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FEEDER FOR STEAM BOILERS OR GENERATORS.

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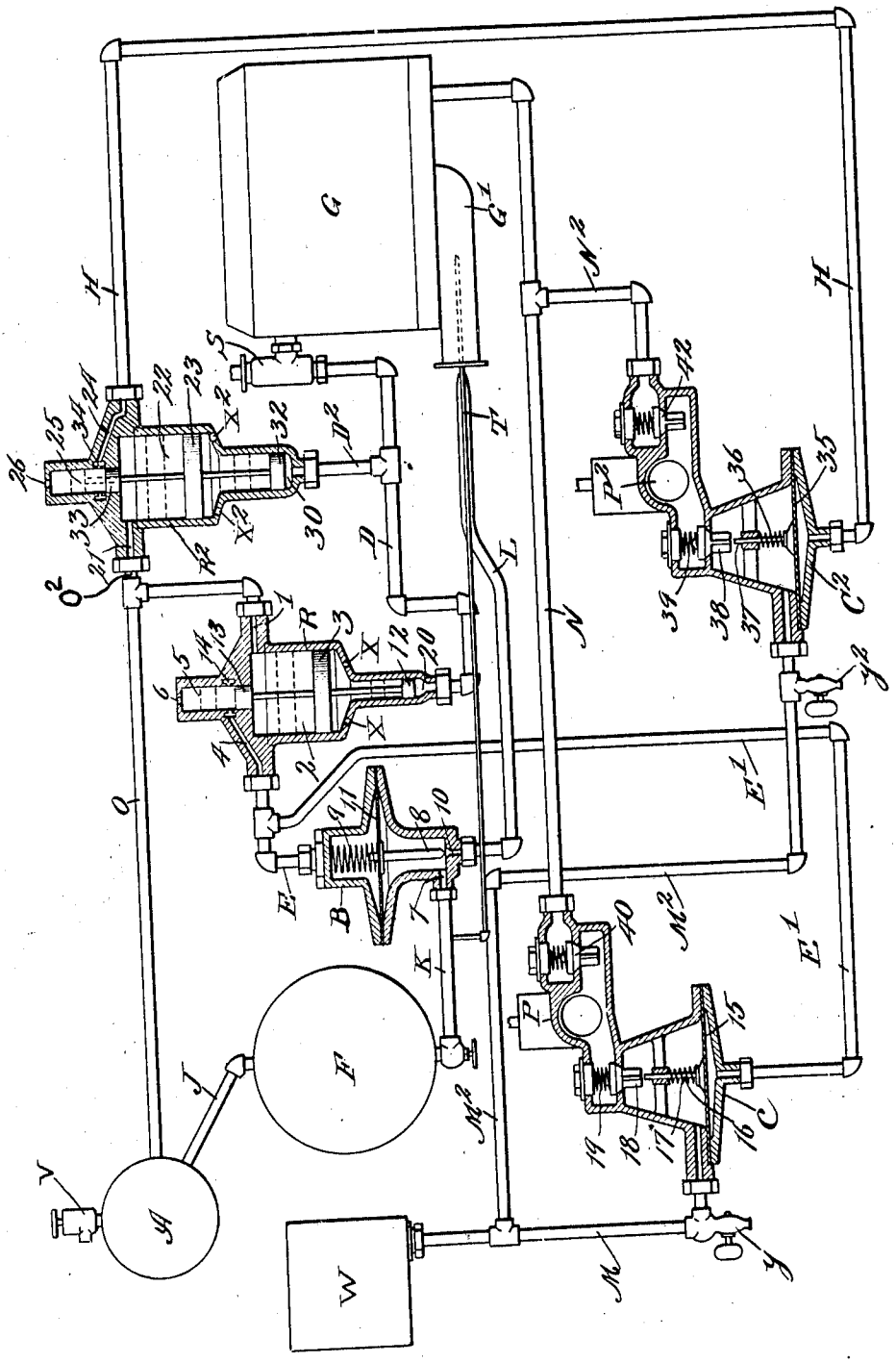

Witnesses:

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UNITED STATES PATENT OFFICE.

