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W. T. BOTTOMLEY ET AL

LARGE SCALE POWER PRODUCTION FROM SOLID FUEL

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Fig. 1

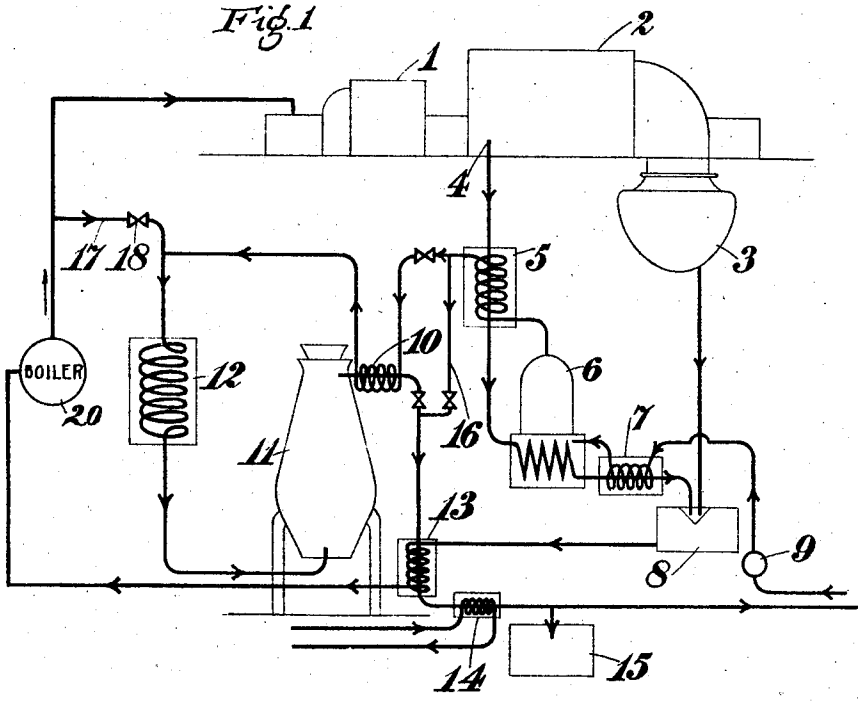
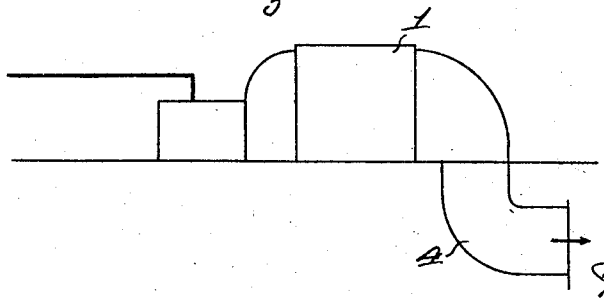


Fig. 2.



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UNITED STATES PATENT OFFICE.

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LARGE SCALE POWER PRODUCTION FROM SOLID FUEL.

Application filed September 20, 1921, Serial No. 502,085, and in Great Britain December 3, 1920.

This invention is for improvements in or relating to large-scale power-production and has particular reference to the economic use of solid fuel for large scale production by means of low-temperature distillation of fuel with the consequent separation of valuable distillation products and of combustible gaseous and solid residue.

It has been previously proposed to supply heat for the low-temperature distillation process by means of steam bled from steam turbines or other engines. It has been found, however, that is not necessary for economy to use the bleed-steam in the distillation plant but that the same economy may be obtained by using the heat only that is contained in the bled steam.

Since the water in the steam passing through the distillation retort and condensers is unfit for further use, a fresh supply of water, hereinafter called the "distillation water" or "distillation steam" must be supplied to make up the deficit. The term "distillation water" used in this specification and in the claims is intended to refer to water to which is transferred the heat of steam obtained from steam turbines or other steam power plant, and the term "distillation steam" is intended to refer to the steam into which such water is converted, and which is used for the low-temperature distillation of fuel.

According to this invention bleed-steam or exhaust steam from a steam power unit is passed through heat-exchanging apparatus wherein its heat is employed to evaporate distillation water and the distillation steam so produced is utilized in a low-temperature distillation apparatus.

Otherwise expressed the invention consists in a method wherein the bleed-steam or exhaust-steam is circulated through a closed circuit comprising one element of a heat-exchanging apparatus and the main boiler serving the steam power unit, and the distillation water is passed through a second circuit comprising the other element of the heat-exchanging apparatus and a low-temperature distillation apparatus, with or without a low-pressure superheater for the steam before it is delivered to the said distillation apparatus.

Conveniently the steam produced from the said distillation water is by-passed through a feed-water heater when the distillation apparatus is out of commission.

The invention also includes apparatus for carrying out the method, such apparatus comprising broadly in combination a steam power unit, a low-temperature distillation apparatus, heat-exchanging apparatus, means to pass bleed-steam or exhaust-steam from the said power-unit through one element of the heat-exchanging apparatus, means to return the condensate therefrom to the boiler serving the said power-unit, means to pass distillation water through the other element of the heat-exchanging apparatus and to convey distillation steam so produced to the distillation apparatus, with or without a low-pressure high-temperature superheater for the distillation steam before it is admitted to the distillation apparatus.

In the drawing:

Figure 1 is a diagrammatic illustration of the preferred form of apparatus for carrying the invention into effect.

Figure 2 is a diagrammatic illustration of a back-pressure turbine showing the manner in which its exhaust steam may be utilized.

In the preferred apparatus for carrying the invention into effect, which is illustrated in Figure 1 of the accompanying drawing by way of example only, steam is bled as at 4 from the low-pressure stage 2 of a condensing turbine 1, 2, 3 and passed through one element of each of several heat-exchangers 5, 6 and 7 wherein the steam is condensed. The condensate passes thence to a hot-well 8.

