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SUPPLY SYSTEM FOR BOILERS.

APPLICATION FILED MAY 7, 1902.

1,011,213.

Patented Dec. 12, 1911.

3 SHEETS—SHEET 1.

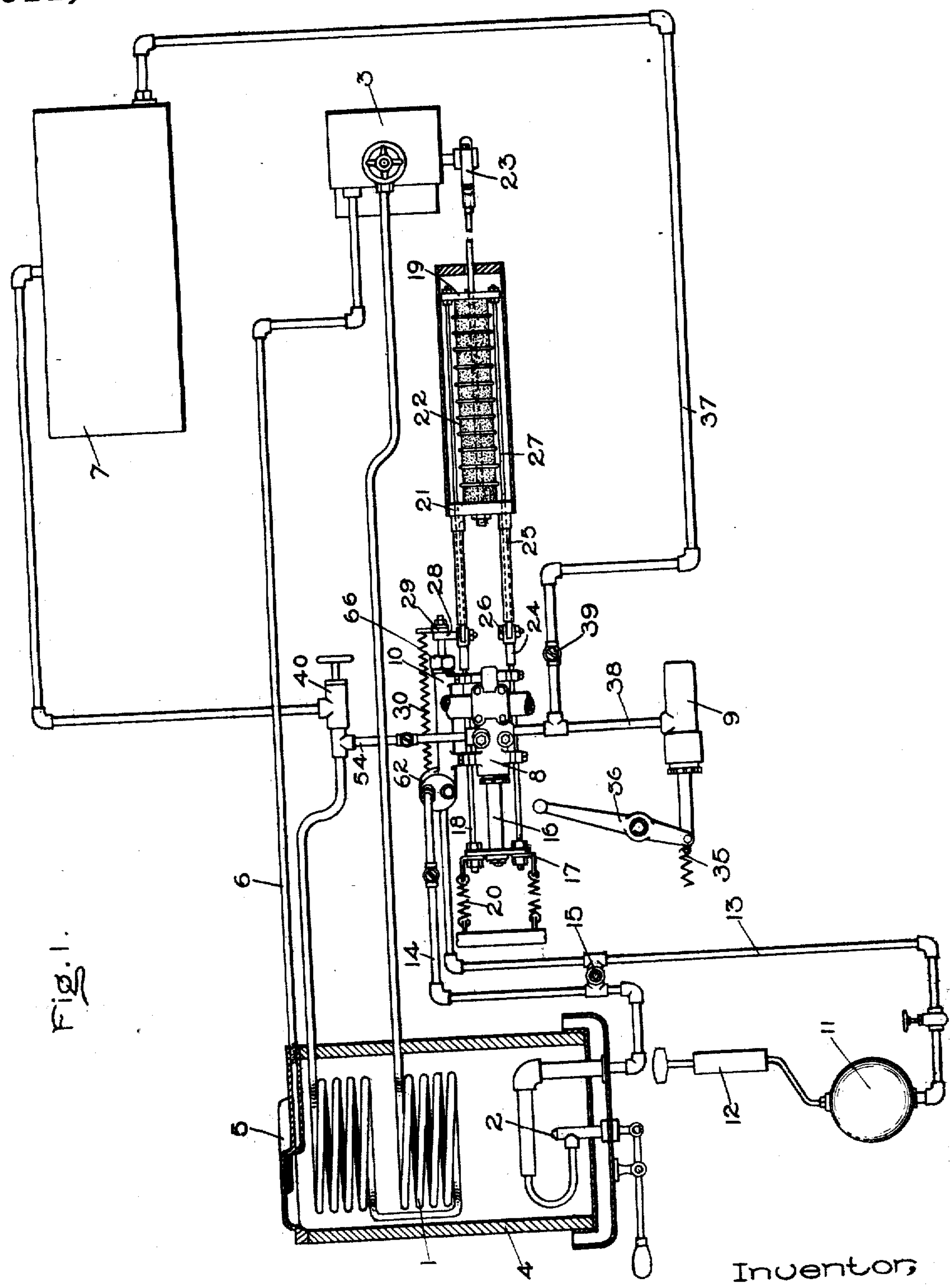

Fig. 1.

Witnesses:

Robt C. Chapman

Alex F. Macdonald

Inventor,
Hermann Lemp,
By Albert G. Davis
Att'y.

