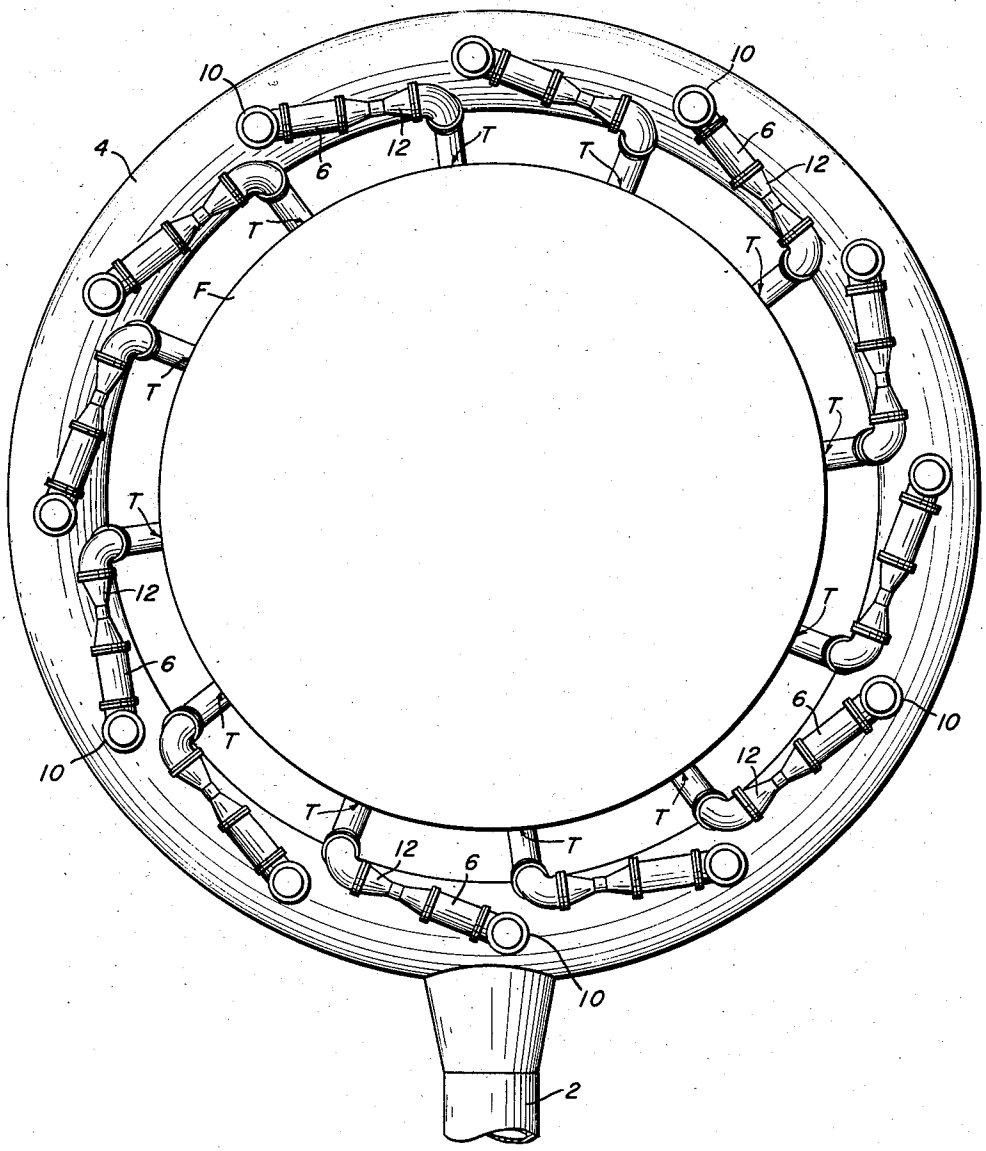
May 12, 1959 F. E. DEMMON 2,886,307

APPARATUS FOR AUTOMATICALLY DISTRIBUTING THE AIR BLAST TO BLAST FURNACES

Filed April 3, 1956 2 Sheets-Sheet 1

FIG. 1.



