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GAS MAIN CONTROLLER.

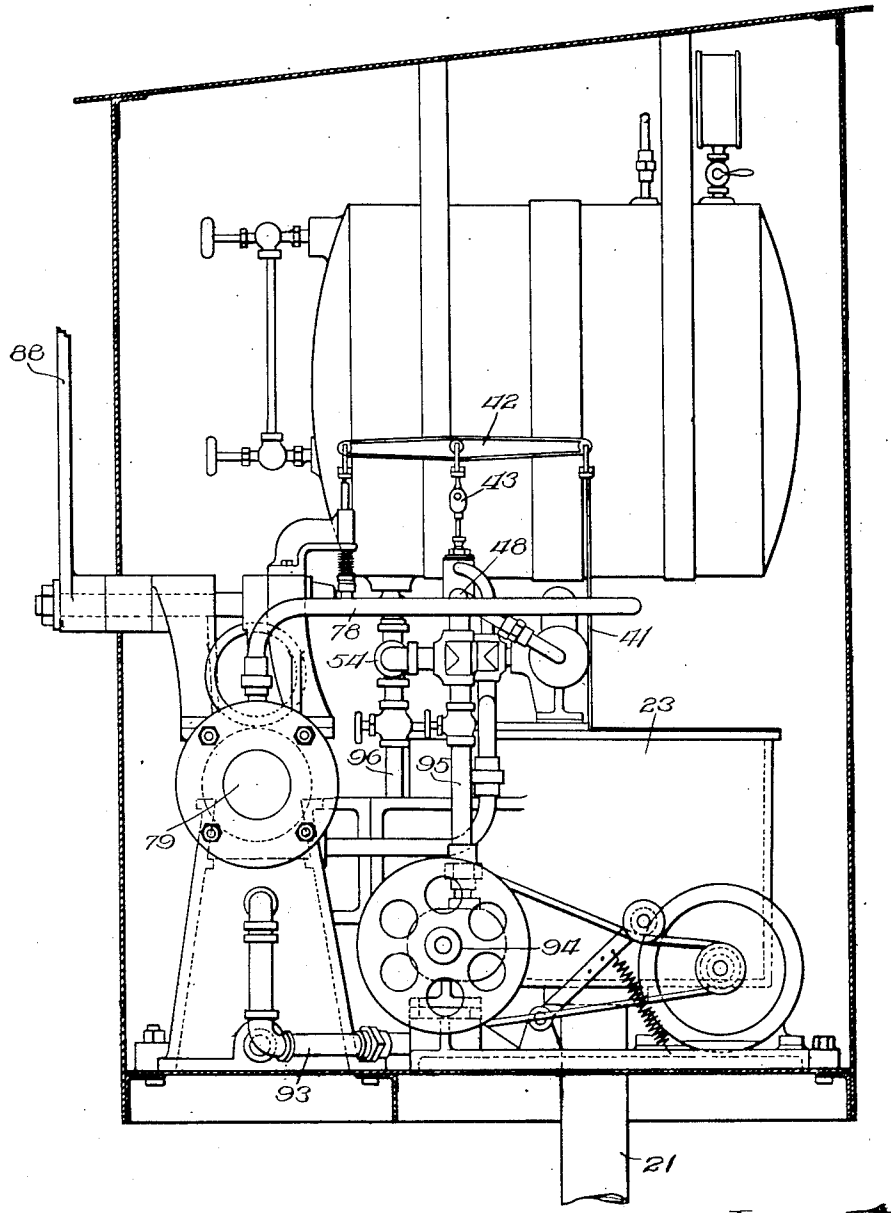
APPLICATION FILED APR. 10, 1920.

1,398,055.

Patented Nov. 22, 1921.

8 SHEETS—SHEET 1.

Fig. 1



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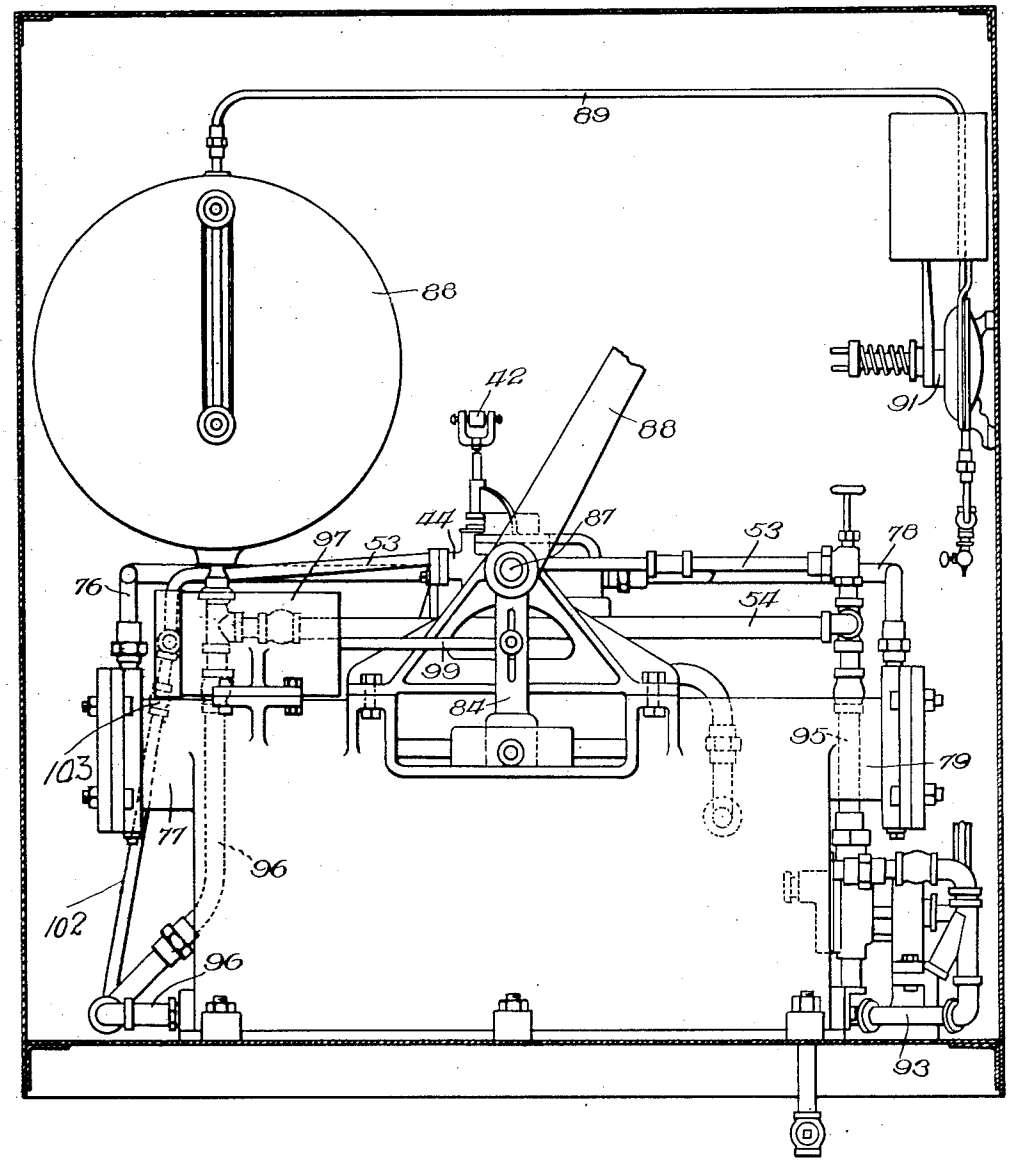
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8 SHEETS—SHEET 2.

