T. G. E. LINDMARK.

COMBINED POWER AND HEATING SYSTEM AND PROCESS.

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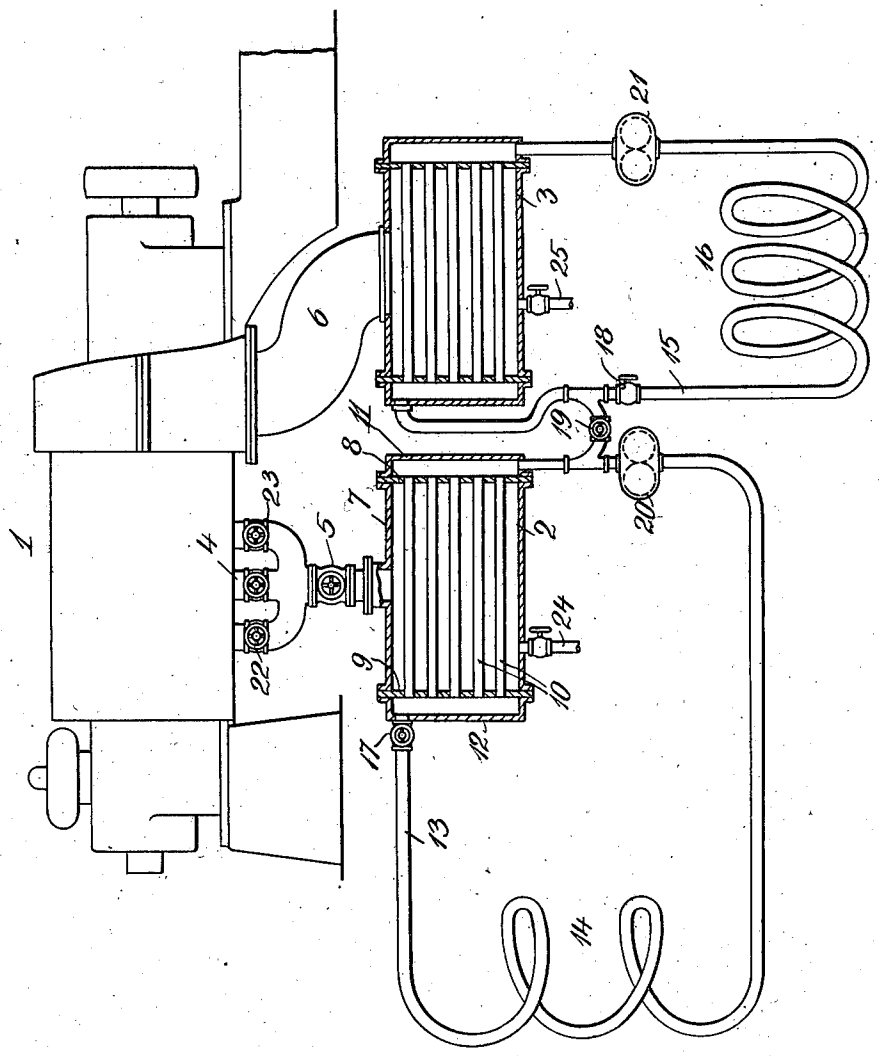

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UNITED STATES PATENT OFFICE.

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COMBINED POWER AND HEATING SYSTEM AND PROCESS.

1,090,485. Specification of Letters Patent. Patented Mar. 17, 1914.

Application filed March 20, 1913. Serial No. 755,691.

To all whom it may concern:

Be it known that I, TORE G. E. LINDMARK, a subject of the King of Sweden, and a resident of Stockholm, Sweden, have invented certain new and useful Improvements in Combined Power and Heating Systems and Processes, of which the following is a specification.

My invention relates to a system of heating by means of steam or other hot working fluid discharged from a heat motor after the doing of work in such motor; and my invention is particularly applicable to multistage heat motors (for example, multistage steam turbines, compound, triple expansion, and quadruple expansion, reciprocating steam engines, etc.), and comprises a process of variably regulating the proportion of initial heat energy converted into power to that imparted as heat, and an apparatus for carrying out said process.

In this specification I will hereafter describe my invention as applied to a multistage steam motor, but it is to be understood that the steam motor is referred to as representing heat motors generally, and that steam is referred to as a working fluid, as representing heated working fluids generally.

According to my invention steam is withdrawn from the steam motor at a plurality of points, one point of withdrawal being, customarily, the ordinary exhaust connection, the other point of withdrawal being a point intermediate the point of steam supply and such ordinary exhaust connection, and being, therefore, a point at which the steam has expanded partially only, and therefore is at a higher temperature than at the point of normal exhaust; and the plurality of steam currents so withdrawn from the motor are discharged into separate steam heaters maintained, customarily, though not necessarily, at different temperatures, (because of the different temperatures of the steam currents supplied to them). In most cases, these steam heaters are condensers, which condense the steam supplied to them and in so doing heat water or other cooling fluid, which cooling fluids are customarily used for heating elsewhere; my system, as applied to steam motors, being a development of what is commonly termed an "exhaust heating system." However, my invention contemplates more than the mere utilization of the waste heat in exhaust steam, since it contemplates the delivery of power and heat in variable relation to each other; that is to say, contemplates the development of greater or less power in the motor, and less or greater heat in the heating system, as conditions may require.