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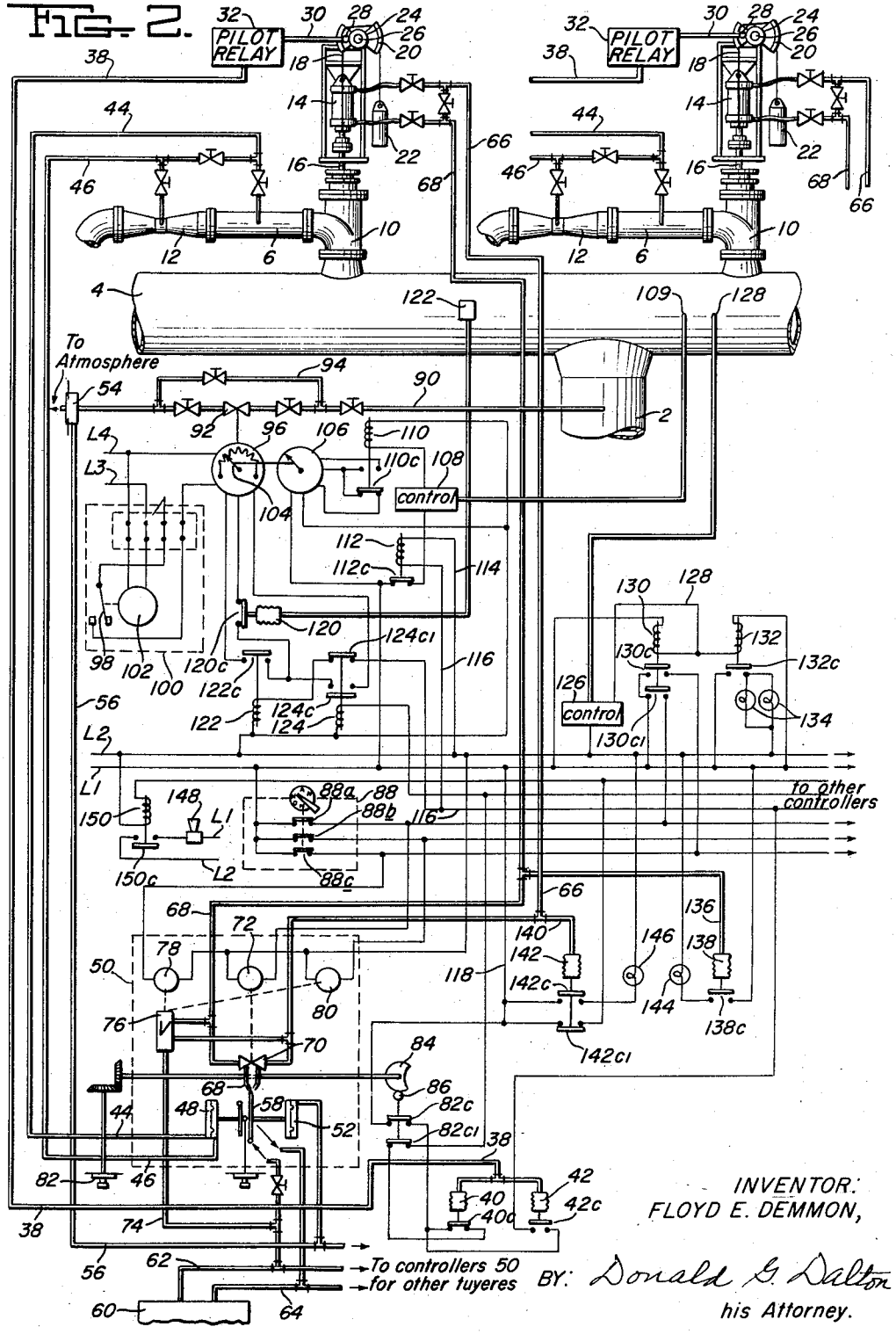
BY: Donald G. Dalton
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APPARATUS FOR AUTOMATICALLY DISTRIBUTING THE AIR BLAST TO BLAST FURNACES

Filed April 3, 1956 2 Sheets-Sheet 2

FIG. 2.



