

AUTOMATIC CONTROL FOR STEAM DRIVEN AUTOMOBILES.

Patented Dec. 17, 1918.

1,287,915.

3 SHEETS—SHEET 1.

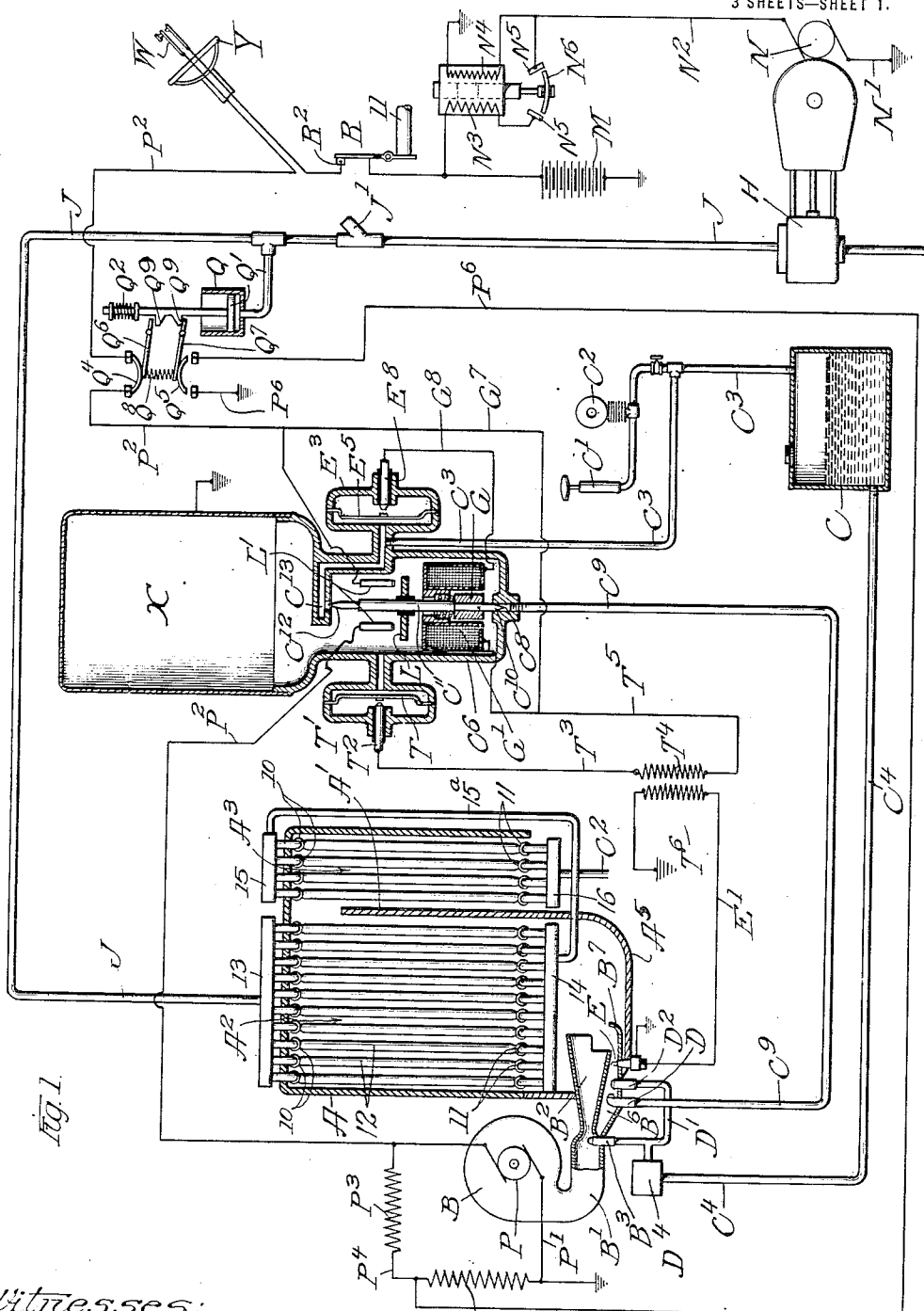


Fig. 1.

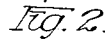
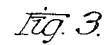
Witnesses:
Stephen Reboia
E. H. Cligg.

Inventor
Abner Doble
By: Charles E. Doughty attys:

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3 SHEETS—SHEET 2.

