Nov. 27, 1934. J. McCALLUM ET AL 1,982,060

CONSERVATION OF HEAT WITHIN A STEAM POWER SYSTEM

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Fig. 2.

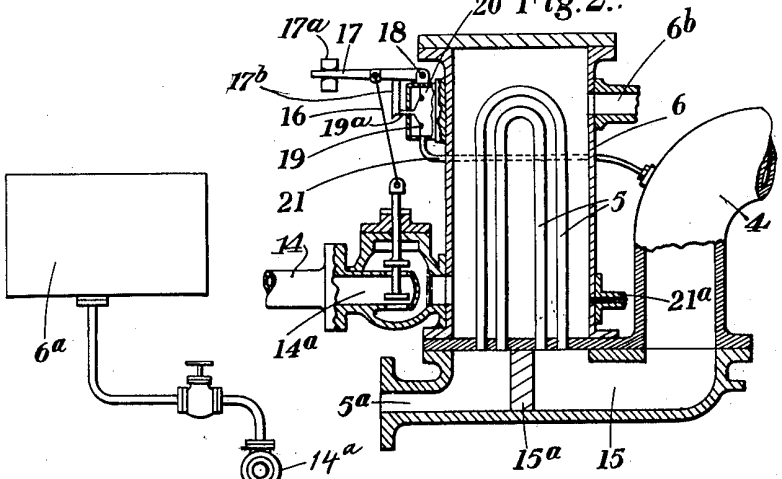

Fig. 1.

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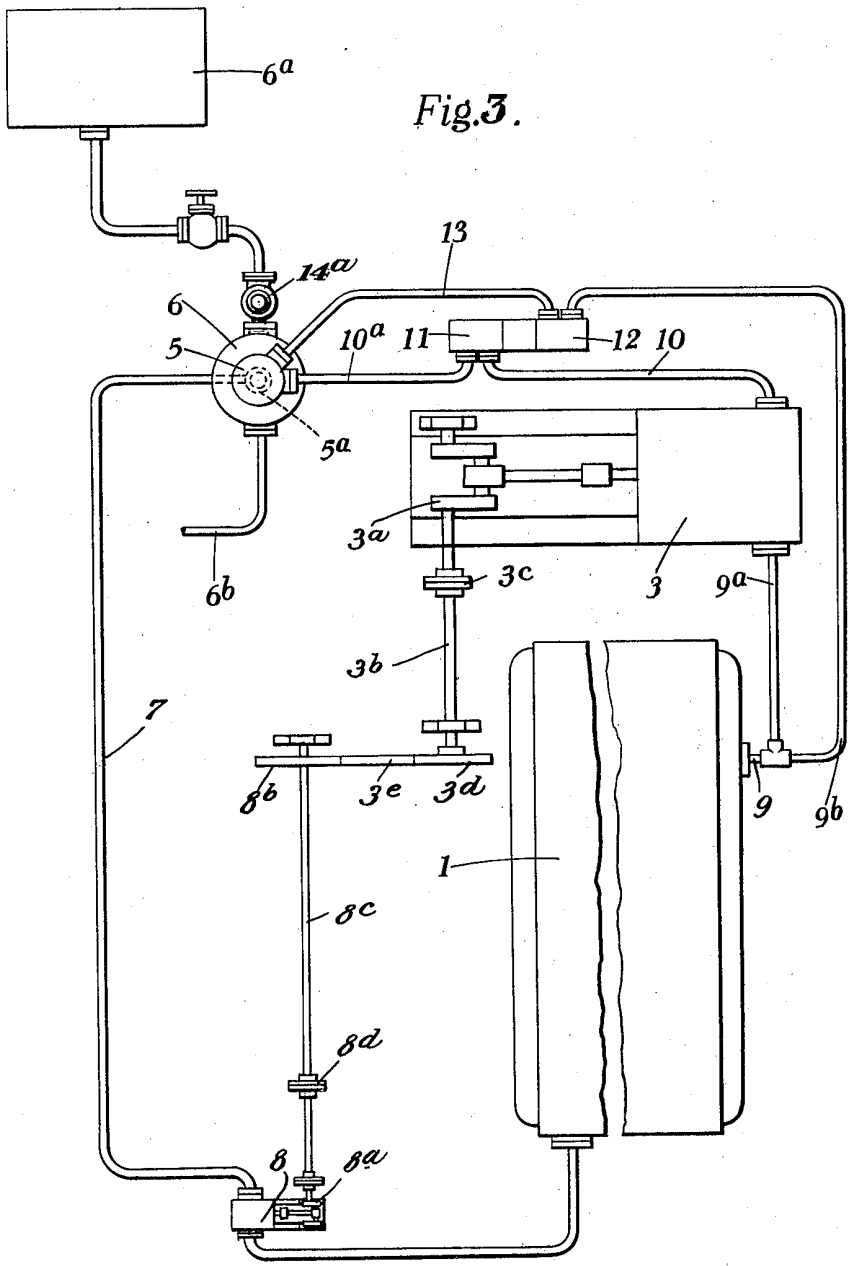
Fig. 3.



