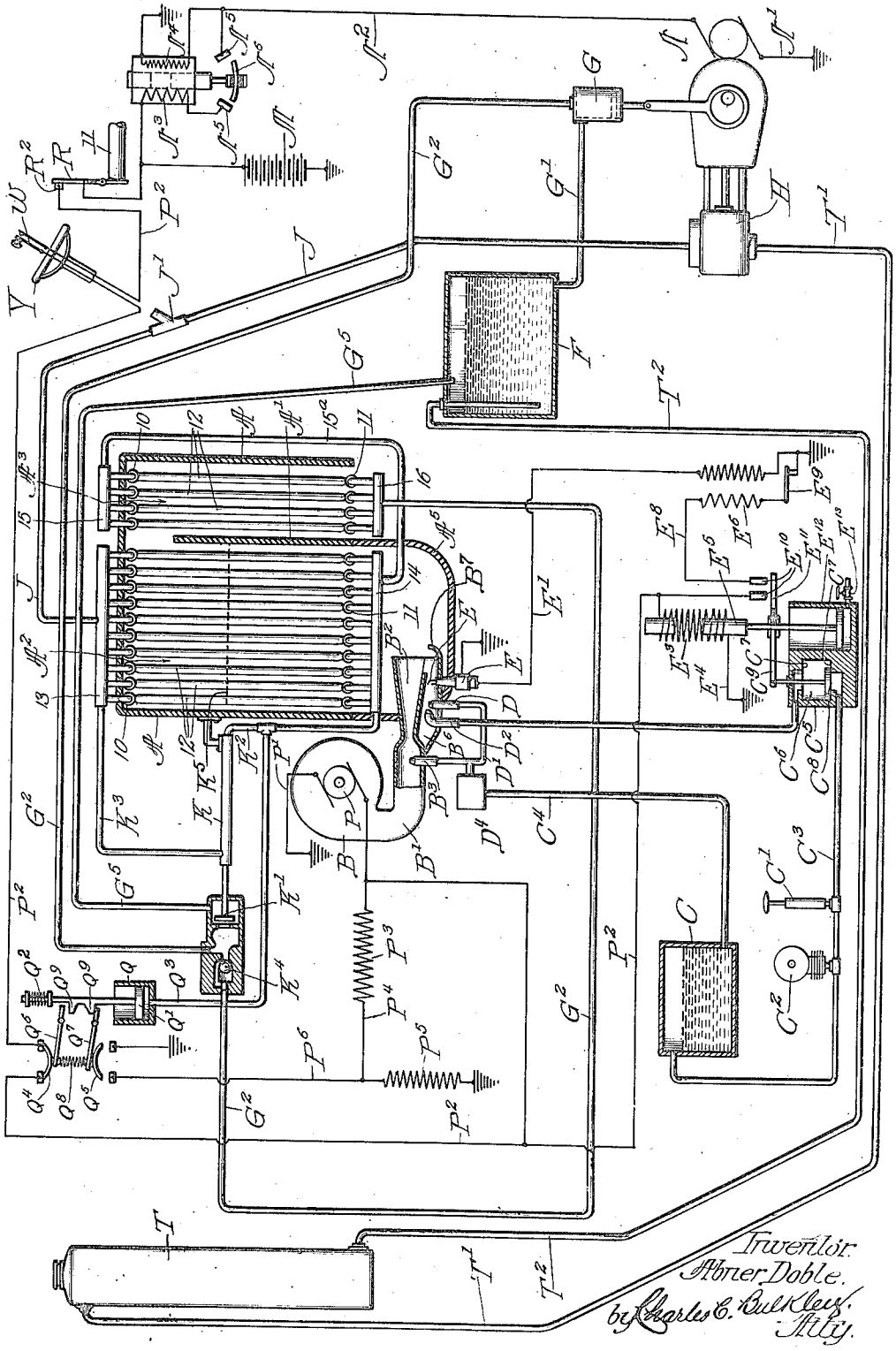
A. DOBLE.

SYSTEM OF AUTOMATIC REGULATION FOR STEAM DRIVEN AUTOMOBILES.

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1,283,109.

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UNITED STATES PATENT OFFICE.