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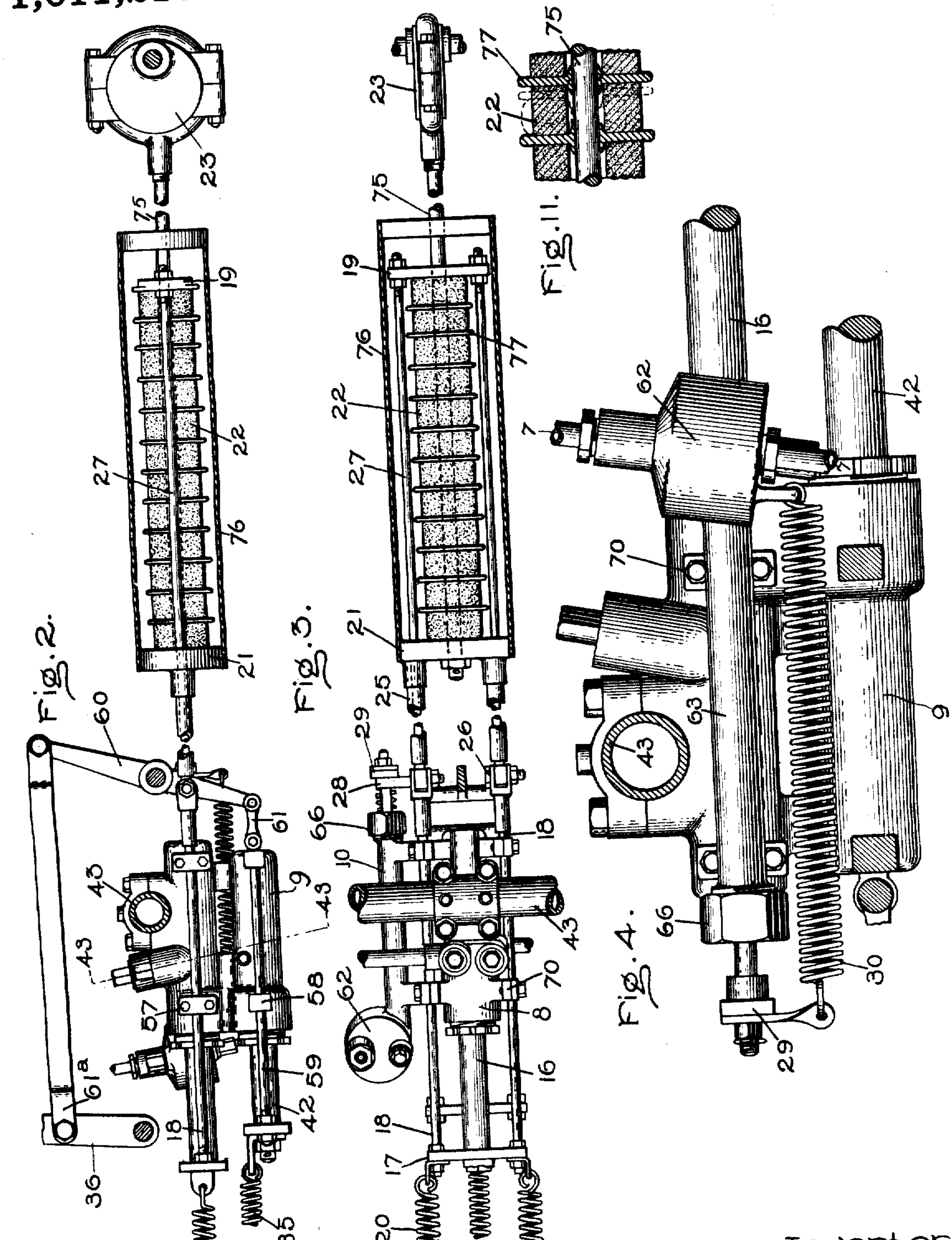

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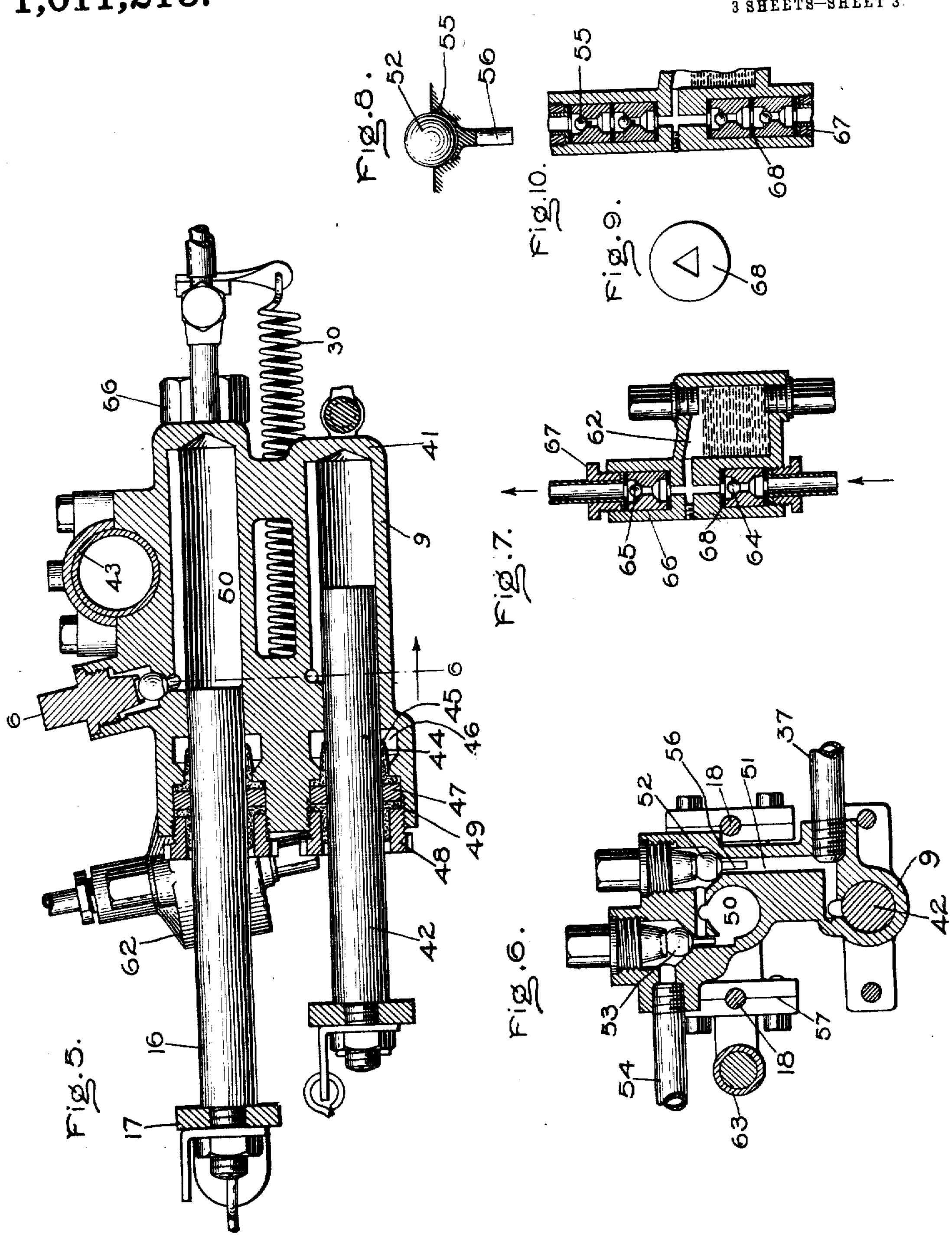

