

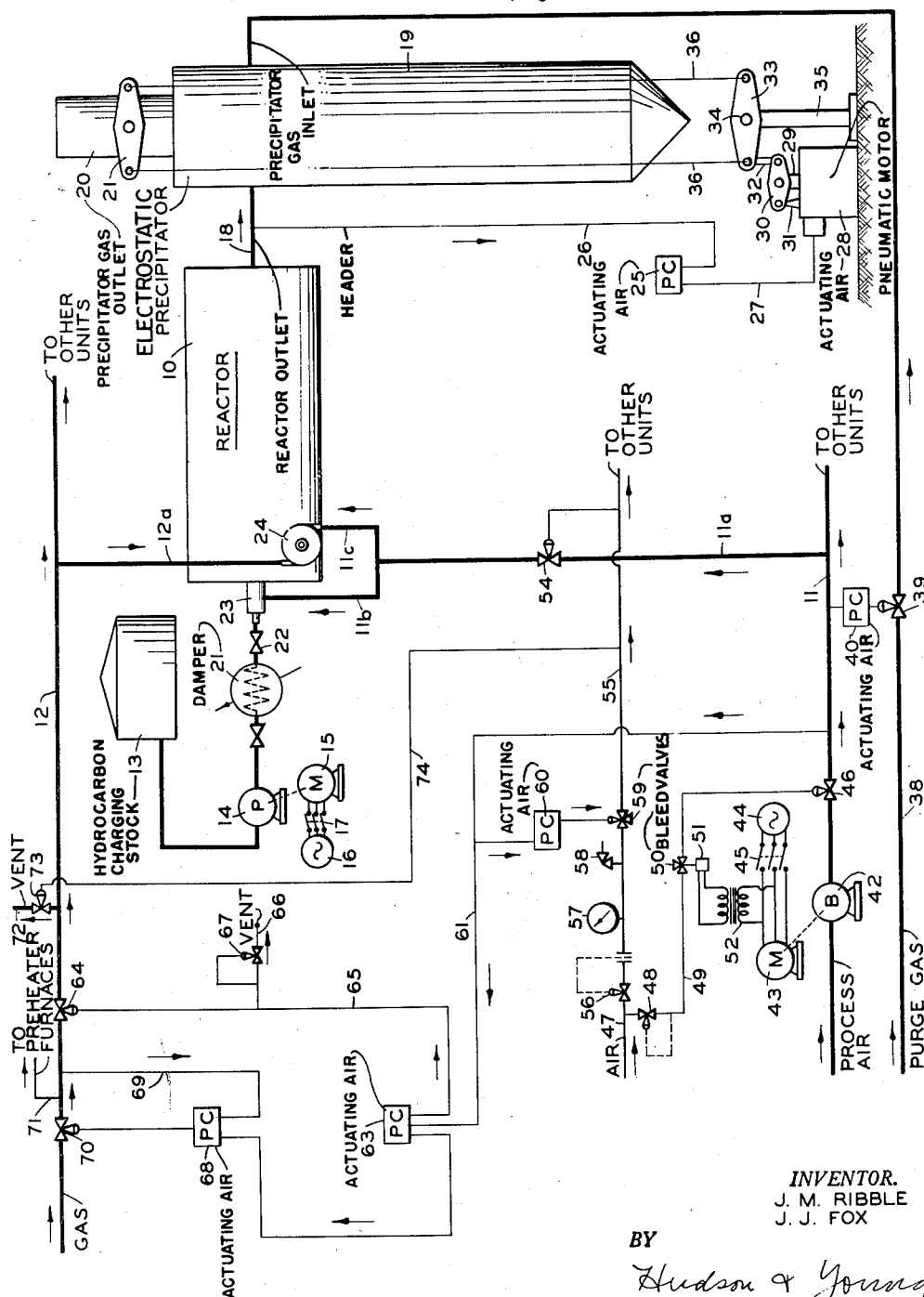
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SAFETY SYSTEM FOR COMBUSTION PROCESS

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SAFETY SYSTEM FOR COMBUSTION PROCESS

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This invention relates to a safety system. In another aspect, it relates to a system for preventing explosions in plant operations involving the burning of a combustible mixture. In still another aspect, it relates to a safety system for a carbon black plant.

In processes where combustible mixtures are burned, the vessels and lines containing the reaction gases may be subject to an increase in oxygen content in the event of a pressure failure in the system due to the entrance of air to the zone of reduced pressure. Such an increase in oxygen content may result in the formation of an explosive mixture in the lines and vessels of the plant.