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SYSTEM OF AUTOMATIC REGULATION FOR STEAM-DRIVEN AUTOMOBILES.

1,283,109. Specification of Letters Patent. Patented Oct. 29, 1918.

Application filed June 7, 1917. Serial No. 173,403.

To all whom it may concern:

Be it known that I, ABNER DOBLE, a citizen of the United States of America, and resident of Detroit, Wayne county, Michigan, have invented a certain new and useful Improvement in Systems of Automatic Regulation for Steam-Driven Automobiles, of which the following is a specification.

My invention relates to steam driven automobiles, and my object is to provide a complete system of regulation for the power plant of a steam driven automobile, which system shall be entirely automatic whereby to relieve the operator of all regulation and control duties and enable him to devote his entire attention to driving the car, and shall maintain the power plant in condition to instantly and effectively respond to the sudden and widely varying demands which are found only in the automobile practice.

Other objects of my invention will appear hereinafter.

Referring to the accompanying drawings, I illustrate in diagram a complete regulation and control system with the various mechanisms in their operating relation all embodying my invention.

In the drawings I illustrate diagrammatically a steam producing unit adapted for the rapid production of high pressure steam for use in automobiles as the propelling force. This structure involves in general a refractory lined casing or shell A open at its bottom, and having a refractory partition or wall A^1 which terminates short of the top wall of the casing to provide communication for the products of combustion from the compartment A^2 to the compartment A^3. In the compartment A^2 there are a plurality of groups of upright evaporator tubes, each group of which consists of an upper and lower common header 10 and 11 respectively, and a multiplicity of evaporator tubes 12 extending therebetween. The upper headers extend outside of the casing on one side and are connected to a common steam manifold 13, while the lower headers are likewise connected to a common water manifold 14. In like manner the compartment A^3 of the shell has groups of upright tubes connected to upper headers and lower headers, the upper headers being connected to a common water manifold 15 outside the casing, and the lower headers being connected to a common water manifold 16 also outside the casing.

Inclosing the under side of the compartment A^2 of the shell is a refractory bowl-shaped firepot A^5 which together with the shell A forms a closed combustion chamber in which the fuel is burned for evaporating the water in the evaporator tubes. The products of combustion of the fuel pass upwardly in the shell A between and around the evaporator tubes which are thus directly subject to the heat thereof, and the spent gases leave the compartment through the passage above the partition A^1 and thence downwardly through the compartment A^3 into the atmosphere. The hot gases passing downwardly act to heat the water in the tubes on its way to the evaporator tubes, the course of the water being hereinafter described. The necessary heat is produced by burning liquid hydrocarbon in the combustion chamber, and this fuel is introduced or projected into the combustion chamber by means of atomizing and mixture-forming apparatus disposed at one end of and outside the combustion chamber. A blower B supplies quantities of air for atomizing the fuel and forming a mixture with said fuel. In actual practice the discharge outlet B^1 of the blower casing divides into two passages which are substantially parallel and which continue through the wall of and into the firepot and form two Venturi tubes B^2. In the drawing, however, the structure is illustrated diagrammatically, and only one of these Venturi atomizers is shown for the sake of simplicity of illustration and explanation. These Venturi tubes extend into the combustion chamber and direct two streams of flame across the combustion chamber to the opposite wall thereof where the flames are diverted or doubled back on themselves, thus forming a double vortex and creating an intense uniform zone of heat for the generation of steam. The liquid fuel is carried in two nozzles B^3, which extend into the center of the Venturi tubes, and as the streams of air from the fan pass through the Venturi passages they draw the fuel from the nozzles and break it up or finely divide it, and at the same time form a combustible mixture which

is projected into the combustion chamber. The liquid fuel is carried in a suitable tank C which contains sufficient supply thereof. In practice this tank is carried on the frame of the automobile at a point somewhat below the fuel nozzles and in order to raise the liquid up to said nozzles I provide a few pounds of air pressure in the tank. This pressure is supplied by a hand pump C^1 and a power driven pump C^2 connected in the air pipe line C^3 leading to the tank. The power pump C^2 is preferably driven by the steam engine which propels the vehicle. The fuel is conveyed to the nozzles by a fuel pipe line C^4 leading from the bottom of the tank. In this line, however, is a float valve regulator D^4 which determines the level to which the fuel normally remains in the nozzles and which may be of any suitable or approved type for the purpose.

