occurring at improper times needlessly inconvenience and annoy the personnel as well as militating against the ultimate purpose and effectiveness of the alarm. Thus if flame should disappear within the combustion chamber at any time during operation, the relay 55 will be deenergized as has already been explained and the above described circuits for the valves 13 and 20 and for the relay 67 and light 80 will be instantly deenergized. However, the maintaining circuit described above for relay 66 will not be deenergized until such time as the stop button 86 is moved away from the terminals 87 and 88. Immediately upon the occurrence of the flame failure and deenergization of the relays 55 and 57, the red light 81 will come on and the bell 82 will begin to ring. The circuit for the bell 82 is as follows: from wire 92 through stop button 86, wire 93, wire 111, wire 112, wire 124, blade 74, contact 78, wire 134, contact 71, blade 69, wire 135, wire 136, bell 82, wire 137, wire 123, wire 109, wire 110, and wire 106 back to wire 93. The circuit for the red light 81 is as follows: from wire 92 through stop button 86, wire 93, wire 111, wire 112, wire 124, blade 74, contact 78, wire 134, contact 71, blade 69, wire 135, wire 138, light 81, wire 139, wire 122, wire 123, wire 109, wire 110,

and wire 106 back to wire 93. The red light will remain on and the bell 82 will continue ringing until the operator pushes the stop button 86 which will deenergize the relay 66, opening the maintaining circuit described above, and deenergization of relay 66 will interrupt the circuits of the red light and the bell.

The system is now shut down but the valve 15 remains in open position. However, before the operator can again put the system into operation he must manually move the valve 15 into closed position so that the switch 17 will become closed to enable completion of the original starting circuit as described above. The manual valve 15 provides an additional safeguard whereby if the automatic valve 13 should fail the operator will be unable to start the system and produce a spark in the combustion chamber which would ignite the gas pouring into the combustion chamber if the path of gas flow through the conduit 12 were not obstructed. Moreover, after having caused combustion to be established at the pilot burner by means of the start button, the operator must manually operate valve 15 to admit the main gas supply and therefore he has the opportunity to assure himself that everything is in proper order before doing so.

When the system has been operating properly and it is desired to shut it down, it is only necessary for the operator to push the stop button 86 which will deenergize the entire system including the relay 66. With both the relays 66 and 67 deenergized, both the red and green lights are out, and the bell 82 does not ring. Thus the disadvantage of many systems used in the past in that the alarm device sounded whenever the system was manually shut down is obviated. The system may of course also be shut down automatically by means of the pressure switch 28 or the low water cut-off 25. In the event of an automatic shut down from the switch 28 or low water cut-off 25, the alarm bell 82 will ring and the red light will come until the stop button 86 is pushed. Opening of switch 29 or switch 26 will deenergize the entire system with the exception of relay 66 which, as explained above, after having once been energized has a maintaining circuit which is dependent only upon the stop button 86.

From the foregoing it will be apparent to those skilled in the art that I have provided a safety control system for combustion apparatus whereby a system can be started, operated, and stopped with the optimum in safety. The interlocking relationship of the controls and the arrangement of the signals and alarms is such that the danger of any exigencies arising such as would create a hazardous condition is practically eliminated. It is noteworthy that the system is of such a nature that the dangers normally attributable to the human element in the operation of these systems is reduced to a negligible factor. Only the barest kind of elementary knowledge and intelligence is required of an operator to safely and satisfactorily operate even a complex system in which my invention is embodied.

It is to be understood that other types of flame detecting mechanism than the electronic device which I have disclosed can be used in the system. Moreover, my invention, particularly that portion of it comprising the alarm and signal relay mechanism, is ideally adapted to use in systems which are automatically started, operated, and stopped. In such a system an automatic switch would of course take the place of the manual

station 85 and the system would be started by closing such a switch and stopped by opening it. A relay switch such as the switch 58 would be used to shunt the switches 14 and 17 after completion of the original starting circuits.

The single form of my invention which I have disclosed is illustrative of one mode of practicing and applying it. There are many changes which may be made in the invention and there are various forms which it may take and it is therefore to be limited only in accordance with the appended claims.

I claim as my invention:

1. In a system of the class described, in combination, a combustion system comprising means forming a combustion chamber, means for supplying fuel to said combustion chamber, means for igniting said fuel, apparatus comprising control means for causing fuel to be supplied to said combustion chamber and for causing said fuel to become ignited, said control means also being operable to terminate combustion in said combustion chamber, means operable to check the capability of said igniting means of igniting incoming fuel, signal apparatus comprising interlocking electrical relays associated with said checking means and a signal device, energization of one of said relays being dependent on said checking means, and another of said relays becoming energized when said one relay is energized, means whereby energization of said other relay becomes independent of said one relay when said other relay is energized, said other relay being independent of said flame detecting means, and said signal device being arranged to give a signal when said one relay is deenergized and said other relay is energized.