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United States Patent Office

2,886,307

Patented May 12, 1959

2,886,307

APPARATUS FOR AUTOMATICALLY DISTRIBUTING THE AIR BLAST TO BLAST FURNACES

Floyd E. Demmon, Hobart, Ind., assignor to United States Steel Corporation, a corporation of New Jersey

Application April 3, 1956, Serial No. 575,802

18 Claims. (Cl. 266—30)

This invention relates to apparatus for automatically distributing the air blast to blast furnaces. The air is delivered to the furnace through a plurality of tuyeres arranged around the periphery of the furnace. The control of the air to the furnace is important in obtaining best operating conditions and controls for that purpose are disclosed in the patents to Hayes No. 1,726,298, dated August 27, 1929, and Burke No. 2,083,046, dated June 8, 1937. While the controls shown therein will operate satisfactorily under normal conditions, they will not operate satisfactorily when unusual conditions occur in the furnace. In actual blast furnace operation it is common for unusual conditions to occur. In some instances the pressure of the air will decrease to a point where operation of the furnace may become dangerous, in other instances conditions within the blast furnace change rapidly and the control will tend to hunt or cycle. Occasionally it is necessary to back-draft the furnace and special means are required to prevent dangerous operation of the control at this time. The blast pressure may become exceedingly high and functioning of the control must be discontinued to prevent damage.

It is therefore an object of my invention to provide a control for automatically distributing air blast to blast furnaces in which means are provided for changing the operation of the control during unusual conditions.

Another object is to provide such a control which will operate without excessive hunting.

These and other objects will be more apparent after referring to the following specification and attached drawings, in which:

Figure 1 is a schematic view of a blast furnace showing the arrangement of the tuyeres; and

Figure 2 is a schematic view of the control of my invention.

Referring more particularly to the drawings, the reference numeral **2** indicates the conduit for supplying air to the tuyeres T of the blast furnace F. The conduit **2** terminates in a bustle pipe **4** from which separate pipe lines **6** lead to the individual tuyeres T. Located in each of the pipe lines **6** is a plug valve **10** and venturi **12**. The position of the plug valve **10** is controlled by means of an hydraulic cylinder **14**. A piston rod **16** connects the piston of the hydraulic cylinder **14** to the stem of the valve **10**. A cable **18** is connected to the piston rod **16** and passes over a rotatable sheave **20** with its free end being connected to counterweight **22**. The cable **18** is attached to the sheave **20** so that it moves therewith. A cam **24** is connected to shaft **26** which supports the sheave **20**. A cam follower **28** is in contact with cam **24**. The cam follower **28** is connected by means of a rod **30** to an Askania Pilot relay **32**. This well known device, by means of a diaphragm and hydraulic pilot valve, produces a hydraulic pressure proportional to the movement of rod **30** which is emitted through oil delivery line **38**. The oil delivery line **38** is connected to pressure switches **40** and **42**. Switch **40** has a normally closed contact **40***c* and switch **42** a normally open contact **42***c*. It will be

seen that the position of valve **10** is indicated by the position of sheave **20** and that the position of rod **30** is dependent upon the position of the sheave **20** so that the pressure supplied through line **38** will vary according to the position of the plug valve **10**.

Pressure lines **44** and **46** are connected to the high and low pressure sides of venturi **12**, respectively. Lines **44** and **46** lead to opposite sides of a diaphragm **48** forming part of a well known Askania regulator or controller **50**. A second diaphragm **52** is connected to the high pressure side of an orifice plate **54** through line **56**. A pivotally mounted oil jet **58** is located between diaphragms **48** and **52** and is mechanically connected thereto for movement therewith. Oil is supplied to jet **58** from oil tank **60** through conduit **62** and oil from the control is returned to the tank **60** through line **64**. Oil from jet **58** is supplied through a delivery block and two orifices to lines **66** and **68**. A shut-off valve **70** is arranged in the lines **66** and **68** and is operated by means of solenoid **72**. An oil line **74** is connected to oil supply line **62** between the jet **58** and tank **60**. A three-way valve **76** is provided in the line **74** to control flow of oil to lines **66** and **68**. Operation of valve **76** is controlled by solenoids **78** and **80**. Energization of solenoid **78** causes the valve **76** to move to the position where oil flows to line **68** and energization of solenoid **80** causes the valve **76** to move to the position where oil will flow to the line **66**. Lines **66** and **68** are connected to opposite sides of the piston of cylinder **14**. When oil flows through line **66**, valve **10** will move toward its closed position and when oil flows through line **68** valve **10** will move toward its open position. Suitable shut-off valves may be provided in the various oil lines as shown. Associated with the Askania regulator **50** is a limit switch **82** which includes a cam **84**, cam follower **86** and contacts **82***c* and **82***c***1**. The parts so far described are all part of the Askania regulator. It will be understood that a regulator **50** and associated parts are provided for each of the tuyeres.