This is particularly true of a carbon black plant wherein a vaporized hydrocarbon charging stock is cracked under severe conditions within a plurality of reactors in the presence of gases resulting from the combustion of fuel gas and air. From the reactors, the effluent gas containing carbon black is fed through suitable headers to a precipitator unit wherein the carbon black is electrostatically separated from the gases, which pass to the atmosphere through a stack. The plant may also include one or more cyclone separators to effect further separation of the carbon black from the effluent gases. The effluent from the reactors in such a plant contains substantial quantities of hydrogen and carbon monoxide. During the normal operation of the plant, sufficient oxygen is not present to provide a combustible or explosive mixture.

When a shut down occurs resulting, for example, from a power failure, the blowers supplying air to the process are disabled, thereby reducing the pressure in the system. As a result, air may enter the precipitator through the stack, the oxygen therein mixing with the hydrogen and carbon monoxide in the effluent gases to produce an explosive mixture, which is set off through contact with the heated surfaces of the equipment. Further, when the current supply to the blower motors is interrupted, the blowers may continue to supply air to the process for a short time due to their inertia, and the air thereby introduced may form an explosive mixture with the aforesaid hydrogen and carbon monoxide. It is also readily apparent that the formation of an explosive mixture may be facilitated if the supply of fuel gas to the system is not rapidly interrupted when a shut down occurs.

In accordance with this invention, a safety system is provided with a number of cooperating elements to prevent the existence of an explosive mixture in the system in the event of a shut down. When the pressure in the system decreases, the precipitator dampers are closed and a supply of purge gas is fed to the precipitator unit. In this manner, a superatmospheric pressure is maintained in the system so that air cannot enter through the precipitator stack with resultant formation of an explosive mixture. Further, when the pressure of the air supply to the process decreases to such an extent that the pressure in the system is unduly lowered, the supply of fuel gas to the reactor is cut off, a novel pneumatic control

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system being provided to effect quick closure of a valve in the gas supply line, and a vent pipe in the gas line is opened to bleed the fuel gas from the section of the line between the shut off valve and the reactor. As the pressure in the air supply conduit drops through a marginal operating range, which begins at a pressure substantially below the normal operating pressure and ends at the critical pressure at which the gas supply is interrupted, the supply of gas is reduced in accordance with decreases in air pressure within such marginal operating range.

The safety system also incorporates shut off valves for closing off the air supply to each individual reactor at a point immediately upstream of the reactor, and, in the event of a power failure, a solenoid operated valve causes closure of a valve in the air line just downstream of the electrically-operated blowers to prevent the supply of further air to the system through the inertial effect of the blower. In this manner, the supply of air and gas to the system is so controlled in cooperation with damper control of the precipitator and the supply of purged gas thereto as to prevent the occurrence of a mixture of explosive composition within the system.

Although the safety system has been briefly described in connection with a carbon black plant, it will be understood that certain principles of the invention are applicable to many other types of systems involving the burning of a mixture of fuel gas and air with or without other reactants.

It is an object of the invention to provide an improved safety system for a plant where combustible or explosive mixtures may be formed in the reaction lines and vessels.

It is a further object to provide an improved safety system for a carbon black plant.

Various other objects, advantages and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

The figure is a flow diagram of a carbon black plant utilizing the safety system of this invention.

Referring now to the drawing in detail, the safety system of this invention is shown in connection with a carbon black plant including a reactor 10 to which process air under pressure is fed by a conduit 11 and to which fuel gas, such as natural gas, is supplied under pressure by a line 12. A vaporized hydrocarbon, such as a heavy gas oil, is supplied to the reactor from a storage tank 13 through a main charge pump 14. This pump is driven by a motor 15 which is supplied with current from an alternating source 16 through a switch 17. The products leave the reactor through a header 18 which leads to an electrostatic precipitator 19 to separate the carbon black from the effluent gases. A stack 20 is provided for the gases, and the black is collected from the precipitator in the usual manner. A damper 21 regulates the size of the orifice in the stack 20.

Although the carbon black plant ordinarily includes a number of reactors, we have shown only one reactor as the manner in which the safety system applies to the other reactors will become readily apparent from the following description.

It will be understood that the effluent from all the reactors can go to a common precipitator or, alternatively, individual reactors or groups of reactors can be provided with individual precipitators. Furthermore, other separating devices, such as bag filters or cyclone separators, can be incorporated in the system in conjunction with the precipitator 19.

