H. LEMP.

POWER GENERATING SYSTEM.

APPLICATION FILED JULY 15, 1899.

903,487. Patented Nov. 10, 1908.

Fig. 2.

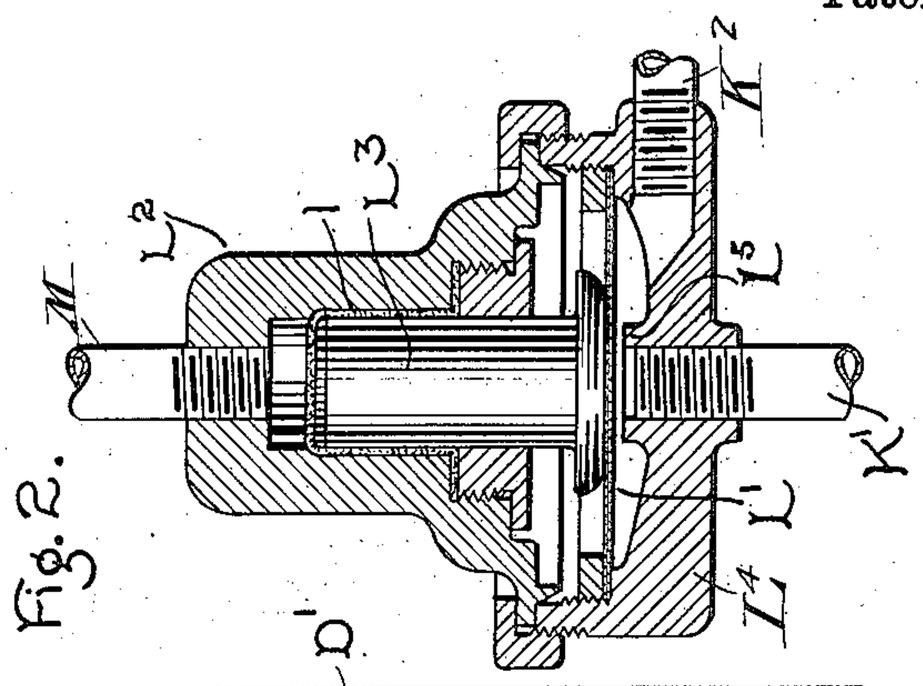
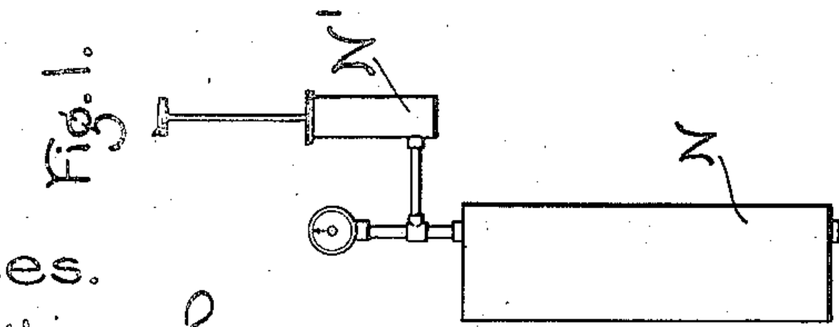


Fig. 1.



Witnesses.
Edward Williams, Jr.
A. F. Macdonald.

Inventor:
Hermann Lemp,
by Albert G. Davis
Atty

UNITED STATES PATENT OFFICE.

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

POWER-GENERATING SYSTEM.

No. 903,487. Specification of Letters Patent. Patented Nov. 10, 1908.

Application filed July 15, 1899. Serial No. 723,900.

To all whom it may concern:

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

My invention relates to power generating systems in general but is illustrated in the form particularly used for operating automobiles, in which service the demand for energy is subject to sudden and wide variations. The energy required to drive an automobile varies principally with the speed, the weight carried and the character of the route traveled. In order to operate such a vehicle with a maximum degree of economy, the supplies of fuel and water to the generating apparatus should vary with the load on the engine and in substantially the same degree.

The object of the invention is the provision of a power generating system of improved construction which will operate with the desired economy under the varying demands made upon it for energy and will require a minimum of care and attention on the part of the operator.