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Att'y.

UNITED STATES PATENT OFFICE.

HERMANN LEMP, OF LYNN, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SUPPLY SYSTEM FOR BOILERS.

1,011,213. Specification of Letters Patent. Patented Dec. 12, 1911.

Application filed May 7, 1902. Serial No. 106,235.

To all whom it may concern:

Be it known that I, HERMANN LEMP, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Supply Systems for Boilers, of which the following is a specification.

It is desirable for systems using flash boilers and hydrocarbon burners to supply the water and fuel in proportionate amounts for ordinary conditions of service, and to provide means whereby under abnormal conditions the supply of fuel can be automatically altered with respect to the water supply; in other words, there are times when the demand for fuel is relatively lesser or greater with respect to the water supply than it is at other times. It is also desirable to provide a manually-actuated water pump whereby an initial pressure may be imparted to the water supplied to the flash boiler.

The present invention has for its object to provide a combined fuel and water pump which is capable of supplying fuel to the burner and water to the boiler in proportionate amounts for normal operation, and which is also capable of automatically varying the relation between the amounts of fuel and water supplied to the burner and boiler respectively, to compensate for the varying or abnormal conditions of service.

For a fuller description of what I consider to be novel and my invention, attention is called to the accompanying description, and the drawings.

Referring to the drawings, Figure 1 is a diagrammatic view of a flash boiler system operating with hydrocarbon fuel, which system is provided with my improved pumps; Fig. 2 is a side elevation of the pumps, together with the actuating device; Fig. 3 is a plan view thereof; Fig. 4 is an enlarged view of the pumps in side elevation; Fig. 5 is a longitudinal section showing the power and manually-actuated water pumps; Fig. 6 is a transverse section taken on lines 6 6 of Fig. 5; Fig. 7 is a sectional view taken on line 7 7 of Fig. 4; Fig. 8 is a detail view of one of the check valves; Fig. 9 is a detail plan view of one of the disks for regulating the movement of the ball valves; Fig. 10 is a slight modification of the valve mechanism of Fig. 7, wherein two valves are arranged in series; and Fig. 11 is a partial sectional view of the rubber buffers and partitions on the eccentric rod forming part of the driving means for the pumps.

Referring to Fig. 1, 1 represents a flash boiler of any suitable construction, heated by the hydrocarbon burner 2, and supplying steam to the engine 3. The burner and boiler are surrounded by a casing 4, which may be of any suitable construction. The top of the boiler is provided with a cover 5 having a suitable chamber to receive the exhaust steam, which latter passes from the engine by the pipe 6. The construction of the chamber and the arrangement of the passage for the exhaust steam is described in a prior application, Serial No. 35,245, filed Nov. 2, 1900, and is therefore not claimed herein. Water is supplied to the boiler from the tank 7, by means of two pumps 8 and 9. In practice, the pump 9 is mounted directly underneath the pump 8, but for the purpose of illustration it is shown as being detached. Mounted on the side of the casing of the water pump is a fuel pump 10, which pump receives its supply of fuel from the tank 11. A hand pump 12 is employed to supply the tank 11 with an initial pressure which is or may be sufficient to heat the boiler when the machine is not running, etc. The fuel tank is connected with the fuel pump by the pipe 13, and the pump is connected with the burner by the pipe 14. Between the pipes leading to and from the pump is a by-pass and a valve 15, which may be operated automatically or by hand, the object of which is to supply fuel to the burner when the pump is not operating and to relieve the pressure on the burner at the time the system is shut down, such, for example, as when the system is mounted on a vehicle and the vehicle is brought to a standstill.

