Dec. 17, 1929. P. M. CABELL 1,739,749

APPARATUS FOR SUPPLYING STEAM TO INTERNAL COMBUSTION ENGINES

Original Filed May 2, 1925 2 Sheets-Sheet 1

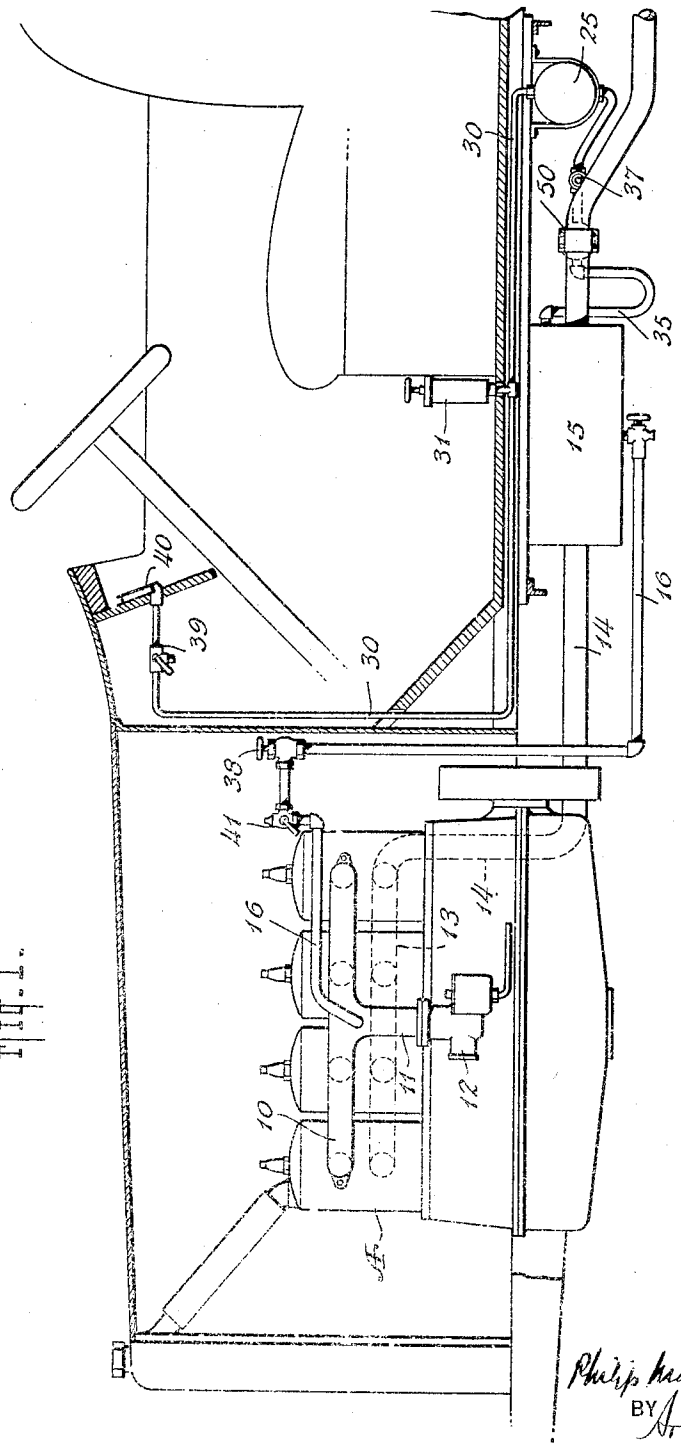


Fig. 1.