In carrying out my invention, a tank or other source of fuel supply is placed under a relatively small initial pressure or head sufficient to supply the fire chamber or burner of the boiler or other vapor generating apparatus when the fire is banked. A power pump is employed to impart service pressure to the fuel. A regulator controlled by the vapor pressure on the engine or motor is provided to regulate the effective delivery of the fuel pump in substantial accordance with the demand for energy. Another pump draws a supply of water from a tank or other source and imparts the pressure necessary to deliver it to the boiler against the vapor pressure therein. The delivery conduit of the water pump is in connection with a regulator, subject to the vapor pressure in the boiler, which controls the effective delivery of the pump in general accordance with the demand for energy. The pumps are of substantial size, require no careful adjustments, and are capable at all times of furnishing an excess of water and fuel; the regulating devices being arranged to automatically take care of the excess. This arrangement is a very satisfactory one and eliminates objectionable conditions which would result if the system were designed to supply water and fuel in exact quantities with respect to the demand.

In the accompanying drawing, which represents an embodiment of my invention, Figure 1 is a diagrammatic representation of a system comprising a steam engine, boiler and the necessary pumps, tanks, piping, etc., and Fig. 2 is a sectional view of a regulating valve.

The boiler shown consists of a seamless tube A of suitable bore, coiled or bent in any desired manner so as to present a large surface to the burner flame. The boiler is preferably divided into sections and the inner end of one section is connected to the outer end of another section, the main steam pipe being connected to approximately the middle of the boiler. A boiler constructed in this manner possesses certain features of advantage which are set forth in another application of mine S. N. 6805, filed Feb. 28, 1900, but the invention is not limited to this particular form of boiler. Other forms or constructions may be used, if desired.

Surrounding the tube or tubes and constituting a fire chamber is a casing or lining B, composed of fire brick or other heat resisting material which confines the burner flame and at the same time shields the body of the vehicle or other support from excessive heat. Surrounding the fire-brick lining is a metallic casing C having a suitable bottom and a top provided with an extension C^1 containing an opening through which the products of combustion may pass under certain conditions. A cover is provided for the opening which may be closed after the apparatus is started. The top is also provided with a false head or chamber D into which the exhaust passes from the engine. This chamber communicates with the external atmosphere through the down flue D^1. The flue D^1 is also connected to the extension C^1, so that when the apparatus is in operation the exhaust in passing downward through the flue D^1 will take with it the products of combustion from the burner. A number of openings C^2 are provided in the sides of the casing C through which the air may enter, as indicated by the arrows, to combine with the fuel. The construction and arrangement of the up and down flues is not claimed herein, as it forms the subject matter of a

separate application, filed by me November 2, 1900 and bearing Serial No. 35,254.

Any suitable type of engine may be employed in connection with my invention, the one shown being a single acting vertical engine. One end of the cylinder E is connected with the boiler by pipe F, and the admission of steam thereto is regulated by the throttle G. The exhaust from the cylinder passes through pipe H to the chamber D over the boiler, thence to the external air by the down flue D^1.

For the purpose of supplying water to the boiler and fuel to the burner, two pumps are provided which are either driven directly by the main shaft of the engine, or through suitable gearing. So long as the action of the pumps varies with the speed of the engine the results will be satisfactory irrespective of the particular means employed in the driving. I prefer to use the arrangement described on account of the economy of operation, but I do not mean to be understood as excluding from my invention structures wherein the pumps are driven at a constant or approximately constant speed either by or independent of the engine, as certain advantages will follow in these cases.

As illustrated in the drawing, H^1 represents a water pump and I an oil pump, preferably of the displacement type. One end of the cylinder of the water pump H^1 is connected to the boiler by the pipe H^2 and the other end is connected to the water tank J by the pipe H^3. An air chamber or dome H^4 is operatively connected to the pipe H^2. Connected to the water pipe H^2 is a relief valve V, of any suitable construction, which is designed to take care of the excess of water supplied by the pump and is set to give the maximum amount of water required by the boiler. Leading from the relief valve to the water tank J is a pipe V^1 that conveys the excess of water back to the tank.

A small manually actuated pump O^1 is used to give an initial water pressure at the time of starting. Shunting the cylinder H^1 and connected to the pipe H^2 at a point opposite the dome, is a pipe H^5. This pipe is provided with a check valve *h* so that water can be forced into the boiler by the manually actuated pump; this arrangement being employed when for any reason the pump H^1 is not running.