Under ordinary conditions of service the pressure on the tank 11 may run from atmospheric pressure to say ten pounds per square inch, but the pressure of the fluid delivered to the burner is considerably higher, such for example, as from 40 to 50 pounds. It would take considerable time for the fuel pressure to decrease, and to obviate this the valve 15 is placed in circuit as described. When the valve is opened the pump is shunted and the pressure on the burner due to the pump is relieved through the by-pass which permits fuel to pass back to the tank. This occupies only a short interval of time until the pressure on the burner becomes substantially that of the tank, whereupon the flow is reversed and the tank supplies the burner so as to maintain the flame in a banked condition. The by-pass valve is left open until the system is again started into operation when the valve is closed so that the fuel discharged by the pump will pass to the burner. The necessity of providing means to quickly relieve the pressure on the burner when the system is shut down, is due to the fact that the working pressure on the burner lags a certain time after the forced draft is stopped. As a result the natural draft does not supply sufficient air to enable the fuel discharged by the burner to burn completely and the flame is sooty and odorous.

The pumps are driven from the engine 3, either directly or indirectly. It is preferable, although not absolutely necessary, that the speed of the pumps bear a fixed relation to that of the engine. The water pump is provided with a piston 16, which is connected to a cross-head 17, and the latter is connected by side rods 18 with the cross-head 19. Between the cross-head 17 and a stationary abutment are extension springs 20, which tend at all times to return the pump piston to its outer position. Between the cross-heads 19 and 21 is a compression spring comprising a plurality of elastic buffers 22, which buffers are so arranged that when the pressure on the piston of the water pump exceeds a certain amount, more or less of the stroke of the eccentric 23, driven by the engine shaft, is taken up thereby. Mounted on the right-hand end of each of the side rods 18 is a head 24, which is connected by the pivot 26 to the rods 27, the latter being connected to the cross-head 19. The object in providing the pivoted connections 26 is to permit the cross-heads 19 and 21 and springs 22 to rise and fall under the action of the eccentric 23. It is to be noted that the side rods 18 have a reciprocating motion and are held in suitable guides. Mounted on an extension on one of the pivots is a projection or fork 28, which engages with a stop or head 29, formed on the end of the oil pump piston. This fork is capable of moving independently of the piston under certain conditions as will hereinafter appear. The head 29 is provided with a projection, and secured to this projection and to a stationary abutment on the pump casing is an extension spring 30, which constitutes a motor and is employed to actuate the fuel pump. The fork 28 pulls the piston out of the cylinder as the eccentric 23 revolves, and the extent of this withdrawing movement is controlled by the movement of the water pump, or in other words by the pressure on the water end of the flash boiler. The motor or spring 30 performs the actual operation of pumping, and the spring is so adjusted that when the pressure on the burner, due to any cause, exceeds a predetermined amount, as for example when it exceeds the amount the burner can handle efficiently, the fuel pump piston is permitted to shorten its stroke without regard to the total movement of the fork 28; that is to say, if the pressure on the burner is at or near its maximum, the spring 30 will be distended, and the fork 28, while it pulls the piston out to the limit of its movement on each stroke, is free to move toward the left independent thereof. By reason of the arrangement described the supply of fuel to the burner and water to the boiler is automatically controlled by the spring-actuated water pump, yet an additional compensating means is provided for the fuel pump whereby the pressure may be maintained at a predetermined maximum, even though the pressure of the water system is below the normal. In practice I prefer to set the valves of the fuel pump and so proportion its piston and stroke that it has a slight lead over the water pump.

The piston of the manually-actuated water pump 9 is moved in one direction by the extension spring 35, and in the opposite direction by the lever 36, which may be operated by hand or by the foot as is desired. This pump is connected to the water tank by the pipes 37 and 38, the latter also connecting it to the power pump, a suitable check-valve 39 being provided to prevent the water from working back into the supply tank on the discharge stroke of the piston. The power and manually-actuated pumps both receive their supply from the same pipe, and certain of the valves are common to both. When the pressure of the water supply exceeds a predetermined amount, the relief valve 40 will open and discharge the surplus water, or water and steam as the case may be, back into the tank 7.

Referring now to the detail construction of the pumps, Fig. 5, the water pump comprises a casing 41, in which are mounted the manually-actuated piston 42, and the power-actuated piston 16. The casing is adapted to be bolted to a frame, tube, or support 43, in any suitable manner, and when placed in position on a carriage is preferably tilted downward in order that the head of each piston may be lower than the cross-head. Referring to Fig. 2, when the pumps are mounted on the vehicle the line 43 43 assumes a vertical position.

Each of the pistons is provided with a packing wherein 44 represents a flanged sleeve having the cross-section of the cylindrical portion gradually decreasing in thickness toward the end, as is indicated at 45. The object in making this sleeve thin at the end is to make it closely hug the piston and prevent the fluid from escaping. Surrounding the end of this packing is a chamber 46, which becomes more or less filled with fluid, and whatever fluid is contained in this chamber tends to cause the sleeve to embrace the piston more closely. Situated back of the packing is a disk 47, and between the disk 47 and the adjustable nut 48 is a second packing comprising a cylinder 49, having a flanged end, which flange engages with the disk 47. Another feature of importance in connection with this packing is the fact that no matter how hard the nut 48 is screwed into place, it will not cause undue friction on the piston, and by reason of the peculiar construction of the end 45 of the packing there is no danger of the fluid escaping. This arrangement is particularly important where the pump is to be in the hands of relatively unskilled persons. The packings can be made in large quantities and sold as supplies, and may be readily inserted in place by the operator, or otherwise. I find it desirable to use the same kind of packing for all of the other pumps. Referring to Fig. 6, the arrangement of the valves will be apparent. 50 represents the cylinder for the piston 16, and 42 represents the piston of the manually-actuated water pump 9. Water is supplied to both of the pumps from the pipe 37. Formed in the casing of the pump is a passage 51, which is provided at its upper end with a check-valve 52. As the piston 42 is moved back and forth by the operator, water is received from the pipe 37, and passes through the passage 51, past the check-valves 52 and 53, into the delivery pipe 54, the latter being connected to the boiler. When the power-actuated pump is in operation, water is received from the pipe 37, as before, and on the suction stroke the check-valve 52 is raised, and on the delivery stroke this valve remains closed, while the valve 53 opens and permits the water to flow into the pipe 54.

