July 9, 1968 T. A. ROHRER 3,391,866

BURNER CONTROL SYSTEM

Filed April 29, 1966

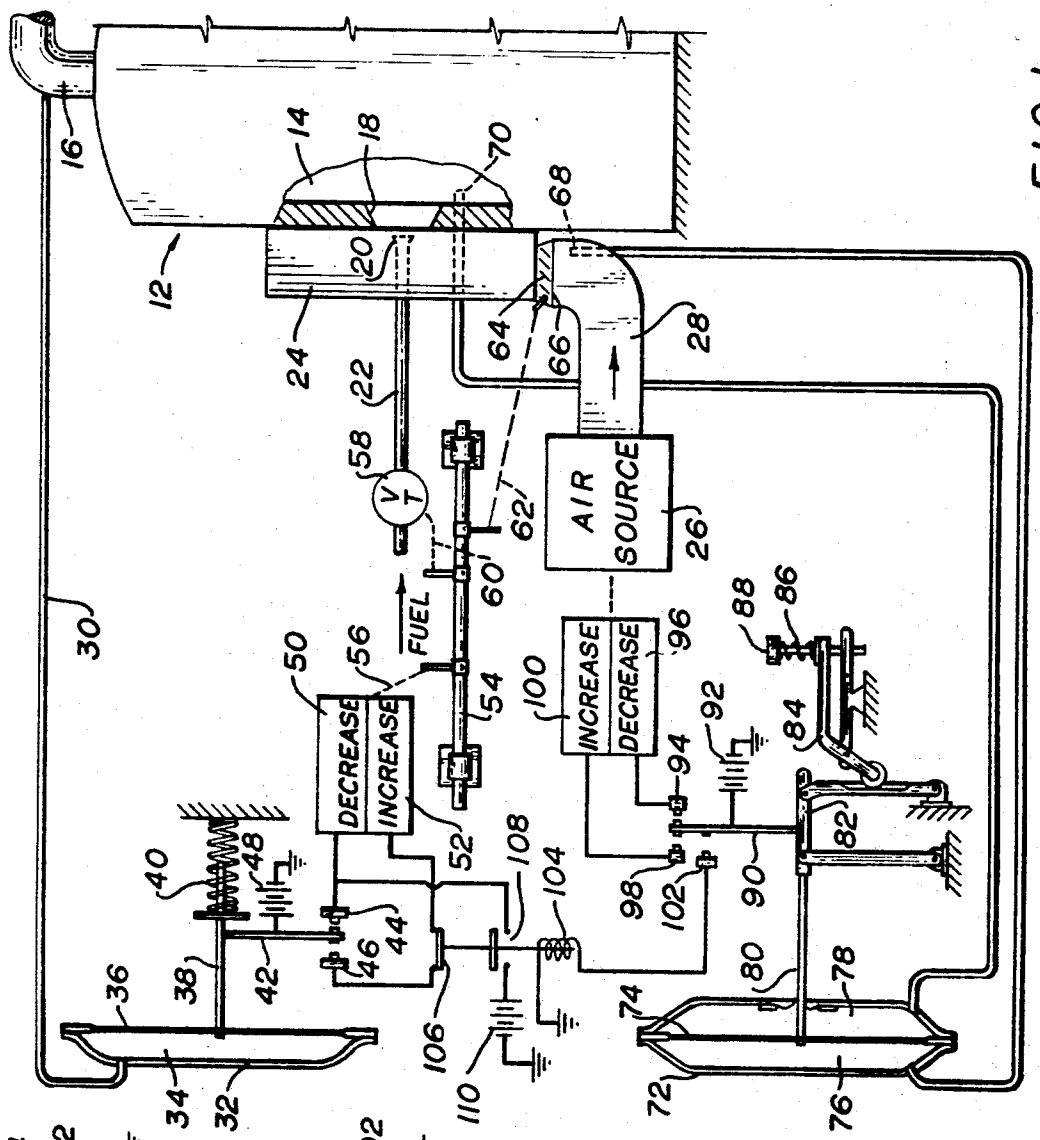

FIG. 1

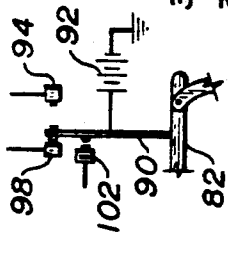

FIG. 2

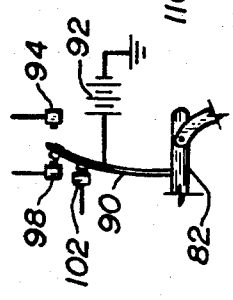

FIG. 3

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United States Patent Office

3,391,866

Patented July 9, 1968

3,391,866

BURNER CONTROL SYSTEM

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Filed Apr. 29, 1966, Ser. No. 546,377
3 Claims. (Cl. 236—14)

ABSTRACT OF THE DISCLOSURE

An auxiliary electrical contact associated with a single-pole double-throw switching mechanism which interrupts fuel input to a burner. An armature forming part of the single-pole double-throw switch that moves into contact with the auxiliary contact only after closing one of the poles of the switch. A burner system employing the auxiliary contact.

This invention relates to a control system for a burner of the type used for firing a steam boiler combustion chamber and more particularly to such system in which an adequate and safe supply of combustion air is assured at all times.

In automated burner control systems of the type used to fire steam boilers, it is conventional practice to vary input flow rates of fuel and combustion air in order to maintain a constant steam pressure at the output of the boiler. It is essential in such systems that the amount of fuel and combustion air be properly proportioned relative one another so that optimum combustion is secured at all times. Should the rate of air inflow be inadequate, for example, as a result of malfunction of the control system or the forced air producing apparatus, excess fuel is delivered to the combustion chamber and can cause sooty or smokey operation thereof, and in some extreme cases, dangerous explosions.

An object of the present invention is to provide a burner control system which automatically reduces the rate of fuel inflow when the rate of air inflow is inadequate to support full fuel combustion. This object is achieved by providing in an electrical air flow controlling circuit an auxiliary contact which establishes a circuit only when the combustion chamber demands a greater flow of combustion air than the air control system is capable of delivering. The auxiliary contact is connected in circuit so as to reduce automatically the rate of fuel inflow irrespective of steam pressure output of the boiler.