Fig. 2



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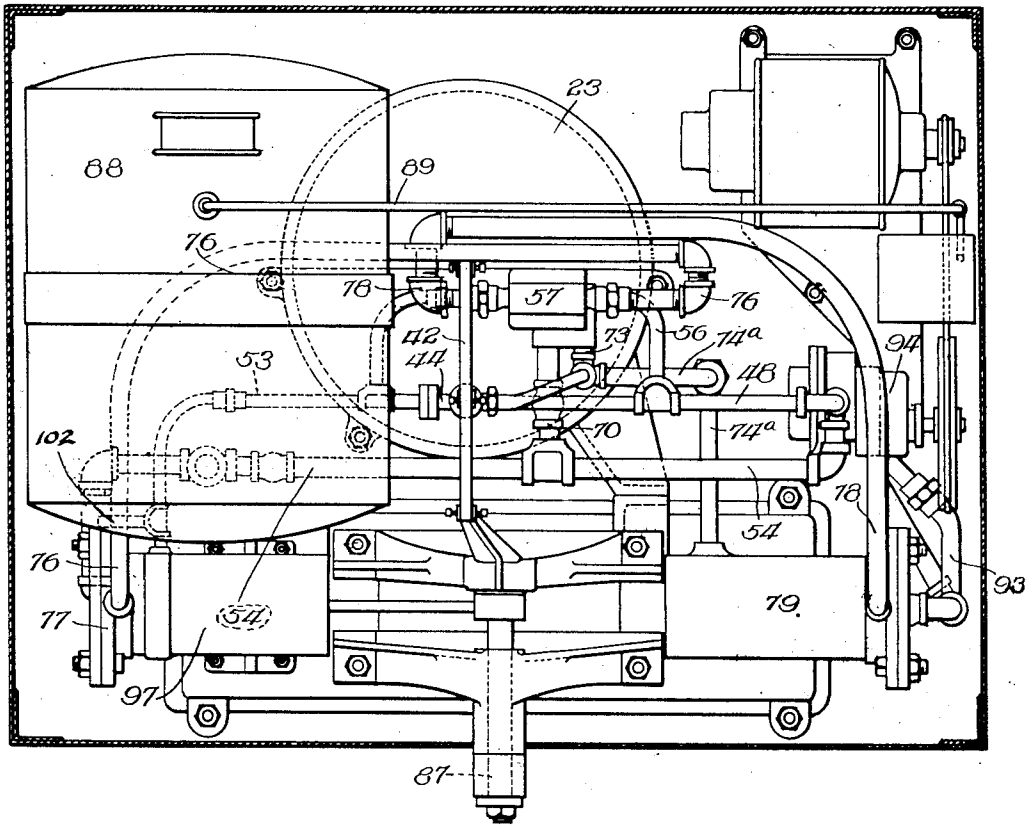
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8 SHEETS—SHEET 3.

Fig. 3



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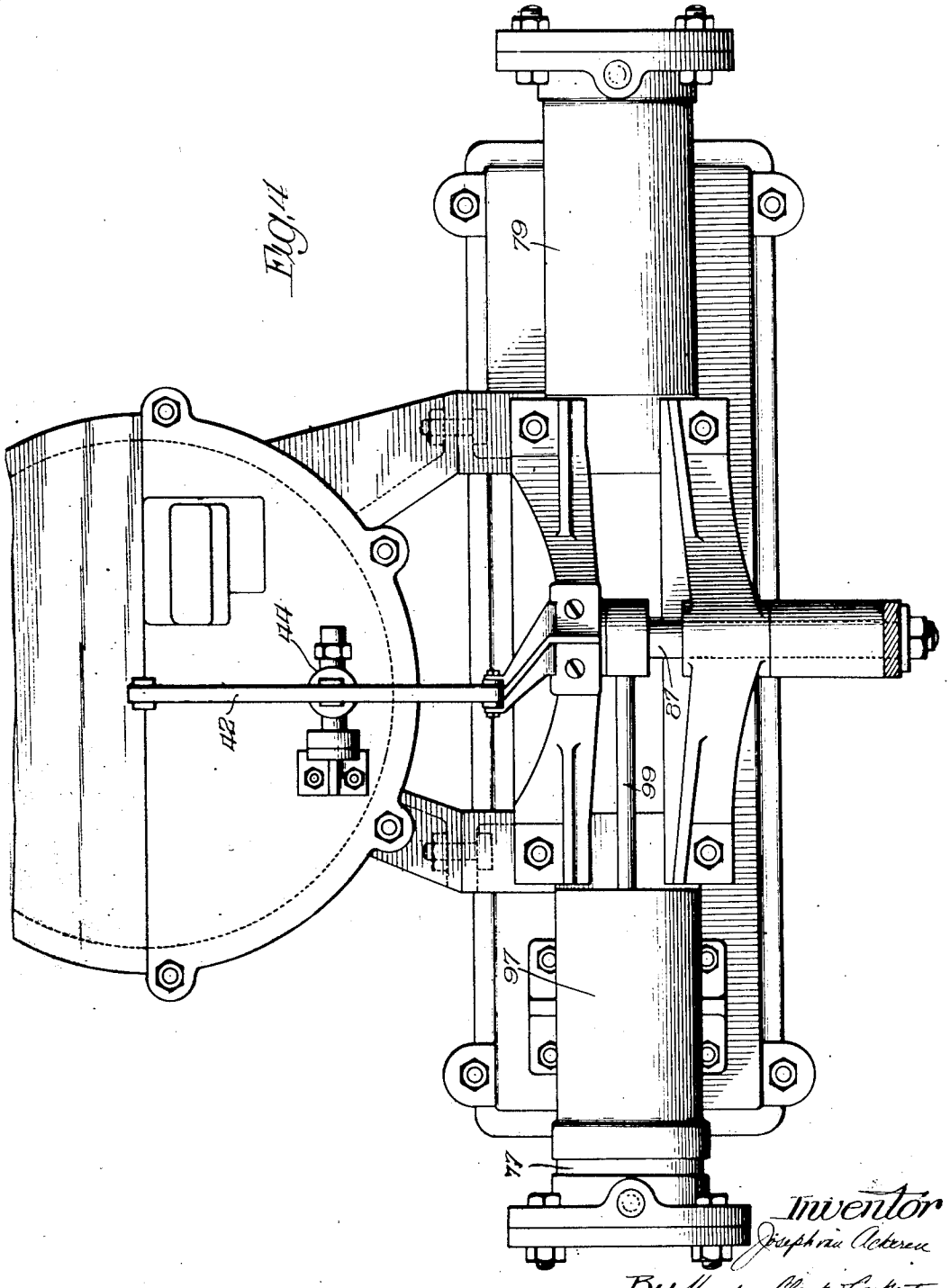
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8 SHEETS—SHEET 4.

