March 18, 1930. J. KEMNAL 1,751,004

POWER GENERATING SYSTEM AND METHOD OF OPERATING THE SAME

Original Filed May 7, 1923 2 Sheets-Sheet 1

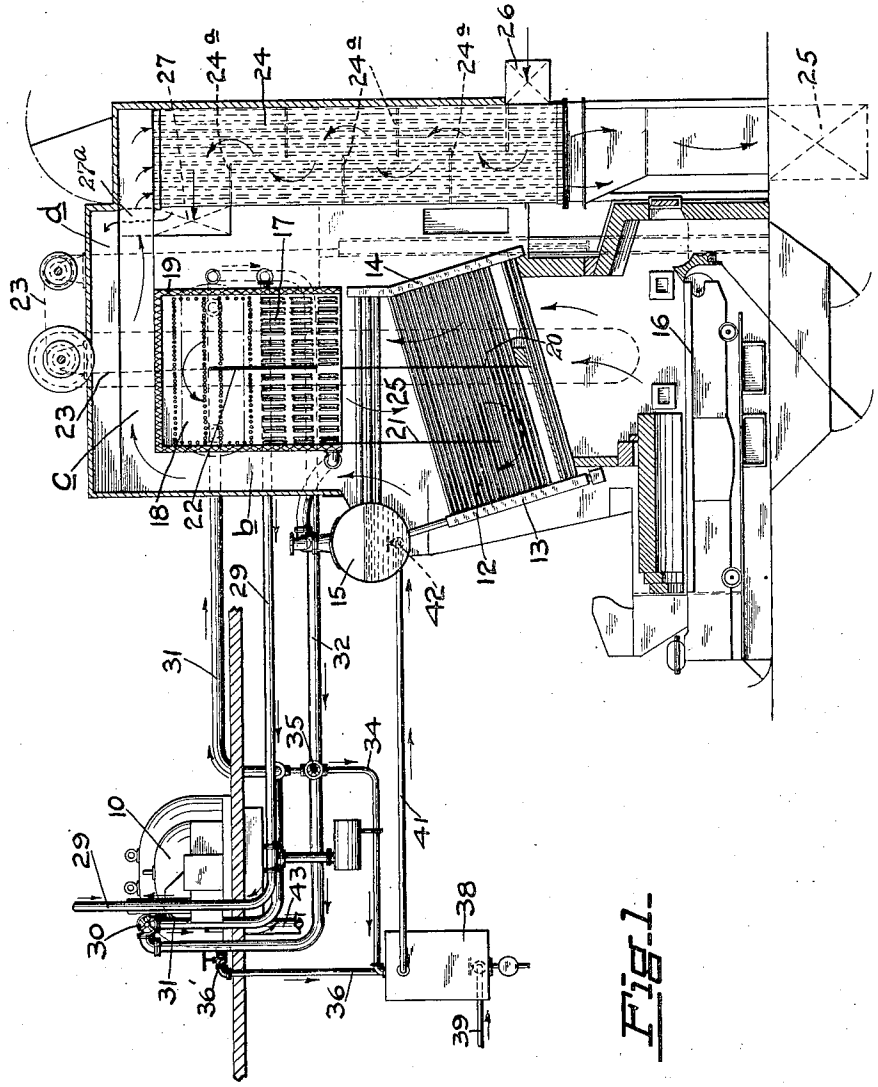


Fig-1.