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FEEDER FOR STEAM BOILERS OR GENERATORS.

1,026,191. Specification of Letters Patent. Patented May 14, 1912.

Application filed January 27, 1909. Serial No. 474,581.

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Dunnfield, in the county of Warren and State of New Jersey, have invented a certain new and useful Improvement in Feeders for Steam Boilers or Generators, of which the following is a full, clear, and exact specification, reference being had to the accompanying drawings.

The object of the invention is to provide an improved apparatus which shall automatically control the supply of an additional amount of feed water to the generator or boiler at such times as the boiler is required to furnish more steam than can be produced from the water ordinarily supplied to it.

In the regular operation of a steam motor carriage it will frequently occur as in climbing heavy grades that the engine is called upon to supply a much greater amount of power than is ordinarily required. This invention is especially adapted for automatically supplying to the boiler of a steam motor carriage, the increased amount of water required to produce the additional supply of steam necessary for the operation of the engine at such times.

The invention is in the nature of an improvement on the invention which forms the subject matter of my co-pending application Serial No. 474580, filed January 27, 1909, and consists in the construction and combination of parts hereinafter described, and pointed out definitely in the claims.

In the drawing, the figure shows a diagrammatic view with some of the parts in section of the arrangement of this improved apparatus, the various parts of which may be placed in horizontal or vertical or any other convenient positions.

Referring to the parts by letters, and in the present exemplification of the invention: A represents an air tank in which any desired pressure is maintained, either by the operation of an air pump driven by hand or by power, or by other well known or convenient means. F represents a fuel supply tank for containing gasolene, kerosene or other liquid fuels. W represents a water tank for containing the supply of water. G represents a steam generator, preferably of the flash type for evaporating the water and supplying the steam, the generator being provided with any suitable form of burner G′ consuming liquid fuel. A pilot tube T may also be provided for lighting the burner and which may preferably receive its supply from the same source as the burner G′. R represents a regulator for regulating the supply of water and fuel to the generator G. B represents a fuel controller for governing the admission of fuel to the burner of the generator G. P represents a feed pump driven by power or any convenient means for forcing the supply of water into the generator G. The feed pump is constructed in combination with a controller or governor located at the base of the suction chamber of the pump, and which has communication with the suction chamber. C designates generally the water controller governing the suction valve of the feed pump P. Water is supplied to the feed pump P through the pipe M, leading from the supply tank and entering the suction chamber of the pump at its lowest point and below the diaphragm 15 and said chamber may be drained on one side of the diaphragm through a suitable drain cock Y. The feed pump P is connected to the generator G by the pipe N. The regulator R is connected to the generator G by the steam pipe D, and also to the fuel controller B by an air pipe E and to the water controller C by the air pipe E′. Air is admitted to the fuel supply tank F from the tank A by means of the pipe J thus maintaining the same pressure in the fuel supply tank as in the air tank A. Fuel is admitted to the generator G from the tank F, through the pipes K and L between which pipes is located the fuel controller B and with which both pipes have communication; the pipe L being controlled by the fuel controller B through the medium of the valve 8. The operation of this portion of the apparatus is as follows: Any desired pressure may be maintained in the air tank A. For general purposes a pressure of fifty pounds per square inch will be found to be ample. The pressure from the air tank A is carried through the pipe O to the regulator R, where it is admitted by the port 1 to the cylinder 2. Communicating with the cylinder 2 is a cylinder 5 having a port 6 through which the latter cylinder has communication with the atmosphere. Arranged preferably in the wall of the cylinder 5, beyond the cylinder 2 is an annular chamber 14 which has communication with the cyl-