It will be noted that the discharge valve 53 is common to both the power and the manually actuated water pumps.

The check-valves employed are of novel form and are shown in Fig. 8. I have found that it is a matter of great difficulty to provide check-valves for fluid pumps, particularly those employed on automobiles, which will not leak. The water used contains more or less impurities, and when a foreign substance lodges between the valve and its seat, the former will not close, causing more or less of a leak, which at times is sufficient to materially interfere with the operation of the system. I overcome this objection by providing a more or less conical seat 55, which is arranged to receive the valve 56. The valve resembles a tack in formation, in that it has a large head and a relatively small shank or stem. No effort is made to have the head make a close fit with the valve seat, since it is not depended upon to cause the closing of the passage. For this latter, dependence is placed upon a small, soft rubber ball above the stem 56. When the pressure is in such a direction that it tends to force the valve against its seat, the ball is distorted somewhat so that it will make a close fit with the tapered or conical valve seat 55. As soon as the pressure is relieved, the rubber, owing to its resiliency, will again assume its spherical form, and being very light is easily lifted due to the delivery stroke of the pump piston 42, or the suction stroke of the power pump piston 16. I have tried using a soft rubber ball without the support, but find that there is a tendency at high pressures for the ball to be forced into the passage beyond the seat, resulting in an injurious chafing of the rubber. The support 56 being relatively incompressible obviates this difficulty as it prevents the ball from being unduly distorted, and the wall forming the seat does not chafe it. The stem of the support serves to prevent the ball from moving from its proper position relative to the valve seat.

Referring to Fig. 2, it will be noted that the side rods 18 are mounted for reciprocating movement in the guides 57, which may readily be detached for the purpose of inspecting or repairing the pump. Formed on the lower portion of the pump casing are guides 58 for the side rods 59, the latter being employed to actuate the piston 42 of the manually-actuated water pump. The rods 59 are connected at the right-hand end, and in turn are connected to the lever 60, by means of the link 61. The lever 60 is connected to the lever 36 by means of the link 61ª.

With pumps employed for thin fluids, such as naphtha or kerosene, great difficulty is experienced in providing a good packing which will prevent the fluid from leaking, and yet not offer undue resistance to the movement of the piston. I overcome the objection to the above by utilizing a body of heavy viscous material, such as glycerin, which is contained in a reservoir 62, and arranging the pump in such a manner that the naphtha or kerosene does not enter the pump cylinder. The reservoir 62, Figs. 4, 5 and 7, is provided with one or more detachable screw-threaded plugs by means of which the reservoir can be filled or inspected. The reservoir should be nearly filled with the glycerin or other heavy viscous material and have a capacity equal to about one and one half times that of the cylinder. On the suction stroke of the pump piston the said fluid is drawn into the cylinder 63; this causes the suction valve 64 to rise, and the volume of fluid admitted is dependent upon the area and stroke of the piston. On the forward or delivery stroke of the pump the glycerin is forced back into the chamber, and the naphtha or kerosene drawn into the reservoir on the suction stroke is forced past the check-valve 65 into the burner. As previously stated, the pumps are preferably tilted downward so that the reservoir 62 represents the highest elevation. By using glycerin and arranging the parts as described, the thin fluid employed for fuel does not enter the pump cylinder, hence an ordinary soft packing which can be adjusted by the gland 66 may be used.

The valves which I employ on the fuel pump are also of novel construction. I may use the valves previously referred to when the viscous material in the reservoir is of such a nature that it does not affect the structure of the rubber, but where the contrary is the case I use metal balls 65 and conical metal seats. The casing is provided with two connecting valve chambers, namely, the suction chamber and discharge chamber, and mounted therein are cylindrical pieces 66, having corresponding faces at the top and bottom, and also corresponding conical valve seats to receive the valves. The object in making the ends of these pieces similar is so that they can be reversed in case one side becomes worn. This is important where the repair has to be made while on the road, or by a mechanic more or less unfamiliar with the details of construction. In making the change it is only necessary to remove the gland 67 and the disk 68, after which the valve seat may be reversed. Another important advantage in this construction lies in the fact that the number of valves in series may be increased by simply extending the casing forming the support. For example, in Fig. 7 the casing is just long enough to inclose one piece 66, while in Fig. 10 the casing has been increased slightly in length and two pieces 66 are mounted therein. It will be seen that a single retaining means such as a gland 67 is employed to hold all of the valves in place, and it is obvious that the number can be varied at will. This means that only a single joint is employed in tightening, that the parts are duplicates, and furthermore that no piping or connections have to be changed. It will be noted that the disk 68 is provided with a triangular opening. This opening is of such size and shape that the ball 65 in rising cannot choke the passage of the fluid nor can it be stuck in the open position. In Fig. 10 I have shown a slight modification of the valve construction in that two valves 55 are placed in series relation. This is true both of the suction and the delivery valves. The object in providing such an arrangement is to insure the proper admission and cutting off of the fluid supply at the end of each stroke. Where only one ball is employed, there is a chance that foreign matter will lodge between the valve and its seat, causing more or less leak, but the chance of both valves being held open at the same time by foreign matter or otherwise is very remote. I have shown two valves in series, but more can be employed if desired.