Fig. 4.



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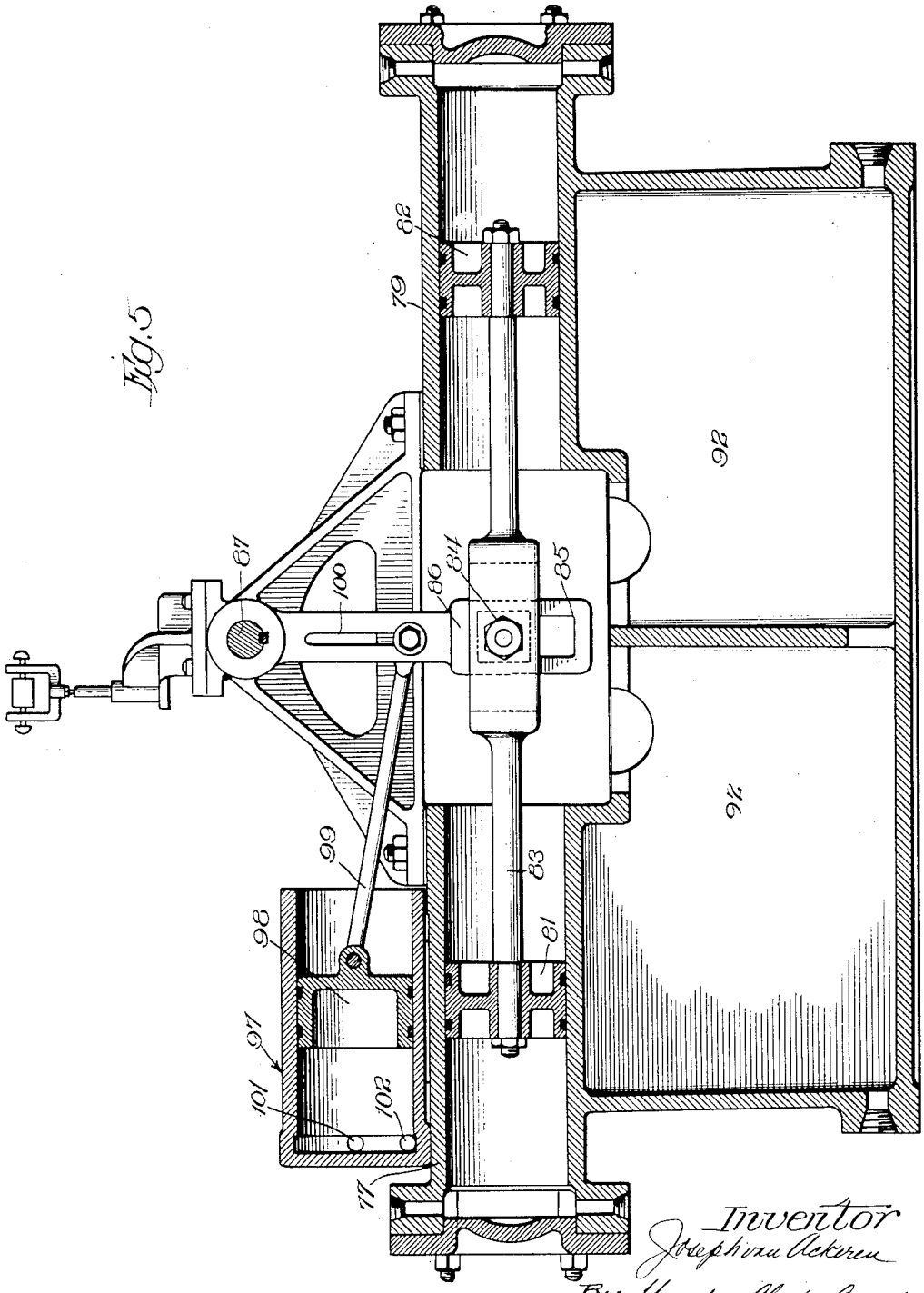
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8 SHEETS—SHEET 5.

Fig. 5



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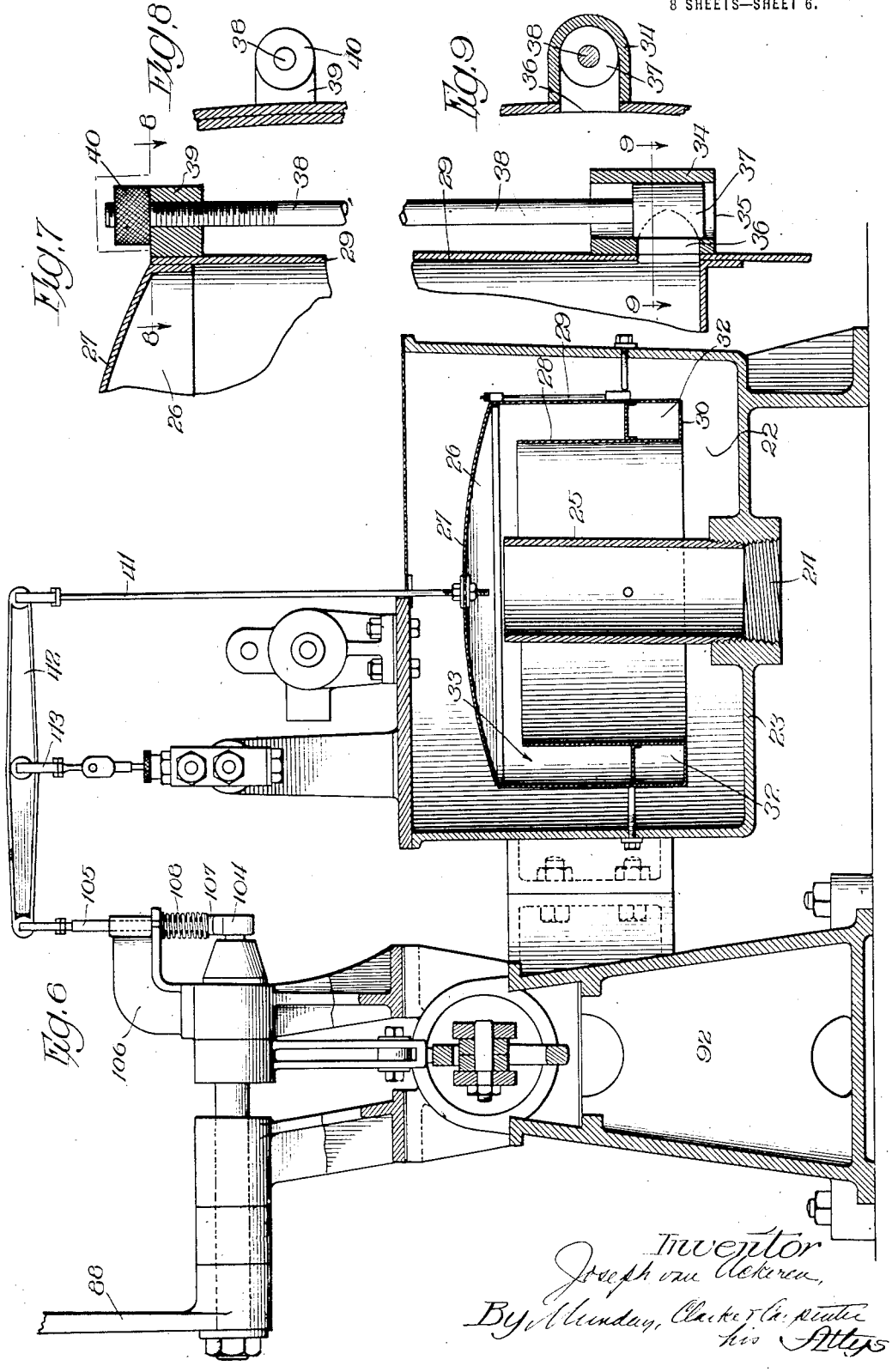
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APPLICATION FILED APR. 10, 1920.