inder 5 and also with the port 4. A piston 13 is arranged within the cylinder 5 and is connected to move with the piston 3. The annular chamber 14 and the port 4 are so located with respect to the cylinder 2 that when the piston 3 is moved in one direction the piston 13 is adapted to assume a position between the cylinder 2 and the chamber 14 to cut off communication between the chamber and the cylinder 5 (as shown in full lines in the drawing). When the piston 3 is moved in the opposite direction, the piston 13 is adapted to assume a position between the chamber 14 and the port 6 to prevent the escape of air to the atmosphere through the port and to reëstablish communication between the chamber 14 and the cylinder 2 (as shown in dotted lines in the drawing). The cylinder 2 is provided with ports X—X on the side of the piston opposite to the side on which the cylinder 5 is located whereby said cylinder 2 will always have communication with the atmosphere so as not to retard the movement of the piston 3. The pressure from the air tank A is carried also to the fuel supply tank F through the pipe J forcing the gasolene or other fluid fuel under like pressure to the fuel controller B on one side of the diaphragm 11 through the pipe K and the port 7. A valve 8 in the fuel controller B is normally seated by the spring 9, closing the port 10 to the pipe L but when fuel under pressure is admitted through pipe K and port 7, the pressure operating on the diaphragm 11 to which the valve is connected, overcomes the action of the spring 9 and unseats the valve 8 to admit fuel to the burner of the generator G through the port 10 and pipe L. When the fuel is ignited in the combustion chamber in the generator G, which may be accomplished by the pilot tube or burner T, the water in the generator is heated and evaporated, producing steam under pressure. This steam pressure is at all times admitted through the pipe D to the cylinder 20 in the regulator R and operates on the piston 12, which latter is connected to and moves with the pistons 3 and 13. The relative areas of piston 12 and piston 3 are so proportioned that at any predetermined relation between the steam pressure in the cylinder 20 and the air pressure in the cylinder 2, the total pressure on the two pistons 12 and 3 practically balance each other. When the steam pressure in the generator G rises above the normal amount required to maintain this balance, the pressure in the cylinder 20 forces the piston 12 in one direction, carrying with it the piston 3 against the air pressure in the cylinder 2, and moving the piston 13 to a position to close the communication between the port 4 and the atmosphere through the cylinder 5 and the port 6. This movement of the piston 13 brings the annular chamber 14 at the same time into communication with cylinder 2 and the air pressure from port 1 of cylinder 2, is then admitted into the fuel controller B through pipe E on the other side of the diaphragm to balance the fuel pressure on the diaphragm 11. When the fuel pressure is thus balanced the spring 9 then forces the valve 8 to its seat, closing the port 10 and automatically cutting off the supply of fuel to the heater of the generator G.

Any suitable means may be provided for rendering the feed pump inoperative but a simple and effective means for accomplishing this end will now be described.

Simultaneously with the stoppage of the supply of fuel to the heater of the generator G the air pressure is admitted to the one end of the water controller C through the pipe E′ and on one side of the diaphragm 15 therein. The diaphragm 15 in the water controller C is normally held in an inoperative position by the spring 16, but when the air pressure is admitted to the water controller C back of the diaphragm, the air pressure acting on the diaphragm 15 overcomes the spring 16 and forces the rod 17 which is connected to be operated by the diaphragm, into engagement with a suction valve 18 in the feed pump P to unseat the valve and render the pump inoperative, thereby stopping the supply of water to the generator G. When the generator G is thus deprived of its supply of fuel and water, the steam pressure therein will gradually be reduced with more or less rapidity, depending upon the demand. When the steam pressure falls below the amount required to maintain on the piston 12 in the regulator R a balance with the air pressure on the piston 3, the pistons 3 and 12 will be moved or shifted by the air pressure against the steam pressure, and the piston 13 will be carried beyond the annular chamber 14 to the position shown in full lines in the drawing. The port 4 will be thus again placed in communication with the atmosphere through the cylinder 5 and the port 6 and one side of the diaphragm 11 in the fuel controller B will be relieved of the air pressure which latter escapes through the pipe E and the port 4. The pressure of the fuel on the other side of the diaphragm 11 then overcomes the action of the spring 9, which seats the valve 8 thereby compressing the spring to raise the valve 8, to again admit a supply of fuel through the port 10 and the pipe L to the burner of the generator G where it is ignited by the pilot burner T, maintained constantly lighted for that purpose. Simultaneously one side of the diaphragm 15 in the water controller C will be relieved of the air pressure, which latter escapes through the pipe E′, and ports 4 and 6. The spring

16 then forces the rod 17 out of engagement with the suction valve 18 allowing the latter to be seated by the action of the controlling spring 19 permitting the feed pump P to again become operative and supply water to the generator G. An ordinary check valve 40 is provided in the pump P.