Distillation water is passed by means of a pump 9 through the other elements of the heat-exchangers 7, 6, 5 respectively in the reverse direction and thence through a further heat-exchanger 10 which is heated by the steam and gases as they issue from a low-temperature retort 11. After leaving this further heat-exchanger 10, which imparts additional superheat to the distillation steam thus generated, the latter is conveyed through a low-pressure high-temperature superheater 12 and thence to the lower end of the retort 11.

Steam, mixed with distilled gases, leaves the top of the retort 11 and passes into the additional heat-exchanger 10, and on leaving it is passed through a feed-water heater

13 and then into a cooling apparatus 14, the feed-water heater 13 and the cooler 14 condensing out the steam and the tar which passes to a receiver 15, the residual gas being collected in the receiver. The gas passes on to a stripping plant of the usual type.

Feed-water for the boiler 20 is taken from the hot-well 8 and passes through the feed-water heater 13. In cases when the retort 11 is out of commission a by-pass circuit, indicated at 16, is provided by which the distillation steam is passed from the heat-exchangers direct to the feed-water heater.

For starting the plant, means are provided for introducing high-pressure steam from the boiler 20 through a conduit 17 and reducing valve 18 direct into the retort 11 by way of the low-pressure high-temperature superheater 12 above referred to.

Obviously, instead of using bleed steam as described above, the exhaust from a turbine, for example a back-pressure turbine as shown in Figure 2, or other steam power plant may be used in an analogous manner. Thus the part designated 1 in the drawing may represent such a steam power unit and the pipe 4 may be assumed to be connected directly to its exhaust outlet. Obviously in this case the whole of the steam from the back-pressure turbine or other steam-plant will pass into the heat-exchangers 5, 6, 7.

Since it is necessary that the pressure of the distillation steam passing into the retort should be above atmospheric pressure to allow for the drop of pressure in the retort, the distillation water is passed into the heat-exchanger or evaporator by means of a pump 9 as before.

By this invention, the steam used in the boilers and turbines is kept separate from the steam used in the retorts. This invention is particularly advantageous in cases where the distillation water is unfit for use in the boilers without first being purified either by distillation or by being chemically treated.

What we claim as our invention and desire to secure by Letters Patent is:—

1. For utilizing in a low-temperature fuel-distillation process steam from a steam power-unit, apparatus comprising in combination a steam power-unit, a boiler for supplying steam thereto, a low-temperature distillation apparatus, heat-exchanging apparatus, means to pass steam from said power-unit through one element of the said heat-exchanging apparatus, means to return the condensate therefrom to the said boiler, means to pass "distillation water" through the other element of the heat-exchanging apparatus, whereby it is converted into "distillation steam", means to convey said "distillation steam" to the distillation apparatus, a feed-water heater for the said boiler, and means to by-pass "distillation steam" delivered from the heat-exchanging apparatus through said feed-water heater instead of through the distillation apparatus when the latter is out of commission.

2. For utilizing in a low-temperature fuel-distillation process steam from a steam power-unit, apparatus comprising in combination a steam power-unit, a boiler for supplying steam thereto, a low-temperature distillation apparatus, a plurality of heat-exchanging units, means to pass steam from the power-unit in succession through one element of each of the heat-exchanging units, means to pass the condensate therefrom to said boiler, a feed-water heater in the connection to the boiler through which the condensate passes, means to pass "distillation water" in succession through the other element of each of the heat-exchanging units in a counter direction to that in which the steam passes therethrough, whereby the "distillation water" is converted into "distillation steam", an additional heat-exchanger for the "distillation steam", a high-temperature low-pressure superheater for the "distillation steam", means to pass the latter through one element of the additional heat-exchanger and through the superheater to the retort, and means to lead products of distillation from the distillation apparatus through the other element of the additional heat-exchanger and through one element of the feed-water heater.

3. For utilizing in a low-temperature fuel-distillation process steam from a steam power-unit, apparatus comprising in combination a steam power-unit, a boiler for supplying steam thereto, a low-temperature distillation apparatus, a plurality of heat-exchanging units, means to pass steam from the power-unit in succession through one element of each of the heat-exchanging units, means to pass the condensate therefrom to said boiler, a feed-water heater in the connection to the boiler through which the condensate passes, means to pass "distillation water" in succession through the other element of each of the heat-exchanging units in a counter direction to that in which the steam passes therethrough, and thereby convert the "distillation water" into "distillation steam", an additional heat-exchanger for the "distillation steam", a high-temperature low-pressure superheater for the "distillation steam", means to pass the latter through one element of the additional heat-exchanger and through the superheater to the retort, means to lead products of distillation from the distillation apparatus through the other element of the additional heat-exchanger and through one element of the feed-water heater, and means to by-pass "distillation steam" after it has left the heat-exchanging units direct to the feed-water heater instead of through the addi-

tional heat-exchanger and the distillation-apparatus when the latter is out of commission.

4. In low-temperature fuel-distillation apparatus, the combination with a source of steam, a heat-exchanger whereof one element is connected to the said source of steam, and its second element has one end for connection to a source of "distillation water," a low-temperature retort, a low-pressure superheater having its outlet connected to the latter, a second heat-exchanger whereof one element is connected in series with the said second element and with the inlet of said superheater, and its second element is connected to the retort-outlet for vapor and gases, and a by-pass pipe connecting the delivery end of the second element of the first said heat-exchanger with the delivery end of the said second element of the said second heat-exchanger for by-passing the distillation steam when the distillation apparatus is out of commission.

In testimony whereof we have signed our names to this specification.

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