1,398,055.

Patented Nov. 22, 1921.

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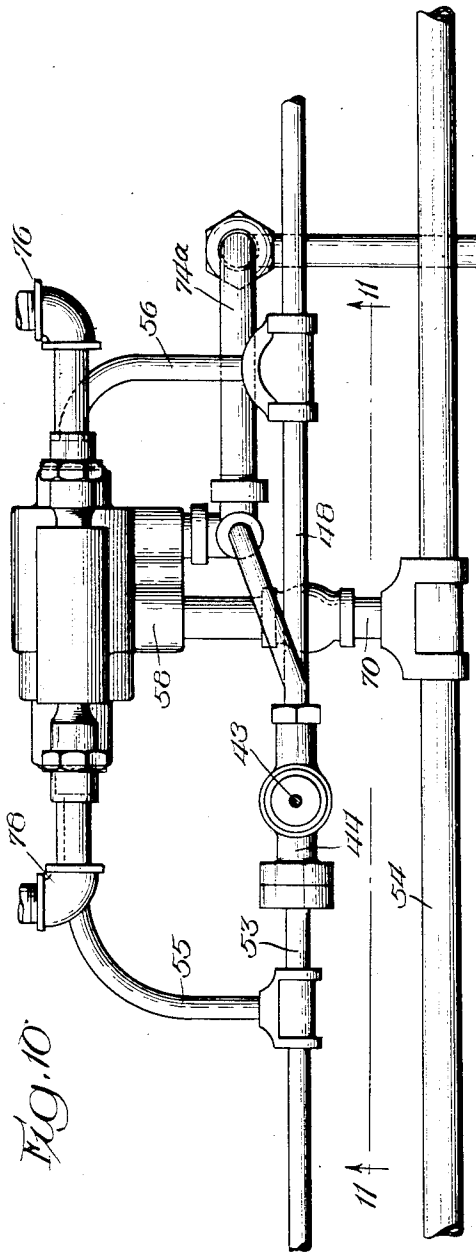


Fig. 10.

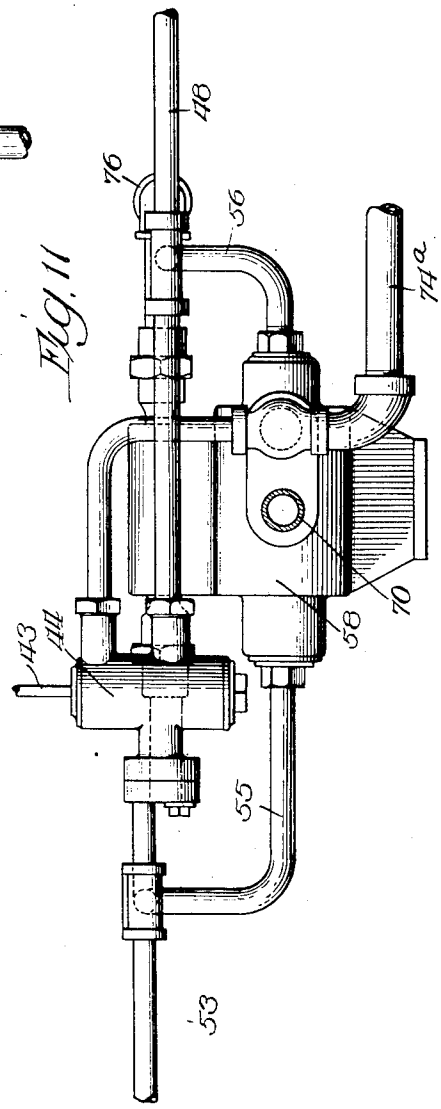


Fig. 11.

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GAS MAIN CONTROLLER.

APPLICATION FILED APR. 10, 1920.

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Patented Nov. 22, 1921.