From the above it will be seen that the regulator R automatically maintains practically a constant steam pressure in the generator G, the relation between the amount of air pressure in the air tank A and the amount of steam pressure in the generator G being determined by the proportional areas of the piston 3 and the piston 12 in the regulator R, a slight variation in the steam pressure carried in the generator G up or down being sufficient to automatically operate the mechanism and reëstablish the normal steam pressure. It will also be seen that the normal pressure to be maintained in the generator G may be varied at the will of the operator by adjusting the safety valve V on the air tank A, any change in the amount of pressure carried in the air tank A automatically effecting a relative change in the amount of steam pressure carried in the generator G. There are occasions, however, in the ordinary use of a steam carriage as in ascending heavy grades, etc., when it becomes necessary for the engine to supply an increased amount of power. At such times the speed of the engine is gradually reduced and as the feed pump is ordinarily driven by the engine, the speed of the feed pump is also reduced with the result that the amount of water supplied to the generator is decreased in like proportion. At such times it is desirable that an increased supply of water shall at once and automatically be supplied to the generator G. In order to accomplish this result there is provided a second regulator R^2, which is similar in construction to the regulator R, and is adapted to regulate the supply of the additional water to the generator G. This regulator R^2 comprises a cylinder 22, in which moves a piston 23. A cylinder 25 similar in construction to the cylinder 5, is arranged to communicate with the cylinder 22, and a piston 33 moves within the cylinder 25 and is connected for movement with the piston 23. The cylinder 25 is provided with an outlet 26 to the atmosphere, and an annular chamber 34 which has communication with the cylinder 25. This annular chamber 34 is located beyond the cylinder 22, so that the piston 33 may assume a position (as shown in full lines in the drawing) to stand between the cylinder 22 and the chamber 34, to cut off communication between the chamber 34 and the cylinder 22, and establish communication with the chamber and the cylinder 25. The piston 33 is also adapted to assume the position shown in dotted lines so as to reëstablish communication between the chamber 34 and the cylinder 22 and to cut off communication between the chamber 34 and the atmosphere through the port 26. The cylinder 22 is also provided with an inlet port 21, corresponding with the port 1 of the regulator R, and which port 21 has communication with the supply pipes O, and O^2. A port 24 is also provided in the regulator R^2, which is similar to the port 4 of the regulator R, and has communication with the chamber 34 and the pipe H, which latter pipe also has communication with the water controller C^2 of the pump P^2.

Communicating with the cylinder 22 and on the side of the piston 23 opposite to that on which the cylinder 25 is located, is a cylinder 30, similar to the cylinder 20 of the regulator R, but is preferably slightly larger than the cylinder 20, so that the piston 32 which moves in the cylinder 30 will be of about ten per cent. greater area than the piston 12. This piston 32 is connected to move with the piston 23, so that when one of the pistons is moved all three of the pistons 33, 23 and 32 are simultaneously moved. The cylinder 30 has communication with the steam supply pipe D, which supplies the cylinder 20, through the medium of a connection D^2, and as the piston 32 of the regulator R^2 is of a larger area than the piston 12 of the regulator R, a greater pressure will be required to move the piston 12 than to move the piston 32, as will be hereinafter set forth.

The feed pump P^2 is of the ordinary construction, preferably of the same construction as the pump P, and may be operated in any desired or suitable manner for forcing the supply of additional water to the generator G through the pipe N^2, and into the pipe N.