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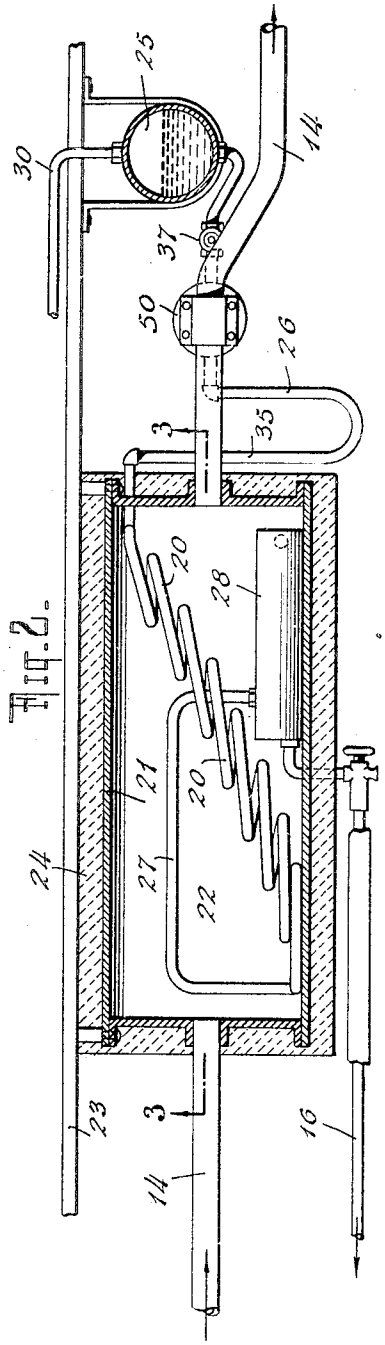


Fig. 2.

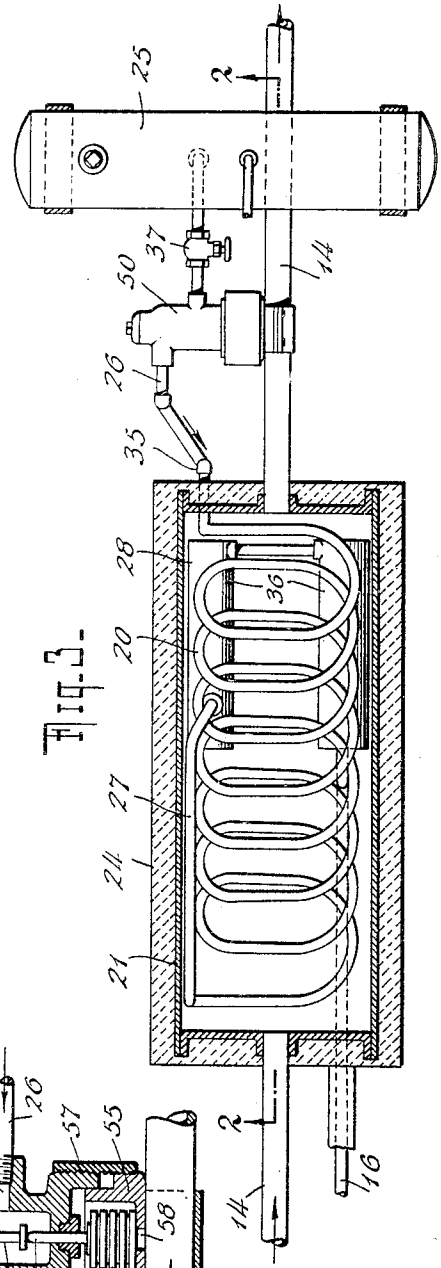


Fig. 3.

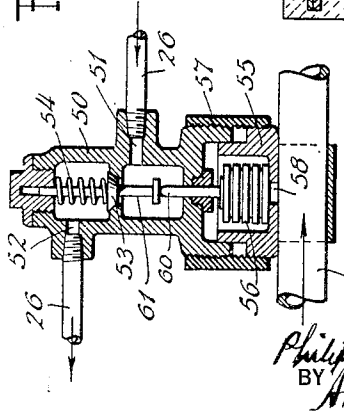


Fig. 4.

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Patented Dec. 17, 1929 1,739,749

UNITED STATES PATENT OFFICE

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APPARATUS FOR SUPPLYING STEAM TO INTERNAL-COMBUSTION ENGINES

Substitute for application Serial No. 27,422, filed May 2, 1925. This application filed March 20, 1929. Serial No. 348,677.