One end of the cylinder of the oil pump I is connected to the oil tank by the pipe I^1 and the other end is connected to the oil feed pipe K through the pipe I^2. Connecting the pipes I^1 and I^2 is a short piece of pipe containing the check valve I^3. This check valve is so arranged that it permits the liquid fuel to flow from pipe I^1 to pipe I^2 under the action of the air pressure in the tank N but prevents its passage in the opposite direction under pressure from the pump. In addition, the pipes are connected by two short sections of pipe K^1 and K^2 which constitute a by-pass, and between these sections is an automatic regulating valve L. The construction of this valve or regulator is clearly shown in Fig. 2, in which L^4 represents the casing or base, and mounted therein is a diaphragm L^1. Secured to the casing is a cylinder L^2, containing a piston L^3 arranged to press on the diaphragm L^1 and cause the latter to engage a seat L^5 and close the opening leading to pipe K^1. To prevent leakage around the piston an elastic packing *l* is employed, which completely surrounds the piston and is firmly seated between a nut and a shoulder on the cylinder. The ratio of the areas of the diaphragm and plunger are, roughly, as one to six, but this ratio can, of course, be made anything else depending upon the relative dimensions of the burner and engine, but once this ratio is determined it need not be altered, the throttle valve R being used for final adjustment. Secured to the upper end of the cylinder is a pipe M which is directly connected to the steam pipe between the throttle valve G and the engine, consequently the steam pressure in the pipe M corresponds to that on the engine. When for any reason the relative pressure in the pipe M falls below that in the pipe K, the diaphragm rises and permits a certain amount of the liquid fuel to pass from pipe K^2 to pipe K^1, and thence through the pipes I^1, I^3 and I^2, thereby forming a local circuit. As soon as the difference in pressure between the pipe K and the pipe M ceases, all of the oil will flow from the tank to the burner.

Oil or other fuel is supplied to the burner from a tank N, and in order to furnish an initial pressure at the time of starting the engine a small hand pump N^1 is employed; this pressure is ordinarily about five pounds, but it can be varied therefrom if desired. By constantly maintaining the fuel tank N under a small or initial pressure, fuel will be supplied to the burner or fire chamber at all times, whether the power fuel pump is working or not.

The construction described is also advantageous because only a relatively small amount of fuel is under high pressure, hence the danger due to broken pipes, particularly if gasolene is employed, is reduced to a minimum. The system is so arranged that there are two connections from the tank to the burner. One of these connections includes the power pump I, while the other connection includes the regulator L. When the diaphragm L^1 of the regulator is raised, fuel passes directly from the tank to the burner, but when the diaphragm is seated, the fuel passes through the power pump. When the pressure due to the pump and that of the supply tank are somewhat nearly equal, both of the connections may be active.

In order to furnish the necessary lubrication for the piston of the engine a small oil pump P is mounted in any suitable manner and belted or otherwise connected to the engine. A pipe P^1 connects the oil pump with the steam inlet pipe F.

The burner Q can be of any desired form. The one shown consists of a plate or vaporizer Q^1 against which the oil is projected under pressure from a small orifice in the part *q*. The size of the opening can be varied by a pin or other device which is carried by the upper end of the rack Q^2. The rack is moved by a pinion Q^3 that is connected to a lever or other suitable actuating device. The burner shown forms the subject matter of a separate application filed by me January 28, 1901, bearing Serial No. 45,028.

Tests made with a vehicle equipped in accordance with my invention show that under various running conditions the steam pressure on the engine will vary proportionately with the work to be performed, it being greatest when running on a level at fast speed or when ascending a steep grade.

The speed of the vehicle can be accurately controlled by the opening and closing of the throttle, providing the boiler pressure is maintained practically constant. There exists therefore a definite ratio between the steam pressure necessary to turn the engine and the pressure necessary on the burner, which ratio is constant through a very wide range and covers all practical conditions.