8 SHEETS—SHEET 8.

Fig. 15

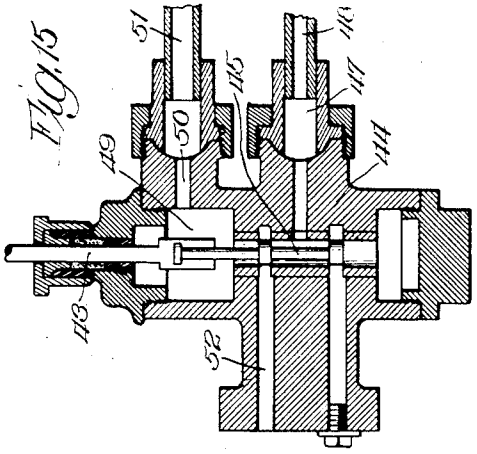


Fig. 14

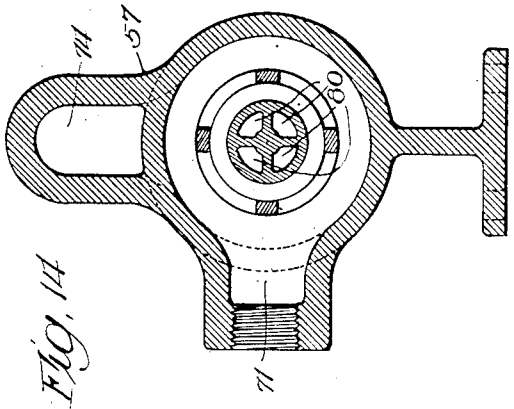


Fig. 12

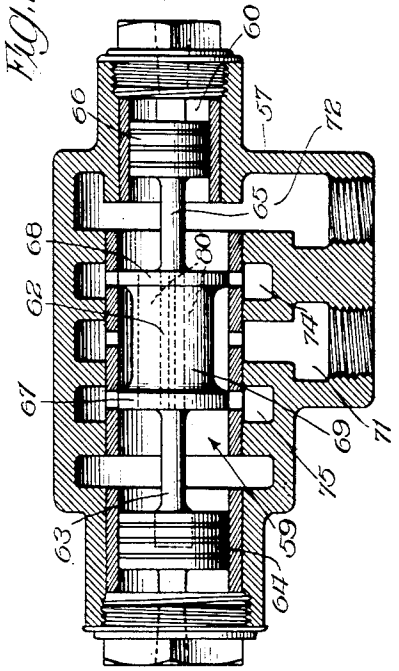
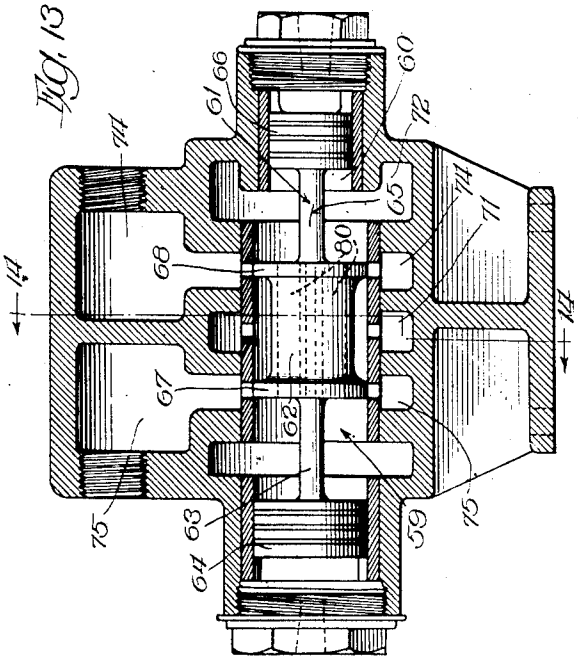


Fig. 13



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UNITED STATES PATENT OFFICE.

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GAS-MAIN CONTROLLER.

1,398,055. Specification of Letters Patent. Patented Nov. 22, 1921.

Application filed April 10, 1920. Serial No. 373,000.

To all whom it may concern:

Be it known that I, JOSEPH VAN ACKEREN, a citizen of the United States, residing in Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Gas-Main Controllers, of which the following is a specification.

This invention relates to pressure regulators for gas mains, more particularly the collecting mains of by-product coking plants in which it is of great importance to maintain substantial uniformity of pressure conditions.

One of the principal objects of the invention is the provision of a pressure regulator that is quickly responsive to relatively minute fluctuations in pressure in a gas main and which, although capable of developing adequate power to operate the controlling valve of the main, is extremely sensitive, and always under the direct control of the very minute fluctuations in pressure in the main. In other words the invention combines the great sensitiveness to pressure fluctuations with an adequate directly responsive power for operating the controlling valve, thereby effecting an immediate regulation of the pressure within the main. The invention has for further objects such other improvements or advantages in construction and operation as are found to obtain in the structures and devices hereinafter described or claimed.

In the accompanying drawings forming a part of this specification, and showing, for purposes of exemplification, a preferred form and manner in which the invention may be embodied and practised, but without limiting the claimed invention specifically to such illustrative instance or instances:

Figure 1 is a right hand side elevation of an arrangement of apparatus constituting a pressure regulator embodying the present invention.

Fig. 2 is a front elevation of the same.

Fig. 3 is a top plan view.

Fig. 4 is an enlarged top plan view of the motor cylinders, the float chamber and other parts.

Fig. 5 is an enlarged vertical section through the motor cylinders and the auxiliary governing cylinder.

Fig. 6 is an enlarged vertical section through the float casing, the motor pedestal and other parts.

Fig. 7 is a fragmentary detailed vertical section of the float.

Fig. 8 is a fragmentary horizontal section on the line 8—8 of Fig. 7.

Fig. 9 is a fragmentary horizontal section on the line 9—9 of Fig. 7.

Fig. 10 is a detailed top plan view of the pipe line connections with the pilot valve and the relay valve.

Fig. 11 is a vertical section on the line 11—11 of Fig. 10, with parts omitted to avoid complication of the illustration.

Fig. 12 is a longitudinal horizontal section through the relay valve casing.

Fig. 13 is a longitudinal vertical section through the same.

Fig. 14 is a transverse vertical section on the line 14—14 of Fig. 13.

Fig. 15 is a longitudinal vertical section through the pilot valve.

The same characters of reference designate the same parts throughout the several views.

As shown in the drawings, a pipe 21 is connected with the bottom of a float chamber 22. The pipe 21 leads from the gas main, the pressure within which is to be regulated by the regulating apparatus and serves to conduct gas from the main to the float chamber. The float chamber 22 is inclosed by a suitable substantially cylindrical casing 23 supported in any suitable manner and having a threaded port 24 in its bottom, into which the aforesaid pipe 21 is screwed. Also screwed in said port 24 and extending vertically upwardly within the float chamber 22 is a pipe 25 which directs the gas from the gas main into the interior of the float mounted within said float chamber 22. The float 26 is of inverted bell shape having a curved top 27 and inner and outer cylindrical walls 28 and 29 joined together at the bottom of the float by means of a horizontal annular connecting portion 30, all as shown more particularly in Fig. 6. Mounted above the annular connecting portion 30 and joining the inner and outer cylindrical walls 28 and 29 is an annulus 31 which forms the top of an annular buoyant chamber 32 at the bottom of the float. This chamber 32 is constantly submerged in the liquid within the float chamber 22 and

serves merely to reduce the weight of the moving parts of the float and the resulting inertia and friction. Above the buoyant chamber 32 the aforesaid inner and outer cylindrical walls 28 and 29 form an annular chamber 33 that is open at the top to the gas pressure within the float and is adapted to be emptied of and to be partially filled with liquid from the float chamber 22, as the float rises and falls upon variation in the gas pressure.

The rate of flow into and out of the annular chamber 33 is regulable by means of an adjustable valve mechanism carried by the float and constructed as follows:—Mounted on the outer face of the outer cylindrical wall 29 of the float is a valve casing 34 having a bottom discharge or entry port 35 and a side port 36 that communicates with a registering port formed in the casing wall 29. A valve head 37 is slidably mounted within the valve casing 34 and is provided with a vertical stem 38 which extends upwardly to the top of the casing wall 29 and is threaded within a socket formed in a lug 39 projecting outwardly from said casing wall 29. The threaded portion of the valve stem 38 projects beyond said lug 39 and threaded on this projecting portion is a knurled adjusting collar 40, by the turning of which the valve stem 38 may be raised and lowered with a consequent change in position of the valve head 37 within the valve casing 34. By this means the port connecting the float chamber 33 with the outer chamber 22 may be shut off entirely or may be varied in size to regulate the flow between said chamber 33 and said outer chamber 22.

When the float is at rest, the liquid level within the chamber 33 is the same as the liquid level in the outer main float chamber 22. On movement of the float however this equilibrium is necessarily disturbed and liquid must pass from one chamber to the other until the liquid in both chambers regains the same level. For example, as the float rises the liquid will necessarily flow from the inner chamber 33 into the outer chamber 22, and as the float falls liquid flows from the outer chamber 22 into the inner chamber 33. The result of this arrangement is that the movement of the float is dampened until the water level in both chambers has regained the same level, such dampening however being without friction and serving merely to regulate the movement of the float under gas pressure fluctuations. The valve construction for adjusting the port connecting the chamber 33 and the outer float chamber 22 provides for regulation of the speed of movement of the float and of the entire governor, it being obvious that the less restricted the flow between the two chambers 33 and 22 the greater the retardation on the speed of movement of the float and the less open the port the less dampening effect the liquid flow will have.