This invention relates to apparatus for supplying steam to internal combustion engines, and the invention aims to provide improved apparatus for this purpose by which steam for mixing with the carbureted air or other explosive gaseous mixture supplied to the engine cylinders may be supplied at a desired constant pressure and at a desired rate, and which apparatus shall be automatic in operation, supplying steam when the engine is in operation, and the generation and supply of steam being automatically stopped when the engine is not in operation. An advantage of my apparatus is that the steam, supplied at any desired pressure, which may be a very low pressure, may be superheated and supplied to the engine at a high temperature.

The invention has been made especially with the idea of providing apparatus for supplying steam to the engines of motor vehicles, but the invention is, of course, adaptable to internal combustion engines used for other purposes.

A full understanding of the invention can best be given by a detailed description of an approved form of apparatus embodying the same, and such a description will now be given in connection with the accompanying drawings showing such an approved form of apparatus. In said drawings:—

Fig. 1 is a view showing somewhat diagrammatically the internal combustion engine and other parts of a motor vehicle equipped with apparatus for supplying steam to the engine in accordance with the invention;

Fig. 2 is a view in elevation on a larger scale of the boiler or steam generator and water supply parts of the apparatus, the boiler casing being shown in section on line 2—2 of Fig. 3;

Fig. 3 is a plan view of the parts shown in Fig. 2, with the boiler casing sectioned on line 3—3 of Fig. 2; and

Fig. 4 is a central sectional view on a still larger scale of the thermostatically controlled water supply valve.

Referring to the drawings, Fig. 1 shows an internal combustion engine A having a mixture or intake manifold 10 to which the explosive mixture is supplied through an intake pipe 11 from a carbureter 12, and having an exhaust manifold 13, shown by dotted lines, from which the exhaust gases pass through an exhaust pipe 14. At a suitable point in the exhaust pipe 14 there is connected the casing of a boiler 15 from which steam passes through a pipe 16 to be supplied to the engine cylinders. The steam supply pipe 16 is shown as connected to supply steam to the intake pipe 11 adjacent the intake manifold 10.

The boiler or steam generator is of the flash boiler type formed by means providing an extended heating surface mounted within a boiler casing so that the extended heating surface will be maintained at a temperature materially above the boiling point of water by the combustion gases passing through the casing. As shown, and most desirably, the boiler is formed by a suitably coiled pipe 20 arranged to provide a relatively long downwardly inclined passage or conduit within a suitable casing 21 connected in the exhaust pipe 14 so that the exhaust gases will pass through the heating chamber 22 within the casing in contact with the boiler pipe 20. The casing may be hung from a member 23 of the chassis frame of the car and is desirably provided with a heat insulating covering 24. The steam pipe 16 is also desirably provided with an insulating covering. Water is supplied to the boiler from a tank 25 through a pipe 26 connected to the upper end of the boiler tube 20, and steam passes from the lower end of the boiler tube through a pipe 27 to an equalizing chamber 28 and thence to the engine through the pipe 16. The water is caused to flow from the tank 25 to the boiler coil by being maintained under pressure in the tank by air forced into the tank through a pipe 30, as by means of an air pump 31 shown in Fig. 1. The pressure under which the water is supplied to the boiler coil determines the pressure under which steam is supplied from the boiler. As the amount of water required for maintaining the desired rate of supply of steam to the engine is relatively small, a water tank of a size which

may be conveniently mounted on the car will hold sufficient water for operation over a relatively long period, and the maintaining of a substantially constant air pressure in the tank will require only infrequent operation of the air pump. The water supply pipe is provided with means whereby the flow of water therethrough to the boiler may be prevented by an opposing steam pressure. For this purpose in the construction shown the pipe includes an up-flow portion 35.

The equalizing chamber 28 is most desirably located within the boiler casing 21, so that the steam will be kept subject to the heat of the exhaust gases until it leaves the equalizing chamber. For convenience, the equalizing chamber is formed by a plurality of cylindrical tanks 36 which may be formed of short lengths of suitable sized tubing. A shut-off valve 37 is provided in the water supply pipe 26, and a valve 38 is provided in the steam supply pipe 16 for regulating the rate of supply of steam to the engine.