Another object is to provide a safety device which is readily adaptable to previously proposed control systems without impairing the accuracy or economy of such previous system. In this respect reference is made to commonly assigned copending application for United States Letters Patent, Ser. No. 448,304, filed Apr. 15, 1965, now Patent No. 3,294,146, in which is disclosed a metering system for supplying combustion air to the combustion chamber. Such metering system employs an adjustable air damper that is adjusted in accordance with the rate of fuel inflow and across which damper the pressure drop is sensed. The previous system discloses apparatus for maintaining constant such pressure drop so that the rate of air inflow is at all times proportional to the position of the damper vanes. In the above-cited patent a flexible diaphragm is positioned in proportion to the pressure drop and carries a movable contact arm with which is associated a pair of fixed contacts. When the air pressure drop sensed is less than a preselected set point, manifesting that inadequate combustion air is being delivered, the moving arm, through action of unequal pressures across the diaphragm, is moved into contact with one of the fixed contacts to establish a circuit to effect increase of air supply. A similar end opposite action takes place should the pressure drop be excessive, a phenomenon occurring when excessive air is delivered through the damper. The present invention provides an auxiliary contact adjacent the first mentioned fixed contact and spaced somewhat therebehind so that as the moving arm is urged against such fixed contact, a circuit will be established through the auxiliary contact if the pressure on opposite sides of the diaphragm is not promptly brought into balance. The circuit established through the auxiliary contact is adapted to terminate increase of fuel inflow rate and to initiate decrease of fuel inflow rate.

Still another object is to provide in a boiler control system of the type described above, an electrical controller having a flexible moving contact arm with at least two contact areas spaced therealong. Fixed contacts mounted in alignment with the contact areas are contacted by the areas sequentially due to the flexibility of the moving arm; such structure lends itself to efficient and economic sequential control of burner regulating functions.