This steam producing unit is designed to utilize the heavier hydrocarbons, such as kerosene or distillate at normal or atmospheric temperature and without pre-heating to convert the liquid fuel into a gas, and furthermore to utilize an electric spark as an agency for initiating combustion of the fuel. The atomizers hereinbefore described produce a mixture of atomized fuel and air which is completely combustible and which burns in the combustion chamber without any smoke or soot whatever. But a mixture of this character which is supplied with sufficient air to be completely combustible, will not ignite directly from a spark of practical proportions. I do find in practice, however, that a mixture which is very rich in hydrocarbon, although incompletely combustible because of insufficient air, will very readily and repeatedly ignite at normal temperature by means of an electric spark, and the advantage of this is that it is instantaneous. I, therefore, provide ignition mechanism for initiating combustion in the streams or sprays of mixture from the main atomizers. The member in which the main Venturi passages are formed also has another or auxiliary passage or chamber B^6 formed between the main Venturi passages, this chamber being closed at its outer end but opens into the inner ends of the main Venturi passages, and is provided with a curved lip B^7, so as to direct the flame from the auxiliary mixture into the path of the main mixtures to directly and instantaneously ignite said main mixture. This chamber has a small atomizer therein designed to produce the character of mixture which will ignite from an electric spark. This atomizer consists of a small liquid fuel nozzle D connected, as diagrammatically illustrated, with the same supply of fuel as the main nozzles, by means of the pipe D^1, the connection being made so that the float regulator will also maintain the proper fuel level in this auxiliary fuel nozzle. A small air nozzle D^2 is positioned to spray the fuel from the nozzle D and produce in the chamber a rich mixture of hydrocarbon at normal temperature. The flame of this mixture is projected to the outlet of the chamber and thence into the path of the sprays from the main atomizers thereby instantly igniting said main sprays. This mixture will ignite by the electric spark produced at the terminals E of a suitable spark plug, these terminals being located in the chamber B^6 in the path of the auxiliary spray. One of the spark plug terminals is grounded and the other connected by conductor E^1 to the secondary winding of a spark coil as hereinafter described. The air for the auxiliary nozzle is taken from the supply of air under pressure in the fuel tank C, through the air pipe line C^3, although in this pipe line there is a valve for controlling the air as will hereinafter appear.

The supply of water for the generation of steam is contained in a suitable tank F preferably located on the frame of the machine in the rear of the power plant. It is taken from this tank by a water pump G through the water pipe G^1 leading from the bottom of said tank, and pumped under the proper pressure to feed water to the steam generator. The pump may be of any suitable type for thus purpose and is preferably driven by the steam engine H which propels the vehicle. In this case, the pump is shown as being driven from the crank shaft of the engine and is mounted on the crank case. A water pipe G^2 leads from the water pump to the lower water manifold 16, the valve of a water level regulator being interposed in this pipe line. The water enters this lower manifold and is distributed to the headers and thence to the individual tubes in the compartment A^3 of the generator. The water flows upwardly in all of these tubes in parallel, and is warmed by the spent gases as hereinbefore described. The heated water is collected by the upper header and manifold 15, and passes to the lower manifold 14 through a pipe 15^a extending between said manifolds. From manifold 14 the water is distributed to the headers, and the multiplicity of upright tubes rising therefrom, and reaches a common level in said evaporator tubes, which level is preferably slightly more than one-half the height of the tubes and which is maintained substantially constant by the water level regulator as hereinafter described. In each of the multiplicity of tubes there is thus provided a small steam zone above the water level, and from these numerous steam zones the steam under the generated pressure is collected by the individual headers and delivered into the upper steam manifold 13, from which it is taken

