STEPPED OPENING FLUID PRESSURE OPERATED VALVE

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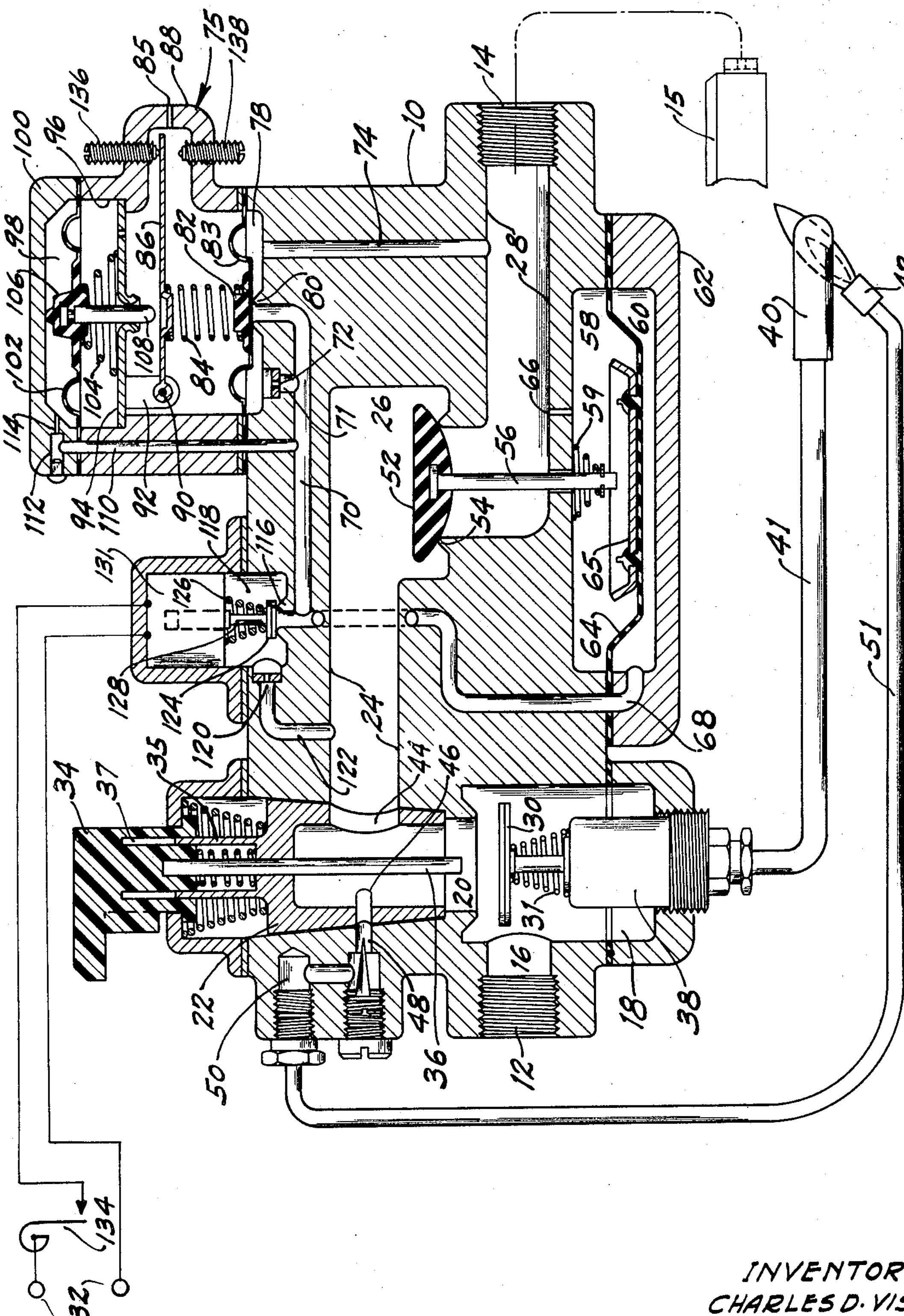

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STEPPED OPENING FLUID PRESSURE OPERATED VALVE

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ABSTRACT OF THE DISCLOSURE

A biased closed gas valve controlling a main passageway is moved openward by a first expansible chamber as it expands. A restricted pressure passageway having a control valve therein connects the chamber with the upstream side of the gas valve and a more highly restricted bleed-off passageway connects the chamber with the downstream side of the gas valve. The pressure in the chamber therefore increases and the gas valve is moved openward when the control valve is opened. A bypass controlled by a biased closed pressure regulator valve permits additional bleed off so as to limit opening of the gas valve to a predetermined partially open position. A second, smaller, expansible chamber having a lost motion operative connection with the pressure regulator operates when it has expanded a predetermined amount to increase the closing bias on the regulator valve, thereby reducing the bleed off through the bypass and causing the gas valve to be fully opened. A passageway connects the second, smaller, expansible chamber with the first expansible chamber and includes a restricting orifice to delay expansion of the second smaller chamber.