The operation of the apparatus as so far described is as follows:—When the engine is in operation the boiler pipe 20 is maintained by the hot gases passing through the chamber 22 at a temperature materially above the boiling point of water. The water under the pressure maintained in the tank 25 tends to flow through the pipe 26 into the upper end of the boiler pipe. Whenever the steam pressure is below the water supply pressure, water will enter the boiler and be immediately converted into steam which will flow to the chamber 28 and thence through the pipe 16 to the intake manifold of the engine at a rate dependent on the adjustment of the steam valve 38. When the steam pressure is equal to, or if it should become greater than, the water supply pressure, the steam acting on the water in the up-flow portion 35 of the water supply pipe prevents water from entering the boiler. When the steam pressure again falls below the water supply pressure, water will again enter the boiler and be immediately converted into steam and restore the steam pressure. The pressure in the boiler will thus be maintained approximately constant, and this is so regardless of the rate, within the capacity of the boiler, at which the steam is allowed to pass to the engine. The rate of supply of steam to the engine at a desired predetermined pressure may thus be varied as desired by adjusting the steam valve 38 and for any given setting of the valve 38, the rate of supply of steam may be varied by varying the steam pressure. The pressure at which the steam is supplied may be varied as desired by varying the pressure maintained in the water tank 25, that is, the pressure under which the water is supplied to the boiler. The pump 31 and a relief valve 39 serve as means for controlling the water supply pressure, and a pressure gage 40 is provided for indicating the pressure. The rate at which steam is supplied to the engine is best determined by adjustment and trial. To aid in such adjustment, a three-way valve 41 is provided in the steam pipe 16 between the valve 38 and the engine by which the steam may be discharged into the atmosphere for observation.

In order that the steam shall be superheated and supplied to the engine at a high temperature, the boiler pipe is desirably made of such length that steam generated in the upper part of the pipe will in passing on through the pipe be heated to approximately the temperature of the exhaust gases. The equalizing tank being located within the boiler casing and the supply pipe 16 being suitably insulated, the steam will be delivered to the intake manifold with but little drop in temperature. The first or upper portion of the boiler pipe should best have a considerable inclination as shown. The inclination of the portion in which the steam is superheated is not of importance.

It would, of course, be undesirable to permit water to enter the boiler when the boiler is not heated to the proper temperature for converting the water into steam, or that there should be any possibility of water flowing through the steam pipe to enter the intake manifold of the engine or the intake pipe 11 and so reach the carbureter. Instead of depending on the shutting off of the valve 37 for preventing such flow of water when the engine is not in operation or before the boiler has become properly heated, I provide means for automatically controlling the flow of water through the pipe 26. Such means as shown, and most desirable, consists of a thermostatically controlled valve connected in the pipe 26 and having its thermostatic element mounted to be influenced to open the valve by heat from the exhaust gases.

The device shown comprises a valve casing 50 having inlet and outlet ports 51 and 52, respectively, to which parts of the pipe 26 are connected and having the chamber within the casing divided between said ports by a partition which is ported and formed to serve as a valve seat for a valve 53 which when seated prevents the flow of water from the inlet port to the outlet port. The valve is pressed toward its seat and normally held closed by a spring 54. The end of the valve casing toward which the valve closes has adjustably secured thereto a part 55 which serves as a seat for a thermostatic element 56. The part 55 and the end of the valve casing are formed with telescoping flanges so as to provide a casing for the thermostatic element, and the part 55 is secured to the valve casing by a threaded connecting sleeve 57 internally threaded with right and left hand threads which extend inward from its two ends respectively, and which threads take on to ex-

ternal right and left hand threads formed on the valve casing and the part 55, so that by turning the connecting sleeve in one direction the part 55 may be adjusted toward the end of the valve casing, and by turning the sleeve in the other direction the part 55 may be moved off away from the end of the valve casing.