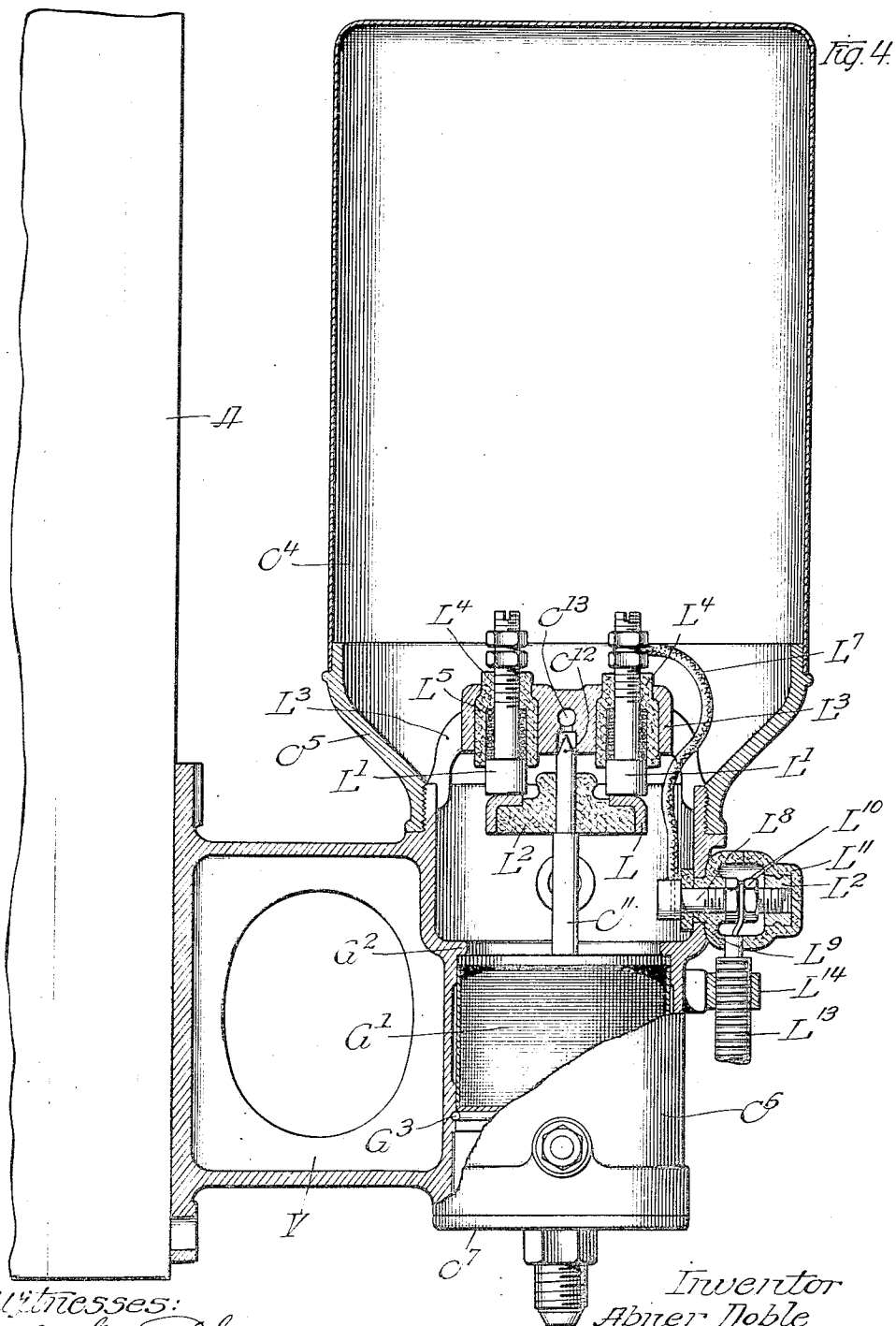


Inventor
of Abner Doble
By Charles C. Puckley
Attys:

A. DOBLE.
 AUTOMATIC CONTROL FOR STEAM DRIVEN AUTOMOBILES.
 APPLICATION FILED JULY 3, 1917.

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 3 SHEETS—SHEET 3.



Witnesses:
 Stephen Febrina
 E. H. Clegg

Inventor
 Abner Noble
 By Charles C. Calkins
 Att'y.

UNITED STATES PATENT OFFICE

ABNER DOBLE, OF DETROIT, MICHIGAN, ASSIGNOR, BY MESNE ASSIGNMENTS, TO DOBLE-DETROIT STEAM MOTORS CO., OF DETROIT, MICHIGAN, A CORPORATION OF DELAWARE.

AUTOMATIC CONTROL FOR STEAM-DRIVEN AUTOMOBILES.

1,287,915.

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Application filed July 3, 1917. Serial No. 178,513.

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 Automatic Controls for Steam-Driven Automobiles, of which the following is a specification.

My invention relates to improvements in power plants for steam driven vehicles, and particularly concerns the control and regulation of power plants of the character wherein the conditions of operation are peculiarly different from steam power plants for any other purpose, in that the demands upon the automobile type of plant are sudden and widely varying, and the response to these demands must be prompt and in accordance with conditions of operation of the automobile.

My invention has for its object the provision of means whereby to provide an improved system of automatic regulation in such power plants for steam-driven vehicles, thus relieving the operator of any control duties in the regulation or control of the generation of the steam, the particular object of my invention being to automatically prevent the main fuel supply from being delivered to the combustion chamber until and unless the controlling mechanism of the means for igniting the fuel is in a predetermined condition of operativeness.

Other objects of my invention will appear hereinafter.

Referring to the accompanying drawings:

Figure 1 is a diagrammatic view of a regulation and control system embodying my invention, the various mechanism involved being shown in their operating relation.

Fig. 2 is a top plan view of the automatic starter control mechanism.

Fig. 3 is a vertical central section substantially on the line 3—3 of Fig. 2.

Fig. 4 is a staggered vertical section substantially on the line 4—4 of Fig. 2.

The automobile power plant which I illustrate diagrammatically in Fig. 1, and in connection with which I will describe my invention, comprises in general a steam generator, a combustion chamber, a main liquid fuel burner and an ignition device or auxiliary burner for the main burner, all of which constitute a steam producing unit

for the rapid production of high pressure steam.