to the engine H by means of the pipe line J. In this pipe line the throttle J^1, which may be of any suitable type is interposed for the purpose of controlling the supply of steam to the engine in accordance with the requirements. The water level regulator may be of any suitable type. In the structure shown in the drawings it is of that type which employs an expansible member K responsive to variations in temperature. This member K is in the form of a tube, one end of which is securely anchored and the other end of which carries a valve member K^1. In practice, this member K is properly secured to the boiler casing, it being shown herein diagrammatically. This regulator tube is disposed at the point corresponding to the point at which it is desired to maintain the water level in the evaporator tubes. One end of the expansible tube is connected by the pipe K^2 to the lower or water manifold 14, and the other end is connected by the pipe K^3 to the upper or steam manifold 13 so that the water will rise in the pipe K^2 and in the regulator tube K when the water level in the evaporator tubes is substantially normal. When the water level in the tubes drops below normal to such an extent that the steam will enter the expansible tube K the increased temperature of the steam will cause the tube to expand in this manner, due to the difference in temperature between the water and the steam in the evaporator tubes, the regulator will operate to maintain the water level substantially constant regardless of the demands for steam made upon the generator. A by-pass water pipe G^5 leads from the regulator valve chamber back to the water tank, which by-pass is controlled by the valve member K^1. Thus when the water level in the evaporator tubes is normal the thermostatic tube or member K will hold the by-pass open and the water pump will circulate the water through the by-pass valve and by-pass back to the tank instead of pumping it against the pressure in the generator. Now on the other hand, when the water level in the generator falls below normal the thermostatic tube K expands, due to the increased temperature of the steam, and operates to close the by-pass valve K^1, compelling the pump to force the water through the pipe line G^2 to the lower manifold 16, and thence through the various tubes of the generator to raise the water level to its normal condition. The regulator valve casing has a suitable check valve K^4 which acts to prevent a flow of water by the back pressure of the steam generator. In other words, the pump normally returns the water to the supply tank except when the level regulator operates to close the by-pass and compels the water to enter the steam generator. By this simple arrangement it will be seen that the regulation of the water level in the evaporator tubes is entirely automatic and requires no attention whatever on the part of the operator. This is true regardless of the demand for steam which is made upon the steam generator. The exhausted or spent steam from the driving engine H is conveyed by a steam pipe line T^1 to the upper end of a condenser T which is of sufficient capacity to condense all of the steam exhausted by the engine. In this manner the water supply is completely conserved and the water of condensation is conveyed or returned to the water tank preferably by gravity through a water pipe line T^2 extending from the lower end of the condenser to the water tank. The condenser in practice is preferably mounted on the forward end of the automobile frame so that while the vehicle is traveling forward it will be subjected to the maximum cooling effect of the air.

The blower and spark ignition mechanism are, in my present system all operated electrically, and are supplied with current for this purpose by a suitable storage battery M mounted in any convenient place on the automobile frame. This battery supplies current for the various purposes at a constant voltage, but in order to keep the battery properly charged, and thereby avoid any necessity of changing batteries, I provide a charging generator or dynamo N which in practice is driven from the engine H through the differential gearing on the rear axle of the vehicle. In the drawing however, it is merely illustrated diagrammatically in its general location. One terminal of this generator is connected to ground by the conductor N^1 and the other terminal is connected to one terminal of the battery by the conductor N^2. The other terminal of the battery is grounded. This circuit is controlled, however, by an automatic low-voltage cut-out. Since the generator is necessarily driven at the variable speed at which the engine operates, there are times, due to this variable speed, when generator voltage falls below the normal charging voltage of the battery and, unless otherwise provided for, would result in an undesirable reversal or counter-flow of current in the charging circuit. For this reason I arrange to automatically connect and disconnect the generator depending upon the voltage conditions at any instant. In the present arrangement this consists of a solenoid having two windings N^3 and N^4, and a switch actuated by its movable core. This switch, consisting of the two contacts N^5 and the bridging member N^6, controls the continuity of the charging conductor N^2 in which is also included the winding N^3 of the solenoid. This winding is of low resistance and capable of carrying all of the

charging current from the generator. The winding N^4 is preferably of high resistance and consumes very little current. It is connected directly to ground from the conductor N^1 in shunt of the heavy winding, but this winding will not be energized to pull up the core until the generator voltage is normal or above normal. When the voltage is normal the solenoid closes the switch and completes the charging circuit. Both windings are cumulative when the current flows in the proper direction but any tendency of the current to reverse will render the windings differential, deënergize the solenoid and cause the switch to open. The winding N^3 also serves to more firmly hold the switch closed when the normal conditions exist.