The general operation of my invention is as follows: The burner is first heated by a torch or other auxiliary device, after which the fuel in the tank N is put under a small air pressure which forces the oil through the pipes K^1, K^2 and K, thence through the vaporizer to the orifice in the part *q*. There being no steam pressure in the pipe M at this time, the diaphragm L^1 will rise against the weight of the piston L^3 and permit the fuel to flow to the burner. After the boiler has been sufficiently warmed, water is pumped into the boiler by the manually actuated pump O^1, and as soon as turned into steam is admitted to the engine through the pipe F and throttle G. As soon as the engine starts into operation both water and fuel pumps begin to act and force water into the boiler on one hand and oil into the burner on the other. As the demand on the boiler for steam increases, due to any cause, the amount of water flowing back to the water tank through the relief-valve or regulator V decreases. The more the throttle is opened the nearer the steam pressure of the engine will be to that of the boiler, and consequently the pressure on the piston L^3 will be increased. In other words, the overflow valve of the oil supply will be weighted and a greater pressure will therefore be exerted on the fuel service and more fuel will be consumed in the burner. Closing the throttle G will cut off the steam from the engine, the pressure on the steam side of the regulating valve L will fall to zero, the pressure which exists in the pipes K and I^2 due to the pump I is sufficient to raise the diaphragm L^1 of the regulating valve and the liquid fuel will flow back into the tank N against the air pressure therein due to the hand pump. In other words, there exists for a few moments in the pipe K a comparatively high pressure, even after the pump I has ceased to operate. As soon as the pressure drops to that of the fuel tank the amount of fuel which is forced through the burner will be greatly reduced, but a sufficient amount, due to the pressure created by the hand pump N^1 will flow to maintain the vaporizer and the boiler tubes at a temperature for immediate starting. On account of the exhaust passing through the chamber D and the down flue D^1, any increase in the amount of the exhaust will correspondingly increase the draft on the burner. As the amount of steam admitted to the engine is decreased, the draft on the burner is simultaneously and correspondingly decreased. This means that the draft on the burner is automatically varied to meet the conditions of service. Hence there will be no choking of the fire gases within the boiler under any conditions. With this method of control, the operator is entirely free from care as regards the fire and the steam pressure, the fire automatically increasing with the duty performed by the carriage, and vice versa.

When the system is running, the water pump H furnishes an excess of water, which excess is taken care of by the adjustable relief valve V. When the engine is making a great demand on the boiler for steam very little water returns to the tank, but as the demand for steam decreases more and more water will force its way through the valve and back to the tank. While under running conditions it is evident that the pressure on the steam side of the regulating valve L must vary due to momentary changes in steam pressure on the engine, caused by changes in speed or load, consequently the amount of oil which flows from the pump to the burner is varied. If the pressure is low the diaphragm will rise and there will be a local oil circulation, but as soon as more steam is admitted to the engine by opening the throttle the diaphragm is more or less firmly seated over the end of pipe K^1 and more oil is forced to the burner.

Those features of my invention relating to the fuel system alone have been divided out at the requirement of the U. S. Patent Office under the provisions of Rules 41 and 42, and form the subject matter of a divisional application, Serial No. 157,546, filed May 18, 1903.

In accordance with the provisions of the patent statutes, I have described the princi-

ple 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 merely 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. In a power generating system, a boiler, a burner therefor, an engine, means for supplying liquid to the boiler which is under the control of the boiler pressure, and means for supplying fuel to the burner which is under the control of the engine pressure.

2. In combination, a boiler, a burner therefor, an engine connected with the boiler, a pump for supplying liquid to the boiler, means coöperating with the pump for rendering its effective delivery dependent upon the boiler pressure, a pump for supplying fuel to the burner, and means for rendering the effective delivery of the fuel pump dependent upon the engine pressure.

3. In combination, a boiler, a burner, pumps for supplying water and fuel respectively to the boiler and burner, an engine which is connected with the pumps for driving the same, means for controlling the effective delivery of the water pump according to the pressure in the boiler, and means for controlling the output of the fuel pump according to the steam pressure of the engine.

4. In combination, a boiler, a burner therefor, pumps for supplying water to the boiler and fuel to the burner, an engine, driving connections between the engine and pumps which permit the supplies of the pumps to vary as the speed of the engine varies, and means under the control of the steam pressure of the engine which varies the amount of fuel supplied to the burner independently of variations in the action of the pump.

5. In a power generating system, the combination of a boiler, a burner therefor, an engine, pumps tending to supply liquid to the boiler and fuel to the burner in definite proportion, means intermediate the pump and boiler for varying the supply of liquid to the latter, and means independent of the first means and dependent upon the engine pressure for varying the supply of fuel to the burner.

6. In a system of power generation, the combination of a boiler, a burner therefor, an engine, pumps tending to supply liquid to the boiler and fuel to the burner in definite proportion, and means operating independently for varying the supplies of liquid and fuel, one of said means being dependent upon the engine pressure.