In the accompanying drawing I have illustrated diagrammatically a heating and power-generating system embodying my invention, said drawing showing more or less diagrammatically and in elevation a multistage steam turbine, and showing more or less diagrammatically and in vertical section two condensers connected to such turbine, one at an intermediate point, and the other to the ordinary exhaust connection; together with heating conduits served by such condensers.

In said drawing, 1 designates the steam turbine, and 2 and 3 designate condensers and heaters, of which condenser 2 is connected to the turbine, at a point of intermediate expansion of the working fluid, by a pipe 4 provided with a regulating valve 5; while the other condenser, 3, is connected to the exhaust end of the turbine by the ordinary exhaust conduit 6. I have indicated condensers 2 and 3 of the ordinary surface condenser type; but it is to be understood that these illustrations of condensers of a particular type are, in a broad sense, illustrations of condensers generally, and that condensers of any other type, for example, jet condensers, barometric condensers, atmospheric condensers, etc., may be employed without departing from the spirit and scope of my invention; and likewise, steam-heated apparatus of various other types may be substituted for the condensers, without departing from the spirit and scope of my invention; for the condensers, 2 and 3, illustrated, are employed as generic illustrations of any type of apparatus suitable to be heated by hot working fluid discharged from a heat engine. However, in a steam heating system such as constitutes the specific embodiment of my invention illustrated, and in which water or other liquid heat-carrier is to be circulated, closed condensers, or heaters, such as the surface condensers illustrated, are desirable, for the reason that, when such closed heaters are employed in connection with a closed circulation system, excess head on the

return water or heating fluid circulated is not lost.

In the particular construction shown, the condenser or heater 2 comprises a shell 7, end tube sheets 8 and 9, tubes 10 supported by said tube sheets and passing through the interior of shell 7, and headers 11 and 12. Condenser or heater 3 is of similar construction. It will be understood that water or other fluid designed to receive heat from the steam and, by so doing, to condense the steam, is supplied to one of these headers, is caused to flow through the tubes 10 and thence into the other header, and thence passes into the external heating system. I have indicated the condenser and heater 2 as arranged to supply hot water or other heating fluid to a closed circulating system 13 containing a heating coil 14 (which coil 14 is designed to serve as representing, generically, anything to be heated by the fluid circulated through pipe 13); and similarly, I have illustrated the condenser and heater 3 as arranged to supply hot water or other heat fluid to a closed circulating system 15 comprising a heating coil 16 (this coil 16 being likewise a diagrammatic illustration of anything to be heated by the heat fluid circulated through the system 15). The return end of system 13 is connected to the header 11 of condenser 2, and the return end of the circulating system 15 is connected to the corresponding header of condenser 3. Suitable valves 17 and 18 are provided in these two circulating systems, whereby the flow through these systems may be regulated as desired; and I have also indicated a valved cross connection 19 between the two circulating systems 13 and 15, whereby, when desired, more or less of the fluid heated in condenser 3 may be supplied to the fluid to be heated in condenser 2; condenser 3 then serving as a preheater for condenser 2. It will be obvious that, independent of any means for forcing circulation through the heating systems 13 and 15, circulation will normally exist in such systems, when the condensers 2 and 3 are receiving steam, by thermo-siphon action; however, it is preferable to provide forced circulation in these heating systems; for which reason pumps 20 and 21 are preferably provided. These pumps may be driven in any suitable manner.

The temperature of the steam supplied through connection 4 to the condenser and heater 2 will naturally be higher than that of the steam supplied, through the normal exhaust connection 6, to the condenser and heater 3. The temperature of the cooling water supplied by circulating system 13 to the condenser 2, will, in most cases, be relatively high, and, therefore, there will exist, in the condensing space of condenser 2, a relatively low vacuum or even back pressure (*i. e.*, pressure above atmosphere;) the pressure obtaining in condenser 2 depending upon the rate of circulation of the fluid in circulating system 13, and the capacity of such heating system to radiate heat, and therefore to cool the fluid circulating through that system, and depending also upon whether the cross connection 19 from condenser 3 to condenser 2 is open or not; and depending also, of course, on the temperature of the steam supplied from motor 1 to condenser 2 and the rate at which such steam is supplied. By regulating the circulation of cooling fluid through the condenser 2, which regulation may be effected by means of the valve 17, or by varying the speed of the pump 20, or by both, the temperature of the cooling water of condenser 2 may be varied; so varying the back pressure or degree of vacuum in said condenser 2; and by the same means, or, by regulating the valve 5, the proportion of steam delivered by the motor 1 to condenser 2, to the total quantity of steam flowing through such motor 1, may be varied; and in this way the motor may be caused to deliver power and heat in variable relation to each other; more or less of the total heat energy in the steam initially supplied to the turbine being transformed into power, and less or more of such initial heat energy being transferred to the heating system 13, as desired.