The steam generator involves in general a refractory lined casing or shell A open at its bottom and having a refractory partition or wall A¹ which terminates short of the top wall of the casing to provide communication for the passage of the products of combustion from the compartment A² to the compartment A³. In the compartment A² there is a plurality of upright evaporator units, each unit consisting of an upper and lower common header 10 and 11 respectively, and a multiplicity of parallel 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 A³ of the shell has a plurality of units constructed in the same manner and 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 underside of the compartment A² of the shell is a refractory bowl-shaped firepot A⁵ which together with the shell A forms a closed combustion chamber in which the fuel is burned for evaporating the water in the evaporator tube units. The products of combustion of the fuel pass upwardly in the compartment A² of the shell A between and around the evaporator tubes which are thus directly subject to the heat thereof, and in which the water is converted into steam. In these evaporator tubes a water level is preferably maintained in any suitable manner about half way up said tubes. The spent gases leave the compartment through the passage above the partition A¹ and thence pass downwardly through the compartment A³ and out into the atmosphere. The hot gases passing downwardly in the compartment A³ act to heat the water in the tubes on its way to the evaporator tubes, the heated water being conveyed from the upper manifold 15 to the lower manifold 14 by means of the pipe 15^a. The water is supplied to the generator from any suitable source through the pipe C²

which enters the lower water manifold 16. Further description of the structure of this steam generator is unnecessary in view of the fact that for the purposes of my present invention any suitable type of steam generator may be used.

The necessary heat for the generation of steam 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 burner apparatus disposed at one end of and outside the combustion chamber. A blower B supplies quantities of air for atomizing the fuel, forming a mixture therewith, and projecting the mixture into the combustion chamber. In actual practice the discharge outlet B¹ of the blower casing divides into two passages which are substantially parallel and which extend through into the firepot and form two Venturi atomizer tubes B². 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 B³, 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 C¹ and a power driven pump C² connected in a branch of an air pipe line C³ leading to the tank. The power pump C² is preferably driven by the steam engine which propels the vehicle, although in the drawing it is merely illustrated diagrammatically. The fuel is conveyed to the nozzles by a fuel pipe line C⁴ leading from the bottom of the tank. In this line, however, is a float valve regulator D⁴ 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.

The steam producing unit is designed to utilize the heavier hydrocarbons, such as

kerosene, at normal or atmospheric temperature and without preheating or pre-vaporization, to transform 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. The structure illustrated in the drawing is provided with ignition starting 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 B⁶ 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 B⁷, so as to direct the flame from the auxiliary mixture into the path of the main mixture 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 D² connected, as diagrammatically illustrated, with the same supply of fuel as the main nozzles, by means of the pipe D¹, 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 is positioned to spray the fuel from the nozzle D² 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 instantly ignite by the electric spark produced at the terminals E of a suitable spark plug, these terminals being located in the chamber B⁶ in the path of the auxiliary spray. One of the spark plug terminals is grounded and the other connected by conductor E¹ to the secondary winding of a spark coil as herein-after 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 C³, although in this pipe line

there is provided a means for controlling the air as will hereinafter appear.

The blower and spark ignition mechanism are, in my present system, operated electrically, and are supplied with current for this purpose by 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, a charging dynamo N is provided, which in practice is driven by the steam 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 N¹ and the other terminal is connected to one terminal of the battery by the conductor N². The other terminal of the battery is grounded. This circuit is controlled, however, by an automatic low-voltage cut-out. Since the dynamo is necessarily driven at a variable speed, because of the variable speed at which the engine operates, there are times, due to this variable speed, when dynamo voltage falls below the normal voltage at which the battery is charged, and, unless otherwise provided for, there would result an undesirable reversal or counterflow of current in the charging circuit. For this reason the mechanism is so arranged that the dynamo is automatically connected and disconnected, depending upon voltage conditions, at any instant. In the present arrangement this mechanism consists of a solenoid having two windings N³ and N⁴, and a switch actuated by its movable core. This switch, consisting of the two contacts N⁵ and the bridging member N⁶, controls the continuity of the charging conductor N² in which is also included the winding N³ of the solenoid. This winding is of low resistance and capable of carrying all of the charging current from the dynamo. The winding N⁴ is preferably of high resistance and consumes very little current. It is connected directly to ground from the conductor N² in shunt of the heavy winding, but this winding will not be energized sufficiently to pull up the core until the dynamo voltage becomes normal or above normal. When the voltage becomes 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, deenergize the solenoid and cause the switch to open. The winding N³ also serves to more firmly hold the switch closed when the normal conditions exist.

The blower which forms a part of the fuel

burner or atomizer mechanism hereinbefore described, is driven by a small electric motor P, which is illustrated diagrammatically in the drawings, and 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 P¹, and the other terminal is connected in a circuit including the conductor P² which leads from battery M. The conductor P² may be referred to as the main current supply conductor leading from the battery, and includes a manual switch W. This switch of course is preferably located in a position accessible from the operator's position. By the manipulation of this switch the operator may control the entire fuel burning system to start and stop the operation thereof at will, provided, however, as will hereinafter appear, the starting mechanism is in a predetermined condition of operativeness.