Each reactor is supplied with separate inlet and effluent lines and associated equipment in the manner shown in connection with the reactor 10 of the figure. These lines and associated apparatus include a branch conduit

11a for supplying air under pressure to each reactor, a branch line 12a for supplying gas under pressure to each reactor, a preheater furnace 21 for vaporizing the hydrocarbon charge and a valve 22 controlling the supply of vaporized hydrocarbon to the reactor.

Preferably and advantageously, the reactor is of the type shown in Patent No. 2,564,700 to J. C. Krejci and includes a cylindrical reaction chamber to which the vaporized hydrocarbon and air are admitted axially, the air passing through a branch conduit 11b to a tube 23 surrounding the oil injection nozzle. The gas from branch line 12a is mixed with air passing through a branch conduit 11c in a burner 24, the combustible gas-air mixture thence entering the reactor in a tangential direction. In this manner, the axial hydrocarbon stream is surrounded by a spirally swirling blanket of combustion gases which severely cracks the hydrocarbon vapors to form carbon black. The effluent from the reactor, therefore, consists of carbon black suspended in a stream of flue gases which may contain as much as 12 percent hydrogen and as much as 2 or 3 percent carbon monoxide. Since the air and fuel gas are introduced in substantially stoichiometric proportions, however, the oxygen in the air is normally consumed during combustion so that the amount of oxygen in the flue gas is insufficient to form a combustible or explosive mixture.

The safety system of our invention includes a pressure controller 25 which is connected by a line 26 to the header 18 and which produces an output air pressure proportional to the pressure in header 18. This output pressure is transmitted by a line 27 to a pneumatic motor 28 incorporating a piston, not shown, which is controlled by the pressure in line 27 to raise and lower a rod 29 in accordance with the pressure in header 18. Rod 29 is connected to damper 21 by a mechanical linkage which includes a lever 30 fulcrumed at 31 to the motor 28, this lever being connected by a link 32 to a lever 33 pivoted at 34 to a standard 35, the ends of lever 33 being connected, in turn, to the damper 21 by cables 36.

Controller 25 is set so as to tend to maintain a constant superatmospheric pressure within the precipitator 19. To this end, controller 25 can be set so that, as the pressure in header 18 decreases, the damper 21 closes in a proportionate manner to limit the escape of flue gas from the precipitator, and thereby tend to maintain the aforesaid constant superatmospheric pressure therein. Alternatively, controller 25 can be set so as to abruptly close damper 21 when the pressure in header 18 falls below a predetermined value.

Cooperating with the described damper control system is a purge gas unit which includes a line 38 for conveying purge gas, such as natural gas, under pressure to the interior of precipitator 19. The supply of purge gas is controlled by a normally closed pneumatically-operated valve 39 regulated by a pressure controller 40 which, in turn, is controlled by the air pressure in conduit 11. Normally, the pressure in conduit 11 is about four pounds per square inch gauge and this pressure normally causes controller 40 to maintain valve 39 in closed position. When the pressure in air supply conduit 11 drops below a predetermined value, such as one pound per square inch gauge, controller 40 operates to open valve 39 and supply purge gas under pressure to the precipitator. Accordingly, the damper control mechanism and purge gas system cooperate to maintain a superatmospheric pressure in precipitator 19 at all times even when the supply of air to the plant fails. This prevents air from entering the precipitator through stack 20 and the resultant formation of a combustible mixture through mixing of the oxygen in the air with a hydrogen and carbon monoxide in the effluent gases from the reactor.

Process air is supplied to the plant by a system incorporating a blower 42 feeding the main air supply conduit 11. Blower 42 is driven by an electric motor 43

which is connected to a polyphase alternating current source 44 through a switch 45. A power failure in the plant is the most frequent cause of shut down of the equipment. When the power supply is interrupted, the blower continues to operate for a short period of time due to its inertia, thereby tending to force air into the reaction system with resultant formation of a combustible mixture.