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CONSERVATION OF HEAT WITHIN A STEAM POWER SYSTEM

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In Great Britain August 7, 1925

11 Claims. (Cl. 60—92)

This application is a continuation in part of our application Serial No. 97,472, filed March 25, 1926 for Conservation of heat within steam power systems.

Our invention differs from prior arrangements in that whilst the exhaust steam is returned to the steam generator by pumping means, the said steam during its passage from the engine to the generator as hereinafter explained is not allowed to expand freely but is confined. More particularly, the exhaust steam is conducted to a receiver (such as a length or lengths of pipe of small diameter) in which its pressure falls somewhat and its temperature is positively reduced a few degrees by heat abstracting means (such as continuously flowing cold water applied to the exterior of the receiver) the drop in pressure and temperature being only sufficient partially to condense the steam and form "steam-water" i. e., steam mixed with water. Thereafter the water is drawn off by pumping means of which the capacity is not greater than the receiver, the uncondensed steam being entrained with the water and thereby passed back again into the generator.

The temperature of the receiver is maintained as constant as possible and to enable this to be done in accordance with the pressure of the exhaust steam from the engine, the flow of cooling water is under valve control (such as a diaphragm valve acted upon by the exhaust steam).

It is important that the steam entering the receiver be only partially condensed before being drawn off as it is necessary to entrain as much steam as possible with the water so as to return as much of the latent heat as possible to the generator. It has been found that the "steam-water" can be readily pumped into the water space of a generator in which the steam is maintained at a much higher pressure.

Briefly, therefore, the invention consists in providing means for the conservation of heat within a steam power system, comprising, in combination, a steam generator; a steam power unit driven by steam from the said generator; a relatively small receiver, such as a length (or lengths) of pipe of small diameter, for the exhaust steam from the steam power unit; means for abstracting heat from the exhaust steam entering the receiver so as to reduce the temperature of the said steam; means for regulating the rate of such heat abstraction in accordance with the pressure of the exhaust steam from the steam power unit, the stem in the receiver being converted into "steam-water" by being subjected simultaneously to the action of the heat abstracting means, and to the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and means for returning the "steam-water" to the water space of the steam generator, the exhaust steam not being allowed to expand freely but being confined during its passage from the steam power unit to the steam generator.

The formation of "steam-water" in the above circumstances is explained as follows:—

Let the original temperature and pressure of the steam in the receiver be t_1 and p_1 respectively, and let t_2 and p_2 respectively represent the temperature and pressure of the exhaust from the steam power unit. When fresh exhaust steam enters the receiver, the temperature of the resulting mixture of steam will tend to assume the value t_1, the temperature of the steam already in the receiver. Similarly the resulting pressure would tend to assume the value p_1, the pressure of the steam in the receiver. But steam at a temperature t_2 and a pressure p_2 is being continually supplied to the receiver by the exhaust of the steam power unit. Hence, the volume being constant and heat being abstracted from the steam by the cooling means, the pressure p_1 corresponding to the temperature t_1 can only be attained by the deposition of water from the exhaust steam, which deposition accordingly takes place when the exhaust steam enters the receiver.