This invention relates to fluid pressure operated gas valves and particularly to means providing stepped opening movement of the valve.

In many installations, it has been found essential to the safe operation of gas burners enclosed in compact combustion chambers to delay the full rated flow of gas to the burner when starting operation thereof until sufficient draft through the combustion chamber has been developed by combustion of a lesser flow to support the full rated flow.

One method of accomplishing this is to incorporate means which slows the opening of the gas valve sufficiently so that the elapsed time between an initial open position of the valve, which initiates combustion, and the full open position thereof is sufficient to permit the necessary draft to develop. However, because the relatively large diameter poppet type valves commonly employed in fluid pressure or diaphragm operated gas valves are required to be moved only a relatively short distance between their closed and full flow open positions, the operation of an arrangement which relys entirely upon a slow rate of valve opening to provide the required delay becomes quite critical.

Another method of operating the valve to accomplish this purpose is to partially open the valve a predetermined amount at a relatively rapid rate to provide only a sufficient flow of fuel to the burner to insure good ignition, then interposing a predetermined dwell during which the valve remains in this partial open position, and, then, moving the valve to its full open position either at the same rate or more slowly. This method, commonly called stepped opening, provides assurance that a sufficient initial flow occurs immediately for good ignition and that sufficient delay occurs to develop the required draft through the combustion chamber during the dwell.

An object of this invention is to provide a stepped opening fluid pressure operated gas valve in which the valve operating pressure upon starting is regulated at one value thereby to effect a partial initial opening of a biased closed gas valve, is maintained at this value for a predetermined interval, and is then regulated at a higher value thereby to effect full opening of the biased closed valve.

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A further object is to provide a stepped opening fluid pressure operated gas valve, as above, in which a biased closed pressure regulator valve controls a bleed off of available valve operating pressure thereby to regulate the valve operating pressure at the one value when starting, in which a fluid pressure responsive actuator responding slowly to regulated valve operating pressure is operative to increase the closing bias of the regulator valve thereby to increase the valve operating pressure to the higher value and effect full opening of the gas valve, and in which a lost motion connection between the actuator and the regulator valve biasing means provides a predetermined delay in the increase of valve operating pressure.

Further objects and advantages will appear from the following complete description when read in connection with the accompanying drawing.

The single figure of the drawing is a cross-sectional view of a manifold gas valve having a stepped opening, diaphragm operated gas valve constructed in accordance with the present invention.

Referring to the drawing, the device comprises a body generally indicated at **10**. The body **10** may consist of several sections joined together in any suitable manner to permit casting or boring the cavities and passages therein. In the drawing, the body is illustrated as an integral structure with all passages and cavities lying in the plane of the cross-section, thereby to simplify the description, arrangement, and cooperation of the various elements. The body **10** has an inlet **12** adapted to be connected to a supply of gas under pressure and an outlet **14** connected to a main burner **15**. The inlet **12** and outlet **14** are connected by a passageway **16**, a chamber **18**, a passageway **20**, a hollow rotary plug valve **22**, a passageway **24**, a chamber **26**, and a passageway **28**.

A safety cutoff valve **30** cooperates with the seat to control the flow from the inlet to outlet. The valve **30** is biased closed by a spring **31** and is manually opened by depression of a knob **34** having a pin **36** which engages the valve **30**. The valve **30** is held open by an electromagnet **38** energized through leads **41** by a thermocouple junction **40** heated by an adjacent pilot burner **42**. This arrangement prevents the flow of fuel to the main burner when the pilot burner is not burning. The hollow rotary plug valve has a main port **44** in the wall thereof which registers with passageway **24** when the plug valve is rotated to an "on" position. The knob **34** is axially slidable relative to the plug valve **22** on circularly spaced, axially extending tanks **35** which enter circularly spaced sockets **37** in the knob **34**. The knob **34** is thereby also keyed to the plug valve for rotation therewith.

The plug valve **22** is further provided with a circumferentially extending pilot port **46** in the wall thereof which registers with a passageway **48** when the plug valve **22** is in an "on" position. The pilot outlet **50** is connected to pilot burner **42** by a conduit **51**.