The water controller C^2 for the extra supply is of a construction similar to the controller C, and is provided with a diaphragm 35, connected to which is a rod 37, which rod is adapted to be moved by the diaphragm in one direction to engage a suction valve 38 and unseat the same against the tension of a controlling spring 39, as will be set forth. A check valve 42, similar to the check valve 40, may be provided within the pump P^2. The pressure from the air tank A is carried through the pipes O and O^2 to the regulator R^2 where it is admitted by the port 21 to the cylinder 22 moving the pistons 23 and 33 to open the port 24, through the annular chamber 34 to the atmosphere through the cylinder 25 and the port 26. The cylinder 22 on the side of the piston 23 opposite to the side on which the cylinder 25 is located is open to the atmosphere at all times through the ports X^2 in order that the movement of the piston 23 will not be retarded.

When the fuel is ignited in the combustion chamber in the generator G, the water in the generator is heated and evaporated producing steam under pressure. This steam pressure is at all times admitted through the pipes D and D^2 to the cylinder 30, in the regulator R^2 and operates on the piston 32 to move the pistons 23 and 33 in one direction. The relative areas of piston 32 and piston 23 are so proportioned that at any predetermined relation between the steam pressure in the cylinder 30 and the air pressure in the cylinder 22, the total pressure on the two pistons 32 and 23 practically balance each other. When the steam pressure in the generator G rises above the normal amount required to maintain this balance, the pressure in the cylinder 30 moves the piston 32, carrying with it the piston 23 against the air pressure in the cylinder 22 and moving the piston 33 to a position beyond the annular chamber 34 to the position shown in dotted lines in the drawing, thus closing the communication between the port 24 and the atmosphere, through the cylinder 25 and the port 26. The annular chamber 34 is at the same time brought in communication with cylinder 22 and the air pressure from port 21 of the cylinder 22 is then admitted to the water controller C^2 through the pipe H to act upon the diaphragm 35 therein. This diaphragm 35 is normally held in an inoperative position by the spring 36, but when the air pressure is admitted into the water controller C^2, it will act upon the diaphragm 35 to overcome the spring 36 and force the rod 37 into engagement with the suction valve 38 in the feed pump P^2 to unseat the same against the tension of the spring 39 to render the pump inoperative, in which condition it remains as long as the feed pump P is able to supply sufficient water to the generator G to produce all the steam required for the operation of the engine. When, however, the steam pressure in the generator G falls below the amount required to maintain on the piston 32 in the regulator R^2 a balance with the air pressure on the piston 23, the piston 23 and the piston 32 will be shifted by the air pressure against the steam pressure and the piston 33 will be carried beyond the annular chamber 34 to the position shown in full lines in the drawing. The port 24 is thus again placed in communication with the atmosphere through the cylinder 25 and the port 26. The diaphragm 35 in the water controller C^2 will then be relieved of the air pressure which escapes through the pipe H and the ports 24 and 26. The spring 36 then acts upon the rod 37 to move the same out of engagement with the valve 38 to permit the latter to be seated by the action of the spring 39 and the feed pump P^2 becomes operative and supplies water to the generator G. This control of the operation of the feed pump P^2 by the regulator R^2 is in all respects similar to the control of the operation of the feed pump P by the regulator R, but in order to maintain the feed pump P^2 normally in an inoperative condition and to insure that it shall be brought into operation at such times only as the amount of water supplied to the generator G by the feed pump P is not sufficient to produce the amount of steam required by the engine, the cylinder 30 and the piston 32 in the regulator R^2 are made with a diameter about five per cent. greater than the diameter of the cylinder 20 and the piston 12 in the regulator R, although of course this proportion may be varied as desired; all other parts and dimensions in the two regulators being made alike and interchangeable.