The invention will now be described by way of example, and with reference to the annexed drawings, in which:—

Fig. 1 is a diagrammatic plan view of one form of steam power system embodying the features of our invention.

Fig. 2 shows the exhaust steam receiver and pertaining parts in sectional elevation.

Fig. 3 is a view similar to Fig. 1 but of a modification.

Throughout the drawings the same references denote the same or similar parts.

Referring first more particularly to Figs. 1 and 2, numeral 1 denotes the generator from which high pressure steam is supplied, through the steam pipe 2, to the steam power unit 3, here represented as a single cylinder reciprocating engine. After doing work in known manner in the unit 3 the steam passes, by the exhaust pipe 4, to the exhaust steam receiver 5 provided with a restricted outlet 5^a. As shown in Fig. 2, the receiver 5 consists of a system of inverted U-shaped pipes 5 open at their one end to an inlet 15 in communication with the aforesaid exhaust

pipe 4 and at their other end to the aforesaid restricted outlet 5^a, the inlet 15 and the outlet 5^a being separated by the partition 15^a. The receiver 5 is jacketed at 6, and cold water from a suitable supply source, represented as a tank 6^a in Fig. 1, is allowed to flow constantly through the jacket, entering by way of the pipe 14 and leaving by the pipe 6^b. The rate of flow of cooling water through the jacket 6 is determined by a valve 14^a which is controlled automatically by the action of the exhaust steam from the steam power unit 3. To this end the valve proper is connected by a rod 16 to a lever 17 pivoted at 18 on a diaphragm box 20 containing a diaphragm 19 with a projecting pin 19^a bearing against a finger 17^b depending rigidly from the lever 17 which has an adjustable loading weight 17^a. Steam from the exhaust pipe 4 has access, by way of pipe 21, to the interior of the diaphragm box 20 at one side of the diaphragm. It is evident that deflection of the diaphragm 19 under the steam pressure raises the lever 17 about its pivot, by reason of the contact of the diaphragm pin 19^a and the finger 17^b, thereby opening the valve 14^a an amount proportional to the steam pressure.

As the outlet end 5^a of the receiver 5 is reduced the steam cannot escape freely from the receiver but is confined or delayed therein and while being so delayed it is acted on by the cooling water circulated through the jacket 6 and its temperature lowered below that of the exhaust steam in the pipe 4 of the system, the combined action of the compressive effect of the fresh quantities of entering steam and the sudden reduction of the temperature causing the steam in the receiver 5 to be converted into "steam-water" which is drawn off by the pipe 7 and returned by the pump 8 directly to the water space of the generator 1. The pump 8 is shown as a reciprocating pump having its crank shaft 8^a operatively connected with the crank shaft 3^a of the steam power unit 3. The connection may comprise a suitably journalled shaft 3^b coupled at 3^c to the crank shaft 3^a and having a chain wheel 3^d round which and a similar chain wheel 8^b on a shaft 8^c coupled at 8^d to the crank shaft 8^a there passes a driving chain 3^e.

The receiver 5 is not of large capacity and, as its outlet 5^a is reduced, the water of condensation in passing through the reduced outlet entrains the uncondensed steam with it, the steam and water passing to the pump 8, which is of smaller capacity than the receiver 5, and thence to the generator. It is important that the receiver 5 should be of small diameter so that the cooling water circulating through the jacket 6 will quickly act on the steam and partially condense it, the condensate being drawn off as it is formed and entraining a comparatively large volume of uncondensed steam. The temperature of the receiver 5 should be constantly maintained below that of the exhaust steam in the pipe 4 and in practice we have found that a temperature of about 5° F. lower than that of the exhaust steam in 4 is desirable.