In accordance with our invention, this is prevented by providing a pneumatic motor valve 46 in air conduit 11 just downstream of the blower 42. This valve is normally maintained in open position by air pressure from a source 47 of instrument air which is transmitted through a pressure regulator 48 and a control line 49. Incorporated in the control line 49 is a solenoid-operated three way bleed valve 50 having an operating winding 51 connected by a transformer 52 with two phases of the polyphase current supply for the motor 43. Solenoid winding 51 is energized while the motor is operating normally so that air is supplied through control line 49 to the valve 46. When the current supply fails or is turned off by switch 45, solenoid winding 51 is de-energized, thereby causing valve 50 to bleed air from control line 49 with resultant closure of pneumatic valve 46. In this manner, the supply of air to conduit 11 is immediately interrupted and no further air is supplied to the system by rotation of the blower 42 due to inertia. If desired, transformer 52 can be connected to the supply conductors between the switch 45 and current source 44 so that valve 46 is closed only in response to failure of the current source, and not when switch 45 is opened. It will be noted that failure of the current also interrupts the operation of motor 15 driving charge pump 14 so that the supply of vaporized hydrocarbon charging stock to the reactor is interrupted when the current source fails.

In accordance with our invention, when the air pressure in conduit 11 drops below a critical value, the air supply to each individual reactor is closed at a point immediately upstream of the reactor. To this end, a pneumatically operated motor valve 54 is provided in each branch air conduit 11a immediately upstream of the associated reactor 10. Each valve 54 is supplied with air under pressure from an instrument air pipe 55 so as to normally maintain it in open position. Pipe 55 receives instrument air from source 47 through a pressure regulator 56, and the pipe is provided with a pressure gauge 57 and a relief valve 58. Inserted in the pipe 55 is a pneumatically operated three way bleed valve 59 controlled by a pressure regulator 60. The sensing element of this regulator, in turn, is actuated by air pressure in a control line 61 connected to conduit 11. When this pressure drops below a critical value, for example, one pound per square inch gauge, regulator 60 operates valve 59 so as to bleed air from pipe 55. The resulting reduction in pressure in this pipe causes each valve 54 to close thereby stopping the flow of process air to each individual reactor.

The safety system of our invention further includes means for interrupting the supply of gas to the main supply line 12 when the air pressure in conduit 11 falls below the critical value. Further, when the conduit air pressure is within a marginal operating range, the supply of gas to line 12 is decreased in proportion to decreases in air pressure within such marginal operating range. This marginal range can be from 2.5 to 1.0 pounds per square inch gauge where the normal air pressure is four pounds per square inch gauge. Thus, when the air pressure is in a normal operating range above 2.5 pounds per square inch gauge, the safety device does not function and the gas supply is uninterrupted. As the air pressure falls from 2.5 to 1.0 pounds per square inch gauge, the air pressure is reduced in a proportionate manner and, when the pressure falls below this marginal operating range, the gas supply is completely interrupted.

To this end, the sensing element of a pressure con-

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troller 63 is connected through line 61 to main air conduit 11. Pressure from this controller is transmitted to a pneumatically operated motor valve 64 through a control line 65 in the gas line 12 to normally maintain it in open position. A vent pipe 66 communicates with control line 65 through a pressure operated valve 67. When the pressure in conduit 11 falls below the critical value, controller 63 releases the pressure in control line 65 thereby tending to close valve 64. Such pressure reduction causes valve 67 to open, thereby permitting the fluid in control line 65 to escape very rapidly through vent pipe 66, with the result that the closing action of valve 64 is extremely rapid. In this manner, the supply of gas to line 12 is rapidly interrupted when the pressure in air conduit 11 falls below its critical value.

Controller 63 also supplies air to one sensing element of a pressure regulator 68. This regulator also has an additional sensing element communicating with gas line 12 through a pipe 69. Regulator 68 controls a pneumatically operated valve 70 in the gas line 12. When the air pressure in conduit 11 is within a normal operating range, for example, above 2.5 pounds per square inch gauge, valve 70 is fully open. As the air pressure decreases within a marginal operating range, as from 2.5 to 1.0 pounds per square inch gauge, valve 70 is gradually closed, thereby proportionately decreasing the supply of gas through line 12 to the reactors. Of course, when the air pressure falls below the critical value of 1.0 pound per square inch gauge valve 64 is rapidly closed to completely interrupt the gas supply.

It will be noted that a branch conduit 71 leads from line 12 between valves 64, 70 to the preheater furnaces so that the gas supply thereto is cut down proportionately when the air pressure is within the marginal operating range but is not completely interrupted during the shut down.