2. In an alarm system for combustion apparatus in combination, means forming a combustion system, means forming an alarm device, a first electrical relay, a second electrical relay, said relays being wired in interlocking relationship, means comprising a switch for starting said combustion system in operation, means whereby said second relay becomes energized upon assurance that combustion can safely proceed, means whereby said first relay becomes energized upon energization of said second relay, means whereby energization of said first relay becomes independent of said second relay when said first relay is energized, means whereby said second relay is deenergized in response to an unsafe operating condition of said combustion system, said first relay remaining energized and means whereby said alarm device gives an alarm when said second relay is deenergized and said first relay is energized.

3. In a signal system, in combination, means forming a signal device, a first electrical relay, a second electrical relay, said relays being arranged in interlocking relationship, means for energizing said second relay, means whereby said first relay becomes energized upon energization of said second relay, said first relay being operable to remain energized independently of the energization of said second relay after becoming initially energized, and means whereby upon deenergization of said second relay only, both relays cooperate in a manner whereby said signal device gives a signal.

4. In a signal system, in combination, means forming a signal device, a first electrical relay, a second electrical relay, said relays being arranged in interlocking relationship, means for energizing said second relay, means whereby said

first relay becomes energized upon energization of said second relay, said first relay being operable to remain energized independently of the energization of said second relay after becoming initially energized, means whereby upon de-energization of said second relay only, both relays cooperate in a manner whereby said signal device gives a signal, and means for deenergizing said first relay to terminate the signal given by said signal device.

5. In a system of the class described, in combination, a combustion system comprising means forming a combustion chamber, means for supplying fuel to said combustion chamber, means for igniting said fuel, apparatus comprising control means for causing fuel to be supplied to said combustion chamber and for causing said fuel to become ignited, said control means also being operable to terminate combustion in said combustion chamber, means operable to detect the presence or absence of flame in said combustion chamber, said last means comprising means responsive to the electrical resistance of a flame in the combustion chamber, signal apparatus comprising interlocking electrical relays associated with said flame detecting means and a signal device, energization of one of said relays being dependent on said flame detecting means, and another of said relays becoming energized when said one relay is energized, means whereby energization of said other relay become independent of said one relay when said other relay is energized, said other relay being independent of said flame detecting means, and said signal device being arranged to give a signal when said one relay is deenergized and said other relay is energized.

6. In a system of the class described, in combination, a combustion system comprising means forming a combustion chamber, means for supplying fuel to the combustion chamber, fuel control means comprising a manually operable device for initiating the supply of fuel, a normally closed switch operable by said device and movable to open position when said device is operated to initiate the fuel supply, fuel igniting means, a manual controller in control of said igniting means, means whereby said fuel igniting means is dependent for operation upon said switch whereby said igniting means cannot be operated unless said manually operable device is in position to prevent the supply of fuel and said device must be manually operated to initiate the fuel supply after said igniting means is in condition for igniting fuel.

7. In a system of the class described, in combination, a combustion system comprising means forming a combustion chamber, means for supplying fuel to the combustion chamber, fuel control means comprising a manually operable device for initiating the supply of fuel, a normally closed switch operable by said device and movable to open position when said device is operated to initiate the fuel supply, fuel igniting means, a manual controller in control of said igniting means, means whereby said fuel igniting means is dependent for operation upon said switch, signal means for indicating when said igniting means

is in condition for igniting fuel, whereby said igniting means cannot be operated unless said manually operable device is in position to prevent the supply of fuel and said device must be manually operated to initiate the fuel supply after said igniting means is in condition for igniting fuel as indicated by said signal means.

8. In a combustion control system, in combination, a combustion chamber, an automatic device and a manually operable device controlling the supply of fuel to the combustion chamber, fuel igniting means, a manual controller for said igniting means, switches associated with said devices and circuit means whereby operation of said igniting means is dependent upon both said devices being in position to prevent the supply of fuel, automatic means operable to respond if said igniting means is in condition to ignite fuel, and said automatic device being responsive to said automatic means.

9. In a combustion control system, in combination, a combustion chamber, an automatic device and a manually operable device controlling the supply of fuel to the combustion chamber, fuel igniting means, a manual controller for said igniting means, switches associated with said devices and circuit means whereby operation of said igniting means is dependent upon both said devices being in position to prevent the supply of fuel, automatic means operable to respond if said igniting means is in condition to ignite fuel, said automatic device being responsive to said automatic means, and signal means for indicating when said igniting means is in condition for igniting fuel whereby said manually operable device may then be operated to initiate the fuel supply.

10. In a combustion control system, in combination, a combustion chamber, a manually operable device controlling the supply of fuel to the combustion chamber, fuel igniting means, a manual controller for said igniting means, a switch associated with said device and circuit means whereby operation of said igniting means is dependent upon said device being in position to prevent the supply of fuel, and automatic means operable to respond if said igniting means are in condition to ignite fuel, and an automatic fuel supply control device controlled by said automatic means.

11. In a combustion control system, in combination, a combustion chamber, a manually operable device controlling the supply of fuel to the combustion chamber, fuel igniting means, a manual controller for said igniting means, a switch associated with said device and circuit means whereby operation of said igniting means is dependent upon said device being in position to prevent the supply of fuel, automatic means operable to respond if said igniting means are in condition to ignite fuel, an automatic fuel supply control device controlled by said automatic means and signal means for indicating when said igniting means are in condition for igniting fuel whereby said manually operable device may then be operated to initiate the fuel supply.

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