The blower which forms a part of the fuel atomizer mechanism hereinbefore described is driven by a small electric motor P which is illustrated diagrammatically in the drawings but which in practice is mounted on the blower shaft. This motor is preferably of the shunt wound type and one terminal of its armature is grounded by means of the conductor P^1 and, the other terminal is connected in the circuit including the conductor P^2 which leads from battery M. The conductor P^2 may be referred to as the main current supply leading from the battery and includes a manual switch W by which the operator controls the entire combustion system. This switch may be of any suitable type and is illustrated diagrammatically as being located on the steering wheel Y of the automobile. The shunt field P^3 is connected in a shunt circuit to ground formed by the conductor P^4 leading from conductor P^2 and deriving its energizing current therefrom. This shunt field also includes a resistance P^5 in series therewith and when this resistance is in circuit the minimum current flows in the shunt field circuit and the blower motor operates at the greater of two speeds, at which it is designed to operate, thus supplying the maximum quantity of air and fuel to the combustion zone. In the present system, this maximum speed is the normal operating speed of the blower, and the quantity of fuel consumed as a result is capable of meeting the predetermined maximum demands for which the plant is designed. When the field resistance is cut out of the circuit, the maximum current flows in the field, rendering this field stronger and reducing the speed of the motor. These operating conditions are controlled by a regulator which is arranged to be responsive to the pressure conditions in the steam generator. This regulator consists of a cylinder Q in which a piston Q^1 operates against the action of a spring Q^2. The cylinder is connected by means of the pipe Q^3 with the lower water manifold 14 of the generator so that the piston will be directly responsive to the pressure of steam in the generator. This regulator actuates two switches Q^4 and Q^5 which are carried on small pivoted arms Q^6 and Q^7 respectively. A spring Q^8 positioned between the arms tends to close both switches. These switch arms project into the path of two projections Q^9 on an extension of the regulator piston and are arranged to be actuated by the movement of said piston. As before explained the piston responds to variations in pressure in the generator. At normal pressure conditions the switch Q^5 is held open and the switch Q^4 closed. Switch Q^5 controls a ground shunt circuit P^6 around the field resistance P^5, and, upon a predetermined increase in steam pressure above normal, the pressure regulator closes this shunt circuit, thus strengthening the motor field and reducing the speed of the motor, the effect of which is to reduce the fuel supplied to the generating unit until the pressure again becomes normal, whereupon the speed of the motor is again restored to normal. However, should the pressure abnormally increase beyond a point where the reduction of fuel will take care of the situation, the regulator actuates switch Q^4 and opens the circuit of the entire combustion system until the pressure is reduced. To be specific the normal pressure is intended to be between 400 and 500 lbs., and at 500 lbs. the motor speed is reduced, and at 600 lbs. the entire combustion system stops. Thus the entire combustion system is under the control of the logical factor, namely the steam pressure, in a plant of this character, and this control and regulation is entirely automatic.

As a matter of precaution in the event by any chance that the water level in the generator drops to a dangerously low point, I provide a low-water cut-out which controls the main circuit to the entire combustion system. This consists of a switch R contained within a box mounted outside of the generator casing and positioned to be actuated by one of the lower or water headers 11 of the generator. This switch consists of a pivoted arm controlling the contacts R^2 through which the main current supply conductor P^2 extends from battery.

The initial ignition mechanism, involving the sparking device and auxiliary atomizer, is only needed momentarily at the time when combustion is to be initiated. The operation of this mechanism is of course required whenever abnormal conditions bring about the discontinuance of the combustion system and the necessity of re-ignition. Re-ignition of the main mixture may be brought about by the intensely heated condition of the combustion chamber if the period of idleness has not been long enough to dissi-