Referring to Figs. 3 and 4, the position of the fuel pump with respect to the water pump is clearly shown. The fuel pump is secured to the casing of the water pump by bolts 70, so that it is always maintained in perfect alinement therewith, yet it can readily be detached if it becomes necessary to make any repairs. The piston is provided with a projection or head 29, and secured thereto is a motor or spring 30, the opposite end of the spring being attached to a projection formed on the base of the reservoir 62. I use the term motor in connection with the spring because it is the direct means employed to force the fuel from the supply tank to the burner. The rods 18, which are connected to the power pump piston 16, carry with them a fork or projection 28 which engages with the head 29 and moves the piston outward to the extreme end of its stroke. When the back pressure on the burner exceeds a predetermined amount, the piston will stand at or near the outer end of its stroke, and when it is less the movement thereof will be dependent upon the movements of the fork 28, which is under the direct control of the water pressure. When the pressure on the burner decreases to such an extent that the tension on the spring 30 is sufficient to overcome it, the piston will begin to operate, and its stroke will be dependent upon said pressure, the fork 28 carrying it to the outer end of its stroke for each revolution of the eccentric.

Referring now to the spring-actuated means employed for driving the pumps (Figs. 2, 3 and 11), 21 represents a head which is secured to the tubes 25, the latter being arranged to slide on the rods 27. Extending from the cross-head 21 to the eccentric strap is a rod 75, which forms a rigid connection between them. The cross-head 19 is pivotally connected by rods 27, pivots 26 and rods 18 to the cross-head 17. Between the cross-heads 19 and 21 are a plurality of rubber buffers 22, and surrounding these buffers in a manner to protect them from dust and dirt is a casing 76. It will be observed that the head 19 is pivotally connected to the pump piston, while the head 21 is rigidly connected to the eccentric strap, and that the only connection between these heads is through the medium of the rubber buffers 22.

I have discovered that it is necessary to divide this spring into a plurality of sections instead of utilizing a single rubber buffer, or even two buffers, for the reason that when the rubber is more or less compressed it tends to buckle to a greater or less degree and cause chafing where it rubs on the rod 75. I have further discovered that partitions 77 should be placed between the sections so that they will not rub upon each other as the eccentric operates the pumps and as the position of the parts is changed. It is also desirable to make the bore of the rubber buffers somewhat larger than the diameter of the rod 75, and to provide the partitions 77 with tapered hub-like projections which engage with the said rod and move back and forth thereon under changes in pressure on the water side of the system. In dotted lines is shown the general shape which the buffers assume when under more or less compression. It will be noted that the material tends to expand both outwardly and inwardly, and for that reason the large central bore is necessary. By making the sections relatively short, I find that there is a tendency for the rubber to roll on the plates under compression as distinguished from the rubbing or frictional contact which exists where the parts are made larger. By reason of this construction the life of the parts is materially increased, and the cost of renewals is small.

Reference has been made in this specification to "abnormal conditions of operation" at which time the ratio between water and fuel supplies should be varied. This condition may arise from any one of a number of causes, the principal of which I consider to be as follows: Assuming that the system is on a vehicle and the latter is brought to a standstill, the water in the boiler will be converted into steam and may be discharged wholly or in part therefrom through a suitable relief device. The pressure in the burner is maintained at a point sufficient to keep the parts hot, consequently the boiler acts as a heat storage device. When the water is again pumped into the boiler, steam is formed owing to the retained heat in the boiler structure, and at this time the fuel supply should bear a decreased ratio with respect to the water over that required for normal operations. The reason for this is apparent when it is considered that the boiler is practically empty and the pump is required to do considerable work before steam in any quantity is produced. On the other hand the burner would be provided with an excessive amount of fuel if the fuel pump delivered an amount of fuel in proportion to the water. Again, the vehicle may be in operation and the water supply fail for some reason, such as a broken pipe, a leaking valve, lack of water, etc. Experience has demonstrated that if the water supply fails wholly or virtually and the fuel service is unmodified, then flames will shoot out at the rear of the vehicle, or wherever the boiler and burner are located. From the foregoing it is evident that a means must be provided to supply water and fuel in definite ratio to the boiler and burner for the usual condition of operation, but when for any reason the conditions are disturbed, as by reason of the water supply being interrupted wholly or in part, the pump continuing to operate, the supply of fuel must be limited to a predetermined maximum. By actuating the fuel and water pumps from a common source of power and providing independent means for regulating the stroke of the fuel pump and a controllable by-pass, as described, I am enabled to regulate the fuel supply without danger of overheating the boiler or destroying the vehicle body by fire.