Connected to the top of the float 26 and extending upwardly through the top of the float casing 23 is a vertical rod 41 that is partially connected at its outer end with one end of a horizontal walking beam 42. The center of said walking beam 42 is pivoted on and balanced upon the upper end of a pilot valve stem 43, and the end of said beam opposite to the rod 41 connects with a compensating mechanism, which will be fully described hereinafter. The aforesaid pilot valve stem 43 extends downwardly into the pilot valve casing 44, see more particularly Fig. 15, and carries a valve head 45 that is adapted to slide vertically within the main valve chamber 46 of said pilot valve casing. On the upward movement of the float 26 incidental to increase in pressure within the gas main the valve head 45 is elevated within the main valve chamber 46; conversely, on lowering of the float 26 as the gas pressure within the gas main decreases the valve head is lowered within said chamber 46. Communicating with said pilot valve chamber 46 by means of a duct 47 formed in the casing 44 is a pilot valve constant pressure line 48; the upper end of the vertical chamber 46 opens into an enlarged exhaust chamber 49 and the latter communicates by means of a duct 50 with the pilot valve exhaust line 51; located in a plane above the aforesaid supply duct 47 and communicating with the upper end of the main chamber 46 is a third duct 52 which connects with the pilot valve variable pressure line 53, as shown in Figs. 10 and 11. At its base, the pilot valve is provided with an exhaust chamber communicating through a by-pass of usual form (not shown), with the exhaust chamber 49, thus balancing the valve in the usual manner.

Fluid pressure is supplied to the pilot valve constant pressure line 48 by means of a constant pressure main 54, with which such constant pressure line 48 is connected, as shown in Figs. 1, 2 and 3. With the lifting of the valve head 45 incidental to an increase in pressure in the gas main through the medium of the hereinbefore described connections fluid pressure flows from the pilot valve constant pressure line 48 through the valve chamber 46 and duct 52 out the pilot valve variable pressure line 53. Lowering of the valve head 45 connects the aforesaid duct 52 with the exhaust chamber 49, the duct 50 and the pilot valve exhaust line 51, permitting the fluid pressure to exhaust therethrough.

The pilot valve variable pressure line 53 is connected by means of a branch pipe 55 with one side of the relay valve and the pilot valve constant pressure line 48 is connected with the opposite side of the relay

valve by means of a branch pipe 56. The relay valve 57 constitutes an amplifying valve for augmenting the work performed in the pilot valve casing by the direct fluctuations in gas pressure acting on the float 26 and the construction of such relay valve is best illustrated in Figs. 12 to 14 inclusive: The relay valve embodies in its construction a suitable casing 58 formed with a longitudinal main plunger chamber 59, the latter communicating at one end of the relay valve, namely, the right hand end thereof as viewed in Figs. 12 and 13, with an auxiliary chamber 60 of reduced diameter relative to the aforesaid main chamber 59. Preferably the diameter of the chamber 60 is approximately one-half as great as the main chamber 59. Slidably mounted within the relay valve casing is a plunger 61 constituted of a main valve head 62 positioned within the aforesaid main valve chamber 59 and connected by a stem 63 at one end with a piston 64 also located within said main valve chamber, and connected at its other end by a stem 65 with a piston 66 of reduced diameter and slidable within said auxiliary chamber 60. The aforesaid branch pipes 55 and 56 lead respectively to ends of the relay valve chambers 59 and 60, and as a result of this construction the fluid pressure from the pilot valve variable pressure line 53 is carried to the head of the piston 64 and the fluid pressure from the pilot valve constant pressure line 48 is carried to the head of the piston 66 of reduced diameter. The working surfaces of the relay valve, to-wit: the areas of the piston heads 64 and 66 are, in accordance with the invention, greatly in excess of the working surfaces and areas of the pilot valve and accordingly fluid pressure released by the pilot valve may be applied to the working surface of the piston 64 to operate the same, although with a pressure not greater than that applied to the piston 66 because of the relatively smaller diameter of the latter piston. By reason of the constant pressure on one side, and a variable pressure on only the other side, of the relay, such relay, in accordance with the illustrated embodiment of the invention, operates as a throttling valve in contradistinction to an on-and-off valve, thereby minimizing any tendency of the governor to race or hunt.

The relay valve 57 controls the supply of fluid pressure to a motor for operating the usual controlling valve of the gas main, all of which will be hereinafter described, and for this purpose the fluid pressure to and from said motor passes through the relay valve and is directed thereby in such manner as to produce the desired results. The valve head 62 of the plunger within the main valve chamber 59 of the relay valve is formed with disks 67, 68 respectively located at the opposite ends of said valve head 62 and of a diameter to fit closely the wall of said main valve chamber 59, while the central portion 69 of the valve head 62 is of a reduced diameter, as shown, to provide a surrounding passageway for the circulation of the fluid pressure that enters the valve chamber. Communicating with the hereinbefore mentioned constant pressure main 54 is a branch pipe 70 which leads to and is connected with a fluid pressure supply chamber 71 formed in the relay valve casing and communicating with the main valve chamber 59, as shown in Fig. 12. Also formed in the relay valve casing and communicating with the aforesaid main valve chamber 59 is an exhaust chamber 72 that leads to an exhaust pipe 73 connected with the exhaust main 74ª. At the opposite sides of the supply chamber 71 and formed in the relay valve casing are fluid pressure chambers 74 and 75 that are respectively connected by supply pipes with the opposite cylinders of the motor. From the fluid pressure chamber 74 in the relay valve a supply pipe 76 leads to the left hand motor cylinder 77 and from the fluid pressure chamber 75 a supply pipe 78 leads to the right hand motor cylinder 79. The valve head 62 of the relay valve plunger is provided with a plurality of ducts 80 extending longitudinally therethrough, as shown in Figs. 12 to 14 inclusive, said ducts 80 being adapted under certain conditions, hereinafter described, to connect the aforesaid pressure chamber 75 with the exhaust chamber 72.

Proceeding on the assumption that an excess of pressure in the gas main has effected a lifting movement of the float 26, the pilot valve head 45 is lifted, thereby uncovering the duct 52, with the result that fluid pressure from the pilot valve constant pressure line 48 passes through the duct 52 and the branch pipe 55 to the main valve chamber 59 of the relay valve and against the piston head 64 of the relay valve plunger. Fluid pressure from the same pilot valve constant pressure line 48 is constantly exerted against the piston head 66 of reduced diameter, as such supply of fluid pressure is maintained at all times to the auxiliary chamber 60 through the branch pipe 56. Because however of the greater effective area of the piston 64 with relation to the piston 66, the constant fluid pressure applied at both ends of the relay valve plunger nevertheless moves said plunger toward the right as viewed in Figs. 12 and 13. This results in the disk 68 of the valve head 62 uncovering the ports of the pressure chamber 74 that communicates with the main valve chamber 59 so that said chamber 74 is placed in communication with the fluid pressure supply chamber 71. At the same time the disk 67 of the valve head 62 uncovers the ports of the fluid pressure chamber 75 that lead to