A main valve **52** cooperating with an annular seat **54** formed in chamber **26** around the exit of passageway **28** also controls the flow from inlet **12** to outlet **14**. Valve **52** has a stem **56** extending downward into an upper diaphragm chamber **58** formed as a recess in body **10**, and a spring **59** biases the valve **52** downward in a closed position on its seat **54**. A lower diaphragm chamber **60** is formed by a cup-shaped member **62** attached to the body **10**, and a flexible diaphragm **64** clamped at its periphery between the body **10** and member **62** defines upper and lower main diaphragm chambers **58** and **60**, respectively. The diaphragm **64** includes a relatively rigid disc member **65** centrally positioned and attached thereto. The disc member **65** provides weight to bias the diaphragm downward in the position shown.

The upper diaphragm chamber **58** is adequately vented to outlet passage **28** through a vent **66** so that the upper side of diaphragm **64** is constantly exposed to pressure existing in outlet passage **28**. The lower chamber **60** is also in constant communication with outlet passage **28** through a passage **68**, a passage **70**, a passage **71**, a restricting orifice **72**, the diaphragm chamber **78** of a pressure regulator generally indicated at **75**, and a passage **74**. A valve seat **80** controlled by a pressure regulating valve **82** provides additional venting or bleed off under conditions to be described. The valve **82** forms a part of a pressure regulator diaphragm **83** exposed to atmospheric pressure on its upper side through a vent **85**, and a spring **84** biased between a lever **86** and valve **82** biases the valve **82** closed on its seat **80**.

The pressure regulator **75** further comprises a body member **88** suitably attached to the main body member **10**, the periphery of regulator diaphragm **83** being clamped between these body members. The lever **86** is pivotally mounted at one end on a pivot pin **90** supported in integrally formed ears **92** depending from a centrally perforated disc **94**. The disc **94** is fitted into a bore **96** in the body **88**. A second diaphragm chamber **98** is formed in the pressure regulator **75** by a cup-shaped cover member **100** attached to the upper surface of regulator body **88**. A second flexible diaphragm **102** clamped at its periphery between cover member **100** and regulator body **88** forms a pressure movable, wall defining chamber **98**. The spring **104** between the disc **94** and diaphragm **102** biases the diaphragm in an upward position. Diaphragm **102** has an integral, relatively inflexible, central portion **106** which forms a seat for spring **104** and supports therein a downwardly extending pin **108** which extends through the central perforation in disc **94**. The pin **108** is arranged to engage the lever **86** as it moves downward thereby to increase the bias of spring **84**, but in its normal biased position shown, there is a predetermined spaced relationship between the lower end of pin **108** and lever **86**.

The upper regulator diaphragm chamber **98** communicates with lower main diaphragm chamber **60** through passages **68** and **70**, a passage **110**, a passage **112**, and a restricting orifice **114**, so that a pressure change in chamber **60** is slowly communicated to chamber **98**.

Communication between lower main diaphragm chamber **60** and the inlet **12** is also provided through passage **68**, a valve seat **116** at the upper end of passage **68**, a valve chamber **118**, a restricting orfice **120**, a passage **122**, the passage **24**, main port **44**, the hollow plug valve **22**, passage **20**, chamber **18**, and passage **16**. A solenoid operated valve **124**, biased closed by a spring **126**, cooperates with valve seat **116** to control this communication. The valve **124** has a stem **128** connected to the plunger of a solenoid **130**. The solenoid has a winding **131** connected across power source terminals **132** through a space thermostat **134**. The restricting orifice **120** is larger in diameter than restricting orifice **72** in bleed-off line **71**, so that when solenoid operated valve **124** is opened, the pressure will increase in diaphragm chamber **60**.

OPERATION

The manifold valve device is shown in FIG. 1 in an "on" position; that is to say, the hollow plug valve **22** is in an on position in which gas may flow through its main port **44** to passage **24** and through pilot port **46** to pilot burner **42**. Also, the pilot burner is burning and cutoff valve **30** is being held open by electromagnet **38**. The space thermostat **134** is open, however, so that the solenoid operated control valve **124** is biased closed, whereby communication between inlet **12** and the lower

diaphragm chamber **60** is cut off. Since upper main diaphragm chamber **58** is constantly vented to outlet passage **28** through vent **66** and lower main diaphragm chamber **60** is also constantly vented to the same pressure zone through orifice **82**, the diaphragm **64** is in its lower position and main valve **52** is biased closed by spring **59**.