The action of my invention is as follows, assuming that the parts are set to maintain a water pressure on the boiler of 450 pounds: When the pressure is less than this amount the pump piston 16 will work at full stroke, and as the pressure approaches this point the stroke of the piston will become less and less, until finally it assumes a position of rest and the stroke of the eccentric is entirely taken up in the compression spring 22. The spring is compressed on one portion of the stroke and expands or distends on the other portion of the stroke, hence more or less of the power which is absorbed in one portion of the stroke is given back to the source of energy on the remaining portion of the stroke. Assuming that the parts are set to give a pressure of 50 pounds on the burner, the fork 28 will move in a direction to withdraw the fuel pump piston as it is moved to the right under the action of the eccentric, and if the pressure is less than 50 pounds the motor or spring 30 will force the piston into the cylinder and cause a certain amount of fuel to be delivered to the burner 2. When the pressure on the burner reaches its predetermined maximum the spring 30 will remain in its distended position, and the head 29 will not be affected by the movements of the fork 28, but just as soon as the pressure decreases below 50 pounds the action of the eccentric will again impart motion to the piston and the motor will cause the pump to act.

From the foregoing it will be seen that I have provided a pumping system for supplying the fuel to the burner and water to a boiler, wherein the regulation proper is under the control of the pressure on the water end of the boiler, yet to a certain extent the supply of fuel to the burner is independent, and that this independence of action is automatic. The ordinary operation requires definite quantities of fuel and water, but under certain abnormal conditions the ratio between the fuel and water supplies should be altered somewhat by decreasing the amount of fuel supplied; this last named feature is entirely taken care of by the arrangement of the parts, particularly the fork 29 and the spring 30, and this without thought on the part of the operator.

Those features of the system disclosed but not claimed herein, form the subjects-matter of my co-pending applications Ser. No. 6806 filed February 28, 1900, and Ser. No. 129,859, filed November 3, 1902.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is—

1. The combination of a pump piston and cylinder, a motor having a variable length of stroke for setting the piston in position for its working stroke, and a second motor for imparting a variable working stroke to the piston of the pump.

2. In combination, a driven shaft, a pump, a spring driving connection between the shaft and the pump piston, a second pump, means moving with the connection for setting the piston of the second pump in position for its working stroke, and a motive device for completing the action of the second piston.

3. In combination, a pump, a shaft, a driving connection between the shaft and the pump piston, a second pump, means actuated by the shaft for setting the parts of the second pump in position for its working stroke, and a motor for completing the operation of the second pump.

4. In combination, a variable stroke pump, a second variable stroke pump, the movable member of which can move independently of that of the first pump, a means for partially actuating the second pump, which means has a variable stroke in accordance with the variations in stroke of the first pump, and a spring motor for completing the stroke of the second pump.

5. In combination, a pair of pumps, a driving means, a spring connection between one of the pump pistons and the means, a device moving synchronously with said piston for setting the piston of the second pump in position for the working stroke, and a spring which forces the piston of the second pump into its cylinder.

6. In combination, a piston, a cylinder, a crosshead, guide rods, a driving shaft, a reciprocating means driven by the shaft for setting the pump piston in position for the working stroke, and a separate motive device which is set into operative condition by the said means and is arranged to complete the movement of the piston.

7. In combination, a piston and cylinder, a crosshead, means for imparting a reciprocating movement to the head, a second piston and cylinder, a lost-motion connection between the pistons, and a spring which is placed under stress by the movements of the cross-head and when under stress is employed to move the piston of the second pump.

8. In combination, a power water pump, a manually-actuated water pump, a delivery valve which is common to both pumps, a third pump, means for actuating the power pump and setting the third pump in position for its working stroke, and a motive device which moves the third pump piston an amount depending upon the pressure in its cylinder.

9. In combination, a piston and cylinder, a driving shaft, a spring connection between the piston and the shaft whereby the piston is given a variable stroke, a reservoir which communicates with the cylinder and contains a body of viscous fluid which constantly bears upon the end of the piston, a fluid tank which communicates with the reservoir, and a motive device which completes the stroke of the piston.

10. In combination, a pair of pumps with an elastic driving device for the pump plungers, one plunger being loosely attached to the device and the other plunger unyieldingly attached thereto.

11. In combination, a piston and cylinder, a rod capable of moving longitudinally, a pump actuated thereby, a device carried by the rod which engages with the piston and moves it through a part of its stroke, a driving shaft, a spring connection between the shaft and the rod, and a motor for completing the operation of the piston.

12. In combination, a piston and cylinder, a driving connection for the piston, a cross-head secured to the connection, a second cross-head which is guided by the connection, a driving means which is secured to the second cross-head, and an elastic means between the cross-heads which forms a part of the driving connection and comprises a plurality of elastic buffers.

13. In combination, a piston and cylinder, side rods for driving the piston, a second pair of side rods which are jointed to the first, a cross-head for the second pair of rods, a second cross-head which is guided by the second pair of rods, a driving connection connected to the second cross-head, and a spring which forms a part of the driving connection.

14. In combination, a piston and cylinder, and a valve mechanism mounted in the cylinder comprising two or more valves arranged in series, each valve being mounted

in a detachable piece having similar seats at both ends.

15. In combination, a piston and cylinder, a valve receptacle formed in the cylinder casing, a plurality of detachable valves mounted therein and arranged in series relation, and a single retaining means for holding all of the valves in place.

16. In combination, a valve chamber, a seat therein, and a valve which comprises a spherical body of compressible material and a tack-shaped member of relatively incompressible material carried thereby, the head of which prevents the said body from chafing on the valve seat, and the stem of which maintains the valve in operative relation to said seat.