pate the heat. In any event, however, I do not rely upon this heated condition of the combustion chamber to re-ignite the main atomizer mixture. Instead, I arrange the sparking and auxiliary atomizing mechanism so that it will be brought into operation each time the main atomizing mechanism is started, and substantially simultaneous therewith. I further arrange said mechanism so that it will remain in operation for a pre-determined period of time (long enough to insure ignition of the main mixture) and then be automatically discontinued or cut off and restored to normal ready for a subsequent operation. I provide a solenoid, the energizing winding E^3 of which is connected directly to ground and to the main conductor P^2 by the conductor E^4; hence, whenever the main circuit which includes the conductor P^2 and motor is closed, either by the operator's manual switch or by the pressure regulator switch, the solenoid will be energized, and will remain energized as long as the said circuit is closed. The core E^5 of the solenoid pulls up and closes the circuit of the primary winding E^6 of the spark coil hereinbefore mentioned, this circuit comprises the conductor E^8 connected to the contact of the primary winding E^6 and spark coil interrupter E^9 to ground. This circuit, however, is normally open at the contacts E^{10}. These contacts are adapted to be bridged by a contact arm E^{11} mounted on the solenoid core extension, and are arranged so that the circuit will be first closed and then opened during the pulling-up movement of the solenoid core. Thus the spark will be applied and then disconnected, and will remain disconnected so long as the solenoid core remains energized, with the result that the duration of the spark is momentary. This period of time, however, can be readily regulated, and in the present arrangement the solenoid core extension has a piston which operates in a dash-pot cylinder E^{12}, the action of this dash-pot being regulated by a suitable valve E^{13}. Thus the period of time during which the bridge member traverses the contacts can be determined as desired. In practice I prefer that the spark be continued for a few seconds.

The auxiliary atomizer flame, as hereinbefore mentioned, plays in the path of the main mixture for the purpose of initiating combustion in said main mixture, but this flame need only be of sufficient duration to accomplish this purpose which in practice is practially instantaneous. The auxiliary flame may then be discontinued until again needed. A valve, hereinbefore mentioned, controls the flow of air to the atomizer nozzle and, in order to simplify the mechanism this valve is arranged to be operated by the same solenoid which controls the sparking mechanism, this being possible because the auxiliary spray and the spark for igniting it are required at the same time. This valve C^5 is connected in the air line C^3 leading to the air nozzle D^2. As shown diagrammatically in the drawing, the valve casing is formed at the side of the dash pot, and has a chamber C^6, with which the section of the pipe line C^3 communicates through suitable ports. These ports have valve seats C^7 spaced apart and provided for a valve member C^8. When this valve member is on either of said valve seats, the flow of air to the nozzle is stopped, but during its movement from one seat to the other, the air will flow through the valve chamber and ports to supply the atomizer D^2. The valve member has a valve rod which is connected to an arm C^9, on the solenoid core extension, and is thereby actuated by the solenoid and simultaneously with the sparking mechanism. Thus the ignition mechanism is automatically brought into operation, each time normal conditions are restored in the steam generator, to re-ignite the main atomizer spray, and then automatically discontinued after operating for a comparatively short period of time. When the pressure regulator operates and cuts off the blower and ignition mechanism, the solenoid becomes deënergized and restores its core to normal position. In restoring, however, the switch which controls the sparking mechanism will be momentarily closed on the return movement of the core, but since there is no current in this circuit no spark will be produced at the sparking terminals. Further, the valve which controls the air for the auxiliary atomizer is opened, and in this case the air will flow momentarily, but I arrange the mechanism so that the core will return quickly; hence the momentary spray will be of no consequence.

I claim:

1. In a system for the regulation of the steam power-plant of steam-driven vehicles, the combination of a steam generator, a liquid fuel burning device comprising a blower and liquid fuel atomizer, an electric motor for driving said blower, a circuit including a source of current for said motor, a regulator responsive to steam pressure for controlling the circuit of said motor, an igniter for said liquid fuel burning device comprising a liquid fuel atomizer and a sparking device, and means for controlling said liquid fuel atomizer and sparking device for momentarily operating said igniter.

2. In a steam-driven automobile power plant, the combination of a steam generator, a liquid-fuel atomizer, a blower for operating said atomizer, a motor for driving said blower, an electric spark igniter for igniting the fuel from said atomizer, means responsive to steam pressure for stopping and

starting said motor and igniter, and an automatic controller for limiting the time of operation of said igniter upon being started by said pressure-responsive means.