In the modification illustrated by Fig. 3 the steam from the generator 1 passes by the pipe 9 and branch 9^a to the steam power unit 3. The exhaust steam from the unit 3 is led by pipe 10 to a pump 11 the motor 12 of which is driven by steam obtained from the generator 1 by way of the aforesaid pipe 9 and a second branch 9^b. The steam from the pump 11 is led into the exhaust steam receiver 5 by way of pipe 10^a and the steam from the pump motor 12 is also led into the exhaust steam receiver 5 by pipe 13. As fully described with reference to Figs. 1 and 2, the receiver 5 is water jacketed at 6. The "steam-water" formed in the receiver 5 is returned to the steam generator 1 by the pipe 7 and pump 8 as before.

With the arrangements described in the foregoing it has been found by experiment that while there is a certain loss due to the back pressure in the exhaust of the steam power unit, there is a marked acceleration of the generating action of the boiler and a consequent saving in fuel. By introducing a pump 11, 12 as in Fig. 3, the back pressure on the engine may be reduced.

In order that the invention may be carried readily into effect, we shall refer briefly to the particulars observed in the construction and operation of one embodiment comprising a single cylinder reciprocating engine.

The lever 17 is balanced by the weight 17^a to give a flow of cooling water through the jacket 6 surrounding the receiver 5 at the approximate rate of four pounds of water per minute, corresponding to the flow at the same time of one pound of exhaust steam. The lever 17 has a downwardly depending member 17^b thereon terminating in a cam shaped face 17^c against which the horizontally extending rod member 19^a, which is connected with diaphragm 19 abuts. As diaphragm 19 is moved toward the left under increased steam pressure, rod 19^a moves against the cam face 17^c of downwardly depending member 17^b tending to raise lever 17 and open the valve 14^a. As the steam pressure decreases, rod 19^a moves away from the cam face 17^c, thereby enabling member 17^b to fall. Balancing lever 17 follows in the downward path, resulting in the closing of the valve 14^a. The rate of heat abstraction in the receiver 5 is therefore regulated in accordance with the discharge of the exhaust steam. The area of the surface of the receiver 5 in contact with the exhaust is proportioned so that for each cubic unit of steam in the receiver about from two to three square units of cooling surface are provided, and the relation between the volume of the receiver 5 and the volume of the engine cylinder is approximately as 1 is to 3. During the operation of the engine, the rate of flow of the cooling water is regulated to approximately the value above specified by an inlet valve which is actuated, in known manner, in accordance with the variations of the exhaust steam pressure.

The feed pump for removing the so-called "steam-water" from the receiver is of the reciprocating type and is arranged so that the relative volumes of the pump barrel and engine cylinder are approximately in the proportion of 1 to 33. The area of the constriction at the bottom of the receiver and of the conduit leading from the receiver to the said feed pump is made approximately equal to twice the cross sectional area of a pipe suited to carry, under the same external conditions, ordinary water. The capacity of the said feed pump is kept in constant relationship with the discharge of the exhaust steam by driving the pump from the engine itself, or, should an independent drive for the pump be employed, by connecting the said drive to control means actuated in accordance with the fluctuations in pressure of the engine exhaust. To prevent loss of heat the said pump and its pipe connections may be lagged or insulated.

In starting up the system, the receiver may be heated, by admitting steam at 21a, to a temperature approximately equal to the temperature (about 240° F.) of the exhaust steam, but after the system has been in operation for a short time the exhaust steam will quickly impart heat to the surface of the receiver.

The steam generator of the system may be of any of the well known types, a vertical flue tube boiler being used in the present instance. As expelled from the engine, the steam (generated at 90 lbs. gauge pressure) has a resultant gauge pressure of 10 lbs., equivalent to a temperature of 240° F., and under these conditions the "steam-water" deposited in the receiver as before explained has a temperature of about 235° F., the initial and final temperatures of the water used to cool the receiver being approximately 50° F. and 190°–200° F. respectively.