17. In combination, a piston and cylinder, an actuator for the piston, a valve chamber extending from and connecting with the cylinder, reversible pieces in the valve chamber arranged on opposite sides of the point of connection between the cylinder and chamber, and each having corresponding valve seats in its ends, valves for the seats each comprising a metal base and an elastic ball, and adjustable abutments for regulating the lift of the valves.

18. In combination, a pump, two motors which coöperate to reciprocate the piston of the pump, elastic means interposed between the piston and one of the motors which permits of lost motion between them, a second pump, and a lost motion driving connection between the pump and one of said motors.

19. In combination, a pump, a motor for moving the piston in one direction, a tension device for moving the piston in the opposite direction, and a spring connection between the motor and device which comprises a plurality of elastic buffers and separating plates.

20. In combination, a pump, a driving shaft, a cross-head which is secured to the pump, a second cross-head which is driven by the shaft, a spring connection between the heads, and a casing which surrounds the connection and is movable therewith.

21. The combination of a pump piston, a cylinder, a motor which moves the piston relative to the cylinder for each operation, a means for varying the effective stroke of the motor, a second motor which causes said piston to enter the cylinder by an amount depending upon the pressure within a receptacle, and a receptacle into which the piston discharges.

22. In combination, a pair of pumps, a driving connection for one of the pumps which has a variable length of stroke, means actuated by the driving connection for setting the second pump in position for maximum delivery, and a motor which acts in opposition to said means and effects the delivery stroke of the pump.

23. The combination of a plurality of pumps with a driving means common to the pumps which includes an elastic member, and a separate motive device for the movable element of each pump which coöperates with said means for operating the pumps.

24. The combination of a pair of pumps, a driving device, an elastic connection between the device and one pump which is permanently connected to the device and said pump, a spring coöperating with said device for operating the first mentioned pump, and means which loosely attaches the other pump to said connection.

25. The combination of a pair of pumps, an actuating means common to the pumps and permanently connected to one pump, and a means which permits the other pump to be wholly or partially idle relatively to the actuating means.

26. The combination of a pump, an actuator adapted to have a variable length of stroke, and means for causing the actuator to impart a corresponding stroke to the movable member of the pump under certain conditions and for permitting said member to be idle wholly or partially with respect to the actuator under other conditions.

27. The combination of separate pumps, a variable stroke actuator for the pumps, means sensitive to the pressure in one of the pumps and forming a part of said actuator which governs the effective length of its stroke by said pressure, and a connection between the actuator and another pump including an additional governing means sensitive to the pressure in the last mentioned pump which governs the length of its stroke.

28. The combination of a pair of pumps, means connecting the two which permits one pump to control the action of the other under normal conditions, and means which renders the controlled pump temporarily independent of the controlling pump under abnormal conditions, and an actuator for the pumps attached to the first mentioned means.

29. The combination of a variable-stroke motor, a pump, and means connecting the pump with the motor which permits the stroke of the pump to vary independently of that of the motor.

30. In combination, two variable stroke pumps having oppositely acting pistons, an actuator for the pumps, a device connected to and moving with the piston of one of the pumps, and a connection between said device and the piston of the other pump which transmits motion from one piston to the other, said connection including means which permits the discharge stroke of one pump to control the suction stroke of the other pump.

31. In combination, two pumps, an actuator for the pumps, a driving connection between the actuator and the pumps, means

sensitive to pump pressure and included in said connection which varies the stroke of the pumps correspondingly under certain conditions as to pressure, and a lost motion device coöperating with said means to vary said strokes differentially under other conditions.

32. In combination, two pumps, an actuator for the pumps, a driving connection between the actuator and the pumps, means sensitive to pump pressure and included in said connection which may vary the strokes of the pumps correspondingly within a certain range of pressure on one pump, and a lost motion device coöperating with said means to vary said strokes differentially when the pressure on the other pump tends to exceed a predetermined limit.

33. The combination of a plurality of variable stroke pumps, a common actuator which moves the movable elements of the pumps in one direction, and separate actuating means for each element which impart motion in the opposite direction.

34. The combination of two variable stroke pumps, an actuator common to the pumps for simultaneously causing the discharge stroke of one pump and the suction stroke of the other pump, and separate means acting on the pumps in opposition to the actuator for causing the effective discharge of one pump to vary independently of the other.

35. The combination of two variable stroke pumps and their respective systems, a device acting on one pump which tends to maintain the piston thereof within the cylinder, a device acting on the other pump which tends to maintain the piston withdrawn from the cylinder, an actuator, and means loosely connecting the actuator with the first pump and permanently connecting it with the second pump.

36. The combination of a plurality of pumps, and a driving connection between them, said connection having provision in virtue of which one pump may become automatically disconnected under certain conditions.

37. In combination, an engine, a generator for supplying motive fluid to the engine, a pump for supplying the generator with liquid, said pump having a piston, a reciprocating means actuated by the engine for moving the pump piston outward under certain conditions, a connection between said means and the piston including a lost motion device which becomes effective under certain pressure conditions, and an elastic device receiving energy from the engine which exerts a uniform pressure on the piston in the other direction.

In witness whereof, I have hereunto set my hand this second day of May, 1902.

HERMANN LEMP.

Witnesses:

DUGALD McK. McKILLOP,

JOHN J. WALKER.