the main valve chamber 59 and said chamber 75 is, as a result, placed in communication with the exhaust chamber 72 through the ducts 80 extending through the valve head 62. As soon as the parts have assumed these relations, the fluid pressure flows from the supply chamber 71 to the chamber 74 and thence through the motor supply pipe 76 to the left hand motor cylinder 77, resulting in a movement of the piston in said cylinder to the right as viewed in Fig. 5. The piston in the motor cylinder 79 also moves to the right and the exhaust fluid pressure from said cylinder 79 passes through the pipe 78 to the fluid pressure chamber 75, through the ducts 80 in the valve head 62 to the exhaust chamber 72 and thence out the exhaust branch pipe 73 to the exhaust main 74*a*. The action of the parts is the reverse of that just described on a lowering of the float 26 coincidentally with a decrease in gas pressure in the gas main. On such decrease of pressure, the pilot valve head 45 is lowered so as to shut off the duct 52 from the pilot valve constant pressure line 48, thereby cutting off the supply of pressure to the piston head 64 of the relay valve. The constant supply of fluid pressure to the piston 66 of reduced diameter now becomes effective to return the plunger to normal position, or, if the decrease in pressure in the gas main continue, to move said relay valve plunger to the left thereby placing the supply chamber 71 in communication with the pressure chamber 75 and concurrently placing the exhaust chamber 72 in communication with the pressure chamber 74. Pressure from the constant pressure main 54 now flows to the right hand motor cylinder 79, through the herein above described connections, and the exhaust from the left hand motor cylinder 77 flows into the pipe 76, the chamber 74 and directly into the exhaust chamber 72 from which it passes finally into the exhaust main 74*a*.

The working surfaces of the motor are substantially greater in area than the working surfaces of the relay valve, in that the motor cylinders and the pistons working therein are relatively of much greater diameter than the pistons and other parts of the relay valve. Thus although the pressure of the motive fluid supply to the motor cylinder is no greater than that which actuates the relay valve and which passes through the relatively minute pilot valve, the pressure on the motive fluid being constant throughout the system, the relatively greater surfaces of the motor permit such constant pressure to move the motor pistons to perform their work of actuating the controlling valve of the gas main. Therefore, a constant power fluid controlled by the exceedingly minute fluctuations in pressure in the gas main is made to perform the work of moving the motor pistons and operating the relatively heavy and cumbersome controlling valve of the gas main, the operation of said controlling valve being directly responsive to and absolutely under the control of the gas pressure fluctuations in said main. The pistons 81, 82 of the respective motor cylinders 77 and 79 are connected together by means of a piston rod 83. This rod 83 is connected at 84 in a slot 85 formed in the lower end of a rock arm 86 fixed to and depending from a rock shaft 87. The rock shaft 87 is journaled in suitable bearings and constitutes the operating shaft for the gas main controlling valve. For this purpose the shaft 87 is provided with an operating arm 88, see Fig. 2, which connects with the usual butterfly valve, not shown, in the gas main. The movement of the pistons 81, 82 toward the right, occasioned by an increase in pressure in the gas main, through the operating and controlling connections hereinbefore described, operates the arm 88 to open the butterfly valve in the gas main and thereby reduce the pressure. Reversely, a movement of the two pistons 81, 82 toward the left, produced by a decrease in pressure in the gas main, operates the arm 87 to close the butterfly valve and thereby to permit the pressure to rise in said main.

In the preferred embodiment of the invention, the constant pressure lines of the system are supplied with hydraulic fluid under constant pressure, preferably oil. The constant pressure main line 54 communicates at one end with a constant pressure tank 88, which tank is adapted to supply the oil to said constant pressure main 54. The oil within the tank 88 is kept under constant pressure by means of air under pressure present in the upper end of said tank in the air line 89. The air within the air line 89 passes through a diaphragm pressure regulator 91 of any preferred construction adapted to control an electric switch in the switch box 90, to control the circuit of electric motor for the pump 94, thereby maintaining a constant pressure on the oil in said tank 88. The exhaust main 74ª carries the exhaust oil from the exhaust pipe 51 of the pilot valve and the exhaust pipe 73 of the relay valve to an oil tank 92 located beneath the motor cylinders 77 and 79. From the tank 92 a supply main 93 conducts the exhaust oil to the intake of the pump 94. The discharge side of the pump 94 is connected by means of a branch pipe 95 with the before mentioned constant pressure main 54. The pump provides a means of maintaining the supply of oil in the tank 88. While the oil is flowing through the main 54 from the pump or from the tank 88, the pressure is at all times maintained constant within said main 54 by reason of the air pressure operating as above stated. If desired the tank end

of the constant pressure main 54 may be connected by means of an exhaust branch pipe 96, normally closed, with the tank 92, permitting draining of the tank 88 without the necessity for flowing the oil throughout the entire system.

The invention further provides a fluid pressure controlled balancing means for preventing overthrow of the butterfly valve when operated either by a decrease or an increase in pressure within the gas main and for insuring an immediate adjustment of the butterfly valve to the position determined by the gas pressure within the main. This result is effected, by the invention, by setting up a force working oppositely to the force released upon the motor by the operation of the pilot valve, thereby providing a check on the movement of the parts which becomes effective as soon as a force is released that tends to move the butterfly valve in either direction. Mounted on the motor-cylinder 77 is an auxiliary cylinder 97 within which works a piston 98 connected by a pivoted piston rod 99 with the rock arm 86, the outer end of said pivoted rod 99 being pivoted within an elongated slot 100 formed in said rock arm 86. This construction permits an adjustment of the throw of the piston 98 in proportion to the throw of the pistons 81 and 82. In the head of the cylinder 97, there are two ports, a port 101 that communicates with the pilot valve variable pressure pipe 53 and a by-pass 102 that communicates with the oil tank 92 beneath the motor cylinders 77 and 79. As shown the pilot valve variable pressure pipe 53 extends to the port 101 of the auxiliary cylinder and beyond said port 101 is connected by means of said by-pass 102 with the exhaust line 96 that leads to the oil tank 92.

Assuming that the pistons 81, 82 are traveling toward the right, on an increasing pressure in the gas main and a consequent application of the fluid pressure in the pilot valve variable pressure line 53 to the left hand side of the relay valve, the piston 98 of the auxiliary cylinder moves to the right also and its suction tends to fill the auxiliary cylinder with oil coming both from the tank 92 and the pilot valve variable pressure line 53, the amount of which oil may be adjusted by a needle valve 103 in the aforesaid by-pass 102. The result is that the pressure on the head of the piston 64 is relieved as the butterfly in the gas main is opened and consequently, immediately the increase in pressure in the gas main ceases, the constant pressure exerted continuously on the piston 66 of the relay valve becomes effective to move the relay valve in the opposite direction, reverse the supply to the motor-cylinders 77 and 79 and set up a force tending to move the pistons 81, 82 toward the left. The operation of this balancing force insures a stoppage of the opening movement of the butterfly valve in immediate response to a stoppage of an increase in pressure in the main. When the pistons 81, 82 are moving toward the left to close the butterfly valve the auxiliary piston 98 moves toward the left also thereby tending to increase the pressure on the left hand side of the relay valve and to set up a force tending to reverse the operation of said pistons 81, 82, to open said butterfly valve.