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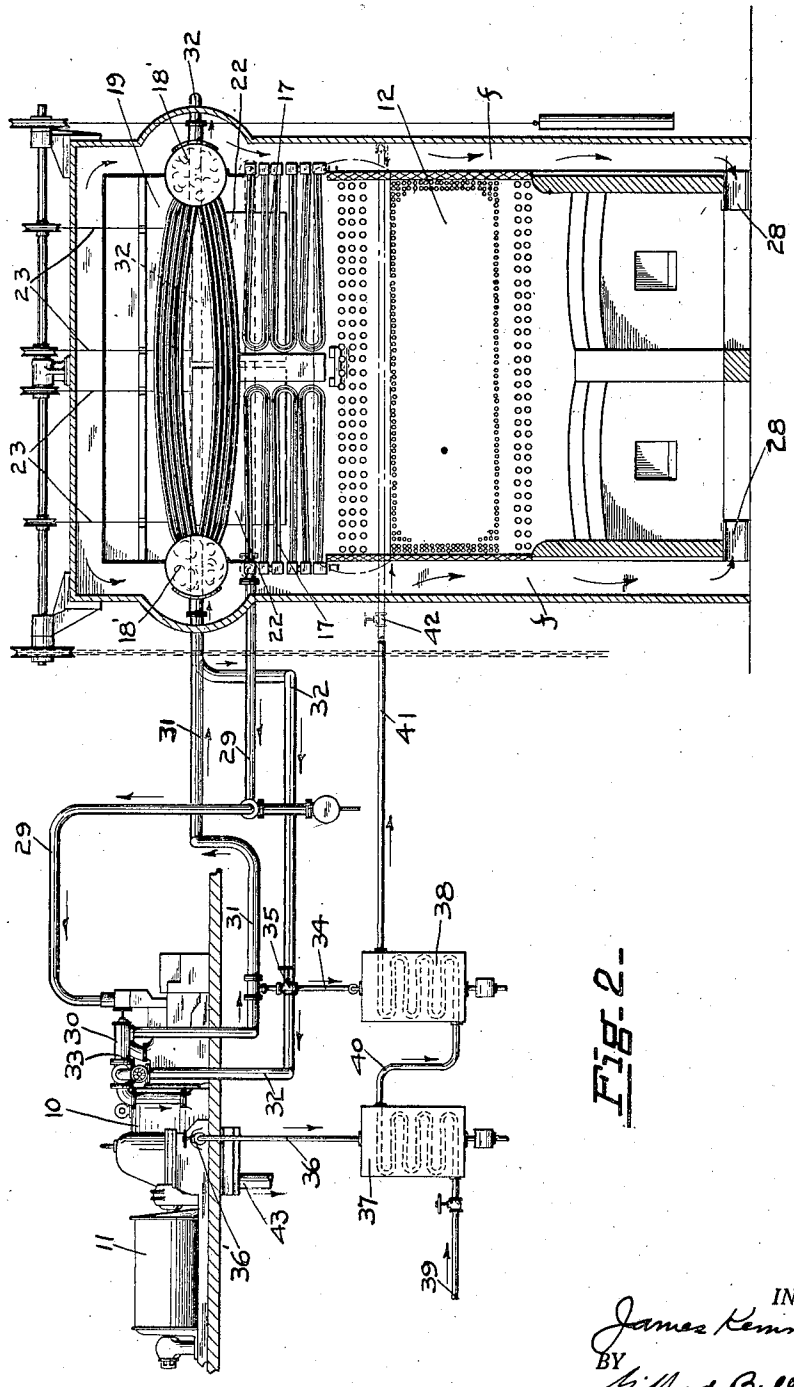


Fig. 2.

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Patented Mar. 18, 1930 1,751,004

UNITED STATES PATENT OFFICE

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POWER-GENERATING SYSTEM AND METHOD OF OPERATING THE SAME

Application filed May 7, 1923, Serial No. 637,088. Renewed August 1, 1928.

My present invention relates to power generating systems in which a multi-stage steam turbine is supplied with steam from a boiler and has for its object the provision of such a system in which high efficiency will be obtained. My invention will be best understood from the following description and the annexed drawings, in which Fig. 1 is a side elevation, partly in section, of a unit of such a system shown more or less diagrammatically, and Fig. 2 is a front elevation, partly in section, of the arrangement shown in Fig. 1.

Like reference characters indicate like parts in the different views.