Under these conditions, when space thermostat **134** closes due to a drop in space temperature, solenoid winding **131** is energized and control valve **124** will open, thereby placing lower diaphragm chamber **60** in communication with inlet **12**. The venting orifice **72** in passage **71** being smaller than the orifice **120** in passage **122**, the pressure in lower main diaphragm chamber **60** now increases, causing the diaphragm **64** to flex upward and move main valve **52** openward a predetermined amount against the biasing spring **59**. This partial opening of main valve **52** is determined by the rate of bleed off which occurs past the pressure regulating valve **82**, which, in turn, is determined by the biasing force of regulator spring **84**.

A headless screw **136** threadedly engaged in pressure regulator body **88** and extending externally and internally through a wall thereof engages the free end of lever **86**. Rotation of screw **136** therefore varies the force of the closing bias of spring **84** on regulator valve **82** and consequently varies the bleed-off rate. The initial partial opening of main valve **52**, which occurs upon opening of control valve **124**, may therefore be predetermined.

Actually the initial partially open position of main valve **52** is predetermined for some particular supply pressure at inlet **12**. If the instant supply pressure is above this particular pressure when control valve **124** opens, more bleed off past the regulator valve **82** will occur and the partial valve opening movement will be less.

If, on the other hand, the instant supply pressure is below this particular pressure, the bleed off past the pressure regulator will be less and the partial valve opening movement will be greater. It will be apparent, therefore, that it is a definite portion of the full rate flow which is predetermined and maintained constant under conditions of varying supply pressure. This portion of the full rated flow is now ignited by pilot burner **42**.

The valve operating pressure which develops in main diaphragm chamber **60** shortly after the opening of control valve **124** is slowly applied to the upper surface of actuator diaphragm **102** through restricting orifice **114**. The slow application of this pressure effects the slow downward movement of the central portion of diaphragm **102** and the pin **108** against the bias of return spring **104**. After a predetermined interval of time, the pin **108** engages the lever **86** and continues downward, compressing spring **84** to increase the closing bias on regulator valve **82** until the free end of lever **86** engages the upper end of a lower adjusting screw **138** threadedly engaged in regulator body **88**. When lever **86** engages the screw **138**, the closing bias on regulator valve **82** is such as to result in a bleed-off rate past the regulator valve **82** which will effect full opening or full rated flow position of main valve **52**. The full rated flow may obviously be varied by adjustment screw **138**.

It will be apparent that main valve **52** will remain in its predetermined, initial, partial open position during the time interval required for pin **108** to move from its upper returned position, shown, to a position of engagement with lever **86**. During this period the predetermined portion of the rated flow through valve **52** will be substantially constant, the length of this period being determined by the size of orifice **114**, the volume of chamber **98**, and the space between the lower end of pin **108** and lever **86**. The rate of increase in the closing bias on the regulator valve, and therefore the elapsed time between engagement of pin **108** with lever **86**, and the application of a maximum closing bias on valve **82** which will effect a full rated flow position of valve **52** will also be determined by these parameters.

The burner **15** will now be operated at full rated flow until sufficient heat is supplied to the space to effect opening of thermostat **132**. The opening of thermostat **132** causes control valve **124** to close, thereby cutting off communication between the inlet **12** and main diaphragm chamber **60**. The existing pressure in chamber **60** and in actuator chamber **98** will now bleed off through orifice **72**, and outlet passage **28**, and, ultimately, to burner **15**. Main diaphragm **64** will now resume its downward position shown, and main valve **52** will close under the bias of spring **69**. The diaphragm **102** and pin **108** will also now resume their upper biased position, shown.

It will be understood by those skilled in the art that the stepped opening means herein described may also be used without modification in fluid pressure operated gas valves employing a system in which inlet pressure is applied to both sides of a valve operating diaphragm to effect closure of the gas valve, and in which a bleed off of pressure from one side of the diaphragm effects an opening movement of the gas valve. In these systems, which are well known and understood, a pressure regulator valve in the bleed-off passageway is biased open by a predetermined biasing force to effect a bleed-off rate resulting in opening movement of the gas valve instead of being biased closed as in the described system.

In the operation of these systems, when employing the described stepped opening means, the usual spring means biasing the regulator valve open is adjusted so as to effect a bleed-off rate which will result in an initial, predetermined, partial opening of the gas valve when a control valve in the bleed-off line is opened. The described stepped opening means then increases the force biasing the regulator valve openward after a predetermined delay during which the operating pressure existing on the lower pressure side of the diaphragm is slowly communicated to the expansible chamber **98**.