If desired, means may be provided for connecting the condenser 2 to the motor 1 at various different points; and therefore I have indicated beside the connection 4, other valved connections 22 and 23. I have also indicated the condensers 2 and 3 as provided with the usual condensate discharge connections, 24 and 25.

When the condensers 2 and 3, or one of them, are atmospheric condensers, the heating fluid circulated through the heating lines 13 and 15, or through that one of said lines which is served by the atmospheric condenser, will be air or whatever other suitable gas is used as the condensing medium in the atmospheric condenser. The term atmospheric condenser as here used is generic to all condensers wherein the condensing medium is a gas.

What I claim is:—

1. A combined power and heating system, comprising in combination a motor adapted to be operated by a heated expansible working fluid, and two heaters connected to such motor at different points of expansion of the working fluid therein, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, one of said heaters being provided with mea.. for va-

rying its heat absorbing capacity without varying the heat absorbing capacity of the other said heater.

2. A combined power and heating system, comprising in combination a motor adapted to be operated by a heated expansible working fluid, and two heaters connected to such motor at different points of expansion of the working fluid therein, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, and a connection between said heaters whereby the one heater may serve as a preheater for the other heater.

3. A combined power and heating system, comprising in combination a motor adapted to be operated by a heated expansible working fluid, two heaters connected to such motor at different points of expansion of the working fluid therein, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, one of said heaters being provided with means for varying its heat absorbing capacity, and a connection between said heaters whereby the one heater may serve as a preheater for the other heater.

4. A combined power and heating system comprising in combination a heat motor adapted to be operated by, and in its operation to expand, a heated expansible working fluid, and two heaters connected to said motor, one of said heaters connected to the terminal exhaust connection of such motor, the other connected at an intermediate expansion point of such motor, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, said second heater provided with means for varying its heat absorbing capacity without varying the heat absorbing capacity of the other said heater.

5. A combined power and heating system comprising in combination a heat motor adapted to be operated by, and in its operation to expand, a heated expansible working fluid, and two heaters connected to said motor, one of said heaters connected to the terminal exhaust connection of such motor, the other connected at an intermediate expansion point of such motor, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, and regulating means interposed between said motor and said second heater.

6. A combined power and heating system comprising in combination a heat motor adapted to be operated by, and in its operation to expand, a heated expansible working fluid, and two heaters connected to said motor, one of said heaters connected to the terminal exhaust connection of such motor, the other connected at an intermediate expansion point of such motor, two circulating conduits, one connected to one of said heaters and the other connected to the other of said heaters and each arranged to conduct heated fluid from and then to return such fluid to its corresponding heater, and a connection between said heaters whereby one serves as a preheater for the other.

7. A combined power and heating system comprising in combination a multistage steam motor and two heaters and condensers arranged to receive steam from different stages of said motor, one of said heaters arranged to receive steam from an intermediate stage of the motor, and a heating system to which such last mentioned heater and condenser is connected, for the flow therethrough of the cooling fluid of that condenser, such heating system provided with means for regulating such flow and being arranged to return to such condenser the cooling fluid received therefrom.

8. The herein described process of variably regulating development of power and heat in a combined power and heating system, which comprises expanding a heated expansible working fluid in a suitable motor, withdrawing a portion of such working fluid from an intermediate expansion point of the motor, and exchanging heat between the working fluid so withdrawn and another fluid to be heated, and variably regulating the rate of absorption of heat by such second fluid, with respect to the rate of supply of working fluid to said motor, and thereby variably regulating the proportion of the initial heat energy of such working fluid converted into power to the heat energy imparted to said heating fluid.

9. The herein described process of variably regulating development of power and heat in a combined power and heating system, which comprises expanding a heated expansible working fluid in a suitable motor, withdrawing a portion of such working fluid from an intermediate expansion point of the motor, and exchanging heat between the working fluid so withdrawn and another fluid to be heated, and variably regulating the rate of absorption of heat by such second fluid, with respect to the rate of supply of working fluid to said motor, and thereby variably regulating the proportion of the

initial heat energy of such working fluid converted into power to the heat energy imparted to said heating fluid, withdrawing the remaining working fluid from the terminal expansion point of the motor, and exchanging heat between such terminal working fluid and another fluid to be heated.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

TORE G. E. LINDMARK.

Witnesses:
WOLDEMAR BOWMAN,
S. SJOGREN.