In the illustrative embodiment, a multi-stage steam turbine 10 is connected to a generator 11 and is supplied with steam from a boiler which, in the form illustrated, has water tubes 12 connected to headers 13, 14, the boiler having a cross drum 15 and a chain-grate stoker 16. Within the boiler setting and above the boiler tubes 12 is a superheater 17 and a reheater 18, the superheater and the reheater being enclosed in a chamber 19, baffles 20 and 21 extending across the boiler tubes to form passes for the gases from the combustion chamber, the baffle 20 having as a continuation a movable baffle 22 suspended from chains 23 by which the vertical position of the baffle 22 may be changed. The reheater 18 has its tubes connected to drums 18′, 18′ on either side of the setting. When the baffle 22 is in the position shown in the figures, the gases from the combustion chamber flow upward at the right of the baffle 20 over the boiler tubes, thence over part of the superheater tubes, thence over the reheater tubes, thence over the remainder of the superheater tubes, and from thence downward and again upward over the boiler tubes, the gases passing between the setting walls and the casing 19 to the upper end of an air heater 24 and out through the outlet 25. It should be noted that the flue gases pass through passages *b* at the front of the boiler and *c* above the casing 19 to the upper end of the air heater 24 and down the tubes of the air heater to the outlet 25. The air heater is provided with baffles 24ª, 24ª to cause the air to flow back and forth across the tubes of the air heater 24. Air for combustion flows in through the inlet 26 over the air heater tubes and then laterally through an opening 27 and from thence upwardly through a passage 27ª to a passage *d* beneath the top of the setting casing and above the casing 19 and the passage *c*, and thence downward through passages *f* between the side walls of the setting and the casing, to openings 28, 28 beneath the grate.

Steam from the superheater 17 passes through pipes 29 to the high-pressure stage of the turbine 10. After passing through the high-pressure stage, some or all of the steam, according to the position of the valve 30, will pass through the pipes 31 to the reheater 18, and from thence through the pipes 32 to the inlet of the next lower stage of the turbine 10, the supply of steam from the reheater being controlled by a valve 33.

Some of the steam from pipe 31 passes through pipe 34 to a feed water heater 38, the supply being controlled by valve 35. A second feed water heater 37 is supplied with steam from between a pair of stages at lower pressure than that in pipe 31 through pipe 36, controlled by valve 36′. The feed water enters the heater 37 from pipe 39, and from thence flows through pipe 40 to the heater 38, from which it passes to the boiler through pipe 41, controlled by valve 42. By having the heaters in tandem and heating them with steam of successively higher temperatures, the feed water is finally heated to any desired temperature. Exhaust steam passes through pipe 43 to the usual condenser.

It has been found that the efficiency of the heat cycle is increased by withdrawing some of the steam as it passes from one stage of the turbine to another and utilizing the heat in the steam thus drawn off to heat the boiler feed water, and I have found that this efficiency is increased if sufficient steam is abstracted from the turbine to heat the feed water to a relatively high temperature, say, 300° F. When, however, the feed water is heater to this relatively high temperature, the usual economizer is so inefficient, because of the relatively small difference between the temperature of the flue gases and the tem-

perature of the water, that there is practically nothing gained from the use of an economizer. On the other hand, the flue gas temperature will be relatively high, because these gases have contacted only with water cooled heating surfaces which are in the general boiler circulation and which are, therefore, themselves of a comparatively high temperature.

To overcome the waste of heat in the flue gases which might be enough to neutralize the advantages obtained from abstracting steam from the intermediate stages of the turbine to heat the feed water, I provide the air heater 24 to abstract heat from the flue gases and return the same to the cycle by supplying heated air to the fuel for combustion purposes. By the combination which I have illustrated, the efficiency of the system is greatly increased over the usual one, in which the feed water would be heated only by the exhaust steam to a relatively low temperature and the temperature of the feed water further raised by passing it through an economizer contacted by the flue gases. I have also found that the total efficiency of the system is increased if the quantity of steam drawn from the intermediate stages of the turbine is sufficient to raise the temperature of the feed water to at least 300° F. by using two interstage feed water heaters in place of a single interstage heater that would raise the temperature to, say, 212° F.

In the arrangement which I have illustrated, it is also possible to control the degree of reheating of the steam in the reheater 18 without materially affecting the degree of superheat of the superheater 17. By raising the baffle 22, it will be seen that some of the furnace gases will be short-circuited between the upper end of the baffle 20 and the lower end of the baffle 22 and that by this means, some of the gases are prevented from passing over the reheater while, on the other hand, all of the gases pass over the superheater 17. If desired, the baffle 22 may be raised to a position where none of the gases will pass over the reheater 19.