Manually operated switch **88** having contacts **88***a*, **88***b* and **88***c* is connected to control the energization of solenoids **72**, **78** and **80**. Only one switch **88** is necessary to control the operation of the solenoids of all of the regulators **50**. The orifice **54** is located in a tap line **90** connected to conduit **2**. A motor operated burden valve **92** is located in the line **90** between the orifice **54** and conduit **2**. A by-pass **94** may be provided around the valve **92** with the necessary valves being provided as shown. The line **56** is connected to the diaphragm **52** of each of the regulators **50**. Motor **96** controls the position of valve **92**. Power for operating burden motor **96** is supplied from power lines L3 and L4 through a switch **98** forming part of controller motor timer **100**. Switch **98** is actuated by motor **102** to interrupt flow of current to motor **96** a certain number of seconds per minute, depending upon the setting of the timer. Therefore, the operation of motor **96** will be intermittent. Associated with motor **96** is a speed control knob **104**, the position of which is adjusted by means of a speed control motor **106**. Motor **106** is reversible and will operate in either direction depending upon the pressure in bustle pipe **4**. The operation of motor **106** is controlled by means of a control **108** having a pressure responsive element **109** communicating with the bustle pipe **4** or hot blast main **2**. Assuming that the control **108** is set for 17.3 pounds per square inch gage, current will not flow through the control **108** as long as the pressure is below 17.3 pounds per square inch gage and relay coil **110** will remain deenergized with the directional circuit to the speed control motor **106** being completed in the direction which adjusts the speed control knob **104** to the slow position as shown. When the pressure increases beyond 17.3 pounds per

square inch gage, control **108** will operate to complete a circuit through relay coil **110**, thus causing its contactor **110***c* to move to its upper position which completes the directional circuit for adjusting the speed control knob **104** to the fast position. Contact **112***c* operated by relay coil **112** is in series with controller **108**. Relay coil **112** is connected to power line L2 through line **114**, and to line **L1** through line **116**, constant **42***c*, contact **82***c*, and line **118**. A low pressure responsive switch **120** is controlled by means of a pressure element **122** communicating with the bustle pipe **4**. Contact **120***c* of switch **120** is located in the neutral line of the directional circuit of motor **96**. If the switch **120** is set so that it will open when the pressure in the bustle pipe drops below 13 pounds per square inch gage the motor **96** will stop when the pressure is below 13 pounds per square inch gage. Contact **122***c* operated by relay coil **122** is provided in the directional circuit to operate the motor **96** in the direction to close the valve **92**. Contact **124***c* operated by relay coil **124** is provided in the directional circuit. When coil **124** is energized contact **124***c* will open preventing motor **96** from opening the valve **92**. Relay coil **124** also operates contact **124***c***1** which can complete a circuit through coil **122**. Over pressure control **126** has a pressure responsive element **128** communicating with the bustle pipe **4**. When the pressure reaches a predetermined high pressure current will flow from line L2 through control **126**, line **128** and through relay coils **130** and **132** connected in parallel to line L1. Energization of coil **130** will close its contacts **130***c* and **130***c***1** to complete a circuit to lines **L1** and **L2** through solenoids **72** and **78**. Energization ol coil **132** will close its contact **132***c* to complete a circuit through alarm bells **134**. Tap line **136** is taken from line **68** to pressure switch **138** having normally open contact **138***c*. Tap line **140** is taken from line **66** to pressure switch **142** having normally open contact **142***c* and normally closed contact **142***c***1**. Closing of contact **138***c* will complete a circuit through light **144** and closing of contact **142***c* will complete a circuit through light **146**. Horn **148** is connected to lines L1 and L2 through contact **150***c* which is controlled by relay coil **150**.

The operation of the control is as follows:

It is placed on automatic by turning the limit switches **82** and back draft switch **88** on automatic. In the drawings the limit switch **82** is shown on automatic and the back draft switch on manual. The contacts **88***a*, **88***b* and **88***c* will be open when the switch **88** is on automatic. Each pressure switch **40** is set so its contacts **40***c* will remain closed as long as its associated plug valve is open at least 50% and each switch **42** is set so its contacts will remain open until its associated plug valve is more than 80% of full open. For various reasons it is not desirable that the plug valves open full wide nor close full shut but the range set forth above may vary. The control **108** is set so that its contacts will close when the pressure in the bustle pipe reaches 17.3 pounds per square inch gage. The low pressure responsive switch **120** is set so that it will open when the pressure in the bustle pipe drops below 13 pounds per square inch gage. Control **126** is set so that its contacts will close when the pressure in the bustle pipe reaches 19 pounds per square inch gage. These pressures are all relative and they may be varied according to the particular furnace on which the control is installed. However, the control **108** is always set at a relatively high pressure above which it is not desired to operate and the control **126** is set at a pressure slightly above that of control **108**. Pressure responsive switch **120** is set at a pressure below which it is not desired to operate in a normal manner. During normal operation the plug valves **10** are open an amount which permits equal amounts of air to flow to each tuyere. The flow of air to each tuyere is measured by the difference of pressure in lines **44** and **46**. This pressure differential is balanced in the associated regulator **50** against the master reference impulse received through line **56**. If the air flow to one of the tuyeres decreases, the differential pressure will also decrease. This causes jet **58** to move to the left thus causing oil to flow through pipe **68** to open the associated plug valves **10** until the pressure differential **44—46** again equals the pressure differential in the lines to the other tuyeres. Of course, the pressure differential of the other tuyeres may also vary, but eventually they will return to the point where the pressure differential in the lines to all of the tuyeres is equal.

When there is an obstruction in one of the tuyeres the flow of air to that tuyere will decrease and the associated plug valve will open. If the obstruction is not eliminated the plug valve will continue to open to more than 80%, thus closing contacts **42***c* associated with that tuyere. This completes a circuit from line **L1** through contact **82***c*, contact **42***c*, lead **116**, contact **124***c***1** and relay coil **122** to line L2. Energization of relay coil **122** closes its contact **122***c* causing the burden motor **96** to operate in a direction to partially close the burden valve **92**. Upon closing of contacts **42***c* a circuit is also completed to relay **112** from line **L1** through line **118**, contacts **82***c*, contacts **42***c* and line **116** to line L2, thus energizing coil **112** and opening contacts **112***c* thereby preventing the energization of relay coil **110** and the moving of contacts **110***c* to the upper position. This is to insure that speed control knob **104** will not be moved to the fast position when the directional circuit of burden motor **96** is completed to partially close burden valve **92**. This closing of the burden valve **92** will disturb the balance between diaphragms **48** and **52** of each of the regulators **50** except the one for the obstructed tuyere in such a manner that the jet **58** will move to the right thus causing oil to flow through conduit **66** to partially close all of the valves **10** except the one leading to the obstructed tuyere. As said valves close, more air in the bustle pipe is diverted to the obstructed tuyere until the obstruction is burned or blown away. If the obstruction is not burned or blown away the valves **10** will continue closing and the blast pressure will rise. Eventually all contacts **40***c* will be open except that associated with the obstructed tuyere. Most of the air will then flow to the obstructed tuyere and will burn or blow the obstruction away. When this occurs the flow of air to that tuyere increases and the associated differential pressure **44—46** will cause the jet **58** of the associated control **50** to move to the right and direct oil to conduit **66** to close the associated valve **10** to the same position as all the other plug valves. When this last plug valve closes below 50% contacts **40***c* associated therewith will open. This opens the last of the parallel circuits to relay coil **124**, thus causing its contacts **124***c* to close and contacts **124***c***1** to open. Closing of contact **124***c* will complete the directional circuit of motor **96** in such a direction as to open burden valve **92**. This increases the pressure in conduit **56** thus moving all the jets **58** to the left and causing all the plug valves **10** to open to a position within the control range. When the first plug valve **10** reaches the control range contact **40***c* associated therewith will close completing a circuit through relay coil **124** thus stopping operation of the burden motor **96**. In this manner the control returns to its normal operating condition and distributes the air equally among the tuyeres.

When one of the plug valves **10** opens completely pressure will build up in the conduit **68** associated therewith, thus closing the associated contacts **138***c*. This completes a circuit from line **L1** to line **L2** through green light **144**, thus warning the operator that the associated valve **10** is all the way open. When one of the plug valves is all the way closed pressure will build up in associated line **66** thus causing associated contacts **142***c* to close and **142***c***1** to open. Closing of contact **142***c* completes the circuit through red light **146**, thus warning the operator that that particular plug valve is all the way closed. Each of the contacts **142***c***1** is in series with relay coil **150** and the contacts **142***c***1** associated with one

valve are in parallel with the contacts **142c1** associated with the other valves. Thus relay coil **150** will be energized as long as any one of the plug valves **10** is open. However, when all of the valves are closed all of the contacts **142c1** will be open and relay coil **150** will be deenergized, thus closing its contacts **150c** and completing a circuit through horn **148**, giving an audible signal to the operator.