7. In a system of power generation, the combination of a boiler, a burner therefor, an engine, a throttle, pumps tending to supply liquid to the boiler and fuel to the burner in definite proportion, and independent means for varying the effective supplies of liquid and fuel, said means being controlled by fluid pressure from opposite sides of the throttle.

8. In combination, an engine, a boiler which requires that water shall be continuously pumped into it, a water pump which is driven by the engine and works against the pressure on the water end of the boiler, a relief valve for the pump, a burner, a fuel pump which is also driven by the engine, a regulator therefor, which is controlled by the steam pressure on the engine side of the throttle, and a throttle-valve which admits steam to the engine and regulator and also controls the pressure on the water end of the boiler.

9. In a power generating system, the combination of a boiler, means including a regulating device for supplying water to the boiler, and means for supplying liquid fuel to the boiler including a regulating valve having an inlet and an outlet, a diaphragm for controlling the connection between the inlet and outlet and a pressure actuated device for moving the diaphragm.

10. In a power generating system, the combination of a boiler, means including a regulating device for supplying water to the boiler, means including conduits for supplying liquid fuel to the boiler, and a regulator for the fuel supply located in one of the conduits comprising a diaphragm which under the influence of the fuel pressure tends to keep the conduit open and a piston actuated by the engine pressure which tends to move the diaphragm against the fuel pressure to close the conduit.

11. In a power generating system, the combination of a boiler, a pump supplying water to the boiler, and means for supplying fuel to the boiler including a regulating valve comprising a diaphragm, a seat, and means for moving the diaphragm relative to the seat to control the flow through the valve.

12. In a power generating system, the combination of an engine, a boiler which furnishes steam to the engine, a pump supplying water to the boiler, and means for supplying fuel to the boiler including a regulating device comprising a base having a chamber with inlet and outlet openings and an annular seat surrounding one of the openings, a diaphragm mounted in the base above the seat, a cylinder secured to the base above the diaphragm, a piston in the cylinder having its lower end in engagement with the diaphragm, and a connection for admitting engine pressure to the cylinder to cause the piston to remove the diaphragm relative to the seat to regulate the flow through the chamber.

13. In a power system, the combination of a fuel tank maintained under an initial pres-

sure, a fire chamber to which fuel flows under the pressure in the tank, a generator heated by the fire chamber, an engine receiving vapor from the generator, means for supplying fuel to the fire chamber at a pressure greater than that on the source, and an automatic controlling valve working under the engine pressure for regulating the supply of fuel at the different pressures to the fire chamber.

14. In a power system, the combination of a fuel tank adapted to be maintained under an initial pressure, means for placing the fuel tank under pressure, a burner, a boiler heated thereby, a casing which receives the fire gases from the burner and is provided with a down-draft flue, an engine receiving steam from the boiler and exhausting into said flue, a pump driven by the engine for increasing the pressure of the fuel in the system and delivering it to the burner, and an automatic regulator controlled by the demand for steam which decreases the supply of fuel to the burner coincident with the decrease in the amount of exhaust from the engine.

15. In a power system, the combination of a fuel tank, a burner, means located between the tank and burner for increasing the pressure of the fuel in the system, a boiler heated by the burner, a casing for the boiler having a down-draft flue, an engine receiving steam from the boiler and exhausting into the flue, and means for increasing or decreasing the supply of fuel to the burner according to the quantity of steam supplied to and exhausted from the engine.

16. In a power system, the combination of a fuel tank maintained under an initial pressure, means for increasing the pressure, a burner, a boiler heated thereby, a casing for the boiler, a down-draft flue for the casing, an engine receiving steam from the boiler and exhausting into the flue, and an automatic regulator working under engine pressure for controlling the supply of fuel to the burner.

17. In a power system, the combination of a fuel tank adapted to be maintained under an initial pressure, a pump for placing the fuel tank under pressure, a burner, a boiler heated thereby, an engine, a throttle valve controlling the supply of steam to the engine, a second pump driven by the engine which delivers fuel to the burner from the fuel tank at an increased pressure, and an automatic regulator working under the steam pressure on the engine side of the throttle for regulating the supply of fuel to the burner.