By causing the gases to flow over part of the setting and the air for combustion to flow over the remainder of the setting, economic losses through radiation are greatly lessened. It is also advantageous, because, if through any leaks, the air or gases flowing over the boiler setting enters such setting, the economic losses are much less than would be the case if cold air were circulating over the setting, and in the case of air leaking into the furnace, the heated air will, where there are combustible elements in the gases, such as carbon monoxide, tend to burn the combustible gases more readily and thoroughly.

It will be understood that the arrangement shown in the drawings is merely illustrative and that the embodiment thereof may be widely varied.

I claim:

1. In a system for generating power, a steam boiler having a superheater, a furnace for the boiler, a steam reheater in the boiler setting, a multiple-stage steam turbine supplied with steam from the superheater, pipes to conduct steam from between a pair of stages to the reheater and from the reheater to an intermediate stage of the turbine, baffling to direct the furnace gases over boiler heating surfaces, the superheater and the reheater and back to the boiler heating surface, and means whereby the proportion of the furnace gases passing over the reheater may be varied to regulate the degree of reheating.

2. In a system for generating power, a steam boiler having a superheater, a furnace for the boiler, a steam reheater in the boiler setting, a multiple-stage steam turbine supplied with steam from the superheater, pipes for conducting steam from between a pair of stages of the steam turbine to the reheater and thence to an intermediate stage of the steam turbine, means for heating the feed water by a portion of the steam taken from between the pair of stages of the steam turbine, and means for regulating the amount of heat imparted to the steam in said reheater.

3. In a system for generating power, a steam boiler having a superheater, a furnace for the boiler, a steam reheater in the boiler setting, a multiple-stage steam turbine supplied with steam from the superheater, pipes for conducting steam from between a pair of stages of the steam turbine to the reheater and thence to an intermediate stage of the steam turbine, means for heating the feed water by a portion of the steam taken from between the pair of stages of the steam turbine, and means for regulating the amount of gases flowing over said reheater.

4. In a system for generating power, a steam boiler having a superheater, a furnace for the boiler, a steam reheater in the boiler setting, a multiple-stage steam turbine supplied with steam from the superheater, pipes for conducting steam from between a pair of stages of the steam turbine to the reheater and thence to an intermediate stage of the steam turbine, means for heating the feed water by a predetermined proportionate amount of the steam taken from between the pair of stages of the steam turbine, whereby the amount of heat imparted to the feed water varies in accordance with the load, and means for regulating the amount of heat imparted to the steam in said reheater.

5. The method of generating power in a system comprising a steam boiler and superheater, a furnace, a steam reheater in the boiler setting, a multiple stage steam turbine and a feed water heater, which consists in conducting steam from the superheater to the

high pressure stage of the turbine, conducting steam from between a pair of stages of the steam turbine to the reheater, utilizing a portion of the last mentioned steam for heating the feed water, and regulating the amount of heat imparted to the steam in said reheater.

6. The method of generating power in a system comprising a steam boiler and superheater, a furnace, a steam reheater in the boiler setting, a multiple stage steam turbine and a feed water heater, which consists in conducting steam from the superheater to the high pressure stage of the turbine, conducting steam from between a pair of stages of the steam turbine to the reheater, utilizing a portion of the last mentioned steam for heating the feed water, and regulating the amount of gases flowing over said reheater.

7. The method of generating power in a system comprising a steam boiler and superheater, a furnace, a steam reheater in the boiler setting, a multiple stage steam turbine and a feed water heater, which consists in conducting steam from the superheater to the high pressure stage of the turbine, conducting steam from between a pair of stages of the steam turbine to the reheater, utilizing a portion of the last mentioned steam for heating the feed water, and regulating the amount of heat imparted to the steam in said reheater in accordance with the load on said turbine.

8. In a system for generating power, a steam boiler having a superheater, a furnace for the boiler, a steam reheater in the boiler setting, a multiple-stage steam turbine supplied with steam from the superheater, pipes for conducting steam from between a pair of stages of the steam turbine to the reheater and thence to an intermediate stage of the steam turbine, means for heating the feed water by a portion of the steam taken from between the pair of stages of the steam turbine, and means for regulating the superheat of the steam leaving said reheater.

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