During a shut down, it is also desirable to prevent as much of the gas in line 12 as possible from entering the reaction system. To this end, a vent pipe 72 communicates with gas line 12 downstream of valve 64. Vent pipe 72 is provided with a pneumatically operated motor valve 73 which is normally held in closed position by air pressure supplied from instrument air pipe 55 through a control line 74. Thus, when air is bled from pipe 55 responsive to a drop in pressure in conduit 11 below the critical value, valve 73 is opened and the gas in line 12 is vented to the atmosphere through pipe 72.

It is a feature of the invention that valves 39, 46, 54, and 64 are provided with a delatching mechanism so that these valves must be manually reset before air or gas can be supplied to the reaction system after a shut down. In this manner, premature entrance of air to the system during a subsequent starting up of the system is effectively prevented. Also, it will be understood that each pressure controller or regulator receives instrument air under pressure through a line, not shown, for actuation of the valve controlled thereby.

The overall operation of the system is as follows when a power failure occurs, it being understood that other parts of the system are operated in the manner already described when a shut down occurs for some reason other than a power failure. The failure of power causes motors 15, 43 to stop, thereby interrupting a supply of vaporized hydrocarbon to the reactor 10 and causing immediate closure of valve 46 through the operation of solenoid valve 50 to close the main air supply conduit and prevent air from entering the system as the blower continues to turn due to inertia. Responsive to the resulting drop in air pressure in conduit 11, the valve 64 is quickly closed, thereby cutting off the supply of gas to the system. Further, air is bled from instrument pipe 55, thereby closing the valve 54 upstream of each reactor and stopping the flow of air into the system at these points. Further responsive to the bleeding of air from pipe 55, vent valve 73 opens to permit the gas in line 12 to escape

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to the atmosphere. The interruption of the air supply also reduces the pressure in header 18 causing damper 21 to close, and purge gas is supplied through line 38 responsive to the opening of valve 39 to maintain a super-atmospheric pressure in precipitator 19, thereby preventing the entrance of air into the system through stack 20.

If the air pressure falls to a point within the marginal operating range, but not below the critical value at which a shut down occurs, the supply of gas to line 12 is reduced in proportion to the drop in air pressure within such marginal operating range with resultant cut back of the gas supplied to the reactors and preheater furnaces.

It will be evident, therefore, that we have achieved the object of our invention providing a safety system which prevents the formation of an explosive mixture in the system during a shut down period, and which reduces the supply of gas to the system when the air pressure falls to a marginal value.

While the invention has been described in connection with a present, preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

We claim:

1. In a plant for producing carbon black including a reactor, an electrostatic precipitator having an inlet and a gas outlet, a damper in the precipitator gas outlet, and a header for conveying reaction products from said reactor to the inlet of said precipitator, a safety system which comprises sensing means responsive to a drop in pressure below a predetermined value in said header, and a motor controlled by said sensing means and connected to said damper for fully closing said damper in response to such drop in pressure.

2. In a plant for producing carbon black including a reactor, a conduit for supplying air under pressure to said reactor, a line for supplying gas under pressure to said reactor, an electrostatic precipitator having an inlet and a gas outlet, a damper in the precipitator gas outlet, and a header for conveying reaction products from said reactor to the inlet of said precipitator, a safety system which comprises means for closing a valve in said gas line and a valve in said conduit when the air pressure in said conduit falls below a predetermined value, means responsive to a drop in pressure below a predetermined value in said header for closing said damper, a source of purge gas under pressure, and means for admitting said purge gas to said precipitator when the air pressure in said conduit falls below said predetermined value.

3. In a plant for producing carbon black including a reactor, a conduit for supplying air under pressure to said reactor, a valve in said conduit, a line for supplying gas under pressure to said reactor, a valve in said line, an electrostatic precipitator having an inlet and a gas outlet, a damper in the precipitator gas outlet, and a header for conveying reaction products from said reactor to the inlet of said precepitator, a safety system comprising a pressure regulator controlled by the air pressure in said conduit and connected to said valve to reduce the gas pressure in said line in proportion to decreases in said air pressure within a marginal operating range, and means for closing said valve in said conduit and said valve in said gas line when the conduit pressure falls below said marginal operating range, a control linkage connected to said damper, and a pressure regulator controlled by pressure in said header and arranged to regulate said linkage to close said damper as the header pressure falls within a predetermined range.