18. In combination, an engine, a boiler having a burner and supplying motive fluid to the engine, a source of fuel, a pump receiving fuel from the source and delivering it to the burner under high pressure, means utilizing the engine exhaust for creating a forced draft on the burner, a valve-controlled conduit which opens and decreases the pressure of the fuel supplied to the burner coincident with the decrease of the forced draft below a certain point, and a single device which controls the operation of the engine and pump, the engine exhaust and the forced draft induced thereby, and the valve of said conduit.

19. In a power system, the combination of a burner, a conduit for supplying fuel at a low pressure thereto, a normally open valve included therein, means for supplying fuel to the burner at a high pressure, a vapor generator heated by the burner, a vapor consumption device, a throttle controlling the supply of vapor thereto, and a means for actuating said valve which is controlled by vapor pressure on the delivery side of the throttle.

20. In a power system, the combination of a source of fuel supply, a boiler having a fire chamber, a pump receiving fuel from the source and discharging it to the fire chamber, a conduit between the high-pressure side of the pump and the fire chamber, a motor receiving motive fluid from the boiler to drive the pump, and a regulator responsive to the initial fluid pressure on the motor for suddenly reducing the pressure of the fuel trapped between the pump and the fire chamber when the pump is shut down.

21. In a power system, the combination of a boiler, an engine for receiving motive fluid therefrom, means for utilizing the exhaust from the engine to produce a forced draft, a burner for heating the boiler, separate supply pipes connected to the burner, means for supplying fuel through one pipe at a relatively low pressure, means for supplying fuel through the other pipe at a relatively high pressure, and a device depending upon the supply of motive fluid to the engine for cutting the high pressure fuel supply into service simultaneously with the supply of motive fluid to the engine and the opening of the forced draft and for cutting the low pressure supply into service simultaneously with the closing of the supply of motive fluid to the engine and the shutting down of the forced draft.

22. In a power system for self-propelled vehicles, the combination of a boiler, an engine for driving the vehicle which receives motive fluid from the boiler, a throttle, a source of fuel supply, a pump arranged to operate during movement of the vehicle which is connected with the tank and the burner, a by-pass around the pump, and a valve in the by-pass controlled by the pressure of the motive fluid delivered to the engine to open when the throttle closes or vice versa.

23. In a power system for self-propelled vehicles, the combination of a boiler, an engine for driving the vehicle which receives steam from the boiler, a throttle for controlling the supply of steam to the engine, a

source of fuel supply maintained under an initial pressure, a pump driven by the engine and connected with the tank and the burner for supplying fuel to the latter at a high pressure, a by-pass around the pump, a valve therein through which fuel passes to the burner under the pressure of the source, and means sensitive to the pressure of steam supplied to the engine for opening the by-pass when the throttle closes or vice versa.

24. In a power system for self-propelled vehicles, the combination of a boiler, an engine for driving the vehicle which receives steam from the boiler, a throttle for controlling the supply of steam to the engine, a source of fuel maintained under an initial pressure, a pump driven by the engine and connected with the tank and the burner for supplying fuel thereto at a high pressure, a by-pass around the pump, a valve therein which operates to suddenly reduce the pressure on the burner by establishing communication between the latter and the source, and means sensitive to the pressure of the steam supplied to the engine to open the valve when the throttle closes or vice versa.

25. In a power system for self-propelled vehicles, the combination of a boiler, an engine receiving steam therefrom which drives the vehicle, a burner for heating the boiler, a source of liquid fuel supply maintained under an initial pressure, a pump driven by the engine which receives fuel from the source and supplies it to the burner at a high pressure, a connection arranged in shunt relation to the pump, a regulator therein which is adapted to permit the pressure on the burner to be quickly relieved or reëstablished during operation of the pump and also to permit fuel to feed to the burner at the pressure of the source when the pump is idle, a forced draft device which is adapted to operate at the same time that fuel at high pressure is supplied to the burner, and a throttle which controls the operation of the engine and pump and also the regulator and the forced draft device.

26. In a power system for self-propelled vehicles, the combination of a boiler, an engine receiving steam therefrom which drives the vehicle, a burner for heating the boiler, a source of liquid fuel maintained under an initial pressure, a pump driven by the engine which receives fuel from the source and supplies it to the burner at a high pressure, a connection arranged in shunt relation to the pump, a regulator therein which is adapted to permit the pressure on the burner to be quickly relieved or reëstablished during operation of the pump and also to permit fuel to feed to the burner at the pressure of the source when the pump is idle, a forced draft device which is adapted to operate at the same time that fuel at high pressure is supplied to the burner, a natural draft device which is adapted to operate at the same time that fuel at low pressure is supplied to the burner, and a throttle which controls the operation of the engine and pump and also the regulator and the forced draft device.