The operation of the apparatus is as follows: As shown above, when the steam pressure in the cylinder 30 in regulator R^2 rises above the amount required to maintain the balance on the piston 32 with the air pressure on the piston 23, the pistons 32 and 23 are shifted in a direction to move the piston 33 to a position to admit the air pressure to the water controller C^2 through the pipe H. The diaphragm 35 then shifts the rod 37 to open the suction valve 38 and render the feed pump P^2 inoperative. As, however, the area of the piston 12 in the regulator R is about ten per cent. less than the area of piston 32 in the regulator R^2 a higher steam pressure is required on the piston 12 in the regulator R to overcome the air pressure on piston 3 than is necessary on piston 32 in the regulator R^2 to overcome the air pressure on piston 23 and consequently the suction valve 18 in the feed pump P is not moved from its normal position, but is free to operate, and the feed pump P therefore continues to supply water to the generator G. For as long a time as the water supplied by the feed pump P to the generator G is sufficient to produce all the steam required by the engine, the steam pressure on the piston 32 in the regulator R^2 will be maintained at a point sufficient to overcome the air pressure on piston 23 and as before described the air pressure will then continue to be admitted through the pipe H to the diaphragm 35 in the water controller C^2 and the rod 37 will thus be held in a position to keep the suction valve 38 constantly from its seat to maintain the feed pump P^2 inoperative. When, however, the amount of water supplied by the feed pump P is insufficient to produce the amount of steam required for the operation of the engine, the steam pressure will gradually fall until it reaches a point when the air pressure on the piston 23 in the regulator R^2 overcomes the steam pressure on the piston 32. The piston 32 is then forced in

a direction to move the piston 33 beyond the annular chamber 34 to the position shown in full lines in the drawing. The diaphragm 35 in the water controller C^2 is thus relieved of the air pressure which escapes through the pipe H. The suction valve 38 in the feed pump P^2 is then again seated by the spring 39 and the feed pump P^2 commences to supply the additional water to the generator G.

The two feed pumps P and P^2 are made of such capacity that the amount of water supplied to the generator G when both pumps are in operation will produce more steam than can be used in the engine when working at its full power. Consequently whenever both pumps are delivering water to the generator G the steam pressure in the generator will gradually rise until it reaches a point where, through the operation of regulator R^2 as before described, the feed pump P^2 is rendered inoperative and remains so until more steam is required to operate the car than can be produced from the water supplied by the feed pump P. The feed pump P^2 as has been before described, is then again brought into operation by the regulator R^2 which thus automatically controls the feed pump P^2 placing it in operation whenever additional water is required and rendering it inoperative whenever the feed pump P is able to supply all the water required. The burner of the generator G supplies sufficient heat to evaporate such a proportion of the feed water when both pumps are in operation as to meet the maximum demand of the engine and at the same time to gradually increase the steam pressure to a point where the regulator R^2 is brought into operation and cuts out the pump P^2 in the manner described.

While in the present exemplification of the invention there is shown and described the preferred manner for automatically and simultaneously controlling the fuel and water supply, it is to be understood that various changes may be made in the construction, operation and arrangement of the several parts without departing from the spirit of this invention.

What I claim as new is:

1. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of regulators for controlling said fluid feed, a fuel feed, means whereby one of the said regulators will control the fuel feed, said regulators having communication with the generator, and means whereby the regulators will be actuated with respect to each other by different degrees of pressure in the generator.

2. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, said regulators being adapted to be acted upon by the generator pressure, and means whereby each of the regulators will be actuated by a degree of pressure different from the degree of pressure necessary to actuate the other regulators.

3. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of pumps for such feed, a regulator for each of said pumps for controlling the supply of fluid from the respective pumps, a fuel feed, and means whereby one of the said regulators will control such fuel feed.

4. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling the fluid feeds, each provided with means whereby the regulators will be actuated by the pressure from the generator, but respectively at different predetermined pressures, one of said regulators acting to control the fuel feed and part of the fluid feed and the other regulator acting to control an additional fluid feed.

5. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators, means whereby the regulators will control the fluid feed, means whereby one of the regulators will control the fuel feed, means whereby the pressure in the generator will act upon all the regulators, means for exerting an opposing pressure on all of the regulators, said regulators being actuated with respect to each other by different degrees of pressure in the generator, and means whereby the said opposing pressure on the regulators may be varied.

6. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, means whereby said regulators will be acted upon by the generator pressure, means for exerting air pressure upon said regulators, means whereby one of the regulators will start and stop all of the fuel and part of the fluid feed simultaneously when a predetermined pressure in the generator is reached, and means whereby the other regulator will control an additional feed of fluid when a different predetermined pressure is obtained.

7. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, means whereby said regulators will be acted upon by the generator pressure, means for exerting air pressure upon said

regulators, means whereby one of the regulators will start and stop all of the fuel and part of the fluid feed simultaneously when a predetermined pressure in the generator is reached, and means whereby the other regulator will control an additional feed of fluid when a different predetermined pressure is obtained, each of said predetermined pressure being varied by variation in the said air pressure.

8. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, means whereby the generator pressure will act upon the regulators, means for exerting an opposing air pressure on the regulators, and means whereby each of the regulators will become operative at a generator pressure differing from that necessary to operate the other regulators.

9. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, means whereby the generator pressure will act upon the regulators, means for exerting an opposing air pressure on the regulators, means whereby each of the regulators will become operative at a generator pressure differing from that necessary to operate the other regulators, and means whereby the operative pressure of each regulator may be changed by altering the air pressure while permitting their relative operative pressures to remain unchanged.

10. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of regulators for controlling said feed, a fuel feed, means whereby one of the regulators will control the fuel feed, means whereby the pressure from the generator will control the regulators, and means whereby all of the fuel feed and a portion of the fluid feed will be supplied to the generator at a predetermined pressure upon one of the regulators, and the remainder of the fluid feed at a lower pressure upon the other regulator.

11. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, means for withholding each of the feeds from the generator, a plurality of regulators for controlling said withholding means, means whereby the generator pressure will actuate the regulators, means whereby one of the regulators will withhold from the generator a portion of the fluid feed at a lower generator pressure, and means whereby the remainder of the fluid feed and all of the fuel will be withheld from the generator by the other regulators at a higher generator pressure.

12. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, means for withholding each of the feeds from the generator, a plurality of regulators for controlling said withholding means, means whereby the generator pressure will actuate the regulators, means whereby one of the regulators will withhold from the generator a portion of the fluid feed at a low generator pressure, and means whereby the remainder of the fluid feed and all of the fuel will be simultaneously withheld from the generator by the other regulators at a higher generator pressure.

13. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, each of said regulators including a movable element, means whereby the generator pressure will act upon each of the said movable elements, and means for exerting an air pressure on said elements in opposition to said generator pressure, the area of the said movable elements exposed to the said opposing pressures differing in each of said regulators.

14. In an apparatus of the character described, the combination with a generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, each of said regulators including a movable element, means whereby the generator pressure will act upon said elements, said movable elements having areas of fixed relative proportions acted upon by the said pressure a source of gaseous pressure, and means whereby said gaseous pressure will also act upon the movable elements and in opposition to the generator pressure, the said relative proportions of areas of the movable elements in each regulator differing respectively from each other.

15. In an apparatus of the character described, the combination with a generator, of a fluid feed, a fuel feed, a plurality of regulators for controlling said feeds, each of said regulators including a movable element, means whereby the generator pressure will act upon said elements, said movable elements having areas of fixed relative proportions acted upon by the said pressure, a source of gaseous pressure, and means whereby said gaseous pressure will also act upon the movable elements and in opposition to the generator pressure, the said relative proportions of areas of the movable elements in each regulator differing from each other, each of said regulators actuating to diminish or increase the fluid supply at a point in the generator pressure different from the pressure at which the other regulators act.

16. In an apparatus of the character de-

scribed, the combination with a vapor generator, of a fluid feed, a pump for supplying the fluid to the generator, said pump being provided with a chamber having an outlet, a valve for the outlet, a diaphragm in the chamber, means operatively related to the diaphragm for unseating the valve, said chamber having a fluid supply inlet on one side of the diaphragm, a fuel feed, a valve for controlling said feed, a regulator for controlling the last said valve, a source of supply of gaseous pressure operating on said regulator, means for exerting pressure upon the regulator to actuate the same against the first recited pressure, and means whereby the actuation of said regulator will permit the first recited pressure thereon to intermittently act upon the said diaphragm in the pump chamber.

17. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of regulators, and means whereby each of said regulators will control a portion of the said feed.

18. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of pumps for such feed, a regulator for each of said pumps, and means whereby the regulators may be controlled by the vapor pressure in the generator, said regulators being actuated with respect to each other by different degrees of pressure.

19. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of pumps for such feed, a regulator for each of said pumps, and means whereby the regulators will be actuated with respect to each other by different degrees of pressure in the generator, whereby the supply of fluid will be automatically increased or decreased respectively as the pressure in the generator decreases or increases.

20. In an apparatus of the character described, the combination with a vapor generator, of a plurality of pumps for supplying a fluid feed, and means controlled by the pressure in the generator whereby the supply of fluid will be automatically increased or decreased respectively as the pressure in the generator decreases or increases, said means including a plurality of regulators having areas of fixed relative proportions acted upon by the pressure from the generator.

21. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of regulators for controlling said feed, means whereby the pressure from the generator will control the regulators, and means whereby a portion of the feed will be supplied to the generator at a predetermined pressure upon one of the regulators and the remainder of the feed will be supplied at a lower pressure upon the other regulators.

22. In an apparatus of the character described, the combination with a generator, of a fluid feed, a plurality of regulators for controlling the fluid feed, means whereby the regulators will be acted upon by the vapor pressure in the generator, means for exerting an opposing pressure upon the regulators, means whereby the regulators will be actuated with respect to each other by different degrees of pressure in the generator, and means whereby the said opposing pressure may be varied whereby the pressure at which each regulator will be actuated will be proportionately changed without varying the relative degree of the actuating generator pressure on the respective regulators.

23. In an apparatus of the character described, the combination with a vapor generator, of a plurality of pumps for supplying to the generator the fluid to be vaporized, said pumps successively furnishing a portion of the maximum fluid feed to the generator, a source of compressed air supply, and means whereby the time at which said portions are supplied may be varied by altering the pressure in the said air supply.

24. In an apparatus of the character described, the combination with a vapor generator, of a pump provided with a chamber, said chamber having an outlet, a valve for the outlet, a diaphragm in the chamber for unseating the valve, a fluid supply pipe having communication with the said chamber between the valve and diaphragm, a regulator, means whereby the generator pressure will act upon the regulator, means for causing an opposing pressure to act upon the regulator, means whereby the action of the regulator will permit the said opposing pressure to actuate the said diaphragm in the pump chamber, and means whereby the point at which the pressure in the generator actuating the regulator may be varied by varying the amount of the said opposing pressure on the regulator.

25. In an apparatus of the character described, the combination with a vapor generator, of a pump provided with a chamber, said chamber having an outlet, a valve for the outlet, a diaphragm in the chamber for unseating the valve, a fluid supply pipe having communication with the said chamber between the valve and diaphragm, a regulator, means whereby the generator pressure will act upon the regulator, means for causing an opposing pressure to act upon the regulator, means whereby the action of the regulator will permit the said opposing pressure to actuate the said diaphragm in the pump chamber, means whereby the point at which the pressure in the

generator actuating the regulator may be varied by varying the amount of the said opposing pressure on the regulator, and means whereby the fluid may be drained from the surface of the diaphragm through the said supply pipe.

26. In an apparatus of the character described, the combination with a vapor generator, of a fluid feed, a plurality of pumps for such feed, a regulator for each of said pumps, and means whereby the regulators will be actuated with respect to each other by different degrees of pressure in the generator, whereby the supply of fluid will be automatically increased or decreased respectively as the pressure in the generator decreases or increases, each of said regulators actuating to diminish or increase the fluid supply at a point in the generator pressure different from the pressure at which the other regulators act.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, on this seventh day of January, A. D. 1909.

CHAS. C. WORTHINGTON.

Witnesses:
M. R. WORTHINGTON,
C. W. COLLIERE.