These and other objects will be more apparent after referring to the following specification and accompanying drawing in which:

FIG. 1 is a partially schematic view of a burner control system employing the present invention;

FIG. 2 is a detail view of a portion of the system of FIG. 1, showing the circuit condition for an ordinary increase in air delivery and

FIG. 3 is simlilar to FIG. 2 showing the circuit condition when the air supply system is unable to meet burner air demands.

Referring more particularly to the drawing, reference numeral **12** indicates a steam boiler having a combustion chamber **14** and a steam outlet header pipe **16** of conventional form. Combustion chamber **14** is fired through a throat opening **18** by a fuel nozzle **20** supplied with fuel, such as oil, from a fuel inlet line **22**. Combustion air is supplied to combustion chamber **14** through throat opening **18** from windbox **24** which communicates with an air source **26**, such as a fan or turbine, through an air duct **28**.

The rate at which fuel and air are supplied to combustion chamber **14** is regulated in accordance with the steam pressure existing in header pipe **16** and for this purpose a pressure tap line **30** communicates the pressure of the steam in the header pipe to a pressure sensor **32**. The pressure sensor includes a chamber **34** in communication with the steam pressure, one wall of the chamber being formed by a flexible diaphragm **36**. Centrally of the diaphragm is a connecting rod **38** which is biased inwardly of chamber **34** by a compression spring **40**. Thus, the position of connecting rod **38** is proportional to the steam pressure in header pipe **16**. Attached to connecting rod **38** is an armature or contact arm **42** which moves in response to changes of steam pressure and connects to a fixed contact **44** when the steam pressure exceeds a preselected pressure and to a fixed contact **46** when the steam pressure falls below a preselected pressure. A power source **48** is connected to armature **42** so that when the armature is connected to fixed contact **44** a control motor **50** is energized to decrease the rate of fuel inflow and when the armature is connected to fixed contact **46** a motor **52** is energized to increase the rate of fuel inflow to the combustion chamber. Motors **50** and **52** are linked to a control shaft **54** by linkage **56**; a throttle valve **58** in fuel line **22** is also linked to control shaft **54** through a link **60** to afford control of fuel line inflow in proportion to steam pressure.

Also linked to control shaft **54** through a link **62** are adjustably-mounted vanes **64** of an air damper **66** which controls the amount of air supplied to windbox **24**.

Because both fuel valve 58 and air damper 66 are linked to control shaft 54 and because the control shaft is positioned in accordance with steam pressure output of the boiler, the fuel and air supplied to the combustion chamber are automatically controlled to maintain constant steam pressure.

For establishing the rate of air flow through damper 66 in proportion to the position of vanes 64 of the damper, the pressure drop across the damper is maintained constant at all times. Accordingly, the rate of air inflow is proportional to the position of vanes 64. The pressure across the damper is maintained constant by providing a pressure tap 68 upstream of the damper and a second pressure tap 70 within combustion chamber 14. Pressure taps 68 and 70 are connected to a differential pressure sensor which includes a pressure chamber 72 centrally of which is a flexible air-impervious diaphragm 74. The diaphragm divides the chamber into compartments 76 and 78 with which pressure taps 68 and 70 respectively communicate. Centrally of diaphragm 74 is attached a connecting rod 80 which is supported outwardly of chamber 72 on a pantograph linkage 82. The connecting rod is biased leftwardly as viewed in FIG. 1, by a lever 84 which is loaded by a compression spring 86, the amount of force provided by the spring being adjustable through an adjusting screw 88. It will thus be seen that the position of connecting rod 80 corresponds to the differential pressure across damper 66. Supported on pantograph linkage 82 for movement with connecting rod 80 is a resilient armature or contact arm 90 to which is electrically connected a power source 92. Armature 90 moves rightwardly when the rate of air inflow exceeds a preselected setting and on such rightward movement a fixed contact 94 connects power source 92 to an electrical control motor 96 which effects a decrease in the output of air source 26. With the advent of a reduction of air inflow below a preselected rate, armature 90 moves leftwardly into electrical contact with a fixed contact 98 which connects power source 92 to a control motor 100 to effect an increase in the output of air source 26.