This operator's 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 P³ is connected in a shunt circuit to ground formed by the conductor P⁴ leading from conductor P² and deriving its energizing current therefrom. This shunt field circuit also includes a resistance P⁵ in series therewith and when this resistance is in circuit the minimum current flows in the 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. The blower thus supplies less air and fuel to the combustion chamber. These operating conditions are controlled by mechanism responsive to generator conditions. In the present case this mechanism is 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 Q¹ operates against the action of a spring Q². The cylinder is connected by means of the pipe J with the upper-steam manifold of the generator so that the piston will be directly responsive to the pressure of steam in the generator. This pipe extends to and conveys steam to the propelling engine H, and has a suitable throttle J¹ therein for controlling the steam to said engine. This pressure regulator actuates two switches Q⁴ and Q⁵ which are

carried on small pivoted arms Q⁶ and Q⁷ respectively. A spring Q⁸ positioned between the arms tends to close the switches. These switch arms project into the path of the two projections Q⁹ 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 Q⁵ is held open and the switch Q⁴ closed. Switch Q⁵ controls a ground shunt circuit P⁶ around the field resistance P⁵, 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 Q⁴ 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 steam pressure, in a plant of this character, and this control and regulation is entirely automatic.

As a matter of precaution in the event 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 device consists of a switch R, which is, in practice, positioned to be actuated by one of the lower or water heads 11 of the generator. This switch consists of a pivoted arm controlling the contact R² through which the main current supply conductor P² extends from battery. In the event that the water level lowers to a point where there is danger of the generator tubes being damaged by excessive heat, the header lengthens by expansion and actuates the switch. Under these conditions the main circuit is opened and cuts out the entire combustion. This of course is restored upon the restoration of normal conditions in the generator.

As I have previously mentioned, the ignition of the main burners occupies but a very short period of time, hence for economical as well as other reasons, it is advisable to discontinue the starting igniter after each time it has performed its igniting operation. Furthermore, I find it to be of decided advantage to prevent the operation of the main burners unless the ignition mechanism is in its pre-determined or

proper condition of operativeness, and thus avoid flooding of the combustion chamber with fuel and the production of smoke and soot, which would result if the main burners were permitted to operate without the coincident operation of the starting mechanism.

In carrying out the idea of a pre-determined period of operation for the ignition mechanism, I store up an auxiliary charge of compressed air of sufficient volume, which, when released, properly operates the starting atomizer for a pre-determined period of time, and upon becoming exhausted, causes the ignition mechanism to discontinue. In the present arrangement I provide a reservoir X of a given capacity, in which I trap a charge of compressed air supplied from the main pressure tank as hereinbefore mentioned. This reservoir tank has at its lower end a tapered bottom head C⁵ (Fig. 3) into which a tubular casing C⁶ is screwed, this casing being in direct communication with the reservoir and containing the operating mechanism. The lower end of this casing has a removable cap C⁷. This cap has a port C⁸ which is connected directly with the air nozzle (Fig. 1) D of the ignition nozzle by means of the pipe C⁹ hereinbefore mentioned, and through which the trapped charge of air is released to the said nozzle. This discharge port C⁸ is controlled by the needle valve C¹⁰ formed at the lower end of a vertical valve stem C¹¹. The admission of air to the tank X is controlled by a needle valve C¹² formed at the upper end of the same valve stem C¹¹, so that both valves will be operated simultaneously. This valve controls an admission port or passage C¹³ formed in the casing C⁶ which terminates in a removable nipple C¹⁴ extending from the side of the casing. This nipple carries a pressure actuated diaphragm switch E³, consisting of a cup member E threaded thereon and having a passage leading to the interior of the cup. The cup also has a passage E⁴ leading to the interior thereof and connected to the pipe C³ hereinbefore mentioned, which leads from the fuel tank or main supply of compressed air C. The cup is covered by means of a diaphragm E⁵ to provide a pressure chamber through which the air passes to the controller reservoir X, so that the diaphragm is subject to and will be actuated by the pressure of the air. The diaphragm is clamped in place by means of a ring E⁶ threaded on the rim of the cup and this ring has a bridge member E⁷ which supports an electric contact in position to be engaged by the diaphragm when said diaphragm is pressed against it by reason of the existence of air under proper pressure in the main tank. The diaphragm grounds the contact through the grounded frame of the structure and closes

a circuit hereinafter described. This is the normal condition of this diaphragm switch so long as there is a supply of compressed air in the fuel tank. Should this supply fail
 5 by reason of leaks, failure of the air pump, or from any other cause, the diaphragm switch opens the circuit. This contact is in the form of a screw E^8 adjustably threaded in a flanged sleeve E^9 clamped in
 10 the bridge by a suitable nut E^{10} . The sleeve and contact are insulated from the structure by means of the insulating bushing and washers E^{11} , and the contact screw has suitable nuts to form a binding post to which
 15 an electric conductor may be attached.