27. The combination of a boiler, a burner therefor, an engine, a conduit between the boiler and the engine, a throttling device in the conduit, a fuel pump for supplying fuel to the burner, a regulating device controlled by the live steam pressure on the engine side of the throttle for increasing the amount of fuel supplied by the pump when the steam pressure on the engine increases and for decreasing it when the pressure falls, and a conduit extending from a point in the first mentioned conduit between the throttling device and the engine for communicating said pressure to the regulating device.

28. In combination, an engine, a boiler which supplies motive fluid to the engine, a burner therefor, a pump for supplying fuel to the burner, a by-pass around the pump, a pressure regulator which is provided with a moving element for controlling the by-pass, and a conduit connecting the regulator with the engine to move said element in a direction to open the by-pass when the active engine pressure falls and to reduce or close said by-pass when the pressure rises.

29. In a system of control, the combination of an engine, a boiler for supplying steam to the engine, a burner therefor, a pump for supplying fuel in excess, means for conveying fuel to the burner, means for conveying the excess of fuel away from the burner, an automatic regulator which admits more fuel to the last mentioned means as the active or initial steam pressure on the engine falls and decreases the excess of fuel delivered to said conveying means as said engine pressure rises, and a connection between the engine and regulator which permits said steam pressure to actuate the regulator.

30. In combination, an engine, a throttle-valve therefor, a boiler supplying steam to the engine and having a burner for heating it, a fuel pump driven by the engine and supplying fuel to the burner, a source of fuel supply for the pump and burner, a regulator controlling the effective delivery of the pump, and a steam-carrying connection extending from a point between the engine and throttle-valve to the regulator for the purpose of controlling the action of said regulator.

31. The combination of a boiler having a fire chamber and a burner in the fire chamber, an engine receiving motive fluid from the boiler, means which tends to supply an excess of liquid fuel to the burner, conduits between said means and the burner, and a device in one of said conduits controlled by the active or initial engine pressure which

automatically regulates the amount of fuel supplied to the burner by said means.

32. The combination of a boiler, a fire chamber therefor, an engine receiving steam from the boiler, a throttle valve for controlling the admission of steam to the engine, means for supplying liquid fuel to the fire chamber under pressure, a regulator for automatically regulating the amount of fuel supplied to the fire chamber, and means for actuating the regulator by live steam received from the engine side of the throttle.

33. In a system of control, the combination of an engine, a source of fuel supply, a boiler having a fire chamber, conduits between the source and the chamber, and a means in said conduits for regulating the supply of fuel to the chamber, which means is under the control of the active or initial engine pressure and increases the supply as said pressure rises and decreases it as it falls.

34. In a system of control for a steam-actuated apparatus, the combination of an engine, a boiler supplying steam to the engine, an oil pump driven by the engine, auxiliary means for giving an initial oil pressure, a regulator for the pump, and a connection extending from a point between the main throttle valve and the engine to the regulator for the purpose of controlling its action by the pressure of the steam supplied to the engine.

35. The combination of an engine, a boiler having a burner for supplying steam to the engine, a fuel circuit, a fuel pump actuated by the engine and capable of supplying an excess of fuel for the burner, a valve situated in the fuel circuit and arranged to vary the amount of fuel delivered by the pump to the burner, and means acted upon by the initial steam pressure of the engine for regulating the opening and closing of the valve.

36. In a system of control, the combination of an engine, a throttle for controlling the supply of steam to the engine, a pump actuated by the engine, a regulator for controlling the effective delivery of the pump which is acted upon by the live steam pressure on the engine side of the throttle, and a connection extending from a point between the throttle and the engine to the regulator for communicating said pressure to the latter.

37. The combination of a steam generator, an engine, a throttle controlling the supply of steam thereto, a burner in coöperative relation to the generator, and separate means which operate one at a time for suppoying different quantities of fuel to the burner according to the operative or inoperative position of the throttle.

38. The combination of a steam generator, an engine receiving steam from the generator, a throttle for controlling the supply of steam to the engine, a burner for heating the generator, means for delivering fuel to the burner for supplying a main flame during open position of the throttle, and a means which is automatically made operative when the other means is made inoperative or vice versa for delivering fuel to the burner to supply a pilot flame during closed position of the throttle.