The thermostatically controlled valve device is desirably mounted on the exhaust pipe 14 as shown with the wall of the part 55 which forms the seat for the thermostatic element resting against the pipe. This wall is shaped to fit against the pipe and is formed with a central opening 58 through which heat from the pipe wall has direct access to the end of the thermostatic element. The thermostatic element, which may be of any usual or suitable form, and which as shown is of a well-known form consisting of an expansible container having a corrugated cylindrical wall and containing a fluid which will expand when heated, is seated on the part 55 over the opening 58 and has connected to its opposite end a rod 60 which extends through an opening in the end of the valve casing provided with a suitable stuffing box. When the thermostatic element expands the rod 60 acts to push the valve 53 away from its seat against the pressure of the spring 54, and when the thermostatic element contracts, the spring again closes the valve. As shown, the rod 60 presses against the end of a rod 61 extending from the valve.

When the exhaust pipe is cold the thermostatic element will be contracted and the valve 53 will be closed. When the engine is in operation, the exhaust pipe becomes heated and heat is transmitted to the thermostatic element, causing the same to expand, and when sufficiently expanded, to open the valve 53 to permit water to flow to the boiler. Adjustment of the sleeve 57 and thereby of the position of the thermostatic element with relation to the valve, will determine the degree to which the thermostatic element must be heated in order to open the valve and hold the valve open. The adjustment should be such that after the engine has been started the valve 53 will not be opened until the boiler has been heated to a sufficient degree to cause the entering water immediately to be converted into steam, and that when the engine is stopped, the valve will be closed before the boiler has cooled below such flash temperature.

By this automatically controlled valve the flow of water to the boiler is prevented except when the boiler is heated to a sufficient temperature for immediately converting entering water into steam, and the operator is relieved from all care in this respect. In starting the boiler it is desirable that water should be admitted slowly until a steam pressure corresponding to the water supply pressure has once been established. The automatic shut-off valve, because of the relatively slow and gradual action of the thermostatic element, operates to give this desired restricted slow flow of water in starting up the boiler.

In addition to the improvement in operation of the engine and the economy of operation resulting from supplying steam, and especially superheated steam, to the engine cylinders, and the advantages of the automatic control features as hereinbefore pointed out, my apparatus has the further important advantage that, because of the way in which the steam pressure is automatically maintained constant, the explosion hazard is eliminated. In this connection, it may be pointed out that, before any considerable excess pressure could be created in the boiler, water in the supply pipe 26 would be forced back by the pressure of the steam and the steam coming in contact with water in the pipe 26 or in the tank 25 would be condensed, thus preventing any substantial increase in pressure even under conditions which might otherwise result in a very great increase in pressure.

This application is a continuation of and substitute for my application Serial No. 27,422, filed May 2, 1925.

What is claimed is:

1. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler under pressure, means for preventing the flow of water to the boiler when the steam pressure exceeds a predetermined pressure and thereby maintaining a constant steam pressure, a connection for supplying steam for the boiler to the engine cylinder, and adjustable means for controlling the rate of delivery of steam to the engine cylinder.

2. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler under pressure, means for preventing the flow of water to the boiler when the steam pressure exceeds a predetermined pressure and thereby maintaining a constant steam pressure, a connection for supplying steam from the boiler to the engine cylinder, and an adjustable restriction in the steam supply passage between the boiler and the engine cylinder for controlling the rate of delivery of steam to the engine cylinder.

3. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler under pressure, means for preventing the flow of water to the boiler when the steam pressure exceeds a predetermined pressure and thereby maintaining a constant steam pressure, a connection for supplying steam from the boiler to the engine cylinder, means for controlling the rate of

delivery of steam to the engine cylinder, and means for varying the water supply pressure to vary the pressure at which the steam is maintained.

4. In combination with an internal combustion engine, a flash boiler, means for supplying water to the boiler under pressure, means for preventing the flow of water to the boiler when the steam pressure exceeds a predetermined pressure and thereby maintaining a constant steam pressure, a connection for supplying steam from the boiler to the engine cylinder, adjustable means for controlling the rate of delivery of steam to the engine cylinder, and heat-responsive means subject to the heat of a part of the engine system for preventing flow of water to the boiler when the temperature of said part is below a predetermined temperature.

5. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler at a predetermined pressure, means for preventing flow of water to the boiler when the steam pressure exceeds the water supply pressure and thereby maintaining the steam pressure equal to the water supply pressure, a connection for supplying steam from the boiler to the engine cylinder, means for controlling the rate of delivery of steam to the engine cylinder, and means for automatically preventing flow of water to the boiler when the engine is not in operation.

6. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler at a predetermined pressure, means for preventing flow of water to the boiler when the steam pressure exceeds the water supply pressure and thereby maintaining the steam pressure equal to the water supply pressure, a connection for supplying steam from the boiler to the engine cylinder, means for controlling the rate of delivery of steam to the engine cylinder, and heat responsive means operative to prevent flow of water to the boiler when the boiler is not heated to a suitable operating temperature.

7. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler at a predetermined pressure, means for preventing flow of water to the boiler when the steam pressure exceeds the water supply pressure and thereby maintaining the steam pressure equal to the water supply pressure, a connection for supplying steam from the boiler to the engine cylinder, means for controlling the rate of delivery of steam to the engine cylinder, and heat-responsive means subject to heat from the exhaust gases and operative to prevent flow of water to the boiler when the amount of heat passing off in the exhaust gases is below a certain minimum.

8. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler at a predetermined pressure, means for preventing flow of water to the boiler when the steam pressure exceeds the water supply pressure and thereby maintaining the steam pressure equal to the water supply pressure, a connection for supplying steam from the boiler to the engine cylinder having a restriction for controlling the rate of delivery of steam to the engine cylinder, means for automatically preventing flow of water to the boiler when the engine is not in operation, and means for varying the water supply pressure.

9. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, means for supplying water to the boiler under pressure, means for preventing the flow of water to the boiler when the steam pressure exceeds a predetermined pressure and thereby maintaining a constant steam pressure, a connection for supplying steam from the boiler to the engine cylinder, a valve in the steam supply connection for controlling the rate of delivery of steam to the engine cylinder, and a two-way valve between said valve and the engine cylinder operable to divert the steam for observation of the rate of delivery of the steam.

10. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, a source of supply of water under pressure, a conduit connecting said source of supply and the boiler formed to prevent flow of steam and water therethrough in opposite directions, a connection for supplying steam from the boiler to the engine cylinder having a restriction for controlling the rate of delivery of steam to the engine cylinder, a valve in said water supply conduit, means for opening and closing said valve including a thermostat, and means adjustable for varying the degree of temperature at which the valve is opened and closed.

11. In combination with an internal combustion engine, a flash boiler formed by a tortuous and continuously downwardly inclined pipe mounted within a chamber forming part of the exhaust conduit of the engine, a closed water tank, means for forcing air into said tank to maintain a desired pressure therein, a water supply connection from said tank to the upper end of said boiler pipe including an up-flow portion, a connection from the lower end of the boiler pipe for supplying steam to the engine cylinder, a valve in said water supply connection, and means for opening and closing said valve including a thermostatic element mounted to receive heat from the exhaust gas.

12. In combination with an internal combustion engine, a water tank, means for forcing air into said tank to maintain a desired

pressure therein, a pipe leading from said tank to the intake manifold of the engine and including an up-flow portion and a down-flow portion beyond the up-flow portion, the down-flow portion being located to be heated to a temperature materially above the boiling point of water by exhaust gas from the engine, a valve in said pipe beyond said down-flow portion for controlling the rate of flow of the steam to the engine, a valve in said pipe between said tank and said down-flow portion of the pipe, and means for opening and closing said valve including a thermostatic element mounted to receive heat from the exhaust gas.

13. In combination with an internal combustion engine, a flash boiler heated by waste heat from the engine, a source of supply of water under pressure, a water supply connection from said source of supply to the boiler having an up-flow portion, a steam supply connection for supplying steam from the boiler to the engine cylinder, a valve in said water supply connection, and automatic means for opening said valve gradually after the engine has been started and the boiler has been heated.

In testimony whereof, I have hereunto set my hand.

PHILIP MASON CABELL.