3. In a steam-driven automobile power plant, the combination of a steam generator, and a liquid fuel burning device therefor comprising a motor-driven blower and a liquid-fuel atomizer, an auxiliary ignition device for said liquid fuel burning device, an electric sparking device for igniting said auxiliary device, a regulator responsive to pre-determined variation in steam pressure for starting and stopping said motor driven blower, and means for cutting off said sparking device at a predetermined time interval after said motor-driven blower is started.

4. In a steam-driven automobile power plant, the combination of a steam generator, and a liquid fuel burning device therefor comprising a motor-driven blower and a liquid-fuel atomizer, an auxiliary ignition device for said liquid fuel burning device, an electric sparking device for igniting said auxiliary device, a regulator responsive to pre-determined variations in steam pressure for starting and stopping said motor driven blower, and electro-magnetic mechanism controlled by said pressure-responsive regulator for cutting off said sparking device at a pre-determined interval after said regulator has started said blower.

5. In a steam driven automobile power plant, the combination of a steam generator, a main liquid fuel burning device therefor, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, automatic mechanism for controlling said main liquid fuel burning device in accordance with generator conditions, and means for governing the duration of operation of said auxiliary liquid fuel burning device independently of said automatic mechanism.

6. The combination of a main liquid fuel burning device, an ignition device therefor, electrically-operated means for starting both the ignition device and the burning device, and electrical controlling means for discontinuing said ignition device after a fixed predetermined period of operation.

7. The combination of a main liquid fuel burning device, an ignition device therefor, automatic mechanism for repeatedly bringing said ignition device and main liquid fuel burning device into operation, and electrically operated means independent of said automatic mechanism for discontinuing said ignition device upon ignition of the main burning device.

8. In a steam power plant for automobiles, the combination of a steam generator, a liquid fuel burning device for said generator, a starting device for said liquid fuel burning device, a pressure regulator responsive to steam generator conditions for bringing said starting device into operation, and means independent of said regulator for discontinuing said starting device after a predetermined period of operation.

9. In a power plant for automobiles, the combination of a steam generator, an atomizer liquid fuel burning device, a motor-driven blower therefor, a circuit including said motor-driven blower, a starting device for said liquid fuel burning device, a circuit therefor, a source of current in said circuits, means for closing said circuits to start said liquid fuel burning device and starting device, and electromagnetic means for discontinuing said starting device in a pre-determined time after being started.

10. In a power plant for automobiles, the combination of a steam generator, a liquid fuel burning device therefor, a motor-driven blower for said liquid fuel burning device, a spark ignition mechanism for said liquid fuel burning device, a circuit for said motor blower and ignition mechanism, a steam pressure actuated device for controlling said circuit, and electromagnetically-controlled means for determining the period of operation of said ignition mechanism.

11. In a power plant for automobiles, the combination of a steam generator, a liquid-fuel atomizer burning device, a motor-driven blower therefor, a circuit for said motor blower including a source of current, a device responsive to steam generator conditions for controlling said circuit to regulate the fuel atomizer in accordance with said generator conditions, an auxiliary fuel atomizer ignition burner for said liquid fuel burning device, a source of air under pressure for said ignition burner, a sparking device for igniting said ignition burner, and an electromagnetic means for controlling said air and sparking device independently of said circuit-controlling device.

12. In a power plant for automobiles, the combination of a steam generator, a liquid-fuel atomizer burning device, a motor-driven blower therefor, a circuit for said motor blower including a source of current, a device responsive to steam generator conditions for controlling said circuit to regulate the fuel atomizer in accordance with said generator conditions, an auxiliary fuel atomizer ignition burner for said liquid fuel burning device, a source of air under pressure for said ignition burner, a sparking device for igniting said ignition burner, electromagnetic means for controlling said air and sparking device independently of said circuit-controlling device, and a manual operator's switch for controlling the circuits of said motor-driven blower, ignition and sparking device.

13. The combination of a fuel-burning device supplying a mixture of air and liquid

fuel and means for controlling said burning device, and an igniting mechanism for said liquid fuel burning device comprising a liquid fuel-atomizer and a sparking device for igniting the spray thereof, a source of air and means for supplying said air to the said atomizer, a source of current for said sparking device, and automatic means for controlling both the said air and current.

