The present invention relates to the art of distributing steam from a central station with incidental production of power, and aims to provide a system whereby it is commercially advantageous to transmit steam from a central boiler plant or station for considerable distances.

The advantages of large high pressure central boiler plants are not commonly utilized by chemical and other manufacturers requiring process steam because it is not often practical to group sizable plants close together. Difficulties have been encountered in attempting to design systems to distribute steam for process use over considerable areas in that steam used for heating in chemical and other manufacturing processes must be cheap. The usual way of providing cheap steam is to generate it at a pressure suitable for use in prime movers and to extract the more valuable higher temperature heat units in a prime mover before sending it to the process.

The steam, however, has always been delivered from the prime mover at low pressure, and its consequent large specific volume has made it impractical to transport it any considerable distance on account of the large pipes required.

Another difficulty has arisen from the cost of make-up water for high pressure boilers. As steam used in process work cannot usually be returned to the boiler as condensate, it has been proposed to reduce the amount of make-up water otherwise needed by using a condenser-evaporator between the boiler plant and the steam consuming process so that raw water may be evaporated for process use by condensing boiler steam and the condensate returned to the boiler plant.

The loss of the relatively expensive treated or distilled make-up water is thereby kept at minimum. However, the evaporators used have delivered steam at low pressure and have been expensive, their cost further reacting against the use of central station steam for process work.

I have discovered that it is possible to avoid the above mentioned difficulties by generating the steam to be used outside the central station in a high pressure evaporator, so that the steam can be distributed economically to points at some distance from the central station, and by reducing the cost of the evaporator by maintaining a relatively high difference in temperature between the condensing space and the evaporating space of the evaporator. However, I do not limit myself in all cases to the use of either an evaporator delivering steam at high pressure or to one operating with a high temperature difference, as certain features of my invention may be employed with ordinary evaporators.

In order that the invention, together with further objects and advantages thereof, may be clearly understood, I will now describe in detail in connection with the accompanying drawing a particular apparatus embodying my invention and adapted to carry out the method of my invention. In said drawing Fig. 1 is a diagrammatic view of an apparatus in accordance with my invention, and Fig. 2 is a longitudinal sectional view of a combination desuperheater and steam separator forming a part of Fig. 1.

Referring to the drawing more in detail, 10 designates a high pressure boiler having a furnace, not shown. The gases used for heating boiler 10 after leaving the boiler are conducted through an economizer 12 for preheating the feed-water for the boiler in the coil 14. Steam from boiler 10 is conducted to a prime mover 16 through a pipe 18. Steam exhausted from prime mover 16 is utilized by condensation to evaporate water to furnish steam to consumers outside the plant containing boiler 10 and prime mover 16. If desired, feed-water for boiler 10 may be heated further after passing through the economizer 12 by means of steam bled from prime mover 16 in known manner. This feature is not part of my invention, however, and is not claimed herein. Preferably the steam for the engine 16 is superheated before use by passing it through a superheater 20 which may be separately fired, if desired, or may be combined with the boiler 10. Both such methods of heating the superheater were well known before this present invention and are not claimed by me. Prime mover 16, which is preferably of the turbine type, is connected to drive a dynamo 22, the current from which is taken off through a switch 24 and feeders 26 to a power distribution system which has an average load which is large in proportion to the rating of prime mover 16 so that the variations in the output of the generating set 16—22 may be taken care of by other generators 22a, 22a connected to the system without inconveniencing the power customers of the system.

The steam exhausted from prime mover 16 is conducted by pipe 28 to a condensing chamber illustrated as a coil 30 forming a portion of an evaporator having a shell 32 surrounding coil 30. Raw water is fed to shell 32 so that it may be evaporated by the condensation of steam in coil 30 to provide cheap steam for sale. As will presently appear, it is desirable to generate steam in shell 32 at a considerable pressure relative to that at which it is consumed. In order that the evaporating apparatus may be relatively small and inexpensive, it is preferred to maintain a considerable difference of pressure, and therefore of temperature, between the condensing chamber in coil 30 and the evaporating chamber in shell 32. In the plant illustrated, this difference in steam pressure is about 150 pounds gage. Steam generated in evaporator shell 32 is conducted by pipe 34 to an apparatus 36 in which it is utilized...
for heating either in a process or otherwise as may be desired. If desired, steam from shell 32 may be superheated at a point close to the shell, but the advantage of so doing is considered unimpor-
tant. As indicated by the break at 38 in pipe 34, it is assumed that ordinarily the point of su-
pressor 38 for the steam furnished by pipe 34 is at such a distance from the evaporator shell 32 that steam can be transmitted economically between the two points only at a considerable pressure. The steam furnished by pipe 34 therefore con-
tains valuable high temperature heat units which I consider desirable to utilize other than for heat-
ing. I have therefore illustrated a prime mover 40

as set relatively close to the steam consuming apparatus 36 and as utilizing steam from the pipe 34 to generate power prior to utilization of such steam at the point 36. The steam from pipe 34 may be superheated, if desired, in the superheater