It will be understood that the foregoing embodiment has been described merely by way of example and as showing what we have done experimentally and it is to be understood that we are not confining ourselves thereto but that various modifications and arrangements may be introduced, in so far as they fall within the scope of the appended claims.

This invention is peculiar in that a partial vacuum is not maintained in the receiver but a pressure which is somewhat less than the actual pressure of the exhaust and also that a temperature always somewhat less than the temperature of the exhaust is maintained constantly in the receiver the exhaust steam being passed rapidly to the receiver which is of comparatively small capacity so as not to permit of much expansion of the steam and to ensure that the whole body of the passing steam as it enters the receiver shall be reduced, in temperature, practically simultaneously throughout, when suddenly acted on by the cold produced by a heat abstracting means, such as constantly flowing water, the result being that the molecules of steam on entering the receiver are acted on by different pressures, the pressure in the receiver and the pressure in the exhaust pipe, and the reaction caused by the difference in pressure plus the drop in temperature, due to the sudden cooling action of the heat abstracting means, causes the steam to be suddenly converted into a steam water (containing a large part of the latent heat of the steam) which can be passed directly by means of a pump, or otherwise, back again into the steam generator.

In certain respects the action is the reverse of the well known flash boiler in which water passing into small highly heated tubes is suddenly converted into steam.

We claim:—

1. Means for the conservation of heat within a steam power system, comprising a steam generator including a water space therein; a steam power unit driven by steam from the generator; a receiver of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; said receiver including a pipe system, means surrounding said pipe system for effecting the abstraction of heat from the exhaust in the receiver; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected simultaneously to the action of the heat abstracting means and to the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and means for delivering the mixture of steam and water directly to the water space of the steam generator.

2. Means for the conservation of heat within a steam power system, comprising a steam generator having a water space therein; a steam power unit driven by steam from the generator; a receiver comprising a system of pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; means surrounding said system of pipes for effecting the abstraction of heat from the exhaust steam in the receiver; a pipe line extending between the steam power unit and the heat abstracting means and having a pump interposed intermediate its length; means for regulating the rate of the heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected to the action of the heat abstracting means, the action of the aforesaid pump and the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and means for returning the mixture of steam and water so formed directly to the water space of the steam generator.

3. Means for the conservation of heat within a steam power system, comprising a steam generator; a steam power unit driven by steam from the generator; a receiver comprising a system of pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; a chamber enclosing said system of pipes and providing a passage for the flow of liquid for effecting the abstraction of heat from the exhaust steam in the receiver; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected simultaneously to the action of the heat abstracting means and to the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and a pipe line extending between the receiver and generator and having intermediate its length a pump driven from the steam power unit for returning the mixture of steam and water from the receiver to the generator.

4. Means for the conservation of heat within a steam power system, comprising a steam generator; a steam power unit driven by steam from the generator; a receiver comprising a system of pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; means enclosing said system of pipes for effecting the abstraction of heat from the exhaust steam in the receiver; a pump interposed between the steam power unit and the heat abstracting means and having an operating motor driven by steam from the generator; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected to the action of the heat abstracting means,

the pump and the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and a pump driven from the steam power unit for returning the mixture of steam and water from the receiver to the generator.

5. Means for the conservation of heat within a steam power system, comprising a steam generator having a water space therein; a steam power unit driven by steam from the generator; a receiver comprising a system of pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; a chamber enclosing said system of pipes and constituting a water jacket for effecting the abstraction of heat from the exhaust in the receiver; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected simultaneously to the action of the heat abstracting means and to the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver, and means for returning the mixture of steam and water so formed directly to the water space of the steam generator.

6. Means for the conservation of heat within a steam power system, comprising a steam generator having a water space therein; a steam power unit driven by steam from the generator; a receiver comprising a system of U-shaped pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; a chamber enclosing said U-shaped pipes for effecting the circulation of a cooling fluid about the pipes and causing the abstraction of heat from the exhaust steam in the receiver; a pump interposed between the steam power unit and the heat abstracting means; means for regulating the rate of the heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected to the action of the heat abstracting means, the aforesaid pump and the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and means for returning the mixture of steam and water so formed directly to the water space of the steam generator, the capacity of said last recited means varying relatively to the capacity of the power unit.