39. The combination of a steam generator, an engine receiving steam from the generator, a throttle for controlling the supply of steam to the engine, a burner for heating the generator, means for delivering fuel to the burner to supply a main flame, means for delivering fuel to the burner to supply a pilot flame, and means acting directly with the throttle whereby the separate supplies of fuel hold a reciprocal relation to each other.

40. In a power system for a motor vehicle, the combination of a propelling motor, a boiler for supplying motive fluid to the motor, a burner for heating the boiler, a fuel reservoir, a pump connected with the reservoir and delivering fuel to the burner, means for operating the pump from the motor, a throttling device controlling the supply of motive fluid to the motor, and means sensitive to the pressure on the motor side of said device for controlling the supply of fuel to the burner independently of the speed of the motor.

41. In a power system, the combination of a single source of liquid fuel supply under an initial pressure, a burner, a controllable means for creating a forced draft on the same, means for supplying fuel from said source to the burner at a definite pressure, and means dependent upon the means for creating a forced draft for permitting fuel to return from the burner to the source when the latter means ceases operating.

42. In combination, a burner, a casing therefor, a natural draft flue and a forced draft flue communicating with the casing, means for inducing a forced draft, means for supplying fuel to the burner, and a means dependent upon the means for creating a forced draft which increases the pressure on the burner at the time the forced draft begins to operate, and relieves the pressure on the burner when the forced draft ceases and the natural draft begins to operate.

43. In a power system for self-propelled vehicles, the combination of a burner, a source of liquid fuel supply maintained under an initial pressure, a pump and connections between the source and the burner for supplying fuel to the latter at a high pressure, a connection arranged to convey fuel from the tank to the burner when the pump is idle or from the burner to the tank when the pressure on the latter is above that on the former; means for creating a forced draft on the burner, and a means for controlling the said connection and the means for creating a

forced draft so as to permit fuel to flow from the burner to the tank simultaneously with the cessation of the forced draft.

44. In a power system for self-propelled vehicles, the combination of a burner, a source of liquid fuel supply maintained under an initial air pressure, a pump and connections between the source and the burner for supplying fuel to the latter at a high pressure for supporting a main flame, means for creating a forced draft on the main flame, a connection extending in shunt relation to the pump to form a by-pass around the latter, a valve therein which when open permits fuel to pass to the burner at the pressure on the source to maintain the flame in banked condition and when closed prevents the fuel delivered by the pump from by-passing, and means for providing a natural draft for the flame when in banked condition.

45. In combination, a burner, a conduit connected therewith through which fuel is supplied to the burner at a suitable pressure, a device employing fluid under pressure for creating a forced draft on the burner, a source of fluid pressure connected with said device, and a manually-controlled means for quickly relieving the pressure on the fuel in said conduit while simultaneously cutting off the supply of fluid to said forced draft device.

46. In combination, a burner, separate means which operate reciprocally to supply fuel to the burner at different pressures, means for creating a forced draft on the burner, and means which simultaneously interrupts the fuel supply of higher pressure and stops the forced draft and at the same time opens the fuel supply of lower pressure.

47. In combination, a burner, separate means which operate reciprocally to supply fuel to the burner at different pressures, means for creating a forced draft on the burner, and means which operates to stop the forced draft and to simultaneously interrupt one fuel supply and open the other thereby permitting the pressure on the burner to be relieved at the time the forced draft ceases operating.

48. In combination, a burner, a casing therefor, a natural draft flue and a forced draft flue communicating with the interior of the casing, means for inducing a forced draft, means for supplying fuel to the burner, and a manually controlled means which simultaneously regulates the forced draft and the fuel supply.

49. In combination, a burner, a casing therefor, a natural draft flue and a forced draft flue communicating with the interior of the casing, means for inducing a forced draft, means for supplying fuel to the burner at high pressure, means for supplying fuel at a lower pressure, and means comprising coöperating devices which simultaneously renders operative the means for inducing a forced draft and the means for supplying fuel to the burner at high pressure while rendering the means for supplying fuel at lower pressure inoperative, or vice versa.

In witness whereof, I have hereunto set my hand this 12th day of July, 1899.

HERMANN LEMP.

Witnesses:
BENJAMIN B. HULL,
MABEL E. JACOBSON.