To recapitulate the control system described to this point, it is convenient to assume that the pressure in steam header 16 has fallen below a preselected pressure and that spring 40 has urged armature 42 leftwardly as viewed in FIG. 1 and into contact with fixed contact 46. Power from power source 48 is thus supplied to control motor 52 and shaft 54 is rotated to open valve 58 to increase the fuel delivered through nozzle 20 and to open damper 66 to increase the rate of air inflow. The rate of air inflow is increased when damper 66 is opened because armature 90 moves leftwardly into connection with fixed contact 98 in response to a temporary decrease in differential pressure between taps 68 and 70. When armature 90 contacts fixed contact 98 power is supplied from power source 92 to control motor 100 to increase the output of air source 26 until the differential pressure sensed at taps 68 and 70 is restored to a preset amount. Should the pressure in steam header pipe 16 increase above a preselected point a reverse action corresponding to that described next above occurs and the steam pressure is thereby regulated.

Should air source 26 fail to provide increased air delivery in response to increased fuel delivery, when a low steam pressure condition is sensed, inadequate air for complete combustion of the fuel will be supplied and boiler 12 will emit smoke and soot at the very least, or explode at the worst. Such inadequate air delivery may arise from a malfunction in air source 26, a malfunction of control motor 100, a malfunction of damper 66 and its control linkage 62, or like unexpected causes. To avoid creation of a condition of inadequate air delivery, the present invention includes a fixed contact 102 mounted adjacent armature 90, which fixed contact is behind fixed contact 98 so that armature 90 is connected to fixed contact 98 before it is connected to fixed contact 102. Electrically connected to fixed contact 102 is a relay coil 104 which has a normally closed contact 106 and a normally open contact 108. Contact 106 is in series between fixed contact 46 and control motor 52 and opening of the contact will prevent an increase in the rate of fuel inflow through nozzle 20. Normally open contact is in shunt with the circuit between fixed contact 44 and control motor 50 and when closed, in response to energization of coil 104, connects a power source 110 to control motor 50. Energization of control motor 50 decreases the rate of fuel inflow through nozzle 20.

The operation of the invention can now be understood by assuming that steam pressure in header pipe 16 has fallen below a preselected point. As described previously, control motor 52 will be energized to increase the rates of fuel and air inflow so as to restore the steam pressure. If the air supply system is functioning properly, armature 90 will connect fixed contact 98, see FIG. 2, and the output of air source 26 will be increased by action of control motor 100. If, because of some system malfunction, the rate of air inflow is increased less than is necessary to afford adequate combustion air for the fuel, the differential pressure between taps 68 and 70 and across diaphragm 74 will not restore armature 90 to the neutral position, but rather, will permit spring 86 to move the diaphragm leftwardly an additional amount. Because armature 90 is flexible it will ultimately establish contact with fixed auxiliary contact 102, which, in turn, connects power from power source 92 to relay coil 104. When the relay coil is energized contact 106 is opened, thereby preventing a further increase of fuel inflow and contact 108 is closed, thereby connecting power source 110 to control motor 50 to reduce the amount of fuel inflow. The consequence of energizing control motor 50 is that vanes 64 in damper 66 are moved toward a closed position and the pressure differential as sensed at taps 68 and 70 is thereby increased. Such differential pressure increase restores diaphragm 74 to a central position whereby relay coil 104 is deenergized and normal system operation restored. If on restoration of normal operation the rate of combustion air is still insufficient to support full combustion, the above-described sequence will be repeated so as to avoid excessive fuel supply to the combustion chamber. Obviously, if the condition of inadequate air continues system repair is necessary. In no event, however, can the combustion chamber be oversupplied with fuel which, as pointed out above, causes a sooty and/or explosive condition.

Because fixed auxiliary contact 102 is behind fixed contact 98, the former is contacted after the latter, thereby avoiding interference with the normal operation of the system. A full equivalent to the specific arrangement shown in the drawings, is a spring mount for fixed contact 98 which permits the contact to yield leftwardly in response to force from armature 90.