In addition to the balancing means hereinabove described, there is provided, by the invention, a mechanical balancing means for checking overthrow of the float. Referring particularly to Fig. 6 the rock shaft 87 is provided with a cam 104. The extreme end of the walking beam 42 from the float rod 41 is provided with a pivoted depending arm 105 that extends through a suitable bracket 106 and is provided at its lower end with a head 107 maintained in engagement with the aforesaid cam 104 on the shaft 87 by means of an encircling spring 108 interposed between said head 107 and said bracket 106. When the float rises the pilot valve rod 43 rises also and the motor is operated to turn the shaft 87 and open the butterfly valve. Turning of the shaft 87 also turns the cam 104 to bring a depressed portion of such cam beneath the head 107 of the rod 105, thereby permitting the spring 108 to depress said rod, which motion is transmitted to the walking beam 42 with a tendency to depress the pilot valve rod 43 and re-center said pilot-valve rod. On movement of the parts in the opposite direction the cam 104 moves to a position to lift the rod 105 and the pilot valve 43 thereby tending to lift the valve head of the pilot valve to its central neutral position.

The invention as hereinabove set forth is embodied in a particular form of construction but may be variously embodied within the scope of the claims hereinafter made.

I claim:

1. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a pilot valve actuated by said movable member; an amplifying relay valve actuated by fluid pressure controlled by said pilot valve; a motor actuated by a fluid pressure line controlled by said relay valve; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

2. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a valve of reduced amplitude operable by the movements of said member; another valve of relatively greater amplitude operable by a fluid pressure line controlled by the aforesaid valve of reduced amplitude; a

motor actuated by a fluid pressure line controlled by said valve of greater amplitude; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

3. In a pressure regulator for gas mains, in combination: a pilot valve having a constant inlet pressure variably released as outlet pressure; a member movable in response to fluctuations in pressure in a gas main for actuating said pilot valve; an amplifying relay valve embodying, a casing, and a valve plunger movable therein and having piston heads, one of reduced area relatively to the other; means for supplying the pilot valve outlet pressure to the piston head of greater area and for supplying the pilot valve inlet pressure to the piston head of reduced area; a motor actuated by a fluid pressure line controlled by said relay valve; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

4. In a pressure regulator for gas mains, in combination: a pilot valve having a constant inlet pressure variably released as outlet pressure; a member movable in response to fluctuations in pressure in a gas main for actuating said pilot valve; an amplifying relay valve actuated by the pilot valve outlet pressure against the pilot valve inlet pressure-head of reduced volume; a motor actuated by a fluid pressure line controlled by said relay valve; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

5. In a pressure regulator for gas mains, in combination: a liquid-sealed bell communicating with the gas main; a pilot actuated by said bell; a magnifying relay valve actuated by a fluid pressure line controlled by said pilot valve; a motor actuated by a fluid pressure line controlled by said relay valve; and means for transmitting power from said motor to a controlling valve for the gas main; substantially as specified.

6. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a pilot valve actuated by said movable member; a magnifying relay valve actuated by a fluid pressure line controlled by said pilot valve; a motor actuated by a fluid pressure line controlled by said relay valve; means for transmitting power from said motor to a controlling valve for the gas main; and means, operable by said power transmitting means, for transmitting a reverse impulse to said pilot valve; substantially as specified.

7. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a pilot valve actuated by said movable member; a magnifying relay valve actuated by a fluid pressure line controlled by said pilot valve; a motor actuated by a fluid pressure line controlled by said relay valve; means for transmitting power from said motor to a controlling valve for the gas main; and an overflow compensator connecting said motor with the pilot valve and acting to reverse the movement of the pilot valve; substantially as specified.

8. In a pressure regulator for gas mains, in combination: a member movable directly by fluctuations of the gas pressure in a gas main; a valve of reduced amplitude actuated by direct connections from said movable member; another valve of relatively greater amplitude controlled by said first-named valve; a power driven motor controlled by said valve of relatively greater amplitude; and means for transmitting power from said motor to a controlling valve for the gas main; substantially as specified.

9. In a pressure regulator for gas mains, in combination: a movable member responsive to the relatively minute fluctuations in pressure in a gas main; a controlling valve for the gas main operable by power greater than that developed by the gas pressure in said main; a source of power under constant pressure; means controlled directly in response to fluctuations of said movable member for releasing power from said source; and means interposed between said member and the controlling valve for applying the power released to working surfaces of progressively increased area to overcome the load of and to operate said controlling valve; substantially as specified.

10. In a pressure regulator for gas mains, in combination: a controlling valve for a gas main; a source of hydraulic power under constant pressure; means responsive to fluctuations in pressure in the gas main for releasing power from such source; and means for applying the power released, through working surfaces of progressively increased area to overcome the load of and to operate said controlling valve; substantially as specified.

11. In a pressure regulator for gas mains, in combination: a controlling valve for a gas main; a source of power under constant pressure; means responsive to fluctuations in pressure in the gas main for releasing power from such source; and means for applying the power released, through working surfaces of progressively increased area, to overcome the load of and to operate said controlling valve, substantially as specified.

12. In a pressure regulator for gas mains, in combination: a controlling valve for a gas main; a source of power under constant pressure; a relay system through which such power is applied in multiplied potential to overcome the load of and to operate said

controlling valve; and means responsive to fluctuations in pressure in the gas main for releasing power from such source; substantially as specified.

13. In a pressure regulator for gas mains, in combination: a member movable in response to the relatively minute fluctuations in pressure in a gas main; a controlling valve for the gas main operable by power greater than that developed by the gas pressure of said main; a source of hydraulic power under constant pressure; means controlled directly in response to fluctuations of said movable member for releasing power from said source; and means interposed between said member and the controlling valve for applying the hydraulic power released to working surfaces of progressively increased area to overcome the load of and to operate said controlling valve; substantially as specified.

14. In a pressure regulator for gas mains, in combination: a friction-free float movable in response to the relatively minute fluctuations in pressure in a gas main; a controlling valve for the gas main operable by power greater than that developed by the gas pressure of said main; a source of hydraulic power under constant pressure; means controlled directly in response to fluctuations of said movable member for releasing power from said source; and means interposed between said member and the controlling valve for applying the hydraulic power released to working surfaces of progressively increased area to overcome the load of and to operate said controlling valve; substantially as specified.

15. In a pressure regulator for gas mains, in combination: a member movable in response to the relatively minute fluctuations in pressure of a gas main; a controlling valve for the gas main operable by power greater than that developed by the gas pressure in said main; a source of power under constant pressure; a pilot valve controlled directly in response to fluctuations of said movable member for releasing power from said source; and a relay system interposed between said member and the controlling valve for applying the power released to working surfaces of progressively increased area to overcome the load of and to operate said controlling valve; substantially as specified.

16. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a valve of reduced amplitude operable by the movements of said member; a source of power under constant pressure; another valve of relatively greater amplitude operable by pressure from said power source and controlled by the aforesaid valve of reduced amplitude; a motor actuated by pressure from said power source and controlled by said valve of greater amplitude; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

17. In a pressure regulator for gas mains, in combination: a member movable in response to fluctuations in pressure in a gas main; a source of power under constant pressure; a pilot valve actuated by said movable member; an amplifying relay valve actuated by pressure from said power source and controlled by said pilot valve; a motor also actuated by pressure from said power source and controlled by said relay valve; and means for transmitting power from said motor to the controlling valve of the gas main; substantially as specified.

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