We claim:

1. In a fluid pressure operated gas valve, a body member having an inlet and an outlet and means forming a main passageway therethrough connecting said inlet and outlet, a biased closed main valve controlling said main passageway, a first expansible chamber operative when expanding to move said main valve openward, a passageway including a control valve connecting said chamber with said main passageway upstream from said main valve, a bleed-off passageway including a biased closed pressure regulator valve connecting said chamber with said main passageway downstream from said main valve and operative to bleed off pressure from said chamber at a rate which results in a predetermined initial opening movement of said main valve when said control valve is opened, a second expansible chamber operative when expanding to increase the closing bias of said regulator valve thereby to reduce the bleed-off rate and effect further opening of said main valve, a restricted passageway connecting said first and second expansible chambers whereby expansion of said second chamber and further opening of said main valve is slowed, and means venting said first and second expansible chambers to said main passageway downstream of said main valve thereby to permit their contraction when said control valve is closed.

2. The fluid pressure operated gas valve claimed in claim **1** in which the closing bias on said regulator valve effects an initial opening of said main valve which permits a predetermined initial flow of gas from inlet to outlet, and in which said second expansible chamber when fully expanded increases the closing bias on said regulator valve so as to effect a further opening movement of said main valve which permits a predetermined greater flow.

3. The fluid pressure operated gas valve claimed in claim **1** in which said second expansible chamber has a fully contracted position and expands freely therefrom a predetermined amount before operatively increasing the closing bias on said regulator valve, whereby the predetermined initial opening of the main valve is maintained for a predetermined interval.

4. In a fluid pressure operated gas valve, a body member having an inlet, an outlet, and means forming a passageway connecting them, a biased closed main valve controlling said main passageway, a first normally contracted expansible chamber operative when expanding to move said main valve openward, a pressure passageway connecting said chamber with said main passageway on the upstream side of said main valve, a normally closed control valve in said pressure passageway, a bleed-off passageway connecting said chamber with said main passageway on the downstream side of said main valve, a pressure regulator valve arranged to close in an upstream direction controlling said bleed-off passageway, resilient means biasing said regulator valve closed with sufficient force to reduce bleed off to a rate which effects an initial partial expansion of said chamber and an initial partial opening of said main valve when said control valve is opened, a second normally contracted expansible chamber operative when expanded to increase the closing bias on said regulator valve thereby to further reduce the bleed-off rate and effect full opening movement of said main valve, a passageway connecting said first and second expansible chambers including restricting means operative to slow expansion of said second chamber thereby to delay full opening of said main valve, and means venting said first and second expansible chambers to a low pressure area thereby to permit their return to a contracted position when said control valve is subsequently closed.

5. The fluid pressure operated valve claimed in claim **4** which includes means forming a lost motion operative connection between said second expansible chamber and said resilient biasing means, whereby said main valve remains in its initial partial open position for a short period of time.

6. A diaphragm gas valve in which a main valve operating diaphragm forms the movable wall of a chamber and is normally subjected to equal pressure on opposite sides thereof whereby a biased closed main valve connected thereto is permitted to close, in which upstream pressure is applied to the chamber through a first passageway at a predetermined rate and is bled-off to a downstream zone through a second passageway at a rate resulting in a net operating pressure effecting movement of the main valve to a desired open position when a normally closed control valve in one of the passageways is opened; the improvement which comprises the provision of an adjustably biased pressure regulator valve in said second passageway, said regulator valve having a first biased condition which results in an initial net operating pressure effecting an initial partial opening of said main valve when said control valve is opened and a second biased condition resulting in a different net operating pressure which effects further opening of said main valve, an expansible chamber having a normally contracted condition and being operative when expanding to effect the adjustment of said regulator valve from its first to second biased condition, and restricted passageway means providing communication between said expansible chamber and a zone of net operating pressure lying between said control valve and said pressure regulator valve, whereby the existing operating pressure is slowly communicated to said expansible chamber thereby delaying further opening of said main valve.

7. The diaphragm gas valve claimed in claim **6** in which the bias of said regulator valve is increased from its first to second biased condition as said expansible chamber expands.

8. The diaphragm valve claimed in claim **6** in which the pressure regulator valve biasing means is a spring biased between the regulator valve and a movable member, in which said expansible chamber engages said movable member upon expanding and increases the bias on said regulator valve, and in which said expansible chamber has a lost motion operative connection with said movable member whereby it expands a predetermined amount from its contracted position before engaging said movable member thereby to provide an interval in which said main valve remains in its initial partial open position.

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