When there is an excessively high pressure in the bustle pipe **4** it is advantageous to have the burden motor **96** operate at a high speed to relieve the high pressure quickly. For best operation the burden motor **96** should operate to open rapidly to relieve the high pressure but should operate slowly to close the burden valve with cycling conditions being checked by the interrupter **100**. When the pressure in the bustle pipe exceeds 17.3 pounds per square inch the contacts of control **108** will close, thus completing a circuit through relay coil **110** and causing contact **110c** to move to its upper position completing the directional circuit to motor **106** which operates to adjust the speed control knob **104** to the fast position so that the operation of the burden motor **96** will open rapidly.

In some instances there is a high pressure condition in the bustle pipe **4** which calls for rapid operation of the burden motor **96** to open the burden valve **92** while at the same time there is an obstructed tuyere which causes the associated plug valve to open and all the other plug valves to close. Thus the burden valve **92** will close rapidly and aggravate the high pressure condition. Since it is more important to relieve the high pressure in the bustle pipe the control **126** is provided. When the pressure in the bustle pipe increases to 19 pounds per square inch the contacts of control **126** close, thus completing circuits through relay coils **130** and **132**. Energization of relay coil **130** closes its contacts **130c** and **130c1**. Closing of contacts **130c** completes circuits from line **L1** through contact **130c** and each solenoid **78** to line **L2**. Closing of contacts **130c1** completes circuits from line **L1** through contact **130c1** and each solenoid **72** to line **L2**. Energization of solenoids **72** closes valves **70**, thus preventing the controls **50** from operating automatically. Energization of solenoids **78** causes valves **76** to operate to permit flow of oil from lines **74** to lines **68**, thus causing all the plug valves to open. After the high pressure is relieved below 19 pounds per square inch the contacts of control **126** will open and coils **130** and **132** are deenergized so that the controls **50** will be on automatic. Energization of coil **132** closes its contacts **132c** completing a circuit through alarms **134** which may be either lights and/or audible horns. If any of the contacts **42c** are closed when the pressure in the bustle pipe reaches 17.3 pounds per square inch a circuit will be completed through relay coil **112** causing its contacts **112c** to open so that no circuit will be completed through relay coil **110**, thereby preventing speed control knob **104** from being adjusted to the fast position while allowing the system to remain on automatic.

When the air is cut off from the furnace, as when checking the furnace at the end of the cast, I have found that all of the plug valves **10** will eventually completely close due to the change in pressure balance on the controls **50**. When the wind is put on the furnace again a terrific surge of pressure against the nearly closed plug valves endangers the blowing engines. The low pressure responsive switch **120** prevents closing of the plug valves under these conditions. When the pressure in the bustle pipe **5** drops belows **13** pounds per square inch the contacts **120c** of switch **120** will open. Since the contacts **120c** are in the neutral line of the directional circuit of motor **96**, the motor **96** cannot operate to close the burden valve. When the pressure again rises above 13 pounds the contact **120c** will close and the controls **50** will again take over.

I have also found that the burden valve **92** may be connected to a separate clean air source having a constant pressure. This has the advantage that the dirt which is present in the air in the hot blast main will not interfere with the proper operation of the control. However, with this arrangement the burden motor **96** will operate more frequently.

While one embodiment of my invention has been shown and described it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

I claim:

1. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of a tap line connected to said supply line, a burden valve in said tap line, a motor for operating said burden valve, an air flow determining means in said tap line on the exhaust side of said burden valve, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said last named air flow determining means to each of said regulators, control means for operating said burden valve motor to close said burden valve when a control valve opens beyond a predetermined amount, a second control means operable when all of the control valves close below a predetermined amount to open said burden valve, and means for causing said burden valve to open rapidly when the pressure in said supply line rises to a predetermined amount.

2. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of a tap line connected to said supply line, a burden valve in said tap line, a motor for operating said burden valve, an air flow determining means in said tap line on the exhaust side of said burden valve, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said last named air flow determining means to each of said regulators, control means for operating said burden valve motor to close said burden valve when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to open said burden valve, means for causing said burden valve to open rapidly when the pressure in said supply line rises to a predetermined amount, and means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount.

3. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of a tap line connected to said supply line, a burden valve in said tap line, a motor for operating said burden valve, an air flow determining means in said tap line on the exhaust side of said burden valve, an automatic regulator associated wtih each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said last named air flow determining means to each of said regulators, control means for operating said burden

valve motor to close said burden valve when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to open said burden valve, means for causing said burden valve to open rapidly when the pressure in said supply line rises to a predetermined amount, means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount, and means for preventing operation of said burden valve motor when the pressure in said supply line falls below a predetermined amount.

4. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of a tap line connected to said supply line, a burden valve in said tap line, a motor for operating said burden valve, an air flow determining means in said tap line on the exhaust side of said burden valve, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said last named air flow determining means to each of said regulators, control means for operating said burden valve motor to close said burden valve when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to open said burden valve, and means for preventing operation of said burden valve motor when the pressure in said supply line falls below a predetermined amount.

5. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines, an air flow determining means associated with said supply line, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, and means connecting an impulse from said second named air flow determining means to each of said regulators; the combination therewith of control means operable when an obstruction occurs at a tuyere for causing the associated regulator to open the control valve of the obstructed tuyere and close the control valves of the remaining tuyeres, a second control means operable when all of the control valves close below a predetermined amount to open all of the control valves, and means for opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount.

6. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, an air flow determining means in each of said pipe lines, an air flow determining means associated with said supply line, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, and means connecting an impulse from said second named air flow determining means to each of said regulators; the combination therewith of control means operable when an obstruction occurs at a tuyere for causing the associated regulator to open the control valve of the obstructed tuyere and close the control valves of the remaining tuyeres, a second control means operable when all of the control valves close below a predetermined amount to open all of the control valves, means for opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount, and means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount.

7. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, control means for operating said master signal varying means to decrease the magnitude of said master signal when any one of said control valves opens wider than a first predetermined amount, control means for operating said master signal varying means to increase the magnitude of said master signal when all said control valves close beyond a second predetermined amount, and means for increasing the magnitude of said master signal rapidly when the pressure in said supply line rises to a predetermined amount.

8. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, control means for operating said master signal varying means to decrease the magnitude of said master signal when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to operate said master signal varying means to increase the magnitude of said master signal, means for increasing the magnitude of said master signal rapidly when the pressure in said supply line rises to a predetermined amount, and means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount.

9. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, control means for operating said master signal varying means to decrease the magnitude of said master signal when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to operate said master signal varying means to increase the magnitude of said master signal, means for increasing the magnitude of

said master signal rapidly when the pressure in said supply line rises to a predetermined amount, means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount, and means for preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

10. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valves in each of said pipelines, meals for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, control means for operating said master signal varying means to decrease the magnitude of said master signal when an obstruction occurs at a tuyere, a second control means operable when all of the control valves close below a predetermined amount to operate said master signal varying means to increase the magnitude of said master signal, and means for preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

11. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, an air flow determining means in each of said pipe lines, means for developing a master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, and means connecting an impulse from said master signal to each of said regulators; the combination therewith of control means operable when an obstruction occurs at a tuyere for causing the associated regulator to open the control valve of the obstructed tuyere and close the control valves of the remaining tuyeres, a second control means operable when all of the control valves close below a predetermined amount to open all of the control valves, means for opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount, and means for taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount.

12. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, and means for automatically opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount.

13. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, means for automatically opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount, and means for automatically taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount.

14. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, means for automatically opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount, means for automatically taking said regulators off automatic and opening said control valves when the pressure in said supply line exceeds the last named pressure by a predetermined amount, and means for automatically preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

15. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, means for automatically opening said control valves rapidly when the pressure in said supply line rises to a predetermined amount, and means for automatically preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

16. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, and means for automatically taking said regulators off automatic and opening said control valves when the pressure in said supply line rises to a predetermined amount.

17. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said

pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, means for automatically taking said regulators off automatic and opening said control valves when the pressure in said supply line rises to a predetermined amount, and means for automatically preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

18. In a blast furnace having a plurality of tuyeres, an air supply line, a pipe line leading from said air supply line to each tuyere, a control valve in each of said pipe lines, means for varying the position of each control valve, and an air flow determining means in each of said pipe lines; the combination therewith of means for developing a master signal, means for varying the magnitude of said master signal, an automatic regulator associated with each tuyere for controlling the position of its associated control valve, means connecting an impulse from each of said first named air flow determining means to its associated regulator, means connecting an impulse from said master signal to each of said regulators, and means for automatically preventing operation of said master signal varying means when the pressure in said supply line falls below a predetermined amount.

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