The valve stem C^{11} is mounted on the movable core G of a solenoid G^1 which is contained within the lower portion of the casing C^6 and by which the core is actuated.
 20 This solenoid is preferably wound upon a spool removably held between an upper flange G^2 of the casing and a removable expansion ring G^3 , and it has a fixed core G^4 extending into the center of the spool in close
 25 relation to the movable core, to provide a more complete magnetic circuit. A coiled spring G^5 positioned in a socket in the fixed core, and, pressing on the movable core, maintains the exit or discharge port C^8 normally
 30 closed against the flow of air to the starting nozzle, and maintains the admission port C^{13} normally open so that the reservoir is normally in communication with the source of supply of compressed air as
 35 hereinbefore described. When the solenoid is energized, however, it actuates the valve stem and reverses these conditions, that is, it closes the admission port and traps the charge of air in the reservoir, and at the
 40 same time opens the discharge port. The opening of the discharge port releases the charge of compressed air in the reservoir which flows to the starter nozzle for a short period of time until the charge is exhausted.
 45 There is sufficient space between the stem and the fixed core, and between the movable core and the solenoid spool, to permit the air to flow freely from the reservoir into the lower portion of the casing C^6 . This
 50 solenoid is connected in a circuit (Fig. 1) from the main conductor P^2 , this circuit being comprised by the conductor G^7 , conductor G^8 , diaphragm switch E^3 , to ground through the casing. The solenoid winding
 55 is connected to the binding posts G^9 (Fig. 3) extending into the interior of the casing and suitably insulated therefrom, and the conductors G^7 and G^8 are connected to these binding posts on the outside of the casing.
 0 Thus it will be observed that when the operator closes the manual switch W , or the automatic devices close the main circuit upon the restoration of normal generator conditions as previously explained, the electro-
 35 magnet or solenoid operates the valves to

cut off the reservoir from the main compressed air supply and release the charge of air in the reservoir to operate the ignition mechanism. In the event, however, that the compressed air either in the main supply
 70 tank or the stored charge in the reservoir fails, there will be no pressure to actuate the diaphragm and the solenoid circuit will not be complete. Under these conditions, the ignition mechanism cannot be operated. Under
 75 normal conditions, that is, when the mechanism is in a predetermined condition of operativeness, and the solenoid circuit closed, the admission port will be maintained closed against the admission of air to the
 80 reservoir, even though the previous charge in the reservoir has become exhausted. I utilize this condition to determine the duration of the ignition spark for the starting atomizer. I provide another pressure actuated
 85 diaphragm switch T^1 constructed identically in the same manner and connected to the casing C^6 in identically the same way as the switch E^3 , as shown in Figs. 1 and 3. This switch needs no further detailed de-
 90 scription. The diaphragm T is acted upon by the air pressure in the reservoir to ground the contact T^2 . This contact is connected by conductor T^3 to one terminal of the primary winding T^4 of the spark coil. The other
 95 terminal is connected by conductor T^5 to the conductor G^7 , hence, at the same time, the solenoid circuit is closed the spark coil circuit will also be closed provided there is air pressure in the reservoir to operate the dia-
 100 phragm switch T^1 , since under this condition the air serves to maintain both the contact T^2 and the contact E^8 closed. Thus the ignition spark will be applied simultaneously with the air to the ignition atomizer.
 105 The spark will also be discontinued at the same time as the air by reason of the exhausted pressure in the reservoir permitting the diaphragm of switch T^1 to move away and open the spark coil circuit. This diaphragm
 110 switch, like the switch E^3 , normally grounds its contact while the pressure of air exists, but responds to the failure or absence of pressure to prevent the circuit from being completed by the operator or the automatic
 115 devices. The secondary winding T^6 of the spark coil has one terminal grounded and the other connected by conductor E^1 to the spark plug, as hereinbefore explained.

In order to prevent the operation of the
 120 main burners unless the starting ignition mechanism is in proper operating condition, I provide a switch in the motor circuit P^2 , which switch is operated by the solenoid whenever the solenoid is permitted to op-
 125 erate under normal conditions. This switch consists of a ring shaped member L arranged, when the solenoid is operated, to bridge a pair of contacts L^1 . The ring member L is mounted upon a suitable disk of in-
 130

insulating material L^2 which is carried by the valve stem. The contacts L^1 are supported by an arch or bridge member L^3 formed integrally with the upper end of the casing C^1 , and arranged to yield in order not to interfere with the seating of the admission valve. These contacts in the present structure consists of bolts with enlarged heads mounted to move vertically in the insulating bushings L^4 . Their upper ends are provided each with nuts to which conductors may be fastened. The insulating bushings L^4 have sockets in which the coil springs L^5 are positioned. The springs act upon the contact members and yieldingly hold said contact members in position to be engaged by the movable bridge member L . These parts are so arranged that, when the valve stem is in its normal condition, the motor circuit will be open, and when the valve stem is actuated to close the upper port and open the lower one, the motor circuit will be completed and the motor started in operation. Thus the motor blower and the main burners cannot be placed in operation unless the starting ignition is in proper condition to instantly ignite said main burners. At the side of the casing, I provide a pair of binding posts with which the contacts L^1 are connected by means of flexible conductors L^7 of any suitable kind so as not to interfere with the movement of said contacts. These binding posts consist of bolts L^8 with heads on their inner ends to which the conductors are fastened. These bolts extend through the casing wall and are insulated by a washer and bushing L^9 , and the nuts L^{10} clamp the bolts firmly in position. A housing is provided for each binding post so as to completely inclose the external connections, this housing consisting of a cup flange in the insulating bushing and a cap member L^{11} of insulating material screwed on the outer threaded end of the bolt. The cap has a metal nut L^{12} embedded therein, which engages the bolt. The conductors leading to these binding posts are preferably inclosed in flexible conduit L^{13} and this conduit is clamped by a clamping member L^{14} to take the strains off the binding posts.

It will be observed that the starting mechanism structure is built as a self-contained unit with none of its parts exposed, except the binding post with which the electrical connections are made. The casing has a suitable bracket V by which it may be attached to any convenient part of the automobile. In practice, this is preferably mounted upon the rear end of the steam generator. All of the operating parts are constructed so that they may be readily adjusted to proper operating conditions at the factory and, by reason of the character of the structure, will remain adjusted. Since all of the operating parts are completely in-

closed, there is no danger of dirt and grit affecting the operation of the structure.

Since the pressure switch E^3 is in open communication with the supply of pressure air in the fuel tank C , the diaphragm E^5 is in contact with the electric contact E^8 closing and holding closed the circuit to the solenoid G , so that whenever the main circuit is closed either manually by the operator at the steering wheel or in response to the steam pressure switch, the solenoid releases the pressure air to the igniter atomizer and also closes the fan motor circuit at L' . In the absence of this pressure air, the fan motor for the main fuel atomizer cannot be operated, nor can atomization take place in the igniter atomizer. Therefore this pressure air performs two functions, the one determining the operation of the main fuel atomizer by controlling the fan motor, and the other in supplying pressure air to the igniter atomizer, and in this sense may be well termed a starter both for the main fuel burner and the igniter.

I claim:—

1. The combination of a liquid fuel burner apparatus, with an ignition mechanism, said ignition mechanism comprising means for determining the operation of the said apparatus.

2. The combination of a liquid fuel burning apparatus, an igniter, a starting device therefor, said starting device controlling the liquid fuel burning apparatus and operating the igniter, and means whereby the operation of the liquid fuel burning apparatus is dependent upon the operation of the igniter starting means.

3. In a liquid fuel burning apparatus arranged to atomize hydrocarbon fuel by a blast of air, an igniting device therefor comprising an auxiliary liquid fuel burning apparatus also arranged to atomize hydrocarbon fuel by a blast of air, a starter for said auxiliary fuel burning apparatus comprising air under pressure for controlling the operation of the main fuel burning apparatus and operating the igniter.

4. The combination of a steam generator, an electrically operated liquid fuel burning mechanism therefor, a circuit and a source of current for said burner, means responsive to steam generator conditions for controlling said circuit, a starting igniter for said liquid fuel burning apparatus comprising a fuel atomizer and a sparking device, an operator's switch for controlling said starting igniter, and means controlling the liquid fuel burning apparatus mechanism and igniter, and operable only upon a predetermined condition of operativeness of said igniter.

5. The combination of a liquid fuel burning apparatus and a starting device therefor comprising an air nozzle, a liquid fuel

nozzle, an igniter, a supply of compressed air for said air nozzle, electromagnetic mechanism controlling the air to said nozzle and said igniter, and means operable upon the existence of a pre-determined pressure of said air for rendering said electromagnetic mechanism operable.

6. The combination of a liquid fuel burning device, ignition mechanism therefor, means for initiating the operation of said ignition mechanism, and means operable only upon the establishment of operation of said means for initiating the operation of said ignition mechanism to render said liquid fuel burning device operable.

7. The combination of a main liquid fuel burning device, an auxiliary burner for igniting said main burner, a control device for initiating the operation of both burners, a source of fluid under pressure for operating said auxiliary liquid fuel burning device, and means for rendering said control device effective only upon the presence of pressure on said operating fluid.

8. The combination of a steam generator and a fuel burning device, an auxiliary liquid fuel burning device for igniting said liquid fuel burning device, an operator's manual control device for initiating the operation of both liquid fuel burning devices, a source of compressed air for operating said auxiliary liquid fuel burning device, and means responsive to the presence of a predetermined pressure on said air for rendering said control device effective, and automatic mechanism responsive to generator conditions for controlling said liquid fuel burning devices.

9. The combination of a steam generator and a fuel burning device, an auxiliary burning device for igniting said burning device, an operator's manual control device for instituting the operation of both burning devices, a source of compressed air for operating said auxiliary liquid fuel burning device, means responsive to the presence of a predetermined pressure on said air for rendering said control device effective, automatic mechanism responsive to generator conditions for controlling said liquid fuel burning devices, and means for discontinuing said auxiliary after a predetermined period of operation.

10. The combination of an electrically operated liquid fuel burning device, a starting igniter therefor, comprising an air operated liquid fuel atomizer, and a spark ignition device therefor, a circuit and a source of current for said liquid fuel burning device, a source of compressed air for said starting igniter, and means subject to said compressed air for controlling said circuit.

11. The combination of an electrically operated liquid fuel burning device, a starting igniter therefor, comprising an air operated

liquid fuel atomizer, and a spark ignition device therefor, a circuit and a source of current for said liquid fuel burning device, a source of compressed air for said starting igniter, an electromagnetic mechanism for controlling said circuit to start the liquid fuel burning device, a circuit for said electromagnetic mechanism, a control switch for said circuit, and means subject to the pressure of said air for rendering the operation of said control switch effective.

12. The combination of a liquid fuel air operated liquid fuel burning device, a supply of compressed air sufficient to operate said liquid fuel burning device for a predetermined period of time, means for releasing said air to operate said liquid fuel burning device, a main fuel liquid fuel burning device adapted to be ignited by said air operated liquid fuel burning device, and means subject to the pressure of said air, at the supply for preventing the operation of said main liquid fuel burning device in the absence of said supply of air.

13. The combination of a main liquid fuel burning device, an auxiliary air operated ignition liquid fuel burning device therefor, a control device for starting said auxiliary liquid fuel burning device, and means preventing the operation of said main liquid fuel burning device when said control device for the auxiliary burner fails to operate.

14. The combination of a main liquid fuel burning device, an auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, a source of compressed air for operating said auxiliary liquid fuel burning device, an operator's control device for controlling the air from said source to said auxiliary liquid fuel burning device, and means for preventing the operation of said main liquid fuel burning device upon the failure of compressed air for said auxiliary liquid fuel burning device.

15. The combination of an electrically operated main liquid fuel burning device, an air operated auxiliary liquid fuel burning device for igniting said main liquid fuel burning device, a reservoir arranged to contain a supply of air for operating said auxiliary liquid fuel burning device for a predetermined period of time, and an electromagnetically operated valve mechanism for releasing the air to auxiliary liquid fuel burning device, and a source of current for said main liquid fuel burning device and valve mechanism.

16. The combination of a supply of compressed air, a reservoir connected with said supply and containing a pre-determined charge of said compressed air, control mechanism for cutting off said reservoir from said supply and for releasing the charge in the reservoir, a liquid fuel-burning device operated by the released charge of air, and

means for rendering said control mechanism ineffective when the air pressure fails.

17. The combination of a supply of compressed air, a reservoir connected with said supply and containing a pre-determined charge of said compressed air, control mechanism for cutting off said reservoir from said supply and for releasing the charge in the reservoir, a main liquid fuel burner controlled by said control mechanism, an auxiliary liquid fuel burning device operated by said released charge of air, and means for rendering said control mechanism ineffective when the air pressure fails.

18. The combination of a main supply of compressed air, a reservoir connected therewith and for holding a pre-determined charge of air, an electromagnetically actuated valve mechanism for cutting off said reservoir from said supply and for releasing the charge in said reservoir, a liquid fuel atomizer device operated by said released air during the period of discharge from the reservoir, a spark igniter for said burning device, and an automatic pressure switch arranged to discontinue said spark igniter upon the cessation of pressure in said reservoir.

19. The combination of a main supply of compressed air, a reservoir connected therewith and for holding a pre-determined charge of air, an electromagnetically actuated valve mechanism for cutting off said reservoir from said supply and for releasing the charge in said reservoir, a liquid fuel atomizer burning device operated by said released air during the period of discharge from the reservoir, a spark igniter for said burning device, and an automatic pressure switch arranged to discontinue said spark igniter upon the cessation of pressure in said reservoir, a circuit and a source of current for said electromagnetically operated valve mechanism, a manual switch for controlling said circuit, and an automatic pressure switch in said circuit arranged to prevent the operation of said valve mechanism in the event of failure of air pressure.

20. The combination of a main supply of compressed air, a reservoir for receiving a subsidiary charge of air and having an admission port connected with said supply and a discharge port, a fuel burning device connected with said discharge port, valve mechanism controlling said ports, an electromagnet for operating said valve mechanism to close said admission port and open the discharge port whereby the charge of air in said reservoir will operate said burning device, a sparking device for igniting said burning device, and a device responsive to variations in pressure for discontinuing said sparking device upon the cessation of pressure in said reservoir charge.

21. In a steam driven automobile power plant, the combination of a steam generator, a fuel burning device, a motor driven blower for operating said burning device, a circuit for said motor and means controlling said circuit, a starting igniter for said burning device, a main source of air under pressure, a pre-determined auxiliary source of air for said starting igniter supplied from said main source, valve mechanism for controlling the supply of air to said auxiliary source and from the auxiliary source to said igniter, electromagnetic means for operating said valve mechanism and said motor circuit controlling means, an automatic device operable to maintain said electromagnet deenergized to prevent the operation of said motor and igniter unless the pressure of air is at a pre-determined normal.

22. In a steam driven automobile power plant, the combination of a steam generator, a fuel burning device, a motor driven blower for operating said burning device, a circuit for said motor and means controlling said circuit, a starting igniter for said burning device, a main source of air under pressure, a pre-determined auxiliary source of air for said starting igniter supplied from said main source, valve mechanism for controlling the supply of air to said auxiliary source and from the auxiliary source to said igniter, electromagnetic means for operating said valve mechanism and said motor circuit controlling means, an automatic device operable to maintain said electromagnet deenergized to prevent the operation of said motor and igniter unless the pressure of air is at a pre-determined normal, a sparking device for said igniter, and an automatic device for discontinuing the spark when the air from said auxiliary source is exhausted.

23. The combination of a reservoir for air at a predetermined operating pressure, a liquid fuel burning device, means for releasing the air to said liquid fuel burning device, a sparking device for said liquid fuel burning device, and means operable to control said sparking device in response to pressure conditions of said air.

24. In an automobile power plant, the combination of a liquid fuel burning device, a reservoir containing a quantity of air under pressure for operating said liquid fuel burning device, a predetermined period of time while exhausting from said reservoir, a sparking device for said liquid fuel burning device, and a control device for said sparking device dependent for its operation upon the existence and absence of pressure in said reservoir.

25. The combination of a liquid fuel burning device, a reservoir arranged to contain a predetermined charge of air under pressure

sure for operating said liquid fuel burning device, releasing means for the air to said liquid fuel burning device, and means for automatically replenishing the charge of air in said reservoir after each discharge.

26. The combination of a liquid fuel burning device, a reservoir arranged to contain a predetermined charge of air under pressure for operating said liquid fuel burning device, releasing means for the air to said liquid fuel burning device, means for automatically replenishing the charge of air in said reservoir after each discharge, a sparking device for said liquid fuel burning device, and an automatic device normally maintaining said sparking device operative while pressure exists in said reservoir.

27. The combination of a liquid fuel burning device, a reservoir arranged to contain a predetermined charge of air under pressure for operating said liquid fuel burning device, releasing means for the air to said liquid fuel burning device, means for automatically replenishing the charge of air in said reservoir after each discharge, a main liquid fuel burning device arranged to be ignited by said liquid fuel burning device, and means contingent upon the operation of said liquid fuel burning device for rendering said main burner operative.

28. In an automobile power plant, the combination of a main liquid fuel burning device, an automatic starter for said liquid fuel burning device, means for operating said main burner contingent upon the operation of said starter, and manual control mechanism for said liquid fuel burning device dependent for its effectiveness upon the operative condition of said starter.

29. In an automobile power plant, the combination of a main liquid fuel burning device, an automatic starter for said liquid fuel burning device, means for operating said main burner contingent upon the operation of said starter, a steam generator, and control mechanism for said liquid fuel burning device responsive to generator conditions and dependent for its effectiveness upon the operative condition of said starter.

30. In an automobile steam plant, the combination of a steam generator and a fuel burning device therefor, an air operated starter for said liquid fuel burning device, an operator's control device for said starter, and means rendering said control device ineffective unless the starter is in a properly operative condition.

31. In an automobile steam plant, the combination of a steam generator and liquid fuel burning mechanism therefor, ignition mechanism for said fuel burning mechanism, automatic controlling means subject to steam generator conditions for controlling said

fuel burning mechanism, an operator's manual control device for controlling said fuel burning mechanism, and means rendering both of said controls ineffective in the event of failure of operation of said ignition mechanism.

32. In an automobile steam plant, the combination of a steam generator and liquid fuel burning mechanism therefor, ignition mechanism for said fuel burning mechanism, automatic controlling means subject to steam generator conditions for controlling said fuel burning mechanism, an operator's manual control device for controlling said fuel burning mechanism, means rendering both of said controls ineffective in the event of failure of operation of said ignition mechanism, and means for discontinuing said ignition mechanism upon a predetermined period of operation.

33. The combination of a reservoir tank for compressed air, valve means controlling the admission of air to said tank, valve means for controlling the discharge of air from the tank, an electromagnet for operating both of said valves, a circuit for said electromagnet, a pressure-actuated switch normally holding said circuit closed while pressure exists in the supply of air for said tank but adapted to open the circuit upon absence of pressure, and means effective to energize said electromagnet while said circuit is closed.

34. The combination of a reservoir tank for compressed air, valve means controlling the admission of air to said tank, valve means for controlling the discharge of air from the tank, an electromagnet for operating both of said valves, a circuit for said electromagnet, a pressure-actuated switch normally holding said circuit closed while pressure exists in the supply of air for said tank but adapted to open the circuit upon absence of pressure, an operator's switch effective to control the operation of said electromagnet while said circuit is closed, a liquid fuel burning device operated by the discharge of air from said tank, a spark igniter for said burner, a circuit for said spark igniter, and a pressure switch normally closing said circuit while pressure exists in said tank but operable upon predetermined decrease in pressure in said tank to open said circuit and discontinue said spark igniter.

35. The combination of a reservoir tank for compressed air, valve means controlling the admission of air to said tank, valve means for controlling the discharge of air from the tank, an electromagnet for operating both of said valves, a circuit for said electromagnet, a pressure-actuated switch normally holding said circuit closed while

pressure exists in the supply of air for said tank but adapted to open the circuit upon absence of pressure, an operator's switch effective to control the operation of said electromagnet while said circuit is closed, a liquid fuel burning device operated by the discharge of air from said tank, a spark igniter for said liquid fuel burning device, a circuit for said spark igniter, a pressure switch normally closing said circuit while pressure exists in said tank but operable upon predetermined decrease in pressure in said tank to open said circuit and discontinue said spark igniter, a main fuel burning device arranged to be ignited by said liquid fuel burning device, a motor driven

blower for operating said main liquid fuel burning device, a circuit for said blower, and a switch operable by said electromagnet for closing said motor circuit. 20

36. The combination with liquid fuel burning apparatus, and means for supplying fuel thereto, of ignition mechanism for said liquid fuel burning apparatus, said fuel supplying means embodying preventative means operable by said ignition mechanism whereby said preventative means control the fuel supplying means whenever the ignition mechanism is inoperative. 25

Signed by me at Detroit, Michigan, this 21st day of June, 1917. 30

ABNER DOBLE.