14. The combination of a liquid fuel burning device and ignition mechanism therefor, comprising a liquid-fuel atomizer and a spark igniter, a source of air for said atomizer, a source of current and a circuit for said spark igniter, and means for automatically controlling said air and circuit to cut off said ignition mechanism when said liquid fuel burning device becomes ignited.

15. The combination of a liquid-fuel burning device, an electric spark ignition device therefor, and means independent of said liquid fuel burning device for momentarily operating said ignition device whenever said liquid fuel burning device requires ignition.

16. The combination of a steam generator, a liquid-fuel burning device therefor, electrically-controlled means responsive to generator conditions for stopping and starting the operation of said liquid fuel burning device, and a momentarily-operating ignition device responsive to said starting and stopping means for re-igniting said liquid fuel burning device.

17. The combination of a motor-driven liquid-fuel atomizer, an electric spark-ignited liquid-fuel burning device for igniting said atomizer, electromagnetic mechanism operable, when energized, to control the operation of said spark-ignited liquid fuel burning device, a source of current, a circuit for said motor-driven atomizer and said electromagnetic mechanism including said source of current, and means controlling said circuit.

18. The combination of a motor-driven liquid-fuel atomizer, an electric spark-ignited liquid-fuel burning device for igniting said atomizer, electromagnetic mechanism operable, when energized, to control the operation of said spark-ignited liquid fuel burning device, a source of current, a circuit for said motor-driven atomizer and said electromagnetic mechanism including said source of current, and an operator's manual switch for controlling said circuit.

19. The combination of a motor-driven liquid-fuel atomizer, an electric spark-ignited liquid-fuel burning device for igniting said atomizer, electromagnetic mechanism operable, when energized, to control the operation of said spark-ignited liquid fuel burning device, a source of current, a circuit for said motor-driven atomizer and said electromagnetic mechanism including said source of current, a steam generator subject to the heat of said atomizer, and means automatically responsive to generator conditions for controlling said circuit.

20. The combination of a motor-driven liquid-fuel atomizer, an electric spark-ignited liquid-fuel burning device for igniting said atomizer, electromagnetic mechanism operable, when energized, to control the operation of said spark-ignited liquid fuel burning device, a source of current, a circuit for said motor-driven atomizer and said electromagnetic mechanism including said source of current, a steam generator subject to the heat of said atomizer, and a steam-pressure operated device for controlling said circuit.

21. In a steam-driven power plant, the combination of a steam generator, a liquid fuel burning device for said generator, a starting device for said liquid fuel burning device, means responsive to steam generating conditions for bringing said starting device into operation, and means independent of said last-mentioned means for discontinuing said starting device after a predetermined period of operation.

22. In a power plant for automobiles, the combination of a steam generator, a liquid fuel burning device therefor, a motor-driven blower for said liquid fuel burning device, a spark ignition mechanism for said liquid fuel burning device, a circuit for said motor blower and ignition mechanism, a device operable in response to the steam generator conditions for controlling said circuit, and electromagnetically-controlled means for determining the period of operation of said ignition mechanism.

23. In a steam-driven automobile power plant, the combination of a steam generator, a main liquid fuel burning device therefor, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, automatic mechanism for controlling said liquid fuel burning devices in accordance with the generator conditions, and means for igniting said auxiliary liquid fuel burning device.

24. In a steam-driven automobile power plant, the combination of a steam generator, a main liquid fuel burning device therefor, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, automatic mechanism for controlling said liquid fuel burning devices in accordance with the generator conditions, and an electric sparking device for igniting said auxiliary liquid fuel burning device.

25. In a steam-driven automobile power plant, the combination of a steam generator, an electrically-operated main liquid fuel burning device therefor, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, a sparking mechanism for igniting said auxiliary liquid

fuel burning device, a circuit for said main liquid fuel burning device and said sparking mechanism, and a manual switch for controlling said circuits.

26. In a steam-driven automobile power plant, the combination of a steam generator, an electrically-operated main liquid fuel burning device therefor, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, a sparking mechanism for igniting said auxiliary liquid fuel burning device, a circuit for said main liquid fuel burning device and said sparking mechanism, a manual switch for controlling said circuits, and automatic mechanism for controlling said main liquid fuel burning device in accordance with generator conditions.

Signed by me at Detroit, Mich., this 31 day of May 1917.

ABNER DOBLE.