40 42 prior to its utilization in prime mover 40. In case load conditions on engine 40 reduce the tem-
perature of the steam exhausted therefrom below that required by apparatus 36, the steam from prime mover 40 may be reheated in the reheater

44 prior to its use in 36. I prefer to utilize, for such reheating, steam taken from the pipe 34 at a point ahead of prime mover 40 and which can be conducted to the reheater 44 through a valved pipe 46.

It is desirable to return condensate formed in coil 30 to the boiler 10 and for this purpose a pipe 48 is employed in which is a feed pump 50 which forces the condensate through the coil 14 previously mentioned and into the boiler 10.

Preferably the raw water supplied to evaporator shell 32 is preheated and in order to obtain a higher efficiency from the system the heat of the gases discharged from boiler 10 is employed for this purpose, although in the arrangement illus-

trated this is done indirectly. As shown, cold raw water is forced by pump 51 into a heat exchanger 52 within which is a coil 54 con-
nected into the pipe line 48 so that feed water for boiler 10 is cooled prior to passing through the economizer 14 and the gases from the boiler 10 are therefore discharged from the system at a minimum temperature and with minimum loss of heat. At the same time the raw water for the evaporator is preheated and, due to the pressure and temperature at which the condensate is formed, the temperature of the raw water delivered by the heat exchanger 52 may be considerable. This temperature may be further increased, if desired, by bleeding steam from turbine 16 for heating the raw water. The pre-

heating of water to be evaporated by means of steam exhausted from a prime mover is not claimed herein and therefore is not illustrated.

The preheating of the raw water before its intro-
duction into evaporator 32 precipitates certain carbonates and thereby permits, by drawing them off from the preheater 52 or evaporator 32 from time to time in the usual manner, the removal of such impurities which might otherwise reduce the efficiency of the evaporation.

Although the two are in different steam cir-
cuits, it is desired to govern the supply of steam to prime mover 16 somewhat in proportion to the use of steam at point 36. For this purpose, I provide a valve 55 in the supply line 18 for con-
trolling the passage of steam to prime mover 16 and I regulate the amount of opening of valve 55 preferably by means of the steam pressure in the evaporator shell 32. For this purpose, I have

illustrated valve 55 as having a rod or valve stem 53 coupled to a movable element 58 forming part of a metal “siphon” or like elastic bellows 60, the interior of which is supplied with steam from the shell 32 by the pipe 62. In order, however, to prevent prime mover 16 from running away in case the hand-operated switches 25 are opened, I have provided in this connection a circuit breaker.

The circuit of dynamo 22, I also provide the prime mover 16 with a speed controlling governor valve 64 of an ordinary type. The governor 64, however, is adjusted to act more slowly than that ordinarily employed for prime movers of electric generating stations so that engine 16 may deliver its full rated load somewhat irrespective of the other generating sets 22a, 22b, supplying the electric distribution system to which dynamo 22 is connected whenever the demand for steam at point 36 occurs.

It is well-known that steam engines, especially steam turbines, deliver saturated steam only at a certain given load, depending upon the design of the turbine. It therefore is to be assumed that the steam in pipe 26 will be either wet or superheated for a majority of the time, depending upon load conditions on engine 16.

I have found, however, that the best efficiency is obtained from the condensing surface 30 when the steam is saturated. In order to avoid using greater heating and condensing surface in the

evaporator than otherwise would be necessary, I therefore have shown in the pipe 28 intermediate prime mover 16 and evaporator 32 a means which can be used for either removing moisture or superheat from the steam in such pipe. For this purpose I have provided a shell 66, the internal arrangement of which is illustrated in detail in Fig. 2. For coping with wet steam I have pro-