4. In a plant for producing carbon black including a reactor, a conduit for supplying air under pressure to said reactor, a valve in said conduit, a line for supplying gas under pressure to said reactor, a valve in said line, an electrostatic precipitator having an inlet and a gas outlet, a damper in the precipitator gas outlet, and a header for conveying reaction products from said reactor to the inlet of said precipitator, a safety system comprising a pressure regulator controlled by the air pressure

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in said conduit and connected to said valve to reduce the gas pressure in said line in proportion to decreases in said air pressure within a marginal operating range, means for closing said valve in said conduit and said valve in said gas line when the conduit pressure falls below said marginal operating range, a control linkage connected to said damper, a pressure regulator controlled by pressure in said header and operatively connected to said linkage to effect closure of said damper as the header pressure falls within a predetermined range, a source of purge gas under pressure, and means for admitting said purge gas to said precipitator when the pressure in said conduit falls below said predetermined value.

5. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a line for supplying fuel gas under pressure to said reactor, and means for supplying a vaporized hydrocarbon charging stock to said reactor, a safety system which comprises pneumatically-actuated valves in said gas line and said air conduit, a pressure controller actuated by pressure in said conduit and connected to said valve in the gas line to decrease the flow of gas through said line in proportion to decreases in air pressure within a marginal operating range, means for supplying air under pressure to both valves to normally maintain them in open position, and means responsive to a drop in pressure in said air conduit below said marginal operating range to bleed the air from both pneumatically-operated valves and thereby close said valves.

6. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a line for supplying fuel gas under pressure to said reactor, and means for supplying a vaporized hydrocarbon charging stock to said reactor, a safety system which comprises pneumatically-actuated valves in said gas line and said air conduit, a source of instrument air under pressure, an instrument air pipe connected to said source, means for bleeding air from said pipe, means transmitting the pressure in said pipe to said pneumatically-operated valve in said conduit, a pressure regulator controlled by air pressure in said conduit and connected to said bleeding means to bleed air from said pipe responsive to a drop in said pressure below a predetermined value, a second pressure regulator controlled by pressure in said conduit, a line for supplying air connecting said second pressure regulator to the pneumatically-operated valve in said gas line so that said valve is closed when said air pressure in said conduit drops below a predetermined value.

7. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a line for supplying fuel gas under pressure to said reactor, and means for supplying a vaporized hydrocarbon charging stock to said reactor, a safety system which comprises pneumatically-actuated valves in said gas line and said air conduit, a source of instrument air under pressure, an instrument air pipe connected to said source, means for bleeding air from said pipe, means transmitting the pressure in said pipe to said pneumatically-operated valve in said conduit, a pressure regulator controlled by air pressure in said conduit and connected to said bleeding means to bleed air from said pipe responsive to a drop in said air pressure below a predetermined value, a second pressure regulator controlled by air pressure in said conduit, a control line for supplying air connecting said second pressure regulator to the pneumatically-operated valve in said gas line so that said valve is closed when the air pressure in said conduit drops below a predetermined value, an auxiliary vent pipe connected to said control line, and a pneumatic valve in said vent pipe controlled by pressure in said control line to quickly bleed air from said control line when the pressure therein falls below a predetermined value, thereby to effect a quick closing of the valve in said gas line.

8. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a

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line for supplying fuel gas under pressure to said reactor, and means for supplying a vaporized hydrocarbon charging stock to said reactor, a safety system which comprises pneumatically-actuated valves in said gas line and said air conduit, a source of instrument air under pressure, an instrument air pipe connected to said source, means for bleeding air from said pipe, means transmitting the pressure in said pipe to said pneumatically-operated valve in said conduit, a pressure regulator controlled by air pressure in said conduit and connected to said bleeding means to bleed air from said pipe responsive to a drop in said air pressure below a predetermined value, a second pressure regulator controlled by pressure in said conduit, a control line for supplying air connecting said second pressure regulator to the pneumatically-operated valve in said gas line so that said valve is closed when said air pressure drops below a predetermined value, a vent pipe communicating with said gas line at a point between the valve therein and said reactor, a normally closed pneumatically-operated valve in said vent pipe, means for supplying air from said instrument pipe to said last-mentioned valve to normally maintain it in closed position, said valve opening when air is bled from said instrument pipe, a third pressure regulator controlled jointly by the outlet air pressure of said second regulator and by pressure in the gas line downstream of the pneumatically-operated valve therein and connected to a valve in said gas line to reduce the rate of flow of gas through said gas line in proportion to decreases in air pressure within a marginal operating range.

9. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a blower for supplying air under pressure to said conduit, an electric motor connected to said blower for driving said blower, a current source for said motor, a gas line for supplying fuel gas under pressure to said reactor, and means for supplying a vaporized hydrocarbon feed stock to said reactor, a safety system which comprises a pneumatically-operated valve in said gas line, a pair of pneumatically-operated valves in said conduit, one valve being positioned immediately upstream of said reactor and the second valve being positioned immediately downstream from said blower, a pressure regulator controlled by the air pressure in said conduit between said valves and connected to one valve in the conduit and said valve in the gas line for closing said one valve in the conduit and said valve in the gas line when the conduit pressure falls below a predetermined value, and a solenoid valve connected to and controlling said pneumatically-operated valve downstream of said blower, said solenoid valve having an operating winding connected in circuit with said current source and said motor to effect closure of said downstream valve upon occurrence of a power failure.

10. In a carbon black plant including a reactor, a conduit for supplying air under pressure to said reactor, a line for supplying fuel gas under pressure to said reactor, a blower connected for supplying air to said conduit, a motor connected to said blower for driving said blower, a current source for said motor, an electrostatic precipitator, having an inlet and a gas outlet a damper in the precipitator gas outlet, and a header connected for conveying reaction products from said reactor to the inlet of said precipitator, a safety system which comprises a pneumatically-operated valve in said gas line, a pair of pneumatically-operated valves in said air conduit, one valve being positioned immediately upstream of said reactor and the other valve being positioned immediately downstream of said blower, a pressure controller responsive to air pressure in said conduit and connected to close the valve in said gas line and said valve upstream of said reactor when the air pressure drops below a predetermined value, means connected in circuit with said motor and said current source to effect closure of said valve downstream of said blower responsive to a power failure, a pressure controller responsive to pressure in said header

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connected to close said damper when the header pressure falls below a preselected value, and means responsive to the air pressure in said conduit for admitting a purge gas to said precipitator when the air pressure in said conduit falls below said predetermined value.

11. A safety system for a process wherein fuel gas is burned with air which comprises, in combination, a reactor, a conduit for supplying air to said reactor, a line for supplying gas to said reactor, a pressure controller having sensing devices in said line and said conduit, and connected to maintain a predetermined relationship between the pressure in said line and the pressure in said conduit when the latter pressure is within a marginal operating range, a pneumatically-operated motor valve in said line, a pipe connected for supplying air from said pressure controller to said valve to normally maintain it is open position, a vent conduit communicating with said pipe, a normally closed valve in said vent conduit, and means for opening said normally closed valve when the pressure in said pipe drops below a predetermined value, thereby to rapidly bleed air from said pneumatically-operated valve in the gas line and rapidly close same.

12. A safety system for a process wherein fuel gas is burned with air which comprises, in combination, a reactor, a conduit for supplying air to said reactor, a line for supplying gas to said reactor, a pressure controller having sensing devices in said line and said conduit, and connected to maintain a predetermined relationship between the pressure in said line and the pressure in said conduit when the latter pressure is within a marginal operating range, a motor valve in said line controlled by the pressure in said conduit to stop the flow of gas through said line

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when the conduit pressure falls below said marginal operating range, an instrument air line, means for bleeding said instrument air line, a pressure controller responsive to conduit pressure and connected to said bleeding means for bleeding air from said air line when the pressure in said air conduit falls below a predetermined value, a pneumatically-operated valve in said conduit upstream of said reactor, and means for applying air from said instrument air line to said valve to normally maintain it in open position.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 22,886	Ayers	June 3, 1947
1,710,839	Peebles	Apr. 30, 1929
1,772,920	Smoot	Aug. 12, 1930
1,797,368	Rumbarger	Mar. 24, 1931
2,059,411	Stubblefield	Nov. 3, 1936
2,071,285	Johnson	Feb. 16, 1937
2,074,883	Ziebolz et al.	Mar. 23, 1937
2,081,860	Quick	May 25, 1937
2,134,745	Ziebolz et al.	Nov. 1, 1938
2,197,904	Terry	Apr. 23, 1940
2,212,606	Klinker	Aug. 27, 1940
2,219,359	Goit et al.	Oct. 29, 1940
2,232,901	Brisbane	Feb. 25, 1941
2,385,317	White	Sept. 18, 1945
2,564,700	Krejci	Aug. 21, 1951

OTHER REFERENCES

"News from Abroad," Chemical Engineering, pages 203 and 205, September 1950, vol. 59, No. 9.