Thus, it will be seen that the present invention provides an extremely reliable and uncomplex apparatus for avoiding the sustained oversupply of fuel to a combustion chamber. Because the invention in essence requires only the addition of a fixed contact and a relay, it is readily adaptable to existing installations without substantial interruption of service and at extremely low cost.

Although one embodiment of the invention has been shown and described, it will be apparent that other adaptations and modifications can be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. A burner system for firing a steam boiler combustion chamber comprising means for sensing the output steam pressure of said boiler, means responsive to said sensing means for increasing the rate of fuel inflow in response to a decrease in steam pressure and decreas-

ing the rate of fuel inflow in response to increase in steam pressure, said rate increasing means including an electric circuit having a series connected normally closed contact that constitutes the sole energizing conection to said rate increasing means, air control means responsive to last said means for proportionately increasing the supply of air inflow on increase of fuel inflow rate and decreasing air inflow on decreasing inflow fuel rate, and means responsive to said air flow increasing means and independent of output steam pressure for opening said normally closed contact to disable said fuel increasing means only when insufficient combustion air is supplied to the combustion chamber by said air flow controlling means.

2. A burner system for firing a steam boiler combustion chamber comprising means for sensing the output steam pressure of said boiler, means responsive to said sensing means for increasing the rate of fuel inflow in response to a decrease in steam pressure and decreasing the rate of fuel inflow in response to increase in steam pressure, air control means responsive to last said means for proportionately increasing the supply of air inflow on increase of fuel inflow rate and decreasing air inflow on decreasing inflow fuel rate, and means responsive to said air flow increasing means for disabling said fuel increasing means when insufficient combustion air is supplied to the combustion chamber by said air flow controlling means, said air control means comprising a flexible resilient armature, means for moving said armature in a first direction in response to insufficient air delivery to said combustion chamber and in a second direction opposite said first direction in response to excessive air delivery to said combustion chamber, a first fixed contact mounted relative to said armature for connection thereby in response to armature movement in the first direction, a second fixed contact mounted relative to said armature for connection thereby in response to armature movement in the second direction, said first fixed contact being connected in circuit to said air inflow increasing means and said second contact being connected in circuit to said air inflow decreasing means, and an auxiliary fixed contact spaced on the same side of said armature as said first fixed contact, said auxiliary contact being spaced relative said first contact so that said armature connects to said auxiliary contact at a lower proportionate air inflow rate than the air inflow rate at which the armature connects to said first fixed contact, a relay having a coil in circuit with said auxiliary contact, said relay having a normally closed contact and a normally open contact, means connecting said normally closed contact in circuit with said fuel rate increasing means, and means connecting said normally open contact in shunt with said fuel rate decreasing means.

3. Apparatus for controllably supplying fuel and combustion air to a steam boiler combustion chamber comprising a fuel line for delivering fuel to said combustion chamber, a valve in said fuel line for controlling the rate of fuel flow therethrough, a first electric motor for opening said fuel valve, a second electric motor for closing said fuel valve, means responsive to the output steam pressure of said boiler for electrically energizing said first motor when the steam pressure falls below a preselected magnitude and for energizing said second motor when the steam pressure exceeds a preselected magnitude, an air damper having at least one adjustable vane linked to said first and second motors so that the position of said vane corresponds to the position of said valve, means for supplying combustion air through said damper to said combustion chamber, means for sensing the pressure drop across said damper, an armature linked to said pressure drop responsive means and being constrained to move along a path in proportion to the pressure drop sensed by said sensing means, first and second fixed electrical contacts disposed in said path for alternate connection by said armature, said first fixed contact being positioned for connection by said armature when the pressure drop across said damper falls below a preselected magnitude, said second fixed contact being disposed in said path for connection by said armature when the differential pressure across said damper exceeds a preselected magnitude, a third electric motor in circuit with said first fixed contact for increasing the rate of air supplied by said air supplying means, a fourth electric motor in circuit with said second fixed contact for decreasing the flow of air supplied by said air supplying means and a third fixed contact mounted in fixed spaced relation to said first fixed contact so that said third contact is connected to said armature only after said first contact, and means in circuit with said third contact for simultaneously supplying power to said first motor and for interrupting power to said second motor.

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