vided within shell 66 a known steam separator arrangement comprising helical vanes 68 fixed to a central core 70 tapered at both ends. The whirligig action set up by the vanes 68 acts to throw the moisture in the steam against the inner face of the shell 66 so that it drains down to the bottom of the shell and can be removed through the valve pipe 72. As shown in Fig. 1, pipe 72 preferably connects the interior of the shell 66 with the pipe 46 on the inlet side of pump 50 so that water separated from the steam and discharged through pipe 72 is retained in the circuit of the boiler 10. Preferably also the end of the tapered core 70 nearest the outlet of shell 66 has a flaring conical shield 74 fixed thereto to prevent a film of water which may flow along the surface of core 70 from discharging into the exit section of the pipe 28. For coping with superheated steam which may be discharged from engine 16, I provide within the shell 66 a spray nozzle 76 for discharging a spray of water into the interior of shell 66 at the mouth of the inlet section of pipe 28 and between the mouth of the pipe and the front end of the core 70. The vanes 68 and core 70 therefore are in a position to facilitate the superheating of the steam by intimately mixing the water spray from the nozzle 76 with steam passing through the 140 shell. Water for the nozzle 76 is preferably pro-

vided through a valve pipe 78 which connects into the pipe 48 on the high pressure side of the pump 50. In order that the attendants may be apprised of conditions of superheat or wetness in the steam and may regulate the operation of the exhaust of engine 16, I provide a steam

gage 77 and thermometers 79, 79 connected to pipe 28, and a gage glass 81 connected to shell 66.

While the operation of my improved system 150
will be obvious to those skilled in the art from the foregoing description, it may be summarized for purposes of convenience as follows: Steam is generated in boiler 10 preferably at a pressure of the order of 1200 lbs. gage and is then superheated in a superheater 20 preferably to about 750° F. or more before being used in the engine 16 for driving the dynamo 32. Exhaust steam from engine 16 is used in evaporator 32 to evaporate raw water, at the same time condensing the exhaust from the engine. The exhaust from the engine should preferably, however, be brought to the point of saturation before use in the evaporator in case it is either wet or superheated when leaving the engine. Condensate from the evaporator 32 is pumped back to the boiler 10 through a heat exchanger 52 in which the raw water for the evaporator is preheated and the condensate cooled, the condensate then going to the boiler through the economizer 12.

As the evaporator is operated normally at about 250 lbs. gage, the condensate is sufficiently hot to raise the raw water to the point at which many impurities may be eliminated. At the same time, the condensate is, however, cooled in the heat exchanger so that the gases leave economizer 12 at a low temperature and the system containing boiler 10 operates at high efficiency. As the steam generated in the evaporator 32 is at a considerable pressure, it may be transmitted for distances economically impossible when using steam at about 15 to 30 lbs. gage, but it contains valuable heat units which are utilized in a second prime mover 40 before use in a process or other steam consuming apparatus at the point 36. Steam may be heated either before or after it is used in prime mover 40 or both, as desired.

It will be seen that my method and apparatus are adapted to furnish by-product steam at low cost over a relatively large area, this result being promoted by delivering to the consumer only such steam as is generated from raw water and by the high thermal efficiency of the system as well as by the high distribution pressure of the steam delivered to the consumer. It will be understood, however, that the embodiment of the invention above described is illustrative only and that certain of the mechanical elements and sub-combinations as well as certain of the process steps and sub-combinations herein disclosed may be used independently of each other and that none of the appended claims is limited to any detail of the above description except insofar as such detail is clearly and positively expressed in a claim.

I claim:

1. A steam generating and distributing system comprising a steam operated prime mover, a boiler for supplying steam to said prime mover, an evaporator receiving steam exhausted from said prime mover and having means for condensing said steam and for evaporating water thereby, and a pressure line receiving steam from said evaporator and delivering steam to a consumer at a relatively great distance from the evaporator as compared to the prime mover, an apparatus intermediate the end of said line and said consumer and adapted to absorb energy from the steam and to reduce the pressure thereof substantially to that of said consumer, said evaporator and steam distribution line being constructed for a pressure relatively high as compared to the pressure at which steam from the evaporator is finally utilized, a pump for forcing condensate from the evaporator to the boiler supplying the prime mover and a valved connection for conducting water from the high pressure side of said pump to a point in the system intermediate the prime mover and the condensing space of the evaporator.

2. A steam generating and distributing system comprising a steam operated prime mover, an evaporator receiving steam exhausted from said prime mover and having means for condensing said steam and for evaporating water thereby, a pressure line receiving steam from said evaporator and delivering steam therefrom to a consumer, a boiler for supplying steam to said prime mover, a pump for forcing condensate from said evaporator to said boiler, and a valved connection for conducting water from the high pressure side of said pump to a point in the system intermediate the prime mover and the condensing space of the evaporator.

WILBUR H. ARMACOST.