7. Means for the conservation of heat within a steam power system, comprising a steam generator; a steam power unit driven by steam from the generator; a receiver comprising a multiplicity of U-bend pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the power unit is passed; a chamber for cooling water surrounding said pipes for effecting the abstraction of heat from the exhaust steam in the receiver; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected simultaneously to the action of the heat abstracting means and to the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and a pump driven from the steam power unit for returning the mixture of steam and water from the receiver to the generator.

8. Means for the conservation of heat within a steam power system, comprising a steam generator; a steam power unit driven by steam from the generator; a receiver comprising a system of pipes of which the volume is smaller than the volume of the working chamber of the steam power unit and into which the exhaust of the said power unit is passed; a fluid chamber surrounding said system of pipes for the circulation of cooling fluid around said pipes for effecting the abstraction of heat from the exhaust steam in the receiver; a pump interposed between the steam power unit and the heat abstracting means; means for regulating the rate of such heat abstraction in accordance with the discharge of the exhaust steam, the steam in the receiver being converted into a mixture of steam and water by being subjected to the action of the heat abstracting means, the pump and the compressive effect of fresh quantities of further exhaust steam at a higher temperature and pressure than the steam already in the receiver; and a pump driven from the steam power unit for returning the water deposited in the receiver to the generator.

9. In a steam power system comprising a steam generator, a steam power unit driven by steam from the generator, and means for pumping back the exhaust from the power unit to the generator, the combination of a pipe system through which the exhaust passes to the pumping means and the volume of which is smaller than the volume of the working chamber of the power unit, a chamber enclosing the pipe system for circulating a cooling fluid about the pipes, said chamber having cooling-fluid inlet and discharge connections, a valve disposed in the inlet connection, a diaphragm box, a diaphragm therein, means admitting exhaust from the power unit to the box to actuate the diaphragm in timed relation to operation of the power unit, and means operatively connecting the diaphragm and the valve, whereby the valve is opened and closed automatically in accordance with the prevailing steam pressure and the cooling is regulated so that a mixture of steam and water is formed in the pipe system for return to the generator by the pumping means.

10. In a steam power system comprising a steam generator, a steam power unit driven by steam from the generator, and means for delivering exhaust from the power unit to the generator, the combination of a pipe system through which the exhaust passes and the volume of which is smaller than the volume of the working chamber of the power unit, a fluid chamber enclosing the pipe system and having cooling-fluid inlet and discharge connections, a valve disposed in the inlet connection, a diaphragm box, a diaphragm therein, means admitting exhaust from the power unit to the box to actuate the diaphragm in timed relation to operation of the power unit, a pin projecting from the diaphragm through the box, a weighted lever pivoted adjacent the box, means on the lever contacting with the pin to cause movement of the lever with the diaphragm, and means connecting the lever with the valve, whereby the valve is opened and closed in accordance with the prevailing steam pressure and the cooling is regulated so that a mixture of steam and water is formed in the pipe system for return to the generator.

11. In a steam power system comprising a steam generator, a steam power unit driven by steam

from the generator, and means for pumping back the exhaust from the power unit to the generator, the combination of a pipe system through which the exhaust passes to the pumping means and the volume of which is smaller than the volume of the working chamber of the power unit, a chamber for a cooling fluid enclosing the pipe system and having cooling-fluid inlet and discharge connections, a valve disposed in the inlet connection, a diaphragm box mounted upon said chamber, a diaphragm therein, means admitting exhaust from the power unit to the box to actuate the diaphragm in timed relation to operation of the power unit, means operatively connecting the diaphragm and the valve whereby the valve is opened and closed automatically in accordance with the prevailing steam pressure, and means for relieving the back pressure of the power unit.

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