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A. C. STALEY

AUTOMOTIVE STEAM POWER PLANT

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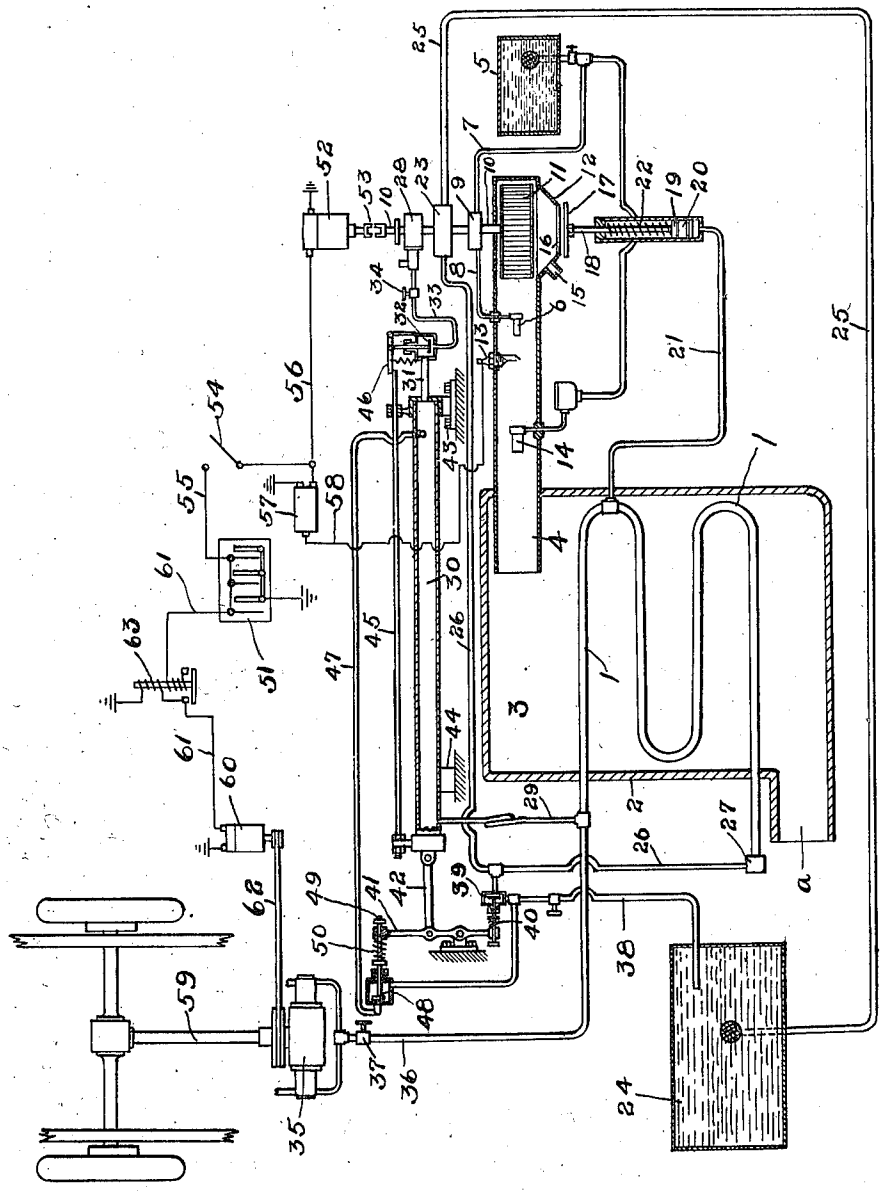

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AUTOMOTIVE STEAM-POWER PLANT.

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This invention relates to an automotive steam power plant and is particularly adaptable for use in connection with motor propelled vehicles, motor boats and the like, requiring an exceedingly simplified system whereby the same may be successfully operated by unskilled operators, the primary feature of the invention being the provision of a combined manually operated starting mechanism which is eventually converted into an automatic system for continued service.

A further feature of the invention is in so constructing and combining the various features of the invention that the temperature of the steam generated will control the operating mechanism while the pressure of the steam will be employed for controlling the fuel supply for generating the steam.

A still further feature of the invention is the provision of means for automatically cutting out the operating parts of the controlling mechanism in the event certain elements of the device fail to properly function.

Other objects and advantages will be hereinafter more fully set forth and pointed out in the accompanying specification.

In the accompanying drawings, the figure is a diagrammatic view of a steam power plant showing the same employed for driving a motor propelled vehicle, parts being shown in section.

Referring to the drawings, 1 indicates a steam generator of the single coil or continuous flow type which may be of any approved form, although in the drawings it is shown as consisting of a contra-flow type in which the water enters at the bottom of the coil and the steam is drawn off at the top thereof. The coil or steam generator 1 is preferably surrounded by a casing 2 in the upper portion of which is formed a furnace 3, and by entering the end of the burner 4 through the casing 2 and into the furnace section 3, the hot gases resulting from the combustion of fuel supplied by the burner 4 will be carried downwardly in the casing around the coils of the steam generator and discharged through a port *a* at the lower end of the casing.

In the particular type of burner shown, liquid is used as a fuel which may be contained in a tank or receptacle 5, the fuel from said tank being supplied under pressure to the spray nozzle 6 through the medium of suitable pipings 7 and 8 and a pump 9 which is connected with pipes 7 and 8. The pump 9 is connected with a main driving shaft 10, and mounted on said shaft is a suitable blower 11 which is encased in a housing 12 associated with the closed end of the burner 4, the blower wheel supplying the requisite air to the spray nozzle 6 for causing combustion, and said fuel is ignited preferably by a spark plug 13 entering the wall of the burner 4, preferably in advance of the spray nozzle 6 and in the path of the fuel discharged therefrom.

A secondary fuel nozzle 14, preferably of the aspirating type, is entered in the burner 4 ahead of the spray nozzle 6 so that the spray nozzle will act as a pilot for igniting the fuel emitted from the secondary nozzle, the blower wheel 11 determining the amount of fuel discharged from the secondary nozzle. Both nozzles 6 and 14 may receive their fuel from the same tank if the same fuel is used for both nozzles, and from separate tanks in the event one fuel is used for one nozzle and another fuel for the other nozzle.

The lower end of the housing 12 is provided with an opening 15 which has a constant area and sufficient air is drawn through this opening for supplying the pilot spray nozzle 6 while the enlarged orifice 16 is formed in the lower end of the housing 12 through which air is drawn to supply the secondary nozzle 14, and cooperating with the orifice 16 is a damper 17 so that varied amounts of air may be drawn through said orifice. The damper 17 is mounted upon a stem 18, which stem is entered into a cylinder 19 and has at its lower end a piston 20 which, when pressure is applied to the piston will move the damper towards the orifice 16 and graduate the supply of air passing therethrough. The lower end of the cylinder 19 is connected with the steam generator 1 through a pipe section 21 so that the pressure of the steam within the generator will regulate and control the amount of air passing through the orifice 16 by gradually forcing the damper 17 towards the orifice as the pressure of the steam increases.

As the pressure of the steam decreases in the steam generator the damper 17 is moved away from the orifice 16 through the medium of a compression spring 22 surrounding the stem 18 between the piston 20 and one end of the cylinder 19.

Also associated with the shaft 10 is a feed water pump 23 which supplies water from a water tank 24 through pipes 25 and 26, the pipe 25 extending from the tank 24 to the pump 23, while the pipe 26 extends from the pump 23 to the lower end of the steam generator or coil 1, a check valve 27 being provided for preventing a return flow from the steam generator into the pipe 26.

Also associated with the shaft 10 is an auxiliary steam engine 28 which is employed for driving the water pump 23, the fuel pump 9 and the blower wheel 11, the engine 28 receiving steam from the generator 1 through a pipe 29, thermostat 30, pipe 31, high temperature shut-off valve 32 and a pipe 33, the pipe 33 having a valve or throttle 34 therein for shutting off the steam from the engine 28. By conveying steam from the generator pipe 1 to the auxiliary steam engine 28 through the thermostat 30, and pipes connected therewith, the operation of the main driving engine 35 is not in any manner disturbed or affected by the operation of the auxiliary steam engine, as steam is conveyed to the driving engine through a pipe 36 extending directly from the steam generator 1 to the engine 35, the pipe 36 having a throttle valve 37 for cutting off the steam to the driving engine.

When the power plant is first started, the same being in a cold condition, water will circulate through the steam generator, and in order to prevent the same from choking the engines 28 and 35 the valves 34 and 37 remain closed, and due to the fact that the pump 23 is operating, water will be pumped from the tank 24 and forced through the pipe 26 towards the lower end of the steam generator 1, but as the steam generator is already filled with water, means is provided for returning the water to the tank 24 without necessarily passing through the steam generator 1, and to this end a pipe 38 is extended from the pipe 26 to the tank 24, a valve 39 intersecting the pipe 38 which is normally held in closed position by a spring 40, but the tension of said spring is less than the resistance of the check valve 27, consequently when the water is forced through the pipe 26 the valve 39 will open prior to the opening of the valve 27 and cause the water to descend through the pipe 38 into the tank 24 and not enter the steam generating coils 1.

The stem of the valve 39 is connected with a pivotally mounted rocking lever 41, said lever being pivotally connected to one end of the thermostat 30 by means of a link 42, consequently the expansion or contraction of the thermostat will operate the rocking lever 41 for closing and opening the valve 39. One end of the thermostat 30 is fixed to a bracket 43 while the opposite end thereof rests upon and has sliding engagement with a suitable guide 44, consequently when the thermostat expands or contracts it will move lengthwise and rock the lever 41 on its pivot. The high temperature shut-off valve 32 is controlled by the action of the thermostat 30 by mounting a rod 45 on the movable end of the thermostat and extending the rod longitudinally of the thermostat and in position to engage with a spring operated lever 46 employed for holding the valve 32 from its seat. The lever 46 is so constructed that so long as the free end thereof is in engagement with the rod 45, the valve 32 will be held unseated, but in the event of extreme temperature within the thermostat, resulting in extreme longitudinal expansion of the thermostat, the rod 45 will be moved out of engagement with the end of the lever 46 so that the valve 32 will be instantly closed, thereby cutting off steam from the auxiliary steam engine and stopping further operation of the entire power plant.

Prior to raising the temperature of the water to a prescribed degree, or until it is fully converted into steam, a certain amount of water and steam will enter the thermostat, and means is provided for preventing an accumulation of water and steam within the thermostat to such an extent as to choke the engine 28, after throttle 34 is opened, such means comprising a pipe 47 connected to the thermostat adjacent the fixed end thereof and extending into connection with the pipe 38 at a point below the valve 39.

In order to separate the steam from the water prior to its full conversion into steam a bleeder valve 48 intersects the pipe 47 thereby separating the steam from the water at this point and preventing the water from entering the engine 28. The stem 49 of the bleeder valve 48 is also connected with the rocking lever 41, but on the opposite side of the pivot of the rocking lever from the valve 40, consequently the bleeder valve 48 will be positively moved to closed position by the expansion of the thermostat 30.

The stem 49 has a spring 50 thereon, which when pressure is directed against it by the rocking lever 41, will close the valve 48, but will not fully close until the water within the upper portion of the steam generator has been fully converted into steam, at least to such an extent as to be taken into the engine 28, while the valve 39 is so arranged that it will still remain open after the valve 48 is closed, the spring 50 yielding on continued pressure being directed thereagainst by the rocking lever, consequently the supply of water passing through the

pipes 25 and 26 incident to the operation of the pump 23, will continue to flow through the pipe 38 into the tank 24 until such time as the thermostat 30 has sufficiently expanded to close the valve 39 thereby causing the water to overcome the resistance of the check valve 27 and enter the lower end of the coils 1.

In the event the engine is running under a light load and consequently necessitating less steam to operate the same, and as the pump 23 is throwing a constant and uniform stream of water the pressure within the coils will cause the water to overcome the resistance of and partially or fully open the valve 39 and return the surplus water to the tank 24.

It will further be seen that as a substantially constant flow of steam is passing through the thermostat 30, the temperature of the thermostat will be maintained substantially uniform, hence the valve 39 will likewise be maintained in a substantially fixed operative position, as it is controlled solely by the expansion and contraction of the thermostat. This will insure a substantially constant uniform feed of the water to the generating coils and as the auxiliary engine 28 is running at a substantially constant load, a substantially constant flow of steam will be fed to the auxiliary engine, giving a uniform sensitive close control between the water feed valve controlling the same and the engine driving the water feed pump, and which will not be influenced by the variable operations of the main engine.

Prior to generating steam to such an extent as to operate the auxiliary steam engine 28, it is necessary to provide means for rotating the shaft 10 for operating the various elements connected therewith, and to this end a storage battery 51 is employed for energizing an electric motor 52, and said motor is automatically connected with or disconnected from the shaft 10 by means of a clutch 53, a manually operated switch 54 being provided for closing a circuit through wires 55 and 56 connected respectively with the battery 51 and motor 52. A spark coil 57 is also connected with wire 56 and will be energized when the switch 54 is closed to energize the electric motor 52 and through a wire 58 the current is carried to the spark plug 13 for igniting the fuel discharged from the spray nozzle 6.

The engine 35 is connected to the driving shaft 59 of a motor propelled vehicle and in order to recharge the battery 51 a dynamo 60 is provided which is connected with the battery 51 through the wire 61, and the dynamo is driven from the driving shaft 59 in any suitable manner, as by means of a belt 62. To prevent discharge of the battery, due to the dynamo voltage falling below the battery voltage, incident to the operation of the main engine 35 at reduced speed, a reverse current relay 63 is positioned between the battery 51 and dynamo 60 and intersecting the wire 61.

In applying the power plant to use, as when the water within the feed generator is cold, the switch 54 is manually closed which will energize the electric motor 52 from the battery 51 thereby setting up operation of the auxiliary steam engine 28, feed water pump 23, fuel pump 9 and blower wheel 11, the closing of said switch also energizing the plug 13 so as to cause sparks to emit therefrom and ignite the fuel product discharged from spray nozzle 6. The air created by the blower wheel 11 will set up aspirating action through the secondary nozzle 14 and this fuel will be ignited from the spray nozzle 6. This action starts up the heating operation, but owing to the fact that the feed water pump 23 is also connected with the shaft 10, which operates the fuel pump 9 and blower wheel 11, circulation of water is set up through the pipes 25 and 26 and as the steam generating coils are already filled with water and owing to the resistance of the check valve 27, the water is shunted from the generator coils and is carried to the water supply tank through the pipe 38, the valve 39 being unseated.

During this firing-up process, the hot water and steam produced in the generator will pass through the pipe 29 into the hollow thermostat 30, and thence through the pipe 47 and bleeder valve 48 where the water is returned to the water tank 24. Incident to the increased temperature of the steam within the thermostat, said thermostat will expand, and incident to increasing the temperature of the steam to a prescribed degree the thermostat will have closed the valve 48 causing the steam to be discharged directly into the auxiliary steam engine 28.

As soon as the steam begins to operate the engine 28 the switch 54 is again opened, thereby cutting out the battery 51. The system will automatically operate for pumping fuel and water and for driving an air blast to the nozzles so long as the steam continues to enter the engine 28, and the amount of fuel aspirated through the nozzle 14 will be determined by the pressure of the steam within the coils from the fact that as the pressure increases the damper 17 will be gradually closed thereby reducing the volume of air passing through the orifice 16, and consequently lowering the aspirating effect of the air on the nozzle 14 and decreasing the amount of fuel discharged therefrom. Likewise, as the pressure decreases in the coils 1 the damper will open and the volume of air be increased for causing an increased supply of fuel to be aspirated from the nozzle 14.

When a vehicle is to be driven the throttle

37 is opened admitting steam directly from the heating coils to the main driving motor 35, and as the engine is arranged to drive the dynamo 60 the battery 51 will be recharged.

With this form of device it will be seen that the primary driving engine is in no manner employed for operating the steam power plant and that the steam to said engine may remain cut off until such time as it is desired to drive the vehicle.

By providing a separate engine for operating the power plant the pilot nozzle may be kept burning at all times which is an essential feature in cold and freezing weather, but it will be understood that the fuel to said nozzle may be cut off when the vehicle is standing idle by closing the throttle 34 and stopping the engine 28. In this event it will be necessary to employ the battery for re-energizing the power plant in the event that the steam remaining in the generator coils is insufficient to operate the engine 28.

In a continuous flow single tube steam generator the water is introduced at one end and is progressively heated until it is raised to the temperature at which the water will start to vaporize for the particular pressure involved, in this instance approximately 485° F. for 600 pounds pressure per square inch. This zone might be termed the preheating or economizing zone.

A further addition of heat will result in a conversion of the water into steam, and immediately after leaving the preheating zone, steam bubbles will form, increasing in numbers until at some particular point in the travel of the water and steam, all the water will be converted into steam. This zone of mixed water and steam is known as the evaporating zone.

By passing the steam through an additional length of tubing subjected to heat, the steam is now heated in the absence of water as no further water is available at this point for vaporization, hence the steam will be raised in temperature above that of vaporization and become superheated. The amount of superheat which the steam receives depends largely upon the length of tubing through which it must pass and to the amount of heat to which it is subjected before leaving the generator. By varying the superheating surface, which is done by advancing or retarding the water heating and evaporating zones by the admission of more or less water into the generator, it is possible to control the superheat thereby.

The mechanism shown in the accompanying drawing secures this variation or control in the following manner.

Suppose the main engine is operating at some predetermined load, such as half load, the valve 39 will be positioned by the thermostat so as to admit but a portion of the water pumped in the generating coils and the balance returned to the water tank. The thermostat to maintain this condition is subjected to some defined steam temperature, so determined by the adjustment of the mechanism.

In like manner it is necessary to supply the proper amount of heat to evaporate the water pumped and produce steam of the prescribed temperature. This is done by setting the pressure control of the heat supply means so that at some predetermined pressure, such as 600 pounds, the heat supplied will just maintain these conditions.

Now suppose the throttle to the main engine is opened or the load upon the generator is increased still further, the demand for steam from the generator is increased and steam removed from the generator faster than water is pumped in to take its place. As a result, the amount of water in the generator decreases, reducing the pressure therein and operates the heat producing elements so as to increase the amount of heat generated.

Furthermore, the evaporating zone is retarded and the superheating zone increased with the result that both the ratio of heat to water and the amount of steam superheating surface will have been increased. As a result the temperature of the steam must increase due to either or both of the above causes, the increased temperature causing the thermostat to expand. This action will further close the valve, 39 and cause a greater amount of water to enter the generating coils. At full load a still further drop in pressure will result and incident to such action the heat will be intensified to such a degree as to practically completely close the valve 39 and enter the entire volume of water being pumped into the generator. At relatively light loads the pressure will increase and the temperature fall until a uniform condition of temperature and pressure is established under these latter conditions. Thus it will be seen that there is a gradual increase in temperature and decrease of pressure with an increase in load, and for any particular load there is a definite temperature and pressure and this is constant at constant load. With this device a gradual variation of temperature and pressure is obtained, such as may be graphically represented by a line of smooth and even curvature while with the ordinary cut in and cut out structure, a fluctuating or uneven variation is obtained such as would be represented by a broken or jagged line, and this is true even though the engine is operating under constant load.

Having thus fully described my said invention, what I claim as new and desire to secure by Letters Patent, is:

In a steam power plant, a steam generator with burner and fuel supplying means therefor including means for supplying liquid fuel, a blower for causing a variable suction on said means, an air passage leading to the blower, a valve arranged to vary said passage in inverse proportion to the steam pressure, and an ever-open secondary air passage also leading to the blower, substantially as set forth.

In witness whereof, I have hereunto set my hand at Indianapolis, Indiana, this 28th day of August, A. D. nineteen hundred and twenty